Final

Appendices: Shared organics facility feasibility study

10 March 2017

PREPARED FOR

Glenelg Shire Council and Southern Grampians Shire Council

Report title	Appendices: Shared organics facility feasibility study
Client	Glenelg Shire Council and Southern Grampians Shire Council
Draft or final?	Final
Author(s)	Bill Grant
Reviewer(s)	Joe Pickin
Project number	P715
Report date	10 March 2017
Contract date	31 October 2016
Information current to	28 February 2017
Copyright	2017

Disclaimer

Blue Environment prints on 100% recycled content paper

Blue Environment Pty Ltd
ABN 78 118 663 997
Suite 208, 838 Collins St, Docklands Vic 3008
Email: blue@blueenvironment.com.au
Web: www.blueenvironment.com.au
Phone: +61 3 9081 0440 / +61 3 5426 3536

Table of contents

Appendix A: Review of processing technologies

This appendix describes and reviews the main types of available technology that can be used to process FOGO materials and other biomass. The technologies can broadly be described as:

- aerobic composting
- anaerobic digestion
- thermal systems.

Aerobic composting

Aerobic composting uses a controlled process to break down organic materials by microbial action in the presence of oxygen. Organic inputs are typically shredded and blended to achieve the optimal mix of nutrients and moisture. Biological activity generates heat, and piles are managed so they achieve temperatures greater than 55°C. This 'pasteurises' the organics, killing weed seeds and potential pathogens. The composting process coverts the organics into a soil conditioner with beneficial microbes, soil carbon and nutrients.

Composting can produce odours so sites need to be well located and managed to avoid off-site issues.

There is a range of composting systems that could be used to meet GSC and SGSC's needs. These range from 'micro'-scale composting at levels below EPA Victoria's 100 tonne-per-month threshold through to larger scale systems with aeration, air control and treatment.

Based on the potential amounts of organic wastes, the following options have been considered.

'Micro-scale' (less than 1,200 tonnes per year)

Micro-scale composting uses 'low-tech' options to produce smaller quantities of compost. Micro-scale composting could be located on remote council properties or farms with sufficient separation distances from sensitive receptors (at least 200-500m) and away from waterways (at least 100m). EPA Victoria limits applied to similar 'on-farm' composting operations have been 100 tonnes per month on a continual basis or up to 300 tonnes (this is the equivalent of about 1,000 cubic metres of shredded and kerbside bin organics) up to four times per year on a quarterly basis (i.e. up to one 300m load every three months).

The main odour risks from micro-scale operations would be FOGO at the time of delivery and in the first two weeks of primary composting, particularly when piles are turned. These odour risks can be controlled by having sufficient separation distances and working to keep the materials aerobic. This can be achieved by ensuring the piles have a lower carbon to nitrogen ratio and are well mixed and structured to avoid anaerobic (the absence/lack of air) 'pockets'. To create more homogenous conditions in piles, shredded drop-off garden and timber organics could be stockpiled and blended in with bin-collected materials.

This approach was used by City of Goulburn, NSW in their 'City-to-Soil/Groundswell' fermentation system for almost ten years to manage FOGO material.

Central Goldfields Shire currently receives about 500 tonnes of FOGO material per year, and up to 80-100 tonnes a month at peak times. This material is blended with shredded drop-off garden organics and stockpiled in the open with a covering of shredded drop-off garden organics for up to a month before shredding and composting without causing odour problems.

These examples show that micro-scale management of material containing FOGO can be undertaken with minimal odour risk composting operations are well sited.

On-farm composts could be established on several sites, with farmers who have undergone training in the monitoring and management of composts. There are two businesses within the south west who provide compost advisory services to farmers. These companies provide shredded garden organics and forestry waste to the farmers for them to manage dairy effluent and other organic wastes to produce composts for on-farm use. There is potential to supply materials for such operations.

The following micro scenarios have been costed:

Micro covered 'fermentation'

A Micro covered 'fermentation' system such as the 'City-to-Soil/Groundswell' composting system uses a highly humid/wet and partially anaerobic process as well as an 'inoculant' of nutrient and composting bacteria.

Input organics are shredded and blended, wetted to >60% moisture levels and formed into low (1-1.5m high) piles and covered with an impermeable cover or 'tarp'. Piles are then allowed to sit for four weeks, before turning, re-wetting and re-covering. After a further four weeks, materials are managed aerobically using a turned windrow system.

This system was used for kerbside garden organics collected by City of Greater Geelong and Colac Otway as part of a trial of on-farm composting. It is no longer used, with on-farm turned windrow being used instead. The covered fermentation system was not continued because of:

- high costs of 'inoculant'
- high costs associated with irrigating compost piles to achieve and maintain the levels of moisture required for the process
- problems with covers blowing off
- inconsistent compost quality
- a change in focus by the contractor running the on-going composting program, with an emphasis on marketing a pasteurised 'hot mix' to dairy farmers wanting to use the compost to better manage effluents.

The costs of using the covered pile fermentation system would be similar to the micro-scale composts detailed below, with higher costs associated with providing covers, inoculant and irrigation, but reduced turning costs. This option could be considered for micro-scale composting and may be worth trialling in comparison to turned windrow micro-management.

Micro turned pile

Micro-pile turned windrow composting could be used to mix FOGO material with shredded garden organics, and then compost the materials by turning it at least three times over the first three weeks, and then every 7 to 14 days to mature the resulting compost material.

The expected quantities of FOGO and other organics collected by GSC and SGSC will exceed the 100 tonnes per month threshold. It will not be feasible to establish multiple small council-operated composting operations using council staff and equipment to manage the expected 5,000-10,000 tonnes per year. It is anticipated that such a system would only be viable for on-farm composting, with at least five to ten farms participating each year. Participating farms would provide labour and equipment for the management of compost piles, with the councils providing training, oversight and pre-cleaning, shredding and mixing of drop off and FOGO materials.

Cost assumptions are summarised in Table A1. The estimated financial costs of on-farm composting management option are $48-$73 per tonne. This does not include collection costs or avoided landfill costs; it also assumes on-farm composting sites will be established within 50 km of the main sources at Portland and Hamilton.

Table A1: Cost estimate of micro-scale (<1,200 tonnes per year) of council FOGO and drop off organics

Anticipated costs:	Siting	
	Council premises	On-farm
Additional annual project administration	$0.12 per tonne 14 hours per month @ $65/hour, inclusive of on-costs for 6 X 1,200 tonne per year sites	$0.35 per tonne 38 hours per month @ $65/hour inclusive of on-costs for 6 X 1,200 tonne per year sites on farms
Materials cleaning, shredding and blending costs:	$35-$45 per tonne	$35-$45 per tonne
Transport to processing sites	$12 per tonne (@ $0.40 per tonne/km at an average distance of 30km from primary sources)	$12 per tonne (@ $0.40 per tonne/km at an average distance of 30km from primary sources)
Compost management costs:	$6 per tonne (five turnings using council or contracted front end loader at hourly rate of $120/hr turning 100 tonnes or 300 m^3/hour)	Provided by farmer
Product screening costs:	$10 per tonne of input	$10 per tonne of input
Total costs of processing	$63-$73 per tonne of input	$57-$67 per tonne of input
Income from products:	$0-$15 per tonne of input	Nil- farmer owns products
Net costs (not including avoided landfill costs):	$48-$73 per tonne	$57-$67 per tonne

This assessment suggests the per tonne costs of on-farm composting are likely to be similar to some of the other processing technologies, and therefore do not offer a financial advantage.

The advantages and disadvantages of micro scale operations are summarised in Table A2. The risk of disease spread to farms from food is low, but the consequences could be significant. In addition, on-farm composting is also likely to have high administration and coordination costs, and greater risk of disruptive incidents such as restricted traffic access during wet-weather. It is recommended this option is only considered as an interim measure and if other management options prove to be unviable.

Turned windrow composting

Blue Environment's assessment of available organics suggests the appropriate scales of operations are:

- In the order of 5,000 tonnes per year for individual council facilities processing collected FOGO with shredded drop-off GO materials. The shredded GO is needed to 'bulk-up' the FOGO materials, reducing the need to shred FOGO at the time of receival. Larger woody material in FOGO can be composted and then screened out of the finished finer particle compost. The larger woodier material can then be stockpiled and shredded with drop-off GO materials. This reduces processing costs and the need to have a shredder permanently on site.

- In the order of 10,000 tonnes per year for a shared facility processing collected FOGO from both councils and shredded drop-off GO from either of the councils. Once again, shredded GO is needed to bulk up FOGO, with larger woody material being screened from composted material and stored with drop-off organics for shredding at a later date. If a shared facility is established it is proposed that shredded GO from only either Portland or Hamilton is used for bulking up FOGO material. Current on-site management of drop-off GO is likely to be cheaper than transporting and processing materials at the shared facility.

Such facilities will require EPA works approval and licensing, and a facility receiving FOGO materials is likely to be required to have some form of controlled air management of primary composting or separation distances of at least 600-1,000m. EPA guidelines recommend FOGO materials are processed using some form of controlled environment composting, and this will reduce the separation distances required. However, a case would need to be made to EPA that a well- managed and sited small-scale (e.g. less than 5,000 tonnes per year) processing FOGO with GO material without controlled environment processing could manage odour risk with a separation distance less than 500-1,000m. Use of lower cost environmental controls such as aerated covers could reduce the separation distances required by EPA. EPA RD&D (Research, development and demonstration) approval may be required to prove technologies can manage odour from FOGO at these sites.

Table A2: Summary of advantages and disadvantages of micro-scale composting as a management option

Advantages:	**Disadvantages:**
• Does not require EPA works approval and licensing. • Low tech and low cost option. • Farmers can share management costs, providing equipment, labour and oversight. • Good quality composts can improve soils.	• Needs administration and oversight by council or contractors to find sites, train operators, and oversee quality and environmental management. • May not be suited to FOGO materials unless sites are well chosen and managed. • There are potential hygiene/disease and weed risks associated with transport of unpasteurised FOGO and green waste to farms. • Cleaning, shredding and screening costs can be high. • There are risks associated with physical contamination (plastics, glass and metal 'sharps' in particular) being distributed to farms. • There are higher local environmental risks. • External funding support is unlikely to support such systems.
Application to the project: • There are two businesses offering on-farm composting services in the region that could be invited to tender for receival and processing of council managed organics. • Although small scale processing at multiple sites may serve as an interim measure, it is not considered a viable long-term management option unless it has very high levels of quality management.	

Table A3 summarises a costing of individual and shared open windrow composting systems. This suggests that a system using un-shredded FOGO mixed with shredded GO could produce compost for a cost of $51-$58 per tonne. If composts were sold, or valued for council use, at $25 per tonne (approximately $15/m^3), the net cost of the operation would be in the order of $41-$48 per tonne.

Table A3: Cost estimates for individual and shared scale open windrow composting facility.

Cost item	Scale of operation (tonnes per year)	
	5,000	**10,000**
Capital and site establishment costs	$535,000	$660,000
Annualised capital and establishment costs ($ per year)	$69,300	$85,500
Annualised capital and establishment costs ($ per tonne)	$14	$9
Operating costs ($ per year)	$221,300	$425,000
Operating costs ($ per tonne)	$44	$43
Capital and operating costs ($ per tonne)	**$58**	**$51**
Revenue from compost sales ($ per year)	$51,900	$103,800
Revenue from compost sales ($ per tonne of input)	**$10**	**$10**
Net costs ($ per tonne of municipal input)	**$48**	**$41**

Table A4 shows an assessment of the advantages and disadvantages of open windrow composting. It is recommended that this option may only be suited to a <5,000 tonnes per year facility at Heywood transfer station, and possibly Hamilton landfill although EPA may not approve open composting of FOGO at this site due to other neighbouring odour sources and the proximity to houses. It is possible EPA will not allow open windrow management of FOGO for a site processing more than 5,000 tonnes per year. An EPA RD&D approval may be required to show a facility can operate without off-site impact before a works approval will be considered.

Table A4: Assessment of open turned windrow composting

Advantages:	Disadvantages:
• Lower capital costs. • Simple and proven technology.	• Higher odour risk, with a need for separation distance of 500m for a <5,000 tonne per year facility and 500-1,000m for a 10,000 tonne per year facility. An RD&D approval may be needed to prove lesser separation distances would be sufficient. • EPA may not approve open air processing of FOGO. An RD&D approval may be needed to prove these materials could be processed at a site with sufficient separation distances. • EPA is unlikely to approve open air processing of high odour risk feedstocks such as grease trap and food processing waste. • Unlikely to meet requirements for external funding for organics processing infrastructure • Higher operating costs due to the need for manual pile monitoring and more frequent turning. • Higher stormwater management requirements than some in-vessel systems. • Fire risk associated with overheating
Application to the project: • Open windrow composting of FOGO could be considered for an individual (non-shared) facility of less than 5,000 tonnes per year at sites with appropriate separation distances. It could be suitable for the Heywood transfer station site, and potentially the Hamilton landfill precinct. • An RD&D approval may be required to demonstrate the system is appropriate.	

Open uncovered aerated windrow

Aerated windrows use perforated piping under blended piles of compost, with air pumps pushing air through materials to keep them aerobic. Although this is a proven technology that is used to process FOGO and GO organics at a large scale in Adelaide, EPA Guidelines for composting do not recognise this as an appropriate technology for FOGO and other higher odour risk materials. This means that similar restrictions may be placed on this technology as are placed on open windrow composting. As with open windrow composting, separation distances of at least 500-1,000m are likely to be required for up to 5,000 tonnes per year facilities, and at least 1,000m for a 10,000 tonne per year facility. A RD&D application and approval is recommended prior to applying for works approval.

Estimated costings for the use of a Mobile Aerated Floor (MAF) aerated composting system for different scales of operation are summarised in Table A5. These suggest higher capital costs compared to open turned windrow, but slightly lower operating costs due to less need for turning of materials. The advantages of this system over turned windrow systems are: a significantly reduced odour risk because the materials are kept under aerobic conditions at all times; and a reduced need for turning. This reduces the odour risk of operations. Compost piles typically form an aerobic 'biofilter' layer on their outer surface that degrades most odour compounds. Turning disturbs this and can release a plume of higher odour air from within the pile and from the surface of the pile immediately after turning.

EPA requirements for open aerated windrow composting are likely to be the same as for open turned windrow composting facilities. Aerated piles at this scale will also require three-phase power for aeration pumps, as well as the aeration system. Otherwise site development and operation costs will be similar to open windrow composting. The Mobile Aerated Floor system costed is not the cheapest aeration system on the market, but is proven and has longevity where systems using less durable perforated pipes may not last for as long.

It should be noted that uncovered aerated composts can dry out materials, so a source of water for maintaining moisture levels is piles is recommended. This moisture could potentially be supplied by receiving organic effluents or treated wastewater if EPA allowed processing of these waste streams.

Table A5: Cost estimates for open uncovered Mobile Aerated Floor windrows

Cost item	Scale of operation (tonnes per year)	
	5,000	10,000
Capital and site establishment costs	$785,000	$1,060,000
Annualised capital and establishment costs ($ per year)	$101,700	$137,300
Annualised capital and establishment costs per tonne ($ per tonne)	$20	$14
Operating costs ($ per year)	$203,800	$435,000
Operating costs ($ per tonne)	$41	$44
Capital and operating costs ($ per tonne)	**$61**	**$57**
Revenue from compost sales ($ per year)	$51,900	$103,800
Revenue from compost sales ($ per tonne of input)	**$10**	**$10**
Net costs ($ per tonne of municipal input)	**$51**	**$47**

Aerated covered windrows

Aerated covered windrows are essentially the same technology as used for aerated uncovered windrows, but with specialised laminated covers that allow 'small' gas molecules including oxygen and carbon dioxide to pass through them, but traps larger gaseous compounds including odour-causing gases. The cost of these membranes is high (e.g. $100 per square metre) and they must be weighed down to prevent being blown off the piles. Other covered systems have been developed that blow air at the base of piles and extract air from the top of piles. This extracted air is then passed through biofilter piles of more mature compost. Other than the covers, the costs of such a system are similar to uncovered aerated piles.

The main advantages of the covered systems over turned windrow and uncovered aerated piles at the 5,000-10,000 tonnes per year is that the EPA recognises it as an appropriate system for the management of FOGO and other higher odour wastes. This means that approval processes may be less difficult and approval may be granted to process a wider range of materials including SIW food waste, grease trap and other wastes that might attract a higher gate fees.

An estimate of the costs of an aerated covered windrow system using specialist membrane covers is shown in Table A6. This shows the higher capital costs of the system, but also the potential higher income from processing SIW and PIW wastes that could be available from local businesses. This costing suggests covered aerated windrows could process materials for around $63-$72 per tonne without the sale of compost, and $52-$61 per tonne if composts are sold for, or valued at, $25 per tonne. Composts from covered systems can have higher nutrient value due to a reduced loss of nitrogen.

Covered systems do not dry as rapidly as uncovered systems, but it is recommended to saturate materials to 40-60% moisture before covering, so a source of water may be needed.

Table A6: Cost estimates for an aerated covered windrow system

Cost item	Scale of operation (tonnes per year)	
	5,000	10,000
Capital and site establishment costs	$1,095,000	$1,680,000
Annualised capital and establishment costs ($ per year)	$141,800	$217,600
Annualised capital and establishment costs per tonne ($ per tonne)	$28	$22
Operating costs ($ per year)	$219,300	$416,000
Operating costs ($ per tonne)	$44	$42
Capital and operating costs ($ per tonne)	**$72**	**$63**
Revenue from compost sales ($ per year)	$54,400	$108,800
Revenue from compost sales ($ per tonne of input)	**$11**	**$11**
Net costs ($ per tonne of municipal input)	**$61**	**$52**

Covered aerated bays

Covered aerated bays use three-sided tilt slab concrete bays with aeration systems and retractable covers that trap exhaust air. Captured exhaust air is then treated through a biofilter pile of compost. These systems have similar capital costs to covered windrow, but have the advantage of having more secure covers and air control. The technology meets EPA requirements for the processing of FOGO and other higher odour risk materials, and can be largely automated, with temperature monitoring using probes in the material and exhaust air being used to control aeration levels.

An estimated costing of the Spartel FABCOM aerated bay system is shown in Table A7. This is automated and monitored/managed remotely via a mobile internet connection. Cheaper non-proprietary systems could be designed and developed. Capital costs for aeration bays are in the order of $350,000 for the first 1,000-1,200 tonne per year vessel and $250,000 for each subsequent vessel, meaning a shared facility will cost in the order of $1.85 million including front-end loader and screening equipment. FOGO material could be bulked up with shredded drop-off organics and screened after composting. A shredder based permanently on site would cost at least $80,000-$120,000 to purchase plus operating costs.

The costing from Table A7 suggests processing costs of $69-$85 per tonne of input without the sale of organic products or receival of SIW or PIW gate revenue. This would fall to around $49-$57 per tonne if all of these income streams are received.

Table A7: Cost estimates for covered aerated bays

Cost item	Scale of operation (tonnes per year) 5,000	10,000
Capital and site establishment costs	$1,410,000	$1,910,000
Annualised capital and establishment costs ($ per year)	$182,600	$247,400
Annualised capital and establishment costs per tonne ($ per tonne)	$37	$25
Operating costs ($ per year)	$241,300	$440,000
Operating costs ($ per tonne)	$48	$44
Capital and operating costs ($ per tonne)	**$85**	**$69**
Revenue from compost sales ($ per year)	$54,400	$108,800
Revenue from industrial waste gate fees ($ per year)	$85,500	$85,500
Net revenue ($ per year)	$139,900	$194,300
Net revenue ($ per tonne of municipal input)	**$28**	**$19**
Net costs ($ per tonne of municipal input)	**$57**	**$49**

In-vessel systems

In-vessel systems are fully enclosed and sealable ‘tunnels’ (chambers) where the materials are aerated either through a false floor (such as the Western Composting Technology (WCT) system at Shepparton) or through the introduction of air into a chamber where materials are agitated and moved along the chamber by an internal auger (such as the Hotrot system). These technologies have higher capital costs but have the advantage of being fully enclosed with full air control and treatment. They can therefore receive a wider range of materials and potentially have smaller separation distances.

A costing for a WCT-style compost tunnel is provided in Table A8. This suggests costs of $97-$120 per tonne without income from the receival of SIW and PIW and sale of composts, dropping to $77-$92 per tonne if this income is received. This technology is unlikely to financially competitive with other options at this scale of operation. If additional municipal organics could be attracted to a larger 20,000 tonnes per year facility (with capital costs of $5.35 million), per tonne costs would fall to around $65-$75 per tonne and even lower if additional SIW and PIW gate revenues could be secured.

Table A8: Costing of Western Composting Technology (WCT) in-vessel composting

Cost item	Scale of operation (tonnes per year) 5,000	10,000
Capital and site establishment costs	$2,850,000	$3,850,000
Annualised capital and establishment costs ($ per year)	$282,300	$378,600
Annualised capital and establishment costs per tonne ($ per tonne)	$56	$38
Operating costs ($ per year)	$316,300	$590,000
Operating costs ($ per tonne)	$63	$59
Capital and operating costs ($ per tonne)	**$120**	**$97**
Revenue from compost sales ($ per year)	$54,400	$108,800
Revenue from industrial waste gate fees ($ per year)	$85,500	$85,500
Net revenue ($ per year)	$139,900	$194,300
Net revenue ($ per tonne of municipal input)	**$28**	**$19**
Net costs ($ per tonne of municipal input)	**$92**	**$77**

Vertical composting units

Vertical composting units (VCUs) are large (e.g. 4.5m high x 2.5m x 2.5m) top-fed vessel composting units. Materials are loaded at the top of the chamber and are subjected to temperatures of up to 70-80°C (generated by the self-heating of materials lower in the chamber). This promotes rapid degradation and volume loss. As materials migrate down the chamber (as finished products are taken from the bottom of the unit) they undergo a full hot composting process. The system is fully automated after loading. Temperature and oxygen levels are maintained through an automated aeration system. Materials are processed within 7-14 days, but can be held for longer if throughput is lower. Units are insulated, sealed and the exhaust air is treated by a biofilter.

Units are designed for a throughput of 5-6 tonnes per day, so a facility to process 5,000 tonnes per year would require four to five units to handle peak periods, and a 10,000 tonne per year facility will require eight to nine units. This would also enable the facility to cope with periods of peak throughput.

