TRIALLING INNOVATIVE & SUSTAINABLE DOMESTIC WASTEWATER TREATMENT & DISPOSAL SYSTEMS

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Abstract

This three-year project involved trialing five different systems incorporating current and new generation technology: re-circulating sand filter (RSF), pulse-dosed aerobic sand filter (PDASF), enhanced treatment oxidation system (ETOS), filtered septic tank system and effluent landscaped sand mound (ELM), and a re-circulating media filter.

The objectives of this project were to develop and trial more efficient and alternative wastewater treatment systems with sustainable and cost-effective disposal options with minimal maintenance, using the latest in innovation and the best available technology.

The need to trial and study alternative methods of domestic wastewater treatment and disposal eventuated due to the inability of conventional septic tank systems to effectively treat and dispose of effluent especially in environmentally sensitive areas in soils that are predominately clay based and dispersive with serious potential for tunnel erosion which is widespread throughout he trial areas of Honeywood and Baskerville in the Derwent River Catchment area, north of Hobart.

The positive outcome of this project will give local authorities, site evaluators designers, land developers and owners a wider choice of wastewater treatment and effluent disposal and re-use systems and information and advice on best management practice to property owners.

1 Introduction

Generally the soils within the municipality are clay-based with variable permeability. Some clays are very dispersive and prone to tunnel erosion.

The trial areas have a complex geological distribution with three main features: Jurassic dolerite bedrock, Triassic sandstone/mudstone/siltstone bedrock and colluvial deposits.

Ground investigations have confirmed a more complex geological pattern and this will be included in a future presentation, which has investigated the whole catchment.

The majority of the existing septic tank systems over eight to ten years old have failed for various reasons:- unsuitable soils, insufficient disposal area failure of owners to maintain systems, hydraulic overloading, owner's ignorance on operation of system.

There is now an urgent need for more cost effective and sustainable systems to be developed to effectively treat effluent for re-use.

A wider choice of managed wastewater treatment and disposal systems will allow the public to choose a suitable site-specific system to suite their needs and their environment.

The domestic on-site wastewater systems trialled were:- aerobic re-circulating sand filter; pulse-dosed aerobic sand filter; landscaped sand mound; Enhanced Treatment Oxidation System, filtered septic tank system, and a re-circulating trickling media filtration system.

2 Treatment System Summary

All systems trialled have large volume septic tanks (min. 4500L) with in-tank filters. It is considered most important to have large septic tanks to ensure better quality primary treated effluent prior to secondary treatment. Larger capacity also provides for an increased buffer for toxic discharges, oils and grease, and allows for less maintenance to the system. The systems are designed for low cost maintenance and operation and are suited to most site conditions.

3 Recirculating Sand Filter – Process Innovation

Traditionally, sand-filters for the secondary treatment of primary effluent have been single-pass filters. The sand in these systems was defined as a medium river-sand and the maximum recommended loading rate was 50 litres/m^2/day. The quality of effluent produced is extremely high.

B.O.D. < 5 mg/L* - consistently

S.S. < 5mg/L - consistently

Treatment coliforms 0-10

The purpose of the recirculating sand filter project was to demonstrate the quality of effluent achievable from a filter that considerable smaller in size with a non-traditional media grading.

To encourage wider adoption of the sand filter option in the community it is necessary to offer a design that is less costly to construct. Another incentive to modifying traditional design was to provide a natural media filter that is less susceptible to physical or biological clogging. So to this end, the new filter was constructed using a material larger than sand-size particles. The treatment media layer is a fine aggregate – 5mm-7mm size.

The coarser size treatment media provides much less surface area for the treatment and also allows the flow through the media to be much faster. Hence the need for recirculation, which gives the wastewater more chance to come in contact with the biomass, that grows on the media. The effluent quality measured demonstrates that the more-compact re-circulating sand-filter can achieve results almost as good as the traditional single-pass sand filter, except for disinfection levels. When drip irrigation is adopted the trade off of reduced levels of disinfection is not of any great consequence.

4 Pulse Dosed Aerobic Sand Filter – Process Innovation

Primary treatment occurs in 2 x 3000L horizontal cylindrical septic tanks connected in series. The tanks are rotationally - moulded plastic tanks designed with an outlet chamber to minimise solids carry-over.

