ecomaine

Organics Recycling Feasibility Study

Final Report

November 2013

Prepared by:

Northern Tilth

In association with:

Coker Composting & Consulting

Integrated Waste Management Consulting

and

Tech Environmental

Northern Tilth

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List of Acronyms

Acronym	Definition
ABS	Acrylonitrile butadiene styrene
ACWMA	Alameda County Waste Management Authority
AD	Anaerobic Digestion
APTI	Air Pollution Training Institute
ASP	Aerated Static Pile
ASTM	American Society for Testing and Materials
BMPs	Best Management Practices
BTU	British Thermal Unit
C&D	Construction and Demolition Debris
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CSWD	Chittenden Solid Waste District
CY	Cubic Yard
DBD	Di-electric-barrier Discharge
DEP	Department of Environmental Protection
DGE	Diesel-gallon-equivalent
DOT	Department Of Transportation
DT	Detection Threshold
EAE	Exeter Agri-Energy
ECS	Engineered Compost Systems
EOW	Every Other Week
EPA	Environmental Protection Agency
FCSWMD	Franklin County Solid Waste Management District
GEL	Green Earth Landworks
GIS	Generation Information System
GIS-REC	Generation Information System – Renewable Energy Credits
H20	Water
H_2S	Hydrogen Sulfide
HH	Household
HHV	Higher Heating Value
HP	Horsepower
ISO	International Organization for Standardization
LAWPCA	Lewiston Auburn Water Pollution Control Authority
LHV	Lower Heating Value
MCF	Thousand Cubic Feet
MDEP	Maine Department of Environmental Protection
MOFGA	Maine Organic Farmers and Gardeners Association
MPUC	Maine Public Utilities Commission
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste

Acronym	Definition
MW	Megawatt
MWS	Maine Waste Solutions
NA	Not Available
NAS	Naval Air Station
NE	New England
NGV	Natural Gas Vehicle
NOVs	Notices of Violations
N-P-K	Nitrogen-Phosphorus-Potassium
NPS	Non-point Source
NRCS	Natural Resources Conservation Service
NTP	Non-thermal Plasma
O&M	Operation and Maintenance
PAYT	Pay As You Throw
PFRP	Process to Further Reduce Pathogens
PNGTS	Portland Natural Gas Transmission System
PPA	Power Purchase Agreement
PPB	Pay Per Bag
PSAs	Public Service Announcements
REC	Renewable Energy Credit
RFP	Request for Proposal
RNG	Recycled Natural Gas
RNG/CNG	Recycled Natural Gas/Compressed Natural Gas
RPS	Renewable Portfolio Standard
RRF	Riverside Recycling Facility
RT	Recognition Threshold
SAD	School Administrative District
SCNR	Selective Non-catalytic Reduction
SF	Square Feet
SO_2	Sulfur Dioxide
SRT	Solids Retention Time
SSO	Source Separated Organics
STA	Seal of Testing Assurance
TPY	Ton Per Year
TS	Total Solids
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USGA	US Golf Association
VGF	Vegetable, Garden, Fruit
VOC	Volatile Organic Compound
WPS	Wisconsin Public Service
WTE	Waste To Energy
WWTP	Wastewater Treatment Plant

Glossary

Anaerobic Digestion	Biological treatment process for organic wastes occurring in a reactor devoid of oxygen in which organic matter is converted to an energy-rich, containing methane.
C&D	Construction and demolition debris.
Composting	A controlled, aerobic (with oxygen) biological treatment process in which organic wastes are converted to mature, humified organic matter that can be used as a soil amendment.
Diversion	Separation and removal of a certain type of waste, such as organic waste, from the solid waste stream.
Dry Fermentation	A type of anaerobic digestion for organic wastes with high solids contents.
Every-other-Week (EOW)	Every-other-week, referring to solid waste collection schedule for residential curbside collection programs, which typically involves every week collection of organics and collection of trash and recyclables on alternating weeks.
Materials Recovery Facility (MRF)	A facility designed to separate different types of recyclable material and to remove rubbish or contaminants from materials targeted for recycling.
Participation Rate	The percentage of households for which organics recycling programs are available actually participate in the program.
Pay As You Throw (PAYT)	Solid waste systems in which residents pay for disposal of solid waste based on how much trash (by volume or weight) they generate.
Pay-Per-Bag (PPB)	A type of PAYT program popular in the ecomaine service area in which residents purchase the bags in which they place rubbish/trash.
Set-out Rate	For households participating in a curbside organics recycling program, the percentage of times that the organics containers are actually brought to the curb for collection.
SSO	Source separated organics, such as food scraps and compostable paper after they have been separated from other types of solid waste.
Targeted Organics	Organic wastes targeted for diversion from the solid waste stream.
Trash	The portion of the solid waste stream remaining after recycling and organic waste diversion; the solid waste that is directed to WTE or landfilling; sometimes referred to as ***rubbish.***
Type 1A Residuals	A category of waste materials used in the State of Maine Solid Waste Regulations for materials with a carbon to nitrogen ratio greater than or equal to 25:1, such as leaf and yard waste, wood chips and some vegetative wastes.
Type 1B Residuals	Materials with a carbon to nitrogen ratio greater than 15:1 but less than 25:1, such as animal manure and most produce and vegetable wastes.
Type 1C Residuals	Materials with a carbon to nitrogen ratio of 15:1 or less, such as fish wastes.
Waste to Energy (WTE)	Combustion of solid waste in a boiler in which energy from combustion is captured and used to generate electricity. In the case of ecomaine, the WTE plant uses mass burn technology in two boilers, capturing the heat of combustion in the form of steam that is used to generate electricity in a steam turbine.

Executive Summary

In an effort to further its mission of providing sustainable waste management strategies, ecomaine commissioned this Organic Waste Recycling Feasibility Study to investigate opportunities and methods for developing practical organics diversion, collection, and processing programs in the ecomaine service area. Specifically, the Northern Tilth project team, consisting of Andrew Carpenter from Northern Tilth, Craig Coker from Coker Composting & Consulting, Matt Cotton from Integrated Waste Management Consulting and Dr. Dana Buske and Matt Lannan from Tech Environmental, was hired to perform an overview analysis of the major components of potential organics recycling programs in the ecomaine service area and to provide recommendations for a path forward towards developing these programs. A priority for ecomaine in this study was to have the project team draw on experience from existing organics programs operating under constraints similar to those found in the ecomaine service area. The study was divided into the following seven tasks:

1. ***Waste Composition.*** Determine estimates of the percent of targeted organics in the residential and commercial solid waste streams currently managed at the ecomaine Waste-to-Energy (WTE) plant and, further, provide estimates of the tonnages of targeted organics that could practically be diverted to recycling.
2. ***Organics Collection Systems.*** Provide an overview of organics collection systems that would be applicable to the ecomaine service area, both for communities currently served by curbside collection of trash and recycling and for those communities currently relying on transfer stations for solid waste collection.
3. ***Processing Technologies.*** Provide a review of organics processing technologies, including composting and anaerobic digestion systems, that would be applicable to processing organics collected from the ecomaine service area and make a determination on the most promising technologies based on ecomaine's financial, environmental, and risk minimization priorities.
4. ***Site Evaluations.*** Provide an assessment of the potential for siting an organics processing facility at one of two ecomaine-owned properties as well as investigate the existing capacity for processing organics at merchant facilities in the ecomaine service area and the benefits and risks of developing a partnership with those existing facilities.
5. ***Impacts to WTE Plant.*** Investigate the potential impacts on the ecomaine WTE plant of diverting organics from the solid waste stream, both in terms of the heat value of the solid waste and WTE plant air emissions.
6. ***Markets.*** Investigate potential markets and the dollar value of compost and energy products that would be produced at an ecomaine-owned organics processing facility.
7. ***Economic Analysis and Path for Moving Forward.*** Provide a macro-economic analysis of the organics collections and processing options reviewed and recommendations for moving forward in developing organics recycling programs in the ecomaine service area.

Nationally, organic waste (primarily food scraps, compostable paper, and yard trimmings) represents the largest untapped resource remaining in our solid waste stream. For food scraps in particular, recycling rates are estimated to be less than 4%. Based on the increase in organics recycling programs both in the

US in general and more specifically within the ecomaine service area, there is clearly interest on the part of both the public and entrepreneurs to recover this resource. Some of the reasons that organics recycling programs have been slower to develop than programs for traditional recyclables are related to the changes in disposal behavior necessary to separate organics from trash, the moist and potentially odorous nature of food scraps, the costs necessary to collect organics separately from trash and recycling, and challenges related to processing organics in terms of facility siting, development and operations. In order for ecomaine and its member communities to develop long-lasting, sustainable solutions for recycling organics it is critical to take a deliberate approach in developing organics programs. One of the major goals of this study is to provide the information necessary to help ecomaine and its member communities to develop sustainable organics recycling solutions.

Based on a review of existing solid waste studies from U.S. states, including a recent University of Maine study, it is estimated that between 36,000 and 47,000 tons of the non-spot market tonnage[1] delivered to the ecomaine WTE plant in 2012 consisted of targeted organics (referred to as Source-Separated Organics (SSO) once they have been separated from the solid waste stream). Based on experience from national organics recycling programs, the project team developed the following three potential organics diversion scenarios, which were used as guidance for assessments in sizing and pricing throughout this study:

1. Low-end → 3,100 tons of SSO per year based on a voluntary residential curbside collection program with average participation rates and low-end capture rates.
2. Medium Range → 11,900 tons of SSO per year, from a combination of commercial organics and a voluntary residential curbside collection program with higher participation and capture rates.
3. High-end → 21,000 tons of SSO per year, from a mandatory residential curbside collection program and a higher capture rate for commercial organics.

Review of existing technologies followed by an evaluation of the technologies best suited to ecomaine's priorities, the estimated tonnages that would be diverted in an ecomaine service area-wide program, and the climatic conditions in southern Maine indicated that enclosed aerated static pile (ASP) would be the best fit technology for composting and dry fermentation would be the most promising anaerobic digestion technology for an ecomaine owned and operated SSO processing facility.

Evaluation of the ecomaine's ashfill property and the 258-acre undeveloped parcel owned by ecomaine in Gorham indicated that two potential sites at the ashfill and at least one potential site on the Gorham property would be suitable for developing a combined anaerobic digestion and composting facility sized to process 12,000 tons per year of organics, although each of the two sites at the ashfill would require ecomaine to purchase of additional adjacent property. An assessment of the markets for compost and energy products in southern Maine, based on the quantity and quality of compost and biogas that would be generated by such a facility, indicated that the compost would be worth approximately $275,000 per

[1] Tonnage delivered to ecomaine's WTE plant under contractual agreements.

year, and the energy from the biogas in the form of compressed natural gas (CNG) would be worth between approximately $180,000.

As an alternative to developing an organics processing infrastructure internal to ecomaine, there are approximately 46,000 tons per year of capacity at existing and planned organics processing facilities (combining composting and anaerobic digestion facilities) within a reasonable hauling distance of the ecomaine service area. The majority of this capacity has been developed within the past two years and much of it still available for new incoming materials. The benefits and risks of developing partnerships with these existing processors are detailed in the report.

Using this study's estimates of the composition of residential and commercial solid waste currently combusted at the ecomaine WTE plant, the project team calculated that diversion of the organics would increase the heat value of the waste by 0.8%, 3% and 5% for the low-end, medium range and high-end scenarios, respectively. Based on experience from other solid waste districts which rely on WTE and which have instituted successful organics diversion programs, it appears unlikely that any of these scenarios would have a significant impact on operations of the WTE plant. With regards to air emissions, most regulated parameters should be unaffected, but changes in oxides of nitrogen (NOx) emissions, although they are not likely to cause compliance problems, will require closer scrutiny with increasing organics diversion.

A macroeconomic analysis of 10 potential combinations of diversion, collection, and processing strategies for the ecomaine service area indicated that collection systems for SSO are by far the largest driver for overall program costs. The following table shows the three organics collection systems evaluated for curbside collection, the additional annual estimated cost per participating household, and notes on the system.

Curbside Collection System	Additional annual cost per participating household	Notes
Dedicated Collection[1]	$125	Currently used in most curbside collection programs for organics in the US.
Blue Bag-type Collection	$24	Organics are separated by residents into specially-colored bags and co-collected with trash in the same compartment of the hauling vehicle, does not add additional costs on the hauling end, but does require the development of a sorting operation, which in ecomaine's case would be co-located with the WTE plant.
Every-Other-Week (EOW) Collection	$5	Organics are collected weekly and refuse and recycling are collected on alternating weeks, appears to be the least expensive option, but does involve a shift in residential behavior which will likely require strong political will and support to implement.

[1]*The costs for dedicated collection in the City of Portland is estimated to be lower (approximately $50 per participating household per year) based on their lower reported costs in their current trash and recycling collections programs.*

ecomaine community members represent a wide array of solid waste collection systems with varying population densities and likely with different visions of the need for initiating organics recycling programs. Unlike a single municipality contemplating organics recycling, ecomaine cannot simply make the decision that curbside collection of residential organics will be available to all residents and plan accordingly (both for collections systems and processing).

It is evident from the economic analysis that developing an ecomaine owned and operated stand-alone anaerobic digestion facility is not economically feasible at this time based on the revenue potential of the energy products that could be generated from the biogas, in combination with the operational consideration that the digestate from a dry fermentation facility would need to be composted prior to being marketed as soil amendment. The potential revenue from the energy products would not cover the annualized capital costs and operational costs for a stand-alone anaerobic digestion facility.

Transfer station drop-off programs can be a cost-effective means for recycling organics in communities currently reliant on transfer stations for trash and recycling collections. Experience from existing drop-off programs indicates that they require extensive education and outreach in order to achieve good participation rates.

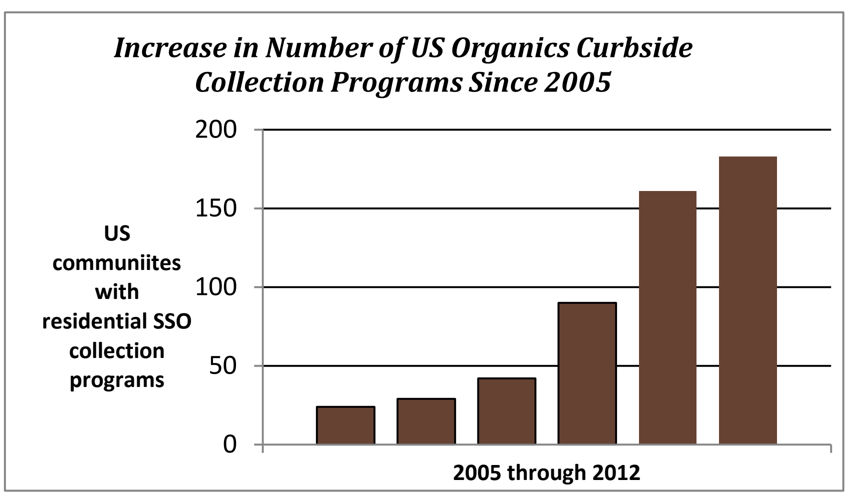
This study concludes with the following recommendations:

- Take a phased approach to developing organics programs, which will provide the opportunity to determine if building an ecomaine-owned facility will be necessary in the long run and to assess the effectiveness of education and outreach in minimizing contamination levels in the SSO.
- Develop partnerships with existing organics processing facilities for the first few years of the programs, using a certification process to ensure that the facilities will meet ecomaine's risk minimization goals. ecomaine should simultaneously further refine the selection of a preferred site for an ecomaine-owned enclosed ASP composting facility and begin the preliminary steps for permitting to allow transition to facility development if existing processors prove to be limited by capacity or the ability to manage contaminants in the SSO.
- Discuss the pros and cons of the different organics collection options with solid waste managers from member communities and facilitate discussions with the communities and their private haulers.
- Identify motivated communities in which to initiate organics programs.
- Facilitate the development of the programs by taking the following steps:
    - provide an organics transfer station or transfer capacity,
    - develop contracted capacity for organics processing by merchant facilities, and
    - develop consistent educational materials that can be used by all the ecomaine communities developing programs.
- Adopt and implement a consistent list of acceptable organics (inclusive, but needing to be refined based on the processors with which ecomaine ultimately contracts services) among the member communities.
- For transfer station drop-off communities, identify member communities that are interested in developing organics drop-off programs and help educate these communities on getting started and maximizing participation rates.

Report Overview

Recycling organic wastes, including food scraps, compostable paper, and other biodegradable materials represents both the greatest current opportunity and one of the greatest challenges to resource recovery efforts in the US solid waste stream. The US Environmental Protection Agency (USEPA) estimates that the country generates approximately 34 million tons of food scraps annually and less than 4 % of that is successfully recovered from the waste stream and recycled (USEPA, 2010). Although recovery of organics from the waste stream is more challenging than for traditionally recycled materials such as paper, glass, metal, and plastic, organics have significant value both as soil amendments through composting and as potential sources of renewable energy through anaerobic digestion. The focus of this study was to investigate methods for diverting and recycling organics from ecomaine's waste stream in a practical, cost-effective manner that is in line with ecomaine's resource recovery goals.

ecomaine is a leader in solid waste resource recovery in New England. From providing a long-term solid waste energy recovery solution in the Waste-to-Energy (WTE) plant to developing a state-of-the-art single-sort materials recovery facility (MRF), ecomaine has consistently provided member communities the best available technologies for recycling, recovering energy from waste, and minimizing the need for landfilling solid waste. Developing organics recycling efforts is an obvious next step for ecomaine's resource recovery efforts. Organics recycling is clearly in line with the organization's mission statement of "***…provid[ing] comprehensive long-term solid waste solutions in a safe, environmentally responsible, economically sound manner, and [being] a leader in raising public awareness of sustainable waste management strategies***". Further, while energy recovery through the WTE plant is a preferred waste management strategy to landfilling, both the State of Maine's and the USEPA's solid waste hierarchies recommend recycling organic wastes through composting (with or without anaerobic digestion) over incineration with energy recovery. Organic materials do have energy value that can be recovered during incineration, but their moisture content makes them less attractive for combustion than some of the other materials in the solid waste stream such as plastics and wood. Although recycling rates for organic wastes are very low nationwide, there has been a dramatic rise in the development of organic waste recycling programs over the past decade. The following graph illustrates the increase in residential curbside collection programs for food scraps in the US from 2005 through 2012 (Yespen, 2013).



Additionally, several recently-developed organics recycling programs in Maine, including Resurgam Zero Food Waste's commercial organics composting operation and Garbage to Garden's residential organics collection service in the ecomaine service area, indicate that there is both interest and demand for providing organics recycling options to residences and businesses in Maine.

Increasing solid waste recycling rates and resource recovery has been a priority for state regulators and solid waste managers in Maine for decades; however, since peaking at 41.5% from 1995 to 1997, recycling rates in the state have stagnated at between 35 and 40% (MacDonald, 2013). In Maine, disposed organics, including food waste, compostable paper, and yard trimmings, are approximately 37% of the residential solid waste stream and consequently, organics recycling efforts offer the best opportunity for significantly increasing recycling rates. Estimates from this study indicate that a high-end organics recycling scenario could increase the amount of material recovered and recycled from the residential solid waste stream in the ecomaine service area by an additional 38%; the estimated 35.5% recycling rate[2] for the ecomaine service area would increase to approximately 49%.

Adding organics recovery and recycling to the WTE plant and single-sort recycling operations could greatly improve ecomaine's ability to provide integrated resource recovery options for solid waste. WTE incineration and organics recycling can be complementary waste management strategies. In the case of ecomaine, removing wet organic waste from the WTE plant can increase the heat value of solid waste and potentially compensate for some of the loss of heat value that has likely occurred with the removal of paper and plastics through successful recycling programs over the past two decades. Two Canadian solid waste districts, Vancouver Metro and the Island Waste Management Corporation on Prince Edward Island, provide good models of solid waste systems that use waste-to-energy in concert with traditional recycling and organic waste recovery. These programs provide high rates of recycling while continuing to create energy from the remaining portion of the solid waste stream. In the case of Vancouver Metro, which uses a mass burn incineration technology similar to ecomaine, recent increases in organics recovery efforts in which virtually all of the communities contributing solid waste to the WTE plant have access to residential curbside organics collection programs, have resulted no negative impacts to operations at the WTE plant (Pitre, 2013).

Environmental Benefits

In addition to increasing recycling rates, recovering organic wastes from the solid waste stream provides other benefits that can increase the sustainability of solid waste management in the ecomaine service area. The conversion of organic wastes to soil amendments through the composting process provides Maine farmers, landscapers, and homeowners alternatives to chemical fertilizers to build soil fertility. Adding compost to soils increases soil water-holding capacity, improves the health of the soil ecosystem, and helps to reduce soil erosion. Removing organic waste from the solid waste stream and ultimately adding it to soil also helps to sequester carbon in soils. When considering energy recovery from organic wastes, the conversion of organic matter to methane, through anaerobic digestion for use as a fuel

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[2] This recycling rate includes the estimate of yard trimmings collected and recycled in the ecomaine service area in accordance with the State of Maine's recycling rate calculation methods. ecomaine's internal recycling rate estimate for the service area, which only includes traditional recyclables, was 29.4% for fiscal year 2013 and would increase approximately 50% (to 44.2%) under this same scenario.

source, is generally more efficient than conversion of this wet organic matter to electricity through combustion in a WTE plant.

Relative to solid waste management, the creation and loss to the atmosphere of methane generated by placing organic waste in a landfill is a large source of greenhouse gas emissions. ecomaine's WTE plant, by extracting energy from solid waste and by creating an inert ash, which is not conducive to the creation of methane when placed in ecomaine's ashfill, generally provides a much lower level of greenhouse gas emissions per ton of waste managed than does landfilling (Bogner et. al., 2007). Recovering organic wastes from the solid waste stream going to the WTE plant and diverting it to composting and/or anaerobic digestion provides even further reductions in greenhouse gas emissions. According to the EPA's WARM model for predicting greenhouse gas emissions from different waste management options, diverting 21,000 tons per year of ecomaine's organic waste to composting (the high-end organics diversion scenario) would reduce greenhouse gas emissions associated with the management of the waste by 2,200 tons of CO_2 equivalents per year (CO_2e/yr). If converting the energy from this same amount of source separated organics (SSO) into electricity through anaerobic digestion, the greenhouse gas emissions would be reduced by an additional 660 tons CO_2e/yr, provided the digester was relatively close to the WTE plant. The bottom line for greenhouse gas emissions is that ecomaine's current solid waste management system already provides much lower emissions compared to landfilling, and implementing organics recycling programs can provide some further reductions to these emissions. .

Economics of Organics Recycling

The costs for processing organic wastes, especially via composting, is almost always less expensive than incinerating or landfilling the material. In the ecomaine service area, the current rate for composting SSO is in the range of $30 to $40 per ton. The 2013 tip fee for ecomaine member communities bringing solid waste to the WTE plant is $70.50. Therefore, on the processing end, recovering and recycling organics offers a substantial cost savings over incineration.

On the other hand, collection costs for any type of solid waste are typically a larger portion of the overall solid waste costs than are the processing costs. Developing organic waste collection programs often involves developing new hauling routes in addition to the existing trash and recycling routes for the residential and commercial wastes in any given community. The extra costs of these additional routes typically exceeds the savings on the processing end for organics, meaning that the overall costs of developing organics recycling programs often represents an increase in overall solid waste management costs.

While commercial organics recycling programs may come closer to being cost-neutral than residential organics recycling programs, in both cases incentives other than costs are often necessary to justify the programs. Mandatory recycling laws, such as those in California, or bans on landfilling organics, such as those being proposed in Massachusetts and Vermont, are potential drivers for developing organics programs. On Prince Edward Island, diverting organics from landfilling in order to protect the island's groundwater resources was a primary driver for organics recycling. One push for developing organics programs in the southern Ontario region has been the scarcity and expense of landfill space. Because the diversion of organics from the solid waste stream requires a shift in behavior from both residents and commercial generators of solid waste, strong political will from community leaders if often necessary to provide impetus to change the status quo. In ecomaine's case, in addition to increasing resource recovery options for community members, the need to move forward deliberately in order to avoid the mistakes of some past organics processing operations (primarily composting operations that have been forced to shut down), and to minimize leakage of solid waste from ecomaine's control, are also incentives to developing successful organics recycling programs.

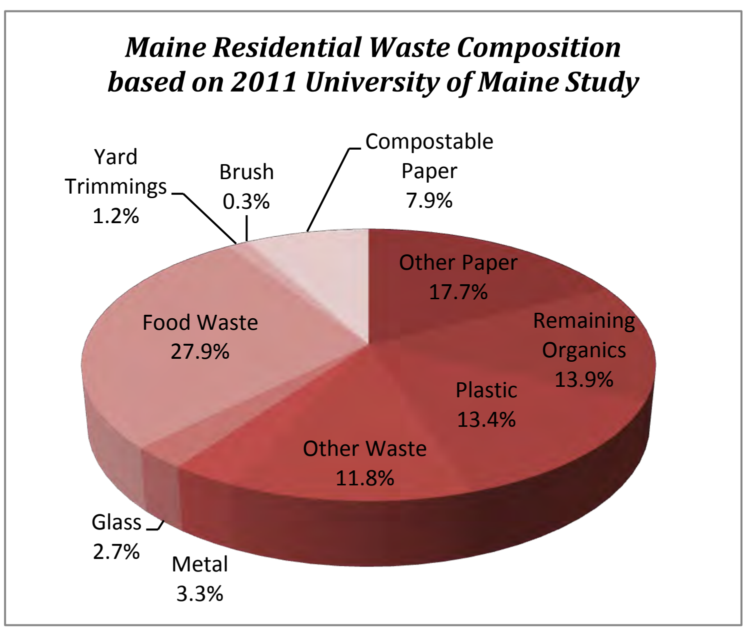
Looking ten years forward, extra costs associated with developing organics recycling programs now may reap benefits in the future. For instance, communities that want to have an integrated system may be more likely to partner with ecomaine to meet their solid waste needs if programs are already in place for organics recovery and recycling. Also, greater participation in organics recycling programs will increase the economy of scale for collection systems, likely decreasing extra costs associated with organics collection systems and processing. In the past, the lack of a consistent organics processor to accept organics has been an impediment to haulers developing commercial organics programs. An organics program administered by ecomaine, with ecomaine either providing a processing facility or a transfer station and contracted capacity for processing organics at existing facilities, will encourage more communities, generators, and haulers to participate in organics recycling programs.

Summary of Tasks 1 through 7

The remainder of this Report Overview provides a summary of the findings in each of the seven tasks completed for the ecomaine Organics Recycling Feasibility Study. The summaries provide an overview of the most relevant findings from each task. The detailed findings for each task, along with the complete lists of references and appendices, are contained in the latter sections of this final report.

Organic Waste in the ecomaine Service Area (Task 1)

Based on data from existing Maine residential waste composition studies and extrapolating from commercial waste composition studies performed across the US, the project team estimates that approximately 36,000 to 47,000 tons of the non-spot market tonnage delivered to the ecomaine WTE plant in 2012 consisted of targeted organics. Yard trimmings (the combination of grass clippings, grass clippings, garden residuals and house plants) already have successful diversion programs in place, with approximately 15,000 tons of these materials being collected and recycled through seasonal curbside collection



programs and transfer station drop-off programs.

Existing organic waste recycling programs in the ecomaine service area currently recover approximately 4,400 tons of food processing wastes and food scraps from the solid waste stream, with the largest fraction of these organics coming from commercial generators, such as seafood processors and larger supermarket chains. Current residential organic waste collection in the ecomaine service area is estimated to be capturing only 2% or less of the estimated 23,600 tons per year of targeted organics in that waste stream.

Organics Composition of Disposed Residential Waste from US Studies					
Area	**Year**	**% Food Waste**	**% Compostable Paper**	**% Yard Trimmings**	**% Targeted Organics**
Maine	2011	27.9%	7.9%	1.2%	37.0%
Vermont	2013	16.7%	6.2%	3.2%	26.1%
Massachusetts	2011	15.5%	7.0%	Not reported	NA
Connecticut	2010	13.7%	9.8%	10.7%	34.2%
Washington	2009	22.7%	5.0%	8.7%	36.4%
Wisconsin	2009	17.5%	7.2%	6.9%	31.6%
Oregon	2009	28.9%	3.8%	5.8%	38.5%
Delaware	2006	11.8%	6.9%	14.2%*	32.9%
Georgia	2005	13.4%	10.7%**	2.1%	26.2%
Pennsylvania	2003	12.2%	10.1%**	7.6%	29.9%
Average		18.0%	6.7%	5.8%	32.5%
				Range	26.2 – 38.5%

**Includes brush.*

***The reported number for "non-recyclable" paper, which may include non-compostable materials.*

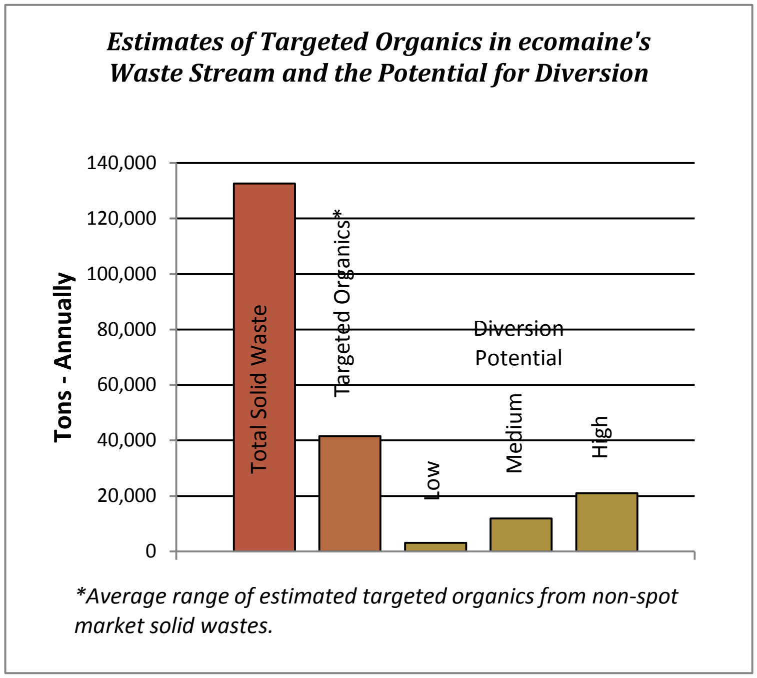
Average values are determined by category, consequently, the average % targeted organics does not equal the sum of the averages from each category.

Due to the success of existing programs in diverting yard trimmings from the solid waste stream, and due to the seasonality of the volumes of yard trimmings generated in the northern New England climate, it is recommended that residential curbside collection programs for organics not target all yard trimmings, but instead should focus primarily on food scraps and compostable paper. Nationally, residential curbside organics programs that do not include yard trimmings report collection rates ranging from 7 to 12 pounds per participating household per week. Three existing residential curbside programs in New England report collection rates on the high end of this range (e.g., from 10 to 12 pounds per household per week).

Based on the estimated solid waste composition and on the predicted rates of recovery of residential and commercial organics, the project team developed three potential scenarios for diverting organic wastes from the non-spot market solid waste stream currently being delivered to the ecomaine WTE plant. Ranging from a voluntary program consisting of relatively low participation rates and capture rates and no commercial collection to a mandatory program with higher participation rates and a high-end estimate for commercial collection, the scenarios are as follows:

- Low-end → 3,100 tons (residential only, voluntary)
- Medium → 11,900 tons (6,800 tons residential and 5,100 tons commercial, voluntary)
- High-end → 21,000 tons (13,900 tons residential and 7,100 tons commercial, mandatory)

It is important to note that because each ecomaine member community will make their own choices regarding if and when to develop organics recycling programs, the amount of organic waste diverted from the ecomaine service area will likely build slowly over time. Even the amount of organic waste diversion estimated for the low-end scenario is unlikely to occur within the first year of communities developing organics programs.



Collections Alternatives (Task 2)

Collections systems often represent the largest costs associated with organics recycling programs. The appropriate organics collection system for any one community is influenced by several factors including the existing infrastructure for trash and recycling collections, population density, projected participation rates, and the types of organics that will be collected in the program. Of ecomaine's 28 member and associate member communities, 13 communities, representing 72% of the population, are serviced by community-wide curbside collection of trash and recycling. The remaining 15 communities rely on residents dropping solid waste off at transfer stations or contracting with private haulers for collection services.

Three models of organics collection systems that are applicable to the ecomaine communities serviced by curbside collection for trash and recycling include:

- ***Dedicated Collection*** – a separate hauling route dedicated to collecting organics only.
- ***Blue Bag-Type Collection*** (a type of commingling with trash) – loosely based on early curbside recycling techniques and recently applied to organics in a few jurisdictions in Minnesota by Blue Bag Organics, this system involves residents or businesses separating targeted organics into specially marked bags that are collected on the same route and in the same compartment as trash to be later separated at a sorting facility.
- ***Co-Collection with Every-Other-Week (EOW) Trash and Recyclables collection*** – using the same hauling routes and equipment as every week collection of trash and recyclables, EOW involves collecting organics weekly, and collecting trash and recycling on alternate weeks. In theory, the same amount of material is collected by the same number of pick-ups on the same routes, but the frequency for trash and recycling collection is reduced. In the split-body trucks currently used in most ecomaine communities serviced by curbside collection, one side of the split body

would be dedicated to organics for each collection, and the other compartment would switch between recyclables and trash.

Dedicated collection of organics is the most widely used collection method in the US, but it is also the most costly as it involves an entirely new collection route in addition to the routes already in place for trash and recycling. Additionally, unless the organics programs require mandatory participation, it is likely that less than half of all households in a given community will participate, which means that the route density will be lower than for trash and recycling, and, consequently, per household costs will be higher. Another consideration is that in northern climates, the additional truck traffic from additional routes can produce significant damage to roads in the winter and early spring. Based on costs from existing curbside programs in the US and from curbside trash and recycling costs in the ecomaine service area, the project team estimates that dedicated curbside organics collection will cost from $7 and $13 per participating household per month in the ecomaine service area.

Part of the appeal of a Blue Bag-type collection program is that the actual hauling costs would not increase over current trash hauling costs; the bags are simply loaded into the same compartment of the truck as the trash on the same route. The additional costs for the Blue Bag-type systems include the costs of the bag, which can be significant if compostable bags are used, and the costs of the operation required to sort the organics bags from the trash with which it was hauled.

The switch to EOW collection has the potential to add organics collection to existing routes with minimal overall increase in collection costs. Additionally, the shift in solid waste disposal behavior associated with the change to EOW collection may provide additional increases in recycling rates as residents have incentive to decrease the trash they generate because it is collected with less frequency. Because the shift to EOW involves a significant change in disposal habits, going down this path requires strong political will and a commitment by the solid waste managers within communities who adapt this strategy to make it work. While it is a major change, it has been successfully implemented in many Canadian communities as well as in Portland, OR, Renton, WA and Hamilton, MA, and is being phased in Tacoma, WA and piloted in Seattle, WA and San Francisco, CA.

For ecomaine member communities that rely on self-haul to transfer stations for solid waste collection, there are several models of organics drop-off programs that could be implemented. Yarmouth, ME already has an organics drop-off program in place, and several long-running programs in Franklin County, MA indicate that participating rates for these types of programs can be relatively high with extensive public education and outreach. For ecomaine member communities that already have a yard trimmings composting operation in place at their transfer stations, collected SSO could be integrated into the existing composting operation, which would result in an overall cost savings relative to not collecting the SSO. For transfer station communities without an existing composting operation, the collected organics could be hauled to local on-farm composting operations with minimal additional costs to the overall solid waste program.

Technology Alternatives Evaluation (Task 3)

Once collected, the two most common methods for SSO are by anaerobic digestion, for the purpose of harvesting energy from the material, and by aerobic composting to produce an organic matter-based soil amendment. The two technologies are not mutually exclusive; when used for processing SSO, anaerobic digestion is typically followed by composting. Composting, though, can be completed without anaerobic digestion. The determination on whether or not to process SSO via anaerobic digestion is largely determined by whether the value of the harvested energy pays for the capital and operating expenses required to anaerobically digest the SSO.

The most common anaerobic digesters in the US are low-solids liquid digesters, such as the digesters used to manage wastewater treatment solids and liquid dairy manures. However, but for a stand-alone SSO anaerobic digestion system, dry fermentation reactors, designed to handle materials with a higher solids content, are often more appropriate. For composting technology, there are a wide variety of systems and methods available, from the low tech open-air windrow systems often used for yard trimmings and on-farm composting operations, to more expensive, enclosed systems that allow for greater throughput per unit area utilized and that provide for more rapid composting and more robust process control.

Taking into account the types of materials that would be collected in an ecomaine organics recycling program, the climate in the ecomaine service area, and ecomaine's priorities to minimize environmental and economic risk in developing and managing an SSO processing facility, the project team used a weighted-matrix evaluation technique to determine the anaerobic digestion and composting technologies best suited to ecomaine. The highest scoring alternatives are shown on the following table. Please note that digestion and composting were considered separately.

Results of Weighted-Matrix Evaluation of Technologies	
Alternative	**Total Weighted Score**
Digestion	
Dry Fermentation	330
Liquid Digesters	182
Composting	
Enclosed Aerated Static Pile	373
Containerized Aerated Static Pile	342
Covered Aerated Static Pile	334
Tunnel Reactor ASP	311
Agitated Bay Composting	305

Dry Fermentation Anaerobic Digester (Oshkosh, WI)

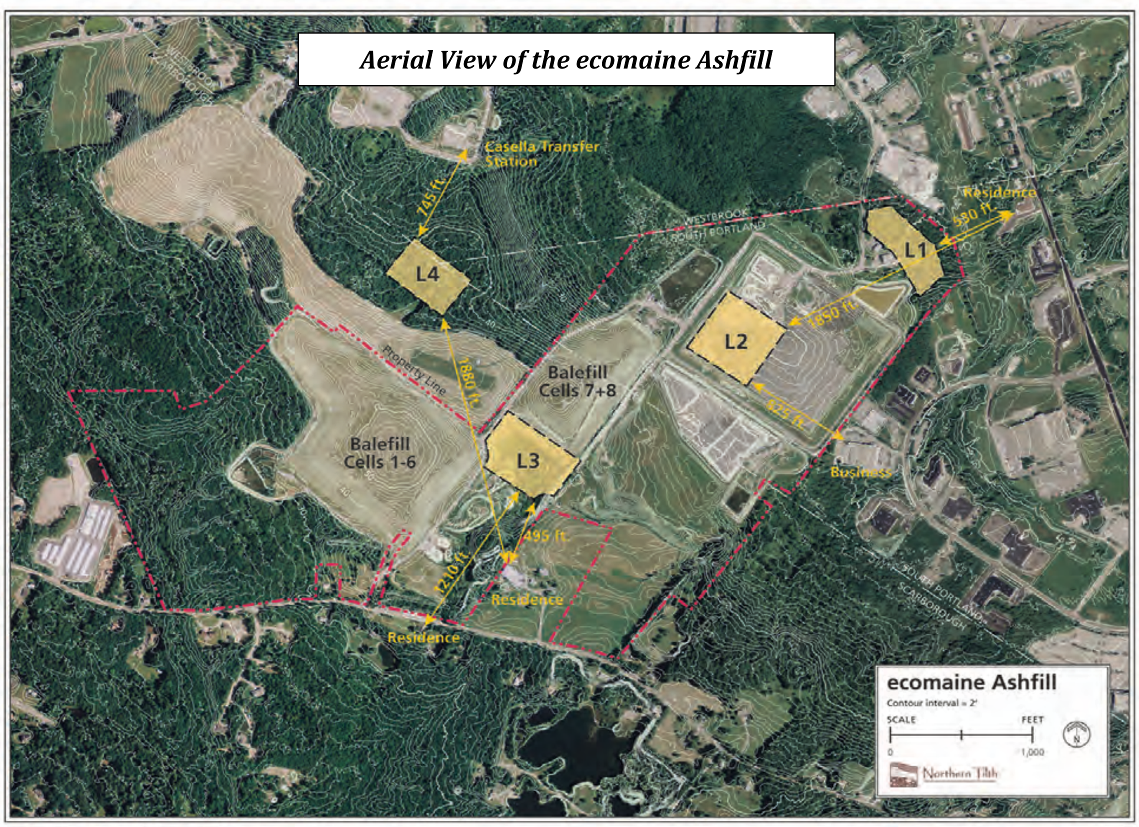
Enclosed Aerated Static Pile Composting Operation (Chittenden Solid Waste District, VT)

Based on the results from this evaluation, the project team developed a preliminary conceptual design for an Enclosed Aerated Static Pile composting system to help frame the analysis of suitable site locations in the site evaluations in Task 4.

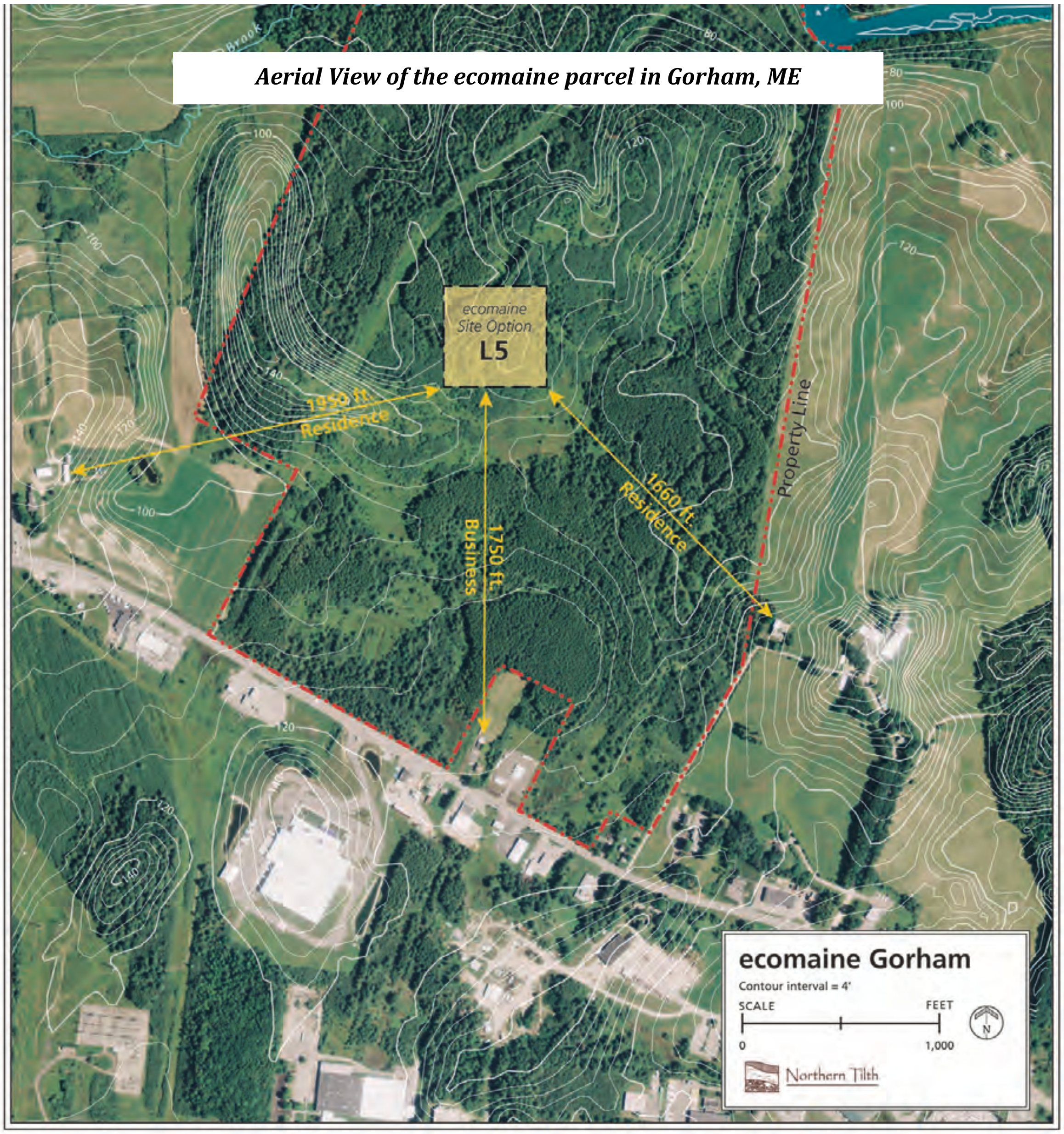
Site Evaluations (Task 4)

ecomaine owns two large parcels of land, including the 260-acre ashfill site that straddles the border between South Portland and Scarborough and a 258-acre, undeveloped site in Gorham. Both of these sites have areas on which organics processing facilities could potentially be built. Consequently, ecomaine has the option of developing an ecomaine-owned facility or relying on the existing composting and anaerobic digestion infrastructure in Maine for processing SSO collected from the ecomaine service area.

Of the locations evaluated on ecomaine-owned land (or land that may be available to ecomaine), a wooded area adjacent to the northwestern border of the ashfill (Site L4) holds the most promise for developing a facility. This location would take advantage of the proximity and existing infrastructure at the ashfill and provide ample setbacks from neighboring residences and businesses. Another area in the center of the property (Site L3) could also work, if, in the future, ecomaine purchases the property, including a farm and residence, which is surrounded by the ashfill property along Running Hill Rd. ecomaine's parcel in Gorham has a high area in the center of the parcel (Site L5) that would allow for large setbacks and visual screens from surrounding properties. Two drawbacks to this site are that the site is completely un-developed and it is a longer distance from the WTE plant than the ashfill.



Aerial View of the ecomaine Ashfill



Aerial View of the ecomaine parcel in Gorham, ME

There is approximately 46,000 tons of "merchant processing capacity" for processing SSO (including anaerobic digestion and composting facilities) within a reasonable hauling distance from ecomaine. Approximately 40,000 tons of this capacity has come on line in the past two years and much of this capacity is has not yet been filled with SSO. Additionally, the permitting process is underway for an additional 30,000 tons of capacity for a planned anaerobic digester at the Brunswick Naval Air Station. In short, there is sufficient available capacity to process the SSO that would be generated by programs within the ecomaine service area, and because organics programs are likely to build slowly, partnering with existing facilities may be favorable to developing a facility on ecomaine-owned property. Not all of the organics processing facilities are likely to meet ecomaine's risk minimization goals though. The following table summarizes advantages and disadvantages to partnering with some of these existing facilities.

Comparison of Attributes of Potential Partnering Options			
Location	Operational Status	Advantages	Disadvantages
Benson Farm, LLC – Gorham, ME	Existing	Proximity to ecomaine, established program, good relationship with DEP, some experience with residential SSO, cost competitive	Composting technology and site upgrade needed to meet capacity and risk minimization needs, low tolerance for contamination
Resurgam Zero Food Waste – Portland, ME	Existing	Proximity to ecomaine, established program, experience with commercial SSO	Planning on moving operations to Maine Waste Solutions Facility in Auburn, Maine (below)
Maine Waste Solutions – MB Bark facility, Auburn, ME	Permitted	Available capacity (once constructed), technology compatible with ecomaine risk minimization needs, experience with commercial SSO	Distance from ecomaine, costs unknown, need more information about tolerance for contamination and compostable bags
Dubois Livestock and Excavating, Inc. – Arundel, ME	Existing	Available capacity, established program, cost competitive	Composting technology not compatible with ecomaine risk minimization needs
Little River Compost – Lisbon Falls, ME	Existing	Technology compatible with ecomaine risk minimization goals	Distance from ecomaine, limited experience with SSO
LAWPCA digesters – Lewiston, ME	Existing	Potentially cost competitive, meets ecomaine risk minimization goals	Distance from ecomaine, lack of pre-processing capacity, low tolerance for contamination
Exeter Agri-Energy digesters – Exeter, Maine	Existing	Potentially cost competitive, meets ecomaine risk minimization goals, experience with handling commercial SSO	Distance from ecomaine, low tolerance for contamination (although they are adding equipment to address this)
Village Green Ventures – Brunswick, ME	Planned	Potentially cost competitive	No previous experience in organics processing, distance from ecomaine, not yet permitted, low tolerance for contamination, may not meet risk minimization goals

WTE Impacts from Organics Recycling Programs (Task 5)

With the development of a successful organics recycling program within the ecomaine service area the characteristics of the solid waste fed to the WTE plant will change. As food scraps and compostable paper are diverted from the solid waste stream, the remaining waste will have less moisture and a higher percentage of plastics, and this shift in waste compositions has the potential to change the heat value of the solid waste as a fuel. In order to assess the impact of changes in the solid waste stream from organics recycling on the operations of ecomaine's WTE plant, the project team used the waste composition profiles from Task 1 to predict changes to heat value in the solid waste under the three diversion scenarios developed in Task 1. For these calculations it was assumed that the tonnage of diverted organics would be replaced with solid waste on the spot market that has a similar composition to the solid waste currently accepted at the WTE plant.

Using these assumptions, the predicted heat value of the solid waste stream increased by 0.8%, 3%, and 5%, respectively, for the low-end, medium and high-end organics diversion scenarios. Because operations at the WTE plant are generally steam-limited, meaning the WTE plant is already generating as much steam as can be used by the steam turbine, the increase in heat value is unlikely to result in more electricity being generated at the WTE plant. Because natural gas is sometimes used to supplement the solid waste in the WTE boilers, especially during wet weather, it is possible that the higher heat value of the fuel could reduce the need for some of the natural gas. In a worst-case scenario, the higher heat value in this steam-limited system could result in the need to lower tonnage fed to the WTE plant. However, experience at a WTE plant in Vancouver, British Columbia which serves a population in which an aggressive organics program that has been developed in the past few years and which uses a similar mass burn technology to that used at ecomaine, indicates that the change in fuel that comes with an organics program will not necessitate taking in less tonnage or any other significant changes to WTE plant operations.

Organics Diversion Scenario	Organics Diverted from WTE (tons/yr)	Adjusted Heat Capacity of Solid Waste (kcal/kg)	Increase in Heat Value of Solid Waste
Current	NA	3,070	NA
Low-end	3,100	3,094	0.8%
Medium	11,900	3,163	3%
High-end	21,000	3,233	5%

Based on current air emissions data from the WTE plant and the predicted changes in emissions that would come with an organics recycling program, the project team has determined that emissions are unlikely to change significantly, but that NOx emissions, which are currently the closest to the limits for the regulated emissions parameters, should be monitored closely to track potential increases.

Market Evaluation (Task 6)

If ecomaine decides to develop their own SSO processing facility, an evaluation of the potential market for energy products from anaerobic digestion and soil amendments from composting is necessary to help determine operating costs and to provide guidance for the production process. In order to evaluate the markets, the project team considered energy and compost products that would be generated from a facility handling 12,000 tons per year of SSO, the mid-range organics diversion scenario from Task 1.

A dry fermentation anaerobic digestion facility processing 12,000 tons per year of SSO would generate approximately 36 million standard cubic feet (scf) of biogas per year. If combusted to convert to electricity, this amount of biogas would produce approximately 1.9 million kWh/yr. Assuming that this electricity could be sold at the $0.10/kWh offered by the Maine PUC's Community-Based Renewable Energy Program, the electricity would provide approximately $190,000 in annual revenues. At this time, though, this offering would only be available if the Maine Legislature votes to extend the program (Cook 2013). If converted to compressed natural gas (CNG), the biogas from the facility would generate approximately 161,000 diesel gallon equivalents (DGE) of fuel per year, which would equate to approximately $180,000 in revenue annually based on the current rate at which Portland Metro is buying natural gas from Sprague Energy, although this price is expected to increase in the future. With the projected increase in CNG use in southern Maine, this market appears to be more promising than converting the biogas to electricity, and consequently, conversion to CNG is used for the cost estimates calculated in Task 7.

The solid by-product (“digestate”) resulting from the dry fermentation anaerobic digestion process requires further processing, typically composting, prior to use as a soil amendment. Its physical form does not lend itself to direct land application when removed from the digesters. Dry fermentation, then, is an energy extraction process, and not the final step in processing organics.

An aerated static pile (ASP) composting system processing 12,000 tons per year of SSO would produce approximately 18,200 cubic yards (CY) of finished compost. Maine has a relatively mature composting industry (primarily for yard trimmings, manure, and biosolids) which provides insight into the likely markets and value of compost sold in in the state. While many promising innovative uses for compost are being developed, including for stormwater management, erosion control, site restoration, and in containerized horticulture, current trends of compost sales suggest that these higher value markets are not yet well developed in Maine. Existing regional compost producers generate an estimated 40,000 CY of compost/year that is marketed in the ecomaine service area. The project team’s estimates are that approximately one-third of this compost is sold primarily to residential and commercial landscaping markets in the price range of $25 to $45/CY for bulk wholesale sales. The remainder is sold or given away primarily to volume markets, mostly topsoil blending operations, in the price range of $0 to $20/CY.

The current market in the ecomaine service area could easily absorb the additional supply of compost that would come from an ecomaine-owned compost facility, provided the quality is high. Using a conservative sales price of $15/CY for 18,200 CY of ecomaine composts going primarily to landscape and topsoil blending markets, the potential revenue from annual compost sales would be approximately $275,000. Should ecomaine decide to develop their own composting facility, the focus on producing a high quality finished product would represent a paradigm shift from ecomaine’s current operations in which the final product is either disposed (as is the case with ash from the WTE plant) or baled and transported to other facilities for further processing. For composting, the value of the final product largely drives the economics of the operation meaning that the production of a high quality end product determines whether or not the project is sustainable over the long run.

Economic Analysis and Conceptual Organics Recycling Plan (Task 7)

Based on the findings of Tasks 1 through 6, and based on the constraints for collecting and processing organics in the ecomaine service area in accordance with ecomaine’s environmental and economic goals, the project team developed several alternatives that accommodated a multitude of choices in terms of diversion strategies, collection options, processing approaches, and product markets. The project team then held a workshop for ecomaine staff on May 21, 2013 to discuss the merits and risks of the different alternatives. Based on feedback from ecomaine staff during the workshop, the project team further refined cost estimates for several systems and ecomaine hired D&B Engineers and Architects to provide a preliminary design and cost estimates for a co-collection SSO system sorting operation.

Ten alternatives were ultimately chosen for macroeconomic analysis. Five “centralized” alternatives included composting or a combination of composting and anaerobic digestion (AD) at an ecomaine owned and operated facility using enclosed ASP composting and dry fermentation AD. Four “decentralized” alternatives were based on ecomaine developing partnerships with existing organics processors, through a certification process that would ensure that the processors could operate in accordance with ecomaine’s risk minimization goals. For the first nine alternatives there were variations in the type of collection systems used, including EOW, Blue Bag-type, and dedicated collection systems. For the Blue Bag-type systems, three of the alternatives (2, 4 and 7) included developing a sorting operation in which the SSO bags would simply be manually sorted from the remainder of the co-collected trash and shipped to a processor. Alternative 8 was a Blue Bag-type collection system in which the sorting operation would include ripping open the SSO bags and then further sorting the contents of the SSO for contamination. The final option (Alternative 10) was considered the Free Market option in which case ecomaine would play no role in organics recycling, and would simply let organics programs in the ecomaine service area develop with the risk of additional leakage of solid waste from its control and the risk of poor management of the organics on the processing end. The alternatives and the per ton price for combined collections (above and beyond current solid waste collection costs) and processing using the medium range organics diversion scenario of 12,000 tons per year) are summarized in the following table.

Some key findings from the macroeconomic analysis are as follows:

- The type of collection system was by far the largest cost component leading to the differences in costs between the alternatives, with EOW collection systems being the least expensive, followed by Blue Bag-type systems and with dedicated collection systems being the most expensive.
- The Blue Bag sorting operation option in which bags are ripped open, separated from the SSO and the SSO is further sorted for contamination has slightly higher capital costs and operations costs than the bag sorting only option, but because this option allows for the use of less expensive plastic (non-compostable) bags, the total costs are less than for the others.
- For centralized options including ecomaine owned and operated facilities, given the same collection systems, composting alone was $38/ton less expensive than the combination of AD and composting.
- Estimated processing costs for composting SSO at an ecomaine owned and operated enclosed ASP facility (taking into account capital and operating expenses) were very similar to estimates for using existing processors to compost or anaerobically digest the SSO ($44/ton vs. $42.50/ton, respectively).

Ecomaine Organics Collection and Processing Alternatives					
Alt.	**Where**	**Ultimate Capacity**	**Collection**	**Processing Technology**	**Per Ton Cost (collections and processing)**
1	ecomaine property	12,000 ton/yr	EOW Collection	Composting Only	$71
2	ecomaine property	12,000 ton/yr	Blue Bag-type Collection	Composting Only	$178
3	ecomaine property	12,000 ton/yr	Dedicated organics collection	Composting Only	$383
4	ecomaine property	12,000 ton/yr	Blue Bag-type Collection	AD and Composting	$216
5	ecomaine property	12,000 ton/yr	Dedicated organics collection	AD and Composting	$421
6	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	EOW collection	"Certified Merchant Processors"	$74
7	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Blue Bag-type Collection	"Certified Merchant Processors"	$181
8	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Blue Bag-type Collection with bag-opening operation	"Certified Merchant Processors"	$153
9	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Dedicated organics collection	"Certified Merchant Processors"	$386
10	Decentralized (free market)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Haulers develop most cost-effective approach	Any processor	NA ($186,000 per year loss due to leakage)

This study compared cost estimates for implementing curbside organics collection programs in three example ecomaine communities with different current arrangements for collection of trash and rubbish, using the same assumptions that were used to develop the estimates for the ten collection and processing alternatives and assuming that the SSO would be processed at an existing organics processor that would be certified by ecomaine as a suitable partner. For the City of Portland, due to its lower reported costs for curbside collection of trash and recycling, the difference in cost between dedicated collection and the other two options (on a population weighted basis) is not as large as that difference for the other two communities.

Organics Recycling Costs for Communities Representing Different Curbside Collection Models in the ecomaine Service Area			
Community	**Gorham**	**Scarborough**	**Portland**
Existing trash and recycling collection model	*PPB*	*Curbside Cart*	*PPB-municipal*
Approximate # HH served	5,100	7,800	23,400
Assumed participation rate	45%	45%	45%
Price per bag of trash	$2.50	NA	$2.00
Reduction in purchased trash bags per month	1	NA	1
Savings to residences on trash bag purchases*	$68,850	NA	$252,720
Tons per year of SSO collected	500	764	2,293
Processing savings to the community for recycling SSO	$6,246	$9,553	$28,660
Additional annual costs for containers for participating HH	$9,180	$14,040	$42,120
		Dedicated Collection	
Additional hauling costs per year	$275,400	$421,200	$505,440
Additional processing costs per year	$8,501	$13,001	$39,003
Container costs (from above)	$9,180	$14,040	$14,040
Overall Increase in Annual Costs	**$286,834**	**$438,688**	**$529,823**
		Blue Bag Collection *(w/ bag and contaminant removal)*	
Additional hauling costs per year	$0	$0	$0
Additional processing costs per year for sorting operation	$42,136	$64,444	$193,332
Additional costs for Blue Bag program bags	$9,994	$15,285	$45,856
Container costs (from above)	$9,180	$14,040	$42,120
Overall increase in annual costs	**$55,064**	**$84,216**	**$252,648**
		EOW Collection	
Additional hauling costs per year	$0	$0	$0
Additional processing costs per year	$8,501	$13,001	$39,003
Container costs (from above)	$9,180	$14,040	$42,120
Overall increase in Annual Costs	**$11,434**	**$17,488**	**$52,463**

**While residents of PPB communities will save money by purchasing less trash bags, this savings will represent a loss of revenue to the municipalities in their solid waste programs, consequently, this savings to residents is not included in the calculation of the overall increase in annual costs.*

The following table summarizes the pros and cons of the three collection options.

Organics Collection Options for Consideration and Relative Costs		
Program	**Pros**	**Cons**
Dedicated collection	• the most widely used collections model for curbside collection of organics in the US (already implemented in the ecomaine service area by Garbage to Garden) • no sorting operation necessary	• the most expensive option • more truck traffic than the other options
Blue Bag-type collection	• no additional hauling costs • sorting operation could allow for contamination removal step	• only one existing model for this type of system in the US, and it is only a little over one year old • sorting operation necessary • lower participation rates dramatically increase per ton processing costs
Co-collection with EOW trash collection	• no additional collections costs for current split-body trash/recycling systems (this has been demonstrated in Hamilton, MA) • no sorting operation necessary • can increase recycling rates for traditional recyclables	• represents a significant shift in disposal behavior patterns for residents • would need strong political support in order to make the shift to EOW

Cost estimates for transfer station drop-off programs for organics were analyzed separately from organics programs for curbside communities because of the difference in collection models. Two potential transfer station drop-off programs were investigated. In the first model, SSO collected at a transfer station would be integrated into an existing yard trimmings composting operation at the same location. In the second model, SSO would be collected in lidded roll-carts or small dumpsters at a transfer station and then transported to a local composting operation (most likely an on-farm composting operation) for processing. For estimating costs, using a transfer station that serves 3,000 households (similar in size to the Yarmouth and Cape Elizabeth transfer stations) and a participation rate similar to the highest rates observed in New England for drop-off programs, the amount of SSO collected would be close to 100 tons per year and would result in a savings of approximately $4,000 per year in the first model and an additional cost of approximately $5,500 in the second model compared to not developing the drop-off programs.

Conclusions and Recommendations

Based on this study's findings, including the macroeconomic analysis completed for this project, the project team recommends the following steps for moving forward with developing organics recycling programs in the ecomaine service area:

- For transfer station drop-off communities, identify member communities that are interested in developing organics drop-off programs and help to educate these communities on getting started and maximizing participation rates.
- For curbside communities, facilitate meetings first with community solid waste managers to discuss the pros and cons of the three collection methods characterized in this study. Second, facilitate meetings between the solid waste managers and their haulers to discuss the logistics of implementing collections by the most promising method for each community (emphasizing the pros and cons of EOW, Blue Bag-type and dedicated collection systems).
- Take a phased approach to developing organics programs, which provides the opportunity to determine if building an ecomaine-owned facility will be necessary in the long run and to assess the effectiveness of education and outreach in minimizing contamination levels in the SSO (which will help to determine if further sorting is necessary).
    - Identify specific communities that are interested in offering organics collection and help these communities choose the initial routes or neighborhoods that provide a good cross section of the community (in order to avoid cherry picking areas that are likely to have high participation and low contamination rates or vice versa).
    - Manage these early programs as the initial phase of a larger service area-wide program instead of discontinuous pilot programs.
- Develop a certification program and contracted capacity with existing organics processors to ensure adequate processing capacity during the first years of development of the programs. Work closely with the processors to develop a final list of allowable organic items, addressing issues such as compostable bags, and have plans in place to manage potential contamination in the SSO.
- Concurrently, for long term planning purposes, explore the potential for buying the parcels of land that would be necessary to develop Site L3 and Site L4 at the ashfill and ultimately decide on whether to plan for an organics processing facility at either of those two sites or at Site L5 at the Gorham parcel. Once a location is chosen, reach out to planning officials within the community in which the site is located and initiate the data gathering process for information that will be required in permitting and developing the site.
- To minimize transportation costs and to provide a consistent drop-off location for haulers, ensure that transfer station capacity exists for organics collected by member communities, considering the following:
    - For Blue Bag-type programs, the sorting operation will also act as a transfer station.
    - For EOW or dedicated collection programs, the construction of a permanent transfer station at the WTE plant would likely be necessary (and was included in cost estimates) as participation increases. For the first phase of the program, it may be possible to

construct a small bunker on the existing tip floor, construct a lower cost fabric building within the footprint of the WTE plant, or partner with a local operator that has a site permitted for the storage of solid waste.

- To minimize the duplication of efforts for communities developing organics programs, establish consistent educational and outreach materials to be used for development of the programs in all ecomaine member communities. This would include a consistent list of "allowable" organics. A recommended list for an inclusive program is included in Section 7 of the full report.

1.0 Organic Waste in the ecomaine Service Area

Key Findings of Task 1

The following items summarize the findings of Task 1: Organic Waste in the ecomaine Service Area.

- A review of recent solid waste composition studies indicate that approximately 36,000 – 47,000 tons of the non-spot market tonnage delivered to the WTE plant in 2012 consisted of targeted organics
- Existing leaf and yard waste programs in the ecomaine owner and associate member communities already divert approximately 15,000 tons of ***yard trimmings*** (collectively leaves, grass, garden residuals and houseplants) and brush from the solid waste stream.
- Existing source separated organics (SSO) programs in the ecomaine service area capture and process approximately 4,400 tons per year of targeted organics, such as seafood processing waste, pre-consumer vegetative wastes from supermarkets and food scraps
- Data from existing drop-off programs for targeted organics in the US indicate that participation in these programs is quite variable, with reported diversion rates ranging from 1 to 27 pounds per person per year in the communities in which they are offered, and successful programs provide insight into methods for increasing participation
- For curbside organics collection programs in the US in which yard trimmings are not included, diversion rates are consistently between 7 to 12 pounds per household per week. Reported collection rates in New England, including in a newly developed program in Portland, Maine and in Hamilton, MA are between 10 – 12 pounds per participating household per week
- Mandatory recycling programs, especially when combined with Pay As You Throw incentives to reduce rubbish tonnage, are much more effective in diverting targeted organics than are voluntary programs.
- A low, medium and high-end scenario for the potential diversion of residential targeted organics from the ecomaine waste stream (not including spot market waste) is as follows:
    - low-end → 3,100 tons
    - medium → 6,800 tons
    - high-end → 13,900 tons
- An estimate on the amount of commercial targeted organics that could be diverted from the waste stream ranges from 5,100 to 7,100 tons, although a more detailed analysis of the make-up of the commercial sector would be required to make a more precise estimate.
- The combined diversion scenarios for both residential and commercial organics used for calculations throughout the study were as follows:
    - low-end → 3,100 tons (residential only)
    - medium → 11, 900 tons (6,800 tons residential and 5,100 tons commercial)
    - high-end → 21,000 tons (13,900 tons residential and 7,100 tons commercial)

In 2012, 63,734 tons of residential solid waste and 68,824 tons of commercial solid waste were delivered to the ecomaine Waste to Energy (WTE) plant, not including the spot market tonnage accepted at the facility. In an effort to determine the potential for organic waste diversion and recycling in the ecomaine service area it is necessary to develop a sound estimate of the organic portion of the waste stream currently delivered to ecomaine's WTE plant. Further, it is necessary to determine the portions of the disposed organic waste stream that are suitable for processing, either through composting and/or anaerobic digestion. Finally, in order to provide a practical estimate of the capacity of organic processing infrastructure that will be required to serve new organics collection programs, it is necessary to determine the portion of the suitable, or *targeted,* organics that could reasonably be expected to be diverted from the municipal solid waste stream based on information from existing organics diversion programs in the US and Canada.

1.1 Residential Waste Composition

1.1.1 Residential Organic Waste Targeted for Collection

The organics portion of the solid waste stream encompasses a wide range of materials, including food scraps (vegetative, meat, dairy, bones, coffee grounds, etc.), leaves, grass, garden trimmings and house plants (collectively ***yard trimmings***), brush, kitty litter, dog waste, diapers and a host of smaller components that don't fit into other waste categories. Relative to organics diversion, soiled and otherwise unrecyclable paper (i.e., used paper towels and other food-soiled paper) are typically categorized as a portion of the paper component of solid waste, but can be and are successfully handled at many organics processing facilities. Existing residential organics programs in the US differ in the breadth of the organic components of the waste stream that are targeted for diversion. Generally, the more inclusive the program (the broader the allowable types of organic materials accepted), the higher the residential participation rate, and the higher the overall diversion rate. Based on a 2010 survey of existing residential organics recycling programs in the US it was determined that 90% of the programs accepted meat and dairy products as part of the food scraps collections (Ecoconservation Institute, 2010). The study also found that including soiled paper can help encourage organics diversion. Animal litter and diapers together constitute a measurable portion of the organic component of the waste stream, but are often not included in residential organics collection programs. For the purposes of estimating the amount of organic waste that could be diverted from ecomaine's solid waste stream into a recycling program, *targeted organics* will include all food scraps, soiled/compostable paper and yard trimmings.[3] Diapers, animal litter and any other wastes in the organics category will not be considered targeted organics for the purposes of preliminary estimates, but a discussion on the merits of including animal litter in an organics diversion program is included below.

1.1.2 Estimates of Residential Waste Composition in Maine

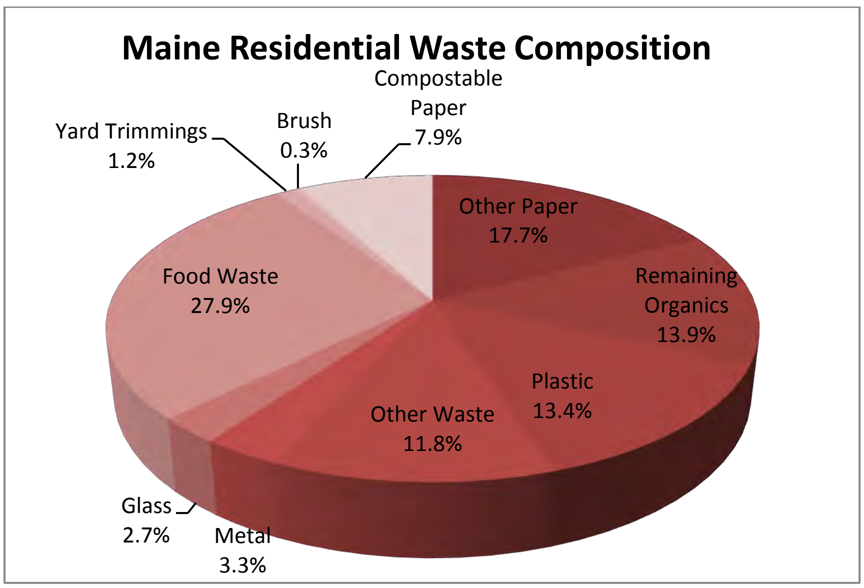
The *2011 Maine Residential Waste Characterization Study* (Criner and Blackmer, 2011) represents the most recent survey of the composition of residential solid waste in Maine. For this study, two *waste sorts*, one in the summer of 2011 and one in the fall of 2011, were conducted using randomly-selected residential waste loads from 17 communities in Maine. The surveyed communities ranged in population

[3] In this study, ***targeted organics*** refers to organic materials targeted for diversion from the solid waste stream and ***Source Separated Organics (SSO)*** refers to targeted organics after they have been separated from the solid waste stream, either at the point of generation (a residence or a commercial operation) or at a centralized sorting facility.

from 892 (Ogunquit) to 41,326 (Augusta). The second largest community in the study was Scarborough, an ecomaine owner member community, with a population of 18,919.

As of 2011, the overall recycling rate for the State of Maine was 39.6% (Maine Department of Environmental Protection 2013). A summary of Maine's residential waste composition, after recycling, as determined by the University of Maine study is included in Figure 1-1. Results from the University of Maine's study indicate that food waste, at 27.9% of the waste stream represents the largest single category remaining in residential waste after recycling. Relative to targeted organics, food-soiled paper and other non-recyclable paper capable of being composted represent an additional 7.9% of the waste stream. The amount of yard trimmings disposed of as solid waste is low (approximately 1.2% of the total waste stream), suggesting that this component of organic waste, which nationally represents approximately 8.6% of the municipal solid waste stream (US Environmental Protection Agency [USEPA], 2010) is already being effectively diverted from disposal in Maine. Results from the University of Maine study suggest that targeted organics (the combination of food waste, compostable paper and yard trimmings) make up 37% of the residential waste stream, which appears to be on the high end of the findings from waste composition studies completed in other states in the US

Figure 1-1 Maine Residential Waste Composition based on 2011 University of Maine Study



The finding in Maine that food scraps represent the single largest component in the disposed solid waste stream mirrors the findings of waste composition studies across the US Relative to other US studies; however, the results indicate that Maine's disposed waste has a higher than average percentage of food waste. Table 1-1 provides a summary of the results of several recent solid waste composition studies from around the country that included results for disposed residential solid waste.

Oregon was the only state that reported a higher percentage of food waste than Maine (28.9% compared to 27.9%). Results from the other states ranged from 11.8% to 22.7%. Comparing

Table 1-1 Organics Composition of Disposed Residential Waste from US Studies

Area	Year	Food Waste	Compostable Paper	Yard Trimmings	Targeted Organics
Maine	**2011**	**27.9%**	**7.9%**	**1.2%**	**37.0%**
Vermont[4]	2013	16.7%	6.2%	3.2%	26.1%
Massachusetts[5]	2011	15.5%	7.0%	Not reported	NA
Connecticut[6]	2010	13.7%	9.8%	10.7%	34.2%
Washington[7]	2009	22.7%	5.0%	8.7%	36.4%
Wisconsin[8]	2009	17.5%	7.2%	6.9%	31.6%
Oregon[9]	2009	28.9%	3.8%	5.8%	38.5%
Delaware[10]	2006	11.8%	6.9%	14.2%*	32.9%
Georgia[11]	2005	13.4%	10.7%**	2.1%	26.2%
Pennsylvania[12]	2003	12.2%	10.1%**	7.6%	29.9%
Average***		18.0%	6.7%	5.8%	32.5%
				Range	**26.2 – 38.5%**

**Includes brush.*

***The reported number for "non-recyclable" paper, which may include non-compostable materials.*

****Average values are determined by category, consequently, the average % targeted organics does not equal the sum of the averages from each category*

methodologies for the waste sorts used to determine solid waste composition, one difference between the University of Maine studies and all of the other studies listed in the table is that the University of Maine study only included "baggable trash" in the waste sorts. The other studies also included bulky waste. Bulky wastes are likely to consist primarily of materials that would not be diverted into an organics recycling program. For instance, the Ohio waste characterization study found that of the bulky materials found in the waste sorts, loose wood was the largest component, followed by carpet and construction and demolition (C&D) debris. Similarly, the Pennsylvania study found that the top three most prevalent bulky items were C&D debris, unpainted wood and painted wood, and that the only compostable element of the bulky items, yard waste, represented only 3.8% of this sub-category of waste. Consequently, by not including bulky waste in the waste sorts, it is possible that the results from the University of Maine study may report a higher percentage of compostable waste than would be found in the actual tonnage of residential solid waste that is delivered to the ecomaine WTE. However, three factors related to the waste stream delivered to the ecomaine WTE suggest that the University of

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[4] DSM Environmental Services, Inc., et. al., 2013
[5] Massachusetts Department of Environmental Protection (MA DEP), 2011
[6] DSM Environmental Services, Inc., et. al., 2010
[7] Washington State Department of Ecology (WA DOE), 2010
[8] Recycling Consultants and MSW Consultants, 2009
[9] Oregon Department of Environmental Quality (DEQ), 2010
[10] Cascadia Consulting Group, et. al. , 2007
[11] Georgia Department of Community Affairs, 2005
[12] Pennsylvania Department of Environmental Protection (PA DEP), 2003

Maine's methodology may be an appropriate estimation of the waste composition of ecomaine's residential waste tonnage:

1. Several of the largest ecomaine communities have Pay Per Bag (PPB) programs, which likely limits the amount of bulky wastes coming to the WTE plant
2. bulky waste is reported as a separate category by ecomaine, and in 2012 bulky waste accounted for only 2.2% of the residential solid waste
3. ecomaine limits the amount of C&D debris (often the largest component of residential bulky waste) coming into the WTE plant

In general, the University of Maine waste composition study indicates that Maine's solid waste is on the high-end relative to food waste composition compared to wastes from other states in the US but is on the low-end relative to yard trimmings. While there are some differences in the University of Maine's waste composition study methodology from those used in other states, ecomaine-specific waste management factors suggest that the results from the study are relevant to the residential solid waste currently delivered to the WTE plant.