The advantages of these units include:

- they have full air control and so meet EPA requirements for processing FOGO and other higher odour risk materials
- they are 'continuous feed' units with material added at the top as needed
- they require little movement and handling of materials
- they have low power costs, with bacterial action providing the heat and gravity providing the energy required to move materials down the VCUs.

A cost estimate for VCU facilities is shown in Table A9. This suggests VCUs are unlikely to be financially cost-competitive with other controlled environment technologies even if they receive SIW and PIW waste and sales revenue from composts.

Table A9: Cost estimates for Vertical composting units (VCU)

Cost item	Scale of operation (tonnes per year)	
	5,000	10,000
Capital and site establishment costs	$2,058,400	$3,706,700
Annualised capital and establishment costs ($ per year)	$266,600	$480,000
Annualised capital and establishment costs per tonne ($ per tonne)	$53	$48
Operating costs ($ per year)	$263,700	$509,800
Operating costs ($ per tonne)	$53	$51
Capital and operating costs ($ per tonne)	**$106**	**$99**
Revenue from compost sales ($ per year)	$54,400	$108,800
Revenue from industrial waste gate fees ($ per year)	$85,500	$85,500
Net revenue ($ per year)	$139,900	$194,300
Net revenue ($ per tonne of municipal input)	**$28**	**$19**
Net costs ($ per tonne of municipal input)	**$78**	**$80**

HotRot in-vessel systems

The HotRot system uses modular horizontal aerated chambers. Organics are shredded and fed into one end and a horizontal screw moves materials along the chamber, agitating and aerating it as it goes. Units can have capacity of around 10 tonnes per day so multiple units would be needed to manage peak demand.

Materials are processed in 14-21 days and the output is a semi-matured compost suited to further maturation or application to non-sensitive used land. The composts are self-heating, but the units need three-phase power to drive the internal screw. The supplier is NZ based and maintains several units in Australia, including Melbourne Zoo.

A cost estimate is provided in Table A10 and suggests this may be a cost-competitive technology.

Table A10: Cost estimate for Hotrot composting system

Cost item	Scale of operation (tonnes per year)	
	5,000	10,000
Capital and site establishment costs	$1,860,000	$3,110,000
Annualised capital and establishment costs ($ per year)	$179,200	$299,600
Annualised capital and establishment costs per tonne ($ per tonne)	$36	$30
Operating costs ($ per year)	$253,800	$480,000
Operating costs ($ per tonne)	$51	$48
Capital and operating costs ($ per tonne)	**$87**	**$78**
Revenue from compost sales ($ per year)	$54,400	$108,800
Revenue from industrial waste gate fees ($ per year)	$85,500	$85,500
Net revenue ($ per year)	$139,900	$194,300
Net revenue ($ per tonne of municipal input)	**$28**	**$19**
Net costs ($ per tonne of municipal input)	**$59**	**$59**

Anaerobic digestion (AD)

Anaerobic Digestion (AD) systems use bacterial biodegradation of organics and other nutrients under anaerobic conditions to produce bio-gas (methane) that is then used to generate heat, power or a gas-fuel that can substitute for natural gas or transport fuel.

The viability of AD systems depends on a range of factors including:

- gate fee revenue generated from receiving different materials
- total and net exportable heat, power or fuel generated by the system
- the potential for heat and power to be used locally
- bio-gas production is influenced mainly by feedstock composition (wet or dry content), operating temperatures (mesophilic or thermophilic) and unit configuration (single or multiple, vertical or horizontal, batch or continuous).

AD systems can be categorised into three main types: 'aqueous'/liquid AD , 'solid' AD or 'hybrid' wet-dry systems. These are explained further below.

'Aqueous'/liquid AD

In aqueous AD, organic loads (food, sludges, wastewater with organic load) are continuously fed into aqueous digestion tanks where it either dissolves or becomes suspended in a 'soup'. Anaerobic bacteria consume the organics often under mesophilic conditions (35-40°C) to produce bio-gas and digestate. Bio-gas yield is typically lower under mesophilic compared to thermophilic (50-70°C) conditions.

The advantages and disadvantages of aqueous AD systems are outlined in Table A11.

There are few reference facilities in Australia that process mixed organics from Municipal solid waste as they are better suited to liquid wastes and source separated food wastes with high water content.

The EarthPower facility in Camellia, Sydney accepts both solid and liquid food waste from municipal, commercial and industrial sectors but does not accept garden waste. The aqueous AD (<5% Total Solids) can convert up to 50,000 tonnes per year of waste into electricity (capable of powering 3,600 homes) and fertiliser pellets. Types of feedstock processed include grease trap waste, packaged food waste, meat, fruit and vegetables. Garden waste along with glass, metals, plastics and woody wastes in the feedstock are screened out before it is pulped and loaded into the digesters. Digestion takes place in two single stage tanks, each with a capacity of 4,600m^3 under mesophilic conditions. It is believed the amount of waste generated is equal to contamination levels in the feedstock (around 5%).

Such units are not well suited to garden or woody wastes which means feedstock would be limited to source separated food waste and liquid wastes. The viability of this would depend on higher organic loads could be secured. If the proposed meat processing facility near Hamilton is established in the near future, aqueous AD may be an option. The unit could provide industrial heating to the meat works facility if co-located.

Table A11: Aqueous AD assessment summary

Advantages:	Disadvantages:
• Proven system for treatment of wastewater, sludges and food waste • Typically, continuous feed, allowing longer retention time and higher gas yields than batch /solid systems • Organic load can be concentrated through sequential tank systems, reducing the footprint of sites and increasing gas yields • Potentially compatible with systems that extract liquid organic load from mixed waste or more woody organics • Systems are contained, with lower potential for off-site odour during normal operation • Sludge from AD tanks can be used as liquid or dried solid fertilisers.	• Not suited to processing woody solids • Poor record for processing municipal and variable wastes with high solids content due to technical difficulties and production of physically and chemically contaminated organic outputs • High cost for mixed waste processing • Lower exportable energy from mixed waste processing due to the need to sort and separate the organic load • Solid residual organics from which an organic load has been extracted will need to be managed via landfill, thermal energy recovery or aerobic composting. Aerobic management creates a potential odour risk or need for additional housed/vesseled composting areas.
Application to the project: • Best suited to the management of source separated organics from food processing industries • Potentially suited to organic load extracted from 'wet' garden and food organics and mixed putrescible wastes (if such systems are technically proven) • Potentially compatible with a thermal energy recovery facility that can use residuals as fuel	

'Solid' AD

Solid AD is a proven technology commonly employed in Europe to process source separated organics from Municipal solid waste. It is capable of processing variable and non-homogenous materials containing (but not limited to) woody wastes, food wastes, sludge and other organics. However, it is understood that woody wastes would provide little additional value in terms of increasing biogas yields.

Solid AD processing typically involves loading solid organics (15-20% Total Solids) into chambers where it is wetted and held under anaerobic conditions to promote biogas generation. In some versions of this technology, materials are entirely flooded or immersed in water (or organic and biological rich 'liquor' from previous batch loads). In others, the materials are simply wetted and maintained at moisture levels exceeding 60% by weight.

The advantages and disadvantages of solid AD systems are outlined in Table A12.

Both small scale and large-scale options are available, however, there are few local providers of small-scale solid AD systems with most being parented by companies overseas.

Table A12: Solid AD assessment summary

Advantages:	Disadvantages:
• More suited to materials containing woody organics and other solids • More suited to variable/non-homogenous materials • Chambers can be aerated after the anaerobic load to 'compost' residuals	• Typically, this uses a batched process. This reduces the suitability to seasonable variable volumes and can reduce the retention time and gas yield. • Solid organic residuals need to be unloaded manually from chambers and requirement management via landfill, aerobic composting or thermal energy recovery. This creates a potential odour risk or need for additional housed/vesseled composting areas.
Application to the project: Solid AD would be best suited if the council were to recover 25,000-30,000 tonnes per year of source separated garden and food organics. As a result, it may not be suited to the project.	

'Hybrid' wet/dry systems

'Hybrid' wet/dry systems load solid organics into tanks or vessels and then flood these with water or 'liquor' from other AD tanks. Biogas is recovered from the organic load of the solid organics over a 1-2 week period. The vessels are then drained and aerated to pasteurise and 'compost' the solids. The liquid drained from the vessels can be used to flood the next batch of organics or used to yield further biogas from aqueous AD tanks. The digestate from the aqueous vessels can be treated as liquid fertiliser or dried to make a granular fertiliser. The pasteurised and partially composted solids from the solids vessels can be further composted or applied directly to land in less sensitive land uses.

DiCOM system developed by AnaeCo in Shenton Park, Western Australia is capable of processing 50,000-60,000 tonnes per year of mixed municipal solid waste. The AD system is coupled with a 'dirty' material recovery facility to remove contaminants such as plastics, metals and glass from the feedstock before the homogenised organic fraction is loaded into vertical digesters. Digesters are then flooded with liquid to initiate anaerobic digestion under thermophilic conditions. The Bio-gas produced is captured and converted into electricity and heat. Following this the digesters are drained and aerated to allow composting of the digestate. It is understood the facility is not currently operating because landfill disposal is more cost competitive.

The advantages and disadvantaged of a hybrid wet/dry AD system are summarised in Table A13.

Table A13: Hybrid AD assessment summary

Advantages:	**Disadvantages:**
• The 'solids' processing component can be a smaller part of a larger wastewater AD treatment facility • More suited to materials containing woody organics and other solids • More suited to variable/non-homogenous materials • Chambers can be aerated after the anaerobic load to 'compost' residuals • Renewable energy with facilities have exportable energy yields of 80% (i.e. 20% of heat and power is used to run the facility, but 80% is surplus and could be sold).	• High capital costs • Needs water and preferably a source of wastewater with BOD exceeding 1,500-2,000 mg/L or organic load • Typically, this is a batched process. This reduces the suitability to seasonable variable volumes and can reduce the retention time and gas yield. The latter can partially be overcome by the reuse of 'liquor' from systems where solids are immersed in liquid, which extracts and concentrates some organic load • May be odour associated with receival of organics and unloading of vessels • Solid organic residuals need to be unloaded manually from chambers and requirement management via landfill, aerobic composting or thermal energy recovery. This creates a potential odour risk or need for additional housed/vesseled composting areas.
Application to the project: • Such a system could process wastewaters, as well as SIW and PIW organics with a relatively small minimum separation distance. • This option may meet the needs of both councils and the proposed meat works (Australian Meat Farmers) at Hamilton, both treating waste and generating heat or heat and power for the AMF meatworks.	

Review of AD systems

Blue Environment has identified and assessed possible AD systems suited to the likely scale and feedstocks available. Our assessment suggests:

- Grid-connected AD facilities are unlikely to be viable at the scale likely to be possible with the available feedstocks. At least 25,000-50,000 tonnes per year of FOGO and other organic inputs would be needed before grid connection was viable. Smaller units may be viable for CHP systems co-located with a user of heat and power from the unit. This is based on feedback from technology providers consulted. An exception to this could be an AD facility treating other effluent, but also capable of processing FOGO, such as the proposed AMF meatworks at Hamilton.

- Conventional aqueous AD technologies are not suitable for processing FOGO materials due to the presence of woody fibrous materials, soil and other contaminants.
- 'Dry'/solid AD systems capable of processing FOGO materials are available. One small scale provider, Smartferm claims units as small as 4,000-10,000 tonnes per year can be used for local (not grid connected) power and heat. Such a facility would need to be co-located with a use of heat and power. Other 'Dry' systems identified, such as Bekon require 25,000-30,000 tonnes per year of input.
- If AMF's Hamilton facility, or a similar commercial generator of suitable effluent, becomes available, a 'hybrid'/'wet-dry' system that can extract biogas from FOGO may be possible as part of a large aqueous AD unit for treating wastewater. Such a facility could also manage stockyard wastes, commercial food, and PIW organics such as grease trap waste and food processing effluents. It is recommended SGSC and GSC continue to liaise with AMF regarding the potential to develop this option further. A technology such as the DiCom system may be suitable.
- The outputs from such an AD facility will include:
  - Wastewater, which may require further treatment prior to discharge to sewer or use in irrigation. If it is discharged to sewer the operator will incur a trade waste discharge cost. If it can be reused for irrigation or environmental uses no cost will be incurred. AMF believe they have sufficient vacant land at their proposed Hamilton site to manage wastewater on site, but detailed water budgeting will be needed to establish this.
  - Solids from non-digested woody and fibrous organics. This material will require aerobic composting for a period to pasteurise and stabilise it. It may have high odour when first removed from anaerobic chambers. Systems that aerate and compost materials in the same chamber as they are treated anaerobically during the AD process are preferred as they will reduce this odour risk. The compost will have market value. Composts from AD processes often have higher nitrogen and other nutrients than solely aerobic composts. They also tend to have higher moisture content and are 'humidified' (i.e. converted into a highly humic/stable organic carbon form of compost). These composts can command a market premium.
  - Digestate sludge. This sludge is made up of suspended soils and the sloughed cell walls of dead bacteria. It is typically rich in nutrient. This can potentially be sold as a liquid fertiliser or dried to make a granular fertiliser.
- The viability of an AD facility is likely to depend on the facility being able to secure a large and steady-stream supply of SIW and PIW organics or wastewater with organic load.

Site requirements for an AD facility capable of processing FOGO with other higher odour organics are likely to include:

- Receival areas and storage bays/bunkers for solid and liquid/'non-spadeable' wastes. Given the high odour potential of this material, these areas are likely to need to be fully enclosed, and have a non-porous storage area.
- Shredding and pulverising equipment to convert solid materials to a fine pulp that is more susceptible to AD bacterial decomposition.
- Access to natural gas or electricity to heat AD facilities initially, and electricity to power grinding equipment and pumps.

- A co-located user for heat or combined heat and power.
- If power is to be supplied to the grid, the facility will need access to the grid.

The facility will require EPA works approval and licensing. A minimum separation distance of 300-500m is likely to be required for a facility receiving up to 14,000 tonnes per year of FOGO and other grade 3 and 4 wastes. This is assuming that it has an enclosed receival area and undertakes thorough aeration and deodorising of materials before they are excavated from the AD vessels. Odour modelling may be required as part of the works approval process. If materials removed from AD chambers are to be further composted and matured through open windrowing, a larger separation distance (such 1,100m) may be required.

It has been difficult to develop costing estimates for AD facilities at the scale likely to be supported by the potentially available FOGO.

Only one supplier consulted (Smartferm) indicated that they can supply a facility that can receive less than 25,000 tonnes per year. Smartferm is a relatively low-tech AD system consisting of demountable sealed chambers/units with a flexible synthetic cover that allows gas storage and pressurisation. The minimum sized facility is 10,000 tonnes per year. This facility is based on two 5,000 tonnes per year units to allow batching. However, because each batch needs a retention time of at least 21 days, up to three units (with capacity for 15,000 tonnes per year) would be required.

Alternatively, an active unit could be evacuated of bio-gas, opened and reloaded with a second batch of organics and then resealed. This would interrupt anaerobic processing and potentially result in an odour risk. Ideally each batch is allowed to run for at least 21 days under anaerobic conditions until bio-gas yields fall. After loading, materials are initially managed aerobically to allow composting bacteria to self-heat and pasteurise materials and create high oxygen demand. After 12 hours, oxygen is excluded from chambers and materials are heavily irrigated. These rapidly become anaerobic and generate bio-gas over a 21-day period. Once bio-gas yields fall, materials are again aerated with exhausts being managed through a biofilter. Organic materials removed from chambers may need further aerobic composting to stabilise them. They may also have odour taint from organic compounds produced during the anaerobic phase.

The supplier of Smartferm provided an estimated capital and operating cost of $26 per tonne of the unit alone (i.e. not including material shredding, loading, and post-process management) for a minimum sized 25,000 tonnes per year facility, but would not provide a ‘per unit’ cost. This cost estimate is competitive with the capital and operating costs of other technologies. The Smartferm units are pre-fabricated ‘shipping container’ type units that are demountable, and therefore can be trialled and removed for use at other sites, so may have lower capital and capital depreciation costs, and lower financial risks than other systems. It may be possible to trial the Smartferm units if a user of bio-gas energy can be located.

A costing for a Smartferm system is shown in Table A14. This includes estimates for other equipment and operating costs, as well as the potential value of energy and organic product produced. This assessment suggests the Smartferm system could be competitive with the aerobic composting systems reviewed.

Ideally such a facility would be co-located with a user of gas/heat such as greenhouses, food or dairy processing or a timber kiln, which could also process some of their organic by-products through the facility. The unit is not well suited to the proposed AMF meat works because their primary need is a wastewater treatment system. It could be used to treat paunch and holding yard wastes with FOGO material if wastewater were managed separately. Odour risks associated with the receival of materials and removal of materials from AD chambers make it unsuited to district heating projects such as the Henty Park scheme or Hamilton swimming pool.

The Smartferm processing option is worth investigating further if non-grid users for biogas energy (for heat or CHP) can be found.

Table A14: Cost estimates for Smartferm AD system (for a 10,000 tonne per year facility)[1]

Cost item	Estimated costs
Capital and site establishment costs	$1,710,000
Annualised capital and establishment costs ($ per year)	$164,700
Annualised capital and establishment costs per tonne ($ per tonne)	$16
Operating costs ($ per year)	$522,500
Operating costs ($ per tonne)	$52
Capital and operating costs ($ per tonne)	**$69**
Revenue from compost sales ($ per year)	$130,000
Revenue from industrial waste gate fees ($ per year)	$85,500
Net revenue ($ per year)	$312,700
Net revenue ($ per tonne of municipal input)	$31
Net costs per tonne of municipal organics	**$30**

1. A 5,000 tonne per year facility will not be technically possible.

Other recent 'reference facilities' in Australia for AD are considerably larger and mainly aqueous AD systems for processing liquid and PIW organic wastes. A proposed 'dry' AD facility (using the Bekon system) processing 25,000-30,000 tonnes of FOGO and other in Bendigo, was estimated to cost over $5 million in 2008. Internationally, smaller Bekon systems are in operation, but these are mainly in Germany where the market for renewable energy is more favourable than in Victoria. It is possible a smaller Bekon unit could be co-located with a user of bio-gas energy. The capital costs can be expected to be comparable or greater than for the Smartferm system. The Beckon system is also not a continual feed process, so multiple small chambers would be required for fortnightly and weekly deliveries of materials.

No other AD system has been costed. If the AMF meat processing works proceeds, it is recommended SGSC and GSC discuss how a hybrid wet-dry AD system might be incorporated into the facility's wastewater and paunch treatment systems. A hybrid 'wet'/dry' system may be suitable. It is difficult to provide a costing for this system as it would need to be a scaled sub-component of the larger AMF wastewater treatment AD plant. The suppliers of the DiCom system suggested a grid connected system would need at least 40,000-60,000 tonnes of FOGO material, but were open to the idea of designing smaller units for an off-grid application. This system is not a continual feed process, so chambers would be needed for each batch of material. This means a minimum of two chambers would be required for fortnightly delivery of FOGO, and an impractically high four-chambers would be required for weekly deliveries of material.

Thermal energy recovery

There is a range of different thermal energy recovery systems available. The following review considers options that may be viable at the scale of operation possible within the Shires. This assessment considers options for smaller volumes of municipal organics, but also investigates options if facilities could attract a wide range of inputs.

Single combustion chamber 'gasifiers' or boilers

Single combustion chamber 'gasifier' technology is a form of incineration that heats fuels/inputs under low oxygen conditions in a chamber resulting in the release of volatile gases that are then combusted in the same chamber. This means the fuel inputs do not combust directly. The systems do not allow for recovery of a gas. Such systems are commonly used in the timber industry to use waste biomass to produce heat for timber-drying kilns and other processes. There are a few reference facilities in Australia using them for other applications such as pool heating and hospital heating.

These units are best suited to screened waste timber and potentially green waste drop off from resource recovery centres. They are however, not so well suited to 'wet' garden and food organics with a high moisture content. Feedstock generally needs to be pre-sorted to remove contaminants such as plastics, metals and treated timber that may produce toxic fumes (dioxin and furan) and more bottom ash. With appropriate emissions control, timber, plastics, cardboard/paper can be burned although these systems can be expensive and likely to add $1-2 million to the costs of any project.

Table A15 highlights the advantages and disadvantages of Single combustion chamber 'gasifiers' systems.

Table A15: Single combustion chamber assessment summary

Advantages:	**Disadvantages:**
• Proven technology for small scale woody biomass • Potentially cleaner emissions from the same feedstock as direct combustion, with less risk of dioxin and furan generation and some tolerance for non-chlorinated plastics. Heavy metal timber treatments will remain a problem. • Can produce heat to drive steam turbines or direct or low level industrial heat	• Potential and perceived risks associated with emissions. This is low risk if the feedstock is dry, woody and homogenous. • Track record for variable and mixed waste streams is poor. Expensive emissions control and treatment systems are needed for these streams. This means the viable scale of the technology needs to be large. • Conversion of heat to steam to drive turbines reduces the efficiency of power generation relative to systems which use internal combustion or gas turbines • Requires shredding of feedstock • Power consumption is generally high • Footprint is typically greater than those that produce 'syngas' (synthetic gas from thermal gasification systems that can be stored and used as a natural gas substitute).
Application to the project: • Potentially a viable technology provided emissions controls are adequate • Best suited to a dry woody and homogenous feedstock • Unsuited to mixed waste materials streams at the scale required	

Single combustion chamber 'gasifier' units may be suited to providing industrial heat or for district heating projects such as that at Portland where heat demand is likely to be continuous. Where heat demand varies seasonally, buffer tanks would be needed to ensure the operating efficiency is maintained.

Gasification/pyrolysis systems

Gasification/pyrolysis systems thermally decompose fuel (timber, garden organics, cardboard/paper, plastics/synthetics and food) under a low oxygen environment to generate a 'syngas' or liquid fuel that is extracted from the heating chamber which is then used as a fuel. They are better suited to dry and homogenous feedstocks. Fluctuations in moisture levels tend to reduce the operating efficiency and possibly the net exportable energy because more heat is required to dry inputs. It can also potentially damage equipment such as turbines and engines and cause pollution risk from emissions.

Syngas is the main output of gasification and it can be converted into heat, gas or electricity. However, without a cleaning process to improve the quality of syngas, converting syngas into gas or electricity is considered a less viable option than if used for heating.