First-stage secondary treatment is performed in a horizontal-flow anaerobic rock-filter with a cross-section of 1.5m wide x 400mm deep and 12 metres long. This unit has proved to be most effective at reducing BOD and SS by more than 50%. To enhance performance, the surface has been planted with a variety of waterweeds with rhizomes in their root system to (supposedly) diffuse oxygen into the water.

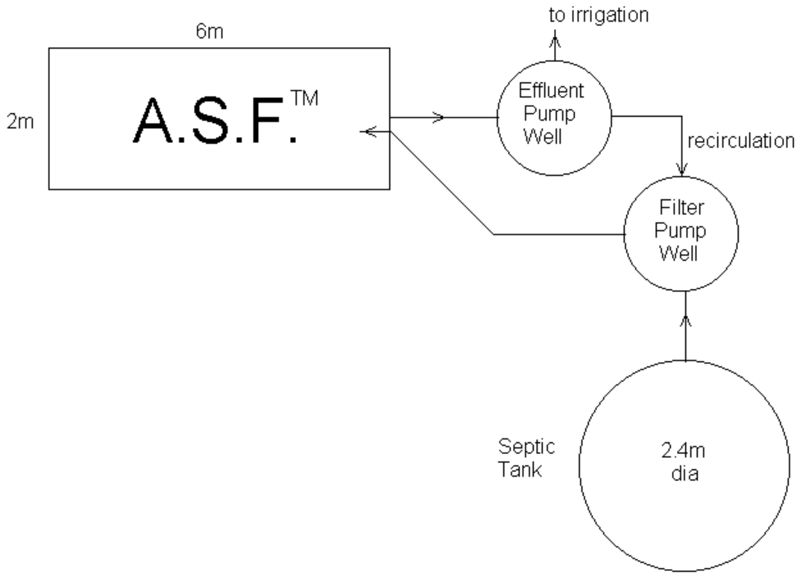

Figure 1 – Aerobic Sand Filter (schematic)

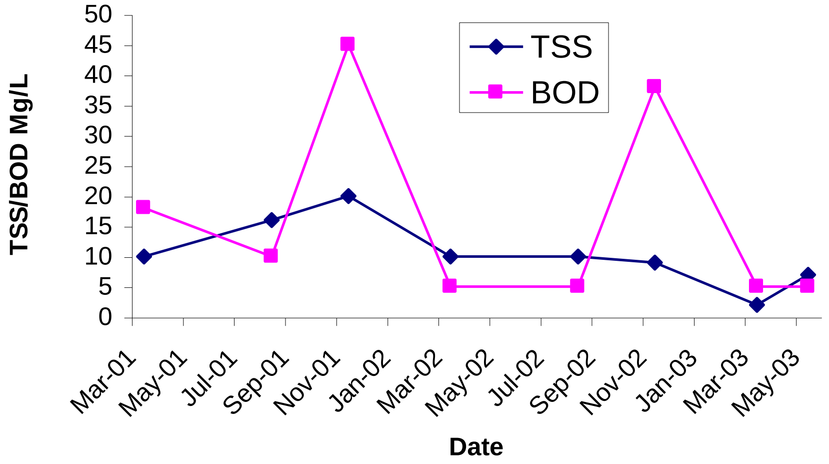

Figure 2 – Aerobic Sand Filter (performance)

Aerobic Sand Filter - Mean Analysis											
	pH	TSS	BOD	P	NH_3	NO_3^-	NO_2^-	Total N	TKN	TDS	TFC
Outlet	7	12	13	12	18	24	0.31	38	27	361	2000

The final stage of secondary is a sand-filter using medium-sand on the filter medium. Before being dosed onto the A.S.F.™ the rock-filter effluent is filtered through an in-line stainless steel gauze filter which is backwashed before and after each filtering cycle to prevent any accumulation of difficult-to-remove slimes/scum/solids. The operation of filtration has been extremely reliable. Dosing onto the A.S.F.™ is through "water-flow" dripper line. The pulse dosing applies an effective 1mm thick layer over the 40m² surface each pumping event. The effluent moves down through sand by capillary action i.e. the effluent moves down over the surface of the media grains still leaving air space in the voids for maximum aeration.

The final effluent has consistently yielded bacteriological counts of less than 10 cfu per 100mL, which means the effluent is naturally disinfected to a standard acceptable for above-ground / spray irrigation.