1.1.3 Impact of Population Density on Residential Waste Composition

Several waste composition studies have investigated the impact of population density on residential waste composition. In general, these studies have found population density has little impact on waste composition. The 1994 University of Maine study determined that differences in waste composition as they relate to population size were not statistically significant, although there was a slight decrease in food waste as a percentage of the total waste stream with increasing population. This study also found no difference in the waste composition profile when comparing inland and coastal communities. In the 2002 Vermont waste composition study, differences in residential waste composition between urban/suburban and rural areas were determined to be small and likely an artifact of sampling variability, leading the study to conclude that the residential waste stream was relatively homogenous throughout Vermont. The Wisconsin solid waste composition study from 2009 found no significant change in food waste as a percentage of the waste stream when comparing residential wastes from three categories of population density (large metro, small metro and rural). The Pennsylvania study showed very little difference in the organics as a percent of the total disposed waste stream between urban, suburban and rural collection areas. In the Pennsylvania study, food scraps as a percentage of the solid waste stream were determined to be 12.4%, 11.2% and 13.1% and total organics were found to be 34.9%, 33.6% and 34.4% for urban, suburban and rural sectors, respectively.

Because of the geographic and demographic similarities between the two states, the population density-related conclusions of the Maine and Vermont studies are most relevant to waste from ecomaine's service area, but the findings from the Wisconsin and Pennsylvania studies provide further evidence that the percentage of targeted organics in the residential waste stream is not likely to change significantly between ecomaine member communities as a result of population density. Consequently, for the purposes of estimating targeted organics in the residential waste stream in the ecomaine service area, no adjustments will be made based on population density of the communities from which the waste is being generated.

1.1.4 Estimate of Targeted Organics in ecomaine's Residential Waste Stream

Based on the previous information, when including food waste, compostable paper and yard trimmings as targeted organics, results from the University of Maine study suggest that 37% of the residential waste stream in Maine has the potential to be diverted to an organics recycling program. Applying this percentage to the 63,734 tons of residential solid waste hauled to the ecomaine WTE in 2012, approximately 23,600 tons of targeted organic waste per year have the potential to be diverted to a recycling program.

1.2 Commercial Waste Composition

To date there has been no systematic quantification of the composition of commercial solid waste in Maine. In order to estimate the amount of targeted organics in ecomaine's commercial waste stream it is necessary to draw on information gathered in other areas of the US. Table 2 provides a summary of the targeted organics portion of the commercial waste stream from several US states, based on waste characterization studies completed within past ten years, all of which used comparable, generally accepted waste sort methods.

A more precise method for determining the amount of targeted organics in the commercial solid waste stream is to look at the results of surveys specifically identifying tonnages of targeted organics from commercial generators, such as restaurants and grocery stores, which are likely to produce higher volumes of targeted organics. While this type of study has not been completed in Maine, Massachusetts, Connecticut and Vermont have all had such studies completed in the past four years. The 2009 Vermont study investigated high-volume commercial food scraps generators town by town (Stone Environmental, 2009).

In Vermont, the Chittenden Solid Waste District (CSWD) provides a potentially good comparison to the ecomaine service area because both entities service a major northern New England city (Burlington in CSWD and Portland for ecomaine) and the smaller suburban and rural communities surrounding it. The Vermont study by Stone Environmental found that commercial food waste generators in the CSWD generate approximately 12,600 tons per year of food scraps and food processing waste. Commercial generators in the CSWD generate approximately 45% of the 90,000 tons per year (or 40,500 tons) of municipal solid waste in the district (Moreau, 2013). Applying the findings of the Vermont study to the amount of commercial solid waste generated within the CSWD, the targeted organics from the highest-volume commercial generators represent approximately 31% of the commercial solid waste stream.

1.2.1 Estimate of Targeted Organics in ecomaine's Commercial Waste Stream

Without a Maine-specific study of the composition of the commercial waste stream, one method for estimating the amount of targeted organics in Maine's commercial solid waste stream is to use the range found from other state studies. Applying the range of percent targeted organics determined in Table 1-2 (17.9% to 34.1%), the quantity of targeted organics in the 68,824 tons of commercial waste handled in the ecomaine WTE in 2012 is estimated to be between 12,300 and 23,500 tons. Another method would be to apply the percent of targeted organics estimated in the CSWD commercial solid waste stream from the Vermont study of food scraps generators (31%) to ecomaine's commercial solid

Table 1-2 Organics Composition of Disposed Commercial Waste from US Studies

Area	Year	Food Waste	Compostable Paper	Yard Trimmings	Targeted Organics
Vermont[13]	2013	11.2%	3.8%	2.9%	17.9%
Massachusetts[14]	2011	13.7%	5.0%	Not reported	NA
Connecticut[15]	2010	13.2%	6.1%	2.9%	22.2%
Wisconsin[16]	2009	11.4%	4.2%	3.2%	29.0%
Oregon[17]	2009	24.6%	6.2%	2.7%	34.1%
Washington[18]	2009	22.3%	6.7%	0.8%	29.5%
Delaware[19]	2006	13.6%	8.1%	2.0%	23.7%
Georgia[20]	2005	12.4%	10.7%*	3.0%	25.2%
Ohio[21]	2004	14.1%	11.1%*	2.9%	30.2%
Pennsylvania[22]	2003	11.8%	8.3%*	2.5%	22.6%
Average		14.8%	7.1%	2.5%	26.2%
				Range	**17.9% – 34.1%**

**Data reported for "non-recyclable" paper, which may include non-compostable materials.*

waste tonnage, which yields an estimate of 21,340 tons per year. The application of the CSWD data to the ecomaine commercial tonnage puts the estimated targeted organics within the range estimated based on existing state solid waste composition studies but suggests that the actual tonnage would be in the upper end of the range.

Taken together, the estimated quantity of targeted organics in the ecomaine service area, from both residential and commercial solid waste (not including solid waste from the spot market), is between 36,000 and 47,000 tons. It should be noted, however, that the amount of targeted organics in a waste stream does not equate to the amount of targeted organics that can practically be captured from the waste stream (see Section 1.4).

1.3 Existing Organics Programs in the ecomaine Service Area

1.3.1 Yard Trimmings

The University of Maine's 2011 waste composition study found that yard trimmings represent only 1.2% of "baggable" residential waste. The 2002 waste composition study from Vermont also indicated that

[13] DSM Environmental Services, Inc., et. al., 2013
[14] MA DEP, 2011
[15] DSM Environmental Services, Inc., et. al., 2010
[16] Recycling Consultants and MSW Consultants, 2010
[17] Oregon DEQ, 2010
[18] Washington DOE, 2010
[19] Cascadia Consulting Group, e.t al., 2007
[20] Georgia Department of Community Affairs, 2005
[21] Engineering Solutions & Design, 2004
[22] PA DEP, 2003

yard trimmings represent a very small portion of the solid waste stream. Based on a survey of the solid waste managers from ecomaine owner member communities, most of the communities have a drop-off program for yard trimmings, and many communities also provide for curbside collection of yard trimmings for a short period of time during the year (typically for a few weeks in the fall to collect leaves). Some communities, such as Cumberland, South Portland and Yarmouth compost their yard trimmings at a municipally-owned, permitted facility or transfer station. Other communities, including Cape Elizabeth, Portland and Windham, transport yard trimmings to private composting facilities. An additional possible factor for the low percentage of yard trimmings in the solid waste stream is that Maine residents are more apt to compost their own yard trimmings and use mulching lawn mowers that return grass clippings to the soil (sometimes known as "grass cycling") than is the case in more densely populated states. Should ecomaine develop a composting program for organics diverted from the waste stream, yard trimmings, particularly leaves, could provide a useful carbon source. However, relative to disposed organics, it appears that yard trimmings are already largely diverted from the waste stream in Maine.

1.3.2 Brush

Brush, at 0.3% of baggable residential waste according to the 2011 University of Maine study, represents an even smaller percentage of the residential waste stream in Maine. Similar to yard trimmings, most of the ecomaine owner member communities have drop-off programs in place for brush. The majority of the communities surveyed by Northern Tilth have programs in place in which a contractor chips the brush on-site at the drop-off location and then transports the ground brush off-site, either to a biomass plant or to bark mulch dealers. The price paid by the end user for the ground wood chips generally subsidizes the grinding and transportation of the wood chips; the communities are not charged for the grinding and removal of the chipped brush. As with the yard trimmings, chipped brush could be a beneficial compost feedstock additive, more for its structural ability than for its carbon content.
Table 1-3 provides a summary of the yard trimmings and brush collection services currently provided by ecomaine owner and associate member communities reporting either drop-off or collection programs for these materials. It should be noted that much of the reporting on the amounts collected in these programs is estimated, not measured, and therefore do not represent precise figures.

1.3.3 Existing Organics Collection Programs

Beyond yard trimmings and brush, there are a small number of organics collection and recycling programs of significant size currently operating in the ecomaine service area. Several organics programs have developed in recent years, and some of these programs are expanding rapidly. Resurgam Zero Food Waste in Portland initiated a commercial food waste recycling program in 2011, and, according to the partners of the business, their collection route has been growing steadily since they started their program. As of October 2012, Resurgam estimated that they were collecting approximately 150 tons of commercial food waste per month from the Portland area and composting it at their facility, which is co-located at Portland's Riverside Recycling facility.

Table 1-3 Reported Yard Trimmings and Brush Collection Programs

	Yard Trimmings		Brush	
Community	***Received/Collected (tons)[23]***	***Destination***	***Received/Collected (tons)[24]***	***Destination***
Bridgton	30	Composted on site	No estimate	Blended with C&D
Cape Elizabeth	500	Private composter	500	Chipped and removed
Casco	50	Composted on site	152	Chipped and removed
Cumberland	160	Composted on site	130	Chipped and removed
Falmouth	140	Composted on site	No estimate	Chipped and removed
Freeport	120	Composted on site	120	Chipped and removed
Gorham	50	Composted on site	50	Chipped and removed
Gray	360	Composted on site	No estimate	Chipped and removed
Hollis/Waterboro	70	Composted on site	510	Chipped and removed
Ogunquit	240	Composted On-site	210	Chipped and removed
Portland	3,030	Private Composter	2,790	Chipped and removed
Saco	500	Private Composter	640	Chipped and removed
Scarborough	560	Private Composter	Some brush combined with yard trimmings: no estimate on remainder	
So. Portland	630	Composted on site	690	Chipped and removed
Standish	40	Private Composter	410	Chipped and removed
Windham	140	Private Composter	260	Chipped and removed
Yarmouth	960	Composted on site	1,070	Chipped and removed
Estimated Totals	**7,550**		**7,530**	

Note: This table represents reported data in ecomaine owner and associate member communities from 2011 Annual Solid Waste Reports and follow-up phone survey.

There are two on-farm composting operations that have expanded beyond composting agricultural waste and are permitted by the Maine Department of Environmental Protection (DEP) to compost regulated wastes including yard trimmings, food waste and seafood processing waste. In the most recently available DEP annual reports for these facilities, Benson Farm LLC, in Gorham recorded composting 750 cubic yards of seafood waste and 2000 cubic yards of yard trimmings in 2011. Benson Farm has more recently started accepting some commercial food scraps and the owner, Ed Benson, estimates that they take in approximately 800 tons per year of that waste stream. Dubois Livestock and Excavating, Inc., located in Arundel, reported composting 1125 tons of food processing waste and 525 cubic yards of horse bedding. The food processing waste composted by these facilities is primarily from the greater Portland region.

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[23] For yard trimmings reported by volume, a bulk density of 400 pounds per cubic yard was used to convert to tonnage. This is the low end of the reported range of bulk density for moist, compacted leaves from the On-Farm Composting Handbook, 1992.

[24] For brush, the conversion was 429 pounds per cubic yard based on shrub trimmings from the On-Farm Composting Handbook, 1992

A new business called Garbage to Garden has initiated a curbside pickup program for residential organics in Portland and four surrounding communities. Subscribers pay $11.00 per month to have weekly pickup of food scraps and other organics in a 6-gallon bucket. Garbage to Garden started in August of 2012 and in February 2013 the business stated that they have close to 700 subscribers (Frank, 2013). The organics collected by Garbage to Garden are currently delivered to Benson Farm, LLC for composting.

In addition to these organics collection operations, there are several smaller institutional and municipal organics recycling programs in the ecomaine service areas, mostly in schools. Tibbetts Family Farm in Lyman, Maine operates a horse manure-based on-farm composting operation and is accepting food scraps from several schools in the Lyman area, including schools in Hollis, Kennebunk and School Administrative District (SAD) 57 (Massabesic Middle School). Tibbetts Family Farm also collects organics from three inns in coastal southern Maine (Tibbetts, 2013). The Town of Yarmouth has started accepting food scraps as part of their yard trimmings collection programs. The Town provides a drop-off location for food scraps at the transfer station, and adds the collected food scraps to their compost piles. The amount collected is very low (5 cubic yards reported in 2011). The Town believes that their backyard composting classes combined with a composting bin giveaway program is a more effective approach for diverting food scraps from the waste stream (Street, 2013).

Hannaford Supermarkets, which owns 15 stores in the ecomaine service area, has had an organics diversion program in place for several years. Currently, Hannaford is diverting approximately 5 tons per month of organics from each of these stores, for a total of approximately 900 tons per year. Some of these organics are processed by Resurgam and Benson Farm, LLC, while some of it is delivered to processors out of the ecomaine service area (Harris, 2013).

Based on the current monthly tonnage reported by Resurgam Zero Food Waste, this business is capturing approximately 1800 tons per year of organics from the commercial waste stream in the ecomaine service area. Using a density of 1800 pounds per cubic yard (Shafiur, 2010) to convert the volume of seafood waste processed by Benson Farm LLC into weight, the two on-farm composting operations are capturing another 2600 tons (675 tons and 1125 tons of seafood processing waste from Benson Farm LLC and Dubois Livestock and Excavating, respectively and another 800 tons of food scraps from Benson Farm). The total estimated amount of targeted organics already collected in the ecomaine service area is approximately 4400 tons per year. Based on their reported food scraps diversion rate of 10 to 12 pounds per household per week, Garbage to Garden is currently picking up between 15 and 20 tons of organics per month (up to 240 tons per year). The existing school programs likely represent even less organics than that being collected by Garbage to Garden.

In summary, while existing commercial programs are capturing a measurable portion of the commercial organics waste stream (between 19 and 29% of the estimated amount of targeted organics in ecomaine's commercial waste stream), current residential collections programs in ecomaine's service area are likely capturing less than 2% of the estimated 23,600 tons per year of targeted organics in the residential waste stream.

1.4 Estimates of Achievable Diversion Rates

As previously described, the project team estimates that between 36,000 and 47,000 tons of targeted organics are currently being burned in the ecomaine WTE annually, not including the spot market tonnage. The portion of this tonnage that can practically be diverted from the waste stream will depend on a variety of factors including whether organics recycling is mandatory or voluntary, the ease of participation for residents and commercial establishments, collection route densities, financial incentives for recycling organics and several other factors.

1.4.1 Residential Diversion Rates

A recent survey of existing residential organics recycling programs in the US indicated that the average participation for households within the serviced areas ranged from 35% to 45% (Ecoconservation Institute 2010). This includes both voluntary and mandatory programs, although only 9% of the programs surveyed included mandatory participation. In programs with mandatory organics recycling, participation rates are much higher than for voluntary programs. A summary of the Portland, Oregon curbside residential organics recycling program, which is mandatory, reported that 78% percent of the households were adding food scraps to their organics collection bins after the first year in which the program was offered (City of Portland, Oregon, 2012). In Canada, the Toronto, Ontario residential organics program reports a participation rate of 90%, and the Halifax, Nova Scotia program is over 80%. Both of these Canadian programs are mandatory. When the San Francisco, California residential organics program was still voluntary, participation rates were estimated to be between 35-40% (Center for a Competitive Waste Industry, 2010).

Curbside collection programs, especially when associated with a Pay As You Throw[25] fee structure, increase organics participation rates and are common in most of the successful organics recycling programs in the US (Ecoconservation Institute, 2010). The Town of Hamilton, Massachusetts has been an early adopter for curbside collection of organics in New England. With a population of only 7800, Hamilton has developed a voluntary curbside organics collection program that has achieved greater than 50% participation rate[26] (Clark, 2013). In concert with the organics program, the town provides free, every-other-week (EOW), collection of rubbish and charges a fee if residents require weekly rubbish pick up. The Hamilton Public Works Director attributes some of the high participation rate to this incentive to generate less rubbish (Tomasz, 2013).

Drop-off organics programs typically have much lower participation and capture rates for organics than do curbside collection programs, although some of the longer running programs demonstrate that participation rates can be substantial. Table 1-4 provides a summary of the transfer station drop-off programs surveyed for this report. The Northfield, MA program, managed by the Franklin County Solid Waste Management District (FCSWMD) and in existence for 10 years represents the longest running

[25] A volume-based pricing method for trash disposal (PAYT)

[26] A recent survey indicated that 50% of the organics carts in Hamilton are brought to the curb on any given collection day, using an assumed set-out rate of 70% (see below), this would translate to a 71% participation rate.

program of those surveyed and also has the highest participation rate. Based on the number of reported households using the Northfield transfer station (900) an using the assumption that each participating household is contributing 10 pounds of organics per week, participation rate in this program is estimated to be 17%.

Two other FCSWMD transfer station communities (Whately and New Salem) also have higher reported collection rates for organics on a per capita basis than the other communities in Table 1-4, and much of this may be related to the extensive education and outreach efforts by the FCSWMD (Ameen 2013). In Northampton, MA, a town with a population of approximately 28,500 residents, the transfer station organics drop-off program started off with only 2% of households participating, collecting the equivalent of approximately 26 tons per year. After two years, the program has more than tripled and is now collecting approximately 80 tons per year (Waite 2013).

Table 1-4 Drop-off Programs: Reported Organics Collection in New England

Community	Population	Tons Collected Annually	Pounds/Person/Year
Northfield, MA	3,000	40	27
Whately, MA	1,500	12	16
New Salem, MA	1,000	4.5	9
Northampton, MA	28,500	80	6
CSWD, VT	158,000	350	4
Cambridge, MA	105,000	75	1
Yarmouth, ME	8,060	4	1

Cambridge, MA, which has a population of close to 105,000 people, has had a drop-off program in place for food scraps since 2008 and currently is receiving approximately 2800 pounds per week (close to 75 tons annually) of food scraps from the drop-off program (Mail 2013). One factor that would contribute to lower participation in Cambridge is that fact residents are provided curbside collection for trash and recycling and are consequently not accustomed to dropping off materials at transfer stations. CSWD servicing a population of approximately 158,000 residents and 62,000 households in and around Burlington, VT, has had a food scraps drop-off program in place since 2002. In 2011, approximately 330 tons of food scraps were collected through this drop-off program (CSWD 2012). The organics collection rate in Yarmouth, Maine's transfer station drop-off program is similar to that reported by Cambridge on a per capita basis.

Participation in an organics program does not translate to diverting 100% of the targeted organics from the waste stream of participating households. Information from existing residential organics programs can provide estimates of the amount of targeted organics that can reasonably be expected to be collected from participating households. Because of the low percentage of yard trimmings in the residential solid waste in Maine and because of the existing collection programs for yard trimmings in ecomaine member communities, the project team will be using information from programs in which food scraps and soiled paper are collected separately from yard trimmings.

In the Ecoconservation survey of existing organics programs, it was found that the collection rate for food scraps (inclusive of meat, dairy products, bones, etc.) and soiled paper from participating households was typically between 7 to 9 pounds per household per week, with some of the more mature programs collecting as much as 12 pounds per household per week (Ecoconservation Institute, 2010). In New England, the Town of Hamilton, Massachusetts has estimated that they are collecting approximately 10.5 pounds per household per week of food scraps and soiled paper (Tomasz, 2013), and the Garbage to Garden project in the Portland, Maine area estimates that they are collecting between 10 and 12 pounds per household per week (Frank, 2013). A residential curbside organics pilot program in Brattleboro, VT also reported collecting between 10 and 12 pounds per household per week, and in that program, animal litter was included in the list of acceptable items (Kahler, 2013). The final report from a residential curbside organics pilot program from CSWD indicated that the capture rate for food scraps and soiled paper was 7.6 pounds per household per week, although this only represents data from the winter months (CSWD, 2001).

Obviously, the more inclusive a collection program for residential organics, the higher the capture rate per household. While kitty litter is not broken out as a separate category in the University of Maine residential waste composition study, and therefore could not be estimated in the targeted organics group, it can represent a measurable portion of the waste stream. Toronto's organics program is inclusive of kitty litter and the City estimates that they receive approximately 0.4 pounds of kitty litter per household per week (Vibert, 2013). Kitty litter is accepted in the Hamilton, MA organics program, although dog waste is not. By accepting diapers in their program, the City of Toronto goes beyond what is typically seen as acceptable in even the most inclusive programs in the US. In order to achieve capture rates on the upper end of the 7 to 12 pounds per household per week range, accepting additional organics such as kitty litter may be desirable for an ecomaine organics program. Diapers, on the other hand, present unresolvable problems for both anaerobic digestion and composting operations, and would likely not be included in an ecomaine program.

Thirteen ecomaine member and associate member communities, representing approximately 85,300 households, have curbside collection of rubbish. Due to the complexities involved in food scraps collection systems for larger multi-unit housing and apartment buildings, most residential organics collection programs are initiated targeting single family homes and smaller multi-family units. Of the 85,300 households with curbside collection in the ecomaine service area, 69,400 are single family households, multi-family buildings up to 4 units and mobile homes (US Census Bureau, 2013). These are the households for which developing curbside collection systems for targeted organics would be the most cost-effective.

An additional consideration in estimating diversion for residential programs is the *set-out rate*, or the percentage of time that households participating in an organics program will actually place their organics containers at the curb. In projecting tonnages for the development of a curbside organics program in Cambridge, Massachusetts, the City's Public Works Department used a set-out rate of 70% (City of Cambridge Public Works Department, 2012). In the CSWD pilot program previously referenced, a set-out rate of 69.3% was reported. For the purposes of estimating the capture of targeted organics in a voluntary curbside collection in the ecomaine service area, a 70% setout rate will be used for voluntary programs. For mandatory programs, a set-out rate of 80% will be used.

A range of tonnages that could be expected to be collected from ecomaine owner and associate member communities in a voluntary curbside organics collection program inclusive of food scraps and soiled paper, using ranges for participation and capture rates from surveys of existing programs is presented in Table 1-5. Additionally, the table includes a high-end range of tonnages that could be captured if ecomaine member communities with existing curbside collection programs developed mandatory organics collection programs. In this case the participation rate is estimated based on reporting from the mandatory programs discussed earlier in this section.

Table 1-5 Estimates for Collection of Targeted Organics in Residential Curbside Programs

Considerations	Lower End	Mid-Range	Upper End
Available Households	69,400	69,400	69,400
Type of Program	Voluntary	Voluntary	Mandatory
Participation Rate	35%	45%	80%
Set-out Rate	70%	70%	80%
Collected Targeted Organics (lbs/HH/week)	7	12	12
Tons per year	3,100	6,800	13,900

The estimated population of the ecomaine owner and associate member communities not served by curbside rubbish collection is 74,400, or 29,800 households using an average occupancy of 2.5 people per household.[27] Using the reported capture rates for other organics drop-off programs in New England, it is likely that if drop-off programs were made available in these communities, the amount of targeted organics collected could be as high as 1000 tons per year in mature programs that include targeted and aggressive public outreach and education programs. As evident in Table 1-4, the range of collected organics tonnage on a per capita basis varies greatly, and it is expected that it would take several years of having a program in place before participation rates on the high end of the range could be achieved.

1.4.2 Commercial Diversion Rates

Estimating diversion rates for commercial solid waste is more complex than for residential solid waste because the composition of the waste varies significantly from generator to generator. Not all commercial businesses generate enough organic materials to justify a separate collection program. A 2002 waste characterization study in Vermont investigated the differences in waste composition between different categories of commercial businesses including office, retail, restaurants, grocery and hotel/motels (DSM Environmental Services, 2002). On the high end, organics represented 59.9% of the waste generated by restaurants sampled in summer, whereas organics were only 13.6% of the waste

[27] ecomaine data.

generated in the retail category of commercial wastes (see Table 1-6). In general, commercial organics programs target locations that generate significant amounts of food and food related wastes. Any place

Table 1-6 Organics in Selected Commercial Sector Solid Waste – Vermont Study Results

Commercial Sector	Food Waste and Yard Trimmings as % of Disposed Waste	
	August	November
Office	18.9%	18.9%
Retail	13.6%	15.4%
Restaurants	59.9%	42.4%
Grocery	39.4%	54.5%
Motels/Hotels	No data	20.4%

at which food is produced, prepared, sold or consumed is a good candidate for organics collection, but the larger the generator, the more likely they are to be willing to participate in a program. In some cases commercial generators of organic waste are located near each other (like restaurants) and can be put together to form an efficient route for the collection vehicle, whereas other generators, like supermarkets may generate significant volumes of organic waste to justify a dedicated organics compactor.

There are very few reliable estimates of “participation” among commercial generators using commercial organics collection services. The experience of one city may not translate well to another city as the mix of commercial generators is not always comparable. An example of this is from the Alameda County Waste Management Authority (ACWMA), which does not process or franchise collection, but oversees organics collection and recycling for 16 jurisdictions in California. A recent study documented the number of businesses participating in each of the ACWMA’s jurisdictions commercial organics programs provides some data on commercial participation in Organics Collection Programs. The cities in the ACWMA vary from large (like Oakland, population 395,000) to small (for example the City of Piedmont, population 10,000) and also vary widely in terms of how much commercial business they have (relative to residential). The total number of commercial business accounts across the 16 jurisdictions is almost 20,000. Of these, approximately 6,600 (about a third) were considered “organics generating businesses.” Of the 6,618 commercial businesses deemed to be generating significant organics, 1,125 are currently participating in an organics collection program (about 17%). The ratio of accounts participating to the total number of organics generating businesses range from 0% (due to lack of data in Oakland, a very large city) to 88% in Piedmont, one of the smallest cities in the County (Cal Recycle, 2006). This suggests using county-wide averages may be misleading.

Consequently, estimates of capture rate from the commercial organics stream within the ecomaine service area based on participation rates and tonnages per participant are not likely to provide effective guidance for planning purposes. One existing program that provides some guidance is the CSWD commercial organics program. CSWD has been accepting commercial organics for several years and it currently receives between 3,000 and 4,200 tons per year at their compost facility. Based on their knowledge of the commercial food waste generated in their service area, CSWD believes that they could divert as much as 7,000 tons of commercial organics per year (Moreau, 2013). As stated above, CSWD offers a good regional comparison to the ecomaine service area. The 68,824 tons of non-spot market commercial waste that ecomaine accepted in 2012 is approximately 70% more than the estimated 40,500 tons that CSWD accepts. Using the assumption that the profile of commercial generators in the two service areas is similar, and that similar collection systems, incentives and processing capacity could be provided in the ecomaine service area, experience from the CSWD program suggests that between 5,100 and 7,100 tons could be diverted to organics processing in the ecomaine service area (70% more than the reported range of 3,000 and 4,200 tons per year diverted by CSWD), with the potential for greater tonnage as the program further matures. Although this estimate may work as a ballpark figure for macro-scale planning purposes, a survey of the commercial generators in the ecomaine service area may be necessary to provide a more precise estimate before developing processing capacity for a service area-wide commercial organics program. One factor that limits the percent of commercial organic waste collected in future programs is that larger scale sources of organic waste, such as those generated by food processors are more sought after by early adapters of composting, and, as is the case with the waste streams from Barber Foods and Cozy Harbor Seafood in Portland, ME, the material is already separated from the solid waste stream and composted.

1.5 Task 1 Summary

Using ecomaine 2012 records and the best available data for determining the residential and commercial solid waste composition in Maine, the project team estimates that between 36,000 and 47,000 tons of the non-spot market waste going to the ecomaine WTE consists of targeted organics. Based on the small percentage of yard trimmings and brush found in residential solid waste in Maine, it appears that these organics are already large diverted from disposal. A survey of yard trimmings and brush programs in ecomaine member and associate member communities confirms that collection and/or drop-off programs for these organics are in place in most communities. A rough estimate of the combined tonnage currently collected by these programs is 15,100 tons.

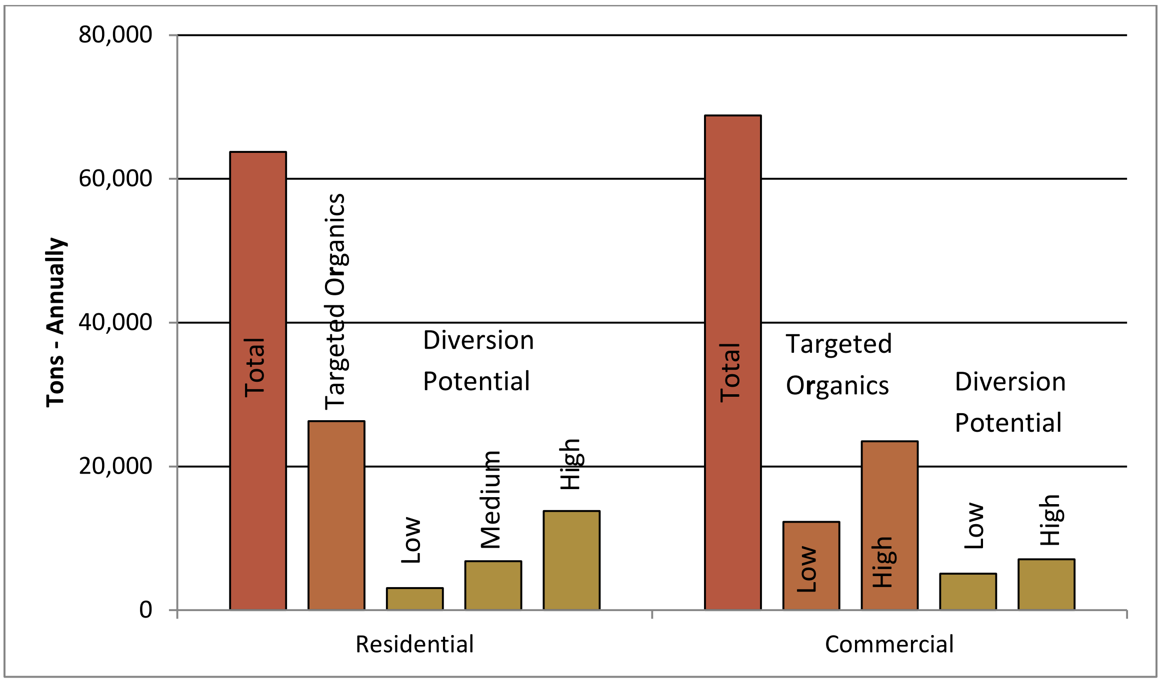
Applying reported recovery rates for residential organics programs to ecomaine member and associate member communities, and using the assumptions that curbside collection of organics, if implemented, would be voluntary and would not be available to residents who do not currently have curbside rubbish collection, Northern Tilth estimates that ecomaine could expect to divert between 3,100 and 6,800 tons of targeted organics from the residential waste stream annually. With the implementation of mandatory organics recycling in combination with Pay As You Throw (PAYT) incentives, diversion rates are estimated at up to 13,900 tons per year. By implementing aggressive public education and outreach campaigns and assuming all transfer station communities participate, an additional 1,000 tons could be collected in drop-off programs from communities not served by curbside collection. While estimates of achievable commercial organics diversion are more difficult to determine, existing programs in ecomaine's service area indicate that commercial generators are willing to separate and divert their organic waste to composting, and experience from CSWD in the Burlington, VT area suggest that a mature program in the ecomaine service area could divert between 5,100 and 7,100 tons of commercial organics.

Total quantities of achievable diverted organics have been broken down into the following three scenarios for use in this study:

- low-end → 3,100 tons (residential only)
- medium → 11,900 tons (6,800 tons residential and 5,100 tons commercial)
- high-end → 21,000 tons (13,900 tons residential and 7,100 tons commercial)

These estimates are illustrated in Figure 1-2.

Figure 1-2 Estimates of Targeted Organics in ecomaine's Waste Stream and the Potential for Diversion



As will be discussed in Section 3.0, if composting is the chosen technology for processing collected organics, a carbon source/structural material will be required to blend with Source Separated Organics (SSO) to achieve proper nutrient balance, moisture content and physical properties for optimum composting conditions. The yard trimmings and brush already collected within the ecomaine service area could provide a substantial amount of the needed amendments if this material could feasibly be diverted to the composting operation. So, while these organics have not been included in the estimate of targeted organics available for removal from the solid waste going to the incinerator, these materials could potentially be a key component of ecomaine's overall organics strategy.

2.0 Evaluation of Organics Collection Options

Key Findings of Task 2

The following items summarize the findings of Task 2: Evaluation of Organics Collection Options.

- Of ecomaine's 28 member and associate member communities, 13 provide residential curbside collection of solid waste and 15 communities rely on residents to either drop off material at town-owned transfer stations or to contract with private haulers for curbside collection. The existing recycling and trash infrastructure and system are often good indicators of the types of organic collection systems that may work for a particular community (i.e., if a city currently uses automated carts for trash and recycling, they will likely use automated carts for organics collection).
- Variations within curbside collection systems for trash and recycling, such as Pay-Per-Bag trash programs and cart versus bag systems can influence organics collection choices.
- With the exception of the City of Portland's municipally run program and the transfer station drop-off programs, ecomaine communities use private contractors to collect trash and recyclables. It is likely that these communities will rely on their service providers to develop an efficient organics collection program.
- Residential organics collection systems that have applicability to the ecomaine service area include Dedicated Collection, Commingled Collection with Trash (a Blue Bag-type system), and Co-Collection with Every-Other-Week (EOW) trash and recyclables collection and Transfer Station Drop-Off.
- Relative to costs, commingled collection is generally less expensive than dedicated collection, and a new program being demonstrated in suburban Minnesota ("Blue Bag Organics") offers an intriguing model of commingled collection of organics and trash that has the potential to work in the ecomaine service area. Co-collection of organics with EOW trash and recyclables collection has the potential to actually decrease overall solid waste costs, but the significant culture shift necessary to accommodate this type of program would necessitate strong political support to make the transition to EOW possible.
- While organics collection programs are developing rapidly across the US and Canada, there is little experience with SSO collection in the ecomaine service area. One option for implementation would be initiate organics collection as a pilot.

There are many different options with which to accomplish collection of organic wastes for recycling, depending on the types of wastes targeted, existing collection systems in place for solid waste, and the demographics of the service area. This section evaluates the current solid waste collection systems in use in the ecomaine service area, reviews organics collection systems in use in other parts of the US and Canada, and evaluates potentially applicable systems for use in ecomaine associate and member communities.

2.1 Current Solid Waste Collection Programs in ecomaine Communities

ecomaine's service area encompasses a wide range of urban, suburban, and rural communities. ecomaine's 28 owner and associate member communities currently either provide curbside collection of solid wastes[28] or allow residents to drop off solid wastes at a transfer station. Of the 13 communities that provide curbside collection, seven have in place a "Pay-Per-Bag" (PPB) program in which residents pay for each bag of trash that they place curbside; recyclables are collected free of charge. Three communities, South Portland, Scarborough, and Saco provide carts for the curbside collection of both trash and recyclables. Limington, Parsonsfield and Hollis are the only communities that provide curbside collection of trash with neither a PPB nor a cart collection system. The remaining 15 communities rely on residents to either drop off trash and recyclables at town-owned transfer stations or contract with a private hauler for curbside collection.

The collection methods for each of the ecomaine owner and associate member communities and their relative locations are shown on Figure 2-1. Current collection arrangements are generally good indicators of how organics might be collected in a given community.

Note on Yard Trimmings

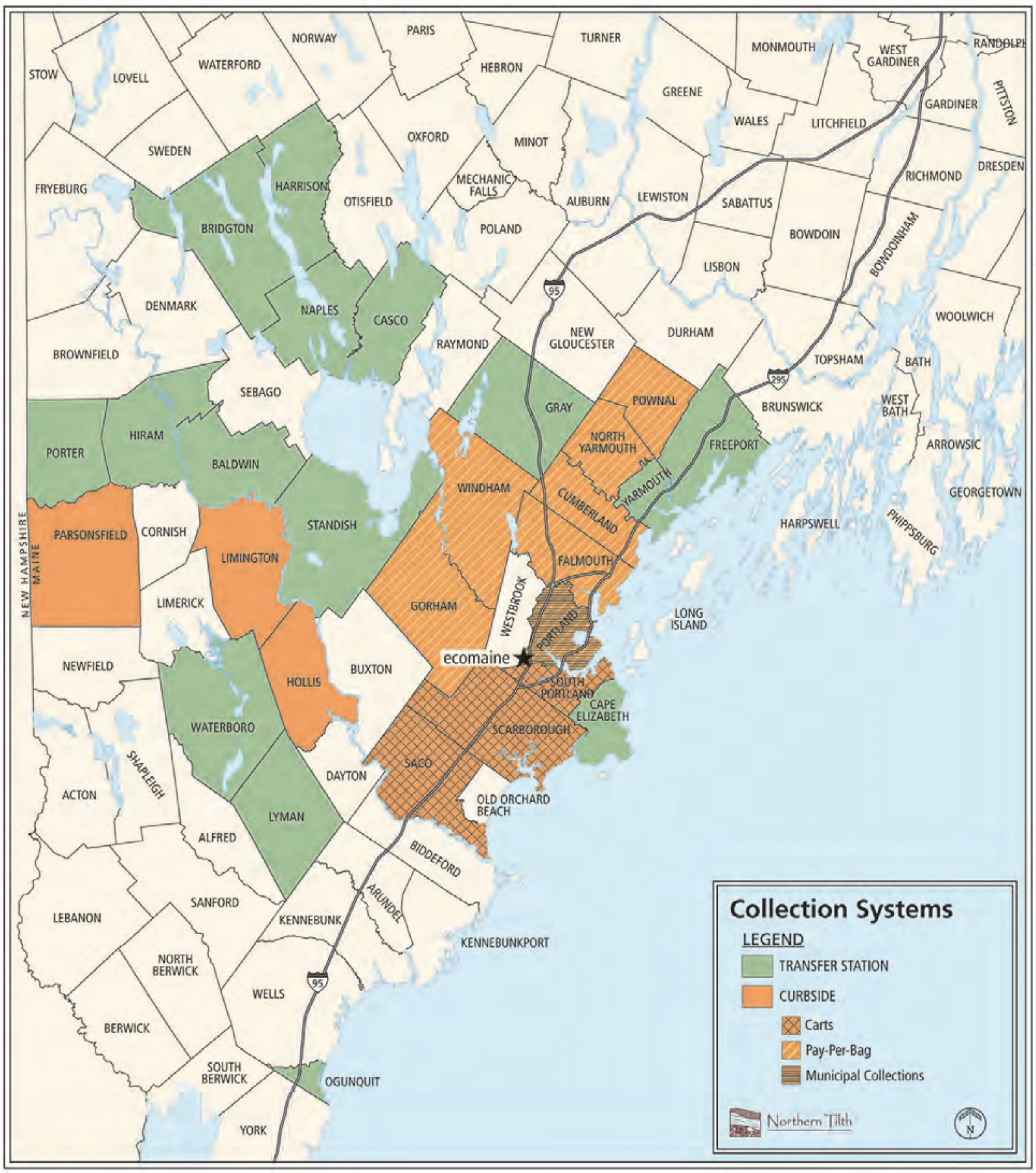
As discussed in Section 1, yard trimmings collection programs are already in place in most of the ecomaine owner and associate member communities, either as seasonal curbside collection programs or transfer station drop-off programs. The generation (accumulation) of yard trimmings in New England is not consistent throughout the year; the volumes vary greatly with the seasons. As an example of this, the Chittenden Solid Waste District (CSWD) in the Burlington, Vermont area reports that one third of their yard trimmings are collected in May, another one third are collected from the 15th of October to the 15th of November and the remaining third is collected throughout the other ten months of the year. This type of volumetric pulse of material is difficult to manage in a weekly curbside organics program. Due to the seasonality of the generation of yard trimmings in Maine, and due to the apparent success of the diversion programs already in place, developing collection programs for the remaining targeted organics, separate from the yard trimmings, makes the most sense for an organics program in the ecomaine service area.

2.1.1 Curbside Communities

As shown on Figure 2-1, curbside collection tends to be offered in the more densely populated communities in and around Portland with Hollis, Limington, Pownal and Parsonsfield as exceptions to this trend. Of the estimated 265,000 residents in the ecomaine owner and associate member communities, approximately 191,000 live in communities served by curbside collection of trash (and, in most cases, recyclables).

[28] In this report, "solid waste" refers to the entire waste stream, including trash (inorganic and non-recyclable and non-compostable wastes), recyclables (including recyclable paper, glass and plastics), and organics (including organics, yard trimmings, food-soiled paper, and compostable bags).

Figure 2-1 ecomaine Communities and Collection Systems



With the exception of Portland, all of the curbside communities contract with a private hauler to perform collection. Currently Pine Tree Waste (owned by Casella Resource Systems) provides collection services for most of these communities, but R.W. Herrick and Oceanside provide service for Gorham and Limington, respectively, and more recently, Waste Management has won the contract for solid waste collection services in Cumberland. Split body trucks are the predominant type of truck used for curbside collection in these communities. Loading ability of the split bodies used in the ecomaine service area includes both manual and semi-automated. In the current collection systems, one side of the split body is used for collecting trash, while the other side is used for collecting recyclables. This provides efficiencies by collecting two waste streams in a single route, and appears to be well suited for the density of the hauling routes in the communities surrounding Portland. This arrangement is also well suited to ecomaine's processing operations. Because ecomaine's single sort recycling facility is co-located with the WTE plant, the hauler does not need to travel a significant distance between unloading the trash and the recyclables. Because the collection services are contracted out, the private haulers have the incentive to determine the most cost-effective truck type and routes for the collection system.

Figure 2-2 Split-Body Truck Unloading Recyclables at the ecomaine MRF.

The City of Portland is the only ecomaine member community that currently collects trash and recyclables using municipal crews. Portland currently uses predominantly manually operated rear-loading packer trucks, each with a crew of two, for collection. For trash, the bags purchased by residents are placed into containers and crews empty them into packer trucks. Recyclables are placed directly into an 18-gallon bin, placed curbside and collected in the same packer trucks, but on a separate route.

Two variations within curbside collection of trash and recyclables in the ecomaine servicea area are described in the following subsections.

2.2.1.1 Curbside with Pay-Per-Bag

Curbside Pay-Per-Bag programs require residents to place all trash into a designated bag, which the resident purchases at grocery stores within the jurisdiction. For example, the Town of Pownal sells their bags for $6.25 for a roll of five, 15-gallon bags, or $13.75 for a roll of five, 33-gallon bags. Bags have a specific color to distinguish them from other town's bags. Residents place bags on the curb and they are picked up by a private hauler, contracted by the community, or, in the case of Portland, by the municipality. In some respects, residents in Curbside Pay-Per-Bag communities may have a slightly better idea of how much they are paying for trash service, though the cost of the bags is only a fraction of their total solid waste cost.

There are seven Curbside Pay-Per-Bag communities within the ecomaine service area, serving approximately 41,100 households.[29]

Compared to transfer station and curbside cart communities, it may be easier to implement curbside organics collection in the towns with Pay-Per-Bag systems in place for three reasons:

- Residents are already accustomed to purchasing and using designated bags for trash.
- The less material that residents put in the paid-for trash bags, the more money they save.
- Pay-Per-Bag participants may have a better understanding of how much they pay for waste removal.

2.2.1.2 Curbside with Carts

Saco, Scarborough, and South Portland, representing approximately 24,200 households, are currently using dedicated carts for both trash and recyclables collection. The carts vary in size between communities, with 65-gallon carts being typically used for recyclables, but trash carts ranging from 35-gallon to 95-gallon (the latter being for larger households). The City of Portland will be purchasing carts for two neighborhoods in the coming year, but at this time the City does not have a city-wide cart program in place. Relevant to this report, carts lend themselves to either semi-automated or fully automated collection which can have an impact on the preferred collection systems for organics.

2.1.2 Transfer Station Communities

Fifteen of the ecomaine owner and associate communities (representing a population of approximately 74,400, or approximately 29,800 households) have municipally-run transfer stations. Residents of these 15 communities are issued vehicle stickers, which allow them to dispose of household wastes at the transfer station. If a resident pays a commercial hauler to bring their waste to the transfer station, the hauler must buy a license and also pay tipping fees. The community typically operates the transfer station and may either haul waste to ecomaine with municipal staff and equipment or may contract with a waste hauling company; either way, tip fees are paid at ecomaine. The transfer station operations and the annual tipping fees are paid by the town and charged back to residents. In most communities this charge is included within an annual tax bill and not broken out in a way that clearly shows residents how much they are paying for trash disposal. These communities also generally allow residents to drop-off recyclables at the transfer station. In some communities, such as Freeport, residents are charged by the bag for trash, providing an element of the Pay-Per-Bag system within the transfer station setting.

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[29] For the purposes of this analysis, “Total Households” means any single family, duplex, mobile home, or multi-family unit up to four units.

2.2 Organics Collection Alternatives

Communities across North America are developing organics collection programs employing a wide variety of collection options for organics. Those options that are most relevant to the conditions existing in the ecomaine service area are described in this section. This section is separated into residential and commercial, as the two segments of the waste stream are traditionally collected separately and often under very different scenarios and cost arrangements.

2.2.1 Collection Alternatives for Residential Organics

There are four general categories for residential organics collection systems that are applicable to the ecomaine service area: commingled collection, co-collection, dedicated collection, and third-party independent collection. These systems, as they relate to collecting residential organic waste, are described in the following subsections.

2.2.1.1 Commingled Collection

"Commingled collection" refers to collecting more than one type of waste together (or "commingled") in a single truck. There are two primary examples of commingled collection for organics. Commingling two types of wastes is different from co-collection, which refers to collecting two distinct commodities in separate compartments within a truck – for example garbage and recyclables in a split-body truck. This option is described below.

Commingled collection with yard trimmings. Along the West Coast of the US and in places with weekly yard trimmings collection, it is common to allow residents to add their food scraps, soiled paper, and other targeted organics to the yard trimmings. This allows an organics program to "piggy-back" on the existing weekly yard trimmings collection program, thus saving significantly on collection costs. As stated above, though, due to the seasonal nature of the generation of yard trimmings in New England, this type of commingled collection is likely not practical for the ecomaine service area.

"Blue Bag" Commingled Collection. The idea of "Blue Bag" collection is a scheme borrowed from early curbside recycling techniques. During the development of curbside recycling programs, some haulers tried to collect mixed recyclables in dedicated Blue Bags

Inclusive vs. Exclusive

The majority of municipal organics collection programs in the US and Canada are considered "inclusive" in terms of the organic materials they accept. While these programs are often referred to as "food scraps collection" programs, most actually accept a wide range of organic materials including food-soiled paper and the other items included in the targeted organics category defined in Section 1. While compostable plastics are emerging as a material category, there continue to be issues with identification, degradability, availability, distribution, and cost. However, recent research suggests that using compostable plastics, particularly bags, helps increase participation rates.[1] Organics collection programs that are exclusive (i.e., that don't allow food-soiled paper, compostable plastics, or other food-related items) typically are doing so because of limitations on the end processing facility (e.g., the composting or digestion facility).

[1]Italy as a Case Study Going the Extra Mile for High Residential Food Waste Capture, Christian Garaffa, Novamont, August 2012.

commingled with trash so that one collection vehicle could be used as opposed to two. The concept was for the resident to place all recyclables in a dedicated and identifiable bag and these bags would be collected in the same vehicle as the regular trash. The Blue Bags would then be separated from the trash at a Materials Recovery Facility (MRF) and sent for additional processing. Although several of these programs were developed for curbside recycling, they have all been replaced with different programs in the US (typically single-stream systems).

Recently, Blue Bag Organics, a subsidiary of Randy's Sanitation which is a private hauler in Minnesota has revived the Blue Bag concept and is applying it to organics. Similar to blue bag recycling, residents are asked to place household organics in a dedicated, identifiable bag, which is collected commingled with the regular trash. Once the truck is unloaded, laborers sort and retrieve the dedicated organics bags, which are consolidated for transfer to a compost facility. This system relies on a custom-designed, compostable bag, which must be distributed to residents. While bag distribution can be a challenge, many of the ecomaine communities already have a system in place for distributing bags to residents, typically by allowing local grocery stores to sell the bags. This same system could be used to distribute custom compostable bags. The challenge of a Blue Bag organics collection program is that once the bags are commingled with trash, the mixed load must be tipped in an appropriate facility and sorted to remove the blue bags from the regular trash. Regardless of participation rates, the entire load must be sorted. For example, if a truck delivers 20 tons of total waste, but only a few households are participating in the Blue Bag program, all of the trash must be sorted, even if it's only for a few bags. This system, like all organics collection programs, becomes more cost-effective as participation and setout rates increase.

2.2.1.2 Co-Collection with Every-Other-Week Trash/Recycling

A number of communities in Canada and a few in the US facilitate cost-effective organics collection programs by collecting trash every other week as opposed to weekly. This is often paired with the collection of recyclables on the odd weeks during which trash is not collected. Organics, then, partly due to their putrescible nature, are collected weekly. Due to the heavy reliance on split body trucks in the ecomaine service area, this type of co-collection could work logistically. Essentially, one of the two sides of the split body truck would be loaded weekly with organics, while the other side would be loaded with trash or recyclables on alternating weeks.

2.2.1.3 Dedicated Collection

Another option for organics collection is a "dedicated" system. This is a common means of collecting curbside organics in places without regular, year-round yard trimmings collection. In most cases a relatively small cart, typically 13 to 26 gallons in size, is given to each resident (either with or without a smaller, in-kitchen container). The carts are collected with a dedicated truck, which must be able to tip the carts, but otherwise could be similar to existing trash trucks. In some communities the same truck used to collect trash in a morning route can be used to run a second organics collection route in the afternoon.

Figure 2-3 Dedicated Organics Collection System – San Francisco, CA

2.2.1.4 Third-party Independent Collectors

Across the US there are dozens of small independent programs that are collecting residential organics using non-traditional methods. Some of these collectors use bicycles while others use small trucks and vans. These programs are taking advantage of the interest by a part of a given community to voluntarily participate in an organics collection program. In Portland, South Portland, Yarmouth, Falmouth, and Cumberland, the group Garbage to Garden, mentioned in Section 1, has been offering this service for almost a year and boasts over 700 accounts. While these non-traditional groups are admirable in their goals and intentions, they are often operating under the radar and typically without any municipal support or oversight. Clearly what Garbage to Garden has accomplished proves that there is at least some interest in a residential organics collection program. However, the demographic captured in the Garbage to Garden program are residents that are willing to pay a premium to recycle organics. Garbage to Garden charges $11 per month for the organics collection service, and this cost is unlikely to be recouped within the confines of the Pay-Per-Bag system that exists in most of the communities to which Garbage to Garden provides the service. For instance, Portland charges $2 per 30-gallon trash bag, and Garbage to Garden is collecting approximately 20 to 30 gallons per month of organics, so the reduction in volume of trash generated would only account for $2 of the $11 monthly fee. Consequently, the Garbage to Garden program is likely to capture only a limited percentage of the households in the communities in which they operate, especially when compared to a curbside program free to residents.

It would be difficult for a small organization like Garbage to Garden to participate in a larger, city-wide or ecomaine service-area-wide program to collect organics. Traditional solid waste haulers are typically more efficient at collecting residential wastes and have the requisite permits, licenses, experience, insurance, and economies of scale to make collecting organic waste a cost-effective proposition. Most third-party collection schemes are fairly exclusive in the allowed materials, generally limiting collection to organics and often excluding more challenging items like food-soiled paper and compostable bags, although Garbage to Garden does include food-soiled paper as an acceptable material in their program. Most municipal organics collection programs tend to be inclusive with regards to the allowable materials in order to increase participation rates and the amount of organics diverted.

2.2.1.5 Transfer Station Drop-off

One method by which transfer station-based communities might participate in an organics collection program would be to establish organics drop-off containers at the transfer stations. There are several examples of organics drop-off programs around the country a few of which were summarized in Section 1. There are two primary challenges to organics drop-off. First, due to potential odors and attractiveness to vectors, the containers must be brought to a suitable processing site within a shorter time frame then most traditions (i.e. bottles, cans & paper) recyclable drop-off materials. Second, drop-offs typically recover a smaller fraction of the available organics than do curbside collection programs for organics (see Table 1-4).

2.2.2 Collection Alternatives for Commercial Organics

There are a variety of alternatives for commercial collection of organics, reflecting the diversity of commercial organics generators. Many smaller generators use dedicated carts, similar to residential organics collection, as carts are easy to move around a generators location. For example, Hannaford's uses numerous dedicated carts as staff finds them easy to move around the store (Figure 2-4). Semi- or fully-automated collection vehicles easily collect carts. Other, larger generators use 3-yard (or larger) bins, which can be collected using front loader trucks. Some commercial front-loading trucks can service both bins and carts using special after-market attachments. Very large generators like sports stadiums or universities may use traditional trash compactors, dedicated to organics only.

Like any collection program, collecting commercial organics efficiently depends on creating route density. This is often accomplished by creating a route of similar generators. For example, in some places restaurants are located in a reasonably concentrated area. As a rule-of-thumb, it may take over 300 accounts to fill a traditional collection vehicle. If you only have 50 small accounts on a route, the route will be relatively costly to operate. In some cases a mix of large and small generators can be collected on the same route to help fill the truck. The ability of a commercial organics collection route to be effective varies based on the nature of the community, the number and type of food-generating businesses, and the ability to get large numbers of businesses to participate. A list of typical food-generating businesses is shown in Table 2-1.

Figure 2-4 Carts Outside of Hannaford Supermarket in Scarborough, ME

Table 2-1 Sources of Commercial Targeted Organics

Commercial	Institutional	Events
Grocery stores Restaurants Food Processing Businesses Food Distribution Centers Nursing Homes Convention Centers Hospitals with dining facilities Hotels/Resorts Sports Facilities/Arenas Office Campuses with Cafeterias	Schools/School Districts Colleges/Universities Prisons Military Bases Large Government Buildings	Music Festivals County Fairs Races/Competitions Farmer's Markets

2.3 Organics Collection Case Studies

Four existing organics collection programs were chosen as examples of existing systems in communities with similar characteristics (population density and climate) to communities in the ecomaine service area in order to provide guidance on collection options that may work for ecomaine. These programs are summarized herein and details are provided in Appendix A.

> **Hamilton, Massachusetts** has been collecting organics city-wide since 2012 after a series of pilot programs. The city uses a dedicated container that is collected year-round by a private hauler in an EOW collection system using split-body trucks.
>
> **Blue Bag Organics** is an innovative program in Minnesota started by a private hauler and implemented in almost a dozen towns. Blue Bag Organics uses dedicated, compostable bags to collect organics commingled with regular trash. This system significantly reduces collection costs while allowing residents to separate organics for composting.
>
> **Ann Arbor, Michigan** is one of only a few municipally-run organics collection programs in the US. Although over 200 cities and towns in the US provide weekly organics collection service, few use city crews to collect organics. Ann Arbor is one of those and, with a population of 114,000, is not significantly larger than Portland, Maine.
>
> **Prince Edward Island (PEI),** the smallest of the Canadian Maritime provinces, consists of 46 municipalities with the largest 10 towns ranging in population from over 30,000 (Charlottetown) to under 1,000 (Alberton, Tignish, and Georgetown). All of the towns on PEI have dedicated food scraps collection.

Table 2-2 summarizes some of the key aspects of these four programs.

2.4 Evaluation of Organics Collection Alternatives

As described in Subsection 2.3, there are a several options for communities to consider when developing organics collection programs. Of these options, four types of programs appear most suitable to communities within the ecomaine service area. This section does not attempt to select an option for a given community, but rather presents an evaluation of the programs which bear further research or piloting in the ecomaine service area.

2.4.1 "Blue Bag-type" Commingled Collection of Organics with Trash

The "Blue Bag" style commingled collection option may be a good fit for those towns with existing Pay-Per-Bag systems as well as other municipalities that use carts (even a possibility for transfer station communities). With the Pay-Per-Bag system, residents would be given or would purchase custom, compostable bags for organics (presumably printed with a distinctive logo and color to easily distinguish them from regular trash bags that would ideally be consistent across the ecomaine service area). Residents would set out the compostable bags with organics alongside the regular trash bags on collection day (presumably inside of a resident-provided trash can). The community's hauler would collect the bags with the trash using the same collection equipment they currently use. Commingled

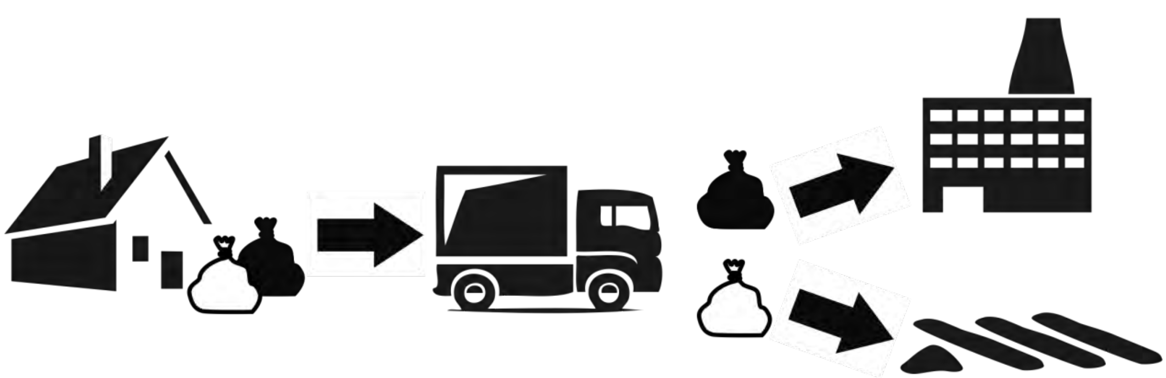
Table 2-2 Summary of Four Organics Collection Case Studies

	Hamilton, MA	Blue Bag Organics[1]	Ann Arbor, MI	PEI, Canada
Total Population	8,374	87,084	114,000	145,000
Households Served	2,640	1,476	27,000	All
Collection Method	Co-collection with EOW trash/recycling using 13-gallon carts	Commingled collected with trash using specially designed compostable bags	Commingled collection with yard trimmings seasonally	Bi-weekly organics using semi-automated trucks
Collection Vehicle	Split Body	Rear Loader	Rear Loader	Rear Loader
Voluntary/Mandatory	Voluntary	Voluntary	Voluntary	Mandatory
Inclusive/Exclusive	Inclusive	Inclusive	Exclusive	Very Inclusive
Cost	No data on per resident cost; however, town reports significant annual cost savings based on reduced disposal and hauling costs	In some cases, no additional cost to resident, in some cases one-time $60 fee plus annual bag costs	One-time cost of $50 for the bin, no additional cost. City pays $18.50/ton to compost	Monthly cost is $205 inclusive of trash, recyclables, organics, and other services
Compost Site	Privately run	Privately run	Privately run	Privately run
Participation	Estimated at 44%. City currently seeking better program metrics	Currently varies from 1 – 23% (see Table A-1 below), but these programs are new; participation rates will likely increase as the program matures	Organics are co-collected with yard trimmings, making participation data for organics difficult to obtain	Overall residential diversion is estimated at 64% and organics setouts outweigh trash setouts

[1] *Blue Bag Organics serves 12 different communities. The total population is 87,084 and there are 1,476 household subscribers.*

bags would be delivered to a suitable location for sorting. Once separated, trash would be sent to the (WTE) plant, while the dedicated organics bags would be consolidated in a roll-off container (or similar) for transport to the organics processing facility (Figure 2-5).

Figure 2-5 Blue Bag-type Commingled Collection of Organics and Trash



An area adjacent to the tipping floor of the WTE plant has been identified as a potential location for developing a sorting station for a Blue Bag-type SSO program. A preliminary design for such a sorting station has been completed by D&B Engineers and Architects and is included as an appendix to Section 7.

An advantage of this type of commingled collection system is that there would be no increase in the actual hauling costs. The same volume of solid waste is handled in the same trucks using the same routes currently used by the haulers. The only difference is that the participating residents will have separated the organics from the remainder of the trash. In the split body trucks used for hauling in most of the Pay-Per-Bag communities, the organics bag would go in the same compartment as the trash bags. The recyclables would remain in the other compartment. This system could also work with the City of Portland's rear packer trucks. Again, the organics bag would simply be commingled with the trash bags. For a dedicated cart system, the organics bag would go into the same cart with the trash. In this case, the total volume in the trash cart does not change, the organics is simply in a separate bag from the remainder of the trash in the cart. For a transfer station community, residents could drop off their organics bags with their trash bags, and sorting would occur at the WTE after the dumpster or trailer from the community is transferred to ecomaine.

There are two disadvantages to this type of system. First, as discussed above, in a program with low participation rates, the entire load delivered to the sorting operation requires sorting even though the percentage of organics bags will be low. One option for the sorting operation, included in the design by D&B Engineers and Architects, would be to construct a rudimentary sorting line at the WTE to separate the organics bags from the remaining trash. This would obviously add significant costs but would have the added benefit of allowing for removal of contaminants from the organics stream and providing an opportunity to separate easily sorted recyclables from the trash stream.

The second disadvantage is that there is only limited experience with this type of collection system. The Blue Bag Organics program in Minnesota has been in place for less than one year and our project team has not identified any similar operating programs in North America.

A critical component of the Blue Bag Organics program is the compostable bag. The bag developed for the program, while meeting the ASTM specifications for compostability, is strong enough to resist splitting or puncturing when compacted with trash in the body of a hauling truck. Compostable bags are sometimes not desired by organics processing facilities. However, if the sorting process for the co-collected organics includes some type of bag-separation technology, a traditional plastic trash bag could be used for organics. Color coding of the bag would obviously remain an important component of this type of system.

2.4.2 Co-Collection with Every-Other-Week Trash Collection

As described in Subsection 2.2.1.2, several communities in Canada and a few in the US are now collecting trash every other week as opposed to weekly. These programs are typically associated with very inclusive, weekly organics collection. The primary advantage of this system is a significant reduction in trash collection and processing cost and communities may use the savings to fund weekly organics collection. The City of Portland, Oregon, the largest US city with EOW trash collection, reports a 38%

reduction in trash tonnage collected after the first full year. In the same period, annual organics collection increased from 30,600 tons to 85,400 tons.

The Town of Hamilton, Massachusetts (profiled in Appendix A) is an example of a "dedicated cart" program used in a co-collection program with EOW trash collection (Figure 2-6). Using split-body trucks, Hamilton's program could be a model for the majority of ecomaine curbside communities in which split-body trucks are already in use. As suggested as a possibility for ecomaine communities in Subsection 2.2.1.2 above, in Hamilton the split-body truck is used to collect organics on one side and trash on the other side on one week, and organics on one side and recyclables on the other side the following week. The key to this approach is that trash is only collected every other week.

Figure 2-6 13-Gallon Green Organics Bin in Hamilton, MA

In southern Ontario communities, EOW collection systems are fairly common, with the municipalities of Toronto, Ottawa, Guelph, Durham, Halton and York (York Regional Council, 2010 and Zigby, 2013) all collecting organics weekly and trash on alternating weeks. There are some variations among these programs, for example, Halton collects recyclables every week instead of alternating recyclables collection with trash. In addition to Portland, OR in the northwestern US, Tacoma, WA is starting to phase in EOW collection, Renton, WA has already moved to EOW collection, while allowing residents to pay extra for every week collection of trash and Seattle has finished a pilot program for EOW collection and is considering implementing the program city-wide.

EOW collection systems are cost-effective, they have been demonstrated to increase recycling rates, and they are becoming more commonplace, with several examples of them having been implemented in both urban and suburban settings. The switch to EOW collection, though, does represent a significant shift in residential solid waste disposal and recycling behavior and must be accompanied by strong political support and extensive outreach to explain to residents that trash is only being collected every other week. Some observers believe that many residents could find this difficult to manage. The Manager of Collection Services in Guelph, Ontario, though, offered the observation that the most resistance to the switch to EOW collection is prior to implementation of the program and that within a couple of months of implementing EOW collection residents are generally satisfied with the change (Scott, 2013).

2.4.3 Dedicated Collection

A primary advantage of dedicated collection is that, once collected, organics do not need to be separated from the trash and may be hauled directly to the composting facility. The major disadvantage is the costs associated with adding additional routes to collect the organics. Each new dedicated organics route requires an additional truck and driver (and possibly additional crew if the loading system is not automated). Initially, then, the cost of adding a dedicated organics collection system is equivalent to doubling the per-household-served costs for trash collection alone. During the start-up of a new organics program, the costs for dedicated collection may even be higher than for trash because the route density will be lower; everybody needs trash removed, but a new, voluntary organics program will likely have participation rates no higher than 35%.

Consequently, participation is critical to build route density and to achieve an efficient collection system. As participation in the organics collection program grows, it is assumed that the volume of trash would decrease, allowing consolidation of existing trash routes and cost savings. In mature programs, when the organics program diverts a significant portion of the total solid waste, trash routes can be consolidated as less trash is being collected per household, allowing for a given collection truck to collect more stops per route. Consequently, as a program matures, some of the extra costs of this additional route may be recouped by efficiencies on the garbage route.

Because of the high route density, more densely populated urban areas such as San Francisco (Figure 2-7), Seattle, Toronto, Halifax, and the larger cities on Prince Edward Island (profiled in Appendix A) in Canada lend themselves to dedicated collection systems. However, there are less densely populated areas, such as Howard County, MD that also use a dedicated organics collection system.

Typically, dedicated organics routes use smaller carts (e.g., 13 to 26 gallons) than are used for trash and recycling. The three ecomaine communities using carts for curbside collection of trash and recycling (Saco, Scarborough, and South Portland) appear to have a large enough population that they could take advantage of the cart collection systems already in place and add a smaller organics cart and a dedicated organics collection route.

Dedicated organics collection could also work in the city of Portland. Using their existing packer trucks, the City of Portland could develop a dedicated route for organics, collecting them in bags or in carts. While Portland’s current trash and recycling system does not rely on cart tippers, the Portland trucks are equipped with tippers. A second alternative would be to offer residents a dedicated custom bag for organics collection, which would be collected in the same manner as the trash bags, in the same trucks but on a separate route. Because City of Portland has the densest population of all the ecomaine communities, it may be the most logical place to start organics collection.

Figure 2-7 Dedicated Organics Carts – San Francisco, CA

2.4.4 Options for Transfer Station Communities

As discussed in Section 1, many communities across the US, including one ecomaine owner member (Yarmouth) provide drop-off locations for residential organics (Figure 2-8). Drop-off systems are an obvious option for collection of organics in communities in which curbside collection is not available and where residents are accustomed to taking trash, recyclables, and/or yard trimmings to the transfer station. Locations that are staffed, such as transfer stations and Public Works yards may reduce the potential for contamination relative to remote drop-off locations. Ideally, drop-off locations are co-located with composting operations so that the material can be simply incorporated into compost piles instead of having to be re-hauled for processing. There are existing programs, though, that provide containers that would allow for transport of drop-off organics to processing facilities. And, as mentioned in Section 2.4.1, with a Blue Bag-type system, organics bags could be dropped off and sorted from trash when received at the ecomaine WTE.

The Maine DEP encourages the incorporation of limited amounts of food scraps and other targeted organics into existing municipal leaf and yard waste operations, as the Town of Yarmouth is doing. Several types of receiving bins can work for organics drop-off programs, including carts, metal bins and even roll-off containers, if the amount of collected organics justifies these larger containers. In Yarmouth's program an asphalt pad surrounded by concrete block walls is used for the drop-off location (Figure 2-8). Yard trimmings are periodically blended with the food scraps to reduce odor prior to incorporating the organics into the on-site yard trimmings compost piles.

Figure 2-8   Residential Organics Drop-Off Program – Yarmouth, ME

As noted in Section 1, the organics drop-off programs in several communities in Franklin County, MA (Figure 2-9) have higher participation rates than the others surveyed for this study. It is difficult in a transfer station drop-off model to replicate the participation rates achieved in curbside collection programs for organics, but according to Jan Ameen (2013), from the Franklin County Solid Waste Management District (FCSWMD) there are several factors in the implementation of a transfer station drop-off program that can increase participation, including

- Providing residents pails with tight-fitting lids for collecting organics that will not spill en route to the transfer station (kitty litter pails work well).
- Providing extensive public outreach at the beginning of the program. For the FCSWMD programs staff or volunteers were on site every day for the first two weeks of the programs to provide pails and flyers about the programs.
- Having Pay As You Throw (PAYT) in place for trash so that a savings is available to the residents when separating organics from the trash.

Because transfer station communities tend to be the less densely populated communities in the ecomaine service area, educational efforts geared towards backyard composting may also be an effective method for diverting and recycling targeted organics. Many of the ecomaine communities, including the Town of Yarmouth, already provide outreach and training on backyard or home composting. Expanding these programs in ecomaine transfer station communities should be encouraged.

Figure 2-9 Bins for Drop-Off Collection of Organics - Whately, MA

Source: Jan Ameen, Franklin County Solid Waste Management District

2.5 Organics Collection Costs

The following subsections present a discussion of costs for residential and commercial organics collection.

2.5.1 Residential Collection Costs

Typically there are two major operating costs involved in both solid waste and organics collection programs: the collection itself (the cost of containers, outreach, new trucks, labor, maintenance, etc.) and the cost of the tip fee at the processing facility. Where the processing facility is located and how much of a tip fee is charged can be an important aspect of the total cost of collection, but the actual collection is the more significant expense. For instance, a recent analysis of the solid waste collection systems in the Chittenden Solid Waste District in Vermont indicated that solid waste collection costs were 78% of the total costs to residential subscribers of weekly curbside collection of trash and recycling (DSM Environmental Services, 2012). In the ecomaine service area, data on solid waste costs also indicate that collection costs are generally a higher portion of the total costs than the processing costs. For instance, in South Portland, collection costs accounted for approximately 73% of the total residential solid waste costs for 2012 (Howard, 2013). In Cumberland, with the Town's new contract with Waste Management for curbside collection of solid waste, the collection costs are forecasted to be approximately 64% of the total costs (Shane, 2013).

Due to the potential for high collection costs, in developing residential organics diversion programs, ecomaine community members should focus on organics collection systems that minimize additional costs to their existing collection systems.

As discussed above, with the exception of the City of Portland, all ecomaine communities with curbside collection of solid waste contract with private haulers for collection services. Ultimately the private hauler will propose a cost for providing organics collection services. However, based on the types of collection systems described above it is possible to provide a comparison of relative costs between the systems. Relative costs for the potential organics collection programs are summarized in Table 2-3 and further discussed in the following paragraphs.

Table 2-3 Organics Collection Options for Consideration and Relative Costs

Program	Collection costs	Processing
Commingled Blue Bag-type collection (organics collected in dedicated bags with trash), similar to the Blue Bag Organics model in Minnesota	Minimal additional costs (primarily the costs of the compostable bags) compared to existing routes	Bags must be separated at a transfer station or similar facility. If separating at the ecomaine WTE tipping floor, additional costs will be determined by the level of sophistication of the separation technology
Co-collection with EOW trash collection	No additional collection costs for current split-body trash/recycling systems. This has been demonstrated in Hamilton, MA	Organics can be direct hauled to organics processor or transferred. The split body model relies on close proximity of the tipping locations for the two separate streams of waste carried in the trucks
Dedicated collection	Equal to duplicate trash route, although some of the costs could be recouped through reduced trash volumes as the organics program develops	Organics can be direct hauled to organics processor or transferred.

Using the Blue Bag commingled collection model, curbside collection costs do not change when integrating organics collection; the same volume of solid waste is handled on the same routes using the same equipment. One additional cost is the price of the bags, and in order to provide incentive for separating organics from trash, it would make sense for the cost of the bags to be taken on by the communities instead of individual residents. In the case of the Blue Bag Organics program in Minnesota, the 32-gallon bags cost $1.06 per bag, which adds close to $4.30 per household per month cost to the program. Recent discussions between Blue Bag Organics and members of our project team, though, indicate that a smaller bag that would be ample for weekly targeted organics collection in Maine would be about half that cost. An additional and potentially significant cost associated with the Blue Bag option is the cost to separate the Blue Bags from the trash. As discussed above, a preliminary design, with cost estimates, completed by D&B Engineers and Architects, for a sorting station developed at the ecomaine tip floor is included as an appendix in Section 7.