Pyrolysis produces different ratios of syngas, liquids hydrocarbons and bio-char depending on the operating temperature and process rate. Under high temperatures, net exportable energy is generally higher as pyrolysis tends to produce more syngas than liquid products. At lower temperatures and longer residence times, pyrolysis produces more bio-char and syngas.

A summary of the advantages and disadvantages of both gasification and pyrolysis is shown Table A16 and Table A17.

Table A16: Gasification assessment summary

Advantages:	Disadvantages:
• Potential for higher energy yields and production of storable gas • Potentially compatible with other gas powered systems including landfill gas energy recovery or natural gas fired kilns, boilers or co-gen/tri-gen plants	• Risks of emissions due to variable and high moisture inputs, as well as potential plastic contaminants • Although gasification is an old technology, most available systems are not yet technically and commercially proven • Best suited to dry and homogenous feedstocks (metals, glass and other non-combustible materials need to be removed from feedstock) • Requires direct supply of heat to sustain high temperatures • Generally high capital cost
Application to the project: • Several potential technology providers have been identified, and several of these can offer facilities of appropriate scale for in the order of \$1-3 million. Systems capable of producing grid-connected power and processing more variable feedstocks are likely to cost in the order of \$2-3 million for a 5,000-10,000 tonne per year facility, not including materials processing costs. These are more likely to be viable at the upper end of this scale and preferably would process higher volumes. • If the major focus of the output is electricity, feedstock consisting of high grade timber is preferred.	

Table A17: Summary of assessment of pyrolysis to produce liquid fuels, gas, heat and biochar

Advantages:	Disadvantages:
• Potential to produce a range of products • Potential to process more variable organic feedstocks • Potential high and 'instantaneous' renewable energy yields	• Most available systems are not yet technically and commercially proven • Best suited to dry and homogenous feedstocks • Lower energy yields if biochar is the main focus of the operation • Markets for biochar are unestablished and uncertain in Victoria • Uncertainty regarding toxic emissions and residues in biochar for some processes. These risks are manageable for the higher tech systems. • Oil/tar produced can be difficult to clean to meet fuel standards • Needs an external heat supply
Application to the project: • Several potentially technology providers have been identified that are local. • If biochar and heat are the main focus, needs to operate at lower temperatures. • Systems of appropriate scale are likely to cost in the order of \$0.5-3 million. Systems capable of producing power and processing more variable feedstocks are likely to cost in the order of \$2-3 million for a 5,000-10,000 tonne per year facility, not including the materials processing costs. These are likely to be more viable at the upper end of this scale.	

Biochar production

FOGO is not a good feedstock for most thermal systems. The exceptions are some bio-char production systems that suppliers claim can handle up to 50-60% moisture in feedstocks. These systems focus on the production of biochar and all generate usable heat, and potentially locally usable power. Higher moisture content will reduce usable heat generated, and ideally feedstock will have 30% moisture.

There is also a trade-off between biochar and energy production with less useable energy produced the more biochar produced.

Markets for biochar in Victoria are not well established. Small amounts are sold at a premium through some nursery supplies stores (at up to $20 for a 5kg container – equivalent to $4,000 per tonne less packaging and distribution costs). There has been minimal uptake of biochar in broadacre agriculture, and the agronomic value of products is uncertain, particularly in areas with better quality soils and reliable rainfall such as the south west. A price of $150-$400 per tonne may be more reasonable to expect for bulk sales. Carbon sequestration via addition of biochar to soil is not currently recognised under the Emissions Reduction Fund (ERF) soil carbon methodologies, so currently there is no potential for Australian Carbon Credit Units (ACCU) to be accredited and sold. The biochar industry is pushing for a ERF methodology to be developed.

Table A18 shows a cost estimate for a low-tech small-scale biochar production unit using FOGO. This suggests biochar production with sales of biochar and a user of heat energy could be competitive with the aerobic composting systems considered. It is recommended that small scale biochar producers should be invited to provide more information about a 5,000-10,000 tonne per year facility, addressing concerns about potential toxic emissions and 'tars'. Highly toxic and carcinogenic polyaromatic hydrocarbons can be formed.

Table A18: Cost assessment of small scale bio-char production (BigChar system)

Cost item	Scale of operation (tonnes per year)_	
	5,000	10,000
Capital and site establishment costs	$1,928,000	$2,928,000
Annualised capital and establishment costs ($ per year)	$249,700	$379,200
Annualised capital and establishment costs per tonne ($ per tonne)	$50	$38
Operating costs ($ per year)	$186,300	$330,000
Operating costs ($ per tonne)	$37	$33
Capital and operating costs ($ per tonne)	**$87**	**$71**
Revenue from compost sales ($ per year)	$75,000	$150,000
Revenue from industrial waste gate fees ($ per year)	$90,000	$180,000
Net revenue ($ per year)	$165,000	$330,000
Net revenue ($ per tonne of municipal input)	**$33**	**$33**
Net costs	**$54**	**$38**

Refuse derived fuel (RDF)

This option involves converting biomass and potentially other calorific waste into a loose or pelletised fuel for use by an off-site energy recovery facility as a fossil fuel substitute. This can be achieved by using some gas and heat from processing (reducing the net export of energy from the facility) or the use of 'bio-drying', which essentially uses the self-heating nature of aerobic compost to dry materials before it is used to make RDF.

It is understood that RDF markets in Victoria are currently limited with few facilities in Australia able to accept RDF. Emerging forestry biomass thermal facilities may be willing to use RDF, however these will need emission controls to avoid the risk of dioxin and furan emissions produced from materials contaminated with chlorinated plastics. Cement kilns reduce this risk as they combust materials at high temperatures for a long residence time in an alkaline environment.

The SUEZ-ResourceCo facility in Wingfield South Australia can convert up to 350,000 tonnes per year of mixed plastics, timbers and textiles to approximately 150,000 tonnes of processed engineered fuel (PEF). Feedstock comes from C&I and C&D activities and other sources with pre-sorted waste and undergoes additional treatment on site to remove contaminants such as steel, concrete, glass and sand. It is understood Adelaide Brighton cement kiln substitutes around 20-30% of coal fuel for PEF.

Gasification facilities using waste feedstocks in Australia have had trouble in meeting emissions standards. Conversion of residuals from MSW processing into RDF may be worth pursuing, however markets for these products will need to be developed.

Thermal systems

The following thermal systems have been considered.

Single combustion chamber 'gasifier'/boiler

The Mt Gambier Aquatic Centre uses a 650kW Binder boiler that runs on woodchips (20-30% moisture) to generate thermal energy for heating the pool. Although such units are sometimes referred to as 'gasifiers', combustion of gas volatilised from the fuel takes place in the same chamber that fuel is heated in, so it is effectively a cleaner form of incineration. The unit can process around 5-10m^3/day (1.5-3 tonnes) of dry woodchips supplied by local forestry companies. The previous boiler unit processed fresh sawdust, however it is understood that because of the variable heat demand and heat exchange pump controls on the new boiler, only dry woodchips are suitable. In addition, feedstock is screened for large woodchips which previously caused blockages in the feeding system. It is believed a cheaper straight gas boiler option was also considered, however the operating cost of the Binder boiler was estimated to be more cost effective over a 10-year period.

Ararat Rural City Council investigated the use of a proposed wood gasifier at the local YMCA facility. Wood waste from the Ararat resource recovery centre was to be used as feedstock to heat the indoor pool and generate electricity for on-site usage. However, there were concerns that noise levels emitted from the generator would not comply with EPA requirements in residential zones and would need to be containerised. An alternative unit producing only heat was considered at the time, however it is believed the project was put on hold due to costs and a decision was made to wait for the outcomes from the regional biomass project at Beaufort Hospital.

In 2014, Beaufort Hospital installed a 110kW Hargassner boiler processing around 92 tonnes per year of dry woodchips to provide heating to the hospital. The unit was installed within a shipping container at an estimated cost of $428,900 with feedstock sourced from local suppliers. It is understood replacing the old gas boilers with the biomass boiler reduced heating costs in the order of $26,800 per year. The unit requires additional ongoing maintenance each year (mainly cleaning). It is believed a similar system is being considered at the Beaufort pool which currently uses natural gas for heating. The biomass system proposed will operate on woodchips sourced from local sawmills and is estimated to reduce heating costs by up to $55,000 per year.

Living Energy is a New Zealand based company who supplied boilers to both Mt Gambier pool and Beaufort Hospital. They provide a range of boilers including the Binder boiler and the Hargassner boiler and could be a potential supplier for such units. The thermal energy output for the Binder boiler ranges from 200kW to 10MW. Feedstocks accepted include woodchips, wood pellets, sawdust and other wood wastes of up to 50% moisture. The Hargassner boilers range in capacity from 25kW to 200kW.

Pyrolysis

There are few commercially proven small scale facilities operating in Australia.

Pacific Pyrolysis operates the PyroChar 300 pilot plant at the Somersby Advanced Engineering Facility in Sydney. The continuous slow-flow pyrolysis demonstration plant has a capacity of around

300kg/hr of dry biomass material and can power a 200kW electrical generator on site. Since 2006, the plant has been used to produce Agrichar™ soil amendments for research programs. However, no known units are operational at the time of writing. Pacific Pyrolysis has a processing system and mechanical designs for two larger units – a 48 (2 tonne/hour) and 96 (4 tonne/hour) dry tonne-per-day commercial units. These units are modular and can be designed with an engine component for electricity production (like the demonstration plant) or to interface with thermal processes such as steam boilers. It has been technically proven to process a range of feedstock such as garden waste, wood waste, bio-solids, husks and manure with a moisture content of up to 70%. However, it is not certain whether it would be suitable for food waste. The unit is believed to be capable of processing feedstocks contaminated with metals, glass (if within the optimum size specification) and film plastics.

New Energy Corporation is the exclusive global licensee for the 'Waste to Energy' technology developed by Entech. The low temperature gasification technology converts organic matter into syngas in low air conditions. Syngas is burned in a separate chamber to drive a boiler to generate steam and electricity. It accepts materials from a range of difficult waste streams such as municipal, industrial, petrochemical, bio-hazardous, pharmaceutical, liquid and tyres. New Energy Corporation is currently developing a facility in the Pilbara, WA with a processing capacity of 70,000-130,000 tonnes per year. The plant is scheduled to operate in 2019 with potential to supply up to 18MW of electricity and 72MW of heat to the community.

City Circle operates an under-grate 'gasification' system in Brooklyn currently capable of processing up to 10,000 tonnes per year of timber waste. Timber waste is sourced from demolition projects where it is shredded and chipped to approximately 80mm before undergoing gasification to generate 1MW of power to the concrete recycling plant. The facility is being used as a research and development plant in preparation for commercial use. City Circle is also looking to construct another gasification plant at its recycling facility in Melton following on from the successful operations at Brooklyn.

Appendix B: Review of specific technologies

The following tables provide detail about the energy recovery and some composting unit suppliers identified and consulted by Blue Environment.

Technology name:	Hot rot – in vessel composting
Supplier details	HotRot organics solutions, NZ (http://www.hotrotsolutions.com/pages/hotrot-technology)
Process details	HotRot system are modular. Materials are loaded into the vessel. A central screw turns slowly to move materials along the vessel and aerate piles. All exhaust can be capture and run through a biofilter. The HotRot process sterilises and partially stabilises materials, and can be used to process odorous feedstocks including food and some organic PIWs. Materials taken from the chambers will still be active and will require maturation before use. These materials could be windrowed on site or delivered to farms for maturation.
Capital costs	Information from the suppliers suggest that a facility consisting of two 2.5 tonne per day modules capable of processing 5tonne per day will cost in the order of \$200,000-\$500,000 for supply and installation, including the civil works associated with developing a site. Additional units could be installed for \$100,000-\$200,000.
Operating costs	The supplier nominated power and maintenance costs of \$4-\$7 per tonne, with total costs in the order of \$34-\$67 per tonne. However, if material needs to be shredded this will add an additional \$40-\$45 per tonne at this small scale of operation, bringing the total costs to \$74-\$112 per tonne.
Pre-treatment of feedstocks required	Ideally inputs will be pre-screened and shredded.
Capacity/scale and flexibility	Units are available in a range of scales: 0.2-0.4t/day, 1.5t/day, 1.8-2.5t/day, up to 10 t/day (3,600 tonne per year). Units are modular, so more than one unit could be used.
Size/footprint requirements	Units are compact. A 5t/day unit (~1,800 tonne per year) would occupy an area of 4m x 14m. Areas for storing material removed from the unit would also been needed.
Management requirements	For garden and food organics containing biobags, materials would need be screened and shredded. Requires three phase power.
Environmental risks	Odour – exhausts are treated through a biofilter. Young composts removed from chambers may have odour risk if not managed. Water pollution – water is contained in chamber. Run-off from stored young composts poses some risk and needs to be contained. Fire – low risk Other – minor noise risk Units can be housed.
EPA and planning requirements	Will be needed if larger than 1,200 tonne per year. A case for a smaller separation distance should be able to made as the system is enclosed.
Technical risk	The system is proven for food industry and restaurant waste, but not for kerbside garden and food organics. However, with size reduction/shredding, the system should work.
Outputs	The compost removed from the hot rot system is similar to a 4-6 week old windrow compost and can be used directly in non-sensitive uses, but the supplier recommends at least 3-4 weeks further maturation prior to use to avoid nutrient draw down when used.
Conclusions/key points	Advantages: • Fully contained and compact • High level of odour control • Easy to use/manage Disadvantages: • High capital costs • Requirement for shredding of garden organics will increase costs • No local supplier of parts for maintenance (systems imported from NZ)

Technology name:	DiCOM
Supplier details	AnaeCo (http://www.anaeco.com/dicom-bioconversion-facility)
Process details	DiCOM is a modular bio-conversion system that incorporates anaerobic and aerobic processing within the same vessel. This occurs in three main stages. Biomass is fed into the DiCOM vessel where aerobic reactions occur to raise the temperature to levels suitable for anaerobic digestion. Liquid containing anaerobes is then added to initiate anaerobic digestion. Air is then introduced to convert digestate into fertiliser. During the anaerobic phase, captured biogas is converted to electricity and heat via the gas-fire generator.
Capital costs	The pilot plant in WA had capacity of 25,000-30,000 tonnes per year of mixed MSW and cost in excess of $5 million. The AD component for processing source separated organics would be less than this and would depend on scale. The supplier suggests a facility would need to process at least 40,000-60,000 tonnes per year of solids to warrant connection to the power grid, but a smaller capacity unit (20,000-40,000 tonnes per year) could be used if it was co-located with an industrial or community user. Costs would be in the order of $2-3 million.
Operating costs	Operating costs for source separated organics would be relatively low, with some decontamination and shredding before materials are loaded, and then unloading and screening of outputs. Outputs may need further aerobic composting to 'mature' them.
Pre-treatment of feedstocks required	Source separated organics would need decontamination and shredding before being loaded into chambers.
Capacity /scale and flexibility	Units are modular and available in increments of 20,000 tonnes per year. At least two modules would be needed because the system is batch-loading.
Size/footprint requirements	Plants have a small footprint. Requires an area of around 0.12-0.2m^2 per tonne of MSW.
Management requirements	Pre-cleaning and shredding of solid organic inputs is required. A source of water or wastewater with organic load is required. The process is a net generator of water, so wastewater treatment facilities or sewer discharge are also needed.
Environmental risks	Low. All materials are processed within a closed vessel. There may be some odour prior to loading and when unloading chambers.
EPA and planning requirements	Works approval and licensing will be required.
Technical risk	A pilot system in WA was used for mixed waste and is not currently operating. Gas yields uncertain.
Outputs	Biogas and fertiliser. Can be configured to produce refused derived fuel.
Conclusions/key points	Advantages: • Local supplier (Western Australia) • Generates renewable electricity • Can be retrofitted to resource recovery centres Disadvantages: • Requires connection to the grid • Requires pre-treatment of MSW
Overall ranking/ potential	Not suited for GSC and SGSC FOGO alone, but may be viable with larger throughputs and if co-located with an industrial user of heat and power. May be suited as part of proposed AMF meat works waste treatment system, although additional solid organics would be needed to achieve a 20,000 tonne capacity if smaller chambers could not be engineered.

Technology name:	Dranco
Supplier details	Organic Waste Systems (OWS) (http://www.ows.be/household_waste/dranco/)
Process details	This system is a high-rate dry digestion process that occurs inside a vertical cone unit in the absence of mixing. Pre-treated feedstock is loaded into the mixer compartment of the feeding pump where it is mixed with digestate. Steam is injected to raise the temperature before it is pumped to the digester through the top of the vessel followed by iron chloride dosing and addition of process water as needed. Large biomass settles to the bottom of the fermenter where it is extracted for compost production. Biogas produced inside the fermenter is collected through the gas storage unit at the top of the unit.
Capital costs	Budget investment is about $7.8 million for a >50,000 tonne per year facility
Operating costs	Not known.
Pre-treatment of feedstocks required	Feedstock needs to be less than 40mm in size and pre-sorted to remove plastics, textiles, metals, stones and glass.
Capacity/scale and flexibility	Up to 50,000 tonnes per year in a single digester. Minimum feedstock input of 3,500 tonnes per year per vessel.
Size/footprint requirements	20,000 tonnes per year unit would occupy around 1,420m2. Requires a concrete foundation.
Management requirements	FOGO materials would need to be macerated. Total solids content in the digester needs to be between 18-45%. Operates 8 hours per day and 250 days a year.
Environmental risks	Odour – air treated through biofilter Fire risk- smoke detection by the gas engines and steam generator and methane detection Other-low noise
EPA and planning requirements	EPA works approval and licence is needed for units recovering more than 1MW of energy.
Technical risk	The supplier suggests a capacity of 10,000 tonnes per year is small for this technology. Can process 20,000 tonnes per year.
Outputs	Electricity, heat, steam from biogas.
Conclusions/key points	Advantages: • Small footprint (process occurs in a single digester) Disadvantages: • No local supplier • Feedstock requires pre-treatment/maceration • Requires electricity and water connection and sewer connection if dewatering stage is needed
Overall ranking/ potential	Not suited to GSC and SGSC needs due to large scale.

Technology name:	EUCOlino
Supplier details	Bioferm Energy Systems (http://www.biofermenergy.com/anaerobic-digestion-2/faq/)
Process details	EUCOlino uses wet anaerobic digestion technology. The system is modular and operates as a mixed plug flow. Feedstock is fed into the digester tank using the PASCO feeder, where it is mixed using horizontal paddles. Biogas produced from fermentation is captured in a biogas bag which is connected to the combined heat and power unit.
Capital costs	Reference plant (consisting of 2 fermentation vessels) processing around 6,000 tonnes per year costs around $1.2 million. Units are pre-fabricated.
Operating costs	Not provided.
Pre-treatment of feedstocks required	Requires pre-sorting of materials. Accepts food waste, manure, biosolids and brewery waste. pH of feedstock should be 7.5 or greater.
Capacity/scale and flexibility	Estimated processing capacity is around 1,000-6,500 tonne per year. Each digester has a capacity of 1,000 tonne per year. Additional tanks can be installed for larger throughputs.
Size/footprint requirements	Requires a concrete foundation for the unit. One digester tank would typically occupy an area of 31m x 4.5m (slightly bigger than a shipping container). Additional space would be required for optional units including gas storage units and PASCO feeding system (additional 8m).
Management requirements	Requires an operator for two to four hours every day for general maintenance.
Environmental risks	Odour – gas is treated through a biofilter. Mixing lobby and digester units are enclosed. Other – low noise
EPA and planning requirements	EPA works approval and licence is needed for units recovering more than 1MW of energy.
Technical risk	Contaminated digestate if materials are not pre-sorted well.
Outputs	Electricity or heat from biogas (depends on if a biogas-fired boiler is installed). Digestate.
Conclusions/key points	Advantages • Pre-assembled and ready to use when delivered • Compact • Odour control Disadvantages • Requires pre-sorting of materials • No local supplier • If biomethane is a focussed output, then additional equipment is needed, increasing capital costs • Organic loading is limited • Requires electricity connection
Overall ranking/ potential	This could be viable as it is a small-scale option. There are no local suppliers and it would need to be imported. Not well suited to woody waste in FOGO and has high capital costs.

Technology name:	Kompogas Digester
Supplier details	Hitachi Zosen INOVA (http://www.hz-inova.com/cms/en/home?page_id=256)
Process details	This is a modular plug flow system that is based on dry fermentation of organics. The system operates under thermophilic conditions. Sorted organic wastes from the feed unit are automatically loaded into the digester where it is allowed to fully digest produce biogas. Around two-thirds of the digestate is discharged for further processing while the remaining portion is re-circulated back to the digester.
Capital costs	Not provided.
Operating costs	Not provided.
Pre-treatment of feedstocks required	Shredding and sorting of organics to remove metals and other non-digestible material.
Capacity /scale and flexibility	Size of the concrete digester (PF1300) is 17,000-23,000 tonnes per year. The steel digester is available in a range of sizes: 16,000-21,000 tonnes per year(PF1200), 20,000-25,000 tonnes per year (PF1500) and 23,000-30,000 tonnes per year (PF1800).
Size/footprint requirements	Requires electricity and water if the feedstock has low moisture content. A PF1300 digester would occupy an area of 33.8m x 7.1 m. A PF1200, PF1500 and PF1800 would occupy an area of 25.5m x 8.5 m, 33.8m x 8.5m and 38.3m x 8.5m respectively.
Management requirements	Feedstock needs to be pre-sorted via visual inspection. Fire risk-would be the same as if natural gas is used. An exclusion zone of around 10-15m is generally needed.
Environmental risks	Odour – managed through biofilter
EPA and planning requirements	EPA works approval and licence is needed for units recovering more than 1MW of energy.
Technical risk	Proven technology for processing organics from MSW where throughputs are higher. Contamination of compost if non-source separated waste is accepted into the feedstock.
Outputs	Heat (hot water or process steam), electricity. Digestate can be mixed with garden waste and composted or dewatered and aerated for 7-10 days. Liquid digestate can then be used as fertiliser.
Conclusions/key points	Advantages: • Local supplier • Pre-fabricated system Disadvantages: • Considered to be cost effective with larger throughputs • Compost needs further processing • Not well suited to garden and woody wastes
Overall ranking/ potential	Would be better suited for larger scales of at least 25,000-30,000 tonnes per year.