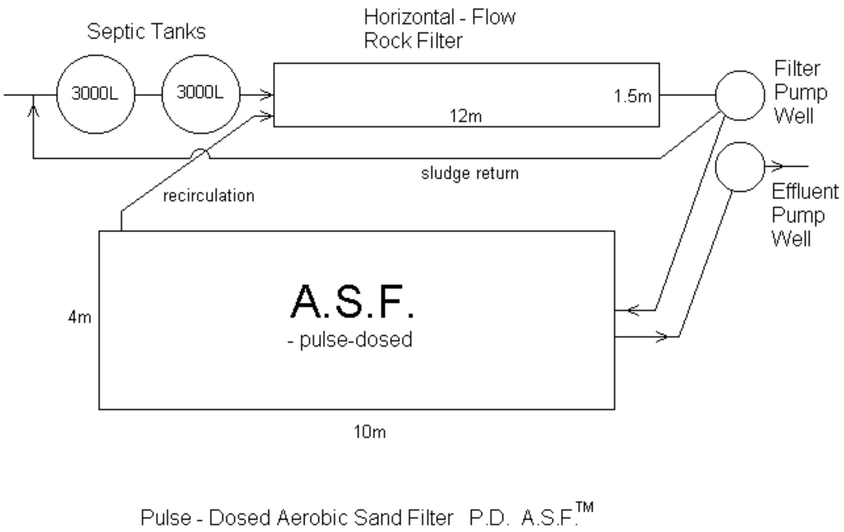

Figure 3 – Pulse Dosed Aerobic Sand Filter (Schematic)

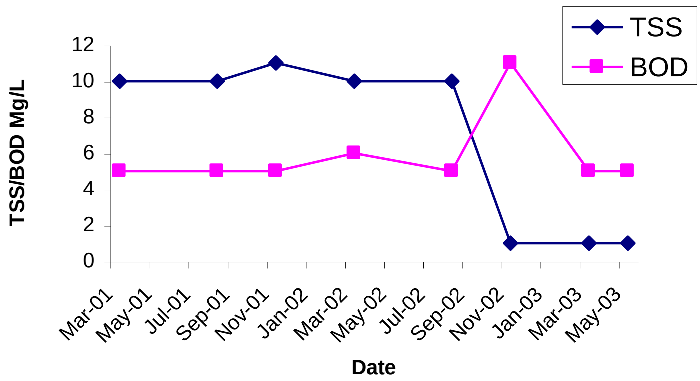

Figure 4 – Pulse Dosed Aerobic Sand Filter (performance)

Gunners Quoin - Mean Analysis											
	pH	TSS	BOD	P	NH_3	NO_3^-	NO_2^-	Total N	TKN	TDS	TFC
Septic 1	7.6	61	250	19	99	<.2	<.05	110	110	429	300,000
Septic 2	7.6	47	200	17	60	<.2	<.05	73	73	392	
Wetlands (Inlet)	7.5	47	235	20	78	<.2	<.05	92	92		
Wetlands (outlet)	7.5	28	158	18	71	<.21	<.05	82			660
S/Filter (outlet)	4.5	<10	<5	14	12	0.44	<.05	67	16	591	<10

5 Enhanced Treatment Oxidation System – Process Innovation

The unit is designed to accept raw household wastewater directly into the aeration stage without primary treatment in a septic tank. The total liquid capacity of the aeration / secondary treatment chambers is less than 2000L which results in the treatment plant being extremely compact. The aeration compartment is divided into 3 cells: the central cell is highly aerated and the rising flow from this cell is then divided into the first cell, which receives the raw waste and the third cell from which the flow stream enters the clarification chamber.

The flow from the clarification chamber is regulated to attenuate the instantaneous peak flows from the house viz. a washing machine dump, a bath draining.

All three cells of the aeration stage contain submerged media.

The aerator used has a low power requirement compared with the blowers used in other makes of Aerated Wastewater Treatment Systems (AWTS). The intention of the design of the enhanced treatment oxidation system is to use a low concentration of ozone in the air supply to reduce the net sludge production in the process i.e. to minimise the quantity of waste sludge generated. Due to problems of establishing reliable operation from the small field ozone generator (using the corona-discharge method), it has not yet been possible to fully demonstrate the reduced sludge production phenomenon in the full-scale system. A successful bench-scale testing program led to the proposal for the full-size unit.