As with Blue Bag commingled collection, co-collection with EOW trash collection could be implemented with no additional collection costs using the split-body trucking infrastructure already in place in most ecomaine curbside communities. Both Hamilton, Massachusetts, and Portland, Oregon, report that with the savings in going to EOW garbage collection (essentially cutting garbage pick-ups in half), they were able to implement organics collection programs using the money that was saved by not collecting garbage weekly. The experience in one city or town is not necessarily going to be the same in another, which is why a pilot of EOW collection is recommended, to see what the potential could be. There is very little published data on the specific volume shifts that occur when collecting large quantities of organics separately and how that might affect a split-body collection vehicle. It is most likely that a

50/50 split body might not work as well as a 60/40 split, with recyclables on the larger side on one week and garbage on the larger side the next (i.e., organics would probably always be a smaller volume, though potentially more weight). In Hamilton, MA, the hauler uses a 60/40 split and in several of the EOW programs in Ontario, Canada, haulers use a 70/30 split.

As discussed above, adding dedicated collection for organics initially would approximately double the costs of trash collection alone on a per-household-served basis. If the addition of dedicated organics collection also necessitated equipment modifications, such as automated cart lifters, the costs would be even higher. Presumably, as route density increases with increasing participation, the reduction in trash volumes would translate into more trash stops per route, and the savings from this increased efficiency on the trash routes would help off-set some of the costs for the dedicated organics route. With a mandatory program in a more densely populated community, such as Portland, these savings could be significant. In a voluntary program in any other of the ecomaine curbside communities, with the anticipated participation rate of 35 – 45% seen in voluntary programs, the savings from improved trash route efficiency would likely be minimal.

It can be hard to parse out exactly how much a given household in the ecomaine service area pays per week or per month, as services are sometimes bundled together (like co-collection of trash and recycling). Individual costs would be based on the cost to the service provider (i.e., the existing hauler) and the type of collection program that was implemented. However, costs from some of the existing curbside trash and recycling programs may provide guidance on the range of expected costs for dedicated collection of organics may cost in the area. Based on 2012 residential solid waste costs for South Portland, removing tip fees associated for processing the solid waste at the ecomaine facilities, the City pays approximately $13.00 per household per month for co-collection of trash and recycling in dedicated carts (Howard, 2013). Based on a new contract in the Pay Per Bag community of Cumberland, residential curbside collection costs for trash and recycling will be approximately $10.00 per household per month (Shane, 2013). And finally, the price provided by a private hauler to Scarborough for collection of trash and recycling on private roads (which, due to the lower density of routes serving private roads, may provide a good comparison to the route density expected in a voluntary organics curbside collection program) is $12.00 per household per month (Shaw, 2013). These collection costs are the expenses charged to the communities by private haulers and do not include the costs of the bags paid by residents in PPB communities, which range in price from $1.00 to $2.70 per trash bag.

Looking at organics collection costs on a national level, a report prepared for USEPA Region 5 ("Best Management Practices In Food Waste Programs") cites a national average for organics collection costs of $7.70 charged to participating households per month (Ecoconservation Institute, 2010). It should be noted that most of the programs analyzed in that report were for commingled food and yard trimmings collection (i.e., commingled) programs, which may change the cost compared to an ecomaine program (e.g. lower costs due to greater route density, or higher cost due to greater volumes per stop). A pilot dedicated organics collection program in Brattleboro, Vermont, in which the waste hauler collected from 150 stops in five hours once per week (Kahler, 2013) translates to a monthly per household collection fee of approximately $12.00 per household per month. As described in Subsection 2.2.1.3, Garbage to Garden charges $11 per month for weekly organics pick-up. A recent study by DSM on the impact of Vermont's Act 148 (a phased approach to banning organics disposal in Vermont landfills) estimated that the increase in costs from an organics collection program when averaged across Vermont households would be between approximately $9.00 to $10.00 per household per month (when assuming that none of the households would be switching to EOW collection), but this included the assumption that 60% of the organics would be collected, suggesting a higher participation rate than for voluntary programs (Siegler, 2013). Finally, estimates given by a private hauler to the City of Cambridge, MA for dedicated organics collection on a voluntary program, anticipating 35% participation rate (City of Cambridge Public Works Department, 2012), equate to an estimated $7.00 per household per month cost.

Considering all of the dedicated collection costs cited above, it is likely that private hauler fees for a dedicated organics curbside collection program, once developed, would be in the range of $7 to $13 per household per month, compared to the minimal extra collection costs that would accompany a commingled Blue Bag-type program or a shift to co-collection of organics with EOW trash and recycling. One consideration worth mentioning, though, is that if the private haulers currently serving ecomaine communities are asked to provide curbside organics collection and if the haulers find dedicated collection to be a better fit for their operations, they may be willing to provide dedicated organics collection at a reduced rate in order to keep the trash and recycling contracts over the long term. As an example, the contractor providing trash and recycling services in Brattleboro, VT has agreed to provide dedicated curbside residential organics collection services at no extra costs in exchange for a longer term contract on trash and recycling collection services (Kahler, 2013). An additional consideration is that costs for a municipally run program, as would likely be the case in Portland, could be considerably lower than the costs that would be charged by a private hauler. Based on the City of Portland's current costs for collection of trash and recycling (provided to the project team by Troy Moon, the City's Environmental Programs and Open Space Manager) it is estimated that dedicated organics collection costs for Portland, using the municipal fleet, could be as low as $4.00 per household per month.

2.5.2 Residential Organics Pilot Collection Costs

Due to the relative inexperience with separate organics collection in Maine, the project team recommends that ecomaine communities and their haulers conduct pilot studies to get real-world cost information for a given system, which would take into account the unique characteristics of a given community. Estimates of costs from two other pilot organics collection programs in New England provide some guidance on potential costs for pilot programs in the ecomaine service area.

The City of Cambridge, Massachusetts, proposed developing a pilot organics collection program of roughly 800 households (one collection route) (City of Cambridge Public Works Department, 2012). The city estimated that the pilot would cost approximately $100,000, not including collection costs, which were estimated using a variety of scenarios (e.g., private versus public collection). This estimate included 180 hours of a consultant's time plus a part-time city employee for a year, the cost of the containers, compostable bags, and educational materials. The city estimated they could utilize composting services for $55/ton.

The city estimated that collection trucks would need to replace seals on a monthly basis. Other costs included the additional miles on the collection vehicle, additional truck maintenance, and additional labor costs. The city estimates that the pilot might collect 250 tons of organics in the first year, based on collecting 12 pounds of organics per household per week. This estimate was revised downward after they received funding to 124 tons per year. This estimate assumed an 85% participation rate for 800 households, each segregating 10 pounds or organics per week, and 70% set-out rate. In most cases a pilot program could be accomplished without purchasing new equipment. If purchasing a collection vehicle were necessary, a new side or rear loader vehicle can cost anywhere from $165,000 to $300,000.

The organics collection pilot program that wrapped up in Brattleboro, VT in 2012 was completed on a very small budget. The program, which included 150 households out of the 2700 households of four units and under that are served by the Town's curbside trash and recycling service, was coordinated by a temporary employee that was paid $7,500 to administer the program. The majority of the curbside carts were donated by cart manufacturers, and the others were provided by the participants. As discussed above, the collection services worked out to be approximately $12.00 per household per month.

Depending on how a pilot for the ecomaine service area is structured, the costs could be considerably less than $100,000 estimated by the City of Cambridge for a one-route pilot. ecomaine could facilitate a pilot program using the goodwill of area haulers and other participants to lower costs. In the event of a co-collection pilot using dedicated compostable bags, it is likely that one of the compostable bag manufacturers could be encouraged to donate the bags necessary for the pilot, and the local hauler should also be encouraged to donate time and resources, which would help them generate cost information for the larger scale project.

Choosing the pilot route should be done both carefully and thoughtfully to ensure that all bias in the collection behavior is understood. ecomaine can participate in the pilot by potentially using its resources to help conduct the bag separation and the transport of the organics to the composting facility.

2.5.3 Commercial Costs

The focus of this report has been on residential organics collection. In many areas of the country, communities develop commercial organics programs prior to developing residential programs. This was the case in many California communities (e.g., San Francisco and Oakland) as well as in Chittenden County, Vermont. In the ecomaine service area some food generators have already developed commercial organics programs. For example, the 15 Hannaford supermarkets in the ecomaine service area have been collecting organics since the late 1990s. Currently most of the collected commercial organics from the ecomaine service area is hauled to private compost facilities.

Conducting a meaningful analysis of commercial waste generation in the ecomaine service area is beyond the scope of this report. If and when ecomaine develops publicly-owned compost and/or digestion capacity, hauling costs, based on distance, and tipping fees will determine which facilities receive commercial organics. There are a number of large food-generating businesses in the ecomaine service area, some of which are already collecting organics. In addition to Hannaford, a number of generators have signed up with Resurgam Zero Waste and Garbage to Garden collects organics from a few institutions (mostly schools in Portland).

There can be a wide range of costs for commercial trash or organics services, commensurate with the diversity of commercial businesses. Fundamentally, commercial collection service, whether it is trash or source-separated organics, will depend on the deal negotiated with a given customer and their service provider. There are a number of variables including the amount of service provided, the collection frequency, and the distance to the end facility (i.e., the transfer station, the waste-to-energy facility, or a compost facility), all of which will bear on the rate a commercial generator pays for service. However, not all businesses generate adequate amounts of organics to participate in a separate collection program. The rate of incentives offered to food-generating businesses may have a significant impact on participation rates. Some generators may be large enough to justify a dedicated roll-off container, but in most cases a route of food-dense businesses will make the most sense. Similar to residential collection, route density- the number of accounts divided by the time/distance between them - will determine the efficiency and cost of the route. Larger generators might want to use larger containers (e.g., a 3-yard debris box) and smaller generators may share containers or use carts. In many programs, haulers use commercial front-load trucks capable of collecting both traditional containers and carts. Based on changes in service and lower tip fees for composting outlets versus taking waste to landfills, a report on organics collection programs from commercial generators in Cambridge, MA predicted an average solid waste cost savings of 10% to generators that develop organics diversion programs (City of Cambridge Public Works Department, 2007).

In general, though, while the additional collection costs for commercial organics are not as high as for dedicated collection of residential organics, commercial generators that choose to recycle organics do not typically see a reduction in overall solid waste costs. Removing organics from the commercial trash can lead to a reduction in disposal costs when switching to a smaller trash container, and the difference in tip fee between disposal (landfill or incineration) and composting provide some additional savings. But these savings are usually less than or equal to the additional costs associated with separate collection of the organics. Two commercial organics haulers with established programs in Massachusetts interviewed by the project team pointed out that the majority of commercial entities recycling their organics do so because it is the right thing to do and not for economic reasons.

Based on commercial organics programs that have operated within the ecomaine service area, there is some limited data on collection costs. For example, Hannaford supermarkets, which have enough stores to provide a dedicated route, are charged approximately $50 per pick up of organics carts at each store. Pick up frequency varies based on collection rates at the stores, but the pick-up charge is independent of the number of 65-gallon carts picked up. The additional fee for composting the organics is approximately $40/ton. Almost a decade ago, R.W. Herrick, Inc., a local trash and recycling hauler, initiated a commercial organics route in the Portland area, which included some of the Hannaford supermarkets as well as restaurants. After managing the program for several years, R.W. Herrick found that it was difficult to get enough route density at the prices that they were charging to make the venture profitable. At the time, R.W. Herrick was charging $3.25 per picked up cart. R.W. Herrick believed that the venture could become profitable over time, but the program ultimately ended because he did not have a reliable compost facility to which he could bring the organics.

2.6 Task 2 Recommendations

Because there is limited experience with organics collection in the ecomaine service area, it is our recommendation that ecomaine towns work with their currently-contracted haulers to develop pilot collection programs. These programs may take different forms depending on which town they are developed in.

ecomaine can facilitate the development of pilot organics collection programs by using its resources and facilities to help conduct the bag separation and the transport of the organics to the composting facility (in the case of a Blue Bag-type collection program).

ecomaine should participate in collection pilots by facilitating identification and contracting with a facility for final deposition of the organics. For example, ecomaine could assist by negotiating an agreement with a composting facility or by using the ecomaine scales to help document organics tonnages collected.

3.0 Technology Alternatives Evaluation

Key Findings of Task 3

The following items summarize the findings of Task 3: Technology Alternatives Evaluation of the Organics Recycling Feasibility Study.

- The principal technologies used for recycling source-separated organic (SSO) are aerobic composting and anaerobic digestion (AD).
- The two technologies are not mutually exclusive; when used together, they are complementary and allow for the extraction of a recovered energy component prior to the manufacture of a soil amendment.
- Most AD systems operational in the US are low-solids liquid digesters (<10% Total Solids [T.S.]), but dry fermentation reactors that handle higher solids content organics, predominantly using European technology, are now being built in the US.
- There is a wide variety of approaches for composting SSO, but most of the operational facilities in Maine are open-air turned windrows.
- Those composting approaches with the most robust odor control approaches tend to be induced-draft aerated static pile with biofiltration or forced-draft aerated static pile with either compost-based or micropore fabric covers.
- Odor control technologies include biological, chemical, and physical systems. The lowest cost, best performance alternatives are biological systems coupled with good process design and management.
- A weighted-matrix evaluation technique was used to focus on those composting and digestion technologies that have the greatest potential to meet the needs of ecomaine in processing SSO. The weighted criteria matrix is a decision-making tool that is used to evaluate alternatives based on specific evaluation criteria weighted by importance.
- The following table presents the highest scoring alternatives.

Alternative	Total Weighted Score
Digestion	
Dry Fermentation	330
Composting	
Enclosed Aerated Static Pile	373
Containerized Aerated Static Pile	342
Covered Aerated Static Pile	334
Tunnel Reactor ASP	311
Agitated Bay Composting	305

- The project team developed a preliminary process design for Aerated Static Pile composting (the highest scoring composting technology) to help frame the analysis of suitable technologies in this task and of suitable sites in Task 4 – Siting Evaluations.

3.1 Introduction

This task evaluates organics recycling technologies for source-separated organic materials (SSO) available to ecomaine. There are two main categories of organics recycling technologies: aerobic composting and aerobic/anaerobic digestion. This section describes these technologies and offers project profiles of organics recycling facilities using these technologies in climates and with feedstocks similar to those expected in the ecomaine service area.

Digestion technologies are either aerobic (with oxygen) or anaerobic (without oxygen); the former is a method of stabilizing wet organic wastes (particularly sewage sludges) using aerators, while the latter produces a usable gas byproduct during the stabilization process. Both types of digestion are traditionally “wet” processes and produce both a solid residual and a wastewater effluent that must be further managed. Recent technology changes in Europe have introduced a batch-type dry form of anaerobic digestion (known as dry fermentation) which is now being developed in the US. Aerobic digestion requires more steps in its process flow, uses more energy and is therefore more expensive, and does not produce a usable gas. Thus, anaerobic digestion (AD) will be the only digestion process further discussed in this section.

Composting technologies utilize an aerobic process to decompose organic materials such as food scraps, biosolids, yard trimmings, water treatment residuals, animal manures, mortalities, and certain industrial solid wastes. It is a microbially-driven, self-heating process that reduces pathogens and weed seeds, and produces a material similar to soil. Well-stabilized (and mature) compost can be stored indefinitely and has a wide variety of uses in residential and commercial landscaping, sediment and erosion control, agriculture, non-point source water quality management systems, disturbed lands remediation, and commercial horticultural applications. Composting technologies include turned windrow, aerated static pile, enclosed aerated static pile, and in-vessel. These technologies will be described in more detail in the following sections.

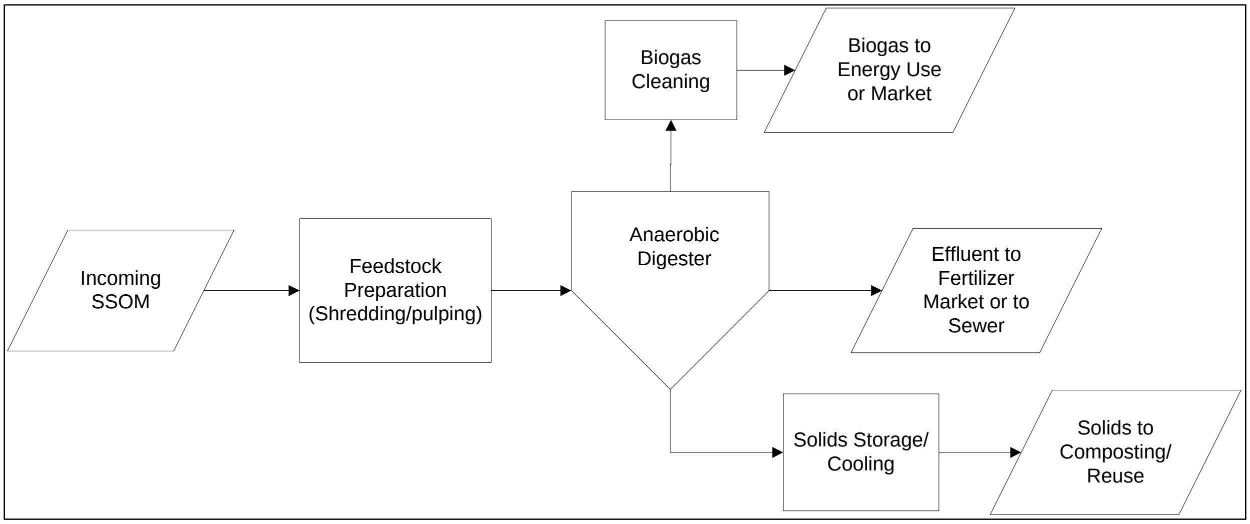
This section also offers background information on the odor control technologies in use at AD and composting facilities, provides project profiles of operating facilities, and evaluates potential suitability of technologies for ecomaine using a weighted matrix criteria evaluation.

3.2 Technology Descriptions

3.2.1 Anaerobic Digestion

Anaerobic digestion (AD) is a biological treatment process in which the lack of oxygen results in feedstock stabilization by a very specific group of microorganisms that produce a usable energy source in the form of biogas. The products of anaerobic digestion are methane, carbon dioxide, trace gases, and stabilized solids. The City of Toronto, Canada has an anaerobic digestion system that processes approximately 115,000 tons per year of SSO. Biogas production is approximately 4,200 cubic feet per ton (cf/ton) of incoming SSO. The biogas has an average methane content of 55 to 65%, but pretreatment would be needed to remove impurities before it can be used for energy production (Van Opstal 2006a and 2006b). A typical process flow diagram for anaerobic digestion is shown in Figure 3-1.

Figure 3-1 Anaerobic Digestion Process Flow Diagram



AD systems can be configured to handle liquid or solid wastes. Liquid waste digesters can be either low-solids (i.e., less than 10% total solids [T.S.]) or high-solids (25%-50% T.S.). Solid waste digesters are known as dry fermentation reactors and normally handle feedstocks with more than 50 to 70% T.S. The majority of AD systems operating in the US today are low-solids liquid systems, which are used at wastewater treatment plants treating sewage sludges and on farms handling liquid animal manures. High-solids liquid digesters are used in Europe and Asia to handle food scraps and similar feedstocks that can be moved by high-solids piston pumps; none are operational in the US at present. Dry fermentation reactors are an emerging AD technology in the US. The first dry fermentation system came on-line in Wisconsin in 2011 (see Subsection 3.3.1 for more information) and others are in various stages of planning, design, or construction.

All AD systems produce biogas, digestate (i.e., the residuals from digestion, which can be either liquid or solid), and effluent (the wastewater from dewatering liquid digestates or the percolate used in dry AD systems). The flammable nature of biogas requires that all processing to be completed in gas-tight systems, which allows for the capture and management of most process odors. The digestion process also reduces the volatile fatty acids produced in decomposition that are a common source of odors. The degree of biogas contaminant removal needed depends on the market for the biogas, with electrical production via a low-BTU generator requiring the least clean-up and injection into existing natural gas distribution pipelines requiring the most clean-up.

The output from the digester is called digestate. Digestate retains most of the nutrients present in the feedstocks being digested and liquid digestates are often land-applied to cropland to capitalize on that nutrient value. Liquid digestates can also be mechanically dewatered to reuse the solids as animal bedding, as a land-applied soil amendment, or as feedstock to an aerobic composting facility. Solid digestates are usually composted prior to beneficial reuse. Consequently, solid waste AD is often an energy-extraction step prior to composting.

Effluent from digestate dewatering is either land-applied on cropland or discharged to a sewer, depending on the distance to, and availability of, suitable farmland. Percolate from solid waste digestion (similar to leachate) is recycled internally to keep the dry fermentation process anaerobic.

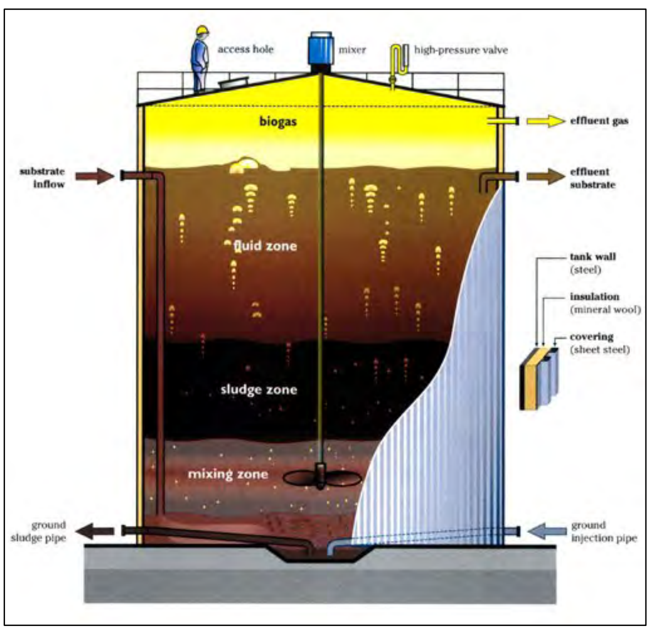
3.2.1.1 Liquid Digesters

There are many styles of liquid AD systems including single stage, two stage, and batch with a variety of control and mixing methods. The most common digester process configuration is a completely mixed, single stage reactor in which the various biochemical conversions are occurring simultaneously in a mixed culture. A single stage reactor is simple to build and operate and effectively promotes conversion to methane. Conversely, AD can be broken down to the processes of hydrolysis, fermentation, and methanogenesis. Process design can consist of reactors in series to create optimal conditions for the bacteria involved in each of these conversion steps. Such a reactor arrangement may require less total reactor volume than a single stage reactor and may result in more complete conversion of the organic wastes to methane. However, systems with multiple reactors are typically more expensive to build and operate.

Anaerobic digesters are operated at two temperature ranges, mesophilic and thermophilic. Most digesters currently operating in the U. S. are mesophilic and run at temperature ranges from 90^{o}F to 110^{o}F. Thermophilic digestion refers to operational temperature conditions above 125^{o} F. Thermophilic digestion can produce 30 to 50 % more methane than mesophilic digestion processes operating at the same residence time. Thermophilic digesters typically generate fewer odors and have greater pathogen destruction than mesophilic systems.

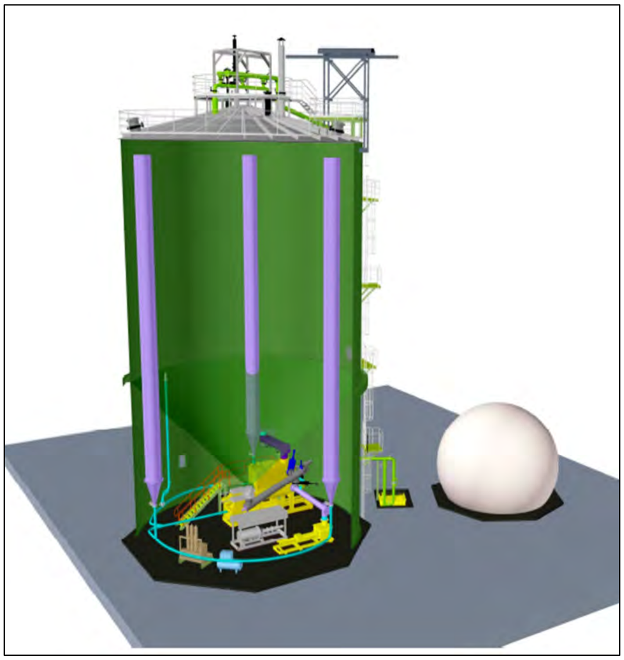
Illustrations of typical liquid digesters are shown in Figures 3-2 and 3-3. Figure 3-3 illustrates a higher-solids liquid “slurry" digester, which can handle feedstocks up to 50% T.S.

Figure 3-2 Typical Low-Solids Liquid Digester



Source: Arcata, CA Wastewater Treatment Plan, Humboldt State University.

Figure 3-3 Typical High-Solids "Slurry" Digester



Source: Organic Waste Systems (OWS), Brecht, Belgium.

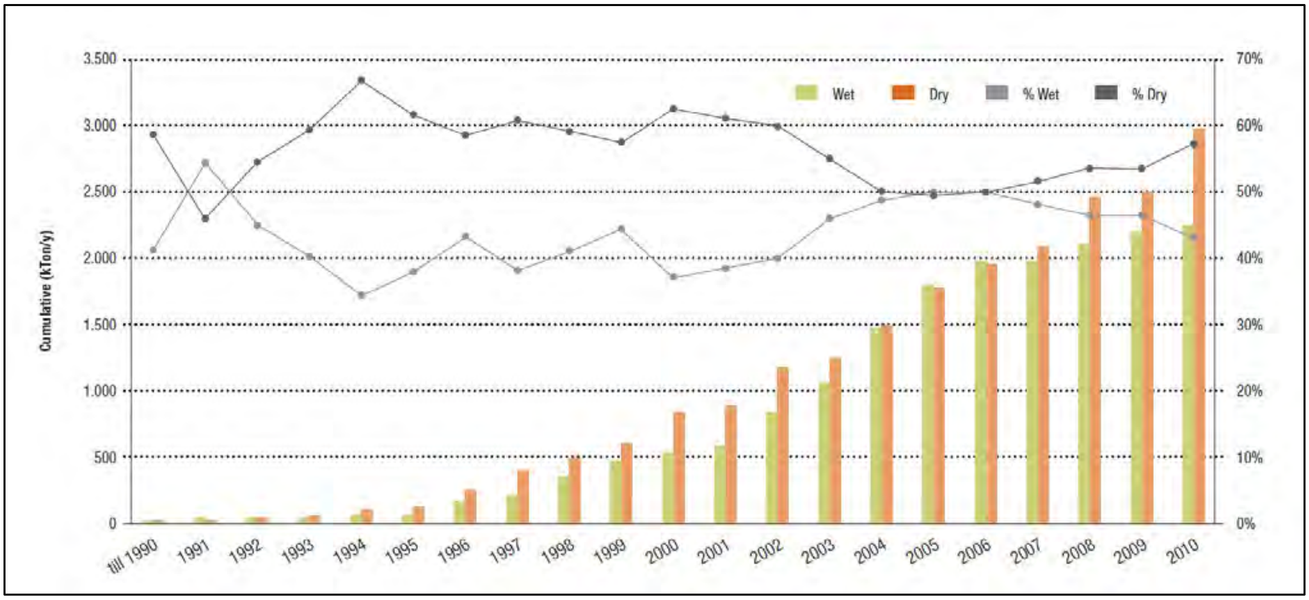
3.2.1.2 Dry Fermentation Reactors

Dry fermentation systems are a newer entry into the waste processing market in the US, but have historically outnumbered liquid systems in Europe, due to the large number of source-separated organics collection programs there (see Figure 3-4). Dry AD systems are better suited to solid waste processing than wet systems due to pumping, clogging, and toxicity issues with wet systems. The first dry AD system in the US managing solid municipal feedstocks came on-line in at a university installation in Oshkosh, WI in November, 2011 (8,500 tons/year capacity); the first municipal/commercial dry AD came on-line in Marina, CA in March, 2013 (5,000 tons/year).

In a batch process, the digester is completely filled with a mix of fresh organic matter and digestate, and then closed with a gas-and liquid-tight seal (see Figures 3-5 and 3-6). The digester remains closed until the end of the desired retention time (around 28 days). It is then emptied and filled with new material, often a mixture of partially digested material that was just removed in addition to the fresh, undigested material. The partially digested material acts as seed material to re-start the digestion process. Digestate recycle rates vary with each vendor's system, ranging from 20% to 50% for dry batch systems and up to 85% for plug-flow (i.e,. unmixed) systems.

Anaerobic microorganisms require a moist environment in which to thrive. A dry system is not moist enough to foster this. To overcome this limitation, a liquid "percolate" is sprayed into the fermenter over the digesting feedstocks. The percolate has already been through an active digester; therefore, it contains anaerobic microorganisms. Once a fermenter has been re-seeded, and percolate has been pumped into it, gas production begins almost immediately. Over the retention time of the digester, the percolate is repeatedly drained and re-sprayed onto the fermenting mass.

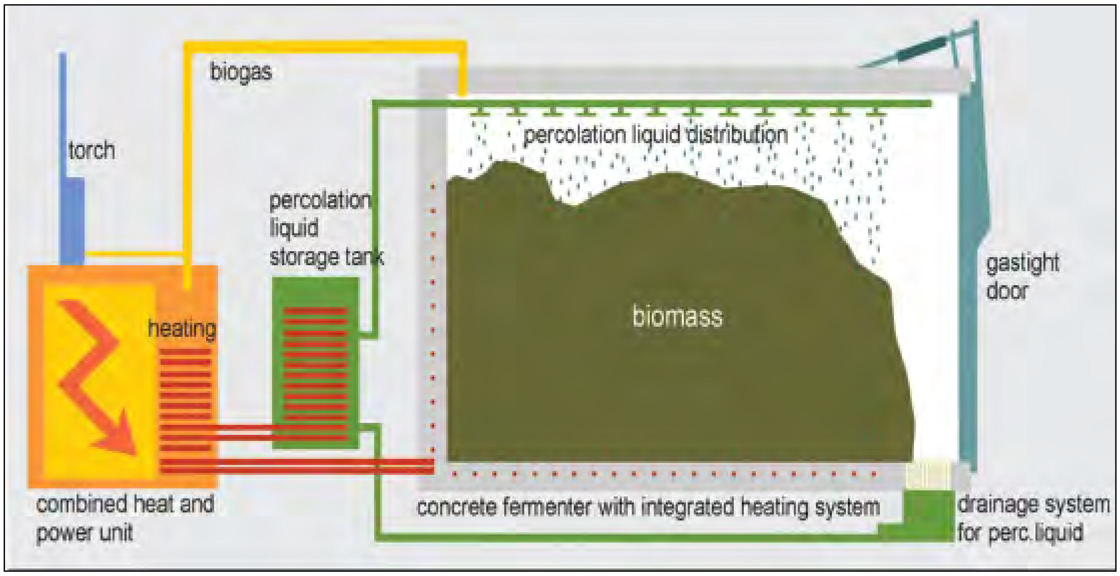
Figure 3-4 Wet vs. Dry AD Systems in Europe



Source: Anaerobic Digestion, European Bioplastics, Berlin Germany, February 2011

Figure 3-5 Loaded Dry Batch AD Fermenter

Figure 3-6 Cross Section through a Dry Fermenter



Source: BEKON Energy Technologies GmbH & Co. KG, Unterföhring, Germany.

Dry batch anaerobic digesters have several advantages over liquid and high solids digesters for processing SSO. The following items highlight some of those advantages:

- Because the dry material is stackable, the units can be loaded and unloaded with front end loaders.
- When the material has finished digesting, it still has a relatively high solids content and can be composted without having to remove excess liquid (although fresh dry compostable feedstock is needed to elevate volatile solids content).
- Pumping liquid percolate is easier than pumping a slurry and has less potential for clogging and equipment wear.
- The fermenter "cells" are modular, so that multiple cells can be loaded and used at different times, ensuring a more even gas production rate.
- A toxicity event, or an upset condition, does not take an entire digester out-of-service, just an individual cell.

Biogas generation rates are a function of the "richness" of the feedstocks; most European plants are handling residential source-separated "biowaste" (kitchen and garden scraps) and are getting gas generation rates on the order of 3,000 cf/ton of feedstock. A feedstock stream of more digestible materials (such as food processing residuals, bakery wastes, brewery wastes, etc.) might produce gas at a rate of 4,500 cf/ton. A January 2013 test of the output of a mixed-waste materials recycling facility (MRF) (i.e., a "dirty" MRF) in Minnesota showed a methane generation potential of 5,700 cf/ton.

Most of the dry fermentation systems use the biogas (55 to 60% methane, 30 to 35% carbon dioxide [$CO_{2]}$) as fuel for a combined heat-and-power (CHP) engine, which requires the gas be condensed to remove moisture and filtered through a charcoal filter to remove hydrogen sulfide. As an example of conversion of biogas to electricity, General Electric's Jenbacher JS3 316 engines (a common type found in AD systems) have a heat rate of approximately 9,400 British Thermal Unit per kilowatt hour (Btu/kWh), which translates to an electrical efficiency of 36.3%. A dry AD system will use about 7 to 8% of the power produced internally (parasitic power). There is not a lot of available data on actual power produced by these gensets in Europe. One American feasibility study *estimated* electrical production of 6.1 million kWh/year (Massachusetts Technology Collaborative, 2010); however, that rate was based on a 20,000 ton/year waste stream with very high gas generation potential. Many of the European plants have gensets with 300 to 400 kW capacities.

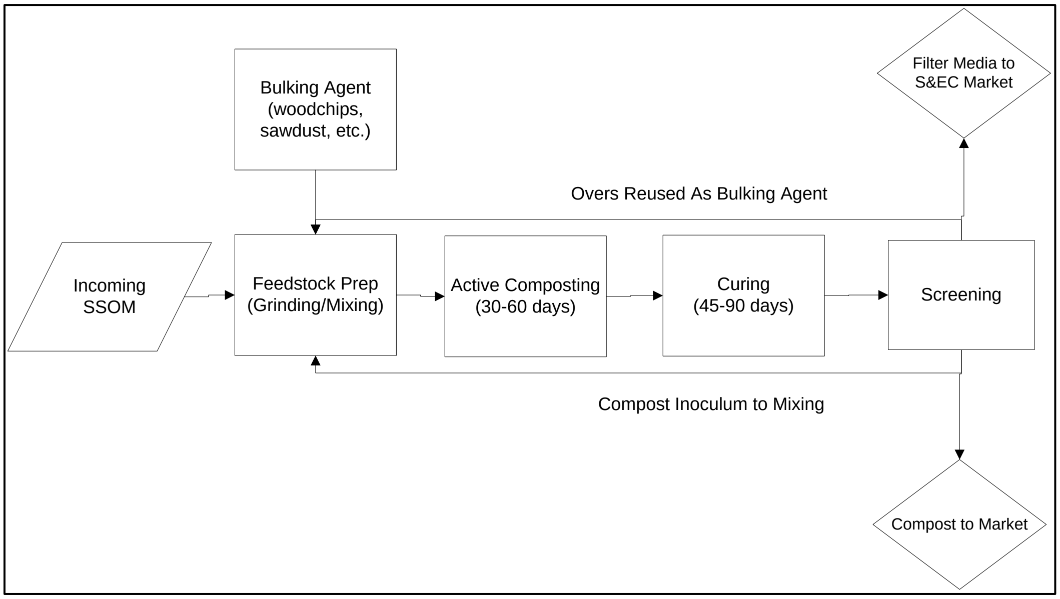
Waste heat from the CHPs is used in European systems for hot water heating (much space heating in Europe is achieved via hot water radiators), for drying of composts and sludges, and for similar uses. The Massachusetts Technology Collaborative study estimated that about 4 MMBtu/hour of heat could be captured for reuse from the engine jacket and from the exhaust stack.

If the biogas is to be reused as "Recovered Natural Gas" (RNG), then other impurities such as CO_2must be removed and the methane content elevated to 97 to 98%. Typical specifications for RNG include maximum concentrations for oxygen, hydrogen sulfide, sulfur, and moisture content, requiring considerable clean-up of biogas.

3.2.2 Aerobic Composting

Composting is the controlled aerobic (with oxygen) decomposition of source-separated organic materials, such as SSO, biosolids, yard trimmings, water treatment residuals, animal manures and mortalities, and certain industrial solid wastes. Composting is a well-proven approach to recycling organic materials; there are between 3,000 and 4,000 operating composting facilities in the US. Compost production requires a medium dry enough to provide pore spaces with free air, but wet enough to sustain biological activity (e.g., around 50 to 55% moisture). Porosity (around 35 to 50%) typically is provided by mixing organic wastes with a bulking agent or amendment, such as wood chips. The addition of woody materials as amendments also serves to raise the carbon:nitrogen ratio of the organic waste materials into the preferred range of 25:1 to 30:1, provided the amendment contains cellulosic carbon (bioavailable carbon). Composting is a relatively simple process that can be performed outdoors in most climates. Because of a desire to operate the process more efficiently, control odors, and minimize the effects of weather, some facilities are constructed under structures, in fully enclosed buildings, or in entirely mechanized facilities (and combinations thereto). Figure 3-7 illustrates a hypothetical process flow diagram for a composting operation. Incoming SSO is often processed by grinding/shredding/mixing to achieve a consistent particle size and to combine the SSO with fresh bulking agent, oversized bulking agent from the screening process, and finished compost (used as a microbial inoculum). After a 30 to 60 day period (faster in some in-vessel systems), the compost is moved to a curing area, where it ages to improve marketability. Curing will take 60-90 days, depending on weather conditions (less if done indoors). Following curing, the compost is screened to a 3/8-inch or ½-inch particle size, and shipped to market. Compost product may also be screened to ¼-inch particle size for turfgrass topdressing and other high-end markets. Oversized bulking agent materials, once screened out, have some market potential as mulches, as filter media in sediment control applications, or are sometimes recycled back into the process.

Figure 3-7 Composting Process Flow Diagram



3.2.2.1 Turned Windrow

One of the most common, flexible, economical methods of composting is windrow composting (Figure 3-8), and it is the most widely-practiced composting approach in Maine. Windrow composting is the predominate method used for composting materials like yard trimmings, but SSO can also be composted using this technology. When windrow composting, the material is placed in long trapezoidal-shaped windrows approximately six to ten feet high and eight to 18 feet wide. The rows are turned or mechanically mixed using a front-end loader or specialized commercial windrow turner. Windrow turners help in maintaining aerobic conditions, particularly those turners whose primary turning action is fluffing instead of flailing. Some smaller commercial windrow turners may limit the windrow height to six feet or less.

Figure 3-8 Windrow Composting

Source: Heads of the Valleys Waste Programme, Brynmawr, Blaenau Gwent, U.K.

Windrow composting operations require the most area of any composting approach; approximately 4,000 cubic yards (cy) of material can be composted per acre per year. Windrows maintain aerobic conditions by natural ventilation of the windrow, where heated inner air rises and is replaced by cooler air coming in from the sides (the chimney effect). As a result, adequate mix porosity is a prerequisite to maintaining aerobic conditions (and thus, minimizing odor problems). As windrows shrink due to material stabilization, they often must be combined with other windrows and re-piled.

Disadvantages to windrow composting of SSO include the following:

- a risk of vector attraction (of bears, rodents, birds, etc.) from exposed food scraps on the surface of the windrow;
- inability to control odors easily;
- difficulty of separating process leachate from rain-induced storm runoff; and
- reduced composting efficiency in extremely wet and/or cold weather conditions (unless enclosed in a building).

3.2.2.2 Aerated Static Pile

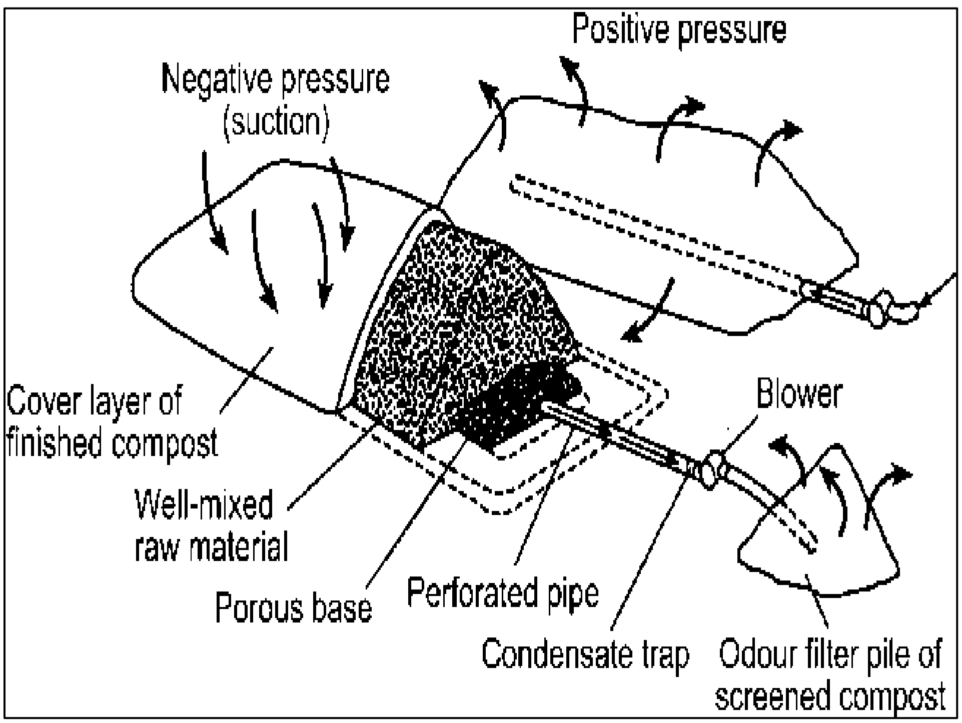
Aerated static pile (ASP) composting was developed as a composting approach for the beneficial reuse of sewage sludge (biosolids) and is a technology well-suited to wet, heavy materials like sludges and manures. Aeration can either be forced draft (positive aeration) or induced draft (negative aeration), or one can have the flexibility to switch between aeration modes. The use of aeration in ASP composting serves to maintain aerobic conditions more thoroughly and completely within the static pile (provided adequate porosity exists), to remove accumulated heat from microbial metabolism, and to dry out the composting material. As ASP piles are not turned or agitated after forming, the prerequisite of adequate porosity to maintain aerobic conditions is more important. It is recommended that large particle size materials like SSO be ground or shredded to a 2-inch minus particle size to ensure adequate composting during the normal 30-day active composting window. A typical ASP three-walled bay facility is shown in Figure 3-9. This facility composts a mix of manures and sawdust.

Figure 3-9 Aerated Static Pile Composting

Source: Coker Composting & Consulting.

The blowers used in ASP composting are generally “off-the-shelf” units, with horsepower varying from 1 to 2 to upwards of 10 horsepower (HP) depending on pile size. Aeration systems are sized to provide a minimum of 500 cubic feet per minute (cfm) of air per dry ton (dt) of volatile solids in the mix and to have the flexibility to increase air flow to over 1,000 cfm/dt during active decomposition of fresh wastes. Aeration rates are often controlled by simple on-off timers.[30] Aeration systems can be run in either “positive” (blowing air into the pile) or in “negative” (pulling air out of the pile) mode. ASP systems in positive air mode can have odor-related issues and, if inside a building, the entire building air volume may have to be treated with a biofilter. Negative mode aeration reduces the volume of air to be treated and, in some cases, emissions can be treated with small individual piles of finished compost at each blower; however larger blowers are needed to overcome the extra static pressure of the biofilter. ASP’s are often covered after pile building with a 6-inch layer of finished compost, which acts both as an insulation blanket to trap heat and as an *in-situ* biofilter (see Figure 3-10).

Figure 3-10 Aerated Static Pile Layout



Source: “On-Farm Composting Handbook,” NRAES-54, p. 30.

An advantage of ASP composting is that individual piles can be sized to accommodate daily or semi-weekly waste generation quantities. Individual piles are practical where raw materials are available for composting at intervals rather than continuously. A disadvantage is that the aeration piping may not be reusable more than once, depending on aeration system configuration, aeration pipe type, and available labor. Figure 3-10 illustrates the use of inexpensive ABS perforated drain pipe.

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[30] Variable-frequency drives are often used to ensure an ongoing supply of oxygen to the pile; fan speed is dictated by pile temperature.

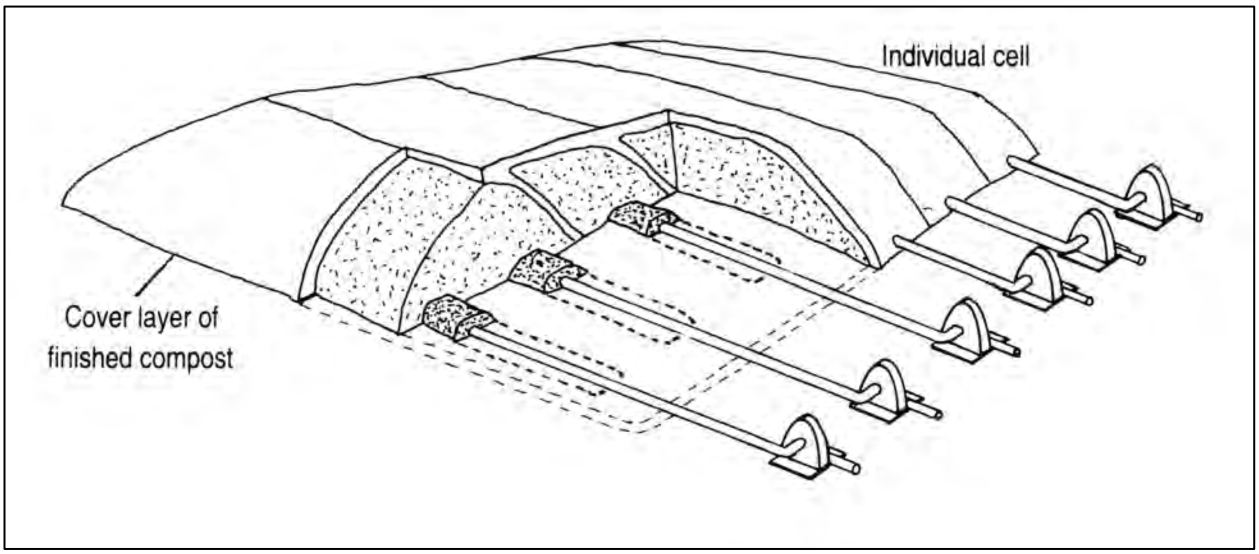
The following paragraphs further describe different variations of ASP systems.

Enclosed ASP. An enclosed ASP composting process has several advantages over open-air method, including reduction of adverse weather effects, better process control, and improved opportunities to manage the air emission and wastewater sidestreams from the process. Structural enclosures can be open-walled pole barns, fabric-covered hoop buildings or pre-engineered metal buildings.

Extended ASP. Extended ASP systems are based on building new aerated static piles immediately adjacent to previously-built piles, so that they share a common “wall” (see Figure 3-11). Extended ASP systems are usually enclosed in a building.

Extended ASP systems offer advantages where there is a continuous flow of materials coming into a composting facility (such as biosolids). They are also more economical of space than individual ASPs and also offer some improvements in air blower efficiencies as the blowers can more readily be manifolded together. The drawbacks to extended ASP are larger buildings are needed and they operate in positive aeration mode, thus often requiring all the building’s air volume be treated by a biofilter. These types of systems are better-suited to larger volumes of feedstocks than are likely available at ecomaine.

Figure 3-11 Extended Aerated Static Pile



Source: NRAES-54, p.31.

Covered ASP. Covered ASP systems consist of covering ASP piles with a breathable fabric. Covered ASP’s are essentially batch systems, in that once the pile is built it remains undisturbed for the duration of active composting and/or curing. This type of system does not allow for moisture addition, but the covering conserves moisture evaporation in the composting process, so moisture addition is not usually needed. Vendors providing covered ASP systems include Engineered Compost Systems (induced draft), W.L. Gore & Associates (forced draft), and Managed Organics Recycling (forced draft). An aerial photograph of a covered ASP is presented in Figure 3-12.

Figure 3-12 GORE Micropore Fabric Covered ASP

Source: W. L. Gore Co., Newark, DE.

Tunnel-type ASP. These are similar to containerized systems but are stationary (Figure 3-13). The technology started with a focus on the mushroom growing industry, then expanded into solid waste and biosolids composting. The process is a three-phase batch composting system. The first two phases are in-tunnel followed by curing as the third phase. The first phase is accomplished in 10 to 14 days of intensive in-tunnel composting. When the first high-rate composting phase is completed, the partially composted material is transferred to a new compost tunnel. Like extended aerated static piles, these types of tunnel reactors are normally used with larger volumes of feedstocks (to justify the higher capital costs); however, some of the smaller scale dry fermentation anaerobic digester (AD) systems (see below) can be combined with small scale aerobic composting tunnel reactors.

Figure 3-13 Christiaens Tunnel, Hamilton, ON

Source: The Christiaens Group, Horst, Netherlands.

Containerized ASP. Containerized aerated static pile compost systems are enclosures that resemble ocean-going shipping containers in size and configuration. Although usually not agitated (hence "static pile") one vendor offers turning augers inside. They are usually aerated by low-horsepower centrifugal fans and are operated as batch-type reactors. These systems are provided by private technology companies, such as Engineered Compost Systems (ECS), HotRot, NatureTech, and Green Mountain Technologies. Figure 3-14 is a photograph of ECS' CV Composter.

Figure 3-14 ECS CV Composter

Source: Engineered Compost Systems, Tacoma WA.

A modification of the mobile configuration illustrated above, is a stationary configuration similar to the tunnel reactors noted above. The ECS SV unit pictured in Figure 3-15 is a stationary composting unit similar to the CV unit.

Figure 3-15 ECS SV Composter

Source: Engineered Compost Systems, Tacoma WA.

3.2.2.3 In-vessel Composting Systems.

"In-vessel" composting systems refer to electro-mechanical engineered technologies for composting. Some of the aerated static pile systems noted earlier are considered in-vessel systems. Two other in-vessel technologies are rotary drum and agitated bay composting systems.

Rotary Drum. Rotary drum composting systems are used for municipal solid waste (MSW), animal mortalities, meat-packing and rendering wastes, and small-scale institutional food wastes(i.e., prisons and university dining halls). This approach uses a horizontal rotary drum to mix, aerate, and move the material through the system. Rotary drum composting for MSW has been practiced since the early 1970's and Bedminister Bioconversion and Conporec are two manufacturers of large, MSW composting systems. Other manufacturers make smaller systems, such as BW Organics, DTE Environmental, XAct Systems (Figure 3-16), and Rotocom.

The drum is mounted on large bearings and turned through a bull gear. A drum about 6 feet in diameter and 16 feet long has a daily capacity of approximately 4 cy with a residence time of three days. In the drum, the composting process starts quickly; and the highly degradable, oxygen-demanding materials are decomposed. Further decomposition of the material is necessary and is accomplished through a second stage of composting, usually in windrows or aerated static piles. The primary advantage of rotary drum composting is it usually achieves the requisite pathogen kill time-temperature relationship (>55^{o} C for three days), and it can reduce potential odor problems due to rapid decomposition of highly degradable organics, which are often the source of odor problems. Air is supplied through the discharge end and is incorporated into the material as it tumbles. The air moves in the opposite direction to the material. The compost near the discharge is cooled by the fresh air. In the middle, it receives the warmed air, which encourages the process; and the newly loaded material receives the warmest air to initiate the process. These types of units can also be used as mixers to combine feedstocks prior to the composting process.

Figure 3-16 X-ACT Systems Rotary Drum

Source: X-ACT Systems, Tenton, Ontario, Canada.

Agitated Bay. The agitated bay system combines controlled aeration with periodic turning. The composting takes place between walls that form long, narrow channels referred to as beds. A rail or channel on top of each wall supports and guides a compost-turning machine. A loader places raw materials at the front end of the bed. As the turning machine moves forward on the rails, it mixes the compost and discharges the compost behind itself. With each turning, the machine moves the compost a set distance toward the end of the bed. The turning machines work in a similar way to windrow turners, using rotating paddles or flails to agitate the materials, break up clumps of particles, and maintain porosity. Some machines include a conveyor to move the compost. The machines work automatically without an operator and are controlled with limit switches. Figure 3-17 is a schematic layout of an agitated bed/bay system. This is the type of composting system in use at the Lewiston-Auburn Water Pollution Control Facility.

Figure 3-17 Agitated Bed/Bay Layout

Source: Eggersmann Anlagenbau BACKHUS GmbH, Edewecht, Germany

Most commercial systems include a set of aeration pipes or an aeration plenum recessed in the floor of the bed and covered with a screen and/or gravel. Between turnings, aeration is supplied by blowers to aerate and cool the composting materials. As the materials along the length of the bed are at different stages of composting, the bed is divided into different aeration zones along its length. Several blowers are used per bed. Each blower supplies air to one zone of a bed and is controlled individually by a temperature sensor or time clock. The capacity of the system is dependent on the number and size of the beds. The width of the beds in commercially available systems ranges from about 6 to 20 feet, and bed depths are between about 3 and 10 feet. The beds must conform to the size of the turning machine, and the walls must be especially straight. To protect equipment and control composting conditions, the beds are housed in a building.

The length of a bed and frequency of turning determine the composting period. Where the machine moves the materials 10 feet at each turning and the bed is 100 feet long, the composting period is ten days with daily turning. It increases to 20 days where turning occurs every other day. Suggested composting periods for commercial agitated bed systems range from two to four weeks, though a long curing period may be necessary.

Hybrid Systems. A hybrid system using both forced aeration and windrow turning has been developed by Green Mountain Technologies (Bainbridge Island, WA) (Figure 3-18). Marketed as the "Earth Pad", there are three installations in the US. The system is located under an open-walled roofed structure, and has an aeration system buried inside a concrete slab. The system is divided into modules, with each module supplied by one blower and with separate zones within each module that can be independently controlled for temperature targets. Each module holds 5,400 cy over 16 days, which allows for 300 cy of incoming feedstocks to be placed daily in a module. Usually two modules are placed side by side for a total of 36 days of active aerated composting. Additional sets of modules can be laid end to end for unlimited expansion capability. During processing, the compost is periodically turned with an elevated face compost turner.

Figure 3-18 Green Mountain Technologies Earth Pad

Source: Green Mountain Technologies, Bainbridge Island, WA.

Table 3-1 Summary of Technology Alternatives

	Advantages	Disadvantages
	ANAEROBIC DIGESTION	
Low Solids	Well demonstrated for liquid phase feedstocks Higher biogas generation potential	Food scraps would need to be liquefied to work effectively in a low solids system. Low contamination threshold
High Solids		Only available from vendors Lots of moving parts Little experience in the US
Dry Fermentation	Can manage solid materials effectively.	Only available from vendors Little experience in the US.
	AEROBIC COMPOSTING	
Windrow	Most common system in us in the US Flexibility, ability to manage diverse feedstocks	Requires large land area, Limited odor control
Aerated Static Pile		
Enclosed ASP	Reduction in adverse weather effects Better process control	Cost (if inside building)
Extended ASP	Enlargement of active composting mass, less land area	Loss of flexibility Cost (of building)
Covered ASP	Membranes can be effective at controlling odors	Only available from vendors Cost
Tunnel-type ASP	Materials enclosed within tunnel	Only available from vendors Limited experience with food scraps
Containerized ASP	Materials enclosed within container	Only available from vendors Emptying containers time consuming
In-Vessel		
Rotary Drum	Feedstocks contained within drum Process speed	Only available from vendors Cost Requires second stage process
Agitated Bay	Limited labor costs, good process control	Only available from vendors Limited experience with food scraps Cost
Hybrid Systems	Can use best attributes of multiple systems	Only available from vendors Limited experience

3.2.3 Odor Management Technologies

As organics recycling requires the managed decomposition of putrescible organic material, it is, by nature, an odorous process. Whether those odors escape from the processing facility and migrate into the environment where they can be detected and perceived can be controlled. Control does not mean elimination; in this context, control objectives are to minimize the potential for odors to cause an off-site nuisance.

The most effective odor control system is good process and facility design coupled with good process management. This requires careful management and operator attention to all aspects of the organics recycling facility, including the following components:

- Waste receipt and mixing: Did someone leave the door open to let odors escape?
- Digestion and/or composting process: Is the recipe correct? Are the biological process conditions correct?
- Materials handling: Did the product get moved to the outside too soon?
- Site management: Are fines getting into the storm water management pond? Has the outside area been patrolled to remove fugitive materials?

All of these factors interplay to minimize the potential for odor episodes, if managed properly.

Technology does play a role in odor minimization. Technologies that remove the chemical(s) causing the odors are either biological (biofiltration), physical/chemical (scrubbers) or chemical (neutralizers). Other technologies are based on dispersing odors more fully (misting systems). Odor treatment technologies share a common objective – to reduce odorous chemical concentrations to below the Recognition Threshold (RT), if not below the Detection Threshold (DT). The RT can be several orders of magnitude higher than the DT, so it can be much more difficult to reduce odors below the detection threshold. But this is where the sharp focus of odor science and the predictive nature of engineered odor solutions run up against the subjective nature of emotional personal reactions to malodors and the regulation of odors under a legal "nuisance" standard rather than a numerical emission limit. Even if an odor has been reduced below the RT, it can still be perceived as, and complained about, a nuisance.

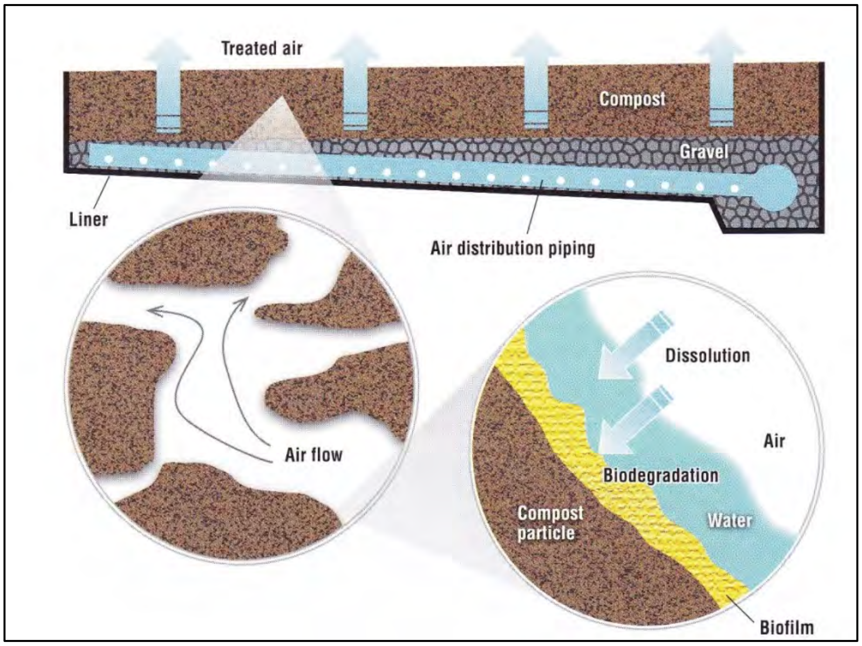
3.2.3.1 Biological Systems

The primary biological system used for odor control is biofiltration. Biofiltration refers to multiple technologies, including bioscrubbers, bio-trickling filters, and biofilters. Most composting facilities with a biological odor control system use biofilters. Biofilters use microorganisms to remove odorous air pollutants. The air flows through a packed bed and the pollutant transfers into a thin biofilm on the surface of the packing material. Microorganisms, including bacteria and fungi, reside in the biofilm and degrade the pollutant. The biofilter bed can be a separate unit or can be integral to the compost pile, usually as a cap or covering of the pile or windrow.

In separate bed systems, which are commonly used with in-vessel and aerated static pile composting systems, air is introduced through a network of perforated pipes at the base of the bed. These pipes are usually embedded in gravel, which acts both as an air plenum to distribute the exhaust evenly through the bed and as a barrier to keep fines from the organic layer above from clogging the pipes. A thick bed of biofilter media, usually 4 to 5 feet deep, lies on top of the gravel (see Figure 3-19). Biofilters are usually designed for a specific Gas Retention Time, which is on the order of 45 to 60 seconds.

With windrow or ASP composting, a cap of screened or unscreened compost on top of the windrow can act as an *in-situ* (in-place) biofilter. This approach was developed in California primarily to reduce odor emissions but it became quickly apparent that it was potentially a method to reduce the volatile organic chemical precursors of ground-level ozone (smog) which is a significant air quality problem in some air districts in that state. A compost cap is built of 2 to 4 inches of screened compost, 6 to 8 inches of

Figure 3-19 Biofilter Cross-Section



Source: "Biocycle", J.G. Press, Emmaus, PA.

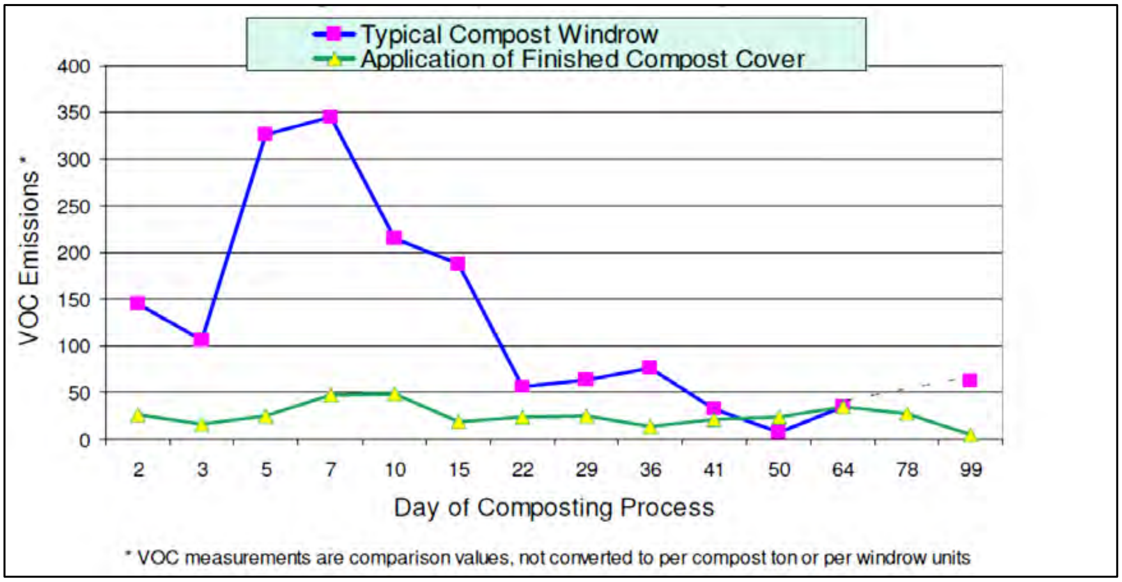
unscreened compost or 12 inches of woody overs. It acts as a filter media that odor molecules must pass through so using screened material increases the surface area of the particles in this filter. The advantage of higher surface area is there is more room for microbes to live on the surface of compost

particles (so there is greater metabolism of odorous compounds); however, the drawback is the finer texture of screened compost reduces air flow through this compost cap. These caps can be tricky to install properly. If the filter media is too finely screened and/or gets too far down the sides of the windrow, it can block off the air flow supporting the chimney effect and starve the windrow of oxygen.

The effectiveness of compost caps has been studied by the University of California at San Diego (SJVAPCD, 2011) and found to produce significant reductions of more than 75% of the volatile organic compound (VOC) emissions in the first two weeks. Figure 3-20 illustrates these findings.

For separate bed systems, several different types of materials can be used as a biofilter media. Media normally consist of an organic substrate to house microbial communities and a bulking agent to ensure adequate porosity for air flow without significant backpressure on the blowers (too much backpressure lowers the airflow of a blower). A compost-woodchip mix is commonly used, but some biofilters use a combination of peat, soil, compost, and wood chips.

Figure 3-20 Effectiveness of Windrow Compost Cap



3.2.3.2 Physical/Chemical Systems

The main physical approach to odor management is scrubbing, where a water and/or chemical solution is sprayed against the exhaust air to absorb the pollutants in the air into the scrubbing solution. Absorption is the process where one chemical (the odorant) is dissolved into the volume of another medium (e.g., water). Scrubbers work by directing an exhaust air stream against a water-based chemical shower. This solution usually contains chemicals such as sodium hydroxide (to remove reduced sulfur compounds) or sulfuric acid (to remove ammonia). In a scrubber, ammonia and hydrogen sulfide are converted to odorless byproducts by chemical reactions.

Ammonia and hydrogen sulfide (H2S) can be absorbed with 99% efficiency in a fraction of a second because these are extremely rapid acid-base reactions. Scrubbers often contain packing media, which work primarily by spreading the liquid over an extended plastic surface to promote contact between the liquid and the passing air. Rings or saddles with more surface area create additional liquid surface, but more plastic surface also means more obstacles to air flow (see Figure 3-21).

The Cape May, New Jersey biosolids composting facility uses scrubbers for odor control. Figure 3-22 is a process flow diagram showing the configuration. The main drawback to scrubbers is a high energy usage and managing a high-strength wastewater.

Another physical approach is to incorporate a high-carbon wood ash into the compost pile or windrow. This approach is used by the biosolids composting facility in the Town of Yarmouth, Maine. The mechanism at work here is adsorption, which is the deposition and adhesion of one chemical (the odorant) onto the surface of another medium, wood ash in this case. The properties of the ash vary considerably from plant to plant, and only ash that has a very high carbon content works well for odor control in composting. In addition to odor control, the low bulk density (approximately 450 pounds/cy)

Figure 3-21 Physical/Chemical Scrubber & Packing Media

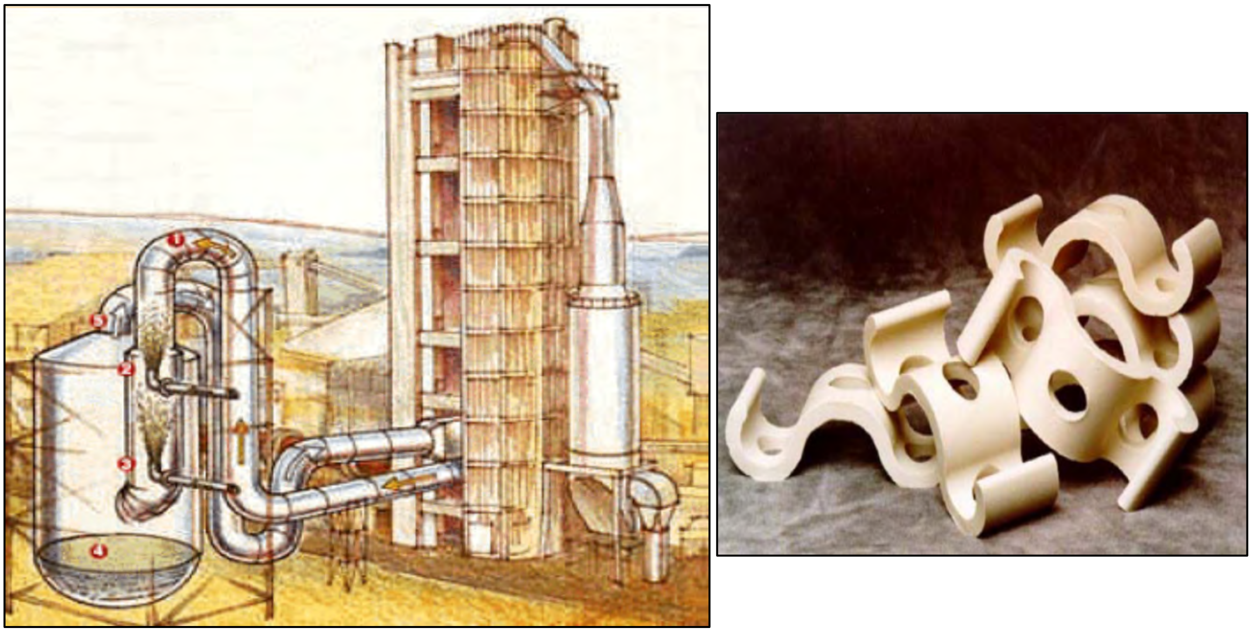
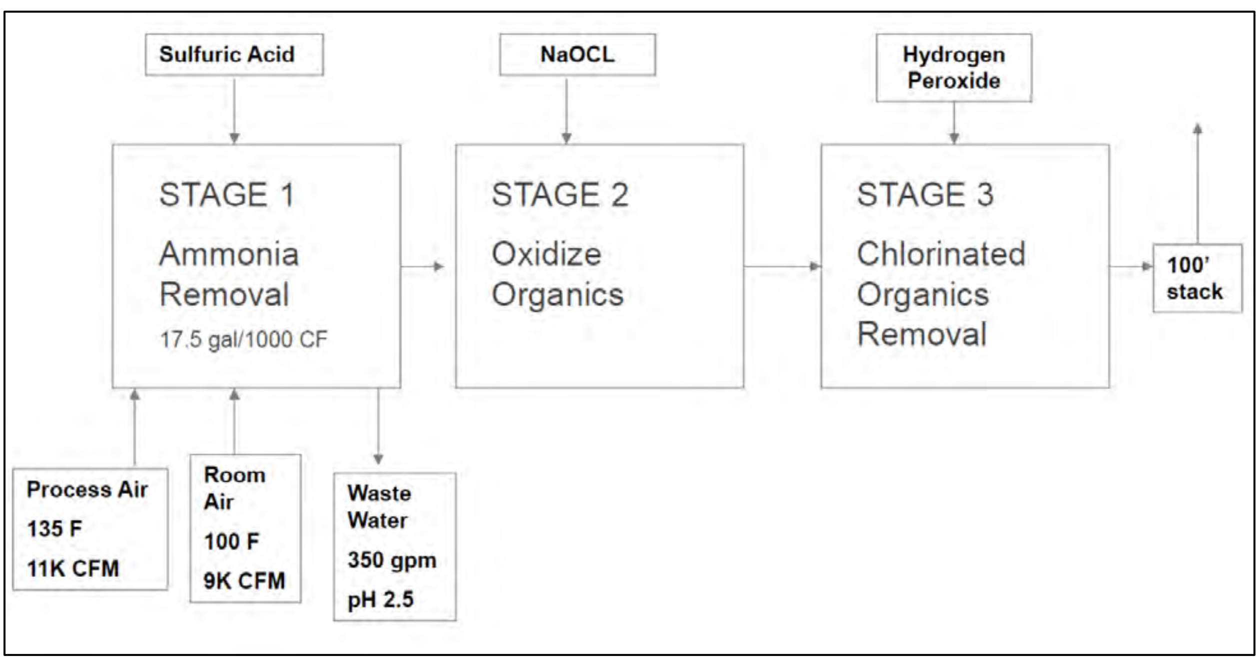


Figure 3-22 Cape May NJ Composting Facility Scrubber Configuration



and the relatively low moisture content improve the physical properties of the compost blend, which otherwise tends toward the moist, high bulk density end of the ideal range for composting. This ash has a surface area of 330 square meters per gram (m^2/gm), whereas activated carbon has a surface area of approximately 500 m^2/gm.

High-carbon wood ash has properties similar to activated carbon. It is produced by the incomplete combustion of wood at temperatures above 700°C, and so, contains particles of biochar, which contributes to the odor absorption character of the ash. While the addition of a high-pH wood ash can raise the compost pile pH and shift the ammonia equilibrium towards gaseous ammonia volatilization, this can be managed by reducing the pH of the ash-amended compost blends by exposure to rainfall and CO_2 from the atmosphere. Full-scale field research has shown that amending piles with 12.5% and 25% high-carbon wood ash by volume can reduce odor emissions by more than 73% and 88%, respectively (Integrated Waste Management Board (2002).

A newer physical/chemical odor control approach is using a technology called “non-thermal plasma” (NTP) to remove odorous chemicals. NTP is one of the processes used to make ozone from oxygen, and ozone has been used for years to oxidize odorous compounds. Non-thermal plasma uses a reactor that consists of two electrodes separated by a void space that is lined with a dielectric material (an electrical insulator that can be polarized by an applied electric field) and is filled with an insulating media. This type of reactor is called Dielectric-Barrier Discharge (DBD). A phenomenon occurs when the voltage through the system exceeds the insulating effect of the media and a large number of electrical discharges occur. In the DBD field in a NTP reactor, ozone reacts with odor-causing compounds to form ammonium nitrate, oxygen, water and carbon dioxide. This technology is being used at a Transform Compost Systems facility in Ontario, Canada.

3.2.3.3 Chemical Systems

Chemical approaches to odor control are usually focused on oxidizing reduced-state compounds (like the chemical solutions in the scrubbers discussion above) or on breaking carbon-hydrogen-oxygen bonds to change the structure of a chemical. Others are called “sequestrants” where chemical formulations sequester, or bind odorous chemicals like amines, ammonia and sulfur compounds. One sequestrant product on the market consists of copper sulfate (an oxidant for the conversion of primary alcohols), benzaldehyde (an almond odor flavoring), and aluminum chlorohydrate (found in deodorants).

Chemical products can be delivered in different ways. Some are applied topically, some incorporated into the pile or windrow and some applied as a misting spray. The chemical formulations on the market today are proprietary formulations so finding reliable information about how they work is difficult. Most facilities do not find the use of inoculants or neutralizers to be a required part of operations, some products, under some circumstances may provide odor control benefits worth considering.

3.3 Project Profiles

Examples of operating facilities using the technologies presented in Subsection 3.2 are included in this section.

3.3.1 AD Facilities

3.3.1.1 Dry Fermentation AD

High-Solids Anaerobic Digestion Facility at University of Wisconsin-Oshkosh

The organics recycling facility at the Oshkosh campus of the University of Wisconsin uses the BIOFerm™ biodigester technology, which is a dry fermentation anaerobic digestion system (Figure 3-23). The 19,000 sf facility consists of four separate reactors and handles 8,000 tons/year of campus food scraps and landscaping debris, animal bedding wastes, and recycled digestate. The mix ratio is one-third food scraps, one-third animal bedding, and one-third yard waste.