Technology name:	Lt-AD
Supplier details	NVP Energy (http://www.nvpenergy.com/technology/)
Process details	This anaerobic digester uses microbes to digest biomass at lower temperatures than conventional AD systems. The system is modular and only requires pumping (no aeration or heating). Low operating temperatures allows more of the biogas from digestion to be converted into energy. It also produces less sludge than activated sludge process.
Capacity/scale and flexibility	Approximately 300m^3/day of wastewater. Not suited to FOGO.

Technology name:	SMARTFERM
Supplier details	Zero Waste Energy (http://zerowasteenergy.com/our-solutions/dry-anaerobic-digestion/)
Process details	Dry anaerobic digestion system. Biomass is loaded into an air-tight chamber where it is aerated to facilitate aerobic conditions resulting in higher temperatures suitable for anaerobic digestion. Liquid containing thermophilic bacteria (percolate) is added to digest the organic material and produce biogas. Percolate is recirculated through the closed loop between the digester and percolate tanks for 20 days. Biogas is captured and stored in the roof-mounted double-membrane bladders. Before the digester is opened, air is circulated through to control odour.
Capital costs	Website estimates 25,000 tonnes per year unit would cost around $26 per tonne.
Operating costs	Not known.
Pre-treatment of feedstocks required	FOGO material would need decontamination and shredding.
Capacity/scale and flexibility	A minimum of 4,000-10,000 tonnes per year of organic waste is needed to efficiently produce electricity. Can be expanded in the future to meet higher loads. Requires at least two chambers to allow for continual processing.
Size/footprint requirements	A 5,000 tonnes per year unit would occupy around 279m^2.
Management requirements	Requires a front-end loader. Additional screening requirement for compost is needed.
Environmental risks	Odour – material receiving area is enclosed. Air is treated via biofilters.
EPA and planning requirements	EPA works approval would be needed if energy recovery capacity is more than 1MW.
Technical risk	Organic loads of between 4,000-10,000 tonnes per year is needed to efficiently produce electricity.
Outputs	Biogas for electricity and heating or compressed natural gas (incoming loads need to be at least 10,000 tonnes per year of organic waste). Pre-mature compost.
'Trialability'	Units are modular and demountable, so could be trialled
Conclusions/key points	Advantages: • Suitable for low organic loads and is scalable • Proven technology for processing organics from MSW • Only requires electricity and water on start-up, once running it generates electricity to sustain operations and recycles water • Local supplier (Bulk Handling Systems, Perth) Disadvantages: • High capital cost • Needs a throughput of at least 10,000 tonnes per year of organics to produce compressed natural gas • Compost requires additional maturation
Overall ranking/ potential	Could be considered and trialled if a user for biogas energy can be found. Will not be viable to connect to the grid at the anticipated scale of operation.

Technology name:	Binder Boiler/Hargassner Boiler
Supplier details	Living Energy (http://www.livingenergy.co.nz/content/products/default.aspx)
Process details	Wood waste is fed through the base of the chamber where it is incinerated to generate heat and bottom ash.
Capital costs	Boiler unit at Beaufort Hospital cost around $430,000.
Operating costs	Not known.
Pre-treatment of feedstocks required	Feedstock may need to be chipped to size.
Capacity/scale and flexibility	Thermal energy output of the Binder boiler ranges from 200kW to 10MW, while the Hargassner boiler ranges from 25kW to 200kW.
Size/footprint requirements	Boiler unit at Beaufort Hospital is enclosed in a 12-metre shipping container. Connection to existing heat system. Cast in-situ concrete drain. Area for fuel storage.
Management requirements	Requires manual loading of feedstock
Environmental risks	Low.
EPA and planning requirements	A works approval and licensing may be required if capacity is >1,200 tonnes per year for garden or FOGO waste. This should not be required for woody biomass.
Technical risk	Limited range of organics that can be accepted. Not well suited to 'wet' garden and food wastes.
Outputs	Heat only.
Conclusions/key points	Advantages: • New Zealand based company supplies to Australia • Proven technology for small scale heating (used at Beaufort Hospital and Mt Gambier pool) Disadvantages: • Only suited for woody wastes and not well suited to wet organic wastes • Produces heat only
Overall ranking/ potential	May be suitable if local heating preferred. Not suited to FOGO because of odour risk, variability of feedstock and moisture content

Technology name:	BIG CHAR Continuous Carbonisation Technology (BIG CHAR CCT)
Supplier details	Pyrocal (http://www.bigchar.com.au/technology.html)
Process details	Fast rotary hearth technology converts waste biomass to charcoal and energy. The technology is a mobile or relocatable pyrolysis unit that cater for dispersed and seasonal feedstocks. It accepts timber, garden waste, food waste, biosolids, paunch waste manures, agricultural product residues and potentially MSW. Feedstock is continuously fed through the inlet at the top of the hearth chamber where it then passes through five levels to the bottom using a roasting wiper.
Capital costs	Typically costs around $650,000 for installation and other infrastructure. Cost will also vary by size and whether the system is fixed or mobile. An additional $1.5 million would be required for emissions treatment for a mixed municipal waste unit due to pollution risks.
Operating costs	Not provided.
Pre-treatment of feedstocks required	Needs to be cleaned and shredded. Cannot process treated timber.
Capacity /scale and flexibility	Three sizes are available: 0.25 tonne per day, 0.64 tonne per day and 1 tonne per day.
Size/footprint requirements	A 0.25 tonne per day unit would occupy 6m x 2.3m, 0.64 tonne per day would occupy 9m x 2.7m and 1 tonne per day unit would occupy 9m x 2.7m.
Management requirements	Utility requirements include electricity, gas supply, water and fire water. Hot water output requires a fire tube heat exchanger. Requires one operator for automated feeding and multiple operators for manual feeding. Requires three phase power.
Environmental risks	Website indicates that emissions are low and additional emissions control is not often required. However, this would vary depending on the type of feedstock and location.
EPA and planning requirements	Better emission controls are required if plastics are to be accepted in the feedstock.
Technical risk	Has not been proven to process MSW.
Outputs	Heat and biochar. Can also potentially produce activated carbon depending on the type of feedstock and if a steam activation process is used (supplementary process).
Conclusions /key points	Advantages: • Local supplier in Queensland • Does not need a supplementary heat supply • Small scale unit • Can produce biochar and heat for industrial heating Disadvantages • Requires gas supply • No commercial facilities operating in Australia
Overall ranking/ potential	This system is more efficient if the focussed output is heat and biochar instead of electricity. May be suitable and is worth considering.

Technology name:	Slow pyrolysis
Supplier details	Pacific Pyrolysis (http://pacificpyrolysis.com/technology.html)
Process details	This technology involves the thermo-chemical decomposition of organic material (biomass) at elevated temperatures in the absence of oxygen.
Capital costs	Not known.
Operating costs	Not known.
Pre-treatment of feedstocks required	Will need cleaning and shredding.
Capacity/scale and flexibility	Needs at least round 16,000 tonnes per year. Smaller scales are possible but becomes inefficient based on the economy of scale.
Size/footprint requirements	<0.25ha
Management requirements	Monitoring, cleaning and shredding of feedstocks. Monitoring of performance. Unloading of char
Environmental risks	Potential pollution emissions
EPA and planning requirements	Works approval and licensing if >1,200 tonne per year
Technical risk	No known facilities operating commercially in Australia.
Outputs	Electricity-a continuous flow slow pyrolysis pilot demonstration plant (the PyroChar 300) north of Sydney has a capacity of approximately 300kg/hr (dry basis) of biomass material and can power a 200kW electrical generator on site. Agrichar™ (i.e. Biochar is marketed under this brand).
Conclusions/key points	Advantages: • Power, heat and biochar production. Disadvantages • More suited to woodier biomass and not FOGO material. • Requires gas supply to start loads. • No commercial facilities operating in Australia.
Overall ranking/ potential	Better suited to woodier and more consistent feedstocks and at a larger scale than anticipated. Not likely to be suitable.

Technology name:	WtGas
Supplier details	New Energy Corporation (http://www.newenergycorp.com.au/projects/)
Process details	This is a low temperature gasification technology where organic matter is converted to a syngas in low air pressure conditions, which reduces the temperature and internal energy demand require for gas volatilisation, making the system more efficient. Syngas generated is burned in a separate chamber to drive a boiler and generate steam and potentially electricity.
Capital costs	$6 million for a 10,000 tonne per year plant producing steam only (excludes civil engineering works, buildings, services, approvals and legal costs).
Operating costs	Not provided.
Pre-treatment of feedstocks required	Cleaning and shredding
Capacity/scale and flexibility	Small scales down to <1,000 tonnes per year are okay, but scale of economy would be 100,000 tonnes per year of MSW based on gate fee of $200/t and PPA of 3c/kWh.
Size/footprint requirements	Requires electricity, water, sewer, gas (alternatively diesel) connection.
Management requirements	Monitoring and cleaning of inputs. Monitoring of system performance
Environmental risks	Fire risk is fully mitigated through design.
EPA and planning requirements	EPA works approval would be needed if energy recovery capacity is more than 1MW.
Technical risk	Materials need to be quite dry, Feedstock ideally needs to have moisture content of 0-30%, although the wetter the material, the less heat that is available to export. 0-30% is the same as dried timber and potentially woodier drop off garden waste or ‘oversize’ materials from a composting facility. FOGO materials may be too wet.
Outputs	Electricity (from syngas) and hydrocarbons
Conclusions/key points	Advantages: • Local suppliers • Potential industrial or community project heat and power Disadvantages: • Capital costs • More suited to drier woody biomass rather than FOGO materials.
Overall ranking/ potential	Not suited to project due to high capital costs and requirement for drier woody biomass.

Appendix C: Review of specific opportunities for energy recovery facilities

This appendix reviews specific opportunities identified through the project for location of energy recovery technologies. It considers the suitability of the sites and the technologies that could potentially be located at the sites.

Hamilton meat works – Australian Meat Farmers

A promising siting option is the potential development of an AD facility at a proposed meat processing facility at Hamilton. The Australian Meat Farmers (AMF) facility has planning approval to establish as facility at Hamilton. This will have capacity to process 400 head of sheep and cattle per day. This would produce in the order of 20-25 tonnes of manure and paunch (stomach and intestine contents) per day, as well as 200-300 kilolitres of wastewater with moderate to high biological oxygen demand (BOD) per day. This equates to about 6,500 tonnes of paunch and manure per year, and over 60-70ML of wastewater per year.

This waste will need treating. Although Wannon Water operates a water treatment plant, including a small-scale AD facility, adjacent to the proposed AMF facility, the plant does not have capacity to process this waste and would require a significant upgrade. AMF are interested in alternatives to Wannon Water due to high trade waste fees.

Options for a shared facility with AMF are discussed as follows.

Anaerobic digestion

The AMF facility will have significant internal heat and power demands. There is potential for an AD unit that can process the AMF facility's wastes as well as FOGO, saleyards waste, and commercial and industrial organics. Depending on the technology to be used, the AD facility could also process resource recovery centre organics either directly through the AD chambers or as part of an aerobic composting of solid residuals from the AD process.

Three potential AD systems could be used:

1. A 'wet'/aqueous AD unit.

These units liquefy organic waste and treat wastewater with an organic load and extract gas from AD tanks. Tank temperature is maintained at levels that promote rapid biological degradation of organics under anaerobic conditions to produce biogas. Examples of such units in Australia include: Earthpower, NSW; Biogass, WA; and Yarra Valley Water, Wollert, Victoria. Potential recoverable energy yields from bio-gas are in the order of 210-225 kilowatt hours (kWh) per tonne of FOGO input using heat recovery or combined heat and power (CHP) recovery systems. In other words, a facility receiving 20 tonnes of FOGO per day would generate 4.2-4.5MWh per day of CHP useable heat and electricity.

These units can tolerate some level of solids, but 'woody' material does not breakdown well under anaerobic conditions. Pre-treatment of woody garden waste can ensure more of this material is susceptible to biodegradation and biogas generation, but some fibrous material will persist. This fibrous material along with bacterial, as well as other solids such as sand, grit and silt form a 'digestate' sludge in the AD tanks. This can be extracted ('bled off') from the tanks and either used as a liquid or dried/pelletised fertiliser or added to composting processes where it adds nutrient value to the products.

The digestate has a market value related mainly to its nitrogen content. Earthpower sell a pelletised form digestate for composting for around of $150 per tonne, with about 1-1.5 tonne of dried product per 100 tonnes of input. The Earthpower facility is now operated by a Veolia and TPI joint venture following the financial failure of the original facility owner. The facility failed because of high capital costs and lack of security of organic feedstock to generate gate fee and power sales revenue. The Biogass facility in WA is co-located with an aerobic composting facility which uses the digestate, other residues, and wastewater from the units to add moisture and nutrient to the composts. It and the Yarra Valley Water facility are still in commissioning stages.

An aqueous AD unit may be suited to AMF needs for waste and wastewater treatment system but is less suited to FOGO material unless it can be macerated into a slurry that can be fed into the unit. Woody material is less digestible and the AD tanks receiving FOGO material would need to be designed to allow for removal of this material. Hepburn Shire Council is currently considering installing a macerator for processing FOGO material prior to processing it though an AD unit, and the outcomes of this pilot facility may prove FOGO can be processed in this way on a smaller scale.

2. A 'dry/solid' system.

These facilities load solid organics into chambers, saturate the materials with leachate extracted from previous batches, reduce the oxygen content of chambers and hold materials at temperatures that promote biogas generation. Once gas yields begin to fall the chambers are aerated through false floor aeration systems and the organics managed as an aerobic compost. This technology is suited to FOGO, other garden organics, stockyard wastes, paunch, commercial organics and PIW organics. Recoverable energy from biogas from AD systems are in the order of 8.5-10kWh per tonnes per day. The compost product will have some commercial value but may need to be further processed through windrow composting to produce a 'mature' or 'stable' product.

One supplier, Smartferm, provides smaller scale 'shipping container' units that could process collected FOGO and AMF's paunch and manure. However, it would not meet AMF's need for a wastewater treatment facility. A smaller scale 'dry'/'solid' unit processing FOGO could potentially be co-located with an aqueous AD facility treating AMFs wastes and provide heat and power to the AMF facility.

3. A 'hybrid' wet/dry system.

These systems load solid organics into a chamber, floods the chamber with aqueous 'liquor' from previous batches, and holds the chamber at temperatures that promote rapid biogas generation. Once gas yields begin to fall, the chamber is drained and the contents aerated as a compost. The liquor drained from the chamber has BOD content and high bacterial count and can be held in tanks where further biogas is produced, or used to flood subsequent batches to promote rapid biodegradation. Digestate sludge could potentially be extracted from liquor tanks as a fertiliser product. The solid residue from chambers can be used as a high nutrient compost product. Such a technology could be well suited to a combined municipal-AMF facility, where AMF will have a need to treat wastewater, paunch and manure in volumes too great to compost using available woody organics. Under such an arrangement, the FOGO organic chamber could be an adjunct to a larger aqueous AD tank-farm, and use some wastewater, manures and paunch from AMF to generate bio-gas and produce organic fertiliser and humidified compost products. Heat and potentially power from a CHP AD facility could meet AMFs internal energy demands. It is unlikely the quantities of gas will be sufficient to fully supply the meat processing works heat and power needs.

The most appropriate technology for a combined municipal organics-AMF waste and wastewater AD unit is likely to be a 'hybrid' solid/aqueous system. A combined heat and power unit meeting the internal energy requirements of AMF facility, with potential spot-price sales of excess power to the grid is likely to be most cost effective. The potential gas and energy yields from the various inputs is shown in Table A19.

Table A19: Estimated biogas and energy yields from a combined FOGO-Australian Meat Farmers Aerobic Digestion (AD) facility

Input	Expected amount (tonnes per year)	Expected bio-gas yield per unit of input (m3 per tonne fresh weight)	Expected bio-gas potential from input source (m3)	Expected CHP useable energy yield (kWh/tonne fresh weight)	Expected yield of CHP energy (MWh/year)	Expected value at $100/MWh ($ per year)
Municipal FOGO	8,000	110	880,000	210-225	1,680-1,800	$180,000
Commercial food	250	110	27,500	225	60	$5,600
Grease trap	500	100	50,000	202	100	$10,100
Paunch & stockyard wastes	6,500	45	292,500	80	520	$52,000
COD of wastewater	60ML = 60,000 tonnes at 2,000mg/L	5-10	300,000 - 600,000	10	600	$60,000
TOTAL					**2,960-3,080**	**$307,700**

Note: Drop-off garden organics have not been considered as part of the AD model as this material can be managed without enclosed management and will add to the required capacity of the 'hybrid' component of the project. It is expected these materials would be managed separately as they currently are. The solid residues from the AD facility could be blended with these materials for open windrow composting.

AMF have planning approval for the development of the meat processing works and are currently working to secure investment in the facility. If this proceeds, it is recommended GSC and SGSC work with them to develop opportunities for a combined AMF-municipal FOGO waste AD facility, with solid residues being aerobically composted using windrow composting with shredded drop-off organics at the AMF or Hamilton landfill site.

Aerobic composting of AMF wastes

Direct aerobic composting of the AMF's potential waste stream is not likely to be a viable option although paunch, triple interceptor and holding yard wastes could potentially be managed through controlled environment composting. However, AMFs main need is a system that can treat wastewater. The volumes of wastewater are high and typically an aerobic composting process will require at least one tonne of shredded woody organic input per cubic metre of water. The demand would be 60,000-70,000 tonnes of woody biomass per year which would almost certainly require large quantities of woody organics from forestry sources. Gate fees would not be able to be charged and a fee for materials and freight costs may need to be paid. In addition, markets for the equivalent volume (i.e. 60,000-70,000 cubic metres) of compost end product would need to be found.

Portland district heating project

An opportunity suggested by GSC is the potential to use biomass to provide energy for a district heating project. This project requires replacement of existing infrastructure from an earlier project that was first established in 1983 using geothermally heated water. In more recent years it has used increasingly expensive natural gas. The system is located at Henty Park and directs heated water for heating several public buildings and two internal public pools during winter and three additional external swimming pool during summer months. The current piping infrastructure needs to be replaced while the natural gas heating plant will need replacement in the near future. The following assessment has only considered the costs of the heating facility and not the piping of heat.

Options for heating include either biogas generation through anaerobic digestion (AD) or thermal energy recovery from the combustion of biomass.

An AD facility could potentially process FOGO, stockyard wastes, and other 'wet' organics (such as organic PIW, and commercial food waste. However, such a facility would have odour risks, and would need to comply with EPA guidelines for organics processing facilities. The main odour risks will be the receival area and during the unloading of chambers. There may also be fugitive air emissions during facility maintenance. In order to operate at the Henty Park site where the current heating plant is in place, a facility will almost certainly require fully enclosed receival and unloading areas, with the bio digestion process being completely enclosed. The likely minimum separation distance required is 250m of the receival area with all processing areas being fully housed/enclosed. This separation will not be possible at the current site.

A thermal unit could be established to process woody biomass, potentially including some clean drop-off garden organics. However, such units are unlikely to be suited to processing FOGO material due to the risks of:

- Odour associated with the storage of material. Such thermal units typically use a 'continual feed' process, with chipped/shredded woody material stored in hoppers and slowly fed into the combustion/gasification chamber. FOGO material has high odour risk and is not suited to such storage.
- Air pollution and poor performance associated with high and variable moisture content inputs, and potentially plastic contamination of materials. Highly toxic compounds can be produced if combustion temperatures fall and if chlorinated plastics are present. Emissions control technologies and the management of toxic contaminants extracted from exhaust gases will add greatly to costs and are prohibitively expensive for smaller scaled thermal energy recovery technologies.
- Moisture content reducing the fuel value of inputs. Although food waste can contain higher calorific fats, oils and carbohydrates, the moisture content reduces the fuel value. Some gasification systems can tolerate higher levels of moisture (some as high as 30-60% moisture by weight), but these are typically focused on producing biochar rather than energy, meaning more input would be needed to generate the same amount of usable energy as thermal units focused on energy recovery from woody organics.

Therefore, although there is potential to establish a thermal system for the district heating project using woody biomass, it is unlikely to meet GSC's and SGSC's need for a processing facility to manage FOGO materials.

Hamilton aquatic centre heating

Another potential small-scale bio-energy project is heating the Hamilton aquatic centre. The issues associated with this option are similar to the Portland district heating option. The site is not suited to an AD facility, so the only practicable option is a woody biomass unit. The site currently uses an estimated 980 GJ of gas and 3,420 GJ of electricity per year. Fully replacing this with a combined heat and power (CHP) gasification unit would require at least 340 tonnes of woody biomass per year (assuming a yield of 10 GJ per tonne for power). There would likely be excess heat energy. This could potentially use some drop-off garden and timber organics, but would not be suited to FOGO or commercial food or PIW organics due to odour, performance and air pollution risks. This means the facility would not meet the objective of processing FOGO materials.

The availability of suitable timber waste for such a facility is uncertain. It may be possible to source forestry bio-mass material for free, but the site will be unlikely to attract woody waste if a gate fee is charged. It is even possible that such a facility will need to pay for suitable material to cover freight and any pre-processing costs.

Similar projects have been undertaken at Beaufort Victoria and Mount Gambier SA, with expected payback periods of 8-12 years at current natural gas prices.

Although this may be a potential bioenergy project, it is not considered further because it does not meet the objective of managing FOGO materials. Wet FOGO and even GO wastes are not well suited to such bio-energy projects which typically use chipped woody waste with less than 20-30% moisture stored in a hopper. Wet FOGO and GO material will have too high a moisture content, and will pose odour and self-heating/combustion risks in storage hoppers. However, this technology might be considered to treat drop-off garden and timber organics with forestry wastes if a 'wet' AD facility is developed to process FOGO and other organics.

The following pages show pictures of some of the units reviewed.

