



Town of Millbury, Massachusetts Organics to Energy Feasibility Study



September 2013



**CDM
Smith**

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Millbury Organics to Energy Feasibility Study

Executive Summary

1.0 Introduction and Background

The Massachusetts Department of Environmental Protection (MassDEP) has proposed a ban on the disposal of source separated organics (SSO) in landfills and incinerations for commercial wastes. Regulations resulting from this ban are expected to be implemented in mid-2014, at which time, approximately 1,000 wet tons per day (wtpd) of SSO would be diverted from landfills and incinerators state-wide to recycling facilities such as anaerobic digestion or composting facilities.

Due to the availability of land which formerly supported its wastewater treatment facility, (131 Providence Street) the Town of Millbury is completing this study to determine the viability of the development of a new organics processing facility at that site. The goal of this facility would be to provide a sustainable outlet for source separated organics and to provide energy savings to the town by offsetting current energy and heat demands from the exiting wastewater pump station and Department of Public Works (DPW) facilities which the site currently supports. The study of this site within the Town is intended to determine its viability for public or private development of this potential facility.

2.0 Organics Quantities and Characteristics

The potential organic waste sources associated with the ban will likely include food wastes from supermarkets, institutions, food producers, and other large generators. MassDEP published a 2002 survey (updated in 2011) which separated food waste generators into several categories and provided an estimate of the locations and quantities of the available waste. Based on this data, it is estimated that there may be approximately 190,000 wet tons per year (wt/yr) of organic waste within a 30-mile radius (regional) of the Providence Street site in Millbury.

Nearby, the City of Worcester contains over 200 food waste generators that could contribute to the organics-to-energy system. In the event that the project is deemed viable following the feasibility phase of the project, local and regional industries should be contacted directly to further refine the locations and quantities of available organic waste within these sectors.

3.0 Conceptual Organics Processing Facility

Since it is unlikely that a facility built at the Providence Street site would be able to attract the full quantity of local or regional organic waste this current study conceptually analyzes two loading/sizing scenarios which are intended to represent the lower and upper bounds of waste acceptance. For the purpose of this study, those scenarios are assumed to include: 10% of regional organic waste (19,000 wt/y); and 50% of regional organic waste (94,000 wt/yr).

The two SSO acceptance conditions were evaluated during this study to evaluate a wide range of potential cost and benefits. Figure ES-1 provides an overview of the capital infrastructure required under each scenario.