Figure 3-23 University of Wisconsin High-Solids Anaerobic Digestion Facility

Each fermentation vessel is 70 feet long by 23 feet wide by 17.7 feet high. Residence time in the vessels is 28 days. An enclosed mixing lobby prevents odorous process air from escaping into the environment.

The mixing lobby is ventilated with 2.6 air exchanges per hour and the air is routed to a biofilter for treatment. The facility produces 23.8 million cubic feet of biogas per year, which is combusted on-site in a 370-kilowatt (kW) CHP generator, producing 2.3 million kilowatt-hours per year (kWh/yr) of electrical power and recovering 7,918 million BTU/yr of heat. The electricity produced is sold to Wisconsin Public Service (WPS) under a Power Purchase Agreement (PPA) and the recovered heat is used for maintaining the digester at mesophilic temperature and heating the facilities throughout the winter months.

SSO wastes and about half of the digestate (the solid residual left over after fermentation) are loaded into one of the four reactors with a front-end loader. Once full, the reactor is closed and the 28-day fermentation process begins with percolation. Percolation is a process where a leachate-like liquid is sprayed onto the organic biomass, filling the biomass pore spaces with liquid, and shifting the bacterial activity to anaerobic digestion, producing biogas. Biogas is collected from all four reactors and is stored in a flexible membrane storage bag above the reactors.

At the end of the 28-day cycle, the percolation process is stopped and the aeration system is turned on. This flushes the methane-rich biogas from the reactor, allowing the reactor to be opened. When the methane content drops below a prescribed level, the exhaust is re-directed to a biofiltration unit, which remains in operation handling reactor air volumes during reactor unloading and reloading.

The biogas produced contains about 60% methane and low levels of contaminants. Biological desulfurization occurs within the fermentation process to reduce hydrogen sulfide concentrations prior to gas entering the combined heat and power unit. Biogas is chilled to remove moisture and further scrubbed with an activated carbon filter. The biogas is then combusted in the CHP engine. Heat is recovered from both the engine jacket and the exhaust air stream. The digestate is composted in turned windrows at an off-site facility for market maturation for a period of several weeks.

The Oshkosh facility was constructed in 2011 for a capital cost of $3.5 million. Other dry fermentation facilities using this technology are in planning, design and/or construction. The BIOFerm™ technology is available from BIOFerm™ Energy Systems in Madison, Wisconsin (www.BIOFermEnergy.com).

3.3.1.2 High-Solids Liquid Co-Digestion

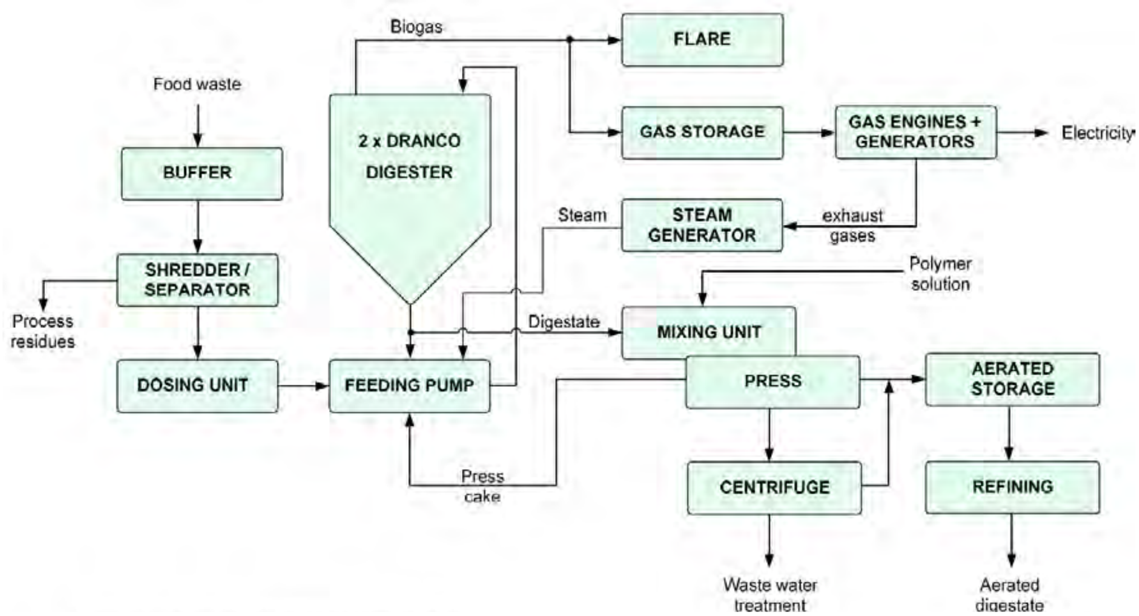
High-Solids Anaerobic Digestion Facility at Busan, South Korea

The DRANCO high-solids anaerobic digestion system was developed in Europe to treat biowaste (kitchen scraps and garden wastes) or VGF waste (vegetable, garden, fruit wastes). The DRANCO system operates at 65 to 75% moisture and is a vertical configuration. The DRANCO unit uses a high-solids piston pump (like a concrete pump) to move solids to the top of the reactor. The solids migrate downward by gravity. Biogas rises and exits the digester through the roof and flows towards the gas storage and treatment. The digestate is extracted from the bottom of the reactor by means of an extraction screw. The largest part of the digestate is recycled for mixing with fresh feedstocks. Residence time in the digester is 20 to 30 days.

The DRANCO plant in Busan, South Korea started operation in 2005, handling 73,000 tons/year of food wastes. While that is significantly larger than what would be needed to handle food wastes in the ecomaine service area, the vendor (Organic Waste Systems) has provided information on a 10,000 ton/year unit. The Busan plant produces over 232 million cf of biogas annually which is converted to 12 million kWh of electricity. A photograph of the plant and the process flow diagram are shown in Figures 3-24 and 3-25.

Figure 3-24 DRANCO High-Solids Liquid Co-Digestion Plant, South Korea

Figure 3-25 DRANCO Process Flow Diagram



According to the manufacturer, a 10,000 ton/year system would produce about 42 million cf of biogas per year, with an average expected electricity production of 2.5 million kWh/year. The digestate, which would be reduced in tonnage from the amount fed to the digesters due to conversion of organic matter solids to biogas, would be composted with greenwaste or woody feedstocks. A 10,000 ton/year plant would have a capital cost of about $15.6 million.

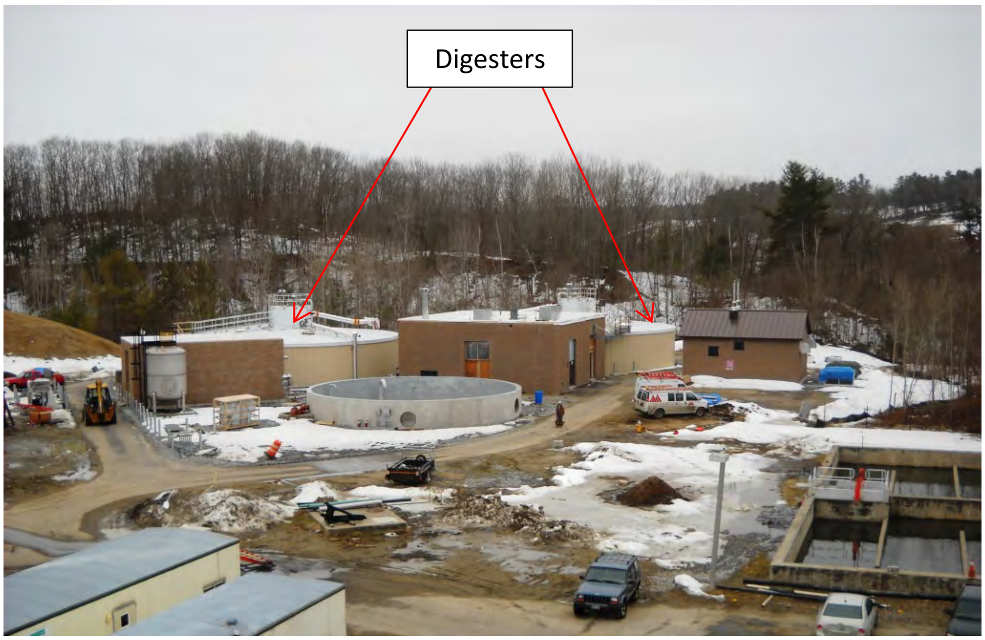
The DRANCO high-solids AD system is available from Organic Waste Systems (OWS), 7155 Five Mile Road Cincinnati, OH 45230; telephone 513-535-6760, http://www.ows.be.

3.3.1.3 Low-Solids Liquid Co-Digestion

Lewiston-Auburn Water Pollution Control Authority (LAWPCA)

LAWPCA is building two conventional, complete-mix anaerobic digesters to both capture energy from and reduce the volume of the biosolids generated at their wastewater treatment plant in Lewiston (Figure 3-26). The digesters consist of two reactors, each with a capacity of 690,000 gallons. The planned solids retention time is 15 to 20 days. The reactors will be fed by chopper pumps and agitated with a Vaughn nozzle mixer. LAWPCA indicated that they had available capacity of about 15% (~10,000 gal/day, assuming a SRT=20 days).

Figure 3-26 LAWPCA Liquid Digester Under Construction



Mac Richardson, LAWPCA's Superintendent, has indicated that LAWPCA may be interested in taking in food scraps to their digestion system if the benefit from the increased gas production and tip fee for the food waste is greater than the costs associated increased solids processing and digestate handling. As their chopper pumps are limited to a ¾-inch minus particle size, pre-shredding of the food waste will be needed. They could receive pre-treated food scraps in one of their septic receiving tanks.

LAWPCA has not decided on a tip fee for food scraps, but Mr. Richardson believes that their extra operating costs may be lower than the $30 to $40 per ton tip fee charged by area composting operations for food scraps. Mr. Richardson indicated that to some extent, the market will guide their choices on outside feedstocks, with biosolids from other facilities, and their higher tip fees, possibly being a more attractive feedstock than food scraps.

LAWPCA plans to burn the biogas in two 230 kW Liebherr engines after treating the gas to remove water, H2S and siloxanes. They intend to use the power produced "behind the meter" at the treatment plant, which has a demand of 3 million kWh/yr. The AD system has been approved by Maine Department of Environmental Protection as a Class 1 renewable energy source.

Exeter Agri-Energy, Exeter(EAE), ME

This anaerobic digester (AD) project is located at Stonyvale Dairy in Exeter, ME and consists of two 400,000-gallon liquid AD reactors handling manure from the dairy (Figure 3-27). EAE also takes in source-separated food scraps, primarily from pre-consumer sources. The system came on-line in December 2011 and is currently handling about 20,000 gallons/day of manure plus 8,000 to 10,000 gallons/day of off-farm organics. The current break-down on off-farm organics is 4 to 8 tons per day of food scraps and the rest is liquid waste (e.g., grease trap waste). They plan to build two more reactors to support expansion to 30,000 gallons/day of manure and 30,000 gallons/day of off-farm organics. They are permitted to take Types 1A, 1B, and 1C wastes.

Figure 3-27 Anaerobic Digesters at Agri-Energy, Exeter, ME

The food scraps are delivered into a concrete block and floored bunker (500-ton capacity) where a REMU loader attachment shreds the food scraps to a 1-inch minus particle size. The shredded scraps are moved by loader to one of two 1,000-gallon in-ground, heated receiving tanks. A 40-hp Baldor chopper pump is used to pump the scraps into the AD reactors. The AD system was provided by CHFour Biogas, a Canadian company. The AD system operates with a 10% digestate recycle and a 25-day solids residence time. The continuously-stirred tank reactors are 65 feet in diameter and 20 feet tall, and are made of 12-inch cast-in-place concrete with heat tubing cast into the walls and a 4-inch insulation layer on the outside. Biogas is stored in a 60-mil flexible membrane storage system above the reactors. Temperatures in the digesters are typically close to 100 ^{o}F.

The digestate (7% total solids [TS]) is dewatered using a screw press, with the effluent recycled for land application on the farm and the solids (30% TS) recycled as animal bedding. The biogas consists of 65% methane, with 600 to 700 ppm of hydrogen sulfide. Moisture is condensed out of the biogas, and oxygen is used to oxidize the H_2S to elemental sulfur prior to the biogas being combusted in a Guascor 957 kW combined-heat-and-power generator. In 2012, EAE produced 5.2 million KWh of power. Routine power production runs around 900 kW. Captured heat is used to heat the reactors and the liquids receiving tanks. They are selling the electricity for $0.10 per kWh and believe that due to the competitive request for proposal (RFP) process for increased capacity, they would probably earn $0.08 to $0.09 per kWh if they expanded their capacity.

3.3.2 Composting Systems

3.3.2.1 Turned Windrow

Benson Farm LLC, Gorham, ME

Eddie Benson owns and operates a 280-acre dairy farm (Benson Farm LLC) that also has an on-site composting facility handling approximately 2,000 cy/year of seafood processing waste and food scraps, not including carbon sources. Feedstocks composted include source-separated food scraps (mostly commercial sources), seafood processing residuals, leaves from local towns, horse manure and bedding, and some dairy manure and bedding. Composting is completed in open-air turned windrows. Benson blends feedstocks volumetrically with a loader bucket, aiming for a ratio of three parts carbonaceous materials to one part nitrogenous materials. Windrows are formed on native soils, and then covered with a layer of carbonaceous amendment, which is renewed following each windrow turning. Windrow residence time is eight weeks for active composting, with curing taking another three to four months.

Benson sells his compost in bulk and bags his compost under the brand name “Surf and Turf” using a Rotochopper Go-Bagger. The compost is approved by the Maine Organic Farmers and Gardeners Association (MOFGA) for use in organic agriculture. 75% of his sales are in the spring; 25% are in the fall. To date, homeowner sales are his largest market. He also makes manufactured topsoil, essentially a 50/50 blend of compost with soil.

Benson has considered expanding into full-time composting, although he is concerned about the long-term availability of enough carbon amendment. He is at his processing limit without building a hardened pad for waste receipt, mixing, and composting. He has had an expansion plan prepared by the engineering staff of the Maine US Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS). The farm can do much of the expansion construction in-house. He has a gravel pit on-site and his bagging room concrete floor was poured with farm labor. Benson has a leachate pond but would need a storm water recycle system if he expanded. He would also want to get a mechanical mixer (SSI or equal) to improve operations.

Resurgam Zero Food Waste, Portland, ME

Resurgam Zero Food Waste, operating under the business name Organic Alchemy LLC (Greg Williams and Brett Richardson) have partnered with CPRC Group to form Maine Waste Solutions, which is licensed to compost up to 400 cy of Type 1B residuals (vegetative waste) and up to 200 cy of Type 1C residuals (seafood waste and other nitrogenous materials) monthly, amended with carbon sources that include leaves, horse bedding and wood chips (or other Type 1A residuals) not to exceed 750 cy of Type 1C residual annually (License No. S-02147-CF-G-E) at the City of Portland's Riverside Recycling Facility (RRF), which is operated by CPRC. Composting is completed using open-air turned windrows, under a fabric roof and with some aeration in the first phase.

While Resurgam is permitted to take in up to 400 cy/month of food scraps, they are currently only processing approximately 240 cy/month. Most of the food waste is pre-consumer commercial food scraps. What little post-consumer material they are getting has very little contamination. Resurgam encourages clean loads with training and discourages contamination with a surcharge, which they have not had to use to date. They collect the food scraps from Portland-area restaurants and groceries in mostly 38-gallon plastic lidded roll carts with plastic can liners secured by rubber bands (they also use some 64-gallon carts) (Figure 3-28). They collect in a lift-gate equipped box truck and unload the carts inside a Calhoun fabric building at the RRF. The building is 100 feet long by 4 feet' wide and rests on asphalt pad made of 3-inch asphalt intermediate course over 12 inches of gravel.

Figure 3-28 Resurgam's Plastic-lined Carts for Food Scraps Collection in Portland

Resurgam uses a volumetric mix ratio of 1.5 parts carbon to 1 part food, mixing with the bucket of a loader inside the building. They form windrows outside then cover the windrows with more amendment. Windrows are turned with a loader every 10 to 14 days. They have been in operation since August 2011 but have not yet sold any compost, indicating that the material is not ready for distribution. They intend to screen at 5/8-inch,, sell under the brand name "Resurgam," and plan to seek MOFGA certification.

MB Bark (a subsidiary of CPRC) has permitted a new facility which is permitted to take in approximately 1,000 tons per month of food scraps in Auburn, Maine. The plan is for this facility to be operation in 2014. Maine Waste Solutions will be the operator of that facility.

3.3.2.2 Aerated Static Pile Composting

Chittenden Solid Waste Management District Composting Facility, Williston, VT

The Chittenden Solid Waste Management District (CSWD) has a composting facility that handles 5,000 to 6,000 tons/year of leaf waste, 1,000 tons/year of grass clippings, and 3,000 to 4,000 tons/year of food scraps. They receive about 400 tons/year of residential food scraps (plus some commercial food scraps) from seven drop-off facilities around the district (similar to the one in use in the Town of Yarmouth, ME). CSWD believes that they have the potential to capture as much as 7,000 tons/year of food scraps, but also have observed that some food-based materials they were accepting are now going to competitor's facilities, particularly digester projects. Incoming feedstocks are amended by wood chips for carbon amendment and for bulking; the wood chips cost CSWD $32 per ton. Feedstocks are mixed by passing them through a 200-hp horizontal grinder, which also reduces particle sizes to optimum levels.

CSWD uses aerated static pile composting, using a two-phase approach. In Phase 1, composting is completed in 2-foot' wide by 50-foot long bays, with 6- to 7-foot tall piles, covered with a 1-inch layer of mature compost. Each bay has four aeration pipes per bay, fed by one 1.5 horsepower forced draft blower (CSWD has the option to switch to induced-draft aeration, using portable 40-cubic yard [CY] roll-offs as biofilters). Composting in Phase 1 takes 16 days. The blowers are operated on 15-minute cycles, with blowers on for four minutes and off for 11 minutes. The Phase 1 system has the aeration pipes enclosed in the pad, covered with steel grates. Phase 1 takes place under a shed roof with open walls shown in Figure 3-29. After 16 days in Phase 1, the compost is removed from the bay, remixed and re-piled onto aeration piping in the Phase 2 bays. Phase 2 is completed in the open, with similar blowers and aeration piping, although Phase 2 aeration piping is above-grade. Phase 2 composting takes another 20 days. Compost is cured for 60 days prior to screening. Rainfall runoff from the Phase 1 shed roof and leachate from the Phase 1 bays is collected in a 20,000 gallon tank and used to improve mix moisture content prior to Phase 2 composting.

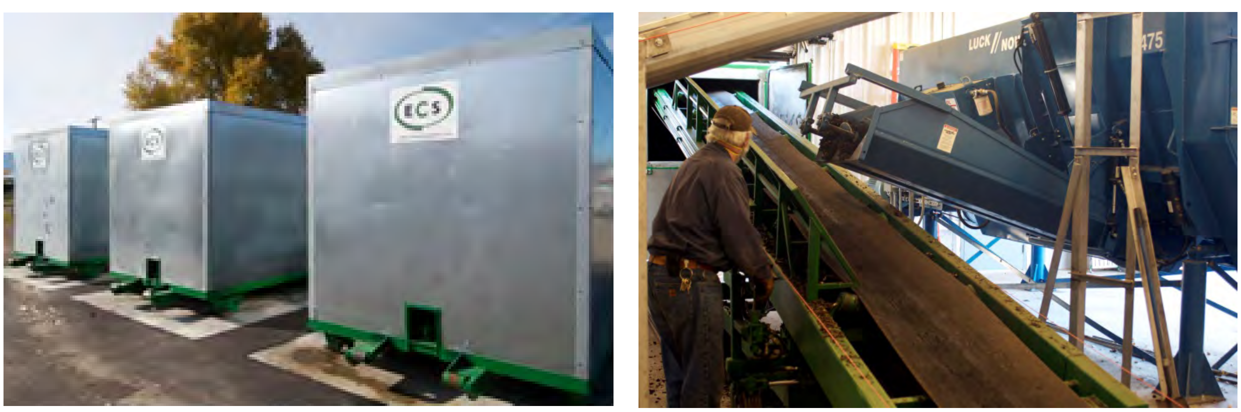
Figure 3-29 CSWD Aerated Static Pile Compost Facility

3.3.2.3 Containerized ASP Systems

Livingston, MT Wastewater Treatment Plant (WWTP) Biosolids Composting Facility

The composting facility at the wastewater treatment plant in Livingston, MT uses the ECS CV Composter. The facility consists of four 40 -cy CV Composter Vessels, a 4.75-cy Luck/Now compost mixer, a loading conveyer, the ECS Comptroller™ (aeration control and data monitoring system), and a biofiltration system (Figure 3-30). The staffing level at the facility consists of one full-time employee. The CV vessels are designed for a 20-year service life. The feedstocks used at Livingston are biosolids and wood chips. The approximate compost production is 1,467 cy/year. This estimate comes from an estimated total daily mix volume of 6.7 cy/day or total daily mix weight of 3.11 tons.

Figure 3-30 Containerized ASP system at Livingston, MT



Feedstock recipes are developed by weight to achieve the best management practices for aerobic composting methods. The feedstocks are placed into the Luck/Now mixer. The mixer includes scales with large displays for achieving accurate mix ratios, and radio-frequency controls so that it can be operated from the front end loader cab. The mixer then discharges its contents onto the vessel loading conveyor and into the CV Vessel. The in-vessel retention time for composting in the CV unit is about 21 days. This process is followed by curing the compost in either passive windrows or small ASP systems. The CV Vessels are moved and unloaded using a roll-off truck.

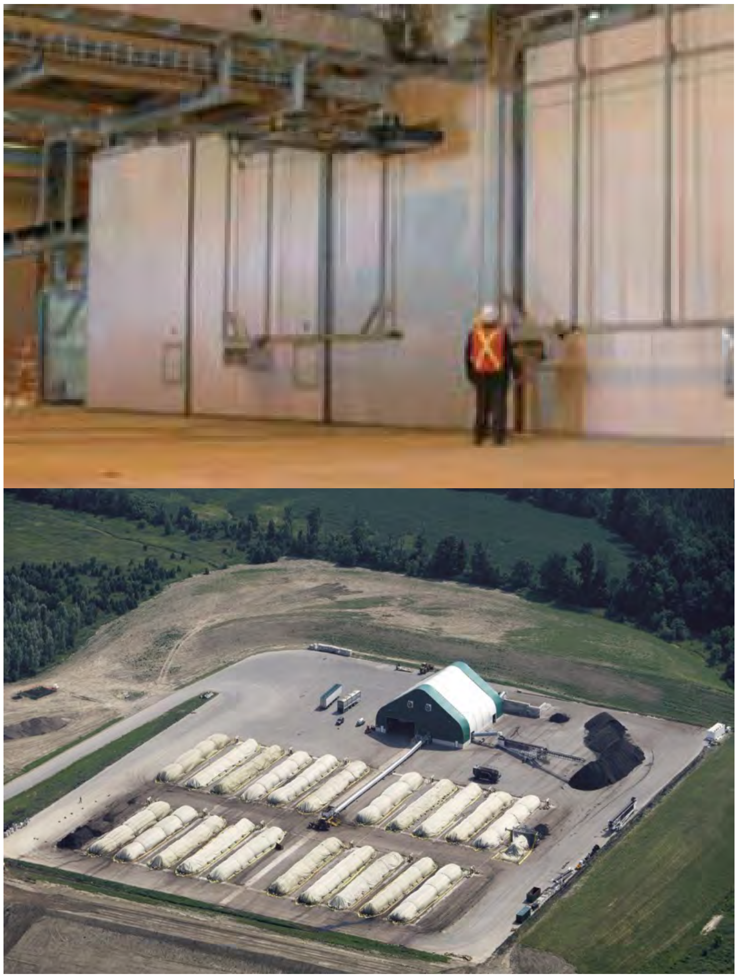
3.3.2.4 Tunnel and Fabric-Covered ASP Composting

Region of Peel Composting Facility, Caledon, Ontario, Canada

The Region of Peel in Ontario, Canada opened the Integrated Waste Management Facility in Brampton in 2006 to handle up to 72,000 tons per year of residential curbside-collected SSO. The facility uses two tunnel-reactor technologies. Six 250-ton Christiaens Group (Netherlands) tunnel composting reactors handle about 60,000 tons/year while eight Herhof Bio-cells handle the remaining 12,000 tons/year. Both are similarly configured, consisting of reinforced concrete boxes that provide an aerobic composting environment by circulating air through perforations in the floor. Leachate is collected and recirculated through an overhead spray system.

A 50-50 mix (by weight) of yard trimmings and SSO is fed through a Vecoplan shredder to reduce particle size to 4-inch minus and to mix feedstocks together. Tunnel reactors are loaded and unloaded with front end loaders. After approximately 7 to 10 days, the material is removed from the tunnels and brought to the Peel Curing Facility in Caledon. Initially this material was being cured in open air windrows. Shortly after the tunnel reactor/curing system came on-line, Peel ran into a firestorm of odor complaints from citizens in the first year of operation. That started a long process of operational and technology modifications to fix the problems and the facility reopened in 2009. One of the improvements was to install a Gore Cover System (microporous fabric) over the curing windrows. Material is now cured under the covers in 24 windrows for 6 weeks and then screened to produce the finished compost. The facility is shown in Figure 3-31.

Figure 3-31 Tunnel and Fabric-Covered ASP Facility in Ontario, Canada



3.3.2.5 Rotary Drum Composting

Green Earth Landworks with Alaska Green Waste Solutions at Anchorage, Alaska

After looking into the possibility of windrow and static pile composting, Alaska Green Waste Solutions decided on using an in-vessel composting method, a rotating BioReactor drum by X-ACT systems. The small footprint and large capacity was a desirable feature of this system. Alaska Waste purchased a 10-foot diameter by 30-foot long vessel and installed it in 2009.

Alaska Green Waste Solutions collects vegetable and fruit waste from grocery stores such as Costco, Fred Meyer, and Carrs/Safeway. Alaska Waste provides grocery stores who are willing to participate 64-gallon tipper carts (at a small rental rate) to collect their vegetable and fruit waste. Horse stables also contribute their manure to this composting operation. Roll-off containers are located at the local stables and picked up weekly. Alaska Waste hauls both the produce waste and manure to its composting system housed in a building on site. The composting system is comprised of the BioReactor, four conveyors, and a mixer. The heat from the BioReactor helps heat the building in which it is housed.

The produce waste is loaded into the mixer and allowed to sit over night to allow excess liquid to drain off. The following morning the mixer is started and two parts wood chips are added to two parts produce waste, and one part manure. After being mixed for 20 minutes, the contents are discharged onto a conveyor that feeds into the BioReactor.

The waste materials take about 7 days to cycle through the BioReactor drum, and about three batches of compost are produced each week. It rotates only a few hours each day. According to the operator, with the help of the EM-1, the temperature of the composting material is kept in the range of 115°F and 145°F. The total volume is reduced by about 20%.

The compost is then moved to Green Earth Landworks (GEL) where it is cured in windrows or static piles. It is then mixed for different projects such as landscaping and erosion control and sold. GEL sells their compost for between $65 and $95 per cy. Their main consumer of compost is the Department of Transportation (DOT).

GEL is part of the Seal of Testing Assurance (STA) program through the United States Composting Council.

3.3.2.6 Agitated Bay Composting

Lewiston-Auburn Water Pollution Control Authority (LAWPCA)

LAWPCA has relied on sludge composting at their wastewater treatment plant since the 1990's. They handle 12,500 wet tons/year at the facility. They use a Longwood agitated bay system with sawdust and shavings as the bulking agent (Figure 3-32). The facility is enclosed in a building and air emissions are treated with a biofilter. Compost is sold under the brand name "MaineGro".The facility is now operating at capacity, but when their proposed AD system comes online in April, 2013, the available capacity will increase by 40%. They are considering using this additional capacity for the merchant composting of sewage sludges produced by other facilities.

Figure 3-32 LAWPCA Agitated Bay Composting Facility

3.4 Weighted Matrix Evaluation

The weighted-matrix evaluation technique was used to focus on those composting and digestion technologies that have the greatest potential to meet the needs of ecomaine in processing SSO. The weighted criteria matrix is a decision-making tool that is used to evaluate alternatives based on specific evaluation criteria weighted by importance. By evaluating alternatives based on their performance with respect to individual criteria, a value for the alternative can be identified. The values for each alternative can then be compared to create a rank order of their performance related to the criteria as a whole. The tool is important because it treats the criteria independently, helping avoid the over-influence or emphasis on specific individual criteria.

3.4.1 Evaluation Criteria and Weighting Factors

All of the technologies evaluated can reliably produce a stable compost product from SSO, with the following considerations:

- Systems that can accept small amounts of fresh SSO daily favor agitated bay and rotary drum processes.
- All the composting systems can be expanded as the quantities of SSO increase although some of the manufactured in-vessel systems are inherently more modular.
- Dry fermentation AD systems are more compatible with composting due to similarities in materials handling techniques and avoiding the need for liquid-solid phase changes.
- Only dry fermentation AD systems can be easily expanded.
- All of the systems evaluated can operate in similar climates to southern Maine.
- Systems that can reduce particle sizes during the composting process favor turned windrow and agitated bay systems (useful with coarsely-ground feedstocks).
- Systems that minimize economic surprises favor those with the least amount of equipment and fewest moving parts, such as aerated static pile systems.
- Aerated static pile systems, either open-air or enclosed, either individual or extended, will all benefit from careful mixing to optimize particle size, C:N ratio and moisture prior to pile formation.
- Day-to-day management is critical to the success of any of these systems, particularly with regards to odor control.

A rigid evaluation against these constraining and defining elements does not adequately differentiate between technologies that should be considered further. Therefore, additional evaluation criteria were selected for use in this project and the rationale for scoring against each criterion is presented in Table 3-2.

Each of these evaluation criteria was assigned a “weighting factor”, a numerical value between 1 and 5, where 1 meant it was not an important criterion, 3 meant it was neither an important nor an unimportant criterion, and 5 meant it was a very important criterion. The weighting factors used for each criterion were assigned by ecomaine and are shown in Table 3-3.

Table 3-2 Organics Processing Technology Evaluation Criteria

Criteria Class	Evaluation Criteria	Explanation
Process & Operability Factors	Experience with similar source separated organics (SSO)	An approach proven to have worked with similar waste would score higher
	Experience in the US	Systems with proven experience in the US would score higher
	Flexibility to handle recipe changes	Recipe changes may occur as the nature of the SSO changes over time; higher flexibility means a higher score
	Sensitivity to process upsets	A process more resistant to upset as a result of operational changes would score higher
	Proven ability to meet pathogen reduction requirements	A regulatory requirement (especially important if pet litter is included in targeted organics)
	Process design favors minimal odor emissions	Process design that minimizes potential for odors would score higher
	Ability to produce finished product in less than 90 days	Affects the amount of space needed for processing and to ensure a useable product is available for market
	Cold weather operability	Ensuring the system will work reliably in Maine winters
	Energy consumption	A system that uses less energy would score higher
	Staffing requirements	A system that can be operated with fewer people would score higher
	Dry vs. wet operation	A dry operation handled with typical solid waste handling equipment would score higher
Constructability Factors	Modularity	As the amount of SSO to be recycled in the future is unclear, a system with modular units that could be purchased separately would score higher
	Ease of expansion	A system where additional components can be easily added would score higher
	Processing system footprint area	A smaller processing area might mean a smaller site would be needed, a consideration in an urbanizing area like Portland
	Relative capital cost	Lower cost would score higher
Maintainability Factors	Mechanical complexity	Lower complexity would score higher
	Operation and Maintenance costs	Lower Operating and Maintenance (O&M) cost would score higher
	Dry vs. wet maintenance	Dry systems are easier to maintain and would score higher
Aesthetic/ Environmental	Odor/air emissions potential & control	Systems with proven odor control features would score higher
	Wastewater emissions potential & control	Systems with less wastewater management issues (leachate or surface water that comes into contact with feedstocks) would score higher
	Noise pollution potential	Systems that are quieter would score higher
Other	Compatibility with ecomaine's solid waste operations	Approaches that are compatible with the existing materials handling nature of ecomaine's operations would score higher
	Relationship to previous system failures	Systems that had not been associated with previously-failed facilities would score higher

Table 3-3 Weighting Factors as Determined by ecomaine.

Criteria Class	Evaluation Criteria	Weighting Factor (1 – 5)
Process & Operability Factors	Experience with similar source separated organics (SSO)	5
	Experience in the US	3
	Flexibility to handle recipe changes	4
	Lack of sensitivity to process upsets	4
	Proven ability to meet pathogen reduction requirements	5
	Process design favors minimal odor emissions	5
	Ability to produce finished product in less than 90 days	2
	Cold weather operability	5
	Energy consumption	4
	Staffing requirements	3
	Dry vs. wet operation	2
Constructability Factors	Modularity	4
	Ease of expansion	4
	Processing system footprint area	2
	Relative capital cost	4
Maintainability Factors	Mechanical complexity	3
	Operation and Maintenance costs	4
	Dry vs. wet maintenance	3
Aesthetic/ Environmental	Odor/air emissions potential & control	5
	Wastewater emissions potential & control	4
	Noise pollution potential	2
Other	Compatibility with ecomaine's solid waste operations	4
	Relationship to previous system failures	5

3.4.2 Evaluation Results

For each of the evaluation criteria, a raw (i.e., unweighted) score was assigned. Scoring was from 1 to 5, where 1 meant the alternative was least favorable with respect to the evaluation criterion and 5 meant it was most favorable. Raw scores are presented in Table 3-4. Scores were assigned based on the knowledge of the Northern Tilth project team about these systems and on best professional judgment. As many of the evaluation criteria are oriented to composting, the digestion alternatives may reflect artificially lower scores. Scoring rationale was as follows:

Experience with similar SSO – As noted in Section 1, the targeted organics for diversion to an organics recycling system will be food scraps, soiled/compostable paper, and yard trimmings. Many of the composting technologies have experience with these feedstocks. The digestion technologies have lesser experience, particularly with low-solid liquid digesters.

Experience in the US. – All of the composting technologies have US installations, some more than others. Low-solids liquid digesters are common in the US; high-solids liquid and dry fermentation systems have less US experience.

Flexibility to handle recipe changes – All composting systems can handle recipe changes well, provided they stay within the recommended C:N range of around 25:1 – 30:1; variations beyond that range will likely result in ammonia volatilization and odor release (at C:N < 20:1) and in greatly extended

Table 3-4 Raw Alternatives Evaluation Score

		Anaerobic Digesters		Composting Systems									
Criteria Class	**Evaluation Criteria[1]**	**Liquid Digesters**	**Dry Digesters**	**Turned Windrows**	**Aerated Static Pile**	**Extended ASP**	**Covered ASP**	**Tunnel ASP Reactors**	**Container ASPs**	**InVessel Reactors**	**Rotary Drums**	**Agitated Bay**	**Hybrid**
Process & Operability Factors	Experience with similar SSO	1	5	5	4	1	4	3	3	4	2	1	1
	Experience in the US	5	1	5	5	3	4	2	4	4	4	4	1
	Flexibility to handle recipe changes	2	4	5	5	5	5	5	5	3	3	5	3
	Lack of sensitivity to process upsets	1	4	5	5	5	5	5	5	5	3	5	3
	Proven ability to meet PFRP	1	2	5	5	5	5	5	5	5	3	5	5
	Process design favors minimal odor emissions	5	5	1	4	3	4	4	4	4	2	4	4
	< 90 days to finished product	1	4	1	4	4	4	4	4	4	1	4	4
	Cold weather operability	2	4	2	5	5	5	5	5	5	3	5	2
	Energy consumption	1	3	5	4	4	4	4	4	2	2	2	3
	Staffing	1	2	2	4	4	4	4	4	4	3	3	3
	Dry vs. wet operation	1	5	5	5	5	5	5	5	5	5	5	5
Constructability Factors	Modularity	1	4	1	3	1	3	1	5	1	1	2	3
	Ease of expansion	1	4	5	4	1	3	2	3	1	1	2	3
	Footprint area	4	5	1	4	5	4	4	4	3	2	5	5
	Relative capital cost	3	2	5	4	2	2	2	2	2	2	2	2
Maintainability Factors	Mechanical complexity	2	4	5	4	3	2	2	2	2	3	2	3
	Operation & Maintenance costs	1	3	4	4	3	3	3	3	3	3	3	3
	Dry vs. wet maintenance	1	5	5	5	5	5	5	5	5	5	5	5
Aesthetic/ Environmental	Odor/air emissions	5	5	1	4	3	4	4	4	4	2	4	4
	Wastewater emissions	1	5	2	4	4	4	4	4	4	3	4	4
	Noise pollution potential	5	5	3	3	2	3	3	3	3	2	2	3
Other	Compatibility with ecomaine	1	5	1	5	4	4	4	4	2	2	4	4
	Relationship to previous system failures	3	3	1	5	4	3	3	4	4	2	4	3

[1] *Raw Scores: 1 = least favorable; 5 = most favorable.*

compost production times (at C:N > 35:1). All systems also benefit from adequate porosity. Systems with material agitation and turning (windrow and agitated bay) are most flexible due to the mixing action of the agitation. Liquid digesters tend to be sensitive to feedstock changes once they are operating in steady-state conditions; dry fermentation systems are less sensitive to recipe changes.

Lack of sensitivity to process upsets – Both composting and digestion are biological systems where microbial action can be inhibited by process upsets, such as lack of moisture in composting and variations in feed rates in AD. Windrow and uncovered ASP composting is subject to moisture losses, and low-solid liquid digesters are sensitive to variations in feed rates.

Proven ability to meet pathogen reduction requirements – This is a requirement of Maine solid waste management regulation when compost feedstocks contain post-consumer food scraps and/or animal litter. All composting alternatives have established ability to meet these requirements, although windrow systems may have trouble reaching temperature throughout the windrow at all times (particularly during winter months). Rotary drum systems may lose temperature as fresh SSO is added. Improper mixing for ASP systems can result in cold spots that do not meet time-temperature requirements. AD systems operating at mesophilic or low thermophilic temperatures (i.e. $< 131^{o}$ F.) will need a higher-temperature finishing step for the digestate, such as composting.

Process design favors minimal odor emissions – Digestion systems offer the highest potential for controlling odors as the entire process occurs in a sealed reactor; enclosed or in-vessel composting systems have reduced odor potential due to the enclosure. Open-air turned windrow and uncovered forced-draft ASP systems have the highest potential for odor emissions.

Ability to produce finished product in less than 90 days - organics recycling systems operate best under steady-state conditions, where incoming feedstocks are processed, digested/composted, cured, screened, and moved to market in a timely fashion. This reduces system area footprint and can reduce capital costs. It can be difficult for windrow composting systems to produce finished product in less than 90 days in the winter in Maine.

Cold weather operability – Enclosed systems (extended aerated static pile, enclosed ASP, agitated bay) scored higher as they are inside a building, which, while not “climate-controlled”, mitigates the effects of adverse winter weather. Outdoor systems, such as ASP and windrows, scored lower, although there are operating outdoor windrow and ASP systems in Maine.

Energy consumption – None of the systems evaluated are offered as having any particular advantage with regard to energy consumption. Many of the forced aeration systems now have variable frequency drives on the blowers, which will greatly reduce electrical consumption (and costs) due to the “spike” from blower start-up. Liquid digestion systems tend to have high energy consumption due to the need to pump liquids.

Staffing – All of the composting alternatives had similar staffing needs, which are between one and two full-time equivalents (higher for low-technology alternatives like windrows). Digestion systems will need higher levels of staffing due to greater mechanical complexity, particularly if electricity generation systems are included.

Dry vs. wet operation – this criterion relates more to digestion than to composting. Liquid digestion systems processing SSO must pre-process the feedstocks to make them pumpable, then dewatering the low-solids digestate (in some cases) prior to digestate reuse. Dewatering digestate produces a wastewater stream that must be handled.

Modularity – Several of the vendor-offered enclosed ASP systems are very modular but require purchasing multiple units, and some are not modular at all. Dry fermentation AD systems and generic ASP systems based on aerated compost bay configuration are very modular. Liquid digestion systems are not modular, by definition, nor are extended ASP systems, due to the need to size the enclosing building for full capacity.

Ease of expansion – Alternatives considered easy to expand included: dry fermentation AD, windrows, ASP, containerized ASP and fabric-covered ASP. Alternatives scored mid-range for expansion were extended ASP, in-vessel units, agitated bay and rotary drum systems. Hard to expand (and, thus, low scoring) alternatives were tunnel composting systems and liquid digesters (both low-solids and high-solids).

Footprint area – Systems with the highest processing densities tend to have the lowest footprint area, favoring all digestion systems, ASP, extended ASP, fabric-covered ASP systems, tunnel systems and agitated bay systems.

Relative capital cost – Digestion systems are the most expensive (due to technological complexity) and windrow systems are the least expensive (due to lack of technology). Those alternatives requiring an enclosing building are scored lower as they are more expensive.

Mechanical complexity – The lack of technology favors windrow composting for this criterion. The in-vessel, agitated bay, and rotary drum systems were scored lower due to the mechanical nature of the agitation systems. Digestion systems were scored lower due to the use of pumps, pulping systems, and biogas cleaning needs.

Operation and maintenance costs – These costs are directly proportional to the degree of technological complexity.

Dry vs. wet maintenance - this criterion relates more to digestion than to composting. Dry fermentation AD systems score higher than liquid AD systems.

Odor/air emissions potential & control – Alternatives like windrows have no opportunity for odor control, other than careful attention to process conditions and weather and were scored lower than systems that normally use biofilters for odor/air pollution control. It can be difficult to capture and treat air from rotary drums and the fresh compost they produce often still has residual odor. Digestion systems have good control systems for odors as they are sealed systems.

Wastewater emissions potential & control – This criterion includes both leachate draining from compost piles, storm water runoff contaminated by contact with fresh solid waste and/or uncomposted materials, and effluent produced by dewatering digestate. Thus, outdoor systems scored lower than in-building systems, and liquid digesters scored lower than dry digesters.

Noise pollution potential – as most of the noise associated with organics recycling systems is derived from mobile equipment, systems with higher need for mobile equipment scored lower (i.e. windrows). Digesters using generators to produce electricity would score lower, but generators are enclosed in structures, which mitigates noise pollution.

Compatibility with ecomaine's operations – ecomaine's operations are focused on solid waste processing and incineration; source-separated materials handling favors alternatives featuring mobile equipment and hydraulic-driven equipment, and disfavors wet systems (i.e. liquid pumping systems).

Relationship to previous system failures – the majority of failed digestion/composting facilities failed due to a lack of good management more than due to a technology problem, but some turned windrow operations have more failures than other composting approaches; there is insufficient experience with AD systems handling SSO to know what risks of failures are.

3.4.3 Weighted Scoring

ecomaine staff assigned values between 1 and 5 to reflect a weighting importance for each evaluation criterion. These weighting factors were multiplied by the raw scores to produce weighted scores. The weighted scores for each alternative were then summed across all evaluation criteria to produce a total weighted score for each alternative. Table 3-5 contains the weighted scores.

The highest scoring alternatives are as follows:

Alternative	Total Weighted Score
Digestion	
Dry Fermentation	330
Composting	
Aerated Static Pile (aerated bays)	373
Containerized Aerated Static Pile	342
Covered Aerated Static Pile	334
Tunnel Reactor ASP	311
Agitated Bay Composting	305

Table 3-5 Weighted Alternatives Evaluation Scores

			Anaerobic Digesters		Composting Systems										
Criteria Class	**Evaluation Criteria[1]**	**Weighting Factor**	**Liquid Digesters**	**Dry Digesters**	**Turned Windrows**	**Aerated Static Pile**	**Extended ASP**	**Covered ASP**	**Tunnel ASP Reactors**	**Container ASPs**	**InVessel Reactors**	**Rotary Drums**	**Agitated Bay**	**Hybrid**
Process & Operability Factors	Experience with similar SSO	5	5	25	25	20	5	20	15	15	20	10	5	5
	Experience in the US	3	15	3	15	15	9	12	6	12	12	12	12	3
	Flexibility to handle recipe changes	4	8	16	20	20	20	20	20	20	12	12	20	12
	Lack of sensitivity to process upsets	4	4	16	20	20	20	20	20	20	20	12	20	12
	Proven ability to meet PFRP	5	5	10	25	25	25	25	25	25	25	15	25	25
	Process design favors min. odor emssions	5	25	25	5	20	15	20	20	20	20	10	20	20
	< 90 days to finished product	2	2	8	2	8	8	8	8	8	8	2	8	8
	Cold weather operability	5	10	20	10	25	25	25	25	25	25	15	25	10
	Energy consumption	4	4	12	20	16	16	16	16	16	8	8	8	12
	Staffing	3	3	6	6	12	12	12	12	12	12	9	9	9
	Dry vs. wet operation	2	2	10	10	10	10	10	10	10	10	10	10	10
Constructability Factors	Modularity	4	4	16	4	12	4	12	4	20	4	4	8	12
	Ease of expansion	4	4	16	20	16	4	12	8	12	4	4	8	12
	Footprint area	2	8	10	2	8	10	8	8	8	6	4	10	10
	Relative capital cost	4	12	8	20	16	8	8	8	8	8	8	8	8
Maintainability Factors	Mechanical complexity	3	6	12	15	12	9	6	6	6	6	9	6	9
	O & M costs	4	4	12	16	16	12	12	12	12	12	12	12	12
	Dry vs. wet maintenance	3	3	15	15	15	15	15	15	15	15	15	15	15
Aesthetic/ Environmental	Odor/air emissions	5	25	25	5	20	15	20	20	20	20	10	20	20
	Wastewater emissions	4	4	20	8	16	16	16	16	16	16	12	16	16
	Noise pollution potential	2	10	10	6	6	4	6	6	6	6	4	4	6
Other	Compatibility with ecomaine	4	4	20	4	20	16	16	16	16	8	8	16	16
	Relationship to previous system failures	5	15	15	5	25	20	15	15	20	20	10	20	15
	Totals		**182**	**330**	**278**	**373**	**298**	**334**	**311**	**342**	**297**	**215**	**305**	**277**

[1] *Weighted Scores: 1 = least important; 5 = most important.*

3.5 Preliminary Process Design

In order to provide a frame of reference for compost facility sizing and amendment needs, Appendix B includes a preliminary process design for a centralized composting facility near ecomaine's other facilities based on an estimate of collecting approximately 12,000 tons/year of SSO (primarily food scraps and soiled paper). The process design recipe includes food scraps, woody materials, recycled compost (used as an inoculant) and oversized carbonaceous amendment from the final product screening process (used as a bulking agent). The recipe is based on recommended process design criteria:

- A carbon – nitrogen ratio of between 25:1 and 30:1
- A mix moisture content of 50% to 55%
- Volatile solids content of at least 80%
- A structural porosity (predicted Free Air Space) of between 40% and 60%

The process flow diagram is a daily volume based on measured bulk density data from other projects, with certain assumptions about volumetric losses in processing. Sizing of the composting facility alternative is based on aerated static pile composting in concrete block bays (similar to the Chittenden VT Solid Waste Management District facility profiled above). As noted elsewhere in this report, other methods of composting include turned windrows and vendor-supplied in-vessel systems.

Preliminary sizing of this alternative indicates it would have the following footprint:

Area Summary				
Process	Width	Length	Area	
	(ft.)	(ft.)	(sq. ft.)	(acres)
Inside Building				
Truck Unloading Area	30	30	900	0.02
Carbon Amendments Storage	20	52	1,033	0.02
Compost Inoculant Storage	12	17	204	0.00
Overs Storage	12	21	250	0.01
Mixing	30	80	2,400	0.06
Composting Area	200	250	50,018	1.15
Curing Area	150	310	46,500	1.07
Screening Area	25	100	2,500	0.06
Product Storage Area	200	450	90,000	2.07
		Total	**193,805**	**4.45**
Outside Behind Building				
Biofilter	100	123	12,250	0.28

4.0 Site Evaluations

Key Findings of Task 4

The following items summarize the findings of Task 4: Site Evaluations for the Organics Recycling Feasibility Study.

- In developing an organics recycling program, ecomaine must determine the most cost-effective manner to ensure sufficient capacity for processing SSO collected from the ecomaine service area while meeting ecomaine's risk minimization goals.
- ecomaine has the option of either developing their own organics processing facility on ecomaine-owned land (there are five potential locations within two separate parcels for siting a facility) or partnering with private ventures that either have or are developing organics processing capacity.
- Of the locations evaluated on ecomaine-owned land (or land that may be available to ecomaine), a wooded area adjacent to the northwestern border of the ashfill holds the most promise for developing a facility. This location would take advantage of the proximity and existing infrastructure at the ashfill and provide ample setbacks from neighboring residences and businesses.
- Areas within the central portion of the ecomaine-owned parcel in Gorham also provide good potential for developing a facility, but the site is completely un-developed and is a longer distance from the WTE plant.
- There is sufficient capacity at existing or planned organics processing facilities in or close to the ecomaine service area to manage the organics that would be generated by an ecomaine-based organics diversion program. However, practical considerations may limit the ability of these operations to manage the type of SSO that would be generated in a residential curbside organics program, and not all facilities would meet ecomaine's risk minimization goals.
- A summary of these existing and planned facilities is included herein, with advantages and disadvantages related to the possibility of developing partnerships with ecomaine for processing ecomaine-based organics.
- Because organics programs within the ecomaine service area will likely build slowly over the first few years, it may be to ecomaine's advantage to partner with existing facilities as the program grows. This could provide an opportunity to determine if building ecomaine-owned organics processing capacity is necessary over the long-term.

4.1 Introduction

The goal of this task is to assess potential sites for building and operating anaerobic digestion and/or composting facilities that would process source-separated organic materials (SSO) collected in the ecomaine service area. In discussing future organics recycling programs, ecomaine has emphasized that the organization is looking for low-risk organics processing alternatives that will produce a quality finished product, while minimizing impacts to neighbors and the environment.

As described in Section 3, odor management is a critical component of successful organics processing facilities. Composting, in particular, has the potential to create nuisance odors if the chosen technology or operating conditions are not suited to the area in which a facility is located. While the majority of composting operations in the country are able to operate without causing unresolved odor problems, there are many examples of sites which have had to close their doors due to an inability to address odor concerns. Additionally, both composting and anaerobic digestion have the potential to generate liquid waste streams that must be properly managed in order to eliminate risks to surface water and groundwater quality. As illustrations of some of the problems that can be encountered during composting, Appendix C includes examples from four Maine compost facilities that were shut down due to a variety of environmental issues. Site evaluations in this report will take these potential risks into account in determining site suitability.

ecomaine owns two large parcels of land, each of which provides potential opportunities for developing organics processing facilities:

- ecomaine's ashfill receives ash from the Waste-to-Energy (WTE) plant. This is an approximately 260-acre parcel of land that contains the ashfill as well as eight closed balefill cells, a leachate collection system, an office and access roads. This parcel of land straddles the border of South Portland and Scarborough, Maine.
- ecomaine also owns an approximately 258-acre undeveloped site in Gorham, Maine that in the early 1990s went through the permitting process to become a processing facility and landfill for construction and demolition (C&D) debris. Permitting for the operation was ultimately approved, but the facility was never built and no waste management activity has occurred at the site.

The ashfill and the Gorham parcels are 2 miles and 5 miles, respectively, from the ecomaine offices and the WTE plant. An evaluation of the suitability for developing organics processing capacity at locations within or adjacent to these two sites is included in this report.

There is existing organics processing capacity available in Maine in the form of both composting operations and anaerobic digesters. Additionally, there are plans in place to build several new facilities in the next couple of years. If moving forward with an organics diversion and processing program, ecomaine may determine that developing partnerships with private organics processing operations may be more cost-effective than building and operating its own infrastructure. Taking this existing infrastructure into account, this report includes a summary of existing and planned organics processing facilities and provides a cursory assessment of the suitability of these facilities for meeting ecomaine's goals of minimizing risks related to operating the facilities and generating a quality finished product.

4.2 Organics Processing Facility Site Suitability Considerations

Several factors influence site suitability for organics processing facilities, including:

- regulations and permitting requirements;
- facility design and operational considerations, such as site access, topography, water management and access to power; and

- environmental considerations - buffer distances to neighbors and other potentially sensitive receptors, presence of sensitive environmental features, etc.

The following subsections discuss the specifics of these factors.

4.2.1 Regulatory Requirements

Maine Solid Waste Chapters 409 and 410 respectively detail the permitting requirements for siting and building processing and composting facilities in Maine. The requirements within these regulations that would have the greatest impact on organics processing facility site suitability at either of the ecomaine parcels include:

- A setback of 100 feet from solid waste boundaries.
- A setback of 100 feet from and a restriction against building in, on, or over a protected natural resource without first obtaining a permit pursuant to the Natural Resources Protection Act. Protected natural resources include coastal sand dune system, coastal wetlands, significant wildlife habitat, fragile mountain areas, freshwater wetlands, great ponds or rivers, streams or brooks.
- A setback of 300 feet from off-site water supply wells or water supply springs.
- A setback of 100 feet from roads and property boundaries.
- A setback of 10,000 feet from airport runways used by turbojet aircraft when putrescible waste is to be handled outdoors in an uncovered or exposed condition.

In addition to the setback criteria, the regulations provide soil drainage criteria that must be met when using in situ soils for staging or processing waste materials. In the case of the facilities that ecomaine may develop, these criteria will likely not be relevant, because processing areas will either be under cover, or will be constructed using asphalt or concrete on top of a constructed pad.

Finally, for compost facilities there is an odor control standard stating that the applicant for any proposed facility "must demonstrate that that the facility will not cause an odor nuisance. The facility may not cause more than a one-hour average odor impact of 2 dilutions to threshold (2D/T), in any calendar year at any occupied buildings" (Chapter 410). While this standard has been in the rules for close to 15 years, to date it has not been used by the ME DEP as criteria for permitting a compost facility (King and Clark, 2013). Permitting experience in Maine indicates that odor control can be demonstrated by adequate setbacks from neighboring residences and businesses in combination with proper management of feedstocks, composting recipes, and management of the composting process.

4.2.2 Operational Considerations

Once collection programs are in place, SSO will be generated and transported to an organics processing facility daily throughout the year. Accordingly, suitable sites will need to provide for unrestricted truck access regardless of weather conditions. Access roads must be constructed to avoid inundation with water during wet periods and without excessively steep slopes in order to allow for access during periods of heavy snow or freezing rain. At intersections with major roads, access roads must provide adequate line-of-sight for safe truck traffic, and truck routes to the sites should avoid roads that are subject to significant frost heaving. In order to minimize turn-around time for trucks delivering organics to processing facilities, short hauling distances from the areas in which organics are collected are desirable.

In order to avoid ponding and wet working conditions and to minimize “run-on” and the need for diversion or treatment of surface water, suitable sites would ideally be located relatively high in the landscape. Working areas within the facility will be flat, and consequently areas that have sloping topography may need grading during facility construction. Facilities constructed in areas with shallow slopes can be designed to take advantage of gravity along the composting process chain, but excessive slopes increase the site work costs in the construction of processing facilities.

Electricity and access to water will be necessary for both composting and anaerobic digestion facilities. If access to electricity and water (from on-site wells) is already in place there will be savings on facility construction. Both composting and anaerobic digestion facilities can consume large amounts of electricity. In these types of facilities, it is more cost-effective if three-phase power is used to run larger electric motors, but it can be very expensive to extend three-phase power into a site from the nearest transmission lines. In some rural areas where the cost of power extension is excessive, it is possible to use external phase converters. Access to potable water for organics processing is not mandatory if the facility has a rainwater harvesting and storm water recycling system, but access to sanitary sewer is beneficial for disposal of processing effluent from some types of anaerobic digester facilities.

4.2.3 Odor and Other Neighbor Considerations

As discussed above, nuisance odors are one of the primary factors contributing to failed composting operations. As detailed in Section 3, proper choices in composting technology, together with biological odor control systems and good compost management, can reduce the potential for odor migration from a composting operation. Even with the best combination of technology and odor management, sufficient buffers from neighboring residences and businesses are required to ensure that odor issues do not negatively impact the longevity and public acceptance of composting operations. The length of a buffer from neighboring properties is important, but not the only consideration related to the ability of odor to impact neighbors. Wooded buffers tend to be more effective than open areas in mitigating odor travelling from composting sites, as the presence of an upper and lower canopy of vegetation intercepts dust particles, which can carry odorous compounds. Additionally, meteorological and topographic considerations are important. Atmospheric mixing and dispersion are the primary means of dissipating odors. During normal atmospheric conditions, when ground surface temperatures are higher than those aloft, odors will disperse more readily due to atmospheric mixing. This condition is considered an unstable atmosphere. The opposite is true when ground temperatures are lower than those aloft (known as a thermal inversion condition, or a stable atmosphere). Unstable atmospheres can be caused by high winds and/or high solar radiation. This condition creates turbulence and tends to disperse odors. Highly stable atmospheres, which tend to occur on clear nights with low ground-level wind speeds, tend to minimize atmospheric turbulence and are generally more favorable to down-wind odor propagation.

Prevailing wind speeds and directions also influence siting considerations. Prevailing wind direction varies across Maine with both season and location. Local influences such as orientation of a valley also may play a key role in dictating prevalent wind direction at any one location. Most of Maine is under northwest to west- northwest winds throughout much of the year and particularly during the winter. During the summer, southwest to southerly winds may become quite frequent across the State. Staff at ecomaine has indicated that the prevailing winds at the ashfill are most commonly from the northwest.

Topography plays a role, too. During inversion periods, air containing higher levels of moisture will migrate down-gradient in stream and river valleys in the direction of land fall. This can be observed in early morning hours where ground fog is seen in stream valleys. Odors tend to follow this same flow pattern. In general, a minimum setback of 1,000 to 1,500 feet from the nearest occupied building is desirable when siting composting operations of the scale that would be developed by ecomaine. Setbacks of less than 1,000 feet are possible but will likely require a greater investment in odor control technology to ensure that nuisance odors are not a problem.

Another consideration for siting processing facilities is well how the operation fits with existing uses of the site and surrounding areas. For instance, composting operations sited at an existing landfill or within the property boundaries of a wastewater treatment plant may be a better fit than siting a facility in an industrial park or a mixed residential/commercial neighborhood.

4.3 Site Suitability of ecomaine-owned Parcels

Assessment of the feasibility of locating an organics processing facility on the ecomaine owned ashfill in South Portland and Scarborough and the parcel in Gorham are described in the following subsections.

4.3.1 Selection of Potential Sites for Organics Processing Facilities

Section 3 includes preliminary sizing estimates for an aerated static pile (ASP) composting facility designed to compost 12,000 tons of SSO per year (Section 3, Appendix B). The area required for such a facility would be approximately 4.7 acres. In combination with an anaerobic digestion processing operation (using dry fermentation technology), a combined facility would have a footprint of approximately 6 acres. While the 15,000 tons per year of SSO is on the higher end of the range estimated in Section 1 to be recoverable from the ecomaine service area, a facility sized for processing this much material would take into account future expansion potential that should be built-in to an initially smaller system. For potential locations of processing facilities within the ecomaine-owned parcels, this will be the size of the system against which site suitability is measured.

4.3.1.1 ecomaine Ashfill

When taking into account the existing operations at the ashfill, including future expansion of the ashfill cells, the largest plots of available land that have a relatively good separation distance from neighboring residences and businesses are the two groups of balefill cells, cells 1 through 6 in the southwestern section of the parcel and cells 7 and 8 in the western-central section of the parcel (Figure 4-1). The balefills contain solid waste deposited prior to the development of the ecomaine (formerly Regional Waste Systems) WTE plant. Accordingly, the solid waste contained in the balefills is more typical of landfilled waste than the ash from the WTE that is currently being placed in the ashfill cells. In particular, the solid waste in the balefills contained organic waste that is subject to decomposition, and which consequently generates methane and over time can cause subsidence of the closed cells.

Based on conversations with Maine Department Environmental Protection (ME DEP) staff, including representatives from the Residuals Management Section and from the Solid Waste Division, it appears unlikely that building permanent infrastructure, such as the bunkers and roofs that would be required for an enclosed ASP composting system, would be allowable on the closed balefill cells. As noted above Chapters 409 and 410 state that processing facilities may not be located "closer than 100 feet to the solid waste boundary of an active, inactive or closed solid waste landfill". According to ME DEP representatives, the intention of this regulation is to avoid building permanent infrastructure on physically unstable areas and to avoid the potential for methane emitted from capped landfill cells to build up to dangerous levels within enclosed areas. While a variance to this rule may be obtainable in certain situations, Maine regulators believed that building a processing facility on the closed balefill cells would pose the risks that this regulation was intended to avoid (King and Clark, 2013).

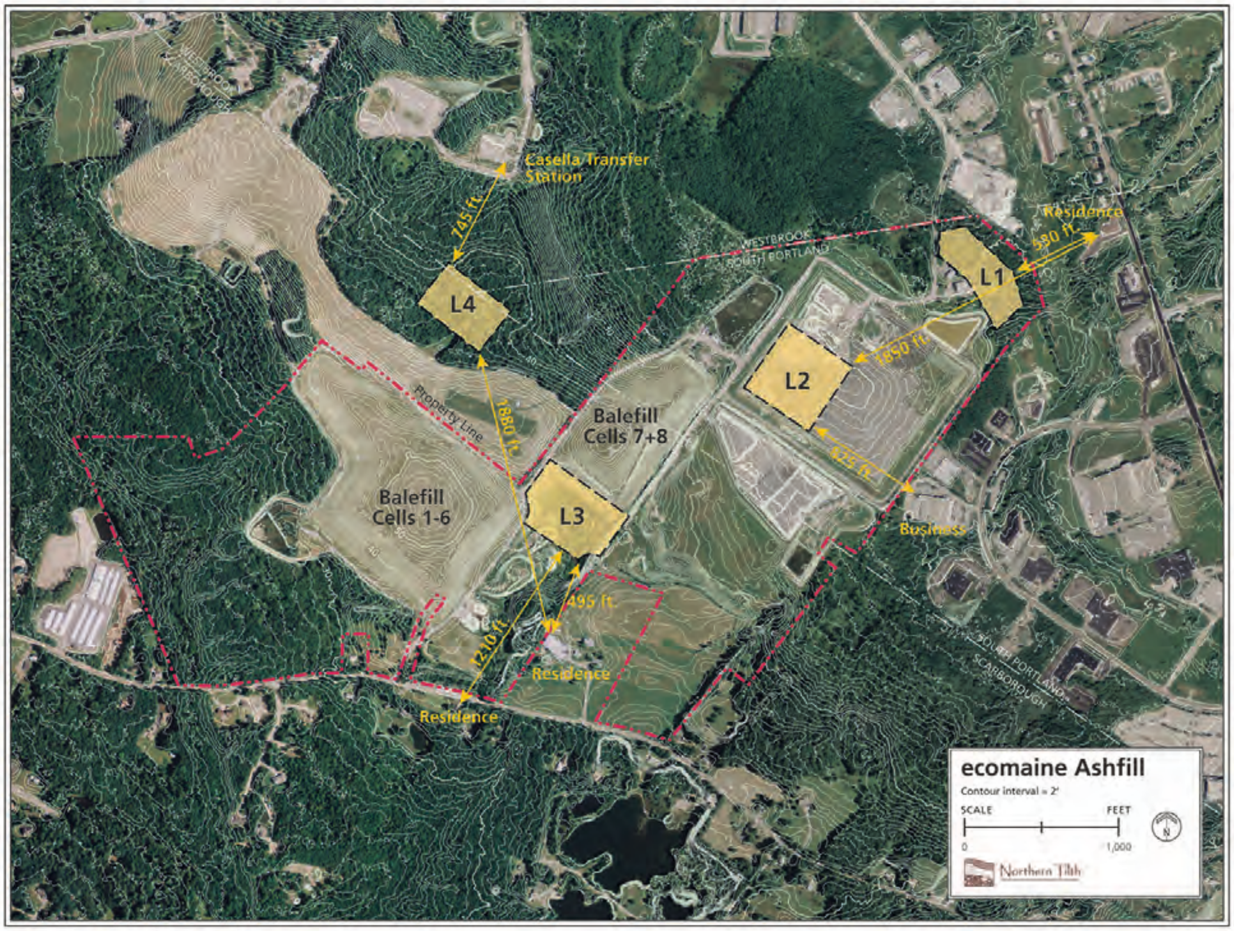
Three other potential areas for locating processing facilities within the ashfill site were identified by ecomaine personnel. One area (Location 1 [L1] in Figure 4-1) is an approximately 4.5-acre triangular-shaped area just north of the ashfill office and bordered on the west by the access road to the ashfill. The second area, L2, is an approximately 14-acre area of the ashfill that will be capped within the next two years. Due to the lack of organic waste in the ashfill (it is burned off during combustion in the WTE plant), minimal settling is expected after the capping, and methane generation from the capped waste would likely be insignificant. For those reasons, this section of the parcel is one for which a variance to the solid waste boundary restriction mentioned above could possibly be obtained. This area will be capped for approximately 15 years, with the expectation that it will be opened up again after that time in order to accept more ash. The third area (L3) is the undeveloped portion of the landfill southwest of balefill cells 7 and 8. This area is currently used to stockpile soils and crushed glass, but room could be made available for a processing facility in this area if this portion of the property was suitable. The wooded area to the west of balefills 1 through 6 was ruled out because it is generally a low-lying , wet area located in poorly drained soils.

Finally, while not currently owned by ecomaine, portions of the wooded land bordering the northwestern edge of the smaller of balefill cells 7 and 8 (L4), offer the benefit of being accessible from the existing ashfill operations while being out of the way of future expansions and of having a significant setback from all current neighboring residences and businesses. If acquisition of a portion of this land large enough to house a processing facility were possible, the area would also provide the additional benefit of allowing for a wooded buffer on all four sites of the facility, an attribute which greatly assists in mitigating fugitive odors from composting operations. If an access road could be built from the ashfill to a processing facility in this location, minimal road construction would be needed to provide access to this site; the location is only 300 feet or so from an existing access road bordering balefill cells 7 and 8.

4.3.1.2 ecomaine's Gorham Property

The 258-acre property in Gorham is mostly wooded, with predominantly fine-textured soils and a mix of upland areas and lower-lying freshwater wetlands. Findings from a field reconnaissance of the site indicated that while wetlands occur throughout the site, they represent less than 30% of the site and are fairly localized leaving significant areas of "developable" upland (Peters, 2012). The site is bordered by agricultural land to the east and west, the Presumpscot River to the north and a commercial zone along

Figure 4-1 Overview of the ecomaine Ashfill in South Portland, Maine

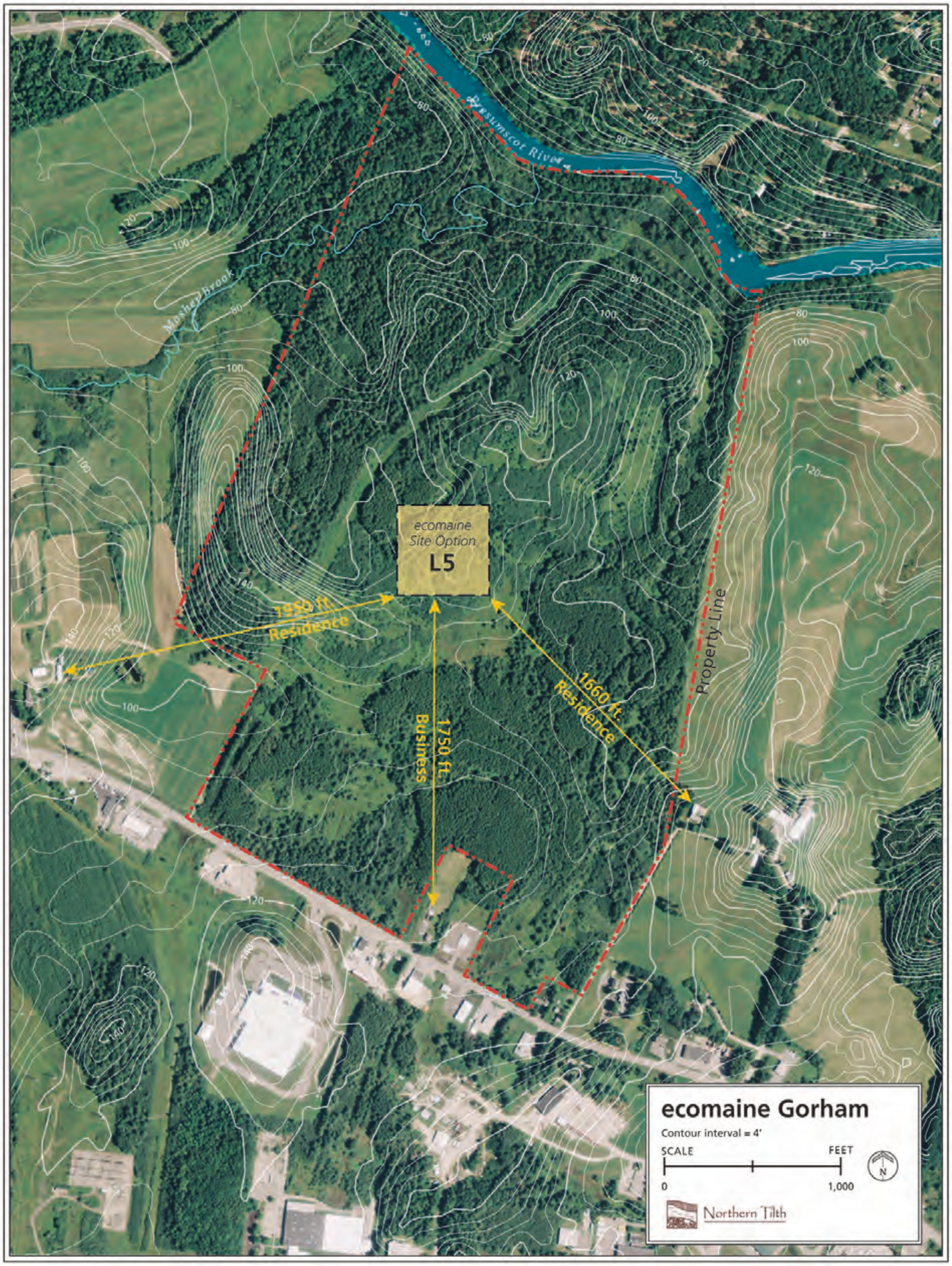


Route 25 to the south. While many areas on the parcel may be suitable for siting an organics processing facility, one upland area (identified as L5 in Figure 4-2) in the center of the parcel seems to offer the best combination of sufficient setback distances from neighboring residences along with a significant area of land high in the landscape that is uninterrupted by mapped wetlands.

4.3.2 Attributes of Identified Locations Relative to Siting Considerations

Relative to the regulatory requirements discussed above, only one of the identified locations, L1 at the ashfill, would be subject to significant limitations. At that location, the 100-foot setback from property boundaries and roadways would remove approximately one-half of the area, reducing the area available for development down to approximately 2 acres. Additionally, the wetlands in this area would necessitate obtaining an additional permit through the Natural Resources Protection Act. Locations 2 and 3 are within 100 feet of a solid waste boundary, but as discussed above, these locations do not present the risks that are intended to be avoided by the requirement and, consequently, a variance could potentially be granted for constructing facilities in those locations. The western end of the runway at the Portland Jetport is within 10,000 feet of the areas identified as Location 1 and Location 2 at the ashfill, but because a facility developed by ecomaine would likely have a waste receiving area that is under cover, this setback should not apply.

Figure 4-2 Overview of the ecomaine Parcel in Gorham, Maine



The locations at the ashfill have several advantages over siting a facility at the Gorham parcel relative to operational considerations. The ashfill is a fully developed, solid waste facility, which provides good year-round truck access, and which has in place three-phase power, water wells, an existing office and a leachate collection and treatment system. The ashfill is within 2 miles of the WTE plant, and already has a pattern of regular truck traffic travelling to and from the WTE plant. Finally, an organics processing facility would be very much in line with the existing use of the site and surrounding properties, including the ashfill and closed balefills, the Casella Waste Systems transfer station to the northwest and the capped paper mill landfill to the west.

Of the potential locations at the ashfill, L1 is not only limited by regulatory requirements, but this location would also have only a 530-foot setback from the nearest residence. This relatively short setback from neighboring residences increases the likelihood of having an odor impact if composting at this location. If L2 were situated in the southwest corner of the ashfill cell (as depicted in Figure 4-1) which will be temporarily capped in the next few years, the closest neighbor would be the businesses on Gannett Drive, which would be approximately 825 feet from the eastern edge of the facility. The nearest residence would be approximately 1850 feet away. With the proper technology and management, the setbacks at L2 might be sufficient, but would provide very little margin for error relative to fugitive odor emissions from composting. Another factor related to this setback is that the prevailing wind on site blows toward the nearest business from L2, and there is no wooded area in this buffer. A major drawback of Location 3 is the temporary status of the site. When this cell is opened up again in 15 years, the compost facility would need to be dismantled and re-located. A location with a secure future would provide a more cost-effective processing option over the life of the facility.

L3 would have a setback of close to 495 feet from the nearest neighbor, the farmhouse on the southern end of the ashfill, which is on a separate parcel of land, but which is surrounded by the ashfill property. As with L1, this would not be a sufficient setback to ensure minimal odor impact to neighbors. However, if ecomaine were to purchase the property on which the farm is located, the next nearest residence would be approximately 1210 feet south on the south side of Running Hill Rd. Because there is some wooded area between L3 and the residences on Running Hill Rd., this setback distance may be sufficient, also with the proper technology and careful management of the composting operation. This area has two challenges that could be addressed with some site work. First, it is a low lying area relative to the surrounding landscape and fill would likely need to be used to elevate portions of the area and direct surface water to the side of the facility. Additionally, with the prevailing winds from the northwest, the topography of the surrounding capped cells could force the wind to be funneled towards the site and “bounce” off the facility allowing for odor to be carried a greater distance than would otherwise be the case. This could be minimized with windbreaks constructed to the northwest of the area.