HotRot in-vessel composting

Source: http://www.hotrotsolutions.com/pages/hotrot-technology

HotRot 3518 composting unit

HotRot 1811 composting unit

HotRot 1206 composting unit

AnaeCo

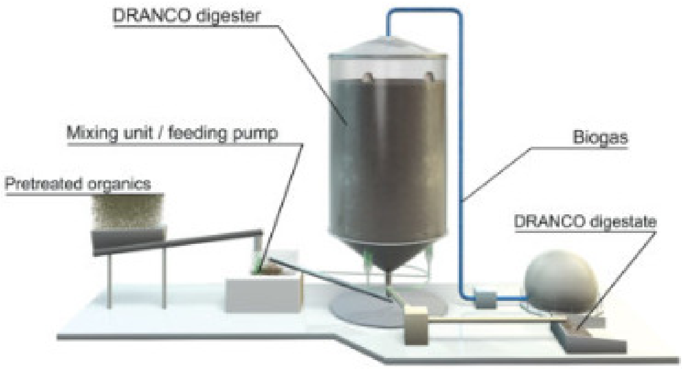
DiCOM bioconversion facility

Source: *http://www.anaeco.com/dicom-bioconversion-facility*

Organic Waste Systems (OWS)

Dranco

Source: *http://www.ows.be/household_waste/dranco/*



Bioferm Energy Systems

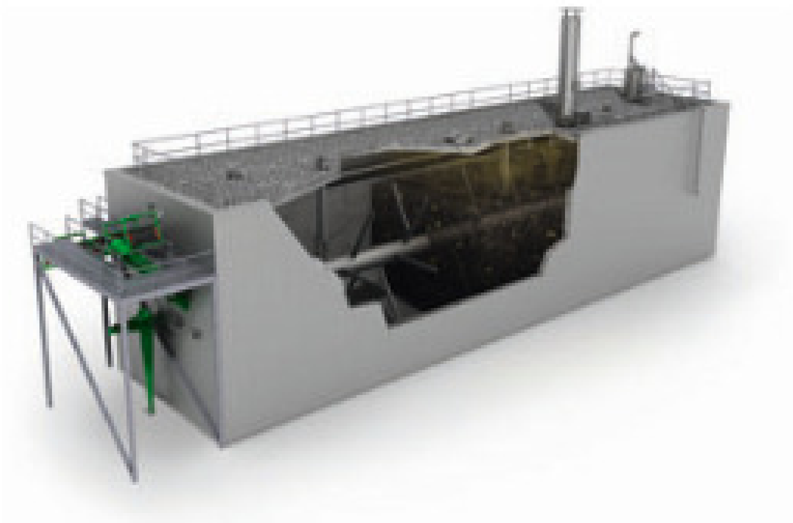
EUCOlino

Source: *http://www.biofermenergy.com/anaerobic-digestion-technology/eucolino_small-scale-digester/*

Hitachi Zosen INOVA

Kompogas Digester

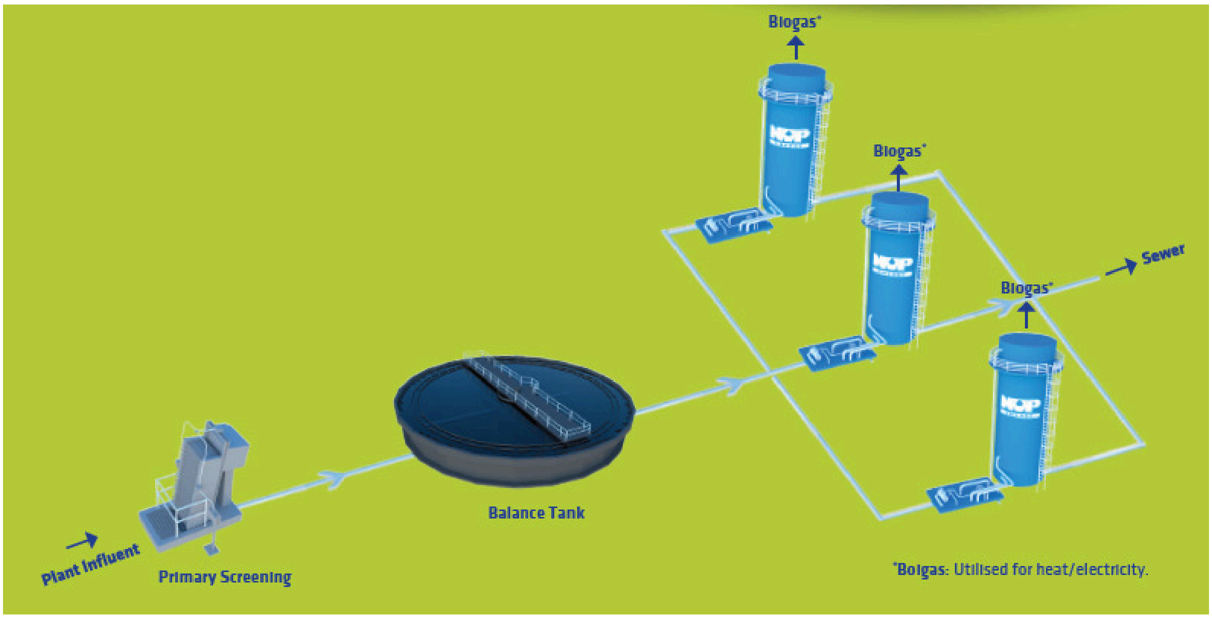
Source: *http://www.hz-inova.com/cms/en/home?page_id=256*



NVP Energy

Lt-AD

Source: NVP Energy Brochure



Zero Waste Energy

SMARTFERM

Source: *http://zerowasteenergy.com/our-solutions/dry-anaerobic-digestion/*

Anaerobic digestor

Living Energy

Binder Boiler

Source: *http://www.mountgambier.sa.gov.au/webdata/resources/files/Case%20Study-Mount%20Gambier%20Aquatic%20Centre%20Biomass%20Boiler.pdf*

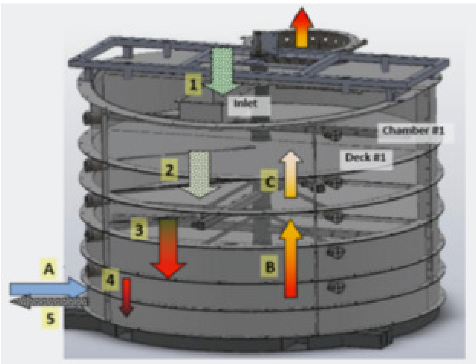
Hargassner Boiler

Source: http://www.livingenergy.co.nz/product/11/hargassner-boilers/29/hsv-25-55kw-chip-boiler.aspx

Pyrocal

BIG CHAR Continuous Carbonisation Technology (BIG CHAR CCT)

Source: http://www.bigchar.com.au/technology/big-char-technology.html

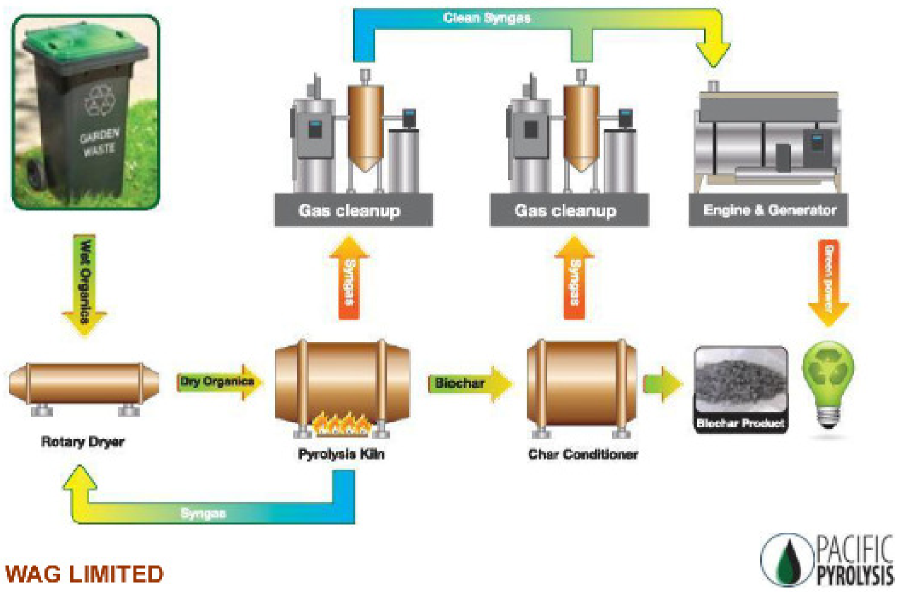


Pacific Pyrolysis

Source: http://pacificpyrolysis.com/technology.html

Slow pyrolysis demonstration facility

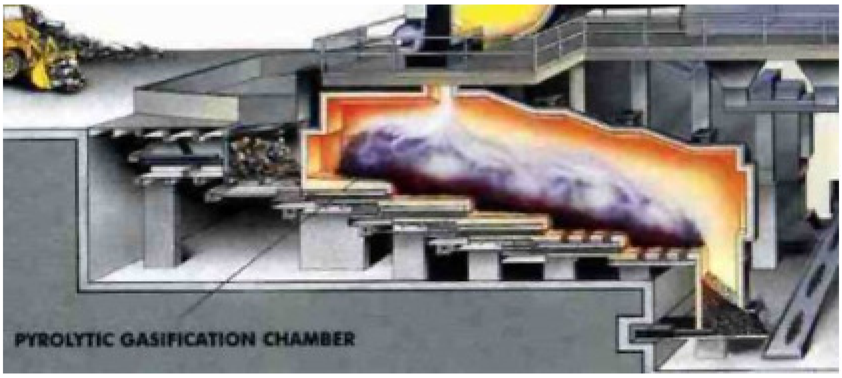
Slow pyrolysis process flow diagram

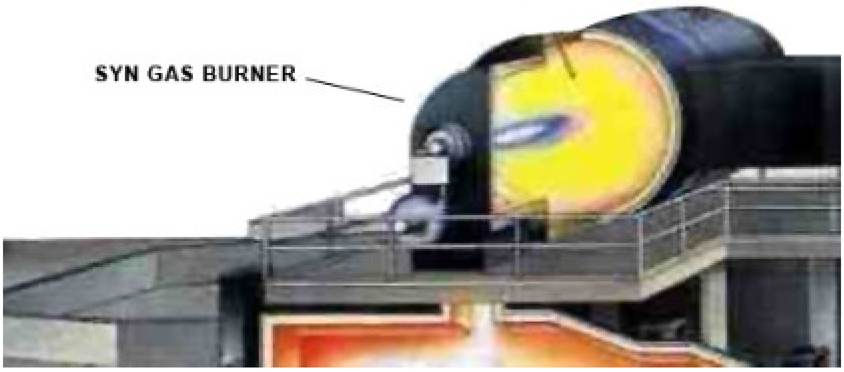


New Energy Corporation

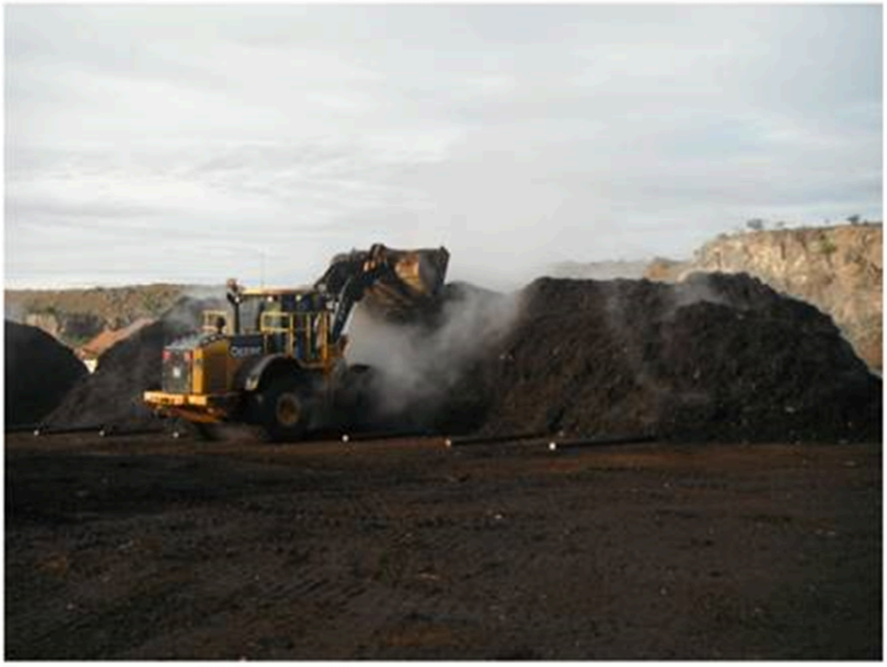
WtGas

Source: *http://www.entech-res.com/wtgas/*





Uncovered aerated composting (MAF)



Covered aerated composting (GORE)

Aerated covered bays (Spartel)

In vessel composting systems

Invessel composting system showing aerated floor and loading of material

Appendix D: Quantification of available organics

This appendix details estimates of biomass available within the Shires and surrounding areas.

Table A20 shows employment within the two Shires.

Table A20: Employment by sectors for Glenelg and Southern Grampians Shire Councils

Industry sector	Glenelg		Southern Grampians	
	Number	% of all employment	Number	% of all employment
Accommodation and Food Services	548	7.3	495	6.4
Administrative and Support Services	125	1.7	125	1.6
Agriculture, Forestry and Fishing	969	12.9	1,447	18.7
Arts and Recreation Services	96	1.3	46	0.6
Construction	418	5.6	541	7.0
Education and Training	549	7.3	617	8.0
Electricity, Gas, Water and Waste Services	62	0.8	47	0.6
Financial and Insurance Services	88	1.2	137	1.8
Health Care and Social Assistance	994	13.2	1,107	14.3
Inadequately described or not stated	64	0.9	185	2.4
Information Media and Telecommunications	41	0.5	98	1.3
Manufacturing	1,346	17.9	401	5.2
Mining	3	0.0	162	2.1
Other Services	236	3.1	237	3.1
Professional, Scientific and Technical Services	186	2.5	236	3.1
Public Administration and Safety	386	5.1	488	6.3
Rental, Hiring and Real Estate Services	73	1.0	46	0.6
Retail Trade	776	10.3	783	10.1
Transport, Postal and Warehousing	389	5.2	276	3.6
Wholesale trade	166	2.2	260	3.4
TOTAL	**7,515**	**100.0**	**7,734**	**100**

Source: ABS 2011 Census data

The available data are not adequate to accurately estimate the quantities of food waste available, but major individual sources are likely to include:

- Food retailing businesses
- Accommodation, food services and hospitality venues
- Food manufacturing businesses
- Portland Aluminium staff and food areas
- Health services and aged care facilities

Previous estimates of landfilled commercial and industrial and construction and demolition wastes suggest the following typical composition (see Table A21). This suggests that about 24% of recoverable food and garden, and 14% of timber could potentially be recovered from landfilled C&I waste along with potentially some biodegradable textiles and other organics. C&D waste typically contains some timber and garden waste, but anecdotally most of this material is managed by pathways other than landfill.

Table A21: Typical composition of landfilled Commercial and Industrial (C&I) and Construction and Demolition (C&D) waste (% by weight)

Material	C&I (% by weight)	C&D (% by weight)
Paper/cardboard	18.8%	0.8%
Food waste	17.1%	0.0%
Garden waste	7.0%	2.7%
Wood/timber	13.0%	11.8%
Textiles	6.5%	1.3%
Other organic	0.4%	0.0%
Other/non-organics	37.2%	83.4%
Total	**100.0%**	**100.0%**

Source: Source: http://www.environment.gov.au/protection/national-waste-policy/publications/waste-generation-and-resource-recovery-australia-report-and-data-workbooks

Port of Portland

Port of Portland has several tenants generating biomass waste that could be suited to energy or composting facilities. Details of this biomass waste are provided in Table A22. The tenants generating these wastes have different ways of managing/disposing of the waste. Most of those consulted by Blue Environment expressed interest in alternative methods of disposal if this reduced costs. However, such materials are only likely to be available if a processing facility was prepared to pay for them to cover freight costs at least. These materials may be suited to a thermal bioenergy facility, or a composting facility either needing woody biomass to process wetter FOGO, food, sludge, or grease trap waste, or with strong markets for compost volume.

Table A22: Other potential sources of biomass – Port of Portland

Source	Types of waste	Estimated quantity	Security of supply	Where materials currently go:
Australian Bluegum Plantations	Wood fines	1,000 tonnes per year	Low	BioGro
Finwaste South West	Garden waste (mixed with commingled waste)	10 tonnes per year	Low	Landfill
GrainCorp	Grain waste	Up to 30,000 tonnes per year	Medium	Local farms
	Waste woodchips/timber/ bark	600-1,200 tonnes per month, or 7,200-14,400 tonnes per year	Low	BioGro
OneFortyOne Plantations	Bark and fibre	Uncertain. Anecdotally is in the order of 2,000-4,000	Medium	Stockpile and give/sell local farms. Sometimes

Source	Types of waste	Estimated quantity	Security of supply	Where materials currently go:
		tonnes per year. Mainly bark, with some woody waste.		BioGro.
South West Fibre	Tub ground bark and other wood fines	12,000 t (on site) (3,000-4,000 tonnes per year). A combination of bark and woody material.	Medium	Stockpile and local farms. Formerly taken by BioGro
TOTAL		**43,210-53,410 tonnes per year**		

Other organics/biomass

There are other sources of forestry and agricultural biomass within the region. These are by-products and are not conventionally 'wastes' in that no cost is associated with disposing of them. Forestry biomass mainly includes barks from debarking and woody waste from thinning and removing lower branches in plantations. These often have market value as an input into commercial composting operations or as a source of wood chip when prices are higher. These materials are suited to thermal energy recovery or as a source of woody waste for composting of wet wastes.

The main agricultural biomass from the area is likely to include dairy shed and yard wastes, some crop residues/stubbles, and spoilt fodder (mouldering hay).

Glenelg and Southern Grampians are major areas for fodder production and consumption. The Western District (Glenelg and Southern Grampians along with Moyne, Corangamite and Warrnambool, produce 500-60 kilotonnes (kt) per year of pasture, lucerne and other fodder crops and a further 500kt per year of silage. Glenelg and Southern Grampians are the most intensively productive areas and it is likely they are responsible for over half of this fodder production. Fodder from northern Victoria and other areas is also imported into the area (RIRDC, 2009) for feedstock. Assuming fodder production and consumption from the two shires of 200-300kt per year, and spoilage losses of 1-5%, there could be in the order of 2,000-15,000 tonnes per year of spoilt fodder available within the shires. Such materials are typically distributed across farms and would be hard to collect. However, a future energy recovery facility willing to pay for such material may be able to attract some of it.

ABS data for cropped areas are shown in Table A23, along with estimates of grain bunker waste and cropping residue (stubbles) available. This suggests 1-2kt of grain bunker waste and 52.5-210kt of stubble could be produced within the two shires each year. Note that stubbles are sometimes cut as hay and so may be included in fodder estimates. As with spoilt fodder, grain and stubble residues are distributed over farms and any future energy facility would need to pay farmers to harvest and freight biomass to the facility.

Another source of organics/biomass could be from the potential development of a proposed meat processing facility at Hamilton by the Australian Meat Farmers (AMF).

Table A23: Estimates of crop residue biomass from cropping for Glenelg and Southern Grampians Shires

	Area of crop (ha/year)[1]		Grain Yield		Non-grain (Oilseed)yield		Estimated bunker/storage losses		Estimated crop residue (includes stubbles harvested as straw)	
Municipality	Grain	Non-grain	Low	High	Low	High	Low	high	Low	High
			2t/ha	4t/ha	1t/ha	2t/ha	1% by weight		1 t/ha	4 t/ha
Glenelg	20,670	6,360	41,340	82,680	6,360	12,720	477	954	27,030	108,120
Southern Grampians	19,810	5,620	39,620	79,240	5,620	11,240	452	905	25,430	101,720
TOTAL	**40,480**	**11,980**	**80,960**	**161,920**	**11,980**	**23,960**	**930**	**1,860**	**52,460**	**209,840**

1 Source ABS National Regional profile data – area under crops

Biomass from other areas

The economies of scale and viability of an organics processing facility will be improved if the facility can attract gate fee income for receiving organic waste from other sources. An analysis of facility costs suggest optimal economies of scale are not achieved until facilities exceed 20,000 tonnes per year.

It is strongly recommended that GSC and SGSC seek to attract organics from other municipalities and other sources to generate gate fee revenue and improve the economies of scale of a shared facility.

Blue Environment consulted waste service businesses and other potential sources of waste within the likely catchment of any shared organic facility. This work has found the following:

- There is potential to attract organics from Moyne and possibly Warrnambool. Moyne currently has a regular kerbside FOGO service collecting in the order of 1,380 tonnes of organics per year from 4,350 premises. Warrnambool does not currently offer a regular kerbside organics service. A private operator provides a FOGO service with limited uptake and another operator provides a resource recovery centre organics drop off service. However, Warrnambool City Council may consider introducing a FOGO service in the medium-term future. This could yield between 1,900 to 5,200 tonnes of kerbside collected FOGO materials per year depending on the type of system introduced and per household yield of organics.
- There is limited potential to attract organics from neighbouring councils to the north of the study area. Horsham, Northern Grampians and Ararat are not expected to introduce a regular kerbside organics collection service in the short to medium term, and have small scale resource recovery centre drop off operations with local 'markets'/outlets for the recovery of organics. They are unlikely to want to pay a gate fee for the processing of organics or freight costs to deliver materials to a shared south-west facility.
- Corangamite Shire is considering development of a regional organics processing site at Naroghid landfill – this is potentially a competitor for organics from Moyne and Warrnambool, as well as councils to their east.
- City of Greater Geelong currently manages in the order of 30,000 tonnes per year of kerbside collected and drop off garden organics through a combination of on-farm composting, commercial composting and 'rehabilitation' projects. This involves a manual pre-cleaning and

shredding of organics, with some materials being delivered to farms where materials are composted under the supervision of a contractor, Camperdown Compost (also trading as Geelong Compost). Other materials are composted by Camperdown Compost Company. The City of Greater Geelong is looking to develop a composting facility.

- City of Ballarat is introducing a garden waste only kerbside collection service, with a preferred processing contractor, Pinegro, which is developing a composting facility at Mount Wallace near Ballan.
- Mount Gambier provides a garden collection service and intends to expand this to a full FOGO service. Materials are processed at BioGro/van Schaiks near Mount Gambier, at a very competitive rate ($35-$45 per tonne). This material is unlikely to be available to a shared south west facility.
- Limestone Coast councils are currently undertaking a biomass mapping exercise, with a view to developing bioenergy projects based mainly around forestry/plantation industry biomass, but also including municipal and commercial organics and other primary industry biomass residues. They could potentially receive biomass from Victoria, although there are AQIS restrictions on the movement of plant matter from Victoria into South Australia due to the risk of myrtle rust. Victoria is a declared area for this plant disease, even though no incidents of myrtle rust have been reported in the south west.