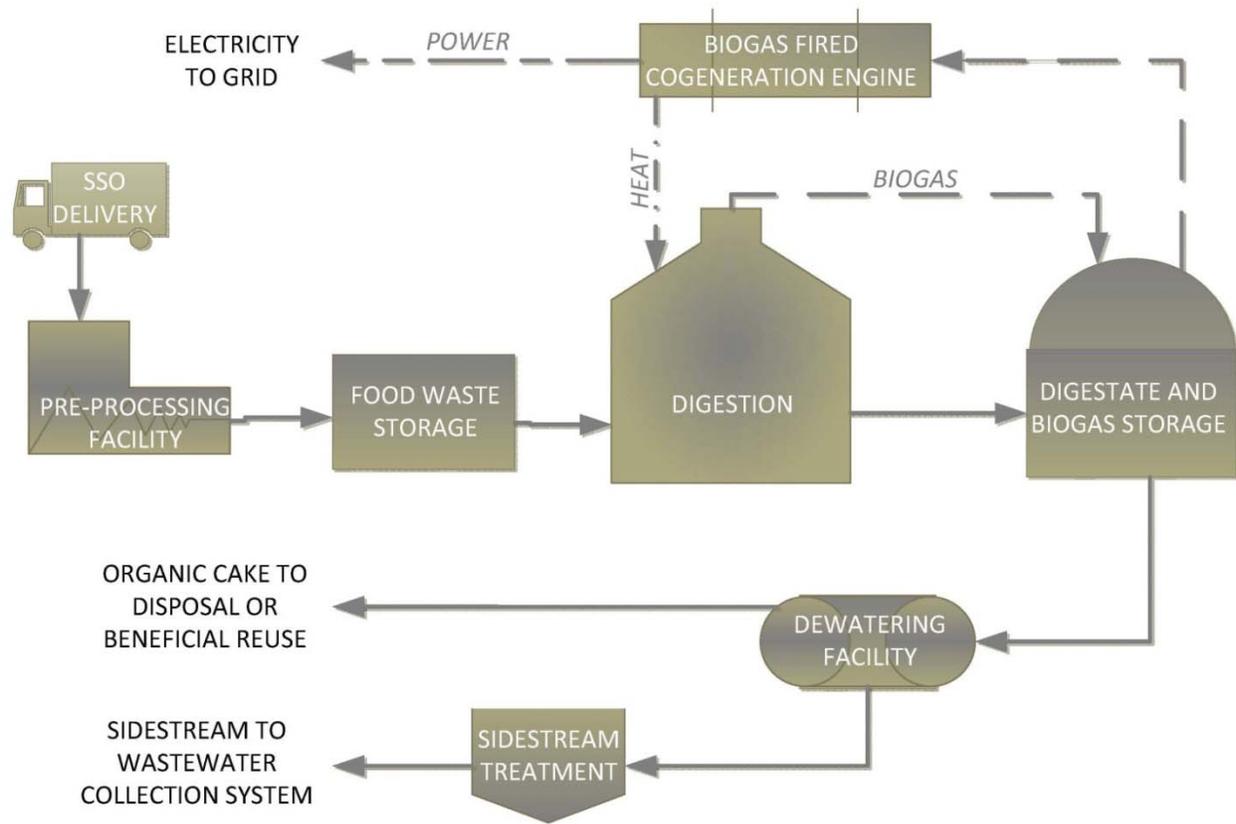


Figure ES-1
Simplified Facility Process Schematic

In general, the infrastructure that would be expected to be required for either option would include: Pre-Processing Facility; Pre-Digestion Food Waste Storage Tanks and Pump Station; New Anaerobic Digester(s) and Ancillary Digestion Equipment; Biogas Collection, safety and boosting equipment; Digestate and Biogas Storage; New Cogeneration Engines; Dewatering Facility; and a Sidestream Treatment Facility. Table ES-1 summarizes some of the key expected process performance values of these systems under average annual conditions for each option.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Potentially Available SSO Waste (wet tons/year)	19,000	94,000
Potentially Available SSO Waste (wet tons/day)	52	258
Digestion Volume (Mgal)	0.60	2.96
EFW Fed to Digester (gal/day)	30,000	148,000
Biogas Produced (cf/day)	299,000	1,523,000
CHP Electrical Production (kW)	840	4,900
CHP Net Electrical Remaining After Onsite Use (kW)	690	4,300
CHP Heat Recovered (MMBtu/hr)	3.6	18.4
CHP Net Heat Remaining after Onsite Use (MMBtu/hr)	0.0	12.0
Dewatered Cake (wet tons/day)	19	91
Dewatered Cake (cy/day)	84	405
Centrate Requiring Disposal (gal/day)	25,000	125,000

Table ES-1
Conceptual Digestion Facility Summary

4.0 Impacts to Existing Parcel and Surrounding Area

A review of available site data was completed as part of this study to determine whether any known hazards, sensitive receptors or other environmental features may pose a concern for this potential project. With respect to potential hazards or protected areas, the features identified in the immediate vicinity of the site were limited to one hazardous material generator listed under the Bureau of Waste Prevention (Barrday Composite Solutions located across the street from the site), and one potential vernal pool location located on the opposite side of the river from the site. It was also determined that the 100-year flood inundation area does include portions of the site.

One additional dataset which was reviewed as part of this study is the Environmental Justice (EJ) population locations. Based on 2010 census data, there is one block group located in downtown Millbury which qualifies as an “Environmental Justice Population.” Though the issue may ultimately not be significant for the project, waste hauling truck routes are likely to be required to access the site through this population and the Town should be cognizant of it as it may impact public acceptance of the project.

5.0 Ownership Options

Section 5 of the Report provides an overview and comparison of various ownership options that may be considered by the Town for implementation of the organics-to-energy center at the Town-owned project site. The ownership options reviewed here incorporate different approaches to the allocation of project responsibility, risks and economic benefits. Ownership options evaluated include municipal ownership, public/private partnership, and site lease/private ownership.