L4 provides the largest setback from neighboring residences. The closest residence to this location is the farmhouse, approximately 1880 feet from the southern edge of the location. The Casella Waste Systems transfer station, at approximately 745 feet from the northern edge of the location would be the closest business. The next closest business would be setback approximately 2000 feet from the location. In addition to the greater setbacks, this location provides for the possibility of having a wooded buffer completely surrounding the facility, which, as noted above, could greatly diminish the impact of fugitive odors from the facility. Due to the nature of the activity at the Casella transfer station, the prevailing northwest wind and the wooded buffer between the transfer station and this potential site, the 825 feet would likely provide an adequate setback. This Location is in the town of Scarborough and is owned by Casella Waste Systems. To date there have been no formal discussions between ecomaine and Casella Waste Systems to determine Casella's interest in selling this portion of their property.

L5 at the ecomaine-owned parcel in Gorham, provides the best opportunity for ample, wooded buffers from neighboring residences and businesses. The closest residence to this location is approximately 1660 feet to the east, with the majority of that distance being covered in forest. The nearest business is a fuel retail operation located on Route 25 to the south of the location, which is approximately 1750 feet to the south through a wooded buffer. Greater setbacks could be achieved at this site by locating further north in the parcel, but Location 5 appears to offer the best combination of good topography (being a relative flat area, higher in the landscape) and sufficient buffer from neighboring residences. The Gorham parcel is bordered on the east and west by agricultural land and to the south by primarily commercial operations. Though an organics processing facility would not be as obvious a match with existing uses at this site as it would at the ashfill site, it is also not an entirely out of character with surrounding uses. The successful permitting of the C&D operation at this location in the 1990s provides some indication that an organics processing facility is in line with acceptable uses for the site, and communications with the Zoning Administrator for the Town of Gorham indicate that such a facility is permissible within the property, which is zoned "industrial" (Galbraith, 2013).

A major disadvantage to locating an organics processing facility at the Gorham site is that the entire parcel is currently undeveloped. All of the infrastructure needed for building and operating a composting and anaerobic digestion facility, including access roads, water wells, sanitary facilities, a leachate collection system, a garage and/or office building, would need to be constructed in advance of or while building the facility. Three-phase power does come as close as the Dunkin Donuts across Route 25 from the western entrance to the site. While not a substantial disadvantage, the site is 3 miles further from the ecomaine WTE plant than the ashfill. If organics collection systems for ecomaine rely on using split body trucks with half of the body loaded with organics and the other half loaded with either rubbish or recyclables, the extra 3 miles needed for unloading organics in Gorham could increase collection costs. If the WTE plant is used as a transfer station for organics collected within the ecomaine service area, the extra mileage to the Gorham site would also add to the overall collection costs compared to delivering to the ashfill site, but this added cost would be minimal.

To summarize the suitability of the five potential locations for siting an organics processing facility on, or adjacent to, ecomaine-owned land, the area of L4, an area of wooded land owned by Casella Waste Systems adjacent to the ashfill, provides the best combination of a sufficient setback from neighbors while taking advantage of the infrastructure already in place at the ashfill. L1 and L3 at the ashfill are too close to neighbors to provide the level of risk minimization that ecomaine requires for this project. L2, which entails developing a facility on top of a capped ashfill, may provide adequate odor-related setbacks with the right technology, but this location would be temporary, requiring re-location after 15 years when this cell of the landfill is scheduled to become active again. L5, in the center of the Gorham parcel of land provides the best option relative to minimizing odor risk. This location would not have any significant restrictions relative to the ME DEP regulations. The downside to this location is that the site is entirely undeveloped and would require construction of significant infrastructure (roads, utilities, etc.) in addition to the construction of the facility itself.

Table 4-1 summarizes the advantages and disadvantages of each site.

Table 4-1 Comparison of Attributes of Potential ecomaine Sites

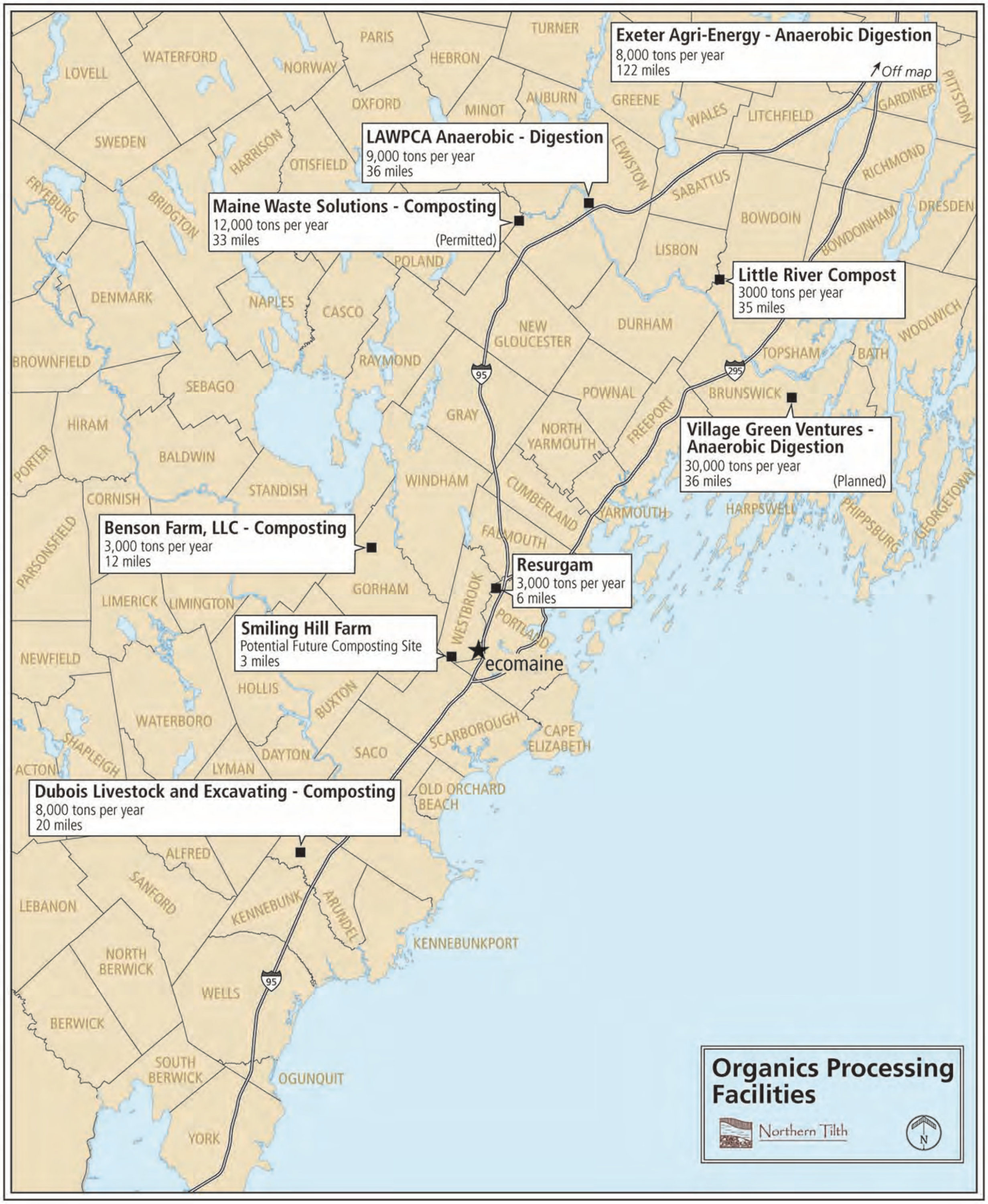
Location	Advantages	Disadvantages
1) Immediately adjacent to and north of ashfill office	Accessibility, existing infrastructure	Low-lying, wet, smaller than needed and miminal setback to occupied buildings
2) On top of the temporarily capped ashfill	Accessibility, existing infrastructure	Temporary; current plan is to open this cell up again to receive ash in approximately 15 years
3) In the un-developed portion of the ashfill between the capped balefills	Accessibility, existing infrastructure, would not interfere with ashfill operations	Low-lying, and minimal setback from nearest occupied building, unless the farm property is purchased by ecomaine
4) Immediately northwest of balefill cells 7 & 8	Accessibility, existing infrastructure, substantial wooded buffer from nearest occupied building	Not currently owned by ecomaine
5) High spot in the center of ecomaine's Gorham parcel	Substantial wooded buffer from nearest occupied buildings, ample room for expansion	No existing infrastructure, greater distance from ecomaine WTE and ashfill

4.4 Private Partners and Merchant Facilities

As noted in Section 1, the actual tonnage of SSO currently being composted or anaerobically digested in the ecomaine service area is relatively small. Due to the development of new facilities and the expansion of some existing facilities, though, there is currently adequate capacity within a reasonable hauling distance from ecomaine to manage the tonnage of organics that could reasonably be expected to be diverted from the WTE in the next five years. However, when taking into the account the technological and environmental requirements that ecomaine would expect from a facility to which its members are delivering organics, there is considerably less capacity. Also, some of the existing capacity may not be well suited to handling some of the targeted organics, such as soiled paper and possibly pet litter that ecomaine would like to include in a diversion program.

The following is a summary of existing organics capacity in the ecomaine service area and a brief discussion of potential limitations of these facilities as they relate to ecomaine's requirements. Based on the findings in Section 3, and based on ecomaine's goals to minimize risks related to operating a composting facility, compost and/or digestion facilities with which ecomaine would partner would have as a minimum, a covered waste receiving area and the first phase of composting would be under cover to minimize the amount of leachate and surface water requiring treatment and to reduce vector attraction. Additionally, adequate setbacks from neighboring residences and businesses would be necessary to minimize the risk of nuisance odors. Figure 4-3 is a map of existing and planned organics processing facilities considered in this report.

Figure 4-3 Organics Processing Facilities in Proximity to ecomaine Service Area



Note: *Distances associated with each facility are road miles (one way) from ecomaine WTE plant. Tonnages associated with each facility are permitted or reported capacity to process SSO.*

The tip fee at these facilities will also be a factor in determining the suitability of these private organics processing options. In speaking to facility operators and owners, some businesses are willing to provide the tip fee that they would charge for taking in SSO and others would not discuss tip fees until a generator is ready to negotiate a contract. Based on information from several of the facilities discussed below, the common range for tip fees for food processing waste, seafood waste and other SSO is between $30 and $40 per wet ton in the ecomaine service area. In all cases, operators expressed that the quality of the SSO that they take in will impact the cost; the greater the contamination, the higher the tip fee. For those facilities further south, and currently accepting SSO from the Boston area, the tip fees are typically higher, ranging between $40 and $60 per ton (City of Cambridge Public Works Department, 2012).

4.4.1 Benson Farm LLC, Gorham, Maine

Technology: Open-air turned windrow composting (see Section 3)

Capacity: Approximately 3000 tons per year of SSO (Type 1B) by permit, but the operator believes that he is close to capacity with his current site.

Initially a solely agricultural composting operation started 20 years ago; this facility branched out 10 years ago and became permitted to accept seafood processing waste (Figure 4-4). The facility has a long track record of successful operations and appears to have a good relationship with the DEP. The tip fee for SSO is competitive and the owner, Ed Benson, has expressed interest in a partnership with ecomaine. Mr. Benson does have experience composting residential SSO as he is currently taking in all of the organics collected by Garbage to Garden.

The Benson Farm, LLC composting operation is relatively “low-tech.” No part of the operation is under cover and run-off from the facility is collected in an earthen basin at the lower end of the windrows. In order to be compatible with ecomaine’s risk minimization goals the operation would need to be upgraded. Mr. Benson has expressed interest in upgrading the facility, and has some plans in place developed by the USDA NRCS office in Cumberland County to do so. The nearest off-farm residences are approximately 1000 feet from the composting operation. If Mr. Benson were to upgrade and expand the operation, he would like move the operations further from the road and have a slightly larger setback from neighboring residences. Based on the current high-end market for the finished product and the equipment used in the process, there is a relatively low tolerance for contamination in feedstocks.

Figure 4-4 Aerial View of Benson Farm, LLC Compost Site

4.4.3 Maine Waste Solutions, Auburn, Maine (planned)

Technology: Aerated windrow composting, under a roof
Capacity: Approximately 12,000 tons per year of SSO

Maine Waste Systems, a joint venture between Resurgam Zero Food Waste and the CPRC Group in Scarborough, Maine has permits in place for a new composting facility. The planned operation will be built at the MB Bark facility in Auburn, Maine (Figure 4-5). The permit for the facility allows for Maine Waste Solutions to compost 12,000 tons per year of Type 1B organics. Through its operation in Portland, Maine Waste Solutions has experience with post-consumer food scraps. Their current program, though, is not as inclusive as the type of program that would likely be developed by ecomaine for residential organics. They do not currently accept compostable bags, and the Portland operation has some restrictions on inputs due their desire for the compost to be approved by the Maine Organic

Figure 4-5 Aerial View of Maine Waste Solutions Planned Compost Facility

***Note:** facility location on map based on review of MWS permit application to ME DEP.*

Farmers and Gardeners Association (MOFGA) for use on certified organic land. Maine Waste Solutions has mentioned that they would be interested in partnering with ecomaine under the right conditions, and would consider having capacity available for non-certified organic compost if necessary. To some extent, Maine Waste Solutions determination on whether or not they will have two compost streams (organic and conventional) will determine their tolerance for contamination and ability to take in compostable plastic.

The facility will use aerated windrows and all blending and active composting will occur under cover. The facility design will be similar to the Resurgam facility profiled in Section 3, but will be considerably larger. A leachate collection and storage system is included in the plans for the facility, as is an engineered surface water collection and treatment system. MB Bark is a large bark processing and storage facility located in a mostly agricultural section of Auburn. Setbacks from the nearest neighbors will be approximately 750 feet, and the separation is partially separated. With the exception of the setback from neighbors, the planned system is generally in line with ecomaine's risk minimization goals and preferred technology. Maine Waste Solutions is not willing to share tip fees at this time, so it is not possible to determine if this will be a cost-competitive option.

4.4.4 Dubois Livestock and Excavating, Inc., Arundel, Maine

Technology: Non-aerated, open-air static pile composting
Capacity: 8,000 tons per year of SSO

As with Benson Farm LLC, Dubois Livestock and Excavating, Inc. started out as an on-farm composting operation, but has expanded and has been composting seafood processing waste in addition to manure and leaf and yard waste for several years. More recently, Dubois expanded their composting license with the ME DEP to accept as much as 8000 tons per year of Type 1B and 1C waste (both vegetative wastes, such as food scraps, and more nitrogen-rich material such as seafood processing waste).

This operation low-tech, involving primarily blending feedstocks into piles that are neither turned, nor aerated, but which naturally compost over time. Composting takes more time under these conditions and, in theory, in order to make a quality, finished compost, there is less room for error in recipe development than with turned windrows or ASP systems. Surface water and leachate management is in place, but is rudimentary and appears to rely to some extent on natural attenuation. In terms of setbacks from neighboring properties, this site is very secluded with at least a 2000-foot wooded buffer from the nearest off-farm residence or business. These setbacks are ample, but the open-air nature of the operation and the lack of air control (either through aeration or windrow turning) are not in line with ecomaine's preferred technology for composting.

In a phone conversation with Northern Tilth on April 23, 2013, Marcel Dubois, one of the owners of the facility, expressed interest in taking in residential SSO. Their pricing would be competitive, but would be dependent on contamination. They have taken in some biodegradable plastic in the past and have not had good luck with the material composting in their system.

4.4.5 Little River Compost, Lisbon Falls, Maine

Technology: Aerated static pile (ASP) composting under a roof
Capacity: Approximately 3000 tons per year of SSO

Originally a biosolids composting operation, this ASP composting system now composts primarily animal manure and seafood waste. Little River does not currently compost food scraps, but is licensed to do so and may be interested in taking in residential SSO in the future.

The ASP composting system at Little River Compost is very similar to the Chittenden Solid Waste District's (CSWD) system profiled in Section 3. The system consists of bunkers covered by a roof, with an aeration system in the floor of the bunkers. Compost leachate and surface water in contact with the compost are minimized by completing the blending and the first phase of composting under cover. Setbacks from the nearest neighbors are approximately 1100' and the separation is a combination of open and wooded land. The composting technology used at this facility matches the preferred choice for composting as determined by the evaluation in Section 3. The current tip fee is competitive, but with residential SSO the tip fee would depend on the amount of contamination and whether or not taking in the material would impact their ability to maintain organic certification for the finished product.

4.4.6 Lewiston Auburn Water Pollution Control Authority, Lewiston, Maine

Technology: Low-solids liquid co-digestion (see Section 3)
Capacity: Approximately 9,000 tons per year of SSO to be co-digested with biosolids from the LAWPCA wastewater treatment plant

Construction on this anaerobic digestion system was completed in April 2013. The digesters are mesophilic liquid anaerobic digesters, as profiled in Section 3. The primary focus for the digesters is to manage biosolids from the wastewater treatment plant, but based on conversations with LAWPCA it is clear that they will have additional digester capacity and are interested in bringing in food scraps and other high energy feedstocks if they do not interfere with normal operations of the digesters (Richardson, 2013).

As noted in the profile of this system in Section 3, while there is a receiving tank available from which to load outside organics, and there are chopper pumps integrated into the digester feeding system, pre-processing (grinding, etc.) of residential SSO would be necessary prior to LAWPCA receiving material. At this time, there are no plans for adding pre-processing to the site. The digestate from the digesters goes to LAWPCA's compost facility, and they already have good markets in place for the finished product. The compost facility, an in-vessel system, also profiled in Section 3, meets ecomaine's risk minimization goals.

Tip fees for SSO may be competitive with composting options, but biosolids with their associated higher tip fees may take up much of the capacity. In general liquid digesters have a lower threshold for contamination than dry fermenters or composting systems.

4.4.7 Exeter Agri-Energy, Exeter, Maine

Technology: Low-solids liquid co-digestion (see Section 3)
Capacity: 8,000 tons per year of SSO from off of the farm to be co-digested with liquid dairy manure

Like the LAWPCA facility, these are also mesophilic digesters and are also profiled in Section 3. Differences between the two systems as they relate to processing SSO from the ecomaine service area include:

- This operation is already receiving and successfully processing SSO.
- Equipment is in place for pre-processing SSO prior to loading into the digesters.
- The solids component of the digestate is being used as dairy cow bedding on the farm associated with the digesters (Stonyvale Farm).
- The liquid stream from the digestate is land-applied on fields owned and managed by the farm

These digesters are a greater hauling distance (122 miles one way) from ecomaine than the other processing facilities considered in this evaluation; however, based on preliminary conversations with Exeter Agri-Energy, a lower tip fee (e.g., lower than the range of $30 to $40 per ton found at most compost facilities in the ecomaine service area) may compensate for the higher hauling fees, making this option possibly cost competitive with other options (Wintle 2013). In general, this digestion system and the bedding and land application systems for the digestate would meet ecomaine's risk minimization goals. As is the case with LAWPCA, there is a relatively low tolerance for contamination using this option. However, Exeter Agri-Energy is considering investing in bag separating equipment, which could help to increase their tolerance for contamination.

4.4.8 Green Village Ventures, Brunswick Naval Air Station, Brunswick, Maine

Technology: Low-solids liquid co-digestion
Capacity: 30,000 tons per year of SSO to be co-digested with an equivalent amount of biosolids

This is a private merchant processing facility under development on the grounds of the former Brunswick Naval Air Station (NAS) using an anaerobic digestion process developed by Quasar Energy (Cleveland, OH). The project is in the initial planning phases. While the timeline is for the project to be up and running by the end of the first quarter of 2014, they are still in the early stages of permitting. This will be a low-solids liquid digester (12% total solids), similar to the ones at Exeter and LAWPCA, so will likely have a low tolerance for contamination. Preliminary indications are that the tip fee will be on the order of $45 to $50 per ton, FOB Brunswick, ME. It is not clear if this project will meet ecomaine's risk avoidance criteria, as "operation of the plant will be outsourced to a service provider" (Weyburn, 2013), and the plan for managing the digestate and effluent from the digestion operation has not yet been finalized.

4.4.9 Smiling Hill Farm, Inc., Westbrook, Maine

Smiling Hill Farm is a 500-acre dairy, lumber mill, and building supply store located on Route 22 in Westbrook, less than one mile west of the entrance to the ecomaine ashfill (Figure 4-6). The project team met with Warren Knight, one of the owners of Smiling Hill Farm on March 14, 2013 to discuss the

Figure 4-6 Smiling Hill Farm: Potential Organics Processing Facility Location

possibility of an organics processing partnership with Smiling Hill Farm. Mr. Knight expressed interest in developing either a composting facility or a combined anaerobic digestion and composting facility on the farm to process SSO from ecomaine along with manure generated on the farm and wood by-products from their lumber mill.

Due to its proximity to ecomaine, the existing uses on the farm and due to the large setbacks from neighbors available on some locations on the farm, this site has very good potential for developing a public/private partnership with ecomaine. The area in which Mr. Knight has indicated he would be interested in developing a facility is located on relatively high and dry land (compared to the lower-lying, fine-textured soils found in the western section of the farm) and would provide a wooded buffer of greater than 1200 feet from the closest neighbors, north of the site on Eleanor Avenue. Access is already developed to this site, and access to water and electricity are available in this area. Mr. Knight is aware of the types of controls that ecomaine would require for an organics processing facility and has a similar vision for minimizing any potential impacts on surrounding properties. Land use in the area is a mix of agricultural, industrial and residential. The City of Westbrook's closed Sandy Hill Landfill is directly east of the potential facility location.

4.4.10 Summary of Private Partner Options

Table 4-2 summarizes the advantages and disadvantages of each of the Private Partner options detailed in the previous subsections.

4.5 Combined Approach

Given that the implementation of a SSO diversion program in the ecomaine service area will likely rely upon voluntary participation, the quantities of SSO diverted will most likely gradually increase over time. Those communities with a "pay-per-bag" solid waste collection system will potentially see a more immediate economic benefit from residential SSO diversion than others in the service area, so participation and setout rates may be higher in those areas. One option for managing this gradual increase in SSO diversion tonnage would be for ecomaine to rely on the existing private-sector partners profiled above to manage this newly-diverted SSO for the first three to five years, and to delay building its own facility until diverted tonnages are projected to exceed the partners' capacities.

This option will be more fully investigated in Section 7 (Conceptual Plan and Economics), but assuming the diversion program is launched only in those 12 communities with curbside collection,-participation rates are on the order of 35% to 45%, setout rates are on the order of 70%, and if quantities per household are on the order of 7 to 12 pounds/week/household, total SSO tonnages to be handled over a three-year period would be around 3,100 tons/year to start, rising to around 6,800 tons/year in three to five years. This tonnage is well within the capacity of the current and planned private sector partners to manage.

The advantages of a combined approach are that it allows ecomaine to encourage the implementation of diversion strategies without incurring the capital expense of a new organics processing facility; it allows ecomaine to determine if diverted tonnages can be replaced with additional tonnages to be

Table 4-2 Comparison of Attributes of Potential Partnering Options

Location	Operational Status	Advantages	Disadvantages
Benson Farm, LLC – Gorham, ME	Existing	Proximity to ecomaine, established program, good relationship with DEP, some experience with residential SSO, cost competitive	Composting technology and site upgrade needed to meet capacity and risk minimization needs, low tolerance for contamination
Resurgam Zero Food Waste – Portland, ME	Existing	Proximity to ecomaine, established program, experience with commercial SSO	Planning on moving operations to Maine Waste Solutions Facility in Auburn, Maine (below)
Maine Waste Solutions – MB Bark facility, Auburn, ME	Planned	Available capacity (once constructed), technology compatible with ecomaine risk minimization needs, experience with commercial SSO	Distance from ecomaine, costs unknown, need more information about tolerance for contamination and compostable bags
Dubois Livestock and Excavating, Inc. – Arundel, ME	Existing	Available capacity, established program, cost competitive	Composting technology not compatible with ecomaine risk minimization needs
Little River Compost – Lisbon Falls, ME	Existing	Technology compatible with ecomaine risk minimization goals,	Distance from ecomaine, limited experience with SSO
LAWPCA digesters – Lewiston, ME	Existing	Potentially cost competitive, meets ecomaine risk minimization goals	Distance from ecomaine, lack of pre-processing capacity, low tolerance for contamination
Exeter Agri-Energy digesters – Exeter, Maine	Existing	Potentially cost competitive, meets ecomaine risk minimization goals, experience with handling commercial SSO	Distance from ecomaine, low tolerance for contamination (although they are adding equipment to address this)
Village Green Ventures – Brunswick, ME	Planned	Potentially cost competitive	No previous experience in organics processing, distance from ecomaine, not yet permitted, low tolerance for contamination, may not meet risk minimization goals
Smiling Hill Farm – Westbrook, ME	Potential to develop	Proximity to ecomaine, compatible with surrounding uses, ability to develop facility in line with ecomaine risk minimization goals	Not yet planned or permitted

processed at the WTE plant; and it supports the continued growth of the private-sector processing infrastructure. The disadvantages of a combined approach are that it requires ecomaine to be dependent on satellite facilities it neither owns nor operates; that it will likely be more expensive to build an organics processing facility in the future than in the present; and continued “leakage” of solid waste into private facilities is a violation of the flow-control provisions of ecomaine’s agreements with its member-owners.

5.0 Waste to Energy Impacts Analysis

Key Findings of Task 5

The following items summarize the findings of Task 5: Waste to Energy Impacts Analysis.

- The ecomaine WTE plant system is generally steam limited and therefore minimal additional energy can be created by diverting organic waste. Instead, any significant changes in enthalpy will have to be offset by changes in operation or waste input.
- Predicted changes to the heat value of the WTE waste stream based on three organics diversion scenarios are as follows:

Organics Diversion Scenario	Organics Diverted from WTE (tons/yr)	Adjusted Heat Capacity of Solid Waste (kcal/kg)	Increase in Heat Value of Solid Waste
Current	NA	3,070	NA
Low-end	3,100	3,094	0.8%
Medium	11,900	3,163	3%
High-end	21,000	3,233	5%

- In theory, if limiting waste input and not making changes to operations is preferred, it is possible that the current waste flow rate would need to be reduced by up to 5% to accommodate an aggressive organics diversion program.
- Practical experience from WTE operators at other plants that have diverted organic waste indicates that it is possible to absorb the added heat from diversion with minor operational changes, and therefore they do not need to reduce the waste flow rate.
- A minor operational change could be accepting different waste that have less heat value or more moisture.
- Another minor operational change could be to add some additional excess air with an eye on still meeting the NOx limits.
- During wet weather periods it is possible that the higher heat value of the waste could help to reduce the amount of natural gas that ecomaine purchases to supplement the solid waste.
- It is unlikely that changes associated with organics diversion will affect any of the criteria pollutants other than NOx.

As ecomaine considers the possible increase in organic waste diversion and recycling in the service area, it is important to consider the impact of these potential changes on operations at ecomaine's Waste to Energy (WTE) plant. The tonnage of waste accepted is a hard limit of 550 tons per day in the solid waste permit, but does not end up being a limiting operational factor. Currently, the plant is limited by heat output and steam produced, rather than by the tonnage of waste accepted.

The primary goal of this task is to estimate the potential impact from the change in heat output of organic waste diversion on waste throughput for three scenarios derived from the findings in Section 1 when compared to today's operational conditions. It is assumed, based on conversations with plant operators that the facility will be run the same after an organics diversion program is in place as it is currently, and that any available input waste stream is unlimited. In other words, any waste diverted from the incoming waste stream can be replaced with the necessary tonnage of waste from other local sources, so total input tonnages and operations were assumed to remain constant, and the 550 tons per day limit will remain in place. It is also assumed that any replacement waste has the same composition as ecomaine's current waste stream.

5.1 Background on WTE Heat Content

In WTE operations, there is a balance between the heat content of the different items in the waste stream. The overall heating value of the input waste stream will vary as the composition of the waste components vary.

The heat balance can be affected by the energy necessary to evaporate any residual water and to bring the waste and ash to the final exhaust temperature (via combustion temperature). Although heat is required to boil water present and to heat it to the combustion temperature, the overall net heat required is really associated with raising the water from inlet "room temperature" to the exhaust temperature. The water acts as a heat sink. Therefore, if there is water present in the waste, such as water in food waste or extra water in the form of snow, ice or rain-soaked trash, the heat sink is higher and can affect the process burn if the moisture level is too high. On the other hand, the amount of waste than can be combusted might be limited if the moisture level is too low.

Each waste component provides a different release of energy when oxidized to carbon dioxide and water. These heating values have been studied and reported in various sources. There are a number of parameters that are used to determine the heat value for the combustion of different fuels, which are measured in units of energy per amount of the substance being combusted, such as Btu/lb. The two main categories are higher heating value (HHV) and lower heating value (LHV). The HHV of each substance is determined by bringing all the products of combustion back to the original pre-combustion temperature, while also including the condensation of any vapor which is produced. On the other hand, the lower heating value (LHV) assumes that energy is necessary to bring any water "along for the ride." So the HHV is calculated with the product of water remaining in liquid form at the initial temperature, while the product of water is in the vapor form for the LHV.

In both HHV and LHV, the energy produced is described on a per weight basis. The basis can vary from an "as-received" basis, to a "dry" (no moisture) basis, to a basis without moisture or ash. In WTE processes, the "as-received" HHV is typically preferred for discussion since it best represents the normal conditions of the waste entering the facility.

5.2 Overview & Waste Composition

In this analysis, the moisture heat sink, which is simply ignored in calculating the "as-received" HHV, is calculated for the current waste percentages and the future waste percentages after diversion. The first part of this calculation involves estimating the ecomaine waste composition. The next part is to determine the reduction in heat value based on the percent moisture and then to compare the changes in heat values that have a direct impact on the waste throughput, since it is assumed that the system is steam limited not waste throughput limited, beyond the 550 tons per day limit.

The existing plant air permit was also studied to determine if any of the current criteria pollutant air emission limits could be a concern in the future. Modified future plant operations could require different excess air levels, which are also addressed as part of this review of the potential impact on the air quality emissions, which were studied as part of this task.

In Section 1, the breakdown of organic waste in the ecomaine service area was described by the project team. The residential waste composition is from the 2011 Maine Residential Waste Characterization Study (Criner and Blackmer, 2011). This study, the most recent survey of the composition of the residential solid waste in Maine, reported that "targeted organics," defined as food scraps, soiled/compostable paper, and yard trimmings, make up 37% of the residential waste stream. The residential waste breakdown, including the amounts of targeted organics, presented in the University of Maine study is shown in Table 5-1.

Table 5-1 Current Composition of Maine Residential Waste

Waste Categories	University of Maine, 2011
TOTAL PAPER	**25.6%**
Other Paper	17.7%
Compostable Paper	7.9%
TOTAL PLASTIC	**13.4%**
ORGANICS	**43.3%**
Yard Trimmings	1.2%
Brush	0.3%
Food Waste	27.9%
Wood	1.1%
Other miscellaneous organics	12.8%
GLASS	**2.7%**
METAL	**3.3%**
OTHER INORGANICS	**11.8%**
Total:	**100.1%**

To date, there has been no systematic quantification of the composition of commercial solid waste in the ecomaine service area. The commercial waste composition was estimated based on a review of information gathered in other areas of the US, as discussed in the Section 1. The estimated commercial waste composition is shown in Table 5-2.

Table 5-2 Assumed Current Composition of Maine Commercial Waste

Waste Categories	Maine*
TOTAL PAPER	**31.7%**
Other Paper	24.6%
Compostable Paper	7.1%
TOTAL PLASTIC	**15.1%**
ORGANICS	**26.8%**
Yard Trimmings	2.5%
Brush	1.3%
Food Waste	14.8%
Wood	3.4%
Other miscellaneous organics	4.8%
GLASS	**2.2%**
METAL	**5.2%**
OTHER INORGANICS	**19.1%**
Total:	**100.1%**

**Estimated based on a review of commercial waste composition data from other states.*

5.3 Calculation of HHV for Current ecomaine Waste Stream

In 2012, roughly equal amounts of residential (63,734 tons) and commercial (68,824 tons) solid waste were delivered to the ecomaine WTE plant, not including spot market waste accepted at ecomaine. The spot market waste was 44,300 tons in 2012, composed of roughly equal amounts of residential and commercial waste. This results in a total of 176,858 tons of solid waste, which is broken down into 85,884 tons of residential solid waste and 90,974 tons of commercial solid waste. Table 5-3 compiles the waste composition information from Tables 5-1 and 5-2 with the "as-received" tonnages to determine the total solid waste composition for ecomaine. Please note at this point the heat value and moisture content has not been discussed. The goal to this point of the analysis was to determine the total mixed waste composition.

Table 5-4 repeats the total waste summation created in Table 5-3 and the "as-received" heat values for the different waste streams (Niessen 2010). Although this portion of the analysis occurs after the calculation of the total waste stream, it is important to note that the categories and subcategories were created at the beginning of this task by grouping waste fuels by like heat values and considering all the potential components when selecting a representative heat value from literature. This allows a single heat value to be used for a group of material such as "TOTAL PLASTICS". At the end of Table 5-4, a weighted heat capacity of 3,186 kcal/kg was calculated for the total waste stream. This weighted average does not include the moisture heat sink.

Table 5-3 Current Estimated Composition of ecomaine Waste

Waste Categories	Residential		Commercial		Total Waste	
2012 As-Received Tonnage	**85,884**		**90,974**		**176,858**	
TOTAL PAPER	**25.6%**	**21,986**	**31.7%**	**28,839**	**28.7%**	**50,825**
Other (Non-packaging) Paper	17.7%	15,201	24.6%	22,380	21.2%	37,581
Compostable Paper	7.9%	6,785	7.1%	6,459	7.5%	13,244
TOTAL PLASTIC	**13.4%**	**11,508**	**15.1%**	**13,737**	**14.3%**	**25,246**
ORGANICS	**43.3%**	**37,188**	**26.8%**	**24,381**	**34.8%**	**61,569**
Yard Trimmings	1.2%	1,031	2.5%	2,274	1.87%	3,305
Brush	0.3%	258	1.3%	1,183	0.81%	1,440
Food Waste	27.9%	23,962	14.8%	13,464	21.1%	37,426
Wood	1.1%	979	3.4%	3,093	2.3%	4,072
Other miscellaneous organics	12.8%	10,959	4.8%	4,367	8.7%	15,326
GLASS	**2.7%**	**2,319**	**2.2%**	**2,001**	**2.4%**	**4,320**
METAL	**3.3%**	**2,834**	**5.2%**	**4,731**	**4.3%**	**7,565**
OTHER INORGANICS	**11.8%**	**10,134**	**19.1%**	**17,376**	**15.5%**	**27,510**
Total:	**100.1%**	**85,970**	**100.1%**	**91,065**	**100.0%**	**177,035**

** Tonnages do not sum to exact total due to rounding errors.*

Table 5-4 Current As-Received ecomaine Waste HHV

Waste Categories	Total Waste As-Received		As-Received HHV (1)		HHV Contribution	
2012 As-Received Tonnage	**176,858**	**100%**	**(Kcal/Kg)**	**(Btu/lb)**	**(Kcal/Kg)**	**(Btu/lb)**
TOTAL PAPER	**50,825**	**28.7%**	**3,778**	**6,814**	**1084.6**	**1956.2**
Other (Non-packaging) Paper	37,581	21.2%	3,778	6,814	802.0	1446.5
Compostable Paper	13,244	7.5%	3,778	6,814	282.6	509.8
TOTAL PLASTIC	**25,246**	**14.3%**	**7,833**	**14,130**	**1117.0**	**2014.9**
ORGANICS	**61,569**	**34.8%**	**2,379**	**4,292**	**827.5**	**1492.6**
Yard Trimmings	3,305	1.9%	1,494	2,695	27.9	50.3
Brush	1,440	0.8%	2,636	4,755	21.4	38.7
Food Waste	37,426	21.1%	1,317	2,375	278.4	502.1
Wood	4,072	2.3%	3,833	6,913	88.2	159.0
Other miscellaneous organics	15,326	8.7%	2,617	4,721	226.5	408.7
GLASS	**4,320**	**2.4%**	**46**	**83**	**1.1**	**2.0**
METAL	**7,565**	**4.3%**	**400**	**721**	**17.1**	**30.8**
OTHER INORGANICS	**27,510**	**15.5%**	**2,086**	**3,763**	**324.2**	**584.8**
Total:	**177,035**	**100.0%**	**--**	**--**	**3,186**	**5,748**

1) Source: Niessen, W., 2010, "Combustion and Incineration Processes", 4th Edition, CRC Press.

The results of the moisture heat sink was then considered in the calculation and is presented in Table 5-5, to give a total adjusted heat value. Essentially, the latent heat of vaporization of water and the heat capacity is included in the analysis which reduces the overall heat value. The moisture percentages included in the table are for "normal" waste (i.e. waste from a dumpster with a lid that prevents the infiltration of snow, ice, or rain). This calculation now presents the heat value of the waste stream received at ecomaine on a "normal" day. At the end of Table 5-5, a weighted heat capacity of 3,070 kcal/kg was calculated for the total waste stream, which includes the moisture heat sink.

Table 5-5 Current ecomaine Waste HHV as Adjusted for Moisture Heat Sink

Waste Categories	As-Received HHV[1]		Total Waste As Received		As Received Moisture[1]	Adjusted HHV Contribution (Water from 68-350°F)	
2012 As-Received Tonnage	**(Kcal/Kg)**	**(Btu/lb)**	**176,858**	**100%**		**(Kcal/Kg)**	**(Btu/lb)**
TOTAL PAPER	**3,778**	**6,815**	**50,825**	**28.7%**	**10.24%**	**1070.7**	**1931**
Other (Non-packaging) Paper	3,778	6,815	37,581	21.2%	10.24%	792	1428
Compostable Paper	3,778	6,815	13,244	7.5%	10.24%	279	503
TOTAL PLASTIC	**7,833**	**14,130**	**25,246**	**14.3%**	**2.00%**	**1116**	**2013**
ORGANICS	**2,379**	**4,292**	**61,569**	**34.8%**	**44.76%**	**754**	**1360**
Yard Trimmings	1,494	2,695	3,305	1.9%	65%	22	40
Brush	2,636	4,755	1,440	0.8%	40%	20	36
Food Waste	1,317	2,376	37,426	21.1%	72%	206	372
Wood	3,833	6,914	4,072	2.3%	20%	86	155
Other miscellaneous organics	2,617	4,721	15,326	8.7%	26.80%	216	389
GLASS	**46**	**83**	**4,320**	**2.4%**	**2%**	**1**	**2**
METAL	**400**	**721**	**7,565**	**4.3%**	**3%**	**16**	**30**
OTHER INORGANICS	**2,086**	**3,763**	**27,510**	**15.5%**	**10%**	**317**	**572**
Weighted Average:	**--**	**--**	**177,035**	**100.0%**	**--**	**3,070**	**5,539**

[1] *Source: Niessen, W., 2010. "Combustion and Incineration Processes," 4th Edition, CRC Press.*

5.4 Calculation of HHV for Future ecomaine Waste Stream

In the future, organic waste could be diverted from the inlet waste stream. Based on conversations with plant operators, it is assumed that the facility will be run the same, the available input waste stream is unlimited, and any waste diverted from the incoming waste stream can be replaced with the necessary tonnage of waste from other local sources, so total input tonnages were assumed to remain constant.

The first potential future scenario for the diversion of organic waste is presented in Table 5-6. This analysis, considered to be the "low end" of the potential organic diversion spectrum, assumes that there will be 3,100 tons of residential waste diverted in the year and no commercial waste diversion. This scenario is considered the minimum that would be diverted if a program were to be implemented. The overall tonnages of waste received were assumed to remain constant and the percentages of waste removed from the targeted organic categories were replaced with waste of the same overall composition as the original, non-organics diverted, waste.

Table 5-6 Future Estimated Composition of ecomaine Waste – "Low End of Targeted Organics Diversion"

Waste Categories	Residential[2]		Commercial[3]		Total Waste[4]	
2012 As-Received Tonnage:	**85,884**		**90,974**		**176,858**	
TOTAL PAPER	**25.8%**	**22,118**	**31.7%**	**28,839**	**28.8%**	**50,957**
Other (Non-packaging) Paper	18.3%	15,750	24.6%	22,380	21.5%	38,130
Compostable Paper	7.4%	6,368	7.1%	6,459	7.2%	12,827
TOTAL PLASTIC	**13.9%**	**11,924**	**15.1%**	**13,737**	**14.5%**	**25,661**
ORGANICS	**42.0%**	**36,092**	**26.8%**	**24,381**	**34.2%**	**60,473**
Yard Trimmings	1.1%	967	2.5%	2,274	1.83%	3,242
Brush	0.3%	267	1.3%	1,183	0.82%	1,450
Food Waste	26.2%	22,489	14.8%	13,464	20.3%	35,953
Wood	1.2%	1,014	3.4%	3,093	2.3%	4,108
Other miscellaneous organics	13.2%	11,354	4.8%	4,367	8.9%	15,721
GLASS	**2.8%**	**2,403**	**2.2%**	**2,001**	**2.5%**	**4,404**
METAL	**3.4%**	**2,936**	**5.2%**	**4,731**	**4.3%**	**7,667**
OTHER INORGANICS	**12.2%**	**10,500**	**19.1%**	**17,376**	**15.7%**	**27,876**
Total:	**100.1%**	**85,973**	**100.1%**	**91,065**	**100.0%**	**177,038**

[1]Tonnages do not sum to exact total due to rounding errors.
[2]Residential removal of 3,100 tons of targeted organics, as per Section 1.
[3]Commercial removal of 0 tons of targeted organics assumed, as per Section 1.
[4]Assumed that tonnage lost from waste diverted is made up by additional waste received from other sources.

In Table 5-5, the percent moisture was added for the current waste composition. The future waste stream calculations in Table 5-7 are similar to those presented in Table 5-5 for the current waste stream. In Table 5-7, the same weighted averaging is done to determine that the low end future adjusted HHV is 3,094 kcal/kg.

The second future scenario for the diversion of organic waste is presented in Table 5-8. This presents an analysis considered to be the "medium range" of organic diversion. The scenario does not attempt to define the expected future scenario directly, but is offered as a mid-level diversion program between the low end and the high end scenarios. For this scenario, the assumption is that there will be 6,800 tons of residential waste diverted in the year and 5,100 tons of commercial waste diversion. The overall tonnages of waste received were assumed to remain constant and the percentages of waste removed from the targeted organic categories were replaced with waste of the same overall composition as the original, non-organics diverted, waste.

Again, the future waste stream calculations in Table 5-9 are similar to those presented in Tables 5-5 and 5-7. In Table 5-9, the weighted average for the medium range future adjusted HHV is 3,163 kcal/kg. The final future scenario examined for the diversion of organic waste is presented in Table 5-10. This scenario represents the "high end" of organic diversion. While it may be possible to achieve even higher levels of diversion than this scenario, this scenario is considered the high end in the study because it

Table 5-7 Future ecomaine Waste Adjusted HHV – "Low End of Targeted Organics Diversion"

Waste Categories	As-Received HHV		Total Waste, As-Received		As-Received Moisture[1]	Adjusted HHV Contribution (Water from 68-350°F)	
2012 As-Received Tonnage	**(Kcal/Kg)**	**(Btu/lb)**	**176,858**	**100%**		**(Kcal/Kg)**	**(Btu/lb)**
TOTAL PAPER	**3,778**	**6,815**	**50,957**	**28.8%**	**10.24%**	**1073.5**	**1936**
Other (Non-packaging) Paper	3,778	6,815	38,130	21.5%	10.24%	803	1449
Compostable Paper	3,778	6,815	12,827	7.2%	10.24%	270	487
TOTAL PLASTIC	**7,833**	**14,130**	**25,661**	**14.5%**	**2.00%**	**1134**	**2046**
ORGANICS	**2,379**	**4,292**	**60,473**	**34.2%**	**44.76%**	**740**	**1336**
Yard Trimmings	1,494	2,695	3,242	1.8%	65.00%	22	39
Brush	2,636	4,755	1,450	0.8%	40.00%	20	36
Food Waste	1,317	2,376	35,953	20.3%	72.00%	198	358
Wood	3,833	6,914	4,108	2.3%	20.00%	87	156
Other miscellaneous organics	2,617	4,721	15,721	8.9%	26.80%	221	399
GLASS	**46**	**83**	**4,404**	**2.5%**	**2%**	**1**	**2**
METAL	**400**	**721**	**7,667**	**4.3%**	**3%**	**17**	**30**
OTHER INORGANICS	**2,086**	**3,763**	**27,876**	**15.7%**	**10%**	**321**	**579**
Weighted Average:	**--**	**--**	**177,038**	**100.0%**	**--**	**3,094**	**5,581**

Table 5-8 Future Estimated Composition of ecomaine Waste – "Medium Range of Targeted Organics Diversion"

Waste Categories	Residential[2]		Commercial[3]		Total Waste	
2012 As-Received Tonnage	**85,884**		**90,974**		**176,858**	
TOTAL PAPER	**25.9%**	**22,275**	**31.8%**	**28,971**	**28.9%**	**51,247**
Other (Non-packaging) Paper	19.1%	16,405	26.0%	23,634	22.6%	40,039
Compostable Paper	6.8%	5,870	5.9%	5,337	6.3%	11,207
TOTAL PLASTIC	**14.5%**	**12,420**	**15.9%**	**14,507**	**15.2%**	**26,927**
ORGANICS	**40.5%**	**34,784**	**24.3%**	**22,132**	**32.1%**	**56,916**
Yard Trimmings	1.0%	892	2.1%	1,879	1.57%	2,771
Brush	0.3%	278	1.4%	1,249	0.86%	1,527
Food Waste	24.1%	20,731	12.2%	11,126	18.0%	31,857
Wood	1.2%	1,057	3.6%	3,267	2.4%	4,323
Other miscellaneous organics	13.8%	11,826	5.1%	4,612	9.3%	16,438
GLASS	**2.9%**	**2,502**	**2.3%**	**2,114**	**2.6%**	**4,616**
METAL	**3.6%**	**3,059**	**5.5%**	**4,996**	**4.5%**	**8,054**
OTHER INORGANICS	**12.7%**	**10,937**	**20.2%**	**18,350**	**16.5%**	**29,287**
Total:	**100.1%**	**85,977**	**100.1%**	**91,070**	**100.0%**	**177,047**

[1]Tonnages do not sum due to rounding errors.
[2]Residential removal of 6,800 tons of targeted organics, as per Section 1.
[3]Commercial removal of 5,100 tons of targeted organics assumed, as per Section 1.
[4]Assumed that tonnage lost from waste diverted is made up by additional waste received from other sources.

Table 5-9 Future ecomaine Waste Adjusted HHV – "Medium Range of Targeted Organics Diversion"

Waste Categories	As-Received HHV		Total Waste, As-Received		As-Received Moisture[1]	Adjusted HHV Contribution (Water from 68-350°F)	
2012 As-Received Tonnage	**(Kcal/Kg)**	**(Btu/lb)**	**176,858**	**100%**		**(Kcal/Kg)**	**(Btu/lb)**
TOTAL PAPER	**3,778**	**6,815**	**51,247**	**28.9%**	**10.24%**	**1079.5**	**1947**
Other (Non-packaging) Paper	3,778	6,815	40,039	22.6%	10.24%	843	1521
Compostable Paper	3,778	6,815	11,207	6.3%	10.24%	236	426
TOTAL PLASTIC	**7,833**	**14,130**	**26,927**	**15.2%**	**2.00%**	**1190**	**2146**
ORGANICS	**2,379**	**4,292**	**56,916**	**32.1%**	**44.76%**	**697**	**1257**
Yard Trimmings	1,494	2,695	2,771	1.6%	65.00%	19	33
Brush	2,636	4,755	1,527	0.9%	40.00%	21	38
Food Waste	1,317	2,376	31,857	18.0%	72.00%	176	317
Wood	3,833	6,914	4,323	2.4%	20.00%	91	165
Other miscellaneous organics	2,617	4,721	16,438	9.3%	26.80%	231	417
GLASS	**46**	**83**	**4,616**	**2.6%**	**2%**	**1**	**2**
METAL	**400**	**721**	**8,054**	**4.5%**	**3%**	**18**	**32**
OTHER INORGANICS	**2,086**	**3,763**	**29,287**	**16.5%**	**10%**	**337**	**608**
Weighted Average:	**--**	**--**	**177,038**	**100.0%**	**--**	**3,163**	**5,706**

[1]Source: Niessen, W., 2010, "Combustion and Incineration Processes", 4th Edition, CRC Press.

Table 5-10 Future Estimated Composition of ecomaine Waste – "High-End of Targeted Organics Diversion"

Waste Categories	Residential[2]		Commercial[3]		Total Waste	
2012 As-Received Tonnage	**85,884**		**90,974**		**176,858**	
TOTAL PAPER	**26.3%**	**22,577**	**31.9%**	**29,023**	**29.1%**	**51,600**
Other (Non-packaging) Paper	20.6%	17,662	26.5%	24,126	23.6%	41,788
Compostable Paper	5.7%	4,915	5.4%	4,897	5.5%	9,812
TOTAL PLASTIC	**15.6%**	**13,371**	**16.3%**	**14,809**	**15.9%**	**28,180**
ORGANICS	**37.6%**	**32,274**	**23.4%**	**21,250**	**30.2%**	**53,524**
Yard Trimmings	0.9%	747	1.9%	1,724	1.40%	2,471
Brush	0.3%	299	1.4%	1,275	0.89%	1,574
Food Waste	20.2%	17,358	11.2%	10,208	15.6%	27,567
Wood	1.3%	1,138	3.7%	3,335	2.5%	4,472
Other miscellaneous organics	14.8%	12,732	5.2%	4,708	9.8%	17,440
GLASS	**3.1%**	**2,694**	**2.4%**	**2,158**	**2.7%**	**4,852**
METAL	**3.8%**	**3,293**	**5.6%**	**5,100**	**4.7%**	**8,393**
OTHER INORGANICS	**13.7%**	**11,775**	**20.6%**	**18,732**	**17.2%**	**30,507**
Total:	**100.1%**	**85,984**	**100.1%**	**91,072**	**100.0%**	**177,056**

[1]Tonnages do not sum due to rounding errors.
[2]Residential removal of 13,900 tons of targeted organics, as per Section 1.
[3]Commercial removal of 7,100 tons of targeted organics assumed, as per Section 1.
[4]Assumed that tonnage lost from waste diverted is made up by additional waste received from other sources.

symbolizes the "maximum" practical diversion rates when compared to other current programs around the country. It is assumed is that there will be 13,900 tons of residential waste diverted in the year and 7,100 tons of commercial waste diversion. The overall tonnages of waste received were assumed to remain constant and the percentages of waste removed from the targeted organic categories were replaced with waste of the same overall composition as the original, non-organics diverted, waste.

Once again, the future waste stream calculations in Table 5-11 are similar to those presented in Tables 5-5, 5-7 and 5-9. In Table 5-11, the weighted average for the medium range future adjusted HHV is 3,233 kcal/kg.

Table 5-11 Future ecomaine Waste Adjusted HHV – "High End of Targeted Organics Diversion"

Waste Categories	As-Received HHV		Total Waste, As-Received		As-Received Moisture[1]	Adjusted HHV Contribution (Water from 68-350°F)	
2012 As-Received Tonnage	**(Kcal/Kg)**	**(Btu/lb)**	**176,858**	**100%**		**(Kcal/Kg)**	**(Btu/lb)**
TOTAL PAPER	**3,778**	**6,815**	**51,600**	**29.1%**	**10.24%**	**1086.9**	**1961**
Other (Non-packaging) Paper	3,778	6,815	41,788	23.6%	10.24%	880	1588
Compostable Paper	3,778	6,815	9,812	5.5%	10.24%	207	373
TOTAL PLASTIC	**7,833**	**14,130**	**28,180**	**15.9%**	**2.00%**	**1245**	**2246**
ORGANICS	**2,379**	**4,292**	**53,524**	**30.2%**	**44.76%**	**655**	**1182**
Yard Trimmings	1,494	2,695	2,471	1.4%	65.00%	17	30
Brush	2,636	4,755	1,574	0.9%	40.00%	22	39
Food Waste	1,317	2,376	27,567	15.6%	72.00%	152	274
Wood	3,833	6,914	4,472	2.5%	20.00%	94	170
Other miscellaneous organics	2,617	4,721	17,440	9.8%	26.80%	245	442
GLASS	**46**	**83**	**4,852**	**2.7%**	**2%**	**1**	**2**
METAL	**400**	**721**	**8,393**	**4.7%**	**3%**	**18**	**33**
OTHER INORGANICS	**2,086**	**3,763**	**30,507**	**17.2%**	**10%**	**351**	**634**
Weighted Average:	**--**	**--**	**177,038**	**100.0%**	**--**	**3,233**	**5,831**

5.5 Impact of Changes in Heat Value of Waste on WTE Operations

The calculated HHV values are presented in Table 5-12, which summarizes the complete analysis. It includes the current and future (after organic diversion) calculated heat values for the input waste streams. As one can see from the comparison of the weighted averages, the future heat value is higher with organic diversion. Since the facility is steam limited and not waste feed rate limited (the maximum steam output is reached before the 550 tons per day waste limit), the potential impacts to the system, assuming that operations remain the same, can be discussed as an adjustment necessary to balance the future heat value to the current heat value. In theory, then, to make this balance, waste feed in the future will need to be from 0.8% to 5% less than it is today without making other operational adjustments, for a low end diversion rate to a high end diversion rate, respectively. Therefore, given the error associated with this task, it is possible that without any adjustments to the operations, the impact of organic diversion necessitate a reduction in throughput by up to 5%.

Table 5-12 Comparison of ecomaine Adjusted HHV Estimates

Waste Categories	Adjusted HHV Contribution (Water from 68-350°F)							
	Current Waste Stream		Low End of Targeted Organics Diversion		Medium Range Targeted Organics Diversion		High End of Targeted Organics Diversion	
2012 As-Received Tonnage:	**(Kcal/Kg)**	**(Btu/lb)**	**(Kcal/Kg)**	**(Btu/lb)**	**(Kcal/Kg)**	**(Btu/lb)**	**(Kcal/Kg)**	**(Btu/lb)**
TOTAL PAPER	**1,071**	**1,931**	**1,073**	**1,936**	**1,080**	**1,947**	**1,087**	**1,961**
Other (Non-packaging) Paper	792	1,428	803	1,449	843	1,521	880	1,588
Compostable Paper	279	503	270	487	236	426	207	373
TOTAL PLASTIC	**1,116**	**2,013**	**1,134**	**2,046**	**1,190**	**2,146**	**1,245**	**2,246**
ORGANICS	**754**	**1,360**	**740**	**1,336**	**697**	**1,257**	**655**	**1,182**
Yard Trimmings	22	40	22	39	19	33	17	30
Brush	20	36	20	36	21	38	22	39
Food Waste	206	372	198	358	176	317	152	274
Wood	86	155	87	156	91	165	94	170
Other miscellaneous organics	216	389	221	399	231	417	245	442
GLASS	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
METAL	**16**	**30**	**17**	**30**	**18**	**32**	**18**	**33**
OTHER INORGANICS	**317**	**572**	**321**	**579**	**337**	**608**	**351**	**634**
Weighted Average:	**3,070**	**5,539**	**3,094**	**5,581**	**3,163**	**5,706**	**3,233**	**5,831**

The impacts on diverting targeted organics from the waste stream were discussed with staff of PEI Energy Systems, which operates the mass burn Waste to Energy plant on Prince Edward Island, Canada Wonnacott 2013 and Myer 2013). In 1997, PEI began an extensive organics diversion program, which was implemented in a very short timeframe and required mandatory source separation, with an estimated diversion rate of 80% of targeted organics. PEI Energy Systems noticed an immediate impact on the fuel once the organics diversion program was in place, with a significant increase in the heat value of the waste. The higher heat value results in hotter burning, which caused several changes in their system, including that the refractories did not last as long. At PEI Energy Systems, the amount of steam generated in their boiler is their limiting factor, so as the heat value of the fuel increased; they had to burn less fuel. Ultimately, as a result of the changes in the heat value of the fuel with the organics diversion program, the PEI WTE plant dropped their annual intake of waste from 30,000 metric tons to 27,000 metric tons, a 10% reduction. This is interesting anecdotally, but it should be noted that PEI has an extremely aggressive, mandatory organics diversion program, which includes fines, extra disposal fees, and waste removal services which refuse to pick up non-separated waste from the curbside. This program is not likely to be representative of what would happen in the ecomaine service area and represents a more extreme case study. Additionally, due to the fact that PEI is an island, the ability of the WTE to accept additional waste with a lower heat value is limited.

The experience of initiating an organics diversion program in a WTE-based solid waste system in Vancouver, British Columbia has been different than the experience in PEI. In the past few years, the majority of the 22 communities served by Metro Vancouver have put in place curbside collection programs for food scraps and food soiled paper. To date, the WTE plant serving Metro Vancouver has maintained the same tonnage (approximately 800 metric tons per day) without making any changes to operations at the WTE (Allan 2013). At several European WTE plants, where aggressive organics diversion programs have increased the heat value of solid waste by as much as 10%, operational adjustments to the heat uptake capacity of the plants have allowed facilities to maintain input tonnages with the changes in waste composition associated with organics diversion (Richter 2013).

The operational experience of the ecomaine WTE plant from the late 1980s until the current time suggests that, as is the case with other WTE plants that have maintained a constant feed rate of solid waste while the heat value of the waste has changed, there is enough flexibility within the system to absorb the impact of some of these changes. In the case of ecomaine, increased recycling rates since the plant started operations has removed increasing amounts (currently 36,000 tons per year) of paper and plastics in addition to metals and glass from the solid waste stream fed to the WTE plant. The predicted impact of traditional recycling programs is to decrease the heat value of solid waste as a fuel (Guyer 2011), and yet ecomaine's feed tonnage and energy output has remained relatively constant since it started operations (Trytek 2013).

When this project began, the project team was interested in learning whether additional electricity, (i.e., energy), could be made by increasing the steam output. However, after discussing this project at the Task 5 kickoff meeting, it was learned that the facility is steam limited and therefore energy limited. Any additional increases in heat from the diversion of organic waste would have to be offset by operational changes or diversion of incoming waste to maintain the current steam production levels. Therefore, if we "draw a box" around the facility with respect to energy, the ultimate energy out will be the same.

It is worth noting, though, that ecomaine does need to supplement the solid waste fuel with natural gas at times in order to achieve optimal burn conditions within the boilers. This is mostly to help compensate for moisture in the waste during periods of wet weather. For the two-year period ending in June of 2013, ecomaine paid an average of $282,000 per year for natural gas. Due to the unpredictability of the impact of weather on the moisture content of the waste, natural gas use fluctuates greatly and the impact of changes in fuel heat value on natural gas use are hard to determine. It is possible, though, that increases in heat value of the solid waste that would come from organic waste diversion could decrease the need for some of the natural gas that ecomaine currently purchases.

5.6 Impact of Potential Changes on Air Emissions

Organic waste diversion, with operations remaining constant, will potentially increase the enthalpy of the burn. If the burn occurs at a higher temperature, there could be a change in potential air emissions. However, given that the system is currently steam limited and not waste feed limited, we anticipate that measures will be implemented to maintain the current steam output and burn temperature. Options include, but are not limited to:

- Scaling back the waste up to 5% according to the potential corresponding increase in enthalpy per pound of waste.
- Changing the waste composition, so that the total waste offers less enthalpy per pound, for example seeking higher moisture materials.
- Adding more water to the burn to compensate for the heat sink lost from organics diversion.
- Making changes to the heat uptake capacity of the WTE plant (e.g. additional refractory to absorb more heat), or;
- A combination of the above.

This subtask assumes however, that the facility finds a way to still meet the heat output limit, or the net heat output reduction is accomplished after the burn. In this case, the air emissions could change if the burn temperature is increased, or if additional excess air is included as a heat sink. This subtask includes a review of how, organic diversion could affect the air emissions from the WTE process if a substitute heat sink is not offered.

As has been stated previously, it was assumed, based on discussions with plant operators, that the available input waste stream is unlimited and that any waste diverted can be replaced with tonnage from other local sources.

Again, the goal of this subtask is not to suggest operational changes or to review the manner in which the plant is currently being operated with an eye on changing operations or modifying the emissions profile to bring emissions closer to the limits. The goal is to provide an overview of the current emissions profile and discuss possible changes that may result from the new waste stream that the plant would see with organic waste diversion. These potential changes to criteria pollutants, namely carbon dioxide (CO), NOx, and sulfur dioxide (SO_2) are considered.

A review of the limits in ecomaine's air permit and the last three years of criteria pollutant emissions data were performed as part of this subtask. Clearly ecomaine is well below the emission limits by design. A review of ecomaine's emissions data shows that the emissions of NOx are limiting, in that they are the closest to the emission limits in the permit. Therefore, any changes that would impact emissions as a result of diverting organic waste should focus on potential changes to NOx. There are two limits for NOx in ecomaine's air permit. The first is on a weight per time basis, as pounds of NOx per hour (lbs/hr). The second is on a concentration basis, as parts of NOx per million parts of flue gas (ppm). The controlling criteria pollutant emissions limit is NOx concentration on a ppm basis.

The emissions data and permit limits are summarized in Table 5-13, both as an average of the last three years of data (2010 – 2012) and as the maximum value over that period. Since the NOx concentration limit is the driving factor, this is the focus of this discussion. The facility is limited to 180 parts per million (ppm) of NOx on a 24 hour basis. According to facility operators, the plant tends to operate at a set-point of approximately 90% of the limit. As shown in Table 5-13, the NOx average emissions are 77% of the limit and the maximum annual NOx emissions were 79% of the limit, which occurred in 2012. The plant steam flow rates are also close to the limits, which will be another factor in limiting plant operations.

Table 5-13 Review of ecomaine Emissions Data, 2010 - 2012

Parameter	CO ppm	CO lbs/hr	NOx ppm	NOx lbs/hr	SO_2 ppm	SO_2 lbs/hr	Steam Flow
Limits:	100	16.64	180	49.22	29	11.04	77-78K[31]
Average	26.4	2.6	137.7	21.2	2.0	1.7	66.4
% of limit	26%	15%	77%	43%	7%	15%	86%
Max	30.1	3.0	142.9	26.4	4.0	2.1	67.5
% of limit	30%	18%	79%	54%	14%	19%	88%

CO is created as a product of incomplete combustion when the system is starved for oxygen. With mass burn there are pockets in non-homogeneous waste that require more oxygen than others, so even with a little more than the theoretical oxygen necessary for combustion, some oxygen starved pockets will exist. These can be minimized by providing even more excess air. Unfortunately, excess air increases NOx emissions.

Emissions of NOx occur from combustion via two separate pathways: the conversion of nitrogen present in the fuel (fuel NOx) and thermal fixation of molecular nitrogen present in the combustion air (thermal NOx). While the formation of fuel NOx is relatively independent of temperature, the formation of thermal NOx is sensitive to changes in temperature, and increases with increasing temperature. The literature suggests that thermal fixation becomes abundant at temperatures above 2500^{o}F, but can be reduced by reducing temperature and residence time (Innovative Combustion Technologies, Inc., 2013

[31] According to ecomaine staff, the steam flow limits are dynamic (changing from year to year), consequently the percentage of the limit reached also fluctuates annually.

and US EPA 2000). Thermal NOx is not expected to be a large contributor at the ecomaine WTE plant process combustion temperatures, which are believed to be no higher than 2200°F (Hewes 2013). Conditions that promote good mixing of fuel and air, and thus, lower emissions of CO, tend to increase the conversion of nitrogen in the fuel to NOx and raise emission levels, as discussed previously. Selective non-catalytic reduction (SCNR) with urea is used in the combustion chamber to control emissions of NOx, by reducing it in the presence of oxygen to harmless molecular nitrogen (N_2) and water (H_2O).

Emissions of SO_2 are acidic and are sometimes referred to as "acid flue gases." Post-combustion controls of lime slurry and a scrubber are used to control emissions of SO_2 as well as other acidic by-products. Creation of SO_2 is influenced by the input waste stream. Gypsum (hydrated calcium sulfate) wallboard products from construction and demolition debris (C&D), in particular, have the ability to increase SO_2 emissions during combustion. Commercial C&D is generally not accepted at the ecomaine WTE plant and the residential contribution of C&D is estimated to be small, and consequently, C&D is usually not a large contribution of SO_2 to the WTE plant emissions.

Typically, combustion processes focus on the inverse relationship between the formation of NOx and the formation of CO on a weight per time basis. When total NOx increases, CO decreases and vice versa. This inverse relationship can be adjusted by increasing or decreasing excess air. In the case of ecomaine, the limiting factor is not NOx on a weight per time basis so the focus is not on the inverse relationship alone, but also includes the potential changes to NOx on a concentration basis.

The concentration might actually increase or decrease with more excess air. To formally determine this change, an ultimate analysis of the waste would need to be performed. Essentially adding excess air will increase NOx on a weight per time basis and increase NOx on a concentration basis (with respect to the original airflow), but may actually result in a lower overall concentration with respect to the new total airflow. Again, it is not the intent here to suggest changes to operations, so assuming no changes, waste input may need to be reduced if the formation of NOx increases as heat increases. However, if some additional air is added, it is likely that the concentration would not change substantially since additional airflow would dilute the formation of NOx and offset any additional NOx formed because of increased heat value.

Predicting changes in the chemical composition of the solid waste delivered to the WTE plant with an organics diversion program is beyond the scope of this study, but a couple of potential changes are worth noting. Organic wastes, particularly food scraps, can have a significant nitrogen content, due to the proteins in organic materials. Consequently as these are removed from the waste stream, the contribution to NOx from the nitrogen in the solid waste fuel may be slightly reduced. Anecdotally, ecomaine has sometimes observed an increase in NOx emissions in the fall that they have attributed to a seasonal increase in yard trimmings in the waste stream (Hewes 2013). Additionally, the sulfur component of organic materials will be reduced in the waste stream as organics diversion increases, but as the percentage of plastics (particularly #3-#7 plastics) increase in the waste stream the contribution of sulfur from those materials may increase.

5.7 Task 5 Summary

As the ecomaine WTE plant considers the possible increase in organic waste diversion and recycling in the service area, it is important to consider the impact of these potential changes on operations at the plant. The calculated HHV values are presented in Table 5-12, which summarizes the current and future (after organic diversion) calculated heat values for the input waste streams. Essentially, in the future the waste feed rate would not be affected much by a small diversion of residential organic waste, but could require up to a 5% reduction in total throughput for a robust organics diversion program, assuming everything else remains constant. While this report does not recommend changes to plant operations, experience from other WTE plants suggest that there may be adjustments that could be made to operating conditions to keep the feed rate of solid waste to the WTE plant constant even with the increasing heat value of solid waste that comes with an organics diversion program. It is also possible that an increase in the heat value of the solid waste could reduce some of the natural gas needed to supplement the fuel in the boilers during periods of wet weather.

Changes to the waste stream could have an impact on air emissions as the heat value of the waste increases and will have to be monitored to keep NOx emissions below permit limits.

6.0 Markets Evaluation

Key Findings of Task 6

The following items summarize the findings of Task 6: Markets Evaluation.

- An ecomaine-owned compost facility processing 12,000 tons per year of Source Separated Organics (SSO) would generate approximately 18,200 cubic yards (CY) per year of finished compost. An ecomaine-owned dry fermentation anaerobic digestion facility processing the same tonnage would generate approximately 36 million standard cubic feet (scf) per year of biogas.
- The primary compost markets from an ecomaine compost facility will likely be landscaping (residential and commercial), topsoil manufacturing, and agriculture. Emerging compost markets such as environmental preservation and restoration through stormwater management, sediment and erosion control and site restoration, and in containerized horticulture are not yet well developed in Maine, but may present market opportunities in the future.
- Existing compost producers in or near the ecomaine service area generate an estimated 40,000 CY/year of compost, about one-third of which is sold primarily to residential and commercial landscaping markets in the price range of $25 to $45/CY for bulk, wholesale sales. The remainder is sold or given away primarily to volume markets, such as topsoil blending operations, in the price range of $0 to $20/CY.
- The current market in the ecomaine service area could easily absorb the additional supply of compost that would come from an ecomaine-owned compost facility, provided the quality is high. Using a conservative sales price of $15/CY for 18,200 CY of ecomaine composts going primarily to landscape and topsoil blending markets, the potential revenue from annual compost sales would be approximately $275,000.
- Biogas produced from an anaerobic digestion process can be combusted (as is) to make electricity or cleaned up to pipeline or vehicle fuel specifications and sold into those markets.
- The biogas generated from a dry fermentation anaerobic digestion facility processing 12,000 tons per year of SSO would translate into approximately 1.9 million kWh of electricity per year or 161,000 diesel gallon equivalents (DGE) of Compressed Natural Gas per year.
- The electricity market for distributed power produced from renewable sources is very robust in Maine, but there may be an opportunity to sell power at an elevated feed-in tariff ($100/MWh) under the Community-Based Renewable Energy Program, which would generate approximately $190,000 in annual revenues.
- The vehicle fuel market has more potential in Maine than the pipeline market, and a new Compressed Natural Gas station has been announced in Westbrook. The market for a "Recycled Natural Gas" fuel product by ecomaine could be about $180,000 annually.
- Digestate from the dry fermentation process is not well suited to land application; consequently, if ecomaine develops an anaerobic digestion facility, the digestate would likely either be composted by ecomaine or sent to a merchant composting facility.

The purpose of this task is to understand, on a preliminary basis, the nature and size of markets for products recovered from Source Separated Organics (SSO) in the ecomaine service area. These products can be broadly grouped into energy products and horticultural products.

An organics recycling facility should be sized and designed to meet two demands: waste management and market demand. This task will focus on the latter aspect, particularly on if there is a market, what kinds of markets there are and the relative strength of these markets. For this task, the project team is using the mid-range organics diversion scenario from Section 1 (i.e., approximately 12,000 tons per year of combined residential and commercial SSO) as a basis to review potential markets for compost, biogas and digestate from an ecomaine-owned compost and/or anaerobic digestion facility. This task report is not a comprehensive marketing study. Markets for compost products include landscaping, topsoil manufacturing, agriculture, sediment and erosion control, environmental site restoration, and storm water management. Markets for recovered energy products include electrical production, natural gas pipelines, and natural gas vehicles.

6.1 Compost Product Characteristics

Compost bears little physical resemblance to the raw material from which it originated. Compost is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. Compost can be utilized directly as a soil amendment, as a topdressing agent for turf, and as a mulch. It is considered a low-grade fertilizer, with typical nitrogen-phosphorus-potassium (N-P-K) values of close to or less than 1% for each nutrient, although this varies as a function of source feedstock materials.

Compost is also used as an ingredient in specialty soils. Compost-based specialty soils include golf course putting green root-zone mix, green roof media, bioretention pond planting media, athletic turf growth media, manufactured topsoil, container mix (for potted plants), and potting soils.

6.1.1 Compost

Quality characteristics common to municipal feedstock-based composts (US Composting Council, 1996) are presented in Table 6-1. Composts made from primarily food scraps or from biosolids can meet or exceed these criteria readily, but can sometimes have high levels of soluble salts, particularly with post-consumer food wastes.

6.1.2 Compost-Amended Soils

Many compost producers also offer compost-based soil blends in addition to selling compost. This is done for several reasons: more inherent demand for these products relative to compost alone, market diversity, mitigating the seasonal nature of compost sales, broadening customers' choices about products, etc.

Table 6-1 Typical Characteristics of Feedstock-Based Composts

Parameter	Typical Range	Preferred Range for Various Applications under Average Field Conditions
pH	5.0 - 8.5	6.0 - 7.5
Nutrient Content (dry weight basis)	N 0.5 - 2.5% P 0.2 - 2.0% K 0.3 - 1.5%	N 1% or above P 1% or above
Water Holding Capacity (dry weight basis)	75 - 200%	100% or above
Bulk Density	700 - 1,200 lbs/yd^3	800 - 1,000 lbs/yd^3
Moisture Content (wet weight basis)	30 - 60%	40 - 50 %
Particle Size (aggregate size)	Note 2	Pass through 1" screen or smaller
Trace Elements/Heavy Metals	Note 2	Meet US EPA Part 503 Regulations
Growth Screening	Note 2	Must pass seed germination, plant growth assays
Stability	Note 2	Stable to highly stable

[1]Feedstock composts are primarily derived from yard trimmings, biosolids, municipal solid waste, or food by-products, or a combination of one or more of these feedstocks.

[2]Typical ranges are not available for these parameters due to variations in compost feedstocks, production methods and qualities

Candidate soil blend products that are offered by some producers include:

- **Bioretention Pond Soil** – 80% C-144 mortar sand + 20% compost. This is a widely used formula for Low Impact Development stormwater management systems.
- **Green Roof Media** – 70% $^5/_{16}$" expanded shale + 20% compost + 10% C-144 sand. This formula is a slight modification of an existing formula used by a Midwest green roof media supplier.
- **Rootzone Mix** – 90% C-144 sand + 10% compost. This formula is an established turf rootzone mix deemed compliant with specifications published by the US Golf Association (USGA).
- **Topsoil** – 40% compost + 60% sandy loam soil. This formula is based on producing a topsoil material with 3 to 5% organic matter.
- **Potting Soil** – 75% peat moss + 10% compost + 15% perlite. This is a modification of a container mix formula used by a major US East Coast greenhouse nursery.
- **Container Mix** – 75% pine bark fines + 15% compost + 10% creek sand. This formula is a modification of a container mix formula used by a container nursery.
- **Turf Media** – 30% creek sand + 30% compost + 40% sandy loam soil. This is a specification for engineered sports turf growth media.
- **Urban horticulture soils** – 80% crushed rock + 20% compost + binder + water. This is similar to a specification for a structural urban soil developed by the City of Olympia, WA.

These types of specialty soils can be formulated by blending and mixing to meet virtually any construction specification. Laboratory testing for several parameters is needed to determine compatibility with published specifications. These parameters are either chemical characteristics or physical characteristics. Chemical characteristics include macronutrients (nitrogen, phosphorus, and potassium), micronutrients (magnesium, calcium, sodium, sulfur, zinc, iron, manganese, copper, and boron), pH, organic matter content, cation exchange capacity, percent base saturation, and soluble salt concentrations. Physical characteristics include bulk density, soil texture classification, soil particle size distribution (sieve analysis), permeability, saturated water capacity and hydraulic conductivity, and porosity.