Appendix E: Review of siting requirements

This appendix considers planning and environment requirements for organics processing facilities. It also considers other issues impacting on the suitability of sites for different types of facilities.

Policy & regulatory background

State regulations

In Victoria, nationally and internationally, some organics processing facilities have historically caused significant odour issues. As a result, EPA requires strict odour management at facilities. These include technical controls (such as enclosed or 'controlled' systems with air capture and treatment) and appropriate separation distances depending on the scale of facilities and the odour risk potential of materials received.

Under the *Environment Protection (Scheduled Premises and Exemptions) Regulations 2007,* an organics processing facility processing more than 100 tonnes of waste per month, or a waste to energy facility generating more than 1MW of power will require a works approval and licence.

Composting facilities

The required separation distance has important implications for the siting of an organics processing facility.

EPA's *Designing, constructing and operating composting facilities* (EPA Publication No. 1588) provides guidance on the separation distances required for composting sites. The separation distance is defined as the space between the composting facility and any sensitive land uses (such as residential dwellings, hospitals, schools, caravan parks, etc.). The separation distance commences from the area of operations rather than the premises boundary.

The EPA guideline classifies wastes according to odour risk, and provides indicative threshold distances for different scaled facilities, feedstock types and technologies used. Wastes are classified according to odour risk potential, with recommended technology requirements for the different classifications (outlined in Figure A1). This shows FOGO and grease trap wastes are classified as grade 3 materials with an enclosed or covered composting technology being recommended.

The EPA Guideline is not specific about separation distances, but recommends distances of >1,100m for a facility receiving up to 14,000 tonnes per year of green waste only and using an open-air environment, turned windrow composting and open maturation. A facility of 14,000 tonnes per year and processing Grade 3 feedstock but using aeration with air control and treatment requires only >500m separation distance. The EPA guide also recommends a separation distance of >600m for a 1,200 tonne per year facility receiving green waste only. According to the guide, composting facilities should be located at least 100m from surface waters.

It can be expected that a facility receiving 5,000-10,000 tonnes per year of garden, FOGO and commercial organics including grease trap will be required to have some form of controlled primary composting system and a separation distance of at least 500m. A separation distance of 500-1,000m is suggested by Blue Environment, given the experience of other small scale facilities processing grease trap waste (such as now closed facilities at Ballan and Kyneton that experienced significant odour issues using turned windrow composting of green and grease trap waste – both closed following EPA and council action due to on-going odour issues).

A case could be made to EPA for open-air management of materials using either uncovered aerated windrows or well-managed turned windrows with separation distances of 1,000-1,500m. It should be noted that larger scale composting facilities, including Jefferies in SA that receive similar materials operate using uncovered aerated composts with separation distances of 1,500m without significant odour issues. A Research, Development and Demonstration (RD&D) approval is likely to be required from EPA to get such an option approved. An RD&D permits a limited period trial of a technology to demonstrate compliance with best practice before a longer-lasting works approval and licence can be sought.

Figure A1 EPA classification of organic inputs and recommendations for minimum processing requirements

Category	Risk level	Waste types	Definitions and examples
1	Lowest	Garden and landscaping organics	Grass, leaves, plants, branches, tree trunks and tree stumps
		Untreated timber	Sawdust, shavings, timber offcuts, crates, pallets, wood packaging
		Natural organic fibrous organics	Peat, seed hulls/husks, straw, bagasse and other natural organic fibrous organics
2	Medium	Municipal source separated kerbside garden waste	Grass, leaves, plants, branches, tree trunks and tree stumps
		Biosolids and aged manure	Biosolids that meet treatment grades T1 to T3[5]. Aged manure that has a dry matter greater than 35%
3	Medium to high	Dewatered sewage sludge and fresh manures	Dewatered sewage sludge (does not meet the T1 to T3 standards), animal manure and mixtures of animal manure and animal bedding organics
		Other natural or processed vegetable organics	Vegetables, fruits and seeds and processing wastes, winery, brewery and distillery wastes, food organics excluding organics in category 4
		Mixed source separated kerbside (Garden waste/food waste - FOGO)	Grass, leaves, plants, branches, tree trunks and stumps, vegetables, fruit and meat
		Grease interceptor trap wastes	Grease trap waste with less than 10% solids
4	Highest	Liquid organic wastes (excluding grease interceptor trap waste with less than 10% solids)	Liquid food waste and liquid food processing wastes (including sludges), liquid animal wastes (blood) and paunch (sludge), grease trap with greater than 10% solids
		Meat, fish and fatty foods	Animal mortalities, parts of carcasses, bone, fish and fatty processing or food

Feedstock category	Recommended technology requirements		
	Open environment	Enclosed or covered environment	Enclosed with secondary odour control
1: Lowest potential risk of harm to human health and the environment	Yes	Yes	Yes
2: Medium potential risk of harm to human health and the environment	Yes	Yes	Yes
3: Medium to high potential risk of harm to human health and environment	No	Yes	Yes
4: Highest potential risk of harm to human health and the environment	No	No	Yes

It is recommended GSC and SGSC seek RD&D approval to trial open-air (turned windrow or uncovered aeration) management of a 5,000 tonne per year scale operation processing FOGO, and potentially some SIW and PIW organics.

Energy from waste (EfW) facilities

EPA's 2013 *Recommended Separation distances for Industrial Residual Air Emissions* has recommended separation distances for industrial air emissions relevant to EfW facilities and other processing activities. For abattoir processing works above 200 tonnes per year a 500m separation distance is required. Facilities processing less than 200 tonnes per year have no specified separation distance. However, EPA still recommends that any dust or odour emissions should not be detectable beyond the boundaries of the premises.

For EfW facilities, the guide indicates that requirements for separation distances would vary case-by-case. Emissions would need to comply with the *State Environment Protection Policy* for air, separation distances If exhaust stacks are required, stack heights would need to be comply with EPA standards. In addition, if a facility is receiving garden and putrescible organics, separation distances similar to a similar sized enclosed composting facility may be required.

The Victorian Planning Provisions also provide recommended separation distances. These are outlined in Table A24.

Table A24: Victorian Planning Provisions recommended separation distances

Type of production use or storage (purpose)	Threshold distance (m)
Abattoir	500
Seafood processor	500
Treatment of organic waste	Determined by EPA on site-specific basis
Waste incinerator:	
• for wood waste	300
• for plastic or rubber waste	500
• for chemical, biomedical or organic waste	Determined by EPA on site-specific basis

The *Environment Protection (Industrial Waste Resource) Regulations 2009* set out requirements for transport and management of industrial waste; these provisions may apply to a proposed EfW facility, subject to the type of feedstock utilised.

Other guidelines

EPA Victoria developed the 2013 Energy from Waste guideline which provides industry, government and the community direction on the expectations and requirements for siting, designing, constructing and operating an EfW facility.

Further guidance is provided in Sustainability Victoria's *Guide to Best Practice for Organics Recovery* (Sustainability Victoria 2009). This guide outlines best practice in planning, design, process technologies, operation, management, products and markets for recovered organic waste.

WorkSafe Victoria also has guidelines around collection, transport and handling of waste which would also be relevant to the operation of an EfW facility.

Electricity and gas supply and distribution

Responsibility for the economic regulation of Victoria's electricity and gas distribution networks was formally transferred from the Essential Services Commission (ESC) to the Australian Energy Regulator (AER) in 2009. However, electricity distribution businesses operating in Victoria must still hold a licence issued by the ESC.

The electricity supply chain consists of generators who produce power, distributors who provide the transmission networks, and retailers who buy electricity and package it with transmission and distribution service costs for sale to residential, commercial and industrial customers. Retailers also provide billing and price risk management services to end-use customers. The AER is responsible for regulating retailer licensing and authorisations in the National Energy Market.

The current systems create challenges for smaller 'distributed energy' or 'local' generators hoping to export power off site. These include:

- Connecting lower voltage and DC (direct current) power to the grid. The grid has historically been designed to distribute high voltage AC (alternating current) power from major suppliers. Most bio-energy projects would generate AC power, but grid connection may be problematic as upgrades of terminal substations may be required to cater for power being fed into the grid within the area.
- Maintaining consistent quantity and 'quality' of power. Inconsistent supply risks 'tripping' systems causing localised blackouts.
- Cleaning bio-gas before distribution to the gas network. If biogas were to be sold back into the gas distribution network, it would need to be cleaned to meet natural gas standards. This requires scrubbing equipment to remove carbon dioxide and other trace 'contaminants' and pressurising gas so that it can safely be fed into the network. The costs of such equipment are currently prohibitive at the likely scale of operation of any shared Anaerobic Digestion (AD) facility.
- Complying with regulatory requirements.
- Low tariffs and a requirement to sell power into the grid in most instances.
- Regulation of off-grid /'over the fence' distribution.
- Inconsistent 'peak demand' for spot selling in South West Victoria.

The technology providers consulted as part of this project consistently suggested energy recovery facilities needed to be at a larger scale (more than 25,000-50,000 tonnes of biomass per year) to be worth considering grid connection or bio-gas distribution to the gas network. They suggested that smaller scale units would only be viable if there was local need for heat or combined heat and power which could use heat and potentially power without a grid connection. This implies co-location of an organic processing facility with the user of heat or heat and power. Direct title-to-title connections (i.e. power connections across title boundaries that are directly shared) are possible, but any connection across a public easement or private title typically requires a grid connection and distribution of the power to the grid.

The Victorian Government is working to address barriers to distributed energy and community energy projects, including simplifying energy licencing agreements and improving the capacity of the grid to allow connection by distributed energy projects.

Appendix F: Assessment of potential sites for future organics processing facilities

Appendix F provides the following assessment of potential sites for future organics processing facilities and evaluates eight locations that were nominated by GSC and SGSC as potential sites for establishing an organics processing facility. These were:

- Hamilton landfill precinct
- Australian Meat Farmers, Hamilton (proposed)
- Wannon Water, Hamilton
- Hamilton Aerodrome
- Heywood transfer station
- Branxholme transfer station
- Portland transfer station
- Henty Park (Portland district heating precinct).

The suitability of each site was assessed on:

- land zoning
- overlays (designated bushfire prone areas, heritage, land subject to inundation and vegetation protection, and other overlays relevant to the permitted use of the land)
- separation distances from sensitive receptors.

Hamilton landfill precinct

Hamilton landfill is located on Elijah Street, Hamilton. There is a small parcel of land south of the landfill site that is owned by Council that may be suited to the establishment of a facility. The area covers about 280m^2, and would require little earthworks and tree clearing. Figure A2 shows the potential location of the site in green with separation distances radiating from the possible centre of activity (at 200m, 500m, 1,000m, 1,500m away).

Figure A2: Aerial photograph of Hamilton landfill precinct showing separation distances at 200m, 500m, 1,000m and 1,500m

Zoning

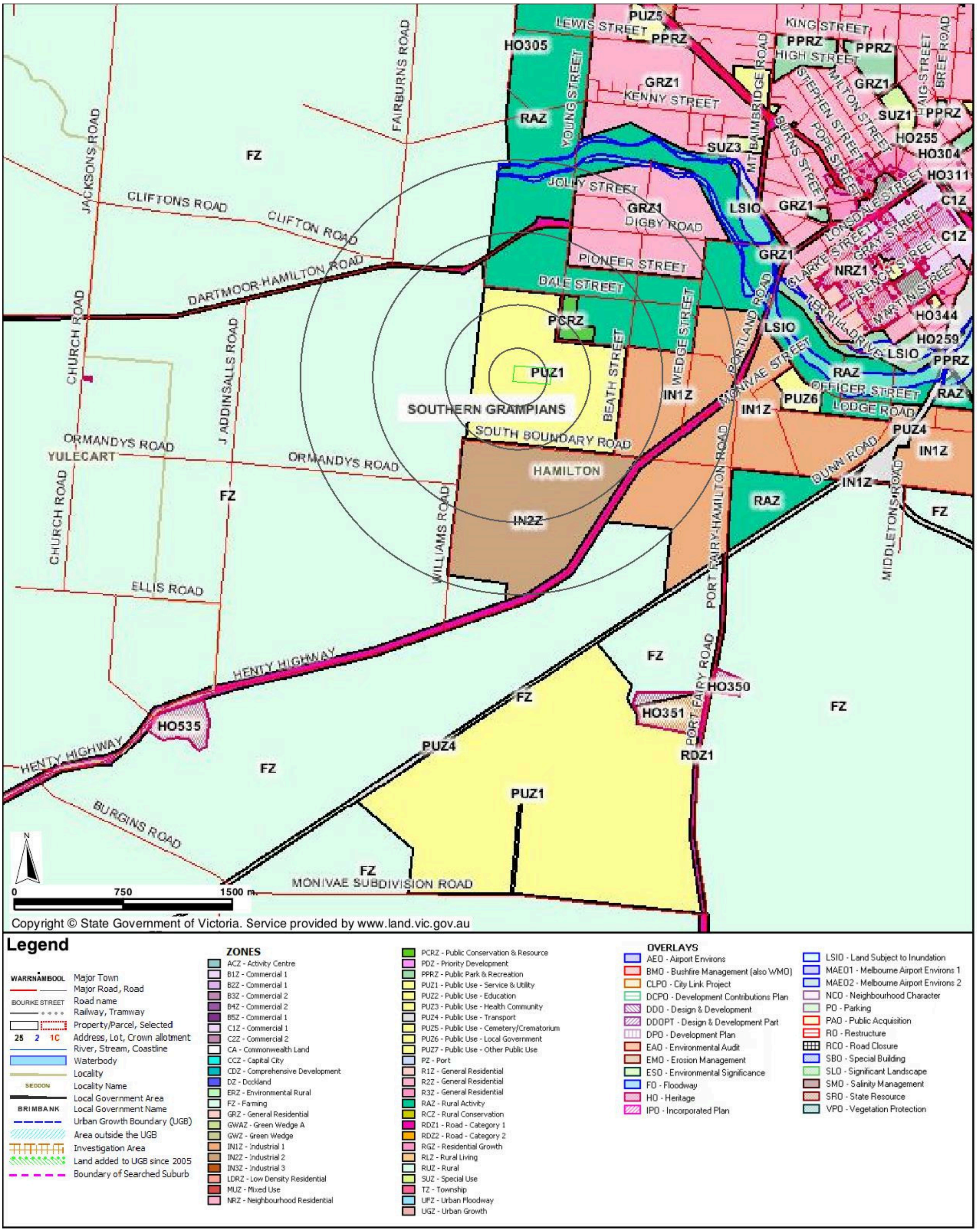
The landfill site is zoned as Public Use – Service and Utility (PUZ1) as shown in Figure A3. This zone requires a permit for industry type use (for material recycling, resource recovery centre, refuse disposal).

Other zones present in the vicinity are:

- Public Conservation & Resource Zone (PCRZ) to the northeast
- Rural Activity Zone (RAZ) to the north
- Industrial 1 Zone (IN1Z) to the east
- Industrial 2 Zone (IN2Z) to the south

- Farming Zone (FZ) to the west.

Figure A3: Zoning of Hamilton landfill precinct and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Overlays

The site (as well as surrounding land, excluding the township of Hamilton) has a designated bushfire prone areas overlay and requires fire management assessment and planning.

Note: the site is not affected by land subject to inundation, vegetation protection or heritage overlays.

Separation distances

The nearest sensitive use zone is General Residential Zone 1 (GRZ1) located within 1,000m to the north.

This site may be suited to a composting facility that has more controlled systems (aerated covered systems). Access to water to manage fires in compost and to avoid fire risk from compost would be needed as well as road access to the site.

This site has sufficient separation distance to establish a facility of up to 14,000 tonnes per year receiving FOGO and other grade 3 and 4 wastes using controlled air composting. The presence of the landfill, wastewater treatment plant, stockyards, and the proposed AMF meat processing plant could result in stricter requirements on enclosed receival areas. Odour modelling will almost certainly be required for this site. MAF, GORE, Spartel or WCT type systems could be considered.

Australian Meat Farmers, Hamilton

The AMF meat works will generate waste and wastewater that needs treatment. There is potential to co-locate a municipal organics facility at or near the site.

There several options available for the development of an organics processing facility at the site.

Site option 1

There is potential for an organics processing facility to be established along the road north east of the proposed meat processing facility as shown in Figure A4. This site has an area of approximately 680m^2. The site has no building facilities at present and would likely need utilities to be installed.

Zoning

The site identified above is zoned as an Industrial 2 Zone (IN2Z). Other zones adjacent to the site are Public Use Zone 1 (PUZ1), Farming Zone (FZ), Industrial 1 Zone (INZ1), Public Conservation & Resource Zone (PCRZ) and Rural Activity Zone (RAZ). Zoning of the site and surrounding areas is shown in Figure A5.

Overlays

This site has a designated bushfire prone area overlay applied to the site and would be subject to special bushfire construction requirements. Heritage, land subject to inundation and heritage overlays do not apply to this site.

There is also a Development Plan Overlay – Schedule 6 (DPO6) across the site. This overlay requires a development plan to be prepared before a planning permit can be issued to the land for industrial uses. All sites to be developed for industrial use also should have reticulated water and sewerage, and serviced sealed roads.

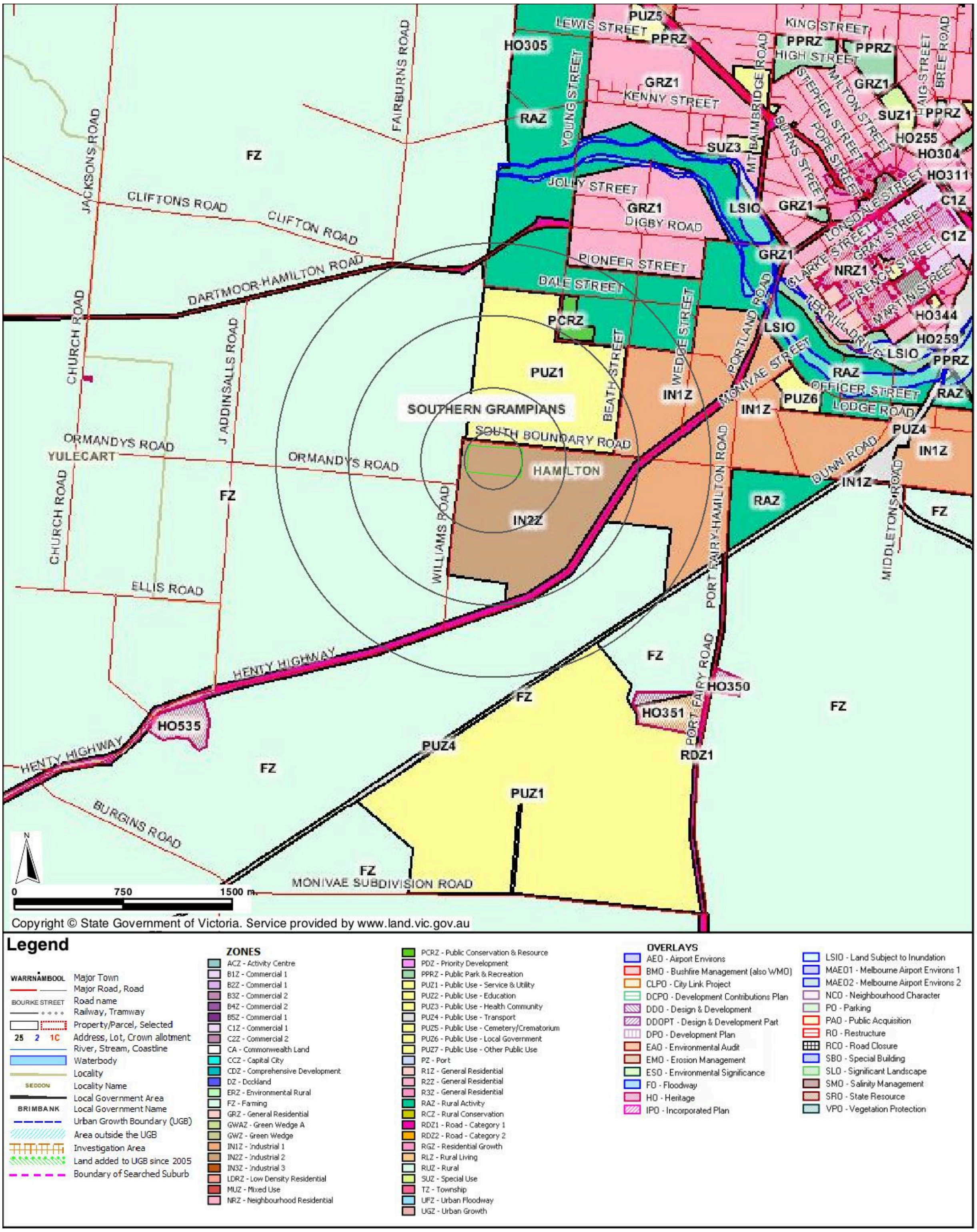
Separation distances

The nearest sensitive receptor is located approximately 1,500m away from the proposed centre of activity. However, there may be some farm houses located within the farming zone that could be affected.

There is opportunity to install an AD system, with heat and potentially power being used at the meat processing facility.

Figure A4: Aerial photograph of the potential site near the meat processing facility (option 1), showing separation distances of up to 200m, 500m, 1,000m, 1,500m from the activity centre.

Figure A5: Zoning of site 1 near the meat processing facility and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Site option 2

This option considers the site being located behind the main factory of the proposed meat processor as shown in Figure A6.

Figure A6: Aerial photograph of the potential site behind the meat processing facility (option 2), showing separation distances of up to 200m, 500m, 1,000m, 1,500m from the activity centre.