Effluent quality from the clarification chamber is good i.e. well within the 20 mg/L BOD, 30mg/L SS limits.

Sludge from the secondary treatment process is stored so that desludging is only necessary at intervals between 3 to 5 years (similar to the recommended interval for a septic tank).

Disinfection of the secondary effluent is by ozonation, which will be dependent on a reliable source of ozone.

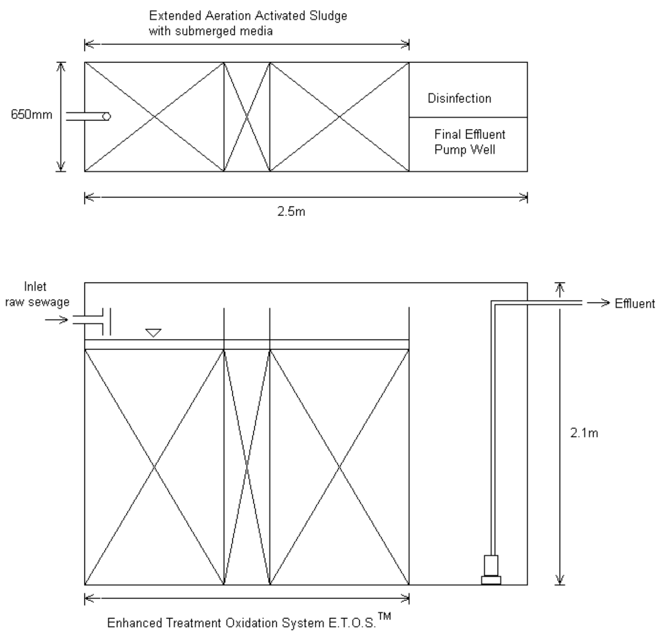

Figure 5 – Enhanced Treatment Oxidation System (schematic)

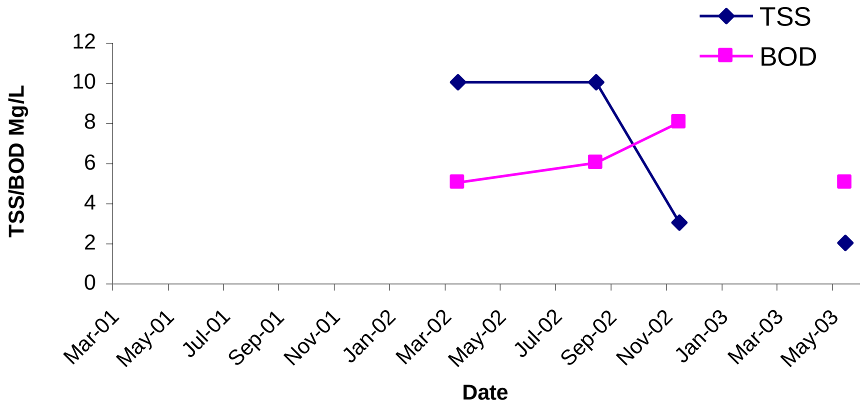

Figure 6 – Enhanced Treatment Oxidation System (performance)

Enhanced Treatment Oxidation System - Mean Analysis										
	pH	TSS	BOD	P	NH_3	NO_3^-	NO_2^-	Total N	TKN	TDS
ETOS	7.1	8	9	14	1.3	1.15	0.38	5.7	3.6	267

6 Filtered Septic Tank System

This system incorporates two 4,500L concrete septic tanks and two disc filters 1mm and 100 microns respectively.

The primary chamber accepts all household wastewater and has approximately 4000L capacity with approximately 4-5 day retention capacity.

The primary effluent is filtered through a 1 mm disc filter measuring 800 mm x 150 mm at the outlet of the primary chamber and has the same retention time in the secondary chamber where it is filtered by a 100 micron filter prior to discharge to the pump chamber. Other filters, such as foam and fabric, will be incorporated into this chamber to gauge their effectiveness.

The effluent is pumped through a small 200 micron disc filter where 20% is re-circulated back through the primary chamber and the remainder is sub-surface irrigated into a 450m^2 landscaped garden area.