The chemical characteristics are important for soil blends used for vegetation growth support (e.g., bioretention ponds, turfgrass, container mixes). Knowing macro- and micro-nutrient levels in soils allows for more accurate formulation of any needed supplemental fertilizer and avoids over fertilization (with the attendant consequences of non-point source pollution contribution). Knowledge of micronutrient levels for elements such as copper, zinc, and boron also allows evaluation of phytotoxicity potential. Developing a database of chemical (and physical) characteristics of compost-based soil blends also offer marketing value in terms of communication of product characteristics to knowledgeable user groups. It also allows easy determination of a product's compliance with published procurement specifications that call for minimum levels of nutrients.

Physical characteristics such as particle size analysis, soil texture classification, permeability, porosity, and hydraulic conductivity are important for determining compliance with published specifications, which gives market value to a product line. For example, a typical Water Quality Design Manual specification for bioretention pond mix calls for a soil permeability (infiltration rate) of 1 to 4 inches/hour, and green roof growth media typically specify a certain hydraulic conductivity (a measure of the ease with which water moves through a soil). Bulk density is important for horticultural media, so that container weights are not excessive.

6.2 Compost Market Characteristics

The following subsections describe the characteristics of potential markets for a compost product and identify existing and potential markets in the ecomaine service area.

6.2.1 Compost Market Segments

The size of the market for compost has been steadily increasing over the past 10 to 15 years as buyers have begun to understand the soil health benefits of compost addition. Compost producers have begun to overcome historical difficulties with product quality and consistency, and recent environmental consciousness has resulted in increased awareness with regard to composting and recycling. The compost market is characterized by strong customer loyalty to a particular product and high repeat sales traffic. Acquiring new customers requires education and outreach, as many potential customers do not fully understand why they should purchase compost and how they can benefit from that purchasing decision.

Markets for composts and compost-based soils have multiple facets. Markets can be described as retail vs. wholesale, dollar vs. volume markets, and traditional vs. emerging markets.

Dollar markets can be described as those with higher unit price potential, but lower volume sales expectations. An example of a potential dollar market for ecomaine's compost would be residential landscaping and gardening. Conversely, volume markets are those with the capacity to support large product volumes, but exhibit a lower unit cost and willingness-to-pay. Examples of volume markets for compost would be used in topsoil blending, agricultural use, and sediment and erosion control. Similar distinctions are possible for compost-based soil products. Manufactured topsoil would be an example of a potential volume market, while sports turf growth media would be a potential dollar market. The distinctions between volume and dollar markets are not definitive, and potential compost markets can fluctuate between both dollar and volume markets depending on project size. For example, a small commercial landscaping job might be considered a dollar market, but landscaping the grounds of a new shopping mall could be considered a volume market.

Many producers try to be active in both markets, but from different perspectives. Predominantly retail-oriented composters will use wholesale volume markets as an "inventory relief valve" to keep excess inventory from accumulating during slow sales periods. Wholesale-oriented composters will keep some retail sales as part of their overall marketing education and outreach efforts.

The potential markets can also be classified as either traditional markets or emerging markets. Traditional markets are those markets where compost-based products have an established familiarity and proven application record. Traditional markets can also be defined as those in which a product is considered well-defined, and has customers with well-developed buying patterns and established customer loyalty. These markets include: landscaping, sports turf, agriculture, containerized horticulture, and use of manufactured topsoil in construction projects.

Emerging markets are those markets were compost based products or the end products themselves are relatively new and unfamiliar to the end users. In these markets, some customers will have established product loyalty, but most are still seeking alternative suppliers for repeat purchases. These markets include: non-point source water quality management (bioretention ponds, bioswales, engineered wetlands, etc.), green roofs and green building practices, erosion and sediment control and environmental restoration (constructed replacement wetlands, contaminated lands remediation and reforestation). The market segments that were examined are shown in Table 6-2.

Table 6-2 Compost Market Segments

	Dollar Markets	Volume Markets
Traditional Markets	Landscaping Turfgrass Sports Turf	Landscaping (large projects) Agriculture Containerized Horticulture Manufactured Topsoil
Emerging Markets	Non-Point Source Water Quality Management Green Roofs	Sediment and Erosion Control Environmental Restoration

6.2.2 Traditional Markets

Traditional markets for compost are landscaping and agriculture. Residential and commercial landscaping is the predominant market for compost and for some types of compost-based soil blends (topsoils). Probable uses for compost include ornamental landscape beds, flower and vegetable gardens, and turfgrass establishment and maintenance. Potential methods of compost use include incorporation into the top 6 to 8 inches of soil, incorporation into plant backfill material, loosely spread on the surface of turf as a topdressing[32], and (more rarely) as a 2-to 3-inch mulch layer.

6.2.2.1 Residential and Commercial Landscaping

This market has several potential sectors including design professionals (landscape architects and consulting engineers), landscape contractors (installation/maintenance), wholesalers/retailers of landscape soil amendment products, and homeowners/gardeners.

Landscape designs typically indicate specific plants, soils, and organic amendments to be used for specific projects. The amount of soil amendments specified in a landscape design is typically based on soil analyses conducted by soil laboratories. Where local soil conditions warrant, some designs call for the importation of topsoil or growing media that must meet suitability specifications. Although landscape architects and engineers can be advocates for compost use through their design specifications, the potential compost purchasers are the landscape contractors.

Landscape contractors are a significant potential market for compost as well as for compost-based growing media. Most commercial landscape jobs are conducted based on bids received from multiple contractors who all estimate project costs from a common set of prepared plans and specifications. If those common project documents do not specifically require the use of compost or compost-amended soils on the particular job, contractors will not factor that cost into their bids.[33] In contrast, most residential work is designed and specified by the property owner working in conjunction with a contractor subject to a negotiated budget. This strategy typically allows residential projects greater flexibility in the consideration of alternative materials and the associated cost.

Landscape contractors also look for convenience. Several composters offer a “one-stop shop” approach, where landscapers drop off collected vegetative debris (paying the going “tipping” or “gate” rate), then load their trucks with one or more products to return to the job site.

Wholesale landscape material supply yards mainly serve contractors and large residential markets. As such, these businesses often stock inventories of compost-based soils (i.e., manufactured topsoil), some types of rootzone mixes, mulches, gravels, stones, and other similar bulk supplies. The retail landscape material supply distribution chain is heavily dominated by “big-box” stores and generally serves smaller residential customers. As such, these businesses are commonly more interested in bagged products. This is evidenced by the local lawn and garden centers increasingly converting the use of their limited space from bulk materials to bagged merchandise.

Homeowners and gardeners represent a significant market share for bulk compost sales. While many residential customers appreciate the convenience of bagged products, there are still a significant number of “pick-up truck-load” (1 to 2 cubic yards per purchase) buyers. These buyers are willing to

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[32] Topdressing refers to spreading a layer of some type of soil amendment (compost or a blend of compost and sand) over the turf surface. It is an alternative to incorporating compost into the soil.

[33] One strategy for ecomaine to consider would be developing draft project specifications for use of compost on municipal construction projects in the service area.

travel some distance to capture cost efficiencies associated with bulk compost purchases, but timely small-scale deliveries and/or more local distribution (through wholesale/retail outlets) are important considerations to sales growth in this market sector.

Compost application rates vary depending on native soil quality and application purpose, but can range from 3 to 6 CY/1,000 square feet (SF) for soil amendment incorporation into ornamental beds, new turf areas, and vegetable gardens or for use as a mulch, and from 1.0 to 1.5 CY/1,000 SF for turf topdressing maintenance. Dedicated compost users might purchase 10 to 20 CY/year for residential landscaping uses.

Compost used as a soil amendment needs only be screened to a 3/8-inch particle size, but in turf topdressing, products should be screened to 1/4-inch. Most often, materials used for turf topdressing are comprised either of sand, are sand-based, or increasingly are organics in the form of compost or in some cases, peat moss. The smaller sized particle is important for the following reasons:

- Application equipment is calibrated to ¼-inch particle size.
- The smaller particle size physically produces a more uniform surface.
- The finer particles filter through the blades of grass and come in direct contact with the soil surface, becoming invisible to the casual observer.
- A smaller particle size means greater surface area exposed to the soil and its fauna. Increased surface area yields quicker decomposition and assimilation into the soil and ultimately the grass plants themselves.

At this finer screening level, the compost must be very dry (less than 40% moisture) so as not to “bridge” in the hoppers of the distribution equipment.

The turfgrass market includes both sports turf and residential/commercial grass areas. The sports turf market includes golf courses (both public and private), athletic fields (baseball, football, and soccer), and other turf areas used for athletic events. This market has potential demand for compost and compost + sand blends, both as a soil amendment in new facilities construction and as a component of a turfgrass maintenance and management program. However, this market can be difficult to penetrate; as turf managers are protective of the large capital investment made in sports turf, particularly in golf courses. In addition, historical difficulties with compost use (i.e., quality consistency, weed seeds, availability, and price) have deterred some turf managers from compost use in favor of more predictable sources such as peat moss.

Whether used as a component of a soil mix for new construction or as maintenance topdressing material, important specifications for compost used in turfgrass applications include:

- Consistency of the compost product
- Grain size (usually screened to a ¼ inch minus)
- Decomposition rate (decomposition produces fines that clog soil pores)
- Absence of any offensive odor
- Absence of weed seeds

- pH of 6.5 to 7.5
- Carbon: nitrogen (C:N) ratios of 15:1 to 20:1

Soil compaction is the primary cause of poor playing field turf performance. Soil compaction is the process of increasing the density of soil by packing the particles closer together and reducing the volume of voids. To combat compaction, turf managers will aerate turf annually. Aeration is the process of creating void spaces within the root zone of the turf by mechanically removing cores of soil. Aeration improves the flow of air, water, and nutrients to the turf roots, thereby allowing the turf roots to grow deeper, resulting in a turf that is healthy, lush, and drought-resistant.

Topdressing is often done in conjunction with aeration. After being applied to the soil surface, the topdressing material is further distributed by dragging a mat or section of chain link fence over the treated area to disperse the topdressing evenly. Topdressing creates a more level surface for the field, helps prevent thatch buildup by providing a more favorable environment for microorganisms, and prolongs the effects of aeration by physically preventing the closure of the mechanically created voids. Topdressing is routinely performed on golf greens and is also used on sports fields and other fine turf areas when soil compaction or thatch problems develop.

Topdressing can be conducted using compost alone as shown in Figure 6-1, or with a sand-compost mixture, such as a 90% sand / 10% compost rootzone mix. Compost used in these applications should meet all of the specifications for use in turfgrass applications as noted above. In addition, compost used in topdressing applications will need to be applied using the same type of equipment currently in use by the turf manager to spread sand and/or granular fertilizer. This will likely require the compost material be screened to ¼-inch-diameter particle size or smaller.

Figure 6-1 Turf Topdressing with Compost

Photo courtesy of Harvest Power.

Independent research has shown the addition of compost to turfgrass has yielded many tangible benefits, including:

- Reduction of the severity and incidence of disease (thereby reducing the necessary chemical inputs such as fungicides).
- Addition of long-term reservoirs of nutrients to soils reduces fertilizer demand.
- Improved soil permeability resulting in a reduction of non-point source runoff pollution and the associated water quality impacts.
- Reduced soil compaction in heavily used playing and sports fields (anecdotal evidence suggests this reduces severity of injuries during play or athletic events).

6.2.2.2 Agriculture

Compost has been used in agricultural applications for centuries. In the past, compost was generated from on-farm sources (i.e., manures). The practice of using recycle-based composts made off-site for farm applications, such as row-crop agriculture, is a more recent trend. Compost use in agriculture is a well-established practice in organic agriculture and is becoming a larger phenomenon in conventional agriculture. The supporting research into crop yields, disease suppression, weed control, and improvements in soil quality from compost additions to agricultural soils has been underway for the past 10 to 15 years. Studies consistently point to improved crop yields, improved crop quality, reduced incidences of root rot-type diseases, and reduced demands for fertilizers, herbicides, and fungicides. In addition, recent research indicates compost use in agricultural soils can significantly reduce greenhouse gas emissions of nitrous oxide, which occur with chemical mineral fertilizers, like anhydrous ammonia (Favoino and Hogg, 2008).

Potential agricultural uses for compost include: incorporation into soil as an amendment prior to planting, surface-applied mulch layers for weed control, and distilling compost into a water-based extract (compost "tea") for use as a foliar spray or in root drench applications. The benefits of compost use in agriculture include improved soil organic matter, increased soil water-holding capacity (resulting in reduced irrigation demand), increased soil microbial activity (one of the reasons for improved disease suppression), long-term slow-release of plant nutrients, and improved soil pH buffering. The main drawbacks to its use in agriculture are the cost of transport to the fields and a historical low willingness-to-pay by farmers. Consequently, many compost professionals use agricultural markets as a lower-paying volume market for inventory management to clear space at their composting facility for other uses.

Product to be used as an agricultural soil amendment need not be as mature and stable as compost used in landscaping or in container mixes as it is often incorporated into soils after crop harvest and allowed to "winter over" until the following spring planting season. One compost producer in the eastern US sells a "Row Crop Compost" that has been composted for the minimal amount of time required to inactivate pathogens in the feedstocks. The material is still unstable and immature, yet sells for $4.00 per cubic yard. It has been used in row crop agriculture with measurable results, including a reported 36.7% increase in yield in King Arthur bell peppers (Burch and Flynn, 2001).

Application rates are dependent on local soil testing for organic matter, but are normally less than 20 tons per acre per year (approximately 40 CY/acre/year). This application rate typically provides an additional 0.4 – 0.5% to total soil organic matter content. Compost used as weed-control mulch has been shown to be more effective when immature due to its phytotoxic effects on weeds (Ozores-Hampton, 2001). It was shown to be effective as a weed control agent in 3-inch thick layers (approximately 10 CY per 1,000 square feet per year).

6.2.3 Emerging Markets

The emerging markets for composts and compost-amended soils are in the areas of environmental preservation/restoration and containerized horticulture. The markets in environmental applications include sediment filtration and erosion control, storm water management systems, constructed wetlands, green roofs, and site remediation. The containerized horticulture markets include potting soils and container mixes.

6.2.3.1 Sediment & Erosion Control

Compost is being used more frequently in applications to prevent erosion and sediment loss from construction sites and to filter sediment out of storm-induced runoff. The main methods of use are compost blankets, compost filter berms, and compost filter socks.

A compost blanket is a slope stabilization, erosion control, and vegetation establishment practice used on slopes to stabilize bare, disturbed, or erodible soils on and adjacent to construction activities. Compost blankets are used for both temporary and permanent slope erosion control and vegetation establishment applications. Blankets are normally applied with a mulch blower truck in an even 2-inch layer over disturbed areas, as shown in Figure 6-2. In addition, the compost can be pre-seeded with any particular seed mix as it is being discharged out of the blower hose. A 2-inch-thick compost blanket consumes 268 CY of compost per acre of blanket.

Figure 6-2 Compost Blanket Installation

Photo Credit: Coker Composting & Consulting.

Compost blankets have a mulch function and cover 100% of the soil surface, thereby providing similar benefits such as reduced raindrop impact and splash erosion, reduced runoff energy and sheet erosion, buffered soil temperature for plants, decreased moisture evaporation, increased moisture holding capacity at the soil surface, reduced runoff volume and velocity, and increased infiltration. The effects of mulching are known to suppress weed establishment. In addition, invasive weed growth has been more closely associated with mineral fertilizers than organic fertility practices such as the use of compost blankets.

Compost blankets also amend the soil, which can provide the following functional benefits: increased soil structure, increased soil aggregates, increased soil aeration, increased infiltration and percolation, increased moisture holding capacity, increased activity of beneficial microbes, increased availability of nutrients, decreased runoff volume and velocity, decreased erosion, and increased plant health and long-term sustainability.

Compost blankets provide slow release organic nutrients, including plant macro and micro-nutrients and are less likely to be transported in storm runoff to receiving waters. This characteristic can reduce pollution and eutrophication of waterways. In site-sensitive areas where nutrient runoff is a concern, compost blankets may release up to one-tenth of the nutrient load when compared to conventional hydroseeding and hydromulching techniques.

A compost filter berm is a sediment-trapping device featuring a specifically-sized mulch/compost filtering material installed using a berm forming device. Compost filter berms reduce the ability of storm water runoff to transport sediment by filtering runoff and dissipating small rills of flow into uniform sheet flow. This technique is primarily used for temporary erosion/sediment control applications, where perimeter controls are required or necessary. The compost filter berm technology is appropriate for slopes up to a 2:1 grade as well as level surfaces, and should only be used in areas that have sheet flow drainage patterns (not areas that receive concentrated flows).

A compost filter sock (see Figure 6-3) is a three-dimensional tubular sediment control and storm water runoff filtration device typically used for perimeter control of sediment and other pollutants such as metals, nitrogen, phosphorus, petroleum hydrocarbons, pesticides, and herbicides on and around construction activities. Compost filter socks trap sediment and other pollutants by filtering runoff water as it passes through the matrix of the sock and by allowing water to temporarily pond behind the sock, allowing deposition of suspended solids. Compost filter socks are also used to reduce runoff flow velocities on sloped surfaces.

6.2.3.2 Storm Water Management

This market consists of various vegetated methodologies for removing non-point source (NPS) pollutants from storm water runoff before the runoff enters waterways. Known as Best Management Practices (BMPs), these techniques include: grassed waterways (bioswales), filter strips, bioretention ponds, and storm water wetlands. Of these techniques, bioretention ponds are considered to be the largest potential market for the ecomaine service area. Nonetheless, all vegetated BMPs can benefit from the addition of compost to the substrate soils. These vegetated BMPs remove non-point source (NPS)

Figure 6-3 Compost Filter Sock

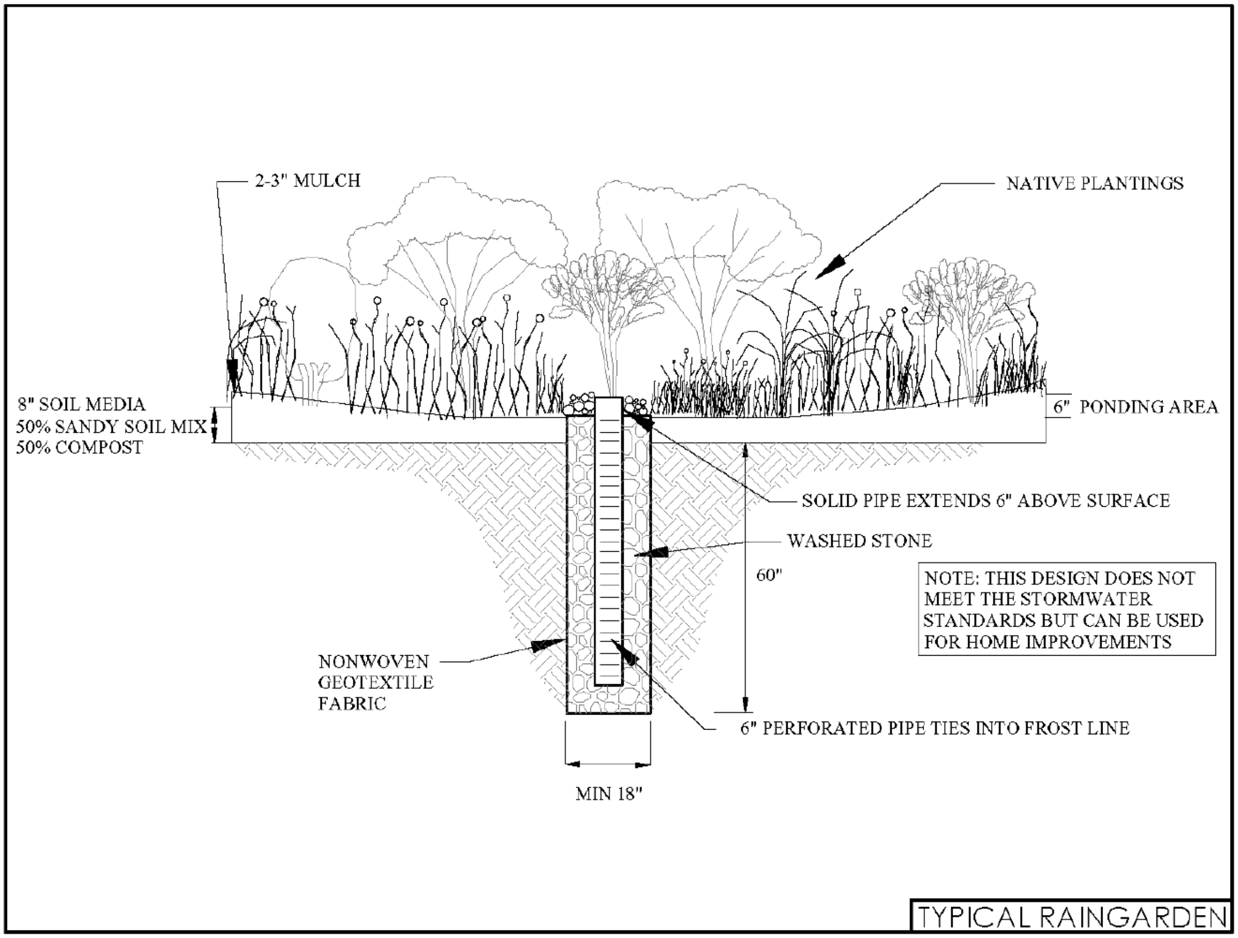
Photo Credit: Filtrexx International, Inc.

pollutants through filtration, absorption, adsorption, and in some cases microbial degradation. NPS pollutants include petroleum hydrocarbons from road and parking lot runoff. The pollution removal efficiencies of these systems are dependent upon the physical, chemical, and biological quality of the substrate used to grow the vegetation.

Bioretention ponds, also known as “rain gardens,” are part of a storm water management infrastructure that is gaining in popularity in many communities. A rain garden is a planted depression that allows rainwater runoff from impervious urban areas like roofs, driveways, walkways, and compacted lawn areas the opportunity to be absorbed. This reduces rain runoff by allowing storm water to soak into the ground. Rain gardens can cut down on the amount of pollution reaching creeks and streams by up to 30%. A conceptual cross-section of a bioretention pond is shown in Figure 6-4.

Rain gardens, bioswales, and vegetated filter strips are designed storm water management facilities that mimic the natural behavior of forested lands in an effort to naturally control hydrology and water quality. These types of BMPs are typically constructed with a thick layer of healthy, plant-growing soil medium. Frequently-used specifications for these plant-growing soils call for a mix of 20% compost and 80% sand, such that the soil mix has a permeability rate of 1 to 6 inches per hour. Many states now have specifications and design standards for bioretention ponds. The Maine DEP published Storm Water Best Management Practices in 2012 include bioretention pond specifications that include the use of compost in the pond designs.

Figure 6-4 Bioretention Pond Cross-Section[34]



Other water-quality related markets for composts are in the soil bed preparation for a constructed wetland area. Wetland is a general term that is often used when referring to three very different systems, such as swamps, bogs, and marshes. Constructed wetlands are different from natural wetlands in that they are designed, built, and operated for human use and benefit. They are constructed in areas where a wetland did not previously exist. Constructed wetlands can be used for storm water or wastewater treatment or to establish a wetlands bank to offset future impacts to natural wetlands due to construction activities. Compost is used to increase the organic matter content of the native soil of the site being converted. As the goal is to mimic the organic-rich nature of true hydric soils, compost amendment for wetlands can be on the order of 100 tons/acre.

[34] Maine Storm Water Best Management Practices Manual, http://www.maine.gov/dep/land/stormwater/stormwaterbmps/ , accessed 5/12/13

6.2.3.3 Containerized Horticulture

The horticultural industry has the potential to use compost in various blends including: potting soils, container substrates, nursery field applications, liner beds, as a band application in rows of ornamentals and trees, and as mulch. While some horticultural agencies currently use compost based blends, nurserymen in general are a conservative group due to the large economic investment they have in their products. As such, those who currently are using peat-based mixes tend to be unwilling to switch from these established mixes to compost-based mixes without significant laboratory and field testing and evidence.

Horticultural media must serve several different purposes, including:

- Retain nutrients in the root zone for plant availability and uptake.
- Hold moisture for access and availability by plants.
- Have adequate porosity of exchange of gases between plant roots and pore spaces.
- Provide anchorage and structural support for the plant, but have a low bulk density.

Compost used in horticultural media must have low bulk density, high porosity and percolation rates, adequate amounts of plant-available nitrogen, and be biodegradable enough to sustain disease suppression but resistant enough to maintain the structural properties of the mix to avoid volume shrinkage in the container. When used in potting soil applications, compost must be mature and well-decomposed as less-stable compost will break down. The particle fines produced during decomposition ultimately will clog the soil pores and air channels, which can lead to excessive moisture retention in the potting soil.

Although traditionally used for nutrient replenishment, compost can be used in field production as an alternative to cover crops. This application also provides additional nutrients to a soil allowing a field nursery to avoid taking a field out of service for one growing season.

Horticultural media recipes are often quite specific and depend on the particular nursery. Components can include sand, crushed rock, peat moss, coir fiber, coconut husks, vermiculite, perlite, and expanded aggregate. For example, one compost producer in Virginia sells a container mix made of 36% peanut hulls, 55% compost, and 9% creek sand. Another producer in North Carolina sells a potting soil made of compost, aged pine bark fines, and perlite (an expanded siliceous rock used to reduce media bulk density).

Traditionally, to enter this market, a compost professional has to initiate a small-scale pilot test with a receptive nurseryman, and once the product has proven successful, offer the product at a price point competitive with what is currently being paid for mixes (if selling a blend) or for peat moss (if the nursery blends their own media). Conversely, premiums can be charged for compost based mixes if some other form of strategic advantage or value can be demonstrated, such as reduced disease incidence or reduced fertilizer requirements.

6.2.4 Existing Compost Market in ecomaine Service Area

As identified in Section 4, there are several existing composting operations in and around the ecomaine service area currently composting commercial organics, manure and yard trimmings. In addition to those composting facilities, many towns have small composting operations in which they compost their own yard trimmings, and there are a handful of smaller on-farm composting operations composting primarily manure and other agricultural by-products. Finally, there are several biosolids composting operations in Maine, including those operated at the wastewater treatment plants of ecomaine member communities Scarborough and Yarmouth. A little to the north of the ecomaine service area, the Lewiston Auburn Water Pollution Control Authority (LAWPCA) has a biosolids composting operation in Lewiston, Maine (included in the Section 3 case studies). And Casella Organics operates a merchant biosolids composting facility (Hawk Ridge) in Unity, Maine. Some of the compost from both of those facilities is marketed within the ecomaine service area.

The established market for compost from these existing facilities is generally geared towards traditional uses, with some of the facilities selling to the dollar markets, and others selling primarily to the volume market. On the high-end of the market are the facilities composting a blend of seafood processing waste and manure, and whose finished product has been approved by the Maine Organic Farmers and Gardeners Association (MOFGA) for use in organic agriculture. These composts sell for as much as $45/cubic yard in bulk and even higher than that when resold from retail outlets. While approved for use in agriculture, their use in residential and commercial landscaping operations remains the largest market for these materials. Manure and seafood waste compost without MOFGA approval tends to sell for a little less, but can still as high as $30 to 35/cubic yard in bulk. This compost also tends to be sold to residential and commercial landscaping operations. A smaller percentage of these composts are used in bagged soil amendment products and used in topsoil blending operations.

Biosolids composts tend to have a higher nutrient content than the other composts produced in Maine, but these composts often sell at a reduced price point as they have perceived (but unwarranted) quality problems in some markets, particularly residential landscaping and gardening. Biosolids composts from Casella Organics and LAWPCA currently sell in the ecomaine service area for between $15 and $18/cubic yard in bulk including delivery. Biosolids composts from the Scarborough and Yarmouth wastewater treatment plants are available for pick up for free to contractors and the public. In Maine, biosolids composts traditionally have been sold into the volume market for blending with low-grade loam to make fertile, organic matter-rich topsoils. Additional markets for the biosolids composts from Maine include use in bark mulch/compost blends and in the creation of root-zone blends for athletic fields. There is a larger market for biosolids compost closer to the Boston area, and, consequently, some of the biosolids compost from both LAWPCA and Casella Organics is marketed south of the ecomaine service area.

Yard trimmings composts from municipally-run composting operations tend to go to a mix of home gardens, general landscaping, and topsoil blending outlets. Some municipalities give it away to residents, while others charge up to $20/cubic yard for the compost. The Town of Yarmouth sells their finished yard trimmings compost for $7/cubic yard and the Town of Bridgeton sells their compost by the pound ($0.06/pound). In general the price range for yard trimmings compost is similar to the price range for biosolids compost in the ecomaine service area.

An estimate of the types, amounts and prices ranges for composts currently marketed in the ecomaine service area is shown in Table 6-3.

Table 6-3 Estimated Compost Quantities and Price Ranges in ecomaine Service Area

Compost Type	Price Range (per cubic yard – bulk sales)	Estimated Quantities (cubic yards per year)
Commercial Organics (including seafood processing wastes) and Manure-based Composts	\$25 - \$45	16,000
Biosolids Composts	\$0 - \$18	15,000
Yard Trimmings Composts	\$0 - \$20	10,000

For the most part, compost prices are proportional to nutrient content (nitrogen, phosphorus, and potassium, or N-P-K) even though they are rarely sold as fertilizers. Biosolids compost, though, which has high nutrient content, often sells at a reduced price point based on the perception issues mentioned above. As an estimate, approximately 40% of the compost marketed in the area (primarily the commercial organics and manure-based compost) is going to the dollar market (in this case, primarily residential and commercial landscaping applications). The remainder is likely going primarily to the volume market with most of the biosolids compost being used in topsoil blends.

6.2.5 Potential Markets for ecomaine Compost

As determined in Task 3 of this study, composting residential and commercial SSO in an enclosed Aerated Static Pile (ASP) facility is the preferred technology option for ecomaine. The quality of compost from this technology would likely have a market value somewhere between the yard trimmings composts and the MOFGA-certified manure/commercial organics-based compost currently produced in the ecomaine service area. The ASP process will produce a homogenous, mature compost and the food scraps portion of the feedstocks will result in a nutrient content higher than what one would typically find in a yard trimmings compost. Provided that compostable bags are not introduced to the composting operation and provided that grass clippings are either not used as a feedstock or are tested to demonstrate that herbicides are not present in the grass, the compost from an ecomaine facility could potentially be certified by MOFGA for use in organic agriculture.

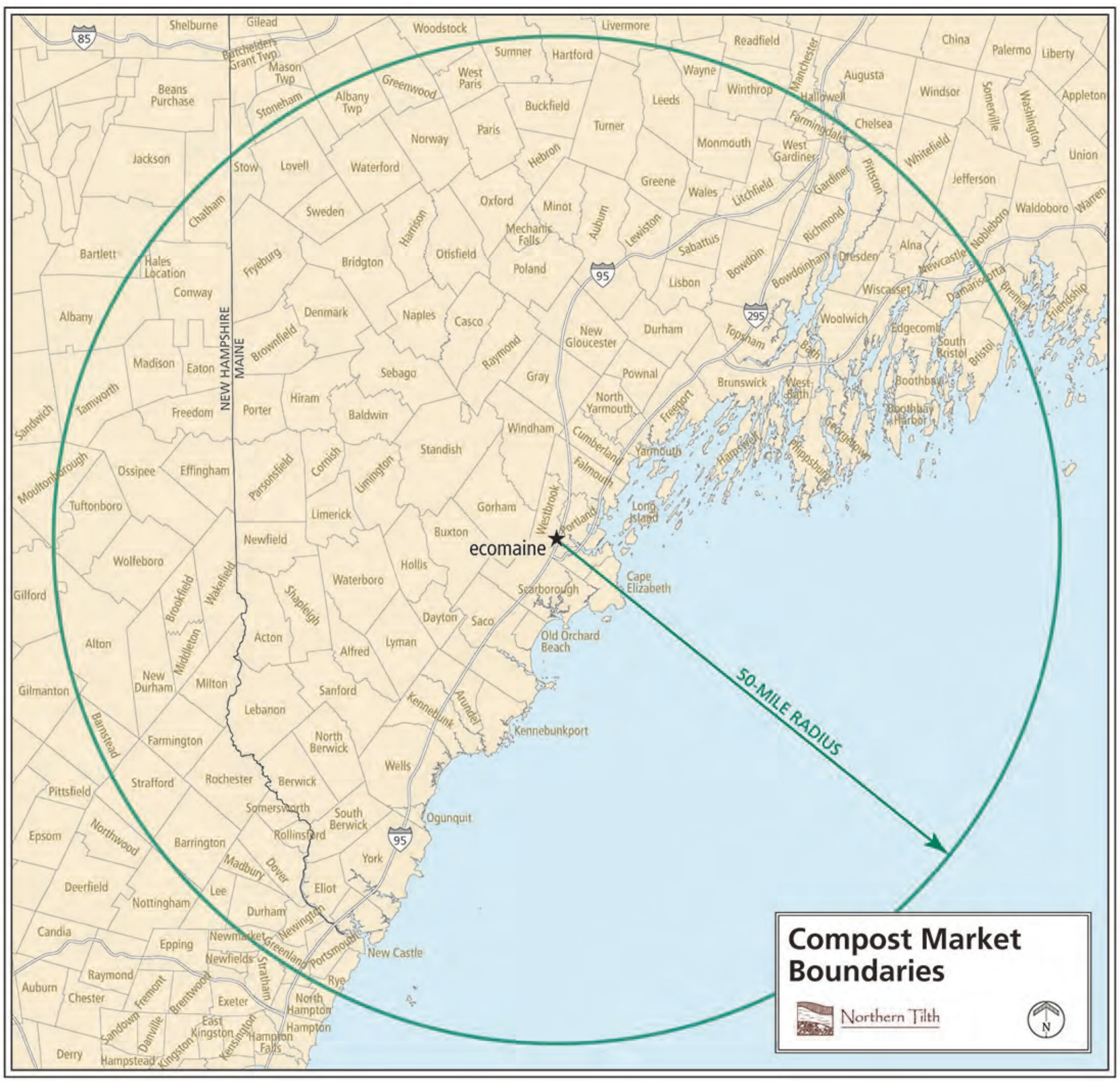
One difference between the compost from an ecomaine facility that accepts residential SSO and those existing facilities using commercial organics and manure as compost feedstocks is that the residential SSO is likely to contain more contaminants (e.g., bits of plastic and other inorganic materials), which can impact the quality of the finished compost. Contamination can be managed, both through educational outreach to residents participating in curbside organics programs, and by screening materials at the compost facility. However, at least for the first few years of developing a curbside residential organics program, it may be prudent to assume that the value of the compost would not be as high as the most valuable composts currently marketed in the ecomaine service area.

Market boundaries for compost and compost-based soil products are a function of several components including packaging (bulk vs. bagged), means of transport (truck, rail, or barge), availability of competing products, and the customer's willingness to pay.

Most compost producers ship their products in bulk via truck, although a few also distribute bagged products by truck. Cost-effective trucking distances are dependent, in part, on the quality of the available road network. For example, for a given shipping cost, one can ship a greater distance along interstate highways than along two-lane rural arterials. Rail and barge shipments are more cost-effective when transporting over 200 miles, but few compost or soil products are shipped by those means.

For the purposes of this markets evaluation, the market boundary was defined as a 50-mile radius from ecomaine. While markets outside the established boundary could be served, it is considered more cost-effective and environmentally sustainable to maximize compost and soils distribution within a localized area. This market boundary is shown in Figure 6-5, assuming a facility located at ecomaine's ashfill site. If in the future there is insufficient product demand within the local area, then marketing efforts should work outward beyond the 50-mile radius along distribution corridors with the highest capacity and speed (i.e., interstate highways).

Figure 6-5 ecomaine Compost Market Capture Zone



The emerging markets for compost discussed above have been slow to develop in Maine. Mark King, an environmental specialist with the Maine DEP Sustainability Unit has observed that uses of compost in bioswales, rain gardens, and other innovative applications are "few and far between" in Maine (King, 2013). Michael Clark in the Surface Water Quality Unit of the Maine Department of Transportation reports that compost use has been minimal in erosion-control blends in road construction projects. Currently, stump grindings are the medium of choice for the Maine DOT for erosion control on steep slopes (Clark, 2013). Maine State Soil Scientist David Rocque has recommended compost use in constructed wetlands on development projects in which wetlands are disturbed and he believes that there has been some use there (Rocque, 2013). However, in general, the emerging compost markets currently represent only a small portion of the total market for compost in Maine. While these markets will likely grow over time, for the purposes of this study it is more realistic to assume that the compost generated at an ecomaine facility would go mostly to traditional markets, primarily commercial and residential landscaping and/or topsoil blending, with a smaller portion going to agricultural markets and possibly for use in higher end soil blends for athletic fields.

Potential compost demand for landscaping in the ecomaine service area will primarily come from residential customers with secondary demand from commercial or institutional settings with landscaped grounds (i.e., banks, medical facilities, etc.). Estimating demand from commercial customers is difficult as they tend to rely on contractors for minimal maintenance needs. There are approximately 300,000 single-family housing units in the southern Maine counties of Androscoggin, Cumberland, Lincoln, Oxford, Sagadahoc, and York (US Census Bureau 2013). If 10% of those households purchased 2 CY of compost annually, that market could absorb 60,000 CY of compost production per year. Assuming an average sales price of $20/CY, this value of this market could total $1,200,000/year.

The agricultural market for compost in the ecomaine service area may be limited. There are approximately 3,800 acres of farmland planted in vegetables in the six Maine counties in the service area (US Dept. of Agriculture 2007). If 20% of that acreage received 20 CY of compost per year, that market could absorb about 15,000 CY annually. Assuming an average price point of $6/CY, this market could be valued at $90,000 annually.

Using a relatively conservative price of $15/CY, an ecomaine facility processing 12,000 tons per year of SSO and generating 18,200 cubic yards of compost would generate approximately $273,000 per year from compost sales.

6.3 Biogas Markets

As noted above, the primary markets for biogas produced from the anaerobic digestion (AD) of SSO are electricity production, "recycled" natural gas (RNG) production for pipeline injection, or compressed RNG production for vehicle fuel. Both virgin and renewable energy production in the US is heavily regulated by Federal and State governments. It is also controlled by external market forces. ecomaine has significant experience in the renewable energy market through the electricity produced by its waste to energy (WTE) plant.

The following subsections describe the three primary biogas markets.

6.3.1 Electricity Production

Biogas is converted to electricity using either a gas turbine or, more commonly, a combined-heat-and power (CHP) generator. As part of an effort to restructure and deregulate the State's electric industry in 1997, Maine was one of the first states in the region to adopt a Renewable Portfolio Standard (RPS) in 1999. Maine's current RPS requirement is composed of two classes: Class I: new renewables and Class II: existing renewables. The Class I requirement, enacted in 2006, applies only for "new" renewable resources, includes qualifying renewables on-line after September 1, 2005, and increases by 1% annually (from 1% of retail sales in 2008 to 10% of retail sales by 2017). However, municipal solid waste facilities and CHP facilities are not eligible for Class 1 in Maine (Maine Renewables Portfolio Standard, 2013). The Class II requirement sets 30% of electric sales as the required renewable percentage to qualify for RPS and allows a broad pool of generation types (including existing projects) to qualify as renewable.

All of the six New England states except Vermont have RPS policies similar to those in Maine. Although each state sets its own state policies with respect to eligibility, the similarities between different states' RPSs create a quasi-regional market for the supply of renewable energy credits (RECs). RECs in Maine are called NEPOOL Generation Information System (GIS) Certificates. GIS certificates are awarded based on the number of kilowatt-hours (kWh) of eligible electricity generated. Maine's RPS has much lower megawatt-hour (MWh) requirements over time than some other New England states due to its relative lower level of retail electricity sales (London Economics International LLC, 2011). The RPS policies of the New England states, coupled with Maine's significant resource potential, have led to the development of a large amount of renewable power in Maine. This is likely to keep prices for renewable energy low for the foreseeable future.

If ecomaine elected to develop a centralized AD plant at a capacity of 12,000 tons/year, using dry fermentation AD, it would produce approximately 1,900,000 kWh/yr. Macquarie Energy, the current purchaser of electricity from ecomaine's WTE plant, has agreed to consider purchasing the power from a proposed AD plant at the prevailing price in place at the time the plant came on-line (Wilson, 2013). Using the 2013 purchase power agreement between ecomaine and Macquarie, which is $40.90/MWh (for both electricity and RECs produced by the plant), this alternative could yield potential revenues of $77,710 per year.

It may be possible for an ecomaine AD facility generating electricity with a CHP to qualify for the Community-Based Renewable Energy Production Incentive.[35] Incentives are a choice of either a 1.5 GIS-REC multiplier, or, for projects less than 1 MW capacity, a power purchase price of $0.10/kWh ($100/MWh). This is the program that qualified the Exeter Agri-Energy facility noted in the Section 3 report. As a 12,000 ton/year AD plant would have about a 250kW capacity, this higher purchase price might be available to ecomaine, and would translate to approximately $190,000 in revenue per year. As of October 2013, though, the 50MW limit for this program has been met, and the Maine Legislature would have to approve additional funding in order to extend this program to future renewable projects

[35] Community Based Renewable Energy Production Incentive, at http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=ME13F&re=1&ee=1, accessed April 23, 2013

(Cook, 2013). The 1.5 GIS-REC multiplier may not be of use to ecomaine as the average Class II GIS-REC price is significantly lower than the Class I price, which, in 2011, was $13.50/MWh.

6.3.2 Recycled Natural Gas Production

A 12,000 ton/year AD system at ecomaine could produce approximately 35,600,000 standard cubic feet (scf) of a biogas annually containing 60% methane, along with contaminants such as carbon dioxide, hydrogen sulfide, and moisture. Use of this biogas in natural gas pipeline distribution systems would require cleaning the contaminants out of the biogas. Natural gas companies indicate the requisite gas quality specifications of their purchased natural gas sources in a tariff document filed with the Federal Energy Regulatory Commission. The retail gas supplier in Portland, Maine is Unitil, but the regional gas supply company is Portland Natural Gas Transmission System (PNGTS). The tariff schedule for Unitil was not available for this study, but the tariff gas quality schedule for PNGTS is as follows:[36]

- Heating value between 967 and 1100 BTU per cubic foot.
- Less than 20 grains total Sulfur (S) and less than ¼ grain of hydrogen sulfide (H_2S) per cubic foot (less than 3.2 ppm total S and less than 0.04 ppm H_2S).
- Less than 0.2% oxygen.
- Less than 3% carbon dioxide and less than 4% combined carbon dioxide and nitrogen.
- Less than 0.015% moisture content.

Gas cleaning equipment is readily available to meet these specifications. Cleaning the biogas to meet specifications such as PNGTS's would produce approximately 21,000,000 scf/yr (21,000 thousand cubic feet (MCF) of cleaned biogas containing 98% methane. PNGTS has specifications for introducing gas into their regional distribution system (Armstrong, 2013), but PNGTS has a minimum meter size of 1,000 mmBTU/day and ecomaine's system would only produce about 57.5 mmBTU/day. Gas introduction specifications from Unitil were not available for this study.

The prices paid for natural gas are determined on either a wellhead basis or on a citygate basis. Wellhead prices are based on the price at the extraction wellhead, which is about $3.35/MCF. Citygate prices are where the gas supply crosses a city border, such as where PNGTS sells to Unitil. That price was $6.80/MCF in Maine as of March 2013 (Natural Gas Monthly, 2013). Assuming ecomaine could negotiate a citygate price for RNG sold to Unitil, this could value the RNG at more than $142,000 annually. A wellhead price point would value this resource at about $70,000 per year.

6.3.3 Compressed RNG for Vehicle Fuel

Biogas can be cleaned up to RNG specifications and then compressed to 4,200 to 4,500 pounds per square inch (psi) for use in Compressed Natural Gas (CNG) fueling stations. There are two CNG refueling stations in Maine; the first opened in Portland several years ago, but is owned by Portland Metro and is not open to the public. The Portland CNG station refuels the METRO bus fleet of 13 CNG-fueled buses (with five more on order), and 10 CNG-fueled school buses. A new public CNG station opened in April

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[36] Portland Natural Gas Transmission System, FERC Gas Tariff Third Revised Volume No. 1, Sec. 6.5, Nov. 2010.

2013 in Bangor, and American Natural Gas announced plans to open a public CNG station in Westbrook, anchored by the Casella Waste truck fleet (NGV Forum, 2013).

RNG/CNG for vehicle fuel is often sold on a "diesel-gallon-equivalent" (DGE) basis. The cleaned up RNG potentially available from ecomaine would equate to 160,700 gallons on a DGE basis. Portland Metro is currently buying natural gas from Sprague Energy at a cost of $5.68/dekatherm ($0.79/DGE) but they expect the price to rise to $8.00/dekatherm ($1.12/DGE) in late 2013 (Kirby, 2013). Portland Metro has indicated a willingness to buy RNG from ecomaine "at comparable rates and if we can refuel our buses at Scott Drive." At a price of $1.12/DGE, this resource could produce a valuation of about $180,000 annually, however, it would require construction of a CNG refueling station at the site, which would be in close proximity to the proposed facility in Westbrook.

6.4 Digestate Markets

As discussed in Section 3, anaerobic digestion is an energy extraction process for SSO; it is not the final step in organics processing. The digestate (the by-product from the digestion process) must be further processed after anaerobic digestion. This section discusses the potential processing options for digestate that would come from an ecomaine anaerobic digestion facility.

6.4.1 Digestate Land Application Options

If ecomaine develops an anaerobic digestion facility for extracting energy from residential and commercial SSO, the ranking process used in Section 3 indicated that dry fermentation would be the most practical technology choice. As discussed in Section 3, the use of liquid digesters for processing residential and commercial SSO would necessitate a phase change of the feedstock, from solid to semi-solid or liquid, and would generate a large liquid effluent stream that would most likely need to be transported to an area wastewater treatment plant for processing at a significant cost. Liquid anaerobic digestion systems have been proven to be cost-effective for digesting sludge at wastewater treatment plants and at dairy farms, where the liquid is incorporated into existing manure land application programs. But there are currently no stand-alone liquid digesters for handling residential and commercial SSO in the US. For the purposes of determining digestate options in this task it is assumed that ecomaine would be using dry fermentation.

In general, digestate from anaerobic digesters can either be directly land applied, typically on agricultural land, or it can be composted to produce a more stable soil amendment for sale in traditional compost markets. Land application is generally a less expensive option than composting for digestate, and it is a relatively common practice in agricultural areas for digestate from liquid digesters on dairies and from wastewater treatment plants. In some cases digestate from liquid digesters is de-watered prior to land application, and is then applied as a semi-solid material, similar to chicken manure or bedded dairy manure. In other cases digestate is land applied in liquid form. The Maine DEP has recently made a revision to the Chapter 419 Agronomic Utilization of Residuals regulations that simplifies the permitting process for land applying digestate derived from non-pathogenic materials, partly in response to the use of anaerobic digestion for handling potato processing waste in Aroostook County.

However, digestate from dry fermentation is not as well suited to land application as the digestate generated in liquid digesters. While digestate from liquid digesters is a relatively uniform, homogenous, and easily spread material (using conventional agricultural equipment), digestate from dry fermenters digesting residential and commercial SSO has the appearance of the material fed to the digesters, although it is typically darker and wetter; and individual components of the waste fed to the digesters are still recognizable (Figure 6-6). Digestate from dry fermentation would likely have some value as a soil amendment, primarily from the nitrogen and phosphorus content of the material, but the physical properties of the material would make it difficult to market to farmers. As with other existing land application programs in Maine, including programs for seaweed processing and fish processing residuals and for non-composted biosolids, digestate from dry fermentation would likely need to be given to farmers for free, and it would be possible that providing cost-sharing to the farmers for spreading the material would be necessary in order to get farmers to participate in a land application program. When taking into account nutrient management planning, trucking and spreading costs associated with a land application, the savings of land application compared to composting the digestate would be greatly diminished. Taking these factors into consideration and that there is no experience in the US with land application of digestate from dry fermentation of SSO, the project team is using the assumption that digestate from an ecomaine dry fermentation facility would be composted.

Figure 6-6 Digestate Unloaded from Dry Fermenter

Source: Coker Composting & Consulting.

6.4.2 Digestate Composting Options

The most common option for digestate from the dry fermentation process is use as a feedstock for composting. Composting dry fermentation digestate is similar to composting residential and commercial SSO that has not been digested with a couple of exceptions. The digestion process reduces the volatile solids (readily available organic matter) content of the SSO resulting in less food and energy for the microbes driving the composting process. Additionally, the bulk density of the digestate is typically greater (i.e., it has more mass per unit volume) than undigested SSO, and consequently, the material may need more compost amendments (wood chips, sawdust, leaves, etc.) in order to provide an appropriate amount of porosity for proper aeration of the composting operation. On the other hand, some of the mass of the SSO is lost during digestion, and consequently, there is less digestate to be composted than would be the case with un-digested SSO; during the digestion process, some of the organic matter in the SSO is converted to biogas, resulting in a reduction of tonnage. As an example, anaerobic digestion through the SmartFerm dry fermentation technology is estimated to reduce SSO tonnage by 12% (SmartFerm, 2013).

As discussed in Section 4, ecomaine will have the option to develop their own composting capacity or to work with existing composting operations for processing of residential and commercial SSO collected in the ecomaine service area. If using a dry fermentation facility to extract energy from the SSO, ecomaine will have the same composting options for the digestate. The differences in the characteristics of the digestate relative to un-digested SSO (i.e., lower volatile solids and higher bulk density) may increase the costs per ton for composting, but with the lower tonnage of digestate compared to un-digested SSO, the total composting costs for the two would likely be similar.

6.5 Task 6 Summary

Should ecomaine decide to develop an anaerobic digestion and/or composting facility for processing SSO, revenues from the products produced at the facility will help to determine the total operating budget. Using the medium range organics diversion scenario from Section 1, an enclosed ASP composting system processing 12,000 tons per year of SSO (not including amendments) would produce approximately 18,200 CY per year of finished compost. A dry fermentation anaerobic digestion facility processing the same tonnage of SSO would produce approximately 36 million scf per year of biogas.

Compost from an ecomaine facility would likely go primarily to traditional compost markets, including residential and commercial landscaping, topsoil blending, and agriculture. The quality of compost from an enclosed ASP system processing SSO would be similar to some of the higher end composts currently produced in the ecomaine service area, but the level of potential contaminants (e.g., plastics) may reduce the dollar value compared to these other composts. A bulk, wholesale value of $15/CY will be used for estimating purposes in the economic analysis of the composting option. Based on the potential for compost sales within the ecomaine service area, the additional compost that would be generated at an ecomaine-owned facility could be easily absorbed by the compost market. Additional emerging markets for compost, such as use in erosion control and storm water run-off systems are developing slowly in the northeastern US and may represent an additional market for ecomaine-produced compost in the long run.

Biogas generated from anaerobically digesting 12,000 tons of SSO could be used to generate electricity, refined to make Recycled Natural Gas (RNG) for pipeline injection, or refined and compressed to make Compressed Natural Gas (CNG) for use to fuel vehicles. Based on the current value of the end product for these three options, CNG appears to have the most value, with the 36 million scf per year of biogas translating to approximately $180,000 per year of revenue, based on a price of $1.12 per DGE.

7.0 Cost Estimates and Conceptual Organics Recycling Plan

Key Findings of Task 7

The following items summarize the findings of Task 7: Cost Estimates and Conceptual Organics Recycling Plan:

- The realities of organics recycling in the present world require that any alternatives developed be defined in recognition of external (and internal) constraints of feedstocks supply, collection, processing, markets, and institutional, regulatory, environmental and economic considerations.
- Bounded by these constraints, the project team developed alternatives that accommodated a multitude of choices in terms of diversion strategies, collection options, processing approaches, and product markets.
- Ten alternatives were developed from the combinations noted above and are shown in Table 7-1. The alternatives included five centralized alternatives and five decentralized alternatives.
- The centralized alternatives are based on either composting or a combination of anaerobic digestion and composting at one of two sites owned by ecomaine.
- The decentralized alternatives are based either on contractual arrangements between ecomaine and one or more of the private and public composting and digestion facilities in or near the ecomaine service area or on a “free market” approach, where ecomaine has little or no involvement.
- Alternative 10, the Free Market alternative, represents the potential for 12,000 tons per year of leakage from ecomaine’s system and is the alternative that ecomaine has the least involvement with, and control over.
- The collection system models used in the alternatives were the biggest driver in the overall costs of collection and processing for organics
- The two alternatives utilizing every-other-week (EOW) collection are the least expensive ($71 to $74 per ton for collection and processing) followed by the Blue Bag-type collection systems ($149 to $216 per ton). Alternatives including dedicated collection are the most expensive ($383 to $421 per ton).
- Pros and cons of the three collection models are as follows:
  - EOW is the lowest cost, but requires the greatest change in disposal behavior for participants.
  - Blue Bag-type collection also offers savings over dedicated collection and, when combined with a sorting operation, can offer more control over contamination in the SSO, but has higher processing costs with lower participation rates and there is only one example of an existing program.
- Dedicated collection is a commonly-used system for SSO, but is significantly more expensive than the other two models.

Key Findings of Task 7 *(continued)*

- The revenues from energy products produced by an ecomaine-owned and operated anaerobic digestion facility would not cover the operating and capital costs of the facility, and, because the digestate from such a facility would still require composting, the options including an ecomaine anaerobic digestion facility were more expensive (by $38 per ton) than for composting only.
- Transfer station drop-off programs for residential organics are relatively inexpensive to develop and can result in overall cost savings when the SSO from the program is integrated into an existing transfer station yard trimmings composting operation.
- Recommendations are given for moving forward with a phased approach to developing an organics recycling program in the ecomaine service area.

7.1 Introduction

The purpose of this study is to evaluate the feasibility of an organics recycling facility to handle the source-separated organic solid wastes (SSO) produced by the ecomaine service area. The purpose of this task was to formulate a set of viable alternatives based on the work completed in the previous tasks, evaluate the capital and operating costs of those alternatives at a high-level basis, refine those alternatives in a workshop with the ecomaine staff, arrive at a consensus as to which alternatives to explore further, and to develop a plan for moving forward based on the most promising alternatives.

7.2 Framing Alternatives

The realities of organics recycling in the present world require that any alternatives be developed by and defined in recognition of external (and internal) constraints of feedstocks supply, collection, processing, markets and institutional, regulatory, environmental, and economic considerations. This project recognized the following constraints:

- ecomaine has low risk tolerance for operational disruptions to organics processing.
- The primary targeted organics are food scraps, compostable/soiled paper, and (potentially) kitty litter.
- Participation in an organics collection program will likely be a voluntary participation program, at least for the first few years of developing a comprehensive program, which limits rates of program growth.
- Yard trimmings are already largely diverted out of the waste stream, so an ecomaine operated compost facility may be carbon-limited. Some portion of the diverted yard trimmings would have to be recaptured to make centralized composting cost-effective.
- The availability of adequate amounts of carbon (woody material) to support composting SSO wastes is potentially available, but unconfirmed.
- The solid waste collection infrastructure in the ecomaine service area is oriented toward residential curbside by private haulers and drop-off programs at transfer stations.

- A dedicated collection route for organics may be challenging from a route density and cost perspective and from the additional impacts to roads in the winter.
- A wide range of different collection vehicles are in use by private haulers, but the split-body model for co-collection of trash and recycling is prevalent among the curbside communities using private haulers.
- The switch to Every-Other-Week (EOW) collection of trash represents a significant shift in residential disposal behavior but presents lower costs and truck miles relative to dedicated collection.
- In ecomaine communities without Pay-Per-Bag (PPB) fees, there is no direct cost to the homeowner for solid waste disposal.
- Centralized processing (composting or anaerobic digestion followed by composting) is feasible at either of the two ecomaine-owned sites.
- The anaerobic digestion recovered energy product could be electricity produced from a combined heat and power (CHP) engine, Recycled Natural Gas (RNG) or compressed natural gas (CNG) for vehicle fuel.
- The compost could be processed for use by high-end markets, but it may be easier to make a product for blending/packaging by others.
- Decentralized processing at merchant facilities is possible, but needs to address ecomaine's risk avoidance requirements.
- Adequate organics processing capacity including anaerobic digesters and composting operations within or close to the ecomaine service area may exist for 3 to 5 years without new infrastructure coming on-line.
- Assuming that solid waste from the spot market will replace organics diverted from the waste to energy (WTE) plant, impacts to the operations of the WTE plant related to developing organics programs will be minimal, based on the findings in Section 5.

Bounded by these constraints, the project team developed alternatives that accommodated a number of key choices in terms of diversion strategies, collection options, processing approaches, and product markets. The different choices included:

- Diversion/Collection alternatives – Residential curbside collection of organics in ecomaine communities would likely be by dedicated organics collection routes, a Blue-bag type collection system, or by implementing every-other-week (EOW) collection of solid waste as described in Section 2. For communities without municipal curbside collection of trash and/or recycling, organics programs would use a drop-off system using appropriate collection containers at existing transfer stations.
- For processing SSO, a centralized facility could be located at ecomaine's ashfill or Gorham property, using a combination of anaerobic digestion (dry fermentation) and enclosed aerated

static pile composting or composting alone. The facility would be sized for a capacity of approximately 12,000 tons/year of SSO (6,800 tons residential and 5,100 tons commercial).[37]

- Anaerobic digestion-derived recovered energy could involve electrical production and sale to Maquarie Energy or recycled natural gas (RNG) production and use by Portland Metro's Compressed Natural Gas (CNG) station and/or the new Casella CNG station planned in Westbrook. For compost markets, options could include landscaping/gardening or producing an ingredient for use in soil blends made by others.
- As there currently appears to be enough existing private processing capacity in the service area, decentralized alternatives could include diverting to private composting/digestion facilities with the communities directing SSO diversion by private haulers (no ecomaine involvement); or partnering with "certified" private merchant processors with ecomaine diverting SSO from the WTE tip floor; or "certifying" private merchant processors with the communities directing SSO diversion by private haulers.

7.3 Alternatives Development

Ten alternatives were developed from the combinations noted above and are shown in Table 7-1. The alternatives included five centralized alternatives and five decentralized alternatives.

7.3.1 Centralized Alternatives

The centralized alternatives (Alternatives 1 through 5 on Table 7-1) were based on a preliminary sizing of approximately 12,000 tons/year of SSO and would be located at either area L3 or L4 at the ashfill or at the Gorham site also owned by ecomaine. Alternatives 1, 2, and 3 would only involve ASP composting. Alternatives 4 and 5 would have both dry fermentation anaerobic digestion and aerated static pile composting (ASP), with production biogas-derived energy products and compost sold to soil blenders. For each group of centralized alternatives, additional differences were in diversion/collection approaches. Alternative 1 uses EOW collection. Alternatives 2 and 4 use a collection model similar to the Blue Bag Organics program in Minnesota.[38] Alternatives 3 and 5 use a dedicated organics collection route separate from the current trash and recyclables collection routes.

The Blue Bag approach is predicated on providing specially-colored bags to participating households to separate their SSO from their garbage. Organics bags would be collected curbside along with their trash by the same rear packer trash truck, or split-body trash/recycling truck for the communities using that system. When the truck arrives at ecomaine's WTE plant tip floor, the commingled loads would be separated and the SSO being redirected to the organics recycling facility. Separation of the bagged SSO from the trash would take place in a separate "sorting station" adjacent to the WTE tip floor. Preliminary plans and cost estimates for the sorting operation are included in the *Preliminary SSO*

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[37] These quantities represent the mid-range organics recovery scenario from Section 1.

[38] The Blue Bag Organics program is so-named as the hauler provides bright blue compostable plastic bags and a blue collection container to subscribers. The model is loosely based on Blue Bag systems that were developed for traditional recyclables in the 1980s.

Table 7-1 ecomaine Organics Collection and Processing Alternatives

Alt.	Where	Capacity	Collection	Processing Technology	Market
1	ecomaine property	12,000 ton/yr	EOW Collection	Composting Only	Compost
2	ecomaine property	12,000 ton/yr	Blue Bag-type Collection	Composting Only	Compost
3	ecomaine property	12,000 ton/yr	Dedicated organics collection	Composting Only	Compost
4	ecomaine property	12,000 ton/yr	Blue Bag-type Collection	anaerobic digestion and Composting	Energy product & compost
5	ecomaine property	12,000 ton/yr	Dedicated organics collection	anaerobic digestion and Composting	Energy product & compost
6	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	EOW collection	"Certified Merchant Processors"	Up to processor
7	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Blue Bag-type Collection	"Certified Merchant Processors"	Up to processor
8	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Blue Bag-type Collection with bag-opening operation	"Certified Merchant Processors"	Up to processor
9	Decentralized (partnering)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Dedicated organics collection	"Certified Merchant Processors"	Up to processor
10	Decentralized (free market)	3,000 – 7,000 ton/yr at first; growing to 12,000 ton/yr	Haulers develop most cost-effective approach	Any processor	Up to processor

Sorting System Mass Balance, Layout and Cost Estimate prepared by D&B Architects and Engineers (Appendix D).

For Alternatives 2 and 4, SSO would be collected in compostable bags and sorting would be managed on a sort line with the SSO bags simply separated from the remainder of the trash in the loads. With the dedicated collection or EOW approaches, each household would separate SSO into a container, which would be picked up by a private hauler (or the City trucks in the case of Portland), who would haul the SSO directly to the organics recycling facility or to an organics transfer station.

7.3.2 Decentralized Alternatives

The decentralized alternatives (Alternatives 6 through 10 on Table 7-1) rely on the existing network of private (and public) organics recycling processors in the ecomaine service area and in nearby areas. These alternatives were sized for 3,000 to 7,000 tons/year of SSO to start, growing to as much as 12,000 ton/year over a period of time, and, in all cases, the processor would have sole responsibility for, and benefit derived of, product marketing and sales. Alternatives 6 through 9 would be contractual partnerships between ecomaine and several of the existing facilities, where the existing processor would be “certified” as to operational reliability and professionalism, adequacy of health and safety practices, and (optionally) conformance to the principles of environmental management as embodied by ISO 14001 certification. Alternative 10 would be the “free market” approach, where ecomaine would have no involvement. This is essentially a “do nothing” approach in which organics diversion continues to grow as programs are developed by entrepreneurs and institutions.

As in the centralized alternatives, the decentralized alternatives differ in the manner in which SSO is collected and delivered to each processor; either by integration of organics collection with trash and recycling through the EOW collection model (Alternative 6), through a Blue Bag-type system where ecomaine separates and redirects the SSO to the processor (Alternatives 7 and 8), or by a dedicated collection of the organics in a separate route with the SSO delivered directly to the processor (Alternative 9). For Alternative 8, the SSO would be collected in conventional plastic trash bags (instead of compostable plastic bags as in centralized alternatives 2 and 4) and the sorting operation would include equipment that would rip open the bags and mechanically separate the bags from the SSO. Workers would manually remove any contamination from the SSO. This alternative was developed because some of the merchant organics processors ecomaine might partner with have low tolerances for contaminants.

7.4 Alternatives Evaluation

Nine of the ten alternatives in Table 7-1, along with a detailed discussion of the findings of the previous tasks in this project, were discussed with ecomaine project staff in a day-long workshop on May 21, 2013. ecomaine staff and management selected a tenth alternative, later re-designated Alternative 8, Decentralized Partnering with Blue Bag-type collection of SSO and development of a SSO sorting station at the WTE plant, as an alternative for further study by the project team. Some of the reasons for selecting this new path for further study included:

- Less financial risk to ecomaine for processing (composting and/or anaerobic digestion), relative to the capital and operating costs of developing and managing an organics processing facility, especially in the first few years of developing organics recycling programs, when the tonnage recovered is expected to be relatively low.
- EOW collection programs clearly are the lowest cost, but represent a significant shift in disposal behavior. Consequently if a Blue Bag-type system represented a low cost alternative it made sense to further explore the economics of this type of system as it would work in the ecomaine service area.
- A Blue Bag-type collection system offers substantial savings over dedicated collection without a significant shift in residential disposal behavior.
- Several of the potential merchant processors that ecomaine might use have a low tolerance for contamination.

- Having a sorting operation that opens the SSO bags and separates the bags from the SSO allows for the use of less expensive plastic bags and allows for sorters to remove potential contaminants.
- The sorting station would allow staff to sort recyclables out of the commercial wastes delivered to ecomaine in between incoming loads of co-collected SSO and MSW.

7.4.1 Costs for Macroeconomic Analysis

After the workshop, all ten alternatives were further evaluated with respect to potential costs, risks of success or failure, and potential implementation issues. A separate study by D&B Architects and Engineers investigated a sorting operation for Alternative 8 that allowed for more refined cost estimates on that alternative (Appendix D). Capital costs, projected operating costs, and estimated annual revenues from product sales were estimated for each of the ten alternatives. Assumptions used in developing estimates were as follows:

- The mid-range organics collection scenario from Section 1 was used in which 6,800 tons of residential and 5,100 tons of commercial organics are collected from ecomaine owner and associate member communities (rounded up to 12,000 tons of total SSO per year). For the residential organics, this study assumed a 45% participation rate in a voluntary program for the approximately 69,400 households currently served by community-wide curbside collection programs for trash.
- Capital costs for an ecomaine-owned organics processing facility were based on the following assumptions:
  - Capital costs would be paid from ecomaine general fund; no debt service was included.
  - Capital costs would be amortized over 15 years.
  - Capital costs for the sorting station at the WTE tip floor were based on the *Preliminary SSO Sorting System Mass Balance, Layout and Cost Estimate* prepared by D&B Engineers and Architects (Appendix D).
  - For dedicated collection and EOW collection, capital costs (estimated based on the construction costs in the D&B Engineers and Architects report) for building a transfer station adjacent to the WTE tip floor were included.
  - Capital costs for dry fermentation anaerobic digestion were based on the estimated cost of $2.1 million for a 5,000 ton/year "SmartFerm" system, scaled up to the 12,000 ton/year level assuming some economies of scale.
  - Capital costs for a RNG/CNG fueling station were based on an assumed cost of $1 million.
  - Capital costs for the ASP composting system were based on the $207/ton capacity capital unit cost figure provided by the Chittenden (VT) Solid Waste District for their new (2011) facility in Burlington, VT.
  - Mobile equipment capital costs included a grinder for processing woody materials ($750,000); front end loaders for handling either wastes or products (2 @ $250,000 each), and a screen for making compost market-ready ($350,000).

    - When using anaerobic digestion, the digestate would be required to be composted; consequently capital and operating costs for anaerobic digestion are additional to composting costs.
- Operating costs for an ecomaine-owned organics processing facility were based on the following assumptions:
    - Operating costs for co-collected SSO were based on the Blue Bag Organics program cost of $20 per collection cart and in-kitchen container and $0.56 per 18-gallon SSO bag, assuming a 5-year life for the carts and including a sensitivity analyses of costs for 30-gallon SSO bags[39] at $1.06 each and for not including a collection cart.
    - The dedicated collection and EOW collection alternatives also included a capital cost of $20 per collection cart and in-kitchen container with an estimated 5-year life.
    - Operating costs for the handling of the SSO bags at the WTE sorting station were assumed to be $521,808 per year for separating the 12,000 tons of SSO from the solid waste with which it would be collected (Appendix D).
    - For the dedicated residential organics curbside collection programs, the collection costs were assumed to be $10/household/month (the average of the $7 to $13 dedicated collection cost estimates in Section 2), with a sensitivity analysis for using the national average of $7.75/household/month (Ecoconservation Institute, 2010).
    - For commercial organics, collection costs are assumed to be revenue neutral; the cost for organics collection is equal to the reduction in service for trash collection.
    - Operating costs for the SmartFerm anaerobic digestion system were based on a vendor estimate of $15/ton.
    - Operating costs for a RNG/CNG fueling station were estimated at $0.33/diesel-gallon-equivalent (DGE).
    - Operating costs for an ASP composting facility were based on previous estimates for similar facilities prepared by Coker Composting & Consulting of $28/ton.
    - Due to the strength of the biomass market in Maine, it was assumed that wood chips for composting would have to be purchased at $25/ton.
    - The cost for managing a compost marketing and sales program was assumed to be $2.50/CY.
    - For the decentralized "partner" program, processing costs were based on an aggregated per ton trucking and tip fee, assuming that the SSO collected from the ecomaine service area would be evenly split between a local composting facility, a second composting facility approximately 30 miles from the ecomaine WTE plant, and the Exeter Agri-Energy anaerobic digestion facility in Exeter, Maine.
    - For the decentralized "partner" program, it was assumed ecomaine would bear an annual cost for administering a facility certification program equal to $50,000 annually.

[39] The Minnesota Blue Bag Organics program uses 32-gallon bags.

- Revenue estimates were based on the following assumptions:
  - It was assumed that the diverted SSO would represent a lost revenue to ecomaine equivalent to a tip fee of $70.50/ton, but that the diverted waste would be replaced by other solid waste at $55/ton.
  - The average price for RNG sold to Portland Metro was assumed to be $1.12/DGE, with a sensitivity analysis if the price of CNG rises (as expected) to $4.00/DGE (Kirby 2013)
  - The average price for compost sold was assumed to be $15/CY ($7.50/ton), with a sensitivity analysis for a compost price of $5/CY ($2.50/ton)

The cost estimates, along with the sensitivity analyses, are presented in Table 7-2. The macroeconomic analysis included in Table 7-2 is designed to make general assessments of differences between the various collection and processing options and should not be interpreted as precise costs for developing organics programs.

Alternative 10, the Free Market alternative, is not included in the table because it cannot be considered a direct comparison to the other alternatives; the collection or processing costs associated with this “do nothing” approach are not known. The Free Market approach represents leakage of the SSO from the ecomaine service area and, assuming that the leakage is equivalent to the tonnage of the medium-range scenario of an ecomaine managed organics program, the loss of revenue to ecomaine is estimated to be $186,000 per year (the difference between the owner member tip fee and the spot market tip fee multiplied by 12,000 tons). This is the alternative in which ecomaine has the least involvement, and control over. The potential for both lost revenue and program upsets (due to nuisance odors, negative environmental impacts, lack of integration with existing collection systems, etc.) are the greatest if going with this “do nothing” approach.

As discussed in Section 2, collection costs are the largest individual cost for most residential curbside SSO programs, and the increase in these costs (compared to not diverting the organics) typically outweigh cost savings realized by having a lower tip fee for composting than for incineration or landfilling. This is especially true for dedicated collection, which is the most common approach to the curbside collection of organics in the US. The cost estimates in Table 7-2 indicate that for the alternatives analyzed for the ecomaine service area it is also the case that the choice of collection system is the primary driver for the total costs of collecting and processing SSO. The alternatives using EOW collection are the least expensive, followed by the alternatives with a Blue Bag-type collection system. The alternatives which include dedicated collection are the most expensive options.

Composting and/or anaerobic digestion costs are included in the processing costs portion of Table 7-2. Based on this analysis, the per ton costs for ecomaine to compost SSO at an ecomaine owned and operated facility ($44/ton) are similar to the estimated costs of paying a merchant facility to process the SSO ($42.50/ton). Anaerobic digestion at an ecomaine-owned facility is not an economically attractive option at this time, based on the assumptions used by the project team in this analysis. As discussed in Section 6, the digestate generated from a dry fermentation digester would need to be composted at a similar cost to composting the SSO without first digesting it. Consequently, the revenue from the energy product derived from the anaerobic digestion process would need to be greater than the annualized

Table 7-2 ecomaine Alternatives – SSO Collection and Processing Cost Estimates & Sensitivity Analyses

Alternatives	1	2	3	4	5	6	7	8	9
Site	ecomaine Property					Decentralized (Partnering)/Certified Merchant Facilities			
Process	Composting Only			AD & Composting		Certified Merchant Processors			
	EOW Collection	Blue Bag Collection	Dedicated Collection	Blue Bag Collection	Dedicated Collection	EOW Collection	Blue Bag Collection	Blue Bag Collection/ open bag/ sort	Dedicated Collection
Markets	Compost	Compost	Compost	Energy product + compost	Energy product + compost	Up to processor	Up to processor	Up to processor	Up to processor
Annual tonnage	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
<u>Operating Costs</u>									
Diversion/Collection Costs ($/yr)[1]	$124,920	$759,587	$3,872,520	$759,587	$3,872,520	$124,920	$759,587	$260,920	$3,872,520
Processing Costs ($/yr) [2]	$481,500	$1,003,308	$481,500	$1,236,438	$714,630	$560,000	$1,081,808	$1,182,480	$560,000
Product Revenues ($/yr)	$273,000	$273,000	$273,000	$453,320	$453,320	$0	$0	$0	$0
Net Annual Operating costs	$333,420	$1,489,895	$4,081,020	$1,542,705	$4,133,830	$684,920	$1,841,395	$1,443,400	$4,432,520
Per ton operating costs	***$28***	***$124***	***$340***	***$129***	***$344***	***$57***	***$153***	***$120***	***$369***
<u>Capital Costs</u>	$7,767,031	$9,711,647	$7,767,031	$15,711,647	$13,767,031	$3,062,000	$5,006,616	$5,840,680	$3,062,000
Annual Amortized Capital Costs	$517,802	$647,443	$517,802	$1,047,443	$917,802	$204,133	$333,774	$389,379	$204,133
Per ton capital costs[3]	***$43***	***$54***	***$43***	***$87***	***$76***	***$17***	***$28***	***$32***	***$17***
Total per ton cost	**$71**	**$178**	**$383**	**$216**	**$421**	**$74**	**$181**	**$153**	**$386**
<u>Sensitivity Analyses (total per ton costs adjusted for sensitivity parameters)</u>									
18-gal Blue Bags at $1.06 each	$71	$225	$383	$263	$421	$74	$228	$153	$386
No curbside carts	$61	$168	$373	$205	$411	$64	$171	$142	$376
National average dedicated collection cost at $7.75/HH/month	$71	$178	$311	$216	$348	$74	$181	$153	$314
Increased price of CNG - $4/DGE	$71	$178	$383	$177	$382	$74	$181	$153	$386
Decrease sale price of compost - $5/CY	$86	$193	$398	$231	$436	$74	$181	$153	$386

1 - Represents the increase in collection costs over current residential curbside trash and recycling collection costs and includes hauling costs, containers and bags for the Blue Bag systems

2 – Includes processing costs for composting and/or anaerobic digestion and for sorting in the Blue Bag systems

3 –Includes compost and anaerobic digestion facility costs, Blue Bag sorting facility costs and transfer station costs for EOW and dedicated collection capital costs and operating costs in order for the project to make sense. Based on the estimates used by the project team for the amount of CNG that could be produced from the SSO and the current market price for the CNG, anaerobic digestion would cost $38 per ton above and beyond the composting costs. Accordingly, Alternatives 4 and 5 in which ecomaine owns and operates a facility with anaerobic digestion and composting are $38 per ton higher than Alternatives 2 and 3, which have the same collection systems, respectively, but in which ecomaine simply composts the SSO.