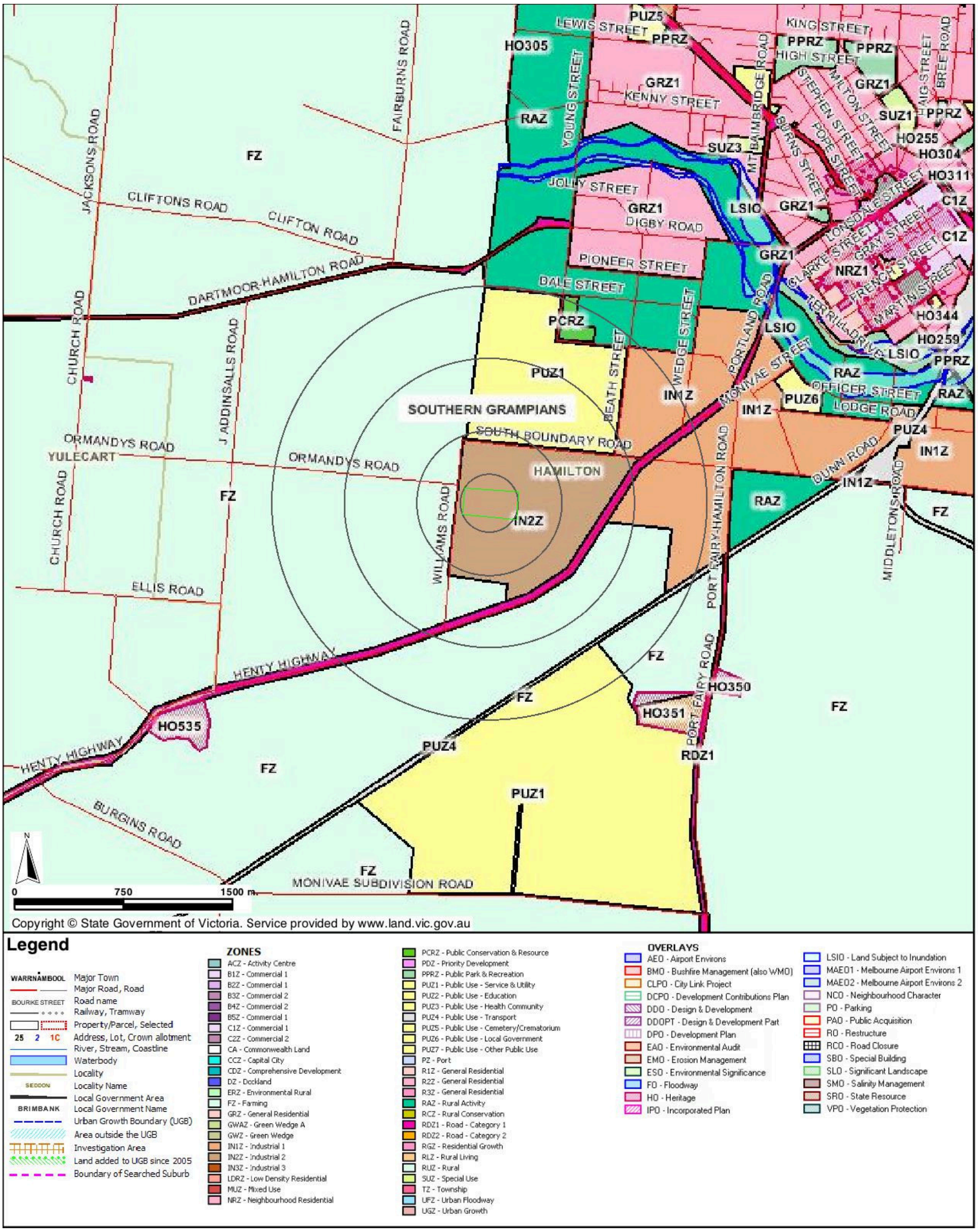
Zoning

Figure A7 shows the location of option 2 remains within the Industrial 2 Zone (IN2Z) and has the same zones surrounding the site as option 1.

Overlay

This site has three overlays applied to the site: designated bushfire prone areas, Development Plan Overlay – Schedule 6 (DPO6) and Aboriginal Cultural Heritage Sensitivity.

Figure A7: Zoning of site 2 behind the meat processing facility and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Separation distances

The nearest sensitive zone (residential zone) is estimated to be 1,700m away from the site. Note there may be some houses within the farming zone in closer proximity to the site that could be affected.

As with option 1, establishing an energy-to-waste facility could provide opportunities for local heating at the meat processing facility. An AD system could be a suitable option.

The site is suited to either an AD or composting site, although AMF's wastewater is more than a composting facility using available municipal organics could process unless a further 40,000 to

50,000 tonnes of garden organics or forestry biomass could be secured. The site could support a hybrid AD facility with windrow composting of solid residuals using drop off garden organics. The presence of the landfill, water treatment plant and stockyards may result in EPA requiring further restrictions on composting. Odour modelling is likely to be required as part of the environmental planning and approvals process.

Wannon Water, Hamilton

This site option, shown in Figure 8A, is located south west of the Hamilton reclamation plant operated by Wannon Water. Approximately 300m^2 of land may be available for an organics facility.

Figure A8: Aerial photograph of Wannon Water site showing separation distances at 200m, 500m, 1,000m and 1,500m

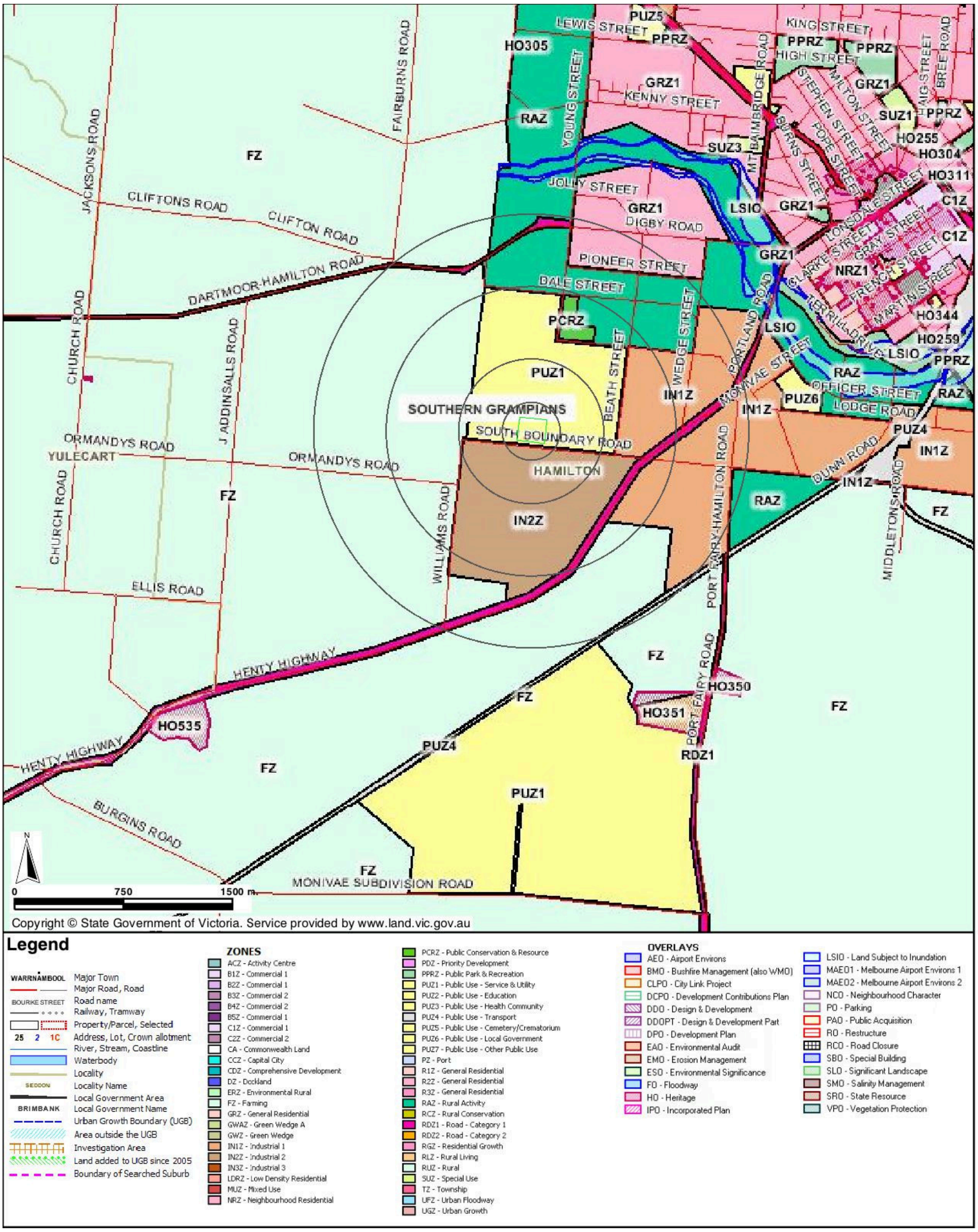
Zoning

This site is zoned as a Public Use – Service & Utility Zone 1 (PUZ1). Zoning of the site and surrounding land is shown in Figure A9.

Overlays

A designated bushfire prone area overlay is applied to this site. Heritage, land subject to inundation and vegetation protection overlays do not apply.

Figure A9: Zoning of Wannon Water site and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Separation distances

This site has 500-1,000m separation distances from sensitive receptors and could only be considered for small-scale composting or controlled environment composting systems. It could be suited to an AD or thermal energy facility.

Hamilton Aerodrome

Figure A10 shows a portion of the land at Hamilton Aerodrome may be a suitable option for a larger scale facility. The site covers approximately 0.3 ha and would require no tree clearing. A composting or thermal system could be established; however, there may be some impacts from odour risk and visual amenity of such a facility next to the airport. Development of the site as a FOGO processing site could restrict other potential developments at the site.

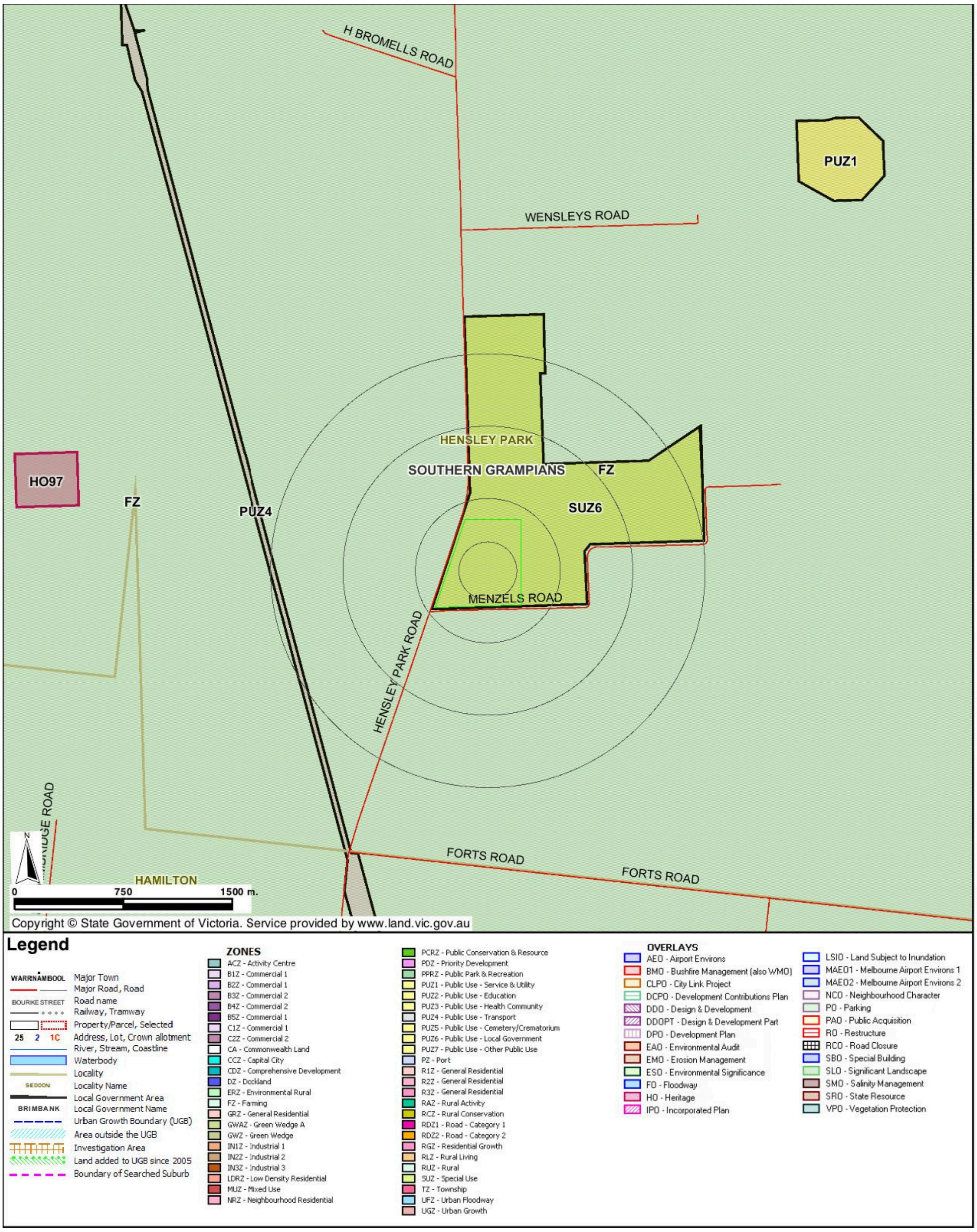
Figure A10: Aerial photograph of Hamilton Aerodrome showing separation distances of 200m, 500m, 1,000m and 1,500m

Zoning

The site is zoned as a Special Use Zone 6 (SUZ6) as shown in Figure A11. According to the *Southern Grampians Planning Scheme* (2015), this zone requires a permit for industry use and "must be generally in accordance with the *Hamilton Airport Master Plan 2011*".

Surrounding land use zones present within a 1,500m separation distance are Farming Zone (FZ) and Public Use Zone 4 (PUZ4).

Figure A11: Zoning of Hamilton aerodrome and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Overlays

The site has a Designated Bushfire Prone Areas overlay, special construction requirements apply. The site has a Design and Development Overlay (DDO4-1) which requires any buildings or works carried out that will be more than one metre above ground level and external materials and finishes are reflective, to have a permit. The site also has both Airport Environs overlay (AEO1 and AEO2) which outlines uses for the land that are permitted. Note that industrial use was not included in those listed as is not being permitted within the zone.

Separation distance

The nearest sensitive receptor is a house located about 1,500m away to the north east.

This site could support a composting facility of up to 14,000 tonnes per year receiving grade 3 and 4 waste with enclosed primary composting with air treatment. The main odour risk is to users of the aerodrome, and any other new businesses developed at the site. It is suggested an enclosed receival area is budgeted for.

The site would be suited to AD or thermal processing systems.

Branxholme former landfill

Branxholme former landfill located on Branxholme-Byaduk Road was inspected and is considered not to be suited due to poor access, small size, uneven filling and steep slope.

Portland transfer station

Portland transfer station is located on Derrill Road, West of Cape Nelson Road in Portland. Figure A12 shows the location of the site at Portland landfill that may be available for establishing an organics facility. The potential site covers an area of approximately 0.1ha with some vegetation along the southern boundary. Note this site would not be suitable for an open organics facility as there are several sensitive receptors (residential properties) nearby. A small, enclosed organics facility might better suited to this site but would have higher costs and still pose odour risks.

Zoning

Figure A13 shows that Portland landfill is zoned as Public Use – Local Government Zone 6 (PUZ6). Other zones surrounding the site are Farming Zone (FZ), Public Park and Recreation Zone (PPRZ), Public Use Zone 5 (PUZ5), Industrial 2 Zone (IN2Z) and Rural Conservation Zone 1 (RCZ1).

Overlays

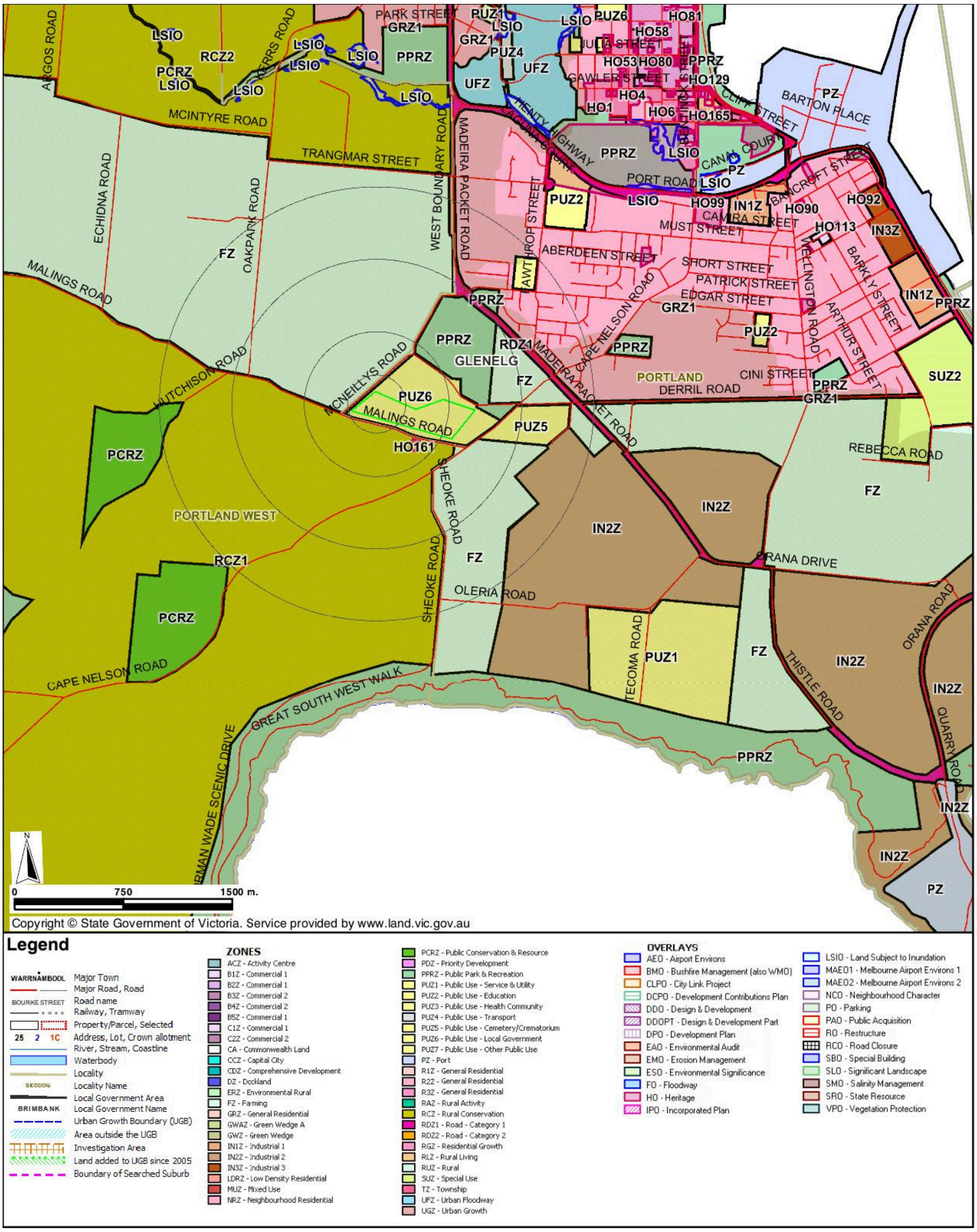
A designated bushfire prone area overlay applies to the site and would be subject to special construction requirements. It is also affected by Aboriginal Cultural Heritage Sensitivity overlay and may require a Cultural Heritage Management Plan.

Separation distances

The nearest residential zone is located 1,000m away but aerial photos show houses within a 500m radius from the site that could be affected. This is unlikely to be a viable site for FOGO composting. Although other areas on the former landfill site are more distant from housing, they are either nearer to recreational areas or contain vegetated area including bandicoot habitat. The site is not considered as an option for future processing.

Figure A12: Aerial photograph of Portland landfill showing separation distance of 200m, 500m, 1,000m and 1,500m

Figure A13: Zoning of Portland landfill and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Heywood transfer station

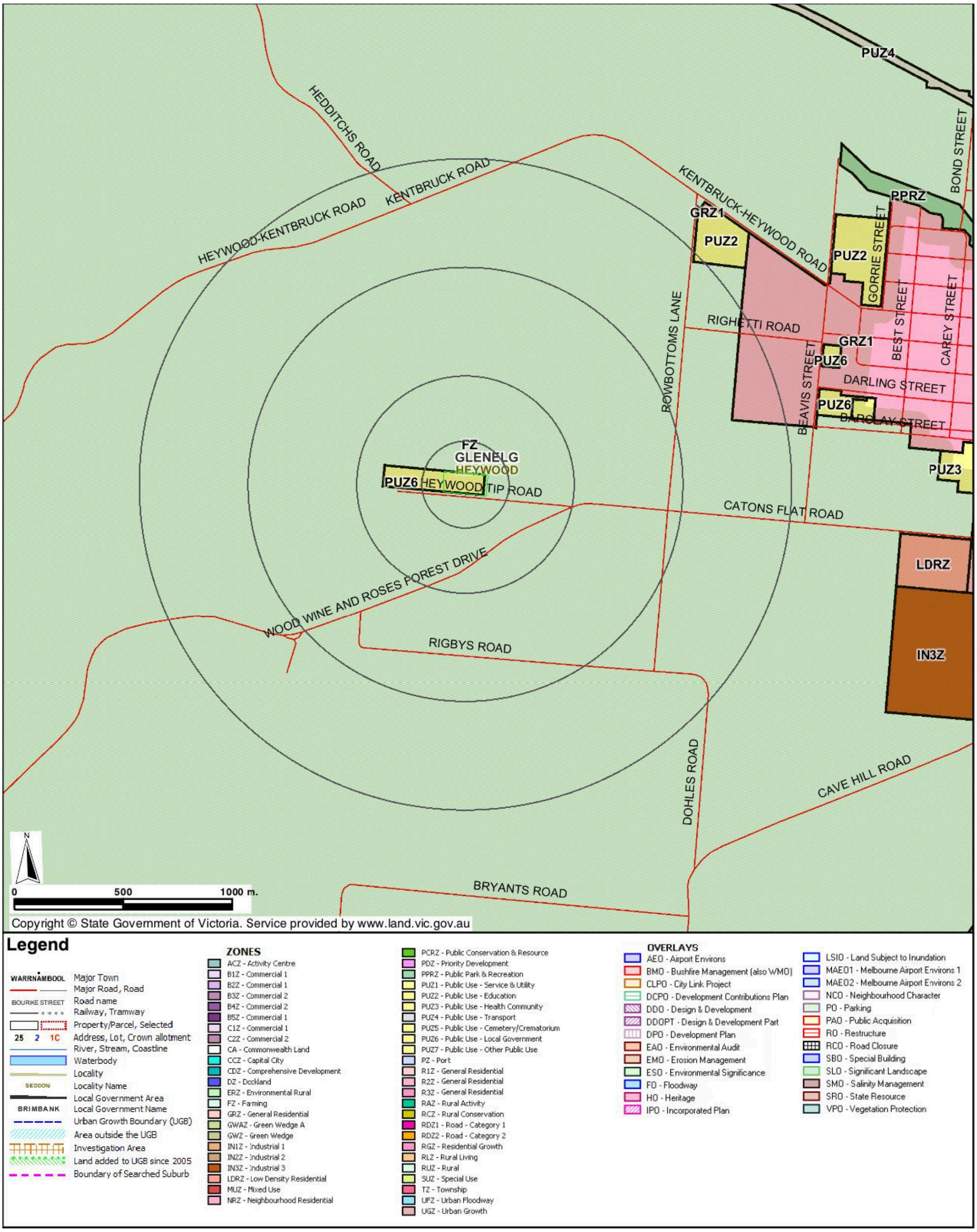
The Heywood transfer station is a former landfill located on Catons Flat Road, Heywood that has 'stockpiles' of dumped C&D. There is a small portion of land (420m^2) on site (Figure A14) that could be used for a smaller scale facility. However, much of the area is vegetated and would require some excavation and tree clearing. The site may have access to power and water but likely no connection to the gas grid. Thermal systems may not be well suited to this site given that there are no major users of heat within 1,500m of the site.