The irrigation pipe systems incorporate in-line drippers at 4.3 L/hr. through a geo-flow sub-surface dripper line and, for comparison, 25 mm poly-pipe with adjustable drippers of 0-45 L/hr. have also been installed. A rota-valve is used in the effluent irrigation line to automatically alternate the distribution of effluent throughout the irrigation areas. Flush valves and vacuum breakers have been incorporated into the irrigation system to aid in the cleansing of the pipe system.

6.1 Effluent Quality

Due to the simple treatment process, the focus was on a reduction in TSS to ensure more effective and sustainable subsurface drip irrigation. TSS analysis has ranged from 28-60mg/L and efforts are continuing to be made to reduce TSS through further filtration.

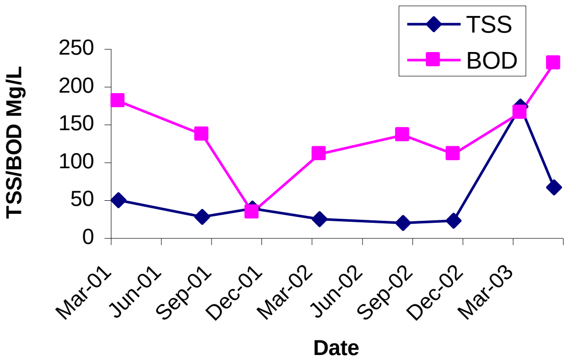

Figure 7 – Filtered Septic Tank System (performance)

Filtered Septic Tank - Mean Analysis										
	pH	TSS	BOD	P	NH_3	NO_3^-	NO_2^-	Total N	TKN	TDS
FST	7.4	36	143	15	49	0.2	0.05	56	56	405

6.2 Effluent Landscape Mound ™ - Description

The E.L.M.™ provides secondary treatment of the septic tank effluent. Normally, effluent that makes the base of the E.L.M.™ is free to infiltrate the underlying soil. If the underlying natural soil permeability is low some effluent can, from time to time, run back into the excess effluent pump well and be irrigated onto suitably-sized landscaped garden / vegetated areas.

E.L.M.™ is an appropriate choice for rocky areas where excavation for, say, an A.S.F.™ (in ground) would be difficult, or in circumstances where the water table in the area is high ie. less than 1.5m below surface. In a high groundwater case, it might also be necessary to line the base of the E.L.M.™ and collect all the effluent for irrigation to a separate area.

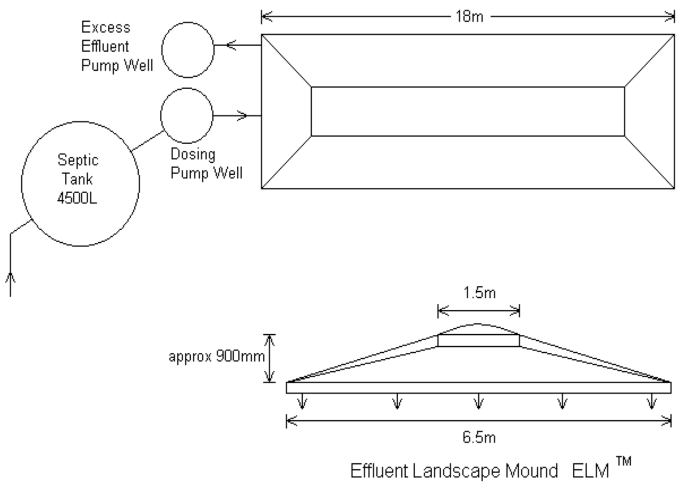

Figure 8 Effluent Landscape Mound (schematic)

Effluent Landscape Mound - Mean Analysis								
	pH	TSS	BOD	P	NO_3^-	TDS	TFC	Cond'
Inlet	7.6	66	250	20	<0.2	393	300,000	1100
outlet	6.6	17	9	11	52.8	502	<50	1060

Acknowledgements

This 3-year project commenced with funds from the Federal Government's Natural Heritage Trust and matched by Brighton Council.

It was decided to trial systems that were innovative and used the latest in technology with emphasis being on low cost maintenance sustainable systems with effluent re-use.

Chris Palmer, the second author, was employed as the consultant to design and oversee the construction and installation of the systems. His knowledge of sand filtration technology and innovations in the treatment of effluent is widely recognized. Sand was the medium used for three of the trial systems.