The two EOW alternatives (1 and 6) at $71/ton and $74/ton respectively are within 10% of each other and, consequently, for the purposes of this macroeconomic analysis with these alternatives are equal with respect to costs. The primary difference between these two alternatives is that for Alternative 1, ecomaine would compost the SSO at an ecomaine-owned facility and in Alternative 6, ecomaine would ship the SSO to an ecomaine-certified facility for processing.

Of the Blue Bag-type collection options, Alternative 8, which includes a sorting operation, in which SSO bags are both sorted from co-collected SSO and are ripped open to allow for bag removal and further removal of contamination from the SSO, is the least expensive alternative at $153 per ton. As indicated in the D&B Architects and Engineers report (Appendix D), this option has slightly higher capital and operating costs than does the sorting operation in which the SSO bags are simply separated from the remaining solid waste. But because of the ability to use lower cost plastic (non-compostable) bags, this alternative has lower overall costs than the other Blue Bag-type options. Alternatives 2 and 7, both using the bag sorting only option, are functionally equivalent at $178/ton and $181/ton respectively. And Alternative 4, similar to Alternative 2 but with an anaerobic digestion step, at $216 per ton, is $38/ton higher than Alternative 2.

Of the alternatives including dedicated collection for SSO, Alternatives 3 and 6 were functionally equivalent at $383/ton and $386/ton, respectively. Again, the option including anaerobic digestion at an ecomaine owned and operated facility was the most expensive for this type of collection system at $421/ton. Some important considerations related to individual program costs, based on the assumptions above, and included in the calculations in Table 7-2 are as follows:

- The price per ton is for ASP composting at an ecomaine owned and operated facility is very sensitive to the sale price of the finished compost. If the compost sale price, due to contamination or some other quality issue, drops to $5/CY instead of $15/CY, the processing costs would jump from $44/ton of SSO to approximately $59/ton.
- The price per ton is for dry fermentation anaerobic digestion at an ecomaine owned and operated facility is also very sensitive to the revenue generated by the product of the processing. When increasing the sale price of CNG from the current price of $1.12 per DGE to $4.00 per DGE, anaerobic digestion pays for itself; the revenue matches the sum of the capital and operating costs.
- For dedicated collection options, using the national average of $7.75 per household per month instead of the ecomaine service area estimate of $10 per household per month lowers the overall collection and processing costs for these alternatives by close to 20%. As noted in Section 2, decreased trash from diverting organics out of the trash may lower trash collection costs slightly over time, which may help to compensate for some of the higher costs of

dedicated organics collection. Additionally, as was the case in Brattleboro, VT when their curbside organics program started in the spring of 2013, there are cases in which haulers may lower the organics collection costs in order to retain trash and recycling contracts.

- Based on the higher costs for dedicated collection, Blue Bag-type collection may be economically appealing because the actual hauling-related costs represent no increase from existing trash routes. The extra costs associated with bag separation and further processing for contaminant removal are included in the report by D&B Engineers and Architects in Appendix D and were incorporated into the estimates in Table 7-2.
- A switch to EOW collection of solid wastes (bi-weekly collection of trash and recyclables and every week collection of organics) represents a major shift in residential solid waste behavior and there are limited examples of this having been implemented in the US. However, the switch has been successfully implemented in Hamilton, MA (as characterized in Section 2) and in several cities in Canada. If the political will exists for this switch, EOW is a cost-effective manner for both providing substantial organics diversion and increasing overall recycling rates. The EOW costs in the macroeconomic analysis summarized in Table 7-2 are based on the experience of Hamilton, MA, which has demonstrated that it is possible to have a voluntary organics program with very high participation in concert with EOW collection with an additional collection of trash on the off-weeks for residents that choose to pay an extra fee that pays for this extra route.
- With the switch to EOW collection, household participation in organics collection is likely to be higher than the 45% used in the macroeconomic analysis. However, for the purposes of comparing costs of the different systems, the 45% participation rate was kept constant across all alternatives.

Table 7-3 provides cost estimates for the scenarios in Table 7-2 for a three ecomaine communities. These cost estimates use the same assumptions as those used to develop Table 7-2. This table also includes savings from generating less trash bags in PPB communities and lower tips fees from processing organics through composting and/or digestion versus combustion in the ecomaine WTE plant.

As discussed in Section 2, the collection costs for the City of Portland on a per household basis are considerably lower than for all of the other ecomaine member communities. This is likely due to a combination of greater route density compared to surrounding communities and that the collection systems are municipally-owned and -managed. For this reason, there is less of a difference in price (on a percentage basis) between dedicated collection and the other two collection methods for the City of Portland compared to other ecomaine curbside communities. In order to use these numbers for other curbside communities, the estimated overall increase in costs translate to approximately $125 for dedicated collection, $24 for Blue Bag-type collection, and $5 for EOW collection per participating household per year.

Table 7-3 Organics Recycling Costs for Communities Representing Different Curbside Collection Models in the ecomaine Service Area

Community	Gorham	Scarborough	Portland
existing trash and recycling collection model	*PPB*	*Curbside Cart*	*PPB-municipal*
approximate # HH served	5,100	7,800	23,400
assumed participation rate	45%	45%	45%
price per bag of trash	$2.50	NA	$2.00
reduction in purchased trash bags per month	1	NA	1
savings to residences on trash bag purchases*	$68,850	NA	$252,720
tons per year of SSO collected	500	764	2,293
processing savings to the community for recycling SSO	$6,246	$9,553	$28,660
additional annual costs for containers for participating HH	$9,180	$14,040	$42,120
	Dedicated Collection		
additional hauling costs per year	$275,400	$421,200	$505,440
additional processing costs per year	$8,501	$13,001	$39,003
container costs (from above)	$9,180	$14,040	$14,040
overall increase in annual costs	**$286,834**	**$438,688**	**$529,823**
	Blue Bag Collection *(w/ bag and contaminant removal)*		
additional hauling costs per year	$0	$0	$0
additional processing costs per year for sorting operation	$42,136	$64,444	$193,332
additional costs for Blue Bag program bags	$9,994	$15,285	$45,856
container costs (from above)	$9,180	$14,040	$42,120
overall increase in annual costs	**$55,064**	**$84,216**	**$252,648**
	EOW Collection		
additional hauling costs per year	$0	$0	$0
additional processing costs per year	$8,501	$13,001	$39,003
container costs (from above)	$9,180	$14,040	$42,120
overall increase in annual costs	**$11,434**	**$17,488**	**$52,463**

**While residents of PPB communities will save money by purchasing less trash bags, this savings will represent a loss of revenue to the municipalities in their solid waste programs, consequently, this savings to residents is not included in the calculation of the overall increase in annual costs.*

7.4.2 Cost Estimates for Drop-Off Programs at Transfer Station Communities

Due to the differences in collection infrastructure among communities in the ecomaine service area, cost estimates for drop-off programs at transfer stations are considered separately in this report. Two basic models for transfer station drop-off programs could work for ecomaine communities which currently rely on transfer stations for collecting trash and recycling:

- Communities that already compost yard trimmings at their transfer stations could simply incorporate collected SSO in with their existing composting operation. This type of operation is encouraged by the Maine DEP and is the model already in place in the Town of Yarmouth. Based on the estimated collection rates for SSO in drop-off programs relative to the amounts of yard trimmings collected by communities with their own composting operations, the addition of limited amounts of SSO would not necessitate the purchase of additional compost amendments. It is likely that the addition of SSO would improve the compost blends from the perspective of creating ideal conditions for the microbial population within the compost piles. Collected SSO could help correct the relatively high carbon to nitrogen ratio often found in yard trimmings composting operations.

- For transfer station communities that either do not currently compost yard trimmings or choose not to incorporate collected SSO into their existing composting operation, the organics would be transported to existing processors at a tip fee commensurate with the market rate for composting SSO in southern Maine ($30 to $50/ton).

For both models, several steps would be required to develop the programs. The initial steps would include providing containers to residents interested in participating the program (5-gallon, sealable containers have proven to work well in the Massachusetts drop-off programs) and providing outreach to residents such as mailers, flyers, newspaper ads, and public service announcements. Additionally, for the first model, integrating SSO into ongoing yard trimmings composting operations at the transfer station, program development would also require the following activities:

- Constructing a suitable drop-off site/bunker where residents can unload their containers.
- Blending the SSO into the existing yard trimmings compost piles. No change in equipment and limited changes in windrow management from existing composting operations should be required.

For the second model, in which SSO collected at the transfer station is delivered to an off-site composting operation, the following additional costs would be included in the program:

- container rental for the SSO that is dropped off by residents;
- hauling costs associated with transporting the SSO, weekly, to a composting facility or organics transfer station; and
- tip fee for processing the SSO at the composting facility.

Cost estimates for a transfer station organics program for each model are included in Tables 7-4 and 7-5. For estimating purposes, a community in which 3,000 households use the transfer station (a figure slightly smaller than the households served by the Cape Elizabeth transfer station and slightly larger than those served by the Yarmouth transfer station) is used.

As would be expected, the cost estimates in Tables 7-4 and 7-5 indicate that a transfer station drop-off program for organics is more cost-effective when the SSO can be integrated into an existing yard trimmings composting operation. In this model, the savings associated with diverting the organics from combustion in the ecomaine WTE plant are greater than the costs associated with setting up and operating the organics program. In the model in which the collected organics need to be transported to an off-site composting operation, the cost of the program is an increase over not implementing the program based on the assumptions that the project team has used in these estimates.

Table 7-4 Cost Estimates for Organics Drop-Off Program with Integration into Existing Yard Trimmings Composting Operation

Cost Basis	Item Description	Comment
	Items and Costs Associated with Organics Collection and Processing	
$16,800	construction of drop-off bunker	based on Yarmouth's reported construction costs
10	year-life of bunker	
$1,680	annual costs for improvements	assuming cash basis
$1,500	Educational outreach - mailers, flyers, public service announcements (PSAs), etc.	Brattleboro, VT spent $1000 for curbside program
5	year cycle for the education program	
$300	annual cost for outreach	
$15	for in-kitchen container and sealable 5-gallon bucket	Whaley, MA costs were $8/bucket w/o in-kitchen container
5	year life for containers	
$3	annual costs for containers	
3,000	number of HH served by transfer station	
17%	participation rate in organics program	Northfield, MA transfer station program participation rate
70%	drop-off rate	the percent of times that participating HH bring in their organics
10	pounds SSO per HH per week	low-end of New England curbside programs reported collection rates
93	tons of SSO per year to drop-off program	
$1,530	costs for containers per year	
$0	increase in annual operating costs for yard trimmings composting	based on Yarmouth, ME experience
$3,510	***sum of annual costs for organics drop-off program***	
$38	per ton of SSO	annual costs divided by SSO tonnage collected
	Savings Associated with Diverting Organics from the WTE	
$70.50	costs per ton tip at WTE	
$6,544	avoided tip fee costs for diverting from WTE	tonnage of SSO collected x WTE tip fee
1.5	hour round trip for solid waste to WTE	
15	tons per trip	
$100	per hour trucking	
$928	avoided trucking costs	
$7,472	***sum of annual savings from diverting organics***	
	sum of costs (or savings) associated with developing organics drop-off program	
$(3,962)	***annual increase over no organics drop-off program***	program represents an overall savings using this model
	Cost Savings to Residents for Reducing Number of Bags of Trash Disposed (relates to PPB transfer stations only)	
$2.00	charge per bag of trash at transfer station	While this is a cost savings to residents, it also represents a loss of revenue to the community's solid waste program.
1	bag less of trash generated/HH/month by participating in organics program	
$12,240	***annual savings to residents participating in the program***	

Table 7-5 Cost Estimates for Organics Drop-Off Program with Transport of Collected Organics to Off-Site Composting Operation

Cost Basis	Item Description	Comment
Items and Costs Associated with Organics Collection and Processing		
$1,400	annual cost for 4Y^3 dumpster rental	from Northfield, MA organics dumpster costs
$75	per hour hauling costs	smaller truck = lower costs than solid waste trailer
1.5	hour per round trip	to composting facility
1	trip per week	frequency necessary to reduce odors/vectors
$5,850	hauling costs per year	
$1,500	Educational outreach - mailers, flyers, PSAs, etc.	Brattleboro, VT spent $1000 for curbside program
5	year cycle for the education program	
$300	annual cost for outreach	
$15	for in-kitchen container and sealable 5-gallon bucket	Whaley, MA costs were $8/bucket w/o in-kitchen container
5	year life for containers	
$3	annual costs for containers	
3,000	number of HH served by transfer station	
17%	participation rate in organics program	Northfield, MA transfer station program participation rate
70%	drop-off rate	the percent of times that participating HH bring in their organics
10	pounds SSO per HH per week	low-end of NE curbside programs reported collection rates
93	tons of SSO per year to drop-off program	
$1,530	costs for containers per year	
$42.50	tip fee for organics at off-site composter	based on aggregated fee calculated for Table 7-2 estimates
$3945	annual tip fee for organics	
$13,025	***sum of annual costs for organics drop-off program***	
Savings Associated with Diverting Organics from the WTE		
$70.50	costs per ton tip at WTE	
$6544	avoided tip fee costs for diverting from WTE	tonnage of SSO collected x WTE tip fee
1.5	hour round trip for solid waste to WTE	
15	tons per trip	
$100	per hour trucking	
$928	avoided trucking costs	
$7,472	***sum of annual savings from diverting organics***	
sum of costs (or savings) associated with developing organics drop-off program		
$5,553	***annual increase over no organics drop-off program***	program represents an additional cost over “do nothing”
Cost Savings to Residents for Reducing Number of Bags of Trash Disposed (relates to PPB transfer stations only)		
$2.00	charge per bag of trash at transfer station	While this is a cost savings to residents, it also represents a loss of revenue to the community’s solid waste program.
1	bag less of trash generated/HH/month by participating in organics program	
$12,240	***annual savings to residents participating in the program***	

7.5 Conceptual Organics Recycling Plan

This report has detailed the amounts of potentially recoverable organics from the ecomaine service area; the potential methods for diverting, collecting, and processing the organics; the potential impacts of organics diversion on the ecomaine WTE plant; and the costs associated with several alternative methods of collection and processing for the organics (referred to as SSO, once it is collected). Taking all of this information into consideration, the remainder of this section is dedicated to providing the benefits and risks of collection and processing choices and a recommended path forward for developing an organics program in the ecomaine service area.

7.5.1 Drop-Off Programs in Transfer Station Communities

Transfer station drop-off programs for organics are simpler models than curbside residential collection programs and require less complex decision-making for developing programs. As discussed in Section 7.4.3, there are two models that could fit for ecomaine communities that rely on transfer stations for solid waste collection. The first model involves incorporating collected SSO into an existing yard trimmings composting operation and the second model involves developing a relationship with an existing, local composting operation, hauling the collected SSO to the composting operation, and paying a tip fee to the composter based on the tonnage delivered.

As outlined in Section 1, without extensive education and outreach to residents, participation rates in transfer station drop-off programs is low. However, several Massachusetts drop-off programs indicate that participation rates can increase significantly by providing residents with containers and reaching out to community members through the media, and, more importantly, in person at the transfer station. For both models, the first step is to develop a physical drop-off location. For communities that will be incorporating the collected SSO into an existing on-site composting operation, this can be as simple as building a concrete-wall bunker in which the SSO is dumped into a pile of yard trimmings and immediately blended. For communities going off-site with the SSO, the collection area will consist of a series of toters or smaller dumpsters (1 to 4 cubic yards depending on the size of the community).

The second step is to provide sealable containers to residents in concert with a public outreach program. Along with the containers, residents would be given a list of acceptable items for collection. While there may be some limitations to the acceptable items based on the composter receiving the material, it is likely that the list of acceptable items from Section 7.5.2.4 would be acceptable to most composters.

For a community integrating drop-off SSO into an existing yard trimmings composting operation, the anticipated tonnage of SSO relative to the amount of yard trimmings expected to be collected by the community suggests that adding the SSO will not result in a need for importing more amendment to their facility. For communities sending their SSO to an off-site composter, the amounts generated will likely be small enough that they could be handled by the average on-farm composting operation. While the risk of overwhelming a composting operation with SSO that cannot be properly managed is minimal from the amounts generated in a transfer station drop-off program, due diligence will be necessary on the part of the community (including occasional site visits to the composting facility) to ensure that the SSO is being properly managed.

As discussed in Subsection 7.4.3, development of a successful transfer station drop-off program in a community in which the SSO will be integrated into a yard trimmings composting operation is likely to result in a net savings to the community's overall solid waste program. For the second model, there will be some additional costs to develop and run the program, but these extra costs should be relatively low. Anticipated tonnages of SSO can be interpolated from the calculations in Tables 7-4 and 7-5. For programs with aggressive public outreach programs, this study estimates that approximately 93 tons could be collected from a transfer station servicing 3,000 households, which translates to approximately 62 pounds per year per household served by the transfer station (or 370 pounds per year per participating household).

The project team recommends that ecomaine determine which transfer station communities are interested in developing organics drop-off programs and help to educate these communities on getting started and achieving maximum participation in the programs. In order to initiate these programs it is important to find a champion in each community who can help coordinate educational efforts and who may be able to get local school students involved in the outreach efforts.

7.5.2 Collection and Processing for SSO from ecomaine Curbside Communities

Each of the ecomaine member communities have a different set of constraints that will drive collection decisions and the decision on whether or not to participate in an organics recycling program. Given the differences within ecomaine communities, one type of collection system may not work for all communities. Additionally, it is unlikely that all of the communities will develop programs simultaneously. Given these conditions, the following pros and cons of the different collection and processing systems reviewed are intended to help the decision-making process for ecomaine and ecomaine communities interested in diverting organics.

7.5.2.1 Collection Systems

EOW Collection Systems.

Pros: As indicated in Table 7-2, due to the low anticipated costs of EOW collection systems, all of the combined alternatives for collection and processing involving EOW collection provide for the lowest overall costs. Additionally, with organics collected weekly and trash and recycling collected on alternating weeks, the diversion of organics is likely to be greatest with this type of collection system. Compared to a Blue Bag-type system, EOW collection does not necessitate a sorting operation at the ecomaine WTE; organics could be delivered directly to a processor, or more likely to an organics transfer station to be developed at the ecomaine WTE. Experiences from other municipalities that have implemented EOW collection indicate that this method increases recycling rates for traditional recyclables as well.

Cons: While EOW collection systems in which organics are collected weekly and trash and recycling are collected on alternating weeks have worked in several Canadian municipalities and now have at least some track record in Portland, OR, Renton, WA and Hamilton, MA, this system does represent a shift in both disposal behavior by residents and a need for collection equipment retrofits by haulers, giving the potential for resistance to this change.

Strong commitment would be necessary by community leaders and public works departments to make this shift successful. This does not provide the contamination removal step possible with the Blue Bag-type collection in concert with a sorting operation.

Blue Bag Collection Systems.

Pros: While a Blue Bag-type collection system appears to be more expensive than an EOW system, this study's analysis indicates that, even when taking into account the capital and operational expenses of developing and running a sorting operation at the WTE, this system can provide substantial collection savings relative to dedicated collection. Additionally, the option in which the SSO bags are ripped open and separated from the SSO provides for a manual contaminant removal step on the sorting line, which can increase the quality of the SSO, increasing the flexibility of where the material can be processed, and possibly lowering the per ton processing fee.

Cons: There is a significant capital investment necessary for the sorting operation and the per ton processing fees are greater with lower participation rates. For instance, in the low-end organics diversion scenario, the sorting costs equate to $194 per ton of SSO recovered. This collection system is more dependent on high participation rates within and among ecomaine communities to make it financially attractive. More high strength plastic bags are necessary for this system than for dedicated collection or EOW collection, and in the case of the option in which the traditional plastic bags are ripped open and removed, this method generates more solid waste than the other options. One question for this option is if customers will agree to the time and inconvenience of source separation if they suspect that co-collection with trash means the SSO is going into the WTE plant anyway.[40] Finally, there is only one existing program in which this model has been used, it is less than two years old, and experience with this model is limited.

Dedicated Collection Systems.

Pros: This is the most time-tested model for curbside organics programs in the US. It has already been proven to work in the ecomaine service area for residents willing to pay a premium for curbside service in the Garbage to Garden program.

Cons: Based on our analysis, this is the most expensive option. This system also does not provide the contamination removal step possible with the Blue Bag-type collection in concert with a sorting operation.

The project team recommends that ecomaine facilitate meetings first with member community solid waste managers to discuss the pros and cons of the three collection methods characterized above, and then between the solid waste managers and their haulers to discuss the logistics of implementing collection by the most promising method for each community.

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[40] At the Blue Bag Organics program in Delano, MN, cameras on the tip floor of the Materials Recovery Facility were used to create live streaming video feed to their website so customers could watch in real time as the bags were unloaded, separated, and reloaded for transport to the composting facility.

7.5.2.2 Processing Systems

There are no risk-free alternatives in developing an organics recycling program or facilities, but it is possible to develop programs that have minimal risk potential. The free market alternative (Alternative 10) carries the greatest risk because ecomaine would be voluntarily surrendering control of up to 12,000 tons/year of SSO in conflict with their contractual responsibility to provide solid waste disposal to member, associate, and contract communities and this SSO may not be managed in a manner consistent with ecomaine's environmental standards.

For the centralized facility alternatives (ecomaine owned and operated facilities), there are site development risks, such as whether the farm adjacent to L3 at the ashfill could be purchased or whether the property on which L4 is located could be acquired from Casella, and whether resistance from neighbors would be significant and unforeseen construction cost issues avoided. There are also program implementation risks, such as whether ecomaine can successfully develop an end-user marketing and sales program for its recovered energy product and/or its compost product; and operational risks of anaerobic digestion and composting facility operations.

The decentralized alternatives also carry risk, particularly in the area of developing strong partnerships that can work within ecomaine's desired goals of minimal operational disruption, minimal adverse public and environmental impacts, robust health and safety programs, and partnerships that can perform reliably for long periods of time.

In following up on the potential for ecomaine to work with existing processing facilities, the project team has had discussions with several of the processors that have expressed interest in providing services to ecomaine. The nature of the discussions was to go over expectations of the SSO that would be generated by organics programs in the ecomaine service area, including tonnages, materials to be included, and the potential for contaminants within the SSO. Two of the processing facilities with the largest capacity in the state, and which also have some experience with processing commercial SSO, are Maine Waste Solutions and Exeter Agri-Energy (see Section 4 for a summary of these operations). They have expressed interest in working with SSO that would come from programs within the ecomaine service area. While neither of these processors currently have experience with significant volumes of residential SSO, both have expressed a willingness to work with ecomaine on issues related to contamination and the use of compostable bags, should a Blue Bag-type collection system be used by ecomaine communities. While exact prices for processing SSO are not available at this time for these facilities, both of the processors have indicated that their pricing would be competitive with the going rate for SSO in Maine. Estimates of processing costs, based on the project team's discussion with these facilities, are included in the macroeconomic analysis in Tables 7-2 and 7-3.

Based on the availability of existing processing facilities that have expressed an interest in handling SSO collected from an ecomaine organics program and on the fact that an ecomaine program is likely to start with a relatively modest amount of SSO over the first years of program development, the project team recommends that ecomaine start with the decentralized processing model in which ecomaine develops a partnership with one or more Maine processors under a contractual relationship that will minimize risks related to environmental concerns (odor and water quality) and volume management.

Concurrently, for long term planning purposes, ecomaine should explore the potential for buying the parcels of land that would be necessary to develop L3 and L4 at the ashfill and ultimately decide on whether to plan for an organics processing facility at either of those two sites or at L5 at the Gorham parcel. The Preliminary Process Design for ASP Composting (Appendix B) provides sizing estimates for a facility designed to compost 12,000 tons per year of SSO. Once a location is chosen, ecomaine should reach out to planning officials within the community in which the site is located and initiate the data gathering process for information that will be required in permitting and developing the site.

Certifying Merchant Facilities

In order to meet ecomaine's risk minimization goals relative to processing organics, the project team recommends the development of a certification program that would both qualify processors as acceptable partners for ecomaine and provide an ongoing review process to ensure organics processed from the ecomaine service area are managed in an environmentally sound manner with an emphasis on worker health and safety, while avoiding nuisances to neighboring residences and businesses of the processing facilities. As discussed in Sections 3 and 4, when not managed with the proper technology and attention to detail, composting has the potential to create nuisance odors and negative impacts to water quality. The goal of the certification program would be to minimize the risks of these impacts at any facility processing materials from the ecomaine service area. As envisioned by the project team, the certification program would include the following elements:

- Evidence of good standing with the Maine DEP.
  - Submittal of any notices of violations (NOVs) from the Maine DEP and corresponding corrective action plans.
  - Copies of annual reports.
- An Odor Management Plan, including the following items:
  - Description of sources.
  - On-site meteorological and odor monitoring programs.
  - Public information management system.[41]
- Temperature log of composting operations to demonstrate that they are meeting the time and temperature requirements set forth by the Maine DEP for the processing of post-consumer organics.
- A Surface Water Control plan including adequate and permitted storm water management systems and a Storm Water Pollution Prevention Plan.
- A Health & Safety program for all employees involved in composting.
- Annual random inspection (and others as needed) by independent consultant working on ecomaine's behalf.
- Notification to ecomaine (within 24 hours) of any event or incident that could imply failure to adhere to ecomaine's requirements.

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[41] A written procedural document that spells out how interactions with the public over odors are to be handled and addressed.

7.5.2.3 Managing Contamination in SSO

With the exception of the Garbage to Garden curbside organics collection service, which includes motivated residents willing to pay for a subscription service and who are consequently more likely to be very thorough in their sorting of the organics, there is very limited experience with processing residential SSO in Maine. Compared to other organic feedstocks processed in Maine, such as manure and food and seafood processing wastes from larger generators, residential SSO from programs with high participation rates are likely to have more contaminants (plastic bags, Styrofoam, and other inorganic materials). Consequently, in planning for a program for residential SSO, it is important to ensure both that plans are in place to minimize contamination in the SSO and to work with facilities that have the flexibility to handle the expected contamination that will come with the SSO. Table 7-6 is a summary of reported contamination rates from several SSO programs.

Based on the project team's review of existing programs, it appears that achieving less than 2% contamination in a residential curbside collection program can be expected with proper education and outreach to communities participating in the programs. With the exception of Toronto, Ontario, all of the residential programs reviewed reported contamination rates of 2% or less, with the two existing programs in New England being less than 1%. Due to the inclusion of diapers and non-compostable plastic bags, Toronto's organics program is much more prone to receiving non-compostable materials than is the case with programs established in the US. In fact, referring to the 20% level of non-compostable materials is a misnomer in that much of the material is actually "allowed" in the program.

In all cases, program operators have stressed the importance of providing extensive outreach to participating households with very clear directions on which materials are and are not acceptable for inclusion with the organics. Additionally, continual feedback between the processors and those responsible for administering the curbside collection programs in critical to maintaining low contamination rates. In the Brattleboro, VT program, the Windham Solid Waste Management District maintains a list serve with participating households and provides instant feedback to customers when avoidable contamination is found in the SSO delivered to the compost facility. The operators at Brick Ends Farm in Hamilton, MA have a close working relationship with the hauler, Hiltz Disposal, for the Hamilton, MA, curbside program and provide constant feedback to the hauler regarding levels of contamination in the SSO. Finally, some processors, such as Dirt Hugger composting in the Dalles, OR, who provide composting services for SSO collected in the Portland, OR residential curbside program, have a contamination surcharge in place (see Sidebar) which provides incentive to the municipality to limit contamination from the residential SSO.

In summary, some contamination within the SSO collected in organics programs in the ecomaine service area is inevitable, but experience from existing programs indicates that the levels can be maintained at a low and manageable level. It is clear that with any organics program, public outreach and education and

Table 7-6 Reported Contamination Levels from Several Organic Waste Recycling Programs

Program	Reported Contamination Levels (wet weight basis)	Comments
Blue Bag Organics, MN – residential curbside SSO[42]	1.3%	mostly plastic film, based on actual waste sort
Portland, OR – residential curbside SSO including yard trimmings[43]	0.7%	as counted at receiving compost facility after minimal hand sort on tip floor at Portland transfer station
Brattleboro, VT – residential SSO[44]	"much less than 1%"	mostly plastic film, provide email feedback to participants when contamination comes in
Hamilton, MA – residential SSO[45]	<1%	mostly plastic bags
San Francisco, CA – residential SSO including yard trimmings[46]	1-2%	operations include rudimentary manual sort on tip floor and sorting station at compost facility
Peninsula Compost, DL – commercial SSO	6-10%	In this program, minimizing contamination through education with the commercial generators has proved challenging
Toronto, ON – residential SSO[47]	20%[48]	very inclusive programs which includes diapers and allows for SSO collection in conventional, non-compostable plastic bags, hence the 20% actually includes materials that are on the "allowed" list

constant feedback between the operators of processing facilities, hauling companies, and communities participating in the programs will be critical to the success of the programs. Several programs, including San Francisco, CA and Hamilton, MA have found that tagging carts in which contamination is found is an effective way to provide feedback to residents on what is not acceptable in the organics containers.

Upfront investment in education and consistent follow up with participating households when contamination is encountered can decrease costs on the processing end, both in terms of providing flexibility on where the material can be processed and reducing the equipment costs, such as sorting lines and vacuums for removing plastics during screening.

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[42] Waste sort performed by Coker Composting & Consulting on August 5, 2013 from a truck load of SSO collected using Blue Bag Organics system and delivered to the Shakopee Mdewakanton Sioux Community compost facility in Prior Lake, MN

[43] Personal communication Tyler Miller , Dirt Hugger Composting, August 16, 2013

[44] Personal Communication, Bob Spencer, Windham Solid Waste Management District, August 9, 2013

[45] Personal Communication, Peter Britton, Brick Ends Farm, August 14, 2013

[46] Personal Communication, Bob Besso, Recology, August 16, 2013

[47] Laura McDowell, York Region Director of Env Promotion and Protection, SSO Programs presentation March 10, 2010

[48] This 20% includes non-compostable materials, such as diapers and non-compostable plastic bags that are included in the list of materials that residents can place in their organics bins

Dirt Hugger Contamination Fees

The Dirt Hugger composting facility in The Dalles, OR, which services Portland, OR, charges fees for received material containing contamination. Loads containing contamination are documented, including date, time, material, and a photo displaying volume and contamination material. As an OMRI Listed facility, Dirt Hugger cannot accept feedstocks that put their Organic Certification at risk (i.e., synthetic substances). Additionally, Dirt Hugger endeavours to have the cleanest feedstock possible for purpose of product quality, cost reduction and worker safety.

Definition of Contamination: *The following wastes are banned from processing at Dirt Hugger:*

- *Any synthetic materials as defined by the National Organics Standards Board including, but not limited to: waxed cardboard, colored or glossy paper, bioplastic-based products (i.e., cups, cutlery, packaging). NOTE: As an exception, bioplastic-based bags (e.g., PLA and PHA) are acceptable as allowed by Portland residential curbside organics program.*
- *Any non-compostable solid wastes, including, but not limited to: plastics, glass, metals, rock/stone, and wood wastes that are pressure-treated, stained, or painted.*
- *Any hazardous wastes as defined by the Oregon Department of Environmental Quality (DEQ).*
- *Any regulated medical wastes as defined by the DEQ.*
- *Any special wastes, including, but not limited to: tires, lead-acid batteries, electronic wastes, polychlorinated biphenyl (PCB)-containing wastes, petroleum products, and radiological wastes.*
- *Any wastes that do not meet the Feedstock Acceptance Protocols of Dirt Hugger, LLC.*

Fees: *Contamination is measured in 'picks' and/or volume, whichever is greatest. 'Picks' are described as a piece/or pieces of contamination that one can pick up with one hand at one point time. The volume of contamination is measured specifically in gallons. This policy is based off of receiving a truck load of organics material, ranging from 25-35 tons.*

- *0-5 gallon / 20 Picks – there is no charge to the customer*
- *6-20 gallon / 21-50 Picks - a $25 contamination fee is charged to customer*
- *21-50 gallon / 51-80 Picks – a $50 contamination fee is charged to customer*
- *51-100 gallons / 81-120 Picks – a $100 contamination fee is charged to customer*
- *101-200 gallons / 121 - 150 Picks – a $200 contamination fee is charged to customer*
- *Over 200 gallons / 150 Picks – Load is accepted, a $200 contamination fee is charged, plus a $35/hr picking charge until all contamination is removed from load.*

7.5.3 List of Acceptable Organics

As discussed in Section 1, the greater the list of items that are accepted for organics recycling, the greater the participation rates and associated recycling rates. Throughout this report it has been assumed that an organics program developed in the ecomaine service area would be inclusive of all types of food scraps, including meat and dairy products, as well as a wide range of compostable paper, including food soiled paper, paper towels, paper-based food containers, etc. Including compostable paper not only increases participation rates and the amounts of organics diverted from disposal, this material also provides a carbon source to help balance the higher nitrogen content of the food scraps, eliminating the need for some of the supplemental carbon sources that will be required during the composting process.

The findings from Section 1 indicated that yard trimmings are already successfully recycled to a large extent in the ecomaine service area. Further, with the seasonal nature of the accumulation of yard trimmings in the northeast, it is advisable to have separate programs for yard trimmings and the remaining targeted organics (food scraps, compostable paper, etc.). This being said, some programs with separate food scraps/compostable paper and yard trimmings collection allow house plants and smaller quantities of yard trimmings in with their food scraps. Provided that yard trimmings do not overfill the containers distributed to participants for organics collection, "topping off" the containers with yard trimmings should be allowed and would provide additional carbon sources to the mix of organics.

Animal litter, especially kitty litter, is often excluded even from some of the more inclusive organics collection programs. As discussed in Section 1, kitty litter can be a significant component of the waste stream and being able to include it in an organics program will help to increase organics diversion rates. If ecomaine does decide to work with private organics processing facilities, the issue of whether to include or exclude animal litter will need to be addressed with the processors. Experience from existing organics programs indicates that is easier to add an acceptable material after starting a program than it is to take one off of the list after participants have become accustomed to separating it out. For this reason, thoughtful consideration of the initial list of acceptable items to include in an organics program is critical.

Based on existing successful inclusive programs, the project team recommends that the items listed in Table 7-7 be included in the list of acceptable organics for programs in the ecomaine service area.

Table 7-7 Recommended Organics for the ecomaine Service Area

Food Scraps	Compostable Paper	Other
Fruit and vegetable scraps	Paper towels/paper napkins	Flowers
Meat and fish (including bones)	Tissue paper	Potted plants
Grains, bread, pasta, and baked goods	Paper bags	Grass and leaves (limited to size of container)
Nuts, beans, seeds	Wrapping paper (check others)	Weeds
Dairy Products	Pizza boxes, paper-based takeout containers (such as Chinet® containers)	Hair
Coffee Grinds/Tea Bags	Uncoated paper plates and cups	
Moldy/spoiled Food	Egg cartons	
Egg shells	Paper containers, cereal boxes	
Cooking oils and fats	Flour and sugar bags	
	Shredded paper	
	Food-soiled newspaper	

As previously discussed, whether or not to include items such as kitty litter or other animal wastes would be based on discussions with private processors that would be managing the material. This would apply to compostable bags, cups and flatware as well.

7.5.4 In-Kitchen Containers and Curbside Carts

For each of the three collection systems, the project team has used the assumption that all participants in residential curbside collection programs will be provided both an in-kitchen 2-gallon container and a curbside cart with a locking lid. The Town of Hamilton, MA uses a 13-gallon curbside cart for organics, and this is a common size for the curbside carts in many of the Ontario Canada organics programs.

Based on the estimated density of the combined food scraps and compostable paper and a capture rate of 12 pounds per household per week, a 13-gallon container would likely have up to 8 gallons of additional space each week available for topping off with yard trimmings, household plants, weeds or other vegetative wastes. For fully automated collection vehicles a larger curbside cart will likely be necessary to make the system work.

7.5.5 Implementing Organics Program in Phases

As discussed throughout this report, ecomaine community members represent a wide array of solid waste collection systems with varying population densities and likely with different visions of the need for initiating organics recycling programs. Unlike a single municipality contemplating organics recycling, ecomaine cannot simply make the decision that curbside collection of residential organics will be available to all residents and plan accordingly (both for collection systems and processing). While this provides challenges in developing consistent organics recycling programs throughout the service area, it also provides the opportunity to develop a program in phases, which can have some advantages over developing a service area-wide program all at once.

For instance, one risk in voluntary organics diversion program development is ensuring adequate participation rates to support the economics of SSO collection and processing facility development. However; developing an ecomaine program in phases (community by community) means that the volume of SSO generated in the first years of a program will be small enough that it should be easily handled by existing processing capacity in the project area. This allows some time for ecomaine to determine whether or not the development of an ecomaine owned and operated processing facility will be necessary or whether it appears that existing processors will continue to be able to successfully handle the material as the program grows. Similarly, implementing a program in phases will allow an assessment on the effectiveness of education and outreach in minimizing contamination levels in SSO. Higher levels of contamination in the initial phases of the program may indicate a necessity for developing a sorting process, similar to the one designed by D&B Engineers and Architects for the Blue Bag-type collection system.

In the case of developing an organics program in Portland, the city is large enough that it may make sense to phase a program in one collection route at a time. In cases where organics collection necessitates purchasing a new truck, this may allow the City to replace old trucks with newer trucks (equipped for organics collection) on a schedule more in line with their existing truck replacement schedule.

In order to initiate a phased approach to developing a program, the project team recommends that ecomaine identify specific communities that are interested in offering organics collection and help

these communities choose initial routes or neighborhoods that provide a good cross section of the community.

Phased Implementation versus Pilot Project

Experiences from existing programs suggest that pilot programs are much more effective when they segue directly into actual program implementation. For example, participants in a stand-alone pilot program initiated in Denver in 2008 expressed disappointment when the pilot program was discontinued after a little over a year, and the City was ultimately persuaded to re-initiate the program as a relatively expensive subscription program for the participants of the pilot program (Ecoconservation Institute, 2010). One of the managers of the City of San Francisco's organics program also stated that moving directly from pilot programs into full-scale implementation is favorable to initiating a pilot program, stopping the program to make assessments of the success of the program, and re-starting the program on a larger scale (Macy 2013).

To the extent possible, as organics programs develop within ecomaine communities, they should be managed as the initial phase of a larger ecomaine service area wide program as opposed to stand-alone pilot projects.

As one goal of developing an organics program is to provide the opportunity for as many residents as possible to participate, it is important that the initial phases of the program include a diversity of neighborhood types and population densities and do not focus solely on residents that would already be inclined to be involved in organics recycling. It has been suggested that including the residences of politicians and community leaders in the first phase of a program can help to promote the program to a wider audience.

7.5.6 ecomaine as Organics Recycling Facilitator

While ecomaine does not have control over the organics collection systems chosen by individual ecomaine member communities, ecomaine can play a crucial role in facilitating the development of programs and ensuring that communities have a stable, consistent delivery site and adequate capacity available for processing organics. As detailed in Task 2, one of the early adopters of commercial organics collection in the ecomaine service area discontinued his organics route largely because he did not have a consistent processing site at which to deliver the organics. Two critical components of organics recycling that ecomaine can provide to its member communities are a transfer station or local site to which organics can be delivered and sufficient capacity at processing facilities that are either certified by ecomaine or operated by ecomaine.

Organics Transfer Station. *For the Blue Bag-type collection system, a sorting facility at the WTE plant will be necessary. For the EOW collection model using split-body trucks, unless the organics processing facility is located in close proximity to the WTE plant, an organics transfer station will be necessary to make deliveries efficient. Even for dedicated collection, as the organics program grows, a transfer station located at or near the WTE plant would likely be an advantage over delivering directly to an organics processing facility, especially if ecomaine communities are working with more than one processing facility. The cost estimates in*

Table 7-2 for a 12,000 ton per year SSO program include estimated costs ($3,060,000) for a transfer station at the WTE plant for all of the alternatives which included dedicated collection and EOW collection alternatives. This was a conservative (high) estimate based on the construction costs of the building area required for the Blue Bag sorting facility; the building would be larger than necessary for simply unloading and re-loading organics. For the first phase of an organics program it may be possible to construct a small bunker on the existing tip floor, construct a lower cost fabric building within the footprint of the WTE plant, or partner with a local operator that has a site permitted for the storage of solid waste. As the program grows, a more refined design for an adequately sized transfer station at the WTE would be developed. On the permitting end, the Maine DEP has indicated that an organics transfer station at the WTE plant would only require a minor revision to the existing solid waste permit for the plant, which is a relatively straightforward permitting process (Hopkins, 2013).

Ensuring Sufficient Organics Processing Capacity. *As discussed above, it is recommended that ecomaine initially work with existing organics processors using the certification program described in Section 7.5.2.2 to process SSO from the ecomaine service area. In addition to ensuring that processors can meet the standards for the certification program, ecomaine could negotiate contracts with the processors based on estimates of SSO that will be collected as the program develops. ecomaine would work closely with the processors to determine acceptable levels of contamination and ensure that the lists of acceptable items in the collection programs are in line with the requirements and needs of the respective processing facilities. As participation from ecomaine member communities increases over time, ecomaine can make a determination on whether it is necessary to develop their own processing facility to meet the needs of the member communities or whether relying on existing facilities will continue to provide adequate capacity and protection from risk.*

Education, Outreach and Training. *In order to minimize the duplication of efforts for communities developing organics programs, ecomaine could establish educational and outreach materials (e.g., flyers, mailings, stickers, PSAs, etc.) that could be used by all of the ecomaine communities in their programs. Whether ecomaine develops partnerships with existing processing facilities or ultimately builds its own processing facility, the list of allowable materials for the organics program should be consistent across ecomaine communities, consequently ecomaine could establish consistent program information for all participating communities.*

7.5.7 Cost Allocation

The major costs related to developing an organics program in the ecomaine service area include hauling costs for communities implementing curbside collection programs (as well as carts and containers for all programs and bags for the Blue Bag program), and processing costs for sorting, transferring and composting and/or anaerobically digesting the collected SSO. Within the processing costs, for any facilities developed by ecomaine (for sorting, transfer or composting), there are both capital costs and operating costs. Using the assumption that SSO diverted from the WTE plant solid waste stream would be replaced with equal tonnage at a spot market rate of $55 per ton, there is a savings to ecomaine of $11 to $12.50 per ton of SSO diverted (based on the $44.00 and $42.50 per ton estimated composting costs for the ecomaine-owned facility and merchant facilities, respectively). In the Blue Bag model, communities will have lower hauling costs than for dedicated collection, but there will be an increase in the processing costs compared to not diverting the SSO. For dedicated collection and EOW collection, the processing costs will be similar to those with no diversion; the per ton costs for the transfer station are roughly equal to the savings for processing the organics rather than combusting them in the WTE plant.

From an economic perspective, the organics model is not the same as for the ecomaine single-sort MRF where the sale of the recyclables allows ecomaine to provide a $0 per ton tip fee, which in turn provides a clear economic incentive to recycle. There is not a strong economic incentive at this time for municipalities to recycle organics. In order to encourage community members to develop organics programs it would be helpful for ecomaine to minimize disincentives.

Infrastructure that ecomaine may develop related to organics recycling, including a sorting station for a Blue Bag-type collection system (if communities choose to go that route), a transfer station for EOW or dedicated collection, and/or a composting facility will become part of the total value of ecomaine. It would make sense, then, for ecomaine to distribute the costs for any organics recycling infrastructure across the entire ecomaine membership (either through using money held in reserve or through annual assessments). The development of this new infrastructure would be in line with ecomaine's goal for providing environmentally responsible solid waste solutions for all of its members and, distributing these costs among all members would allow for those community members choosing to recycle organics to not take on the entire economic burden of this choice.

The costs for collection systems are clearly a community by community choice, and consequently those extra costs will be taken on by the individual communities that develop organics collection programs. The costs for curbside containers, in-kitchen containers and compostable bags, if used, would also be borne by the individual communities, as the types of containers purchased would also be determined by the individual communities. In order to recoup some of the costs related to organics collection and recycling, communities may choose to charge a subscription fee for participants. However, each community would need to balance the desire to maximize participation in an organics program with the extra costs that the community is willing to take on. Subscription fees that would cover the entire costs of the program will likely limit participation to a small percentage of the overall population. In a sense, the Garbage to Garden service is already providing insight into how many households in some curbside communities are willing to pay the full price for curbside collection of SSO.

In the case of a Blue Bag-type system , in which the annual operating costs for running the sorting operation are significant (approximately $44 per ton based on the information from the D&B Engineers and Architects design in Appendix D), the most fair approach for cost allocation would be for the participating communities to pay these extra costs. The communities using the Blue Bag-type system would be getting the benefit of reduced collection expenses relative to dedicated collection, and ecomaine would be taking on the costs of the infrastructure necessary to allow for a Blue Bag-type system, consequently it would make sense that the participating communities would pay for the annual operating costs (attributable to their share of the SSO tonnage) for the sorting operation.

Overall, then, ecomaine could help to minimize the increase in costs to the individual communities choosing to develop curbside SSO programs by distributing infrastructure costs evenly among the ecomaine member communities. Collection costs, which will be based on individual community choices on collection systems, will be borne by the participating communities. By phasing in organics programs, ecomaine will be able to more precisely determine the need and sizing for organics-related infrastructure, which will in turn aid in determining the most fair balance between providing incentives to develop organics programs and dividing the costs among all of ecomaine's member communities.

List of References

Allan, Chris, 2013. Metro Vancouver, Senior Engineer of Solid Waste Services. Personal communication, June 4, 2013.

Ameen, Jan, 2013. Franklin County Solid Waste District. Personal communication. August 16, 2013.

Armstrong, Cynthia, 2013. Trans Canada, Personal communication. May 9, 2013.

Bogner, J. M., Abdelrafie Ahmed, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti, and T. Zhang, *Waste Management*, *In Climate Change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Burch, T. and L. Flynn, 2001. *Compost as an Alternative to Methyl Bromide in Bell Pepper Production*, 2001, unpublished paper available at www.mcgillcompost.com.

Cal Recycle, 2006. Targeted Statewide Waste Characterization Study, Waste Disposal and Diversion. Findings for Selected Groups.

Cambridge, City of, Public Works Department, 2012. Curbside Organics Collection from Residents, Phase 1 Report.

Cape Fear Transportation Authority, 2012. *Compressed Natural Gas Fuel Evaluation*. September, 2012.

Cascadia Consulting Group, DSM Environmental Services, and MSW Consultants, 2007. Delaware Solid Waste Authority Statewide Waste Characterization Study, Final Report.

Center for a Competitive Waste Industry, 2010. *Beyond Recycling: Composting Food Scraps and Soiled Paper*. A report to USEPA Region 9.

Chittenden Solid Waste District, 2013. *CSWD Drop-off Compost Tons by Fiscal Year*. http://www.cswd.net/wp-content/uploads/2012/04/CSWDDrop-OffCompostTonsByFiscalYear.pdf

Chittenden Solid Waste District, 2001. Chittenden Solid Waste District Residential Organics Collection Final Report.

Clark, Gretel, 2013. Recycling Volunteer from the Town of Hamilton, MA. Personal communication. August 23, 2013.

Clark, Michael, 2013. Maine Department of Transportation, Environmental Department. Personal Communication. May 13, 2013

Cook, Christine, 2013. Maine Public Utilities Commission, Personal Communication. October 28, 2013.

Criner, G. and T. Blackmer, 2011. *Maine Residential Waste Characterization Study*. University of Maine School of Economics.

Criner, G., J. Kaplan, S. Juric, and N. Houtman, N, 1994. *Maine's Household Garbage*. Maine Agricultural and Forest Experiment Station Bulletin #841. February 1994

DSM Environmental Services and MidAtlantic Solid Waste Consultants, 2013. *State-wide Waste Characterization Study; Final Draft Report*. Prepared for Vermont Department of Environmental Conservation.

DSM Environmental Services, Inc., Cascadia Consulting Group and MidAtlantic Solid Waste Consultants, 2010. *Connecticut State-wide Solid Waste Composition and Characterization Study Final Report*, prepared for the Connecticut Department of Environmental Protection Solid Waste Management Program.

Ecoconservation Institute, 2010. *Best Management Practices in Food Scraps Programs.* Prepared for USEPA Region 5.

Engineering Solutions & Design, Inc. 2004. *State of Ohio Waste Characterization Study*. prepared for the Ohio Department of Natural Resources.

Favoino, E. and D. Hogg, 2008. *The potential role of compost in reducing greenhouse gases.* Waste Management Research, International Solid Waste Association, 2008; 26; 61.

Frank, Tyler. 2013. Garbage to Garden. Personal communication. February 13, 2013.

Galbraith, David, 2013. Gorham, Maine Zoning Administrator. Personal communication. April 22, 2013.

Georgia Department of Community Affairs, 2005. *Georgia Statewide Waste Characterization Study.* conducted by R.W. Beck.

Guyer, P.J., 2011. *Introduction to Solid Waste Incineration*. Continuing Education and Development, Inc.

Harris, Kasey. Environmental Program Specialist. Hannaford Supermarkets. Personal communication. March 18, 2013.

Hewes, Anne, 2013. ecomaine, Environmental Manager. Personal communication. August 28, 2013.

Hopkins, Carla, 2013. Environmental Specialist, Maine Department of Environmental Protection, Personal Communication. August 13, 2013.

Innovative Combustion Technologies, Inc., 2013. *Combustion Management to Achieve Lower NOx.*

Integrated Waste Management Board, 2002. *Using High-Carbon Wood Ash to Contol Odor at a Green Materials Composting Facility*. Compost Demonstration Project, Sacramento, CA. April 2002.

Kahler, Moss, 2013. Brattleboro, VT Organics Coordinator. Personal communication. May 17, 2013.

King, Mark, 2013. Environmental Specialist, Maine Department of Environmental Protection, and Michael Clark, Environmental Specialist, Maine Department of Environmental Protection. Personal Communication. March 13, 2013 and May 13, 2013.

Kirby, Steve,2013. Portland Metro. Personal communication. May 10, 2013

London Economics International LLC, 2012. Maine Public Utilities Commission (MPUC) RPS Report 2011 – Review of RPS Requirements and Compliance in Maine, January 2012.

MacDonald, George, 2013. Maine Department of Environmental Protection, Director, Sustainability Division. Personal Communication. August 27, 2013.

Macy, Jack, 2013. San Francisco Environment in the City and County of San Francisco, Commercial Zero Waste Coordinator. Personal communication. March 29, 2013.

Mail, Randi, 2013. Cambridge, MA Recycling Coordinator. Personal communication. February 14, 2013.

Maine Department of Environmental Protection. Maine Solid Waste Management Rules, Chp. 409.2 A. (1) and Chp. 410.2 A. (1)

Maine Department of Environmental Protection, Bureau of Remediation and Waste Management, 2013. *Waste Generation and Disposal Capacity Report for Calendar Year 2011*. A report to the Joint Standing Committee on Environment and Natural Resources.

Massachusetts Department of Environmental Protection, 2011. *Massachusetts Waste Characterization Data Material Category Profiles, 2011*. http://www.mass.gov/dep/recycle/ priorities/wcsmater.pdf

Massachusetts Technology Collaborative, 2010. *Feasibility Study of Anaerobic Digestion of Industrial Organic Waste Using Dry Fermentation Technology*, Task Order 09-1, January 2010.

Moreau, Tom. 2013. CSWD General Manager. Personal communication. February 19, 2013

Myer, Heather, 2013. Island Waste Management Corporation Disposal Manager. Personal communication with Andrew Carpenter of Northern Tilth and Dana Buske of Tech Environmental, April 2013.

Maine Department of Environmental Protection, 2013. *Maine Storm Water Best Management Practices Manual*, http://www.maine.gov/dep/land/stormwater/stormwaterbmps/, accessed 5/12/13

Maine Renewables Portfolio Standard, 2013. http://www.dsireusa.org/incentives/ incentive.cfm?Incentive_Code=ME01R&re=0&ee=0, accessed April 23, 2013

Natural Gas Monthly, 2013. http://ycharts.com/indicators/menatural_gas_citygate_price, accessed June 8, 2013

NGV Forum. 2013. Second Public CNG Fueling Station Announced in Maine, April 12, 2013

Niessen, W., 2010. *Combustion and Incineration Processes*, 4th Edition, CRC Press.

Northeast Regional Agricultural Engineering Service, 1992. *On-Farm Composting Handbook.* Edited by Robert Rynk.

Oregon Department of Environmental Quality, 2010. *2009/2010 Waste Composition Study*, Excel File Results, http://www.deq.state.or.us/lq/sw/disposal/wastecompstudy2009.htm

Ozores-Hampton, M., 2001. *Weed Control in Vegetable Crops with Composted Organic Mulches*, Compost Utilization in Horticultural Cropping Systems, Lewis Publishers, 2001, p. 275.

Pennsylvania Department of Environmental Protection, 2003. Statewide Waste Composition Study: Pennsylvania Department of Environmental Protection, Final Report, conducted by RW Beck.

Peters, C., 2012. *Field Reconnaissance of the Gorham Property*, letter report to ecomaine, TRC Solutions, May 23, 2012

Pitre, Marcel, 2013. Metro Vancouver, Senior Project Engineer. Personal Communication. September 27, 2013.

Portland, Oregon, City of, Bureau of Planning and Sustainability, 2012. *New Curbside Collection Service Year One Report*. December 5, 2012.

Recycling Consultants and MSW Consultants, 2010. *2009 Wisconsin State-Wide Waste Characterization Study*. Prepared for the Wisconsin Department of Natural Resources.

Richardson, Clayton “Mac”, 2013. Superintendent, Lewiston Auburn Water Pollution Control Authority, Personal Communication. March 12, 2013

Richter, Ron, 2013. LR Power Solutions. Personal communication. May 15, 2013.

Rocque, David, 2013. State Soil Scientist, Maine Department of Agriculture, Food and Rural Resources. Personal Communication. May 13, 2013

San Joaquin Valley Unified Air Pollution Control District, 2011. *Draft Staff Report- Draft New Rule 4566 (Organic Material Composting Operations)*, June 23, 2011.

Scott, Chad, 2013. City of Guelph, Ontario, Manager of Collection Services. Personal Communication. October 2, 2013.

Shafiur, R, 2010. *Food Properties Handbook*. Average of bulk density range for seafood waste, table 14.7, CRC Press 2010.

SmartFerm from Zero Waste, 2013. Material Flow Diagram – 5,000 TPY SmartFerm Option.

Stone Environmental, 2009. *Potential Food Scrap Generator Weights By County and Town*. Developed for the Central Vermont Solid Waste Management District.

Street, Erik. 2013. Yarmouth Public Works Director. Personal communication. January 23, 2013.

Tibbetts, John. 2013. Tibbetts Family Farm, Lyman, Maine. Personal Communication. February 13, 2013.

Tomasz, John. 2013. Hamilton, MA Public Works Director. Personal communication. February 14, 2013

Trytek, Kevin, 2013. ecomaine, Plant Manager. Personal communication. April 5, 2013.

Waite, Susan. 2013. Northampton, MA Recycling Coordinator. Personal communication. September 24, 2013.

Washington State Department of Ecology, 2010. *2009 Washington Statewide Waste Characterization Study,* ECY Publication No. 10-07-023. Conducted by Cascadia Consulting Group.

Weyburn, David, 2013. Village Green Ventures. Personal Communication. March 19, 2013.

Wintle, Adam, 2013. Exeter Agri-Energy. Personal Communication. March 12, 2013

Wilson, M.V., 2013. Macquarie Energy. Personal Communication. April 23, 2013.

Wonnacott, Dave, 2013. PEI Energy Systems General Operations Manager. Personal communication. April 2013.

US Census Bureau, 2013. *2007-2011 American Community Survey, 5-year estimates.* http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none

US Census Bureau, 2013. Maine Quick Facts, http://quickfacts.census.gov/qfd/states/23000.html, accessed May 12, 2013.

US Composting Council, 1996. *Field Guide to Compost Use*.

USEPA, 2010. Municipal Solid Waste Generation, Recycling, and Disposal in the United States, Tables and Figures for 2010.

USEPA, 2000. *Control of Gaseous Emissions*, Student Manual, APTI Course 415, 3rd Edition.

Vibert, Kevin 2013. Research Analyst, Toronto Solid Waste Management Services. Personal Communication. March 10, 2013

Van Opstal, B., 2006a. *Evaluating AD System Performance for MSW Organics*, Biocycle Magazine, Vol. 45, No. 11, November 2006, p. 35-39.

Van Opstal, B., 2006b. *Managing AD System Logistics for MSW Organics*, Biocycle Magazine, Vol. 45, No. 12, December 2006, p. 39-43.

Yespen, Rhodes, 2013. Residential Food Waste Collection in the US – BioCycle Nationwide Survey. BioCycle Magazine. March 2013.m

York (Ontario) Regional Council, 2013. Report No. 3 of the Environmental Services Committee Regional Council Meeting of March 25, 2010.

Zigby, Phillip, 2013. City of Guelph, Ontario, Coordinator, Marketing & Services Procurement. Personal Communication. October 11, 2013.

Appendix A
Organics Collection Case Studies

A	Town of Hamilton, Massachusetts
B	Blue Bag Organics, Minnesota
C	Ann Arbor, Michigan
D	Prince Edward Island, Canada

Case Study A

Hamilton, Massachusetts[49]

Dedicated Food Scraps Collection and Every Other Week Trash

Key Lesson:	Recycling has increased 24 percent, currently collecting 271 tons of food scraps (11% of total solid waste & recyclables collected in 2012). Town has saved over $100,000 in disposal costs from composting organics[50]. Program has been running just over one year (started April 2012).
Population:	8,374
Households Served:	2,640
Contact:	Michael Lombardo, Hamilton Town Manager

Program Summary

Food scraps are collected weekly in dedicated 13-gallon wheeled carts with a locking lid (manufactured by Orbis). Carts were partially paid for with a grant from the Massachusetts Department of Environmental Protection. Yard trimmings are not allowed in the 13-gallon containers; however, yard trimmings and leaves are collected once in the spring and twice in the fall or can be dropped off at the local compost facility. The town also provides a 2-gallon, inside-the-house container for organics and allows Biodegradable Products Institute (BPI)-certified compostable bags. The program began with a 70-home pilot test followed by a 600-home pilot.

Hamilton's program is very inclusive, allowing food-soiled paper, pizza boxes, and compostable service ware as shown on Figure A-1. Trash is collected every other week, using standardized 35-gallon carts. Residents wanting additional capacity can purchase overflow bags at $1.75 for a 33-gallon bag. Overflow bags are collected on alternating weeks. Single stream recycling is collected biweekly.

The program is available to all residential dwellings up to four units and to small businesses that want to participate. The Town contracts with a private hauler for collection (Hiltz Disposal). Hiltz uses semi-automated, side loading trucks to collect the food scraps on a dedicated route and brings food scraps to Brick Ends Farm for composting.

The Town of Hamiton pays $40 per ton to compost organics, which compares favorably to the $70 per ton that they pay for trash disposal.

[49] "Case Study: Hamilton "Three Sort" Program" Massachusetts Department of Environmental Protection, Bureau of Waste Prevention, January 2013.
[50] Personal Communication, Michael Lombardo, Town Manager. Some of this is from bag revenue from overflow bags.

Figure A-1

COMPOST GUIDELINES

You can compost a lot more than just kitchen scraps in your curbside compost bin. Here's a breakdown of what's acceptable.

LOW-GRADE PAPER

- Tissues
- Paper towels and napkins
- Paper towel / toilet paper rolls
- Paper bags
- Greasy pizza boxes and wet or waxed cardboard
- Small paper items and packaging (pill bottle boxes, price tags, other small items)
- Wrapping paper (no ribbons, foil or tape)
- Tissue paper

KITCHEN SCRAPS & YARD TRIMMINGS

- Fruit and vegetable scraps, including pits and seeds
- Meat, including bones
- Dairy products
- Breads and sandwiches
- Eggshells
- Spoiled/moldy food
- Chopsticks and wooden stir sticks
- Coffee grounds and filters
- Loose tea and tea bags (no tea bag wrappers or plastic tea bags)
- Weeds
- Hair
- Kitty Litter
- Flowers
- Potted plants

MORE COMPOSTABLES

- #7 PLA bioplastic made from corn (can include cups, containers, straws, lids and utensils); trusted brands include Eco-Products®, NatureWorks® and Biocorp®
- Compost bags made from PLA bioplastic; trusted brands include BioBag, Bag-to-Nature, Natur-Bag and Glad compostable bags
- Chinet® (plain paper plates and bowls without a plastic coating)
- Plates, bowls and containers made from sugarcane

PLEASE NO

- Plastic items of any kind, including plastic bags and Styrofoam®
- Plastic-coated paper plates, cups or other items
- Utensils (Forks, Knifes, & Spoons)
- Popcorn bags
- To-go
- Sugar packets
- Liquids, including cooking oil or grease
- Milk or juice cartons (recycle with commingled containers)
- Dryer lint
- Foil or metal
- Tape
- Biohazards, including diapers or sanitary items
- Soap
- Metal
- Leaves
- Pet waste
- Fabric scraps or string (they become tangled in shredding equipment or may be made of synthetic fibers)
- Plastic or Nylon twine (for branches)
- Construction debris

Organic Waste MUST be placed in

QUESTIONS?
Hamilton Residents: visit www.hamiltonma.gov or call (978) 468-5580
Wenham Residents: visit www.wenhamma.gov or call (978) 468-5520 extn. 6

According to a survey completed in 2013, approximately 50% of the households set out the organics carts on collection day[51]. Assuming a set-out rate of 70%, this would translate to a participation rate of 71%. A questionnaire provided to those households that did not set out an organics cart found that the majority either did not have a full cart that week or they were composting in their backyard. Very few respondents stated that they did not participate in the program.

Hiltz Disposal, the contractor for the Hamilton program, purchased a new Heil, 25 yard 60/40 split body truck at an estimated cost of $305,000. The price included modifications to make the truck more watertight and suitable for organics collection. Hiltz reports servicing 3,700 households over 5 days (740 accounts per route) averaging 2.5 to 3.5 tons per day of organics (about 8 pounds per household per week, and taking into account the households that do not set out a cart). Hiltz uses the smaller side of the truck for organics and the larger side for curbside recycling. The challenge for Hiltz is that if the recycling side fills up first, they continue to collect organics until they have finished the route and then they return to collect the remaining recyclables. They report no issues with having one side or the other empty while one side is full. (A problem some predicted, but has not seemed to materialize).

Figure A-2. Hiltz Disposal Modified Split Body

[51] Personal Communication, Gretel Clark, Recycling Volunteer. August 22, 2013.

Many observers credit Gretel Clark, a Hamilton resident, with initially promoting the food scraps program.
In an article on the Harvest Power website, Ms. Clark offers the following insights:
Volunteers Make It Happen: *Gretel managed to jumpstart the Hamilton-Wenham organics program on a purely volunteer basis. The process she went through produced numerous lessons that will be of use to other communities looking to duplicate her success.*
Recruit and Inform: *For the second, broader pilot program, Gretel recruited dozens of "neighborhood captains" who took responsibility for knocking on doors and canvassing designated parts of town. Gretel armed these volunteers with maps, promotional letters and flyers, and encouraged them to get signatures of people who might be willing to participate in an organics recycling program. "Get a group of people who are willing to work hard," Gretel advises.*
Know the Lay of the Land: *Gretel took a hard look at what the two towns were already doing and tried to build on existing programs. Both Hamilton and Wenham had recently started recycling programs for paper, cardboard, metal, plastic and glass, for example. "Asking people to do one more level of recycling is not that difficult," she says, "especially if they already have visual and visceral knowledge" of what is being proposed.*
Power Players: *Gretel says it is critical to "get the ear of the decisionmakers" in town and to get their sympathy for a program. Lining up this type of support will go a long way when it comes to broader outreach and public support.*
Start a Campaign: *If there is a town vote required, Gretel says "a lot of publicity" will help, and organizing a formal push for that publicity will have great value. "Since the program has been underway, a lot of it is the demonstration effect," she says. "People see the green bins and wonder: 'why am I not a part of that?'"*
Love Your Hauler: *"You have to work closely with your hauler," she says, and recognizing the value of a good relationship is essential. A viable program has to have a place to take compostables, as well, she notes, so "make sure there is a convenient, affordable site where your hauler can bring the organics."*
Ones to Grow On: *Gretel's success did not come without its trials. The following are some of the obstacles she encountered, and how she addressed them.*
Finances: *Financing the bins, determining the haulers' fees and arranging for a place to take the compost are all initial challenges. The state DEP pitched in for not quite half of the bins, as did Brick Ends Farm, the hauler and some individual donors in town. The hauler waived the fees for the initial compost program, but now is being paid for the services. The hauler, in turn, pays the composter by the ton to accept the organic waste, and the composter provides free grade #1 screened compost to all the participants.*
Education: *Educating people about what this is takes time, Gretel says. "You have to go through the list of what's acceptable, get them to understand how easy it is, and to overcome the 'ick' factor," she says. Gretel set up a hotline (as an extension of the Town Hall number, which she listens to daily) that people can call anytime with concerns or to ask for in-house coaching. "It's a form of 'high-touch' response that is really important," she notes.*
Inertia: *Keeping a small committee of volunteers focused and motivated in the early stages can be difficult, especially given the standard demands of work and family. "You have to focus on the feedback you get from doing what's right for the environment – that should be enough to keep volunteers going as you push forward."*

Source: Harvest Power Website http://blog.harvestpower.com/superhero-gretel-clark-hamilton-wenham-ma/ accessed 3/21/13

Case Study B

Blue Bag Organics

Dedicated bags, Collected commingled

Key Lesson:	Randy's Sanitation is able to offer food scraps co-collected with trash using a dedicated compostable bag, thus reducing the need for a dedicated route for organics. Using a durable bag that withstands collection and compaction is the key component of this program.Participation can be difficult to measure in co-collected organics.
Population:	See Table A-1 below
Households Served:	See Table A-1 below
Contact:	Blue Bag Organics, Delano, Minnesota

Program Summary

Randy's Sanitation, a private hauler in Minnesota, offers a dedicated, branded co-collection of organics using dedicated "Blue Bags" (32-gallon specially-designed compostable bags). Residents separate allowable organics and place them into the specially designed bag, which is placed into a 32-gallon Blue Bag Organics container with a lid. Most households also receive a 2-gallon kitchen compost bucket. The program is very inclusive; as shown on the attached list of allowable materials (Figure A-2).

On collection day, residents are encouraged to hand-tie the Blue Bag and place it inside the regular refuse cart. After collection, the bags are transported to a Materials Recovery Facility (MRF) where they are separated manually and taken to a privately run compost facility.

The program is currently voluntary and subscription based. In a town where Randy's offers the service, a resident has to opt in and contact Randy's, who then sends out a starter kit, which includes the 32-gallon storage can, two boxes of bags, an in-house kitchen container, and liners. In many cases there is no net cost to the resident to participate, though in some cities Randy's charges a monthly fee to cover the cost of the container and the bags. The difference has to do with how Minnesota charges tax for recycling and how the town negotiated its deal with Randy's.

Randy's Sanitation is currently offering the program in a number of Minnesota cities, including Delano, Hanover, Loreto, Maple Plain, Medicine Lake, Medina, Minnetonka, Orono, Osseo, St. Bonifacius, Watertown, and Wayzata ranging in population from 376 to 18,680. Table A-1 Summarizes program data for these towns.

Figure A-2

City of Wayzata Garbage and Trash Service http://www.randyssanitation.com/residential/wayzata-overview/...

Randy's Environmental Services Sanitation & Recycling

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Residential > Wayzata Overview > Organics Recycling

search...

Wayzata

- Holiday Schedule
- Trash Service
- Recycling
- Organics Recycling
- Yard Waste
- Extra or Bulk Items
- Appliances/Electronics
- Document Destruction
- Public Drop Sites
- Hazardous Waste
- Temporary Dumpsters / Roll Offs
- Special Discounts & Incentives
- FAQ

Organics Recycling is as easy as one, two, three.

1. Collect your food scraps and food-soiled paper products.
2. Empty your food scraps & food-soiled paper products into the Blue Bag Organics composting system - a covered blue can that is lined with a Blue Bag Organics BPI-certified bag provided by Randy's.
3. Hand-tie your Blue Bag Organics can liner and place it inside your regular garbage cart for curbside pickup. We'll separate all Blue Bag Organics from the rest of the trash at our facility. Then off they'll go to a composting facility.

Food Scraps:

- Fruits & vegetables
- Meat, fish & bones
- Bread, pasta & baked goods
- Egg shells
- Dairy products
- Coffee Grounds

Food-soiled paper products:

- Paper towels & napkins
- Paper plates & cups
- Milk & juice cartons
- Pizza boxes/Egg cartons
- Boxes from frozen & refrigerated foods
- Waxed paper & paper containers
- Coffee filters & tea bags
- Fruits & vegetables
- Meat, fish & bones
- Bread pasta & baked goods
- Egg shells
- Dairy products
- Coffee Grounds

Other compostable items:

- Full vacuum cleaner bags
- Dryer lint
- Tissues & cotton balls
- Floral trimmings & house plants

What is not accepted?

- Styrofoam
- Plastics, glass or metal
- Foil-lined containers (juice boxes)
- Kitty litter & pet droppings
- Diapers & wipes
- Grass, leaves & brush

Blue Bag Organics

SOURCE SEPARATED ORGANICS

BlueBagOrganics.com

Click here to learn more about our Blue Bag Organics program

Click Here to contact us with any questions or service requests.

Table A-1 Blue Bag Organics Preliminary Program Data

Town	Population[52]	Estimated Number of Households[53]	Estimated Number of Subscribers	Estimated Subscriber Rate
Delano	5,541	2,052	221	11%
Hanover	2,980	1104	9	1%
Loretto	658	244	47	19%
Maple Plain	1,792	664	102	15%
Medicine Lake	376	139	30	22%
Medina	4,963	1,838	232	13%
Minnetonka	50,435	18,680	451	3%
Orono	7,543	3,017	48	2%
Osseo	2,463	912	n/a	n/a
St. Bonifacius	2,315	857	n/a	n/a
Watertown	4,278	1,584	12	1%
Wayzata	3,740	1385	324	23%

It should be noted that most of these programs are very new and have less than one year of experience. Most organics programs take several years to mature. Also, Minnesota is currently developing its state Master Plan which is expected to require mandatory organics collection by 2030. In the meantime, these programs are voluntary and subscription based. But one should not put too much emphasis on the subscription rate until more time has passed.

As mentioned earlier, Randy's is just starting to look at participation rates in these programs. Each driver is asked to mark on their route sheet whether or not a given household set out a Blue Bag on collection day. Once the bags are separated at the MRF, Randy's is weighing that material to add to their data gathering. However, at this point the data is too preliminary to disseminate. Also, each community has idiosyncrasies which may make it difficult to compare one city to another.

Randy's also offers commercial organics collection, which is typically completed with a dedicated organics truck. However, Randy's is currently in the process of transitioning their dedicated truck organics route to a Blue Bag program, again, to save on collection economics. Once transitioned, all commercial generators will place Blue Bags with organics in them into their regular trash dumpsters and the bags will be separated out at the MRF. Commercial organics rates are based on labor, disposal tonnage and hauling cost. While there are too many variables to generalize, Randy's does expect restaurants and other large food-generating businesses to have more weight in their trash (due to the food scraps) so there are real savings to be had by a business participating in the Blue Bag program.

[52] All population estimates, US Census Bureau

[53] Estimated using persons per household figure from US Census, dividing by total population, if there was no specific figure, 2.7 was used.

Case Study C

Ann Arbor Michigan

Co-collected Yard Trimmings and Food Scraps.

Key Lesson:	Ann Arbor is an example of a public entity collecting its own city's organics. The program was able to be offered at no cost to residents via co-collection with containerized yard trimmings.
Population:	114,000
Households Served:	27,000 single family homes
Contact:	Tom McMurtrie, Solid Waste Coordinator

Program Summary

Since 2008, the City of Ann Arbor has offered residents an option to purchase a cart, which can be used for both yard trimmings and food scraps. Carts are purchased individually, but managed by the City's Customer Service Center. The cost of the carts is a one-time $50 charge regardless of size (32-, 64- and 96-gallon containers are available). The carts are collected seasonally – April 1st through mid-December. During the off-season, residents are encouraged to use their cart as a home composting bin/storage device (see Figure A-3).

During the season, the City uses fully-automated trucks capable of grabbing the carts and emptying them into the truck along a dedicated route. The City's program is one of the few municipal food scraps collection programs that is relatively exclusive. The City accepts fruit and produce waste but does not encourage food soiled paper, pizza boxes, or compostable service ware; they discourage kitty litter and diapers.

The City pays $18.50 per ton to compost. The City-owned compost facility is currently operated under contract by We Care Organics (New York). City staff report no additional costs to residents in implementing the program. The City will be expanding the range of materials accepted over the next year. Unfortunately the City has little reliable data on participation given that it is challenging to measure participation in co-collected routes. An adequate survey of set-outs would require a person to "flip-the-lid" of each yard trimmings cart to determine if the cart contained any food. To date the City has not invested in this type of analysis. Also, the City implemented the food scraps program somewhat simultaneously with a program which discourages leaf collection, thus yard trimmings volumes have gone down (but not as a result of the food scraps program).