6.0 Regulations and Permitting

As part of the current feasibility study, an initial assessment was completed of the regulatory trends, drivers and potential permits required for development of an organics to energy facility in Millbury. Though a specific permitting implementation plan would need to be developed as part of the design phase of this project, the potential permit applications that are likely required to be developed during the design process would include: a non-major comprehensive air quality plan approval from the MassDEP; electrical interconnection application through National Grid; A Notice of Intent (NOI) through the local conservation commission; local planning board approval; letter of request to the Natural Heritage and Endangered Species program; letter of request to the Massachusetts Cultural Resource Information System; and a letter to MassDEP requesting approval for this project would be required. In addition, the contractor would be required to apply for local building permits and stormwater management permits as part of the construction phase of this project.

7.0 Funding and Financing

Though financing projects of this nature can be complex and availability of assistance can vary depending on the ownership option selected, there are a number of possible programs available including state grants, low interest loans and tax incentives which could aid in the project development and financing. As detailed in Section 7, some of the potential grant programs that should be explored for this project include: MassCEC Organics to Energy Program grants, MassDEP Sustainable Materials Recovery grants; National Grid Custom Measures Program Grants; Mass Green Communities Competitive Grants; and Global Climate Change Incentive Mitigation Fund grants. Some of the low interest loans, bond funding and tax credit programs that may prove to be advantageous to this facility development could include: MassDEP Recycling Loan funding; MassDEP Clean Water State

Revolving Fund; Qualified Energy Conservation Bonds; Business Energy Investment Tax Credit; MassDevelopment Tax Exempt Financing and other private tax exempt financing sources. In addition, tipping fees for accepting SSOs and cogeneration electrical production incentives (Net Metering credits and Renewable Energy Certificates) would serve to assist in financing of the required infrastructure.

8.0 Community Engagement

The Town of Millbury understands the importance of community engagement and has initiated these communications prior to and concurrent with the development of this feasibility study. Specifically, the town Department of Public Works held multiple televised public meetings describing the study and the potential facility and also posted study findings and the conceptual site plan on the Town’s website requesting public comments. In addition, this project was the subject of articles within the local newspaper (Millbury-Sutton Chronicle). Though some questions and comments received as part of this process expressed concerns as to transportation and odor issues, the majority of comments received were positive in nature.

9.0 Study Findings

As previously noted, two Source Separated Organics (SSO) acceptance conditions were evaluated during this study so as to analyze a wide range of potential cost and benefits. To compare relative costs and benefits of the alternatives, estimates of probable project cost were developed for each of the acceptance scenarios and the associated operations costs impacts were also conceptually quantified. A summary of the conceptual finances of these options is shown in table ES-2.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Initial Capital Costs	\$35,000,000	\$85,000,000
Annual Capital Costs (Amortized 20 yrs @ 2.5%)	\$2,300,000	\$5,500,000
Annual Operational Costs	\$1,200,000	\$5,100,000
Annual Combined Heat and Power Revenue	\$800,000	\$4,900,000
Net Annual Cost	\$2,700,000	\$5,700,000
Annual SSO Received (wt/yr)	19,000	94,000
Break Even Waste Tip Fee (\$/wt)	\$142	\$61
Break Even Waste Tip Fee without Installation of Pre-Processing (\$/wt)	\$105	\$40

Table ES-2
Conceptual Financial Summary

Based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of \$30 to \$40 per wet ton for pre-processed waste. Though the organics disposal market in the Commonwealth is currently in a state of flux due to the pending waste ban as well as the rapid development of various waste processing facilities, it is not currently known whether this experience in other parts of the country will be seen in Massachusetts. It is important to note, however, that the current average rate for municipal solid waste disposal in Massachusetts is in the range of \$70 per ton, so tipping fees for non-preprocessed waste less than this may be able to be initially borne by the developing organics market in the Commonwealth. Despite this, it remains to be seen how low rates for these wastes, which have an inherent energy value as well as a potential digestate reuse value, will be ultimately driven down by competing processing facilities.

With consideration of the above factors and estimated costs, the apparent financial viability of the two facility sizing options evaluated here can be summarized as follows:

- Alternative A: The development of a facility to accept and process 19,000 wet tons per year of SSO is estimated to cost on the order of \$35M. After accounting for the operations costs and energy benefits associated with the facility, an SSO tip fee between approximately \$