Figure A14: Aerial photograph of Heywood 'tip' showing separation distances of 200m, 500m, 1,000m and 1,500m

Zoning

This site is a Public Use – Local Government Zone (PUZ6) as shown in Figure A15. It is surrounded by mainly Farming Zone (FZ).

Figure A15: Zoning of Heywood 'tip' site and surrounds, showing approximate separation distances of 200m, 500m, 1,000m, 1,500m from the site



Overlays

The site is subject to special bushfire construction requirements as it is located in a bushfire prone area.

Separation distances

There is a residential zone located within approximately 1,300m from the site, and farm house within 500m of the facility.

A case could be made for an up to 5,000 tonnes per year facility using open aeration or turned windrow for FOGO and drop-off organics, but would likely need to be subject to an RD&D to prove this could work before a works approval and licence could be granted.

Portland district heating (Henty Park)

There is an existing heating facility at Henty Park, Portland. This was originally heated using warm geothermal water, and is now heated using natural gas. Both the heating unit and piped-heat infrastructure require replacement.

The location of the site and separation distances are shown in Figure A16.

Figure A16: Aerial photo of Henty Park district heating facility location showing separation distances of 200m,500m, 1,000m, and 1,500m.

The Portland district heating site option would only suite a thermal facility using woody biomass. The site is in a public space near several sensitive receptors and has insufficient separation distances for a composting, AD or a thermal facility processing FOGO material.

Appendix G: Comparative cost analysis of siting options

This appendix provides details of modelling undertaken to compare the costs of the different management options. It considers the relative impact of the different kerbside organics collection systems on organics diversion from landfill and recovery. It also considers the cost impacts of using either individual or shared facilities at Heywood transfer station, Hamilton landfill, or a 'central/equidistant' site located between Portland and Hamilton. Tables A25-A27 show the cost of the different options compared to current landfilling practices.

The kerbside organics recovery systems modelled are:

1. The 'base-case'-current practice.
    - GSC-weekly garbage collection service and no kerbside organics service.
    - SGSC-weekly garbage collections service and an optional FOGO service with low participation rates (about 1,000 households and rising slowly).
2. An Optional fortnightly garden organics collection in both GSC and SGSC (with an increase in participation rate in SGSC).
3. A Compulsory fortnightly garden organics collection in both GSC and SGSC.
4. An optional FOGO service using a fortnightly organics collection and weekly garbage collection.
5. A Compulsory FOGO service using a fortnightly organics collection weekly garbage.
6. A Compulsory weekly FOGO service and fortnightly garbage collection.

Bin lift and depreciation costs

Where organics would be collected fortnightly it is assumed 240L bins are provided and have an average life of 15 years. In Option 6 where organics would be collected weekly, it is assumed the standard bin size would be cheaper 180L or 120L bin and have an average life of 10 years. Also in option 6, a fortnightly collected garbage bin is expected to last for 15 rather than 10 years. These differences account for differences in the estimated annual depreciation costs of bins under different scenarios. The bin lift cost is based on vehicle and driver costs and bin lifts per hour regardless of the bin size and so is a standard for all scenarios.

Findings

The assessment suggests that all FOGO options will result in some net cost increases. This is because even though organics processing costs are likely to be significantly less than landfilling on a per tonne basis, provision of a FOGO service will result in more garden (and some food) organics being disposed to the service than is currently disposed to kerbside garbage bin. This is simply because the FOGO service gives households more bin volume capacity and encourages residents to make use of a more convenient way to 'recycle' garden and food organics. People who avoid placing organics in landfilled garbage for environmental reasons, as well as home gardeners looking for easier ways to get rid of lawn clipping, leaves and prunings will use the service.

Table A25: Assessment of costs of organics recovery systems and processing sites for Glenelg Shire Council

			Base Case	GO Only		FOGO		
			1	Optional 2	Compulsory 3	Optional 4	Compulsory 5	Compulsory – weekly organics, fortnightly garbage and recycling 6
Collection frequency	lifts per year	Organics	0	26	26	26	26	52
		Garbage	52	52	52	52	52	26
Households in served areas			9,550	9,550	9,550	9,550	9,550	9,550
Regular participation rate	% of total	Organics	0%	40%	80%	40%	80%	90%
Number of households regularly using the organics service			-	3,820	7,640	3,820	7,640	8,595
Organics diversion rate per participating household	%	Garden waste	0%	90%	80%	90%	80%	90%
		Food waste	0.0%	0%	0.0%	60%	50%	70%
Expected garden organics diversion per participating household	kg per year		-	37	33	37	33	37
Expected food waste diverted per participating household	kg per year		-	-	-	57	48	67
'Additional' organics collected per additional participating household	kg per year	Garden waste	0	250	200	250	200	250
		Food waste	0	0	0	10	10	15
Total organics diverted per participating household	kg per household per year		0	37	33	94	81	104
Total organics recovered per participating household	kg per household per year		0	287	233	354	291	369
Tonnes organics diverted	tonnes per year		0	141	251	360	616	893
Tonnes organics recovered	tonnes per year		0	1,096	1,779	1,353	2,220	3,170
Expected increase in kerbside recycling	% diversion from kerbside MSW		0%	0%	0%	0%	0%	10%
Kerbside MSW to landfill	tonnes per year		2,900	2,759	2,649	2,540	2,284	1,717
% reduction in landfilled waste	%		0%	5%	9%	12%	21%	41%
Cost assumptions								
Cost per bin lift (90 bins per hour @ $120 per hour)	$ per lift		$1.33	$1.33	$1.33	$1.33	$1.33	$1.33
Deprecation costs of garbage bins	$ per year		$9.26	$9.26	$9.26	$9.26	$9.26	$6.89
Depreciation costs of organics bins	$ per year		$0	$10.68	$10.68	$10.68	$10.68	$9.26
Cost of kitchen caddies. per participating household	$ per household per year		$0	$0	$0	$2	$2	$2
Cost of biobags per year	$ per household per year		$0	$0	$0	$6	$6	$6
Organics processing costs	$ per tonne		$0	$48	$48	$65	$65	$65
Cost to transport to Heywood	$ per tonne		$0	$14	$14	$14	$14	$14
Cost to transport to Hamilton	$ per tonne		$0	$39	$39	$39	$39	$39
Landfill costs (to Stawell)	$ per tonne		$135	$135	$135	$135	$135	$135
Transfer and transport costs to Stawell landfills	$ per tonne		$58	$58	$58	$58	$58	$58
Total landfill costs for MSW (inclusive of transfer, transport and landfill at Stawell)	$ per tonne		$193	$193	$193	$193	$193	$193
Cost calculations								
Collection	$ per year	Organics	$0	$173,240	$346,480	$203,800	$407,600	$744,266
		Garbage	$750,562	$750,562	$750,562	$750,562	$750,562	$396,852
		Total	***$750,562***	***$923,802***	***$1,097,042***	***$954,362***	***$1,158,162***	***$1,141,118***
		Net costs from BAU	***$0***	***$173,240***	***$346,480***	***$203,800***	***$407,600***	***$390,555***
Processing or disposal-Heywood	$ per year	Organics to Heywood	$0	$67,655	$109,794	$106,917	$175,408	$250,453
		Garbage	$560,516	$533,275	$512,087	$490,900	$441,462	$331,937
		Total	***$560,516***	***$600,929***	***$621,881***	***$597,817***	***$616,871***	***$582,391***
Total costs of organics processing at Heywood	$ per year	Organics	$0	$240,895	$456,274	$310,717	$583,009	$994,719
		Garbage	$1,311,078	$1,283,837	$1,262,649	$1,241,462	$1,192,024	$728,789
		Total	***$1,311,078***	***$1,524,731***	***$1,718,923***	***$1,552,179***	***$1,775,033***	***$1,723,508***
		Net costs from BAU	$0	$213,654	$407,846	$241,101	$463,955	$412,430
	%	% Increase	0%	16%	31%	18%	35%	31%
	$ per tonne	Net cost per tonne recovered	$0	$195	$229	$178	$209	$130
	$ per household per year	Net costs per participating household	$0	$56	$53	$63	$61	$48
Processing or disposal costs-Hamilton	$ per year	Organics to Hamilton	$0	$94,779	$153,813	$140,413	$230,362	$328,918
		Garbage	$560,516	$533,275	$512,087	$490,900	$441,462	$331,937
		Total	***$560,516***	***$628,054***	***$665,900***	***$631,313***	***$671,824***	***$660,855***
Total costs of organics processing at Hamilton	$ per year	Organics	$0	$268,019	$500,293	$344,213	$637,962	$1,073,184
		Garbage	$1,311,078	$1,283,837	$1,262,649	$1,241,462	$1,192,024	$728,789
		Total	***$1,311,078***	***$1,551,856***	***$1,762,943***	***$1,585,675***	***$1,829,987***	***$1,801,973***
		Net costs from BAU	***$0***	***$240,778***	***$451,865***	***$274,597***	***$518,909***	***$490,895***
	%	% Increase	0%	18%	34%	21%	40%	37%
	$ per tonne recovered	**Net cost per tonne recovered**	**$0**	**$220**	**$254**	**$203**	**$234**	**$155**
	$ per household per year	**Net costs per participating household**	**$0**	**$63**	**$59**	**$72**	**$68**	**$57**

Table A26: Assessment of costs of organics recovery systems and processing sites for Southern Grampians Shire Council

			Base Case	GO Only		FOGO		
				Optional	Compulsory	Optional	Compulsory	Compulsory – weekly organics, fortnightly garbage and recycling
Collection frequency	lifts per year	Organics	26	26	26	26	26	52
		Garbage	52	52	52	52	52	26
Households in served areas			5,510	5,510	5,510	5,510	5,510	5,510
Participation rate in organics service	% of total	Organics		40%	80%	40%	80%	90%
Number of households regularly using the organics service			1,000	2,204	4,408	2,204	4,408	4,959
Organics diversion rate per participating household	%	Garden waste	80%	90%	80%	90%	80%	90%
		Food waste	0.0%	0%	0.0%	60%	50%	70%
Expected garden organics diversion per participating household	kg per year		73	82	73	82	73	82
Expected food waste diverted per participating household	kg per year		-	-	-	127	106	149
'Additional' organics collected per additional participating household	kg per year	Garden waste	250	250	200	250	200	250
		Food waste	0	0	0	10	10	15
Total organics diverted per participating household	kg per household per year		73	82	73	209	179	231
Total organics recovered per participating household	kg per household per year		323	332	273	469	389	496
Tonnes organics diverted	tonnes per year		73	181	321	461	789	1,143
Tonnes organics recovered	tonnes per year		323	732	1,203	1,034	1,715	2,457
Expected increase in kerbside recycling	% diversion from kerbside MSW		0%	0%	0%	0%	0%	10%
Kerbside MSW to landfill	tonnes per year		3,500	3,319	3,179	3,039	2,711	2,007
% reduction in landfilled waste	%		0%	5%	9%	13%	23%	43%
Cost assumptions								
Costs per bin lift (includes bin purchase and collection costs)	$		$1.33	$1.33	$1.33	$1.33	$1.33	$1.33
Depreciation cost of garbage bin	$ per household per year		$9.26	$9.26	$9.26	$9.26	$9.26	$6.89
Depreciation of organics bin	$ per household per year		$10.68	$10.68	$10.68	$10.68	$10.68	$9.26
Cost of kitchen caddies per participating household	$ per household per year					$2	$2	$2
Cost of biobags per year	$ per household per year					$6	$6	$6
Organics processing costs	$ per tonne		$35	$48	$48	$65	$65	$65
Cost to transport to Heywood	$ per tonne		$35	$35	$35	$35	$35	$35
Cost to transport to Hamilton	$ per tonne		$0	$0	$0	$0	$0	$0
Landfill costs (to Stawell)	$ per tonne		$135	$135	$135	$135	$135	$135
Transfer and transport costs to Stawell landfill	$ per tonne		$45	$45	$45	$45	$45	$45
Total landfill costs for MSW (inclusive of transfer, transport and landfill at Stawell)	$ per tonne		$180	$180	$180	$180	$180	$180
Cost calculations								
Collection	$ per year	Organics	$45,351	$99,953	$199,906	$117,585	$235,170	$429,414
		Garbage	$433,047	$433,047	$433,047	$433,047	$433,047	$228,969
		Total	***$478,398***	***$533,000***	***$632,953***	***$550,632***	***$668,217***	***$658,383***
		Net costs from BAU	***$0***	***$54,602***	***$154,556***	***$72,234***	***$189,820***	***$179,985***
Processing or disposal-Heywood	$ per year	Organics to Heywood	$22,495	$60,291	$99,111	$103,112	$170,924	$244,972
		Garbage to Stawell	$630,000	$597,507	$572,235	$546,963	$487,995	$361,213
		Total	***$652,495***	***$657,798***	***$671,346***	***$650,076***	***$658,919***	***$606,185***
Total costs of organics processing at Heywood	$ per year	Organics	$56,649	$160,244	$299,017	$220,697	$406,094	$674,386
		Garbage	$1,063,047	$1,030,554	$1,005,282	$980,010	$921,042	$590,182
		Total	**$1,119,696**	***$1,190,798***	***$1,304,299***	***$1,200,708***	***$1,327,136***	***$1,264,568***
		Net costs from BAU	$0	$71,103	$184,603	$81,012	$207,440	$144,872
	%	% Increase	0%	6%	16%	7%	19%	13%
	$ per tonne	**Net cost per additional tonne recovered**	**-**	**$97**	**$154**	**$78**	**$121**	**$59**
	$ per household per year	**Net costs per additional participating household**	**$0**	**$59**	**$54**	**$67**	**$61**	**$37**
Processing or disposal-Hamilton	$ per year	Organics to Hamilton	$11,298	$34,917	$57,398	$67,233	$111,449	$159,731
		Garbage	$630,000	$597,507	$572,235	$546,963	$487,995	$361,213
		Total	***$641,298***	***$632,424***	***$629,634***	***$614,196***	***$599,444***	***$520,944***
Total costs of organics processing at Hamilton	$ per year	Organics	$56,648.9	$134,869.8	$257,304.7	$184,818.3	$346,619.1	$589,145.0
		Garbage	$1,063,046.9	$1,030,554.3	$1,005,282.2	$980,010.1	$921,041.9	$590,181.9
		Total	**$1,119,695.8**	**$1,165,424.1**	**$1,262,586.9**	**$1,164,828.4**	**$1,267,661.0**	**$1,179,326.9**
		Net costs from BAU	$0	$45,728.2	$142,891.1	$45,132.6	$147,965.2	$59,631.0
	%	% Increase	0%	4%	13%	4%	13%	5%
	$ per tonne recovered	**Net cost per tonne recovered**	**$0**	**$112**	**$162**	**$63**	**$106**	**$28**
	$ per household per year	**Net costs per additional participating household**	**$0**	**$38**	**$42**	**$37**	**$43**	**$15**

Table A27: Assessment of costs of organics recovery systems and processing sites for shared facility for both Glenelg Shire Council and Southern Grampians Shire Council

			Base Case	GO Only		FOGO		
				Optional	Compulsory	Optional	Compulsory	Compulsory – weekly organics, fortnightly garbage and recycling
Collection frequency	lifts per year	Organics	0	26	26	26	26	52
		Garbage	52	52	52	52	52	26
Households in served areas			15,060	15,060	15,060	15,060	15,060	15,060
Regular participation rate in organics service	% of total	Organics	7%	40%	80%	40%	80%	90%
Number of households regularly using the organics service			1,000	6,024	12,048	6,024	12,048	13,554
Organics diversion rate per participating household	%	Garden waste	0%	90%	80%	90%	80%	90%
	%	Food waste	0.0%	0%	0.0%	60%	50%	70%
Expected garden organics diversion per participating household	kg per year		-	37	33	37	33	37
Expected food waste diverted per participating household	kg per year		-	-	-	57	48	67
'Additional' organics collected per additional participating household	kg per year	Garden waste	0	250	200	250	200	250
		Food waste	0	0	0	10	10	15
Total organics diverted per participating household	kg per household per year		0	37	33	94	81	104
Total organics recovered per participating household	kg per household per year		0	287	233	354	291	369
tonnes organics diverted	tonnes per year		73	222	395	568	971	1,408
tonnes kerbside organics recovered	tonnes per year		323	1,728	2,805	2,134	3,501	4,999
Expected increase in kerbside recycling	% diversion from kerbside MSW		0%	0%	0%	0%	0%	10%
Kerbside MSW to landfill	tonnes per year		6,400	6,178	6,005	5,832	5,429	4,352
% reduction in landfilled waste	%		0%	3%	6%	9%	15%	32%
Cost assumptions								
Bin lift costs ($ per lift) (@ av 90 bins per hr at $120/hr)	$ per lift		$1.33	$1.33	$1.33	$1.33	$1.33	$1.33
Garbage bin depreciation costs (@$71.50 for 180L) per year	$ per household per year		$9.26	$9.26	$9.26	$9.26	$9.26	$6.89
Organics bin depreciation costs (@ $82.50 for 240L; $71.50 for 180L or 120L)	$ per household per year		$10.68	$10.68	$10.68	$10.68	$10.68	$9.26
Cost of kitchen caddies per participating household	$ per household per year					$2	$2	$2
Cost of biobags per year	$ per household per year					$6	$6	$6
Organics processing costs	$ per tonne		$0	$47	$47	$65	$65	$65
Cost to transport to Heywood	$ per tonne		$14	$14	$14	$14	$14	$14
Cost to transport to Hamilton	$ per tonne		$39	$39	$39	$39	$39	$39
Landfill costs (to Stawell)	$ per tonne		$135	$135	$135	$135	$135	$135
Transfer and transport costs to stawell landfills	$ per tonne		$58	$58	$58	$58	$58	$58
Total landfill costs for MSW (inclusive of transfer, transport and landfill at Stawell)	$ per tonne		$193	$193	$193	$193	$193	$193
Cost calculations								
Collection costs	$ per year	Organics	$0	$273,193	$546,386	$321,385	$642,770	$1,173,680
		Garbage	$1,183,609	$1,183,609	$1,183,609	$1,183,609	$1,183,609	$625,820
		Total	***$1,183,609***	***$1,456,802***	***$1,729,996***	***$1,504,994***	***$1,826,380***	***$1,799,501***
		Net costs from BAU	***$0***	***$273,193***	***$546,386***	***$321,385***	***$642,770***	***$615,891***
Processing or disposal costs-Heywood	$ per year	Organics to Heywood	$6,779	$106,689	$173,141	$168,604	$276,613	$394,956
		Garbage	$1,237,000	$1,194,042	$1,160,630	$1,127,218	$1,049,257	$841,232
		Total	***$1,243,779***	***$1,300,731***	***$1,333,771***	***$1,295,822***	***$1,325,870***	***$1,236,187***
Total costs of organics processing at Heywood	$ per year	Organics	$6,779	$379,882	$719,528	$489,989	$919,383	$1,568,636
		Garbage	$2,420,609	$2,377,651	$2,344,239	$2,310,827	$2,232,866	$1,467,052
		Total	***$2,427,388***	***$2,757,533***	***$3,063,767***	***$2,800,817***	***$3,152,249***	***$3,035,688***
		Net costs from BAU	***$0***	***$336,924***	***$643,158***	***$380,207***	***$731,640***	***$615,079***
	%	% Increase	0%	14%	26%	16%	30%	25%
	$ per tonne recovered	Net cost per tonne recovered	$0	$195	$229	$178	$209	$123
	$ per tonne recovered	Net costs per participating household	$0	$54	$49	$64	$58	$49
Processing / disposal-Hamilton	$ per year	Organics to Hamilton	$12,509	$149,463	$242,558	$221,426	$363,273	$518,692
	$ per year	Garbage	$1,237,000	$1,194,042	$1,160,630	$1,127,218	$1,049,257	$841,232
		Total	***$1,249,509***	***$1,343,505***	***$1,403,188***	***$1,348,644***	***$1,412,530***	***$1,359,924***
Total costs of organics processing at Hamilton	$ per year	Organics	$12,509	$422,656	$788,944	$542,812	$1,006,043	$1,692,372
		Garbage	$2,420,609	$2,377,651	$2,344,239	$2,310,827	$2,232,866	$1,467,052
		Total	$2,433,118	$2,800,307	$3,133,184	$2,853,639	$3,238,910	$3,159,424
		Net costs from BAU	$0	$367,190	$700,066	$420,521	$805,792	$726,306
	%	% Increase	0%	15%	29%	17%	33%	30%
	$ per tonne recovered	**Net cost per tonne recovered**	**$0**	**$212**	**$250**	**$197**	**$230**	**$145**
	$ per year	**Net costs per participating household**	**$0**	**$73**	**$63**	**$84**	**$73**	**$58**