While City staff might like to recommend making the program mandatory, they do not feel this is politically feasible at this time. Ann Arbor did recently pass a resolution becoming a "Zero Waste City" which provides some additional motivation to residents to participate in the program.

Figure A-3

Storing food scraps over the winter for spring compost pickup

Q: I like diverting my fruit, vegetable scraps and paper towels from the landfill by putting them into the compost cart during the growing season. What options are available for the 3½ winter months when the curbside compost collection program is dormant from mid-December to April 1st?

A: You can choose to keep putting your produce scraps in your compost cart over the winter! A few Ann Arbor residents piloted this notion and provided the following suggestions.

Place an opened paper yard-waste bag inside the compost cart to hold the food scraps.

★ Always keep food scraps buried under leaves or periodically *cover* food scraps with an inch of dirt (from the garden or bagged).

Or put 1-2 feet of leaves or a couple pieces of flattened cardboard (1-2 large pizza boxes are perfect) at the bottom of the compost cart before adding produce. This buffer at the bottom of the cart allows the materials to slide out more easily in the spring.

Hints:

Add a layer of leaves, a few sheets of shredded newspaper, or sprinkle a shovel-full of dirt/compost over the exposed produce to avoid odors or fruit flies.

Store fruit and vegetable scraps, coffee grounds, tea bags, paper towels, and uncoated paper plates and cups in a covered compost bucket on the counter to take out to the compost cart a few times a week. Use a commercial compost bucket, an opaque plastic storage container, or empty yogurt tub. Some people keep their scraps in the freezer to reduce the number of trips to the compost cart—think of the frozen storage as "vegetable soup fixings" instead of old food.

To keep the compost cart from getting messy, wrap drippy wet items (e.g., coffee grounds, melon rinds) in 1-2 sheets of old newspaper before putting into the compost cart.

If desired, rinse your compost cart in the spring with non-toxic soap and water and empty onto grass or gravel, not down the storm drain.

If your neighborhood has clever raccoons, secure all cart lids with a bungee cord. (Remove bungees while your carts are parked at the street for automated pickup.)

Using your cart over the winter as a home composting bin

"Advanced Master Gardener" Lisa Perschke uses her cart as a home composting bin over the winter. Her recipe: Fill cart 1/2 to 2/3rds with leaves (mower-mulched leaves work best, but this step is not necessary). Add 3-4 shovelfuls of dirt or finished compost and give the shovel a few turns to mix the dirt and tap water (approx 2-4 gallons) until the leaf mulch is as moist as a wrung-out sponge (drier leaves are better than sopping wet). Then just bury the food scraps into the leaf mulch throughout the winter. If the leaves become too frozen to dig, just put some extra leaves (or shredded paper, paper hand towels, napkins) as a top layer to keep the food covered. In April, roll the curb to the street for municipal pickup or empty the contents into your back yard to finish decomposing for a few more months. Always keep all exposed food waste covered. Add water and turn as needed to accelerate the decomposition or let sit as-is. The compost is 'done' when no food waste is visible, the color is dark brown and the texture is crumbly. Blend the finished, nutrient-rich compost into garden soil or spread over landscapes as a top dressing.

Ann Arbor's optional 33, 64, and 96-gallon compost carts are available for $50 from the Customer Service Center on the first floor of Larcom City Hall, open non-holiday weekdays from 8-5, 734.994.2807.
More information at www.a2gov.org/carts and www.a2gov.org/compost

Case Study D

Prince Edward Island, Canada

Dedicated Mandatory Organics

Key Lesson: Significant diversion can be accomplished with mandatory organics collection.

Population: 140,000 (all residents of the Provence, individual municipality populations range from less than 1,000 to over 30,000

Households Served: All

Contact: Heather Myers, Island Waste Management Corporation

Program Summary

Prince Edward Island, on the eastern shore of Canada's Maritime Provinces, developed an extensive integrated organics collection and recycling program in 2002 as a response to groundwater concerns on the island (the island is entirely dependent on groundwater for drinking water supplies). The comprehensive, mandatory program (called Waste Watch) is administered by the Island Waste Management Corporation (IWMC), a quasi-public agency. IWMC provides biweekly collection of organics and trash and monthly collection of recyclables. The organics program is provided to every resident and business on the Island. Each household receives both a dedicated organics cart and a smaller "kitchen container" for household organics. Although individual organics program statistics were not available, the program claims a 64% residential diversion rate, with organics setouts being greater than trash setouts. All organics are composted using an enclosed, aerated static pile composting system operated by a private company (ADI).

The largest towns on Prince Edward Island are shown in the adjacent table based on 2011 data. The population ranges from less than 1,000 to over 30,000 and is relatively dispersed over the 2,000 square miles of the Province.

Town	Population*
Alberton	1,081
Charlottetown	32,545
Cornwall	5,375
Georgetown	678
Kensington	1,385
Montague	5,134
Stratford	8,043
Summerside	15,654
Tignish	998

The organics program is the most comprehensive and inclusive of the four programs profiled in this report. They have a very detailed, web-based, interactive sorting guide which goes into great detail on what materials go in what bin. This is critical with such an inclusive and mandatory program. A graphic representation of this is shown as Figure A-4; however, the figure only shows a portion of the items that are included in the program.

Figure A-4, Page 1 of 2

Figure A-4, Page 2 of 2

Appendix B

Preliminary Process Design for Aerated Static Pile Composting

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Project	ecomaine Organics Feasibility Study	**Proj. No.**	12-1140
Client	Northern Tilth	**Date**	4/5/2013
Analysis	Recipe - Central Composting Facility		rev. 5/17/13

Assumptions:

1. Estimated current total tonnage of SSO is	12,000	tons/yr
2. Assume facility is open 5 days/week		
3. Estimated daily tonnage of food scraps	46.2	tons/day

MIX RATIO CALCULATIONS - Daily

INGREDIENTS	SSO	Carbon Amendment	Compost Recycle	Overs	TOTAL MIX	TARGET
C (% AS IS)	43.7	49.2	13.2	50.1		
N (% AS IS)	2.2	0.9	1.0	1.0		
MOISTURE%	71.5	40.1	45	45		
UNITS IN MIX BY WGT (T)	46.2	15.0	5.0	4.7	70.9	
UNITS IN MIX BY WGT (LB)	92,308	30,000	10,000	9,400	141,708	
UNITS IN MIX BY VOL (CY)	77.2	57.4	11.1	18.8	164.5	
DENSITY (LBS/CY)	1196	522.5	900	500		
POUNDS OF CARBON	40,338	14,748	1,320	4,709	61,116	
POUNDS OF NITROGEN	2,031	279	100	93	2,503	
C:N RATIO	19.86	52.86	13.20	50.61	**24.42**	20 TO 30
POUNDS OF MOISTURE	66,000	12,030	4,500	4,230	86,760	
NUMBER OF UNITS	92,308	30,000	10,000	9,400	141,708	
PERCENT MOISTURE					**61.22**	50 TO 65%
VOLATILE SOLIDS (%)	87.4%	98.3%	44.2%	98.3%		
VOLATILE SOLIDS (LBS)	80,677	29,490	4,420	9,240	123,827	
TOTAL MASS (LBS)	92,308	30,000	10,000	9,400	141,708	
MIX VS (%)					**87.4%**	> 90%
DENSITY (LBS/CY)	1196	522.5	900	500		
DENSITY (KG/M3)	709.6	310.0	533.9	296.6		
% AIR SPACE	36.14	72.10	51.94	73.30		
FEEDSTOCK VOLUME (CY)	77.2	57.4	11.1	18.8	165	
AIR VOLUME (CY)	27.9	41.4	5.8	13.8	88.8	
PREDICTED FREE AIR SPACE					**54.0%**	40-60%

Data sources:

Predicted Free Air Space equation from Alburquerque, J.A., et. al., "Air Space in Composting Research: A Literature Review", *Compost Science and Utilization*, Vol. 16, No. 3, 2008, p. 159-170

Feedstock volatile solids - Komilis, D.P. & R.K. Ham, "The effect of lignin and sugars to the aerobic decomposition of solid wastes", *Waste Management*, Vol. 23, 2003, p. 419-423

Food Scraps C, N, Moisture, VS, Density - April 2011 lab analysis of diverted food scraps, Asheville, NC

Carbon Amendment C, N, Moisture, VS, Density - Sept. 2009 lab analysis of yard trim, Lancaster County, PA

Compost Recycle C, N, Moisture, VS, Density - Jan 2012 lab analysis of food scraps compost

Overs C, N, Moisture, VS, Density - June 2011 lab analysis from poultry composting facility

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Project	ecomaine Organics Feasibility Study	**Proj. No.**	12-1140
Client	Northern Tilth	**Date**	4/5/2013
Analysis	PFD - Central Composting Facility		

Assumptions:
1. Facility is open 5 days/week, 52 weeks/year
2. Facility will use aerated static pile composting with negative aeration
3. Exhaust air to be treated with biofilter

Waste Generation Quantities

1. Daily quantities

SSO	57.7	tons/day
Carbon Amendments	40.0	tons/day
Screened Compost (inoculant)	12.0	tons/day
Screen overs (bulking agent)	8.8	tons/day
Total Daily Tonnage	118.5	tons/day
Total Annual Tonnage	36,969.6	tons/year

2. Daily Volumes (ground up)

SSO	96.5	CY/day
Carbon Amendments	153.1	CY/day
Screened Compost (inoculant)	26.7	CY/day
Screen overs (bulking agent)	35.2	CY/day
Total Daily Volumes	311.5	CY/day
Total Annual Volume	97,173	CY/year

Composting Materials Flows

1. Residence times for ASP composting (winter conditions)

	Composting	Curing	Total
ASP	30 days	60 days	90 days

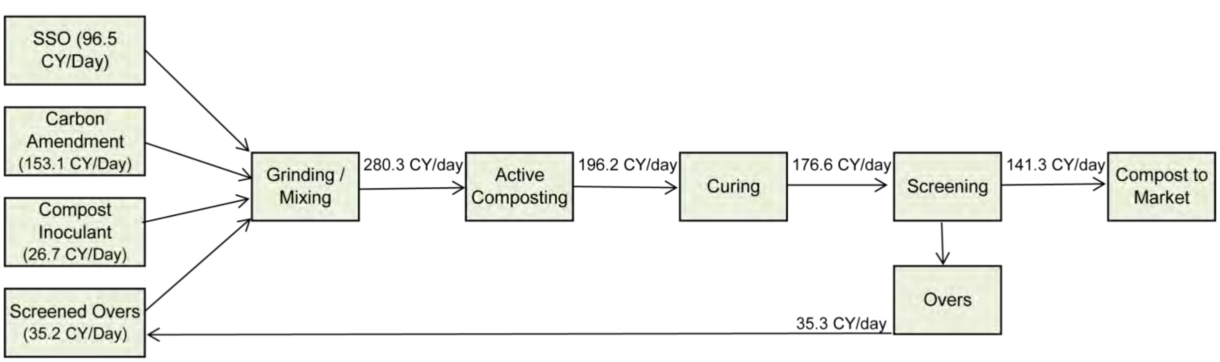
2. Daily Volumes going to composting (assume 10% volume loss in grinding/mixing)
   Daily volumes of mixed feedstocks = 280.3 CY/day
3. Volume of material in Primary Composting

	Residence Days	Mixed feedstocks
ASP	30	8,409 CY

4. Daily Volumes going to curing (assume 30% volume shrink in composting)
   Daily volumes of composted feedstocks = 196.2 CY/day
5. Volume of material in Curing (Secondary Composting):

	Residence Days	Composted Feedstocks
Windrow	60	11,773 CY

6. Daily Volumes going to screening (assume 10% volume shrink in curing):
   Daily volumes of cured feedstocks = 176.6 CY/day
7. Screening
   a. Assume approx. 80% finished compost capture rate and 20% going to overs
   b. Finished compost production (daily):
      Daily volumes of screened compost = 141.3 CY/day
      Daily volumes of overs (mulch) = 35.3 CY/day



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Project	ecomaine Organics Feasibility Study	**Proj. No.**	12-1140
Client	Northern Tilth	**Date**	4/5/2013
Analysis	Central Composting Facility - ASP Sizing		

Assumptions:
1. Facility is open 5 days/week, 52 weeks/year
2. Facility will use aerated static pile composting in concrete block bins with negative aeration
3. Exhaust air to be treated with biofilter

Waste Generation Quantities

1. Daily quantities

Food Scraps & Seafood Wastes	57.7	tons/day
Carbon	40.0	tons/day
Screened Compost (inoculant)	12.0	tons/day
Screen overs (bulking agent)	8.8	tons/day
Total Daily Tonnage	118.5	tons/day
Total Annual Tonnage	36,969.6	tons/year

2. Daily Volumes (ground up)

Food Scraps & Seafood Wastes	96.5	CY/day
Carbon	153.1	CY/day
Screened Compost (inoculant)	26.7	CY/day
Screen overs (bulking agent)	35.2	CY/day
Total Daily Volumes	311.5	CY/day
Total Annual Volume	97,173	CY/year

Composting Materials Flows

1. Residence times for ASP composting (winter conditions)

	Composting	Curing	Total
ASP	30 days	60 days	90 days

2. Daily Volumes going to composting (assume 10% volume loss in grinding/mixing)
   Daily volumes of mixed feedstocks = 280.3 CY/day
3. Volume of material in Primary Composting

	Residence Days	Mixed feedstocks
ASP	30	8,409 CY

4. Daily Volumes going to curing (assume 30% volume shrink in composting)
   Daily volumes of composted feedstocks = 196.2 CY/day
5. Volume of material in Curing (Secondary Composting):

	Residence Days	Composted Feedstocks
Windrow	60	11,773 CY

6. Daily Volumes going to screening (assume 10% volume shrink in curing):
   Daily volumes of cured feedstocks = 176.6 CY/day
7. Screening
   a. Assume approx. 80% finished compost capture rate and 20% going to overs
   b. Finished compost production (daily):
      Daily volumes of screened compost = 141.3 CY/day
      Daily volumes of overs (mulch) = 35.3 CY/day

Feedstocks Receipt/Storage Sizing Calculations

1. Feedstock Receipts
   a. Assume daily delivery of feedstocks with 1 day storage capacity
   b. Assume 2 days storage inventory of amendments inside bldg.
   c. Assume all deliveries by SSO collection or dump truck
      Truck Unloading Area = 30 ft. W
      30 ft. L
2. Ground Amendments storage
   a. Volumes - assume 2 days storage

	Daily	Total
Carbon	153.1 CY	306 CY
Screened Compost (inoculant)	26.7 CY	53 CY
Screen overs (bulking agent)	35.2 CY	70 CY
		430 CY

b. Assume amendments stored separately	
c. Assume maximum amendment depth of	8 ft
d. Footprint of carbon storage bin	1033.5 SF
Assume bin width of	20 ft
Calculated bin length	52 ft
Carbon Amendments Storage Bin =	20 ft. W
	52 ft. L
	8 ft. D
e. Footprint of compost storage bin	180.0 SF
Assume bin width of	12 ft
Calculated bin length	15 ft
Compost Amendments Storage Bin =	12 ft. W
	17 ft. L
	8 ft. D
f. Footprint of overs storage bin	237.6 SF
Assume bin width of	12 ft
Calculated bin length	20 ft
Overs Amendments Storage Bin =	12 ft. W
	21 ft. L
	8 ft. D

Feedstock Mixing

1. Daily Mix Volumes	
a. SSO	96.5 CY/day
b. Amendments	215.0 CY/day
Total	311.5 CY/day
2. Daily mixing volume needed	311.5 CY/day
3. Mixing	
a. Assume mixing with small horizontal grinder (Vermeer HG200)	
b. Assume 10% volume loss in mixing	
c. Daily volume going to composting	280 CY/day
4. Footprint of grinder is 20' L x 7' W so area needed =	30 ft W
	80 ft L

Active Composting

1. Composting residence time	30 days/cycle
2. Total volume in composting during 1 cycle	9,344 CY/cycle
3. Assume one ASP bin filled twice per week	
Bin volume	701 CY/bin
4. Assume ASP bin height =	8 ft
5. Footprint of each ASP =	2,365 SF
6. Assume ASP bin width =	24 ft
7. Calculated ASP bin length =	99 ft
8. Number of ASP bins in each cycle:	
Total volume in cycle/ vol of each bin	14 bins/cycle
9. Area of active composting	33,111 SF
10. Assume 7 bins on each side of open floor in bldg.	
11. Area Needed	
Width: (7 x 24' W) + (8 x 2' W walls)	184 ft W
Length: 99' L x 2 + 50' aisle	247 ft L
12. Composting Space Allocation	200 ft W
	250 ft L

Composting Aeration System

1. Volume of each bin	701	CY
2. Assumed bulk density of compostables	1,100	lbs/CY
3. Wet tonnage in each bin	385.4	wet tons
4. Assumed pile moisture content	50	%
5. Dry tonnage in each bin	192.7	dry tons
6. Aeration rate	1000	CFH / dry ton
7. Aeration needed for each bin	192,711	CFH
8. Fan Air Flow needed	3,212	CFM/bin
Maximum Air Flow @ 6" W.C.	3,500	CFM/bin

Condensate Removal

1. Assume air stream is 100% saturated		
2. Volume of each bin	701	CY/bin
3. Assumed bulk density	1,100	lbs/CY
4. Weight of compostables in each bay	770,844	lbs
5. Assume moisture content =	50%	
6. Weight of water in each bay's batch =	385,422	lbs
7. Assumed moisture content at completion	40%	
8. Weight of water in each bay's batch at completion =	308,338	lbs
9. Water loss	77,084	lbs
10. Assume 30% evaporates out of pile when fan off	23,125	lbs
11. Remaining moisture migrating out through aeration system	53,959	lbs
12. Convert to gallons at 8.34 lbs/gal	6,470	gal
13. Daily production assuming a 30-day cycle	216	gal/day/bin

Biofilter System

1. Assume gas retention time =	60	sec
2. Air flow to biofilter from all bins	49,000.0	CFM
3. Required biofilter volume	49,000	CF
4. Assumed biofilter depth =	4	ft
5. Assumed biofilter footprint =	12250	SF
6. Biofilter dimensions =	100	ft W
	122.5	ft L

Curing System

1. Assumed volume loss in composting	30	%
2. Volume of each ASP bin going to curing	491	CY/bin
3. Number of ASP bins going to curing monthly	14	bins
4. Total volume going to curing monthly	6,868	CY
5. Assumed curing residence time	2	months
6. Total volume in curing per cycle	13,735	CY/cycle
7. Assume cure pile turned with loader with 8 CY bucket		
8. Assumed cure pile height	8	ft
9. Footprint of cure pile	46,356	SF/cycle
10. Assume curing done in static pile in building		
14. Area Needed	150	ft W
	310	ft L

Screening System

1. Assumed volume loss in curing	10	%
2. Monthly volume to screening	6,181	CY/month
3. Assumed percentage of "overs"	20%	
4. Monthly volume of screened compost to storage	5,254	CY/month
5. Monthly volume of overs to storage	927	CY/month
6. Assume use of a 6' x 16' trommel		
a. Dimensions: 50' L x 8' W		
7. Area Needed	25	ft W
	100	ft L

Product Storage

1. Assumed winter storage period	5	months
2. Volume going to storage in winter	26,268	CY
3. Assumed storage pile height	8	ft
4. Storage pile footprint	88,655	SF
5. Assume storage in building		
6. Area Needed	200	ft W
	450	ft L

Area Summary

Process	Width (ft.)	Length (ft.)	Area (sq. ft.)	Area (acres)
Inside Building				
Truck Unloading Area	30	30	900	0.02
Carbon Amendments Storage	20	52	1,033	0.02
Compost Inoculant Storage	12	17	204	0.00
Overs Storage	12	21	250	0.01
Mixing	30	80	2,400	0.06
Composting Area	200	250	50,018	1.15
Curing Area	150	310	46,500	1.07
Screening Area	25	100	2,500	0.06
Product Storage Area	200	450	90,000	2.07
	Total		193,805	4.45
Outside Behind Building				
Biofilter	100	123	12,250	0.28
	Total		12,250	0.28

Appendix C

Compost Operation Closures in Maine

Composting Operation Closures in Maine

Composting is a time-tested, effective means for transforming organic wastes into nutrient-rich soil amendments that can be used in a wide variety of applications. Under certain circumstances, though, the composting process does have the potential to cause nuisance odors and to negatively impact surface and groundwater quality. In Maine there are several examples of composting operations that have been forced to shut down based on odor, air quality and/or water quality concerns. The following is a short summary of some of these operations, each of which was closed down due to a unique set of site and operating conditions.

Winterwood Compost Facility, Lyman, Maine

This compost facility, which accepted food and seafood processing wastes, horse manure and other organic materials, operated from 1997 through 2009. Throughout the history of the facility, the operation received ongoing odor complaints from neighbors and notices of violations (NOVs) from the Maine Department of Environmental Protection (ME DEP) related to controlling the quality of surface water in the vicinity of the composting operation. ME DEP documented surface water contamination directly attributable to the operation, and the owner/operator of the facility was generally unwilling to make changes necessary to prevent the water quality impacts. The case ended up with a Consent Decree, several court dates and ultimately the closure of the facility. **Source**: ***Winterwood Compost Facility, Lyman, Maine: Chronology of Events*** *written by the ME DEP.*

Glowood Farm, Yarmouth, Maine

This was a short-lived composting operation in Yarmouth, Maine in the 1990s. The couple that owned and operated Glowood Farm received a permit to compost food waste. They took in food waste but did not manage it according to typical compost management standards; the food waste was not blended with other amendments, and the piles were not turned. There was a neighbor within 50' of the composting pad, and the piles generated a lot of odor, volatile organic acids and leachate. In hindsight it appears that the couple did not have the resources to either compost the feedstocks adequately, or to address odor issues as they came up. Ultimately, the Town of Yarmouth ended up providing equipment and labor to clean up the site. **Sources**: *Bill Shane, Cumberland Town Manager (formerly with the Town of Yarmouth) and Mark King, ME DEP.*

South Portland, Maine Biosolids Composting Operation

The City of South Portland operated a biosolids composting operation, consisting of windrow composting within a building. Process air from the building was captured and directed through a biofilter to control odor. By most accounts the composting operation was well managed and appropriately sized. The setback distance from neighboring residences proved to be too short, especially as residential development began to fill in around the facility. Ultimately, complaints from nearby residents, mostly related to odors, led to the closure of the facility. **Source**: *Mark King, ME DEP.*

Bangor, Maine Biosolids Composting Operation

The City of Bangor operated a biosolids composting operation that was located adjacent to the municipal airport. This composting operation used aerated static pile (ASP) technology. Pigeons were attracted to the piles, possibly because undersized blowers provided inadequate aeration, leading to more odors than would be emitted in a more heavily aerated system. Due to the potential for the birds to interfere with airport operations, the operation was closed down. **Source**: *Mark King, ME DEP.*

Appendix D

Preliminary Source Separated Organics (SSO) Sorting System Mass Balance, Layout, and cost Estimate

D&B Engineers and Architects, P.C. 2013

D&B ENGINEERS AND ARCHITECTS, P.C.

KNOWN AS DVIRKA AND BARTILUCCI CONSULTING ENGINEERS

3000 Hadley Road, South Plainfield, New Jersey 07080

908-668-4747 • Fax: 908-668-4658 • www.dvirkaandbartilucci.com

October 7, 2013

Kevin Roche
Executive Director
64 Blueberry Road
Portland, Maine 04102

Re: Final Report on Preliminary Source Separated Organics ("SSO") Sorting System Mass Balance, Layout and Cost Estimate

Dear Mr. Roche:

D&B Engineers and Architects, P.C. ("D&B") is pleased to submit this final Report to ecomaine. We greatly appreciate the opportunity to provide our services to ecomaine; and look forward to working under your direction in the future.

Yours truly,

Ted Pytlar

Theodore S. Pytlar, Jr.
Vice President-Solid Waste Group

TSP/ss
Enclosure
cc: Kevin Trytek
Andrew Carpenter
Craig Coker

ecomaine
the future of regional waste systems

PRELIMINARY SOURCE SEPARATED ORGANICS ("SSO") SORTING SYSTEM MASS BALANCE, LAYOUT AND COST ESTIMATE

Prepared By:

D&B Engineers and Architects, P.C.

October 7, 2013

DVIRKA AND BARTILUCCI
CONSULTING ENGINEERS
A DIVISION OF D&B ENGINEERS AND ARCHITECTS, P.C.

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PRELIMINARY SOURCE SEPARATED ORGANICS ("SSO") SORTING SYSTEM MASS BALANCE, LAYOUT AND COST ESTIMATE

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LIST OF EXHIBITS

SECTION 1.0

1.0 INTRODUCTION

The attached mass balance analysis, revised preliminary system layout, and cost estimate by D&B Engineers and Architects, P.C. ("D&B") are based upon the following sources of information:

1. The Report, Organics Recycling Feasibility Study – Task 1: Organic Waste in the ecomaine Service Area, May 8, 2013, prepared by Northern Tilth.

2. The Resource Recovery Facility ("RRF") inspection and meeting with ecomaine and Northern Tilth on July 8, 2013, and follow-up discussions.

3. A review of the RRF design drawings provided by ecomaine.

4. Information regarding the cost to construct the Ash Building at the ecomaine RRF and labor costs for equipment operators and sorters at the ecomaine Materials Recovery Facility (MRF").

5. Preliminary quotations from recycling systems suppliers for the SSO sorting equipment shown in the revised preliminary layout.

SECTION 2.0

2.0 MASS BALANCE AND PRELIMINARY LAYOUT

1. **Draft mass balance**. The mass balance analysis (Attachment 1) provides estimates for the required processing capacity of the system and required sorting rates for Source Separated Organics ("SSO") bags at a the low end, mid range, and high end municipal participation rates. The municipal participation rates were obtained from the Northern Tilth Report. SSO sorting rates (bags per hour) were estimated using daily processing schedules of 2, 4, 6, and 8 hours in order to estimate the number of sorters required to separate SSO bags from the mixed loads of SSO and trash to be processed. The preliminary layout provides 6 sorting stations for SSO bags. The 6 stations will be capable of sorting the SSO bags in the following scenarios:

	Daily Sorting Hours			
	8	**6**	**4**	**2**
Low End	Yes	Yes	Yes	No
Mid Range	Yes	Yes	No	No
High End	Yes	No	No	No

Therefore, it appears that it will be necessary to operate the system for 4 or more hours per day under all participation levels.

The preliminary layout provides 4 sorting stations for contaminants and recyclables. The sorting rates for SSO contaminants using 4 sorters were also estimated in the mass balance analysis. These estimates indicate that the preliminary layout would be adequate to sort the contaminants and some recyclables.

2. **Revised preliminary SSO sorting system layout**. The layout drawings (Attachment 2) display a system that includes the following:

- Building footprint.
- Push walls.
- Tipping area.
- Infeed hopper.

- Drum feeder.
- SSO bag sorting.
- Bag opening.
- Bag removal.
- SSO contaminants sorting.
- Recyclables sorting.
- Sorting booths.
- Trash, empty SSO bags, and contaminants return to the RRF tipping floor.
- Loading of SSO and recyclables into haul vehicles.

The preliminary layout was reviewed with ecomaine and its consultants, Northern Tilth, and Coker Consulting. Comments received were incorporated into the layout.

A description of the sorting sequence is included in the notes to the drawings.

D&B's Scope of Work states that up to 3 options will be studied. The preliminary drawings submitted can be modified for the following potential options:

1. The system layout could also be utilized to only sort SSO bags without bag opening and contaminants sorting, through elimination of the bag breaker, film remover, and sorting stations. This would also eliminate recyclables sorting from the SSO bag contents. Although sorting of loose recyclables could occur. The option to install these features at a later date can be retained. Section 3.0 of this Report includes construction and operations and maintenance costs for the system without the bag breaker and film sorting system.

2. The layout depicts the largest structure that can fit onto the available area adjacent to the RRF tipping hall. Elimination or reducing the size of the storage area would reduce the size and cost of the structure. The height of the structure

could also be reduced by lowering the elevation of the sorting conveyors A and B. The preliminary layout places them at the same height as the pushwall, which is 15 feet. The stockpiling capacity of the storage area with the 15 foot high pushwall is approximately 340 tons (Attachment 1). It is approximately 220 tons with a ten foot high pushwall.

3. There are also options to be considered for the bag opening and film removal functions. The revised preliminary drawings depict automated equipment. However, a simpler approach may be evaluated, wherein bag opening is achieved by a trommel with "breaker bars" and without wall perforations. Film removal would be manual, wherein a sorter would pull the film following the trommel and place it onto the film conveyor. The preliminary estimates of construction and operations costs for an SSO sorting system employing a trommel are provided in Attachment 3.

SECTION 3.0

3.0 COST ESTIMATES

Preliminary cost estimates for design, permitting, construction, operations, and maintenance are presented below.

3.1 Construction Cost

Exhibits 3-1a and 3-1b display the preliminary construction cost estimates. The processing system cost shown in the mechanical category was developed based upon quotations received from 3 system suppliers, Sherbrooke, Van Dyk Baler, and Bezner. The preliminary layout was submitted to the suppliers in order to obtain the quotations. The equipment cost quotations for systems with and without an automated bag breaker and film plastic sorting system were as follows.

	With Bag Breaker/Film Sorting	Without Bag Breaker/Film Sorting
Sherbrooke	$625,000	$275,000
Van Dyk Baler	$1,000,000	$575,000
Bezner	424,242 Euros ($562,893)	219,375 Euros ($291,100)

The quotations do not include shipping, installation, controls, or testing.

The median (Sherbrooke) of the 3 was utilized to develop the cost estimate in Exhibit 3-1a. In order to assess the cost of the SSO system, wherein intact SSO bags would be delivered to the end users, quotations were also obtained for the system without the bag breaker and film sorting system. Exhibit 3-1b provides this cost estimate, also using the Sherbrooke quotation.

The preliminary estimated cost of the SSO system (from Exhibit 3-1a) is compared to the final cost of the Ash Building in Exhibit 3-1c. The per square foot cost of the Ash Building is substantially greater than the SSO system. This is primarily due to the greater cost of the ash processing equipment in comparison to the SSO sorting system.

Exhibit 3-1a

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR SOURCE SEPARATED ORGANICS SORTING SYSTEM (with bag breaker/film sorting system)

Description	Quantity	Unit	Unit Price	Total Cost
Demolition				
Metal Walls				
100 x 40 High	4,000	Square Feet	$15.00	**$60,000.00**
Concrete Floor				**$0.00**
8 x 120	960	Square Feet	$10.00	**$9,600.00**
Foundations				
70 x 8	560	Square Feet	$10.00	**$5,600.00**
Site Work				
122 x 60 x 8	2,169	Cubic Yards	$15.00	**$32,535.00**
Soils				**$0.00**
SUBTOTAL				**$107,735.00**
Site Work				
Grading	1	Lump Sum	$50,000.00	**$50,000.00**
Drainage	1	Lump Sum	$25,000.00	**$25,000.00**
Relocate Utilities	1	Lump Sum	$25,000.00	**$25,000.00**
Utility Connections	1	Lump Sum	$10,000.00	**$10,000.00**
Paving	1	Lump Sum	$25,000.00	**$25,000.00**
SUBTOTAL				**$135,000.00**
Concrete				
Foundation				
510 x 4 x 1/27	76	Cubic Yards	$560.00	**$42,560.00**
Walls				
8372 + 2700/27	410	Cubic Yards	$560.00	**$229,600.00**
Floors				
122 x 60/27	271	Cubic Yards	$560.00	**$151,760.00**
30 x 122 + 30 x 30/27	170	Cubic Yards	$560.00	**$95,200.00**
122 x 30/27	136	Cubic Yards	$560.00	**$76,160.00**
SUBTOTAL				**$595,280.00**

(Continued)

Exhibit 3-1a

Description	Quantity	Unit	Unit Price	Total Cost
Metal				
Building Walls				
15 x 60 + 122 + 60 + 20	3,930	Square Feet	$100.00	**$393,000.00**
15 x 60	900	Square Feet	$100.00	**$90,000.00**
Roof		Square Feet		
60 x 120 Main	7,320	Square Feet	$50.00	**$366,000.00**
60 x 20 Truck Area	1,200	Square Feet	$50.00	**$60,000.00**
Roofing Members	1	Lump Sum	$25,000.00	**$25,000.00**
Structure Supports at Tipping Floor	1	Lump Sum	$10,000.00	**$10,000.00**
Sorting Booth				
122 x 10	1,220	Square Feet	$120.00	**$146,400.00**
Outside Stairs	1	Lump Sum	$2,000.00	**$2,000.00**
SUBTOTAL				**$1,090,400.00**
Mechanical				
Processing System	1	Lump Sum	$625,000.00	**$625,000.00**
Shipping and Installation Labor	1	Lump Sum	$400,000.00	**$400,000.00**
HVAC Sorting Booth/Dust Control	3,660	Square Feet	$32.82	**$120,121.20**
Fire Protection	8,520	Square Feet	$15.00	**$127,800.00**
SUBTOTAL				**$1,272,921.20**
Electrical				
Electrical and Instrumentation (8%)	1	Lump Sum	$300,000.00	**$300,000.00**
SUBTOTAL				**$300,000.00**

(Continued)

Exhibit 3-1a

Description	Quantity	Unit	Unit Price	Total Cost
Landfill Disposal				
Landfill Disposal				**$0.00**
SUBTOTAL				**$0.00**
ALL ITEMS SUBTOTAL				**$3,501,336.20**
Building Permits (0.40%)				**$14,005.34**
Builders Risk Insurance (0.25%)				**$8,753.34**
General Liability Insurance (1.50%)				**$52,520.04**
General Contractors Bonds (1.0%)				**$35,013.36**
SUBTOTAL				**$3,611,628.29**
General Contractors OH&P (15%)				**$541,744.24**
SUBTOTAL				**$4,153,372.53**
General Contingency (25%)				**$1,038,343.13**
TOTAL CONSTRUCTION COST				**$5,191,715.67**
Engineering (10%)				**$519,171.57**
Services During Construction (2.5%)				**$129,792.89**
TOTAL PROJECT				**$5,840,680.13**

Notes:

1. Lump sum pricing was based upon pricing experience from recent projects.

2. Square foot pricing used for the HVAC and Fire Protection were taken from the cost estimate of the Ash Building.

3. If sorting floor elevation was set at 10 feet and not 15 feet high, concrete pricing would be reduced.

4. Concrete pricing ($/cubic yard) was verified by Mr. Peter Nostrand – Telephone Number: (603) 530-2871). This contact was obtained from Mr. Andrew Tilth.

Exhibit 3-1b

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR SOURCE SEPARATED ORGANICS SORTING SYSTEM (without bag breaker/film sorting system)

Description	Quantity	Unit	Unit Price	Total Cost
Demolition				
Metal Walls				
100 x 40 High	4,000	Square Feet	$15.00	**$60,000.00**
Concrete Floor				**$0.00**
8 x 120	960	Square Feet	$10.00	**$9,600.00**
Foundations				
70 x 8	560	Square Feet	$10.00	**$5,600.00**
Site Work				
122 x 60 x 8	2,169	Cubic Yards	$15.00	**$32,535.00**
Soils				**$0.00**
SUBTOTAL				**$107,735.00**
Site Work				
Grading	1	Lump Sum	$50,000.00	**$50,000.00**
Drainage	1	Lump Sum	$25,000.00	**$25,000.00**
Relocate Utilities	1	Lump Sum	$25,000.00	**$25,000.00**
Utility Connections	1	Lump Sum	$10,000.00	**$10,000.00**
Paving	1	Lump Sum	$25,000.00	**$25,000.00**
SUBTOTAL				**$135,000.00**
Concrete				
Foundation				
510 x 4 x 1/27	76	Cubic Yards	$560.00	**$42,560.00**
Walls				
8372 + 2700/27	410	Cubic Yards	$560.00	**$229,600.00**
Floors				
122 x 60/27	271	Cubic Yards	$560.00	**$151,760.00**
30 x 122 + 30 x 30/27	170	Cubic Yards	$560.00	**$95,200.00**
122 x 30/27	136	Cubic Yards	$560.00	**$76,160.00**
SUBTOTAL				**$595,280.00**

(Continued)

Exhibit 3-1b

Description	Quantity	Unit	Unit Price	Total Cost
Metal				
Building Walls				
15 x 60 + 122 + 60 + 20	3,930	Square Feet	$100.00	**$393,000.00**
15 x 60	900	Square Feet	$100.00	**$90,000.00**
Roof		Square Feet		
60 x 120 Main	7,320	Square Feet	$50.00	**$366,000.00**
60 x 20 Truck Area	1,200	Square Feet	$50.00	**$60,000.00**
Roofing Members	1	Lump Sum	$25,000.00	**$25,000.00**
Structure Supports at Tipping Floor	1	Lump Sum	$10,000.00	**$10,000.00**
Sorting Booth				
122 x 10	1,220	Square Feet	$120.00	**$146,400.00**
Outside Stairs	1	Lump Sum	$2,000.00	**$2,000.00**
SUBTOTAL				**$1,090,400.00**
Mechanical				
Processing System	1	Lump Sum	$275,000.00	**$275,000.00**
Shipping and Installation Labor	1	Lump Sum	$300,000.00	**$300,000.00**
HVAC Sorting Booth/Dust Control	3,660	Square Feet	$32.82	**$120,121.20**
Fire Protection	8,520	Square Feet	$15.00	**$127,800.00**
SUBTOTAL				**$822,921.20**
Electrical				
Electrical and Instrumentation (8%)	1	Lump Sum	$250,000.00	**$250,000.00**
SUBTOTAL				**$300,000.00**
ALL ITEMS SUBTOTAL				**$3,001,336.20**

(Continued)

Exhibit 3-1b

Description	Quantity	Unit	Unit Price	Total Cost
Landfill Disposal				
Landfill Disposal				**$0.00**
SUBTOTAL				**$0.00**
SUBTOTAL				**$3,001,336.20**
ALL ITEMS SUBTOTAL				**$3,001,336.20**
Building Permits (0.40%)				**12,005.34**
Builders Risk Insurance (0.25%)				**$7,503.34**
General Liability Insurance (1.50%)				**$33,913.36**
General Contractors Bonds (1.0%)				**$45,020.04**
SUBTOTAL				**$30,013.36**
General Contractors OH&P (15%)				**$3,095,878.29**
SUBTOTAL				**$464,381.74**
General Contingency (25%)				**$3,560,260.03**
TOTAL CONSTRUCTION COST				**$890.065.01**
Engineering (10%)				**$4,450,325.04**
Services During Construction (2.5%)				**445,032.50**
				111,258.13
TOTAL PROJECT				**$5,006,615.67**

Notes:

1. Lump sum pricing was based upon pricing experience from recent projects.

2. Square foot pricing used for the HVAC and Fire Protection were taken from the cost estimate of the Ash Building.

3. If sorting floor elevation was set at 10 feet and not 15 feet high, concrete pricing would be reduced.

4. Concrete pricing ($/cubic yard) was verified by Mr. Peter Nostrand – Telephone Number: (603) 530-2871). This contact was obtained from Mr. Andrew Tilth.

Exhibit 3-1c

COMPARISON OF PRELIMINARY CONSTRUCTION COST ESTIMATES FOR SOURCE SEPARATED ORGANICS SORTING SYSTEM AND ASH BUILDING COST

	Source Separated Organics Building	Ash Building Pricing
Demolition	$107,735.00	Not Included
Site Work	$135,000.00	$65,000.00
Concrete	$595,280.00	$600,000.00
Metal	$1,090,400.00	$700,000.00
Mechanical	$1,272,921.20	$2,055,000.00
Electrical	$300,000.00	$400,000.00
SUBTOTAL	**$3,451,336.20**	**$3,820,000.00**
Building Permits (0.40%)	**$14,005.34**	$15,000.00
Builders Risk Insurance (0.25%)	**$8,753.34**	$10,000.00
General Liability Insurance (1.50%)	**$52,520.04**	$55,000.00
General Contractors Bonds (1.0%)	**$35,013.36**	$40,000.00
SUBTOTAL	**$3,611,628.29**	**$3,940,000.00**
General Contractors OH&P (15%)	**$541,744.24**	$590,000.00
SUBTOTAL	**$4,153,372.53**	$4,530,000.00
Construction Contingency (25%)	**$1,038,343.13**	$830,000.00
TOTAL CONSTRUCTION COST	**$5,191,715.67**	**$5,360,000.00**
Engineering (10%)	**$519,171.57**	$535,000.00
Services During Construction (2.5%)	**$129,792.89**	$135,000.00
TOTAL PROJECT	**$5,840,680.13**	**$6,030,000.00**
COST PER SQUARE FOOT	**$398.04** (8,520 Square Feet)	**$723.21** (5,282 Square Feet)

3.2 Operations and Maintenance Cost

Exhibits 3-2a and 3-2b display the preliminary cost estimates for Operations and Maintenance ("O&M") for the SSO system with and without the bag breaker/film sorting system, respectively. O&M costs were estimated for the low tonnage, mid, and high tonnage scenarios developed in the mass balance. Labor costs for sorters utilized hourly rate information provided by ecomaine. The numbers of sorters for the "without bag breaker/film sorting or SSO" contaminants sorting option," Exhibit 3-2b, were reduced by two (2) sorters to reflect the lack of SSO contaminants sorting. It was assumed that the labor costs for baling of recyclables, maintenance, and cleaning would be absorbed within the existing MRF budget. Assumptions for the quantities of utilities and supplies are shown on the Exhibit. No cost was included for the disposal of residuals since they will be combusted in the RRF. No cost for transportation of the SSO was included because the end users have not been determined. Estimates of the types and quantities of recyclables to be sorted were based upon SSO sort information provided by Coker Composting and Consulting, a subcontractor to Northern Tilth; and an estimate of the quantity of OCC in trash by D&B.

3.3 Annual System Cost

A preliminary estimate of annual system costs was developed by dividing the capital costs over 20 years and adding the annual O&M costs. Exhibits 3-3a and 3-3b display the annual costs of capital and O&M for the system with and without the bag breaker/film sorting, and SSO contaminants sorting, respectfully.

Exhibit 3-2a

PRELIMINARY COST ESTIMATES FOR OPERATIONS AND MAINTENANCE FOR THE SOURCE SEPARATED ORGANICS SORTING SYSTEM (with bag breaker/film sorter)

	Low Volume Cost	Mid-Range Cost	High Volume Cost
Labor			
Supervisor	$52,000	$52,000	$52,000
Sorters	$201,344	$402,688	$503,360
Truck Driver	$35,000	$37,500	$40,000
Baler Operator	$0	$0	$0
Maintenance and Cleaning	$0	$0	$0
SUBTOTAL	**$288,344**	**$492,188**	**$595,360**
Utilities			
Electric	$36,900		$70,625
Water		$57,600	
Sewer			
Gas/Fuel Oil	$30,750	$48,113	$58,854
SUBTOTAL	**$67,650**	**$105,713**	**$129,479**
Supplies			
Fuels and Lubricants	$50,000	$60,000	$75,000
Parts	$25,000	$27,500	$30,000
SUBTOTAL	**$75,000**	**$87,500**	**$105,000**
Residuals Disposal	$0	$0	$0
SSO Transportation			
Recyclables Revenues			
Aluminum Cans	($1,818)	($7,147)	($12,422)
PET Containers	($909)	($3,574)	($6,211)
Old Corrugated Containers	($38,000)	($52,200)	($57,700)
SUBTOTAL	**($40,727)**	**($62,921)**	**($76,333)**
TOTAL ANNUAL COST	**$390,267**	**$622,480**	**$753,506**
COST PER TON	**$128.38**	**$52.08**	**$36.28**
OPERATIONS COST PER TON	**$9.52**	**$9.73**	**$9.60**

Notes:

1. Labor estimates are 8 hours/day Monday – Friday; 5.5 hours/day Saturday.
2. Supervisor – $25.00/hour; Sorters – $22.00/hour.
3. Low Volume – 4 Sorters; Mid Volume – 8 Sorters; High Volume – 10 Sorters.
4. Electricity usage based upon 9 kwh/tons.
5. Gas/fuel oil based upon 0.15 gallons/ton.
6. SSO Plus Trash (Tons Per Year): Low tonnage – 41,000; Mid Range – 64,152; High tonnage – 78,472.
7. SSO Only (Tons Per Year): Low Tonnage – 3,040; Mid Range – 11,952; High Tonnage: 20,770.

Exhibit 3-2b

PRELIMINARY COST ESTIMATES FOR OPERATIONS AND MAINTENANCE FOR THE SOURCE SEPARATED ORGANICS SORTING SYSTEM (without bag breaker/film sorting system or SSO contaminants sorting)

Description	Low Volume Cost	Mid-Range Volume	High Volume Cost
Labor			
Supervisor	$52,000	$52,000	$52,000
Sorters	$151,008	$302,016	$453,696
Truck Driver	$35,000	$37,500	$40,000
Baler Operator	$0	$0	$0
Maintenance and Cleaning	$0	$0	
SUBTOTAL	**$238,008**	**$391,516**	**$545,024**
Utilities			
Electric	$36,900	$57,600	$70,625
Water			
Sewer			
Gas/Fuel Oil	$30,750	$48,113	$58,854
SUBTOTAL	**$67,650**	**$105,713**	**$129,479**
Supplies			
Fuels and Lubricants	$50,000	$60,000	$75,000
Parts	$25,000	$27,000	$30,000
SUBTOTAL	**$75,000**	**$87,500**	**$105,000**
Residuals Disposal	$0	$0	$0
SSO Transportation			
Recyclables Revenues			
Aluminum Cans	($1,818)	($7,147)	($12,442)
PET Containers	($909)	($3,574)	($6,211)
Old Corrugated Containers	($38,000)	($52,200)	($57,700)
SUBTOTAL	**($40,727)**	**($62,921)**	**($76,333)**
TOTAL ANNUAL COST	**$339,931**	**$521,808**	**$703,170**
OPERATIONAL COST PER TON SSO	**$111.82**	**$43.66**	**$33.86**
COST PER TON	**$8.29**	**$8.15**	**$8.96**

Notes:

1. Labor estimates are 8 hours/day Monday – Friday; 5.5 hours/day Saturday.
2. Supervisor – $25.00/hour; Sorters – $22.00/hour.
3. Low Volume – 3 Sorters; Mid Volume – 6 Sorters; High Volume – 9 Sorters.
4. Electricity usage based upon 9 kwh/tons.
5. Gas/fuel oil based upon 0.15 gallons/ton.
6. SSO Plus Trash (Tons Per Year): Low tonnage – 41,000; Mid Range – 64,152; High tonnage – 78,472.
7. SSO Only (Tons Per Year): Low Tonnage – 3,040; Mid Range – 11,952; High Tonnage: 20,770.

Exhibit 3-3a

PRELIMINARY ESTIMATE OF ANNUAL CAPITAL AND NET OPERATIONS, AND MAINTENANCE COST FOR SOURCE SEPARATED ORGANICS SORTING SYSTEM
(with automated bag breaker/film sorting system)

	Low Volume	Mid Volume	High Volume
Annual Capital Cost[1]	$292,034	$292,034	$292,034
Annual Operations and Maintenance[2]	$390,267	$622,480	$753,506
TOTAL ANNUAL COST	**$682,301**	**$914,514**	**$1,045,540**
COST PER TON[3] – SSO PLUS TRASH	**$16.64**	**$14.26**	**$13.32**
COST PER TON – SSO ONLY	**$224.44**	**$76.52**	**$50.34**

Notes:

(1) Taken from capital cost estimate Exhibit 3-1a.
$5,840,680/20 = $292,034/year.

(2) Taken from O&M cost estimate Exhibit 3-2a.

(3) Annual tonnage from Mass Balance Attachment 1.

Exhibit 3-3b

PRELIMINARY ESTIMATE OF ANNUAL CAPITAL AND NET OPERATIONS, AND MAINTENANCE COST FOR SOURCE SEPARATED ORGANICS SORTING SYSTEM (without bag breaker/film sorting or SSO contaminants sorting system)

	Low Volume	Mid Volume	High Volume
Annual Debt Service[1]	$250,331	$250,331	$250,331
Annual Operations and Maintenance[2]	$339,931	$521,808	$703,170
TOTAL ANNUAL COST	**$590,262**	**$772,139**	**$953,501**
COST PER TON[3] SSO PLUS TRASH	**$14.40**	**$12.04**	**$12.15**
COST PER TON – SSO ONLY	**$194.17**	**$64.60**	**$45.91**

Notes:

(1) Taken from capital cost estimate Exhibit 3-1b.
$5,006,612/20 = $250331/year.

(2) Taken from O&M cost estimate Exhibit 3-2b.

(3) Annual tonnage from Mass Balance Attachment 1.

ATTACHMENT 1

MASS BALANCE

Ecomaine
Portland Maine

Mass Balance

Inbound Material SSO	Residential Tons/year	Commercial Tons/year	Totals Tons/Year	Total Tons/week
Low End	3,100		3,100	59.62
Mid Range	6,800	5,100	11,900	228.85
High End	13,900	7100	21,000	403.85

Total Tons Incoming

Based on 5.5 days per week operation

Inbound Material		Residential Tons/year	Commercial Tons/year	Totals Tons/Year	Total Tons/week	SSO Bags/wk	Material handled in 8 hr day			
							tons/hr	bags	Bags/hr	Sorters req'd
Low End		38,000		38,000	730.77		16.61			
	SSO	3,040		3,040	58.46	9,743.59	1.33	221.45	27.68	0.92
Mid Range		38,000	14,200	52,200	1,003.85		22.81			
	SSO	6,840	5112	11,952	229.85	38,307.69	5.22	870.63	108.83	3.63
High End		38,000	19,700	57,700	1,109.62		25.22			
	SSO	13,680	7,092	20,772	399.46	66,576.92	9.08	1,513.11	189.14	6.30

Inbound Material		Material handled in 6 hr day				Material handled in 4 hr day				Material handled in 2 hr day			
		tons/hr	bags	Bags/hr	Sorters req'd	tons/hr	bags	Bags/hr	Sorters req'd	tons/hr	bags	Bags/hr	Sorters req'd
Low End		22.14				33.22				66.43			
	SSO	1.77	295.26	49.21	1.64	2.66	442.89	110.72	3.69	5.31	885.78	442.89	14.76
Mid Range		30.42				45.63				91.26			
	SSO	6.97	1,160.84	193.47	6.45	10.45	1,741.26	435.31	14.51	20.90	3,482.52	1,741.26	58.04
High End		33.62				50.44				100.87			
	SSO	12.10	2,017.48	336.25	11.21	18.16	3,026.22	756.56	25.22	36.31	6,052.45	3,026.22	100.87

SSO contaminants at 1.3%

Inbound Material		Residential Tons/year	Commercial Tons/year	Totals Tons/Year	Total Tons/week	SSO Bags/wk	LBS/hr	Material handled in 8 hr day Required contaminants sorting rate per minute with 4 sorters: LBS/Min
Low End		38,000		38,000	730.77			
	SSO	3,040		3,040	58.46	9,743.59	34.55	0.14
Mid Range		38,000	14,200	52,200	1,003.85			
	SSO	6,840	5112	11,952	229.85	38,307.69	135.82	0.57
High End		38,000	19,700	57,700	1,109.62			
	SSO	13,680	7,092	20,772	399.46	66,576.92	236.05	0.98

Inbound Material		Material handled in 6 hr day	Required contaminants sorting rate per minute with 4 sorters:	Material handled in 4 hr day	Required contaminants sorting rate per minute with 4 sorters:	Material handled in 2 hr day	Required contaminants sorting rate per minute with 4 sorters:
		LBS/hr	LBS/Min	LBS/hr	LBS/Min	LBS/hr	LBS/Min
Low End	SSO	46.06	0.19	69.09	0.29	138.2	0.58
Mid Range	SSO	181.1	0.75	271.6	1.13	543.3	2.26
High End	SSO	314.7	1.31	472.1	1.97	944.2	3.93

Recyclables Recovered from SSO and Refuse

Inbound Material		Totals Tons/Year	Total Recyclables Recovered (t/yr)	Total Alum Recovered (t/yr)	Total PET Recovered (t/yr)	Total OCC Recovered (t/yr)	Total Alum Revenues	Total PET Revenues	Total OCC Revenues
Low End		38,000	380	0	0	380			$ 38,000
	SSO	3,040	9.1	4.5	4.5	0	$ 1,818	$ 909	
High End		57,700	577	0	0	577			$ 57,700
	SSO	20,772	62.1	31.1	31.1	0	$ 12,422	$ 6,211	

1- Percent of SSO in Total Waste Delivered

Low End	8%	
Mid Range	18%	36%
High End	36%	36%

2- Weight of SSO in Bags 12 pounds

3- Sorting Rate 30 bags per person per hour

4- Week is based on 5.5 days of operaion

ATTACHMENT 2

PRELIMINARY LAYOUT

ECOMAINE

PORTLAND MAINE

ecomaine
the future of regional waste systems

SOURCE SEPARATED ORGANICS SORTING SYSTEM

SEPTEMBER 2013

GENERAL MANAGER
KEVIN ROCHE

PLANT MANAGER
KEVIN A. TRYTEK

DIRECTOR OF FINANCE AND ADMINISTRATION
ARTHUR BIRT

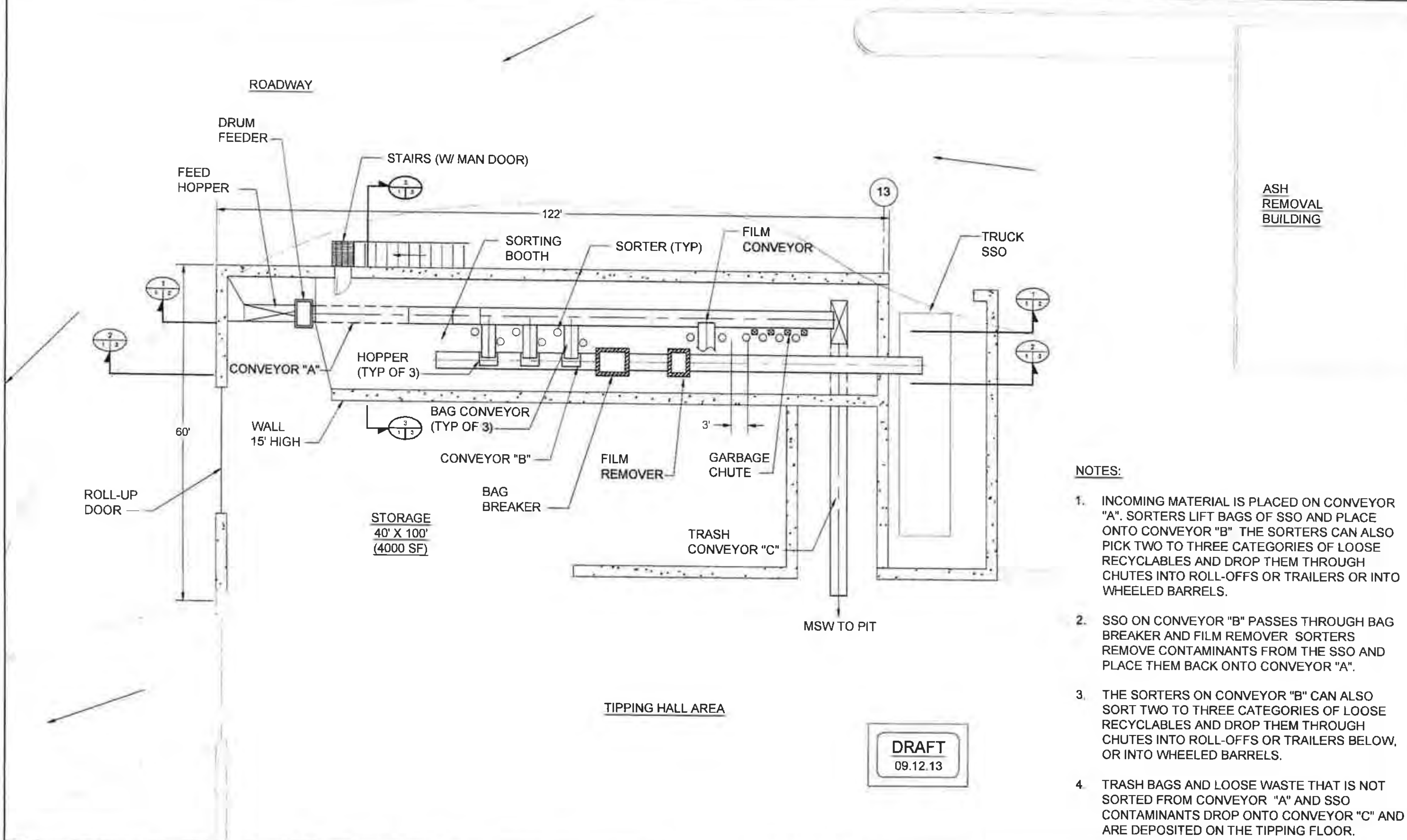
LOCATION MAP
N.T.S

LIST OF DRAWINGS

DRAWING NO.	DRAWING TITLE
-	COVER SHEET
1	PLAN VIEW
2	SECTION VIEW I
3	SECTION VIEW II

DVIRKA AND BARTILUCCI CONSULTING ENGINEERS
A DIVISION OF D&B ENGINEERS AND ARCHITECTS, P.C.

DRAFT
09.12.13



NOTES:

1. INCOMING MATERIAL IS PLACED ON CONVEYOR "A". SORTERS LIFT BAGS OF SSO AND PLACE ONTO CONVEYOR "B" THE SORTERS CAN ALSO PICK TWO TO THREE CATEGORIES OF LOOSE RECYCLABLES AND DROP THEM THROUGH CHUTES INTO ROLL-OFFS OR TRAILERS OR INTO WHEELED BARRELS.

2. SSO ON CONVEYOR "B" PASSES THROUGH BAG BREAKER AND FILM REMOVER SORTERS REMOVE CONTAMINANTS FROM THE SSO AND PLACE THEM BACK ONTO CONVEYOR "A".

3. THE SORTERS ON CONVEYOR "B" CAN ALSO SORT TWO TO THREE CATEGORIES OF LOOSE RECYCLABLES AND DROP THEM THROUGH CHUTES INTO ROLL-OFFS OR TRAILERS BELOW, OR INTO WHEELED BARRELS.

4. TRASH BAGS AND LOOSE WASTE THAT IS NOT SORTED FROM CONVEYOR "A" AND SSO CONTAMINANTS DROP ONTO CONVEYOR "C" AND ARE DEPOSITED ON THE TIPPING FLOOR.

NO	DATE	REVISION	BY
1	8/13	CLIENTS COMMENTS	TB

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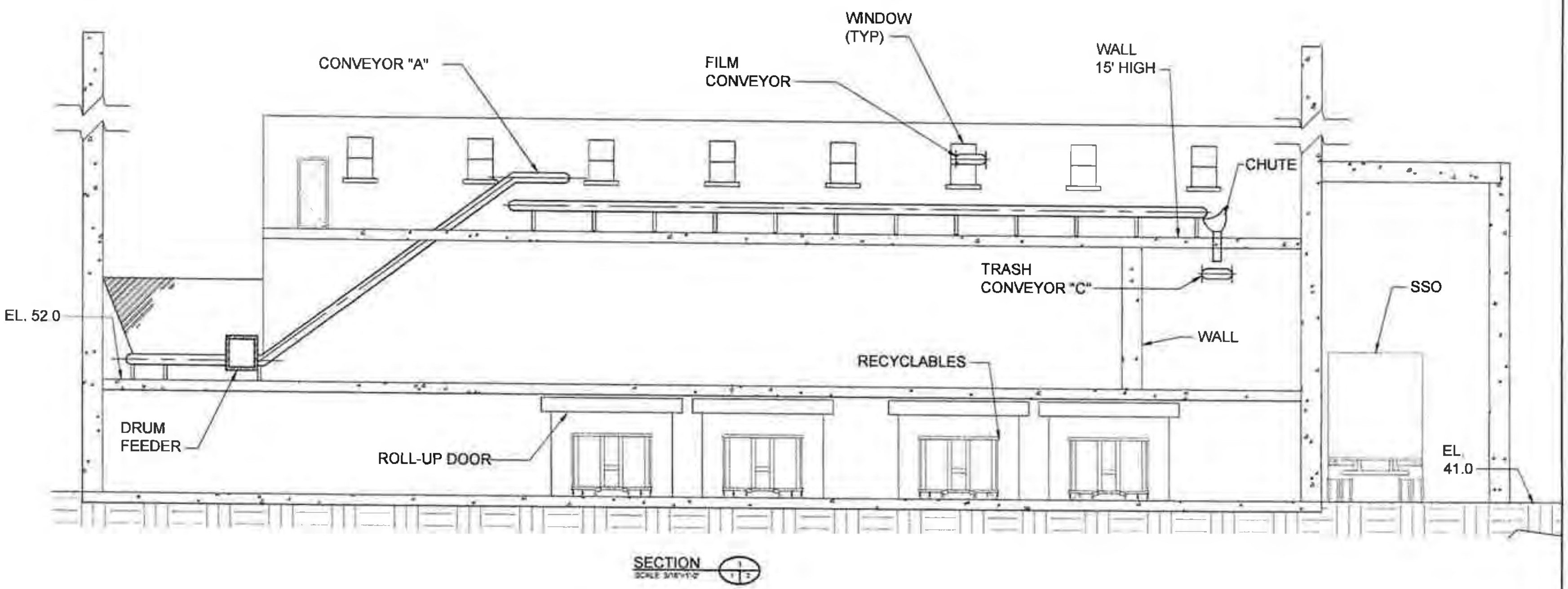
TP	TSB
DESIGNED BY	CHECKED BY
RC	RC

D&B ENGINEERS AND ARCHITECTS, P.C.
KNOWN AS DVIRKA AND BARTILUCCI CONSULTING ENGINEERS

ECOMAINE
PORTLAND MAINE
SOURCE SEPARATED ORGANICS SORTING SYSTEM

PLAN VIEW

PROJECT NO. 3404-01
DATE: SEPTEMBER 2013
SCALE: 1/16" = 1'-00"
DRAWING NO. 1



SECTION

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NO	DATE	REVISION	BY
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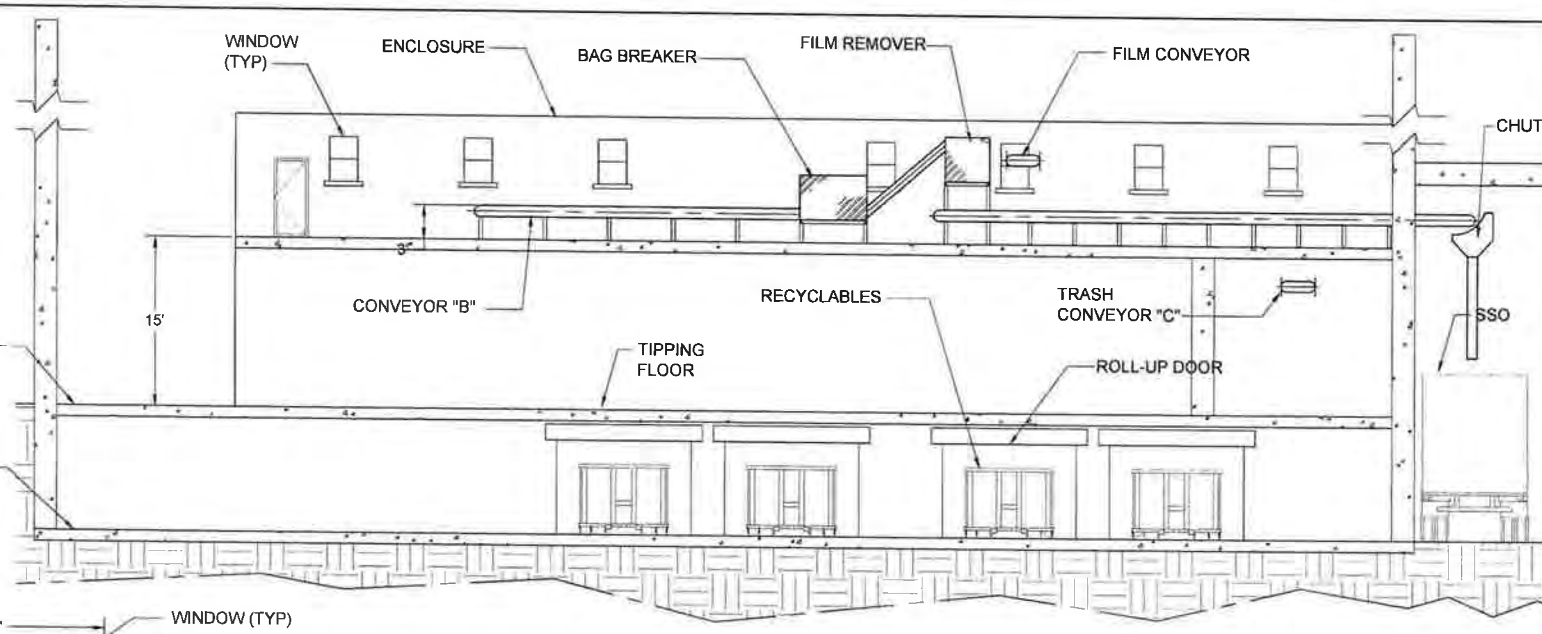
KNOWN AS DVIRKA AND BARTILUCCI CONSULTING ENGINEERS

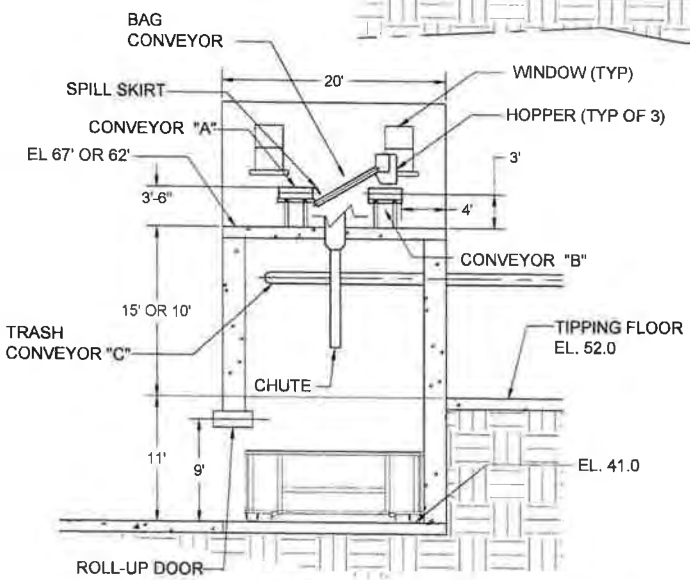
ECOMAINE
PORTLAND MAINE
SOURCE SEPARATED ORGANICS SORTING SYSTEM

SECTION VIEW I

PROJECT NO: 3404-01
DATE: SEPTEMBER 2013
SCALE: 3/16" = 1'-0"
DRAWING NO: 2



SECTION
SCALE 3/16"=1'-0"



SECTION
SCALE 3/16"=1'-0"

DRAFT
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NO	DATE	REVISION	INT
1	8/13	CLIENTS COMMENTS	TB

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PROJECT ENGINEER TP	DRAWN BY TSB
DESIGNED BY RC	CHECKED BY RC

D&B ENGINEERS AND ARCHITECTS, P.C.
KNOWN AS DVIRKA AND BARTILUCCI CONSULTING ENGINEERS

ECOMAINE

PORTLAND MAINE

SOURCE SEPARATED ORGANICS SORTING SYSTEM

SECTION VIEW II

PROJECT NO 3404-01
DATE SEPTEMBER 2013
SCALE 3/16" = 1'-0"
DRAWING NO **3**

ATTACHMENT 3

PRELIMINARY COST ESTIMATES FOR SSO SORTING CONSTRUCTION AND OPERATIONS AND MAINTENANCE UTILIZING A TROMMEL FOR BAG BREAKING

Exhibit A3-1

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR SOURCE SEPARATED ORGANICS SORTING SYSTEM (with trommel)

Description	Quantity	Unit	Unit Price	Total Cost
Demolition				
Metal Walls				
100 x 40 High	4,000	Square Feet	$15.00	**$60,000.00**
Concrete Floor				**$0.00**
8 x 120	960	Square Feet	$10.00	**$9,600.00**
Foundations				
70 x 8	560	Square Feet	$10.00	**$5,600.00**
Site Work				
122 x 60 x 8	2,169	Cubic Yards	$15.00	**$32,535.00**
Soils				**$0.00**
SUBTOTAL				**$107,735.00**
Site Work				
Grading	1	Lump Sum	$50,000.00	**$50,000.00**
Drainage	1	Lump Sum	$25,000.00	**$25,000.00**
Relocate Utilities	1	Lump Sum	$25,000.00	**$25,000.00**
Utility Connections	1	Lump Sum	$10,000.00	**$10,000.00**
Paving	1	Lump Sum	$25,000.00	**$25,000.00**
SUBTOTAL				**$135,000.00**
Concrete				
Foundation				
510 x 4 x 1/27	76	Cubic Yards	$560.00	**$42,560.00**
Walls				
8372 + 2700/27	410	Cubic Yards	$560.00	**$229,600.00**
Floors				
122 x 60/27	271	Cubic Yards	$560.00	**$151,760.00**
30 x 122 + 30 x 30/27	170	Cubic Yards	$560.00	**$95,200.00**
122 x 30/27	136	Cubic Yards	$560.00	**$76,160.00**
SUBTOTAL				**$595,280.00**

(Continued)

Exhibit A3-1

Description	Quantity	Unit	Unit Price	Total Cost
Metal				
Building Walls				
15 x 60 + 122 + 60 + 20	3,930	Square Feet	$100.00	**$393,000.00**
15 x 60	900	Square Feet	$100.00	**$90,000.00**
Roof		Square Feet		
60 x 120 Main	7,320	Square Feet	$50.00	**$366,000.00**
60 x 20 Truck Area	1,200	Square Feet	$50.00	**$60,000.00**
Roofing Members	1	Lump Sum	$25,000.00	**$25,000.00**
Structure Supports at Tipping Floor	1	Lump Sum	$10,000.00	**$10,000.00**
Sorting Booth				
122 x 10	1,220	Square Feet	$120.00	**$146,400.00**
Outside Stairs	1	Lump Sum	$2,000.00	**$2,000.00**
SUBTOTAL				**$1,090,400.00**
Mechanical				
Processing System	1	Lump Sum	$515,000.00	**$515,000.00**
Shipping and Installation Labor	1	Lump Sum	$400,000.00	**$400,000.00**
HVAC Sorting Booth/Dust Control	3,660	Square Feet	$32.82	**$120,121.20**
Fire Protection	8,520	Square Feet	$15.00	**$127,800.00**
SUBTOTAL				**$1,162,921.20**
Electrical				
Electrical and Instrumentation (8%)	1	Lump Sum	$300,000.00	**$300,000.00**
SUBTOTAL				**$300,000.00**

(Continued)

Exhibit A3-1

Description	Quantity	Unit	Unit Price	Total Cost
Landfill Disposal				
Landfill Disposal				**$0.00**
SUBTOTAL				**$0.00**
ALL ITEMS SUBTOTAL				
Building Permits (0.40%)				**$3,391,336.20**
Builders Risk Insurance (0.25%)				**13,565.34**
General Liability Insurance (1.50%)				**$50,870.04**
General Contractors Bonds (1.0%)				**$33,913.36**
SUBTOTAL				**$3,498.163.29**
General Contractors OH&P (15%)				**$524,724.49**
SUBTOTAL				**$4,022,887.78**
General Contingency (25%)				**$1,005,721.95**
TOTAL CONSTRUCTION COST				**$5,028,609.73**
Engineering (10%)				**$502,860.97**
Services During Construction (2.5%)				**$125,715.24**
TOTAL PROJECT				**$5,657,187.95**

Notes:

1. Lump sum pricing was based upon pricing experience from recent projects.

2. Square foot pricing used for the HVAC and Fire Protection were taken from the cost estimate of the Ash Building.

3. If sorting floor elevation was set at 10 feet and not 15 feet high, concrete pricing would be reduced.

4. Concrete pricing ($/cubic yard) was verified by Mr. Peter Nostrand – Telephone Number: (603) 530-2871). This contact was obtained from Mr. Andrew Tilth.

Exhibit A3-2

PRELIMINARY COST ESTIMATES FOR OPERATIONS AND MAINTENANCE FOR THE SOURCE SEPARATED ORGANICS SORTING SYSTEM (with trommel)

Description	Low Volume Cost	High Volume Cost
Labor		
Supervisor	$52,000	$52,000
Sorters	$251,680	$553,696
Truck Driver	$35,000	$40,000
Baler Operator	$0	$0
Maintenance and Cleaning		
SUBTOTAL	**$338,680**	**$645,696**
Utilities		
Electric	$36,900	$70,625
Water	$0	$0
Sewer	$0	$0
Gas/Fuel Oil	$30,750	$58,854
SUBTOTAL	**$67,650**	**$129,479**
Supplies		
Fuels and Lubricants	$50,000	$75,000
Parts	$25,000	$30,000
SUBTOTAL	**$75,000**	**$105,000**
Residuals Disposal	$0	$0
SSO Transportation	Not estimated	Not estimated
Recyclables Revenues		
Aluminum Cans	($1,818)	($12,442)
PET Containers	($909)	($6,211)
Old Corrugated Containers	($38,000)	($57,700)
SUBTOTAL	**($40,727)**	**($76,333)**
TOTAL ANNUAL COST	**$440,603**	**$803,842**
COST PER TON	**$10.75**	**$10.24**

Notes:

1. Labor estimates are 8 hours/day Monday – Friday; 5.5 hours/day Saturday.
2. Supervisor – $25.00/hour; Sorters – $22.00/hour.
3. Low Volume – 5 Sorters; High Volume – 11 Sorters.
4. Electricity usage based upon 9 kwh/tons.
5. Gas/fuel oil based upon 0.15 gallons/tons.
6. Low tonnage – 41,000 tons per year; high tonnage – 78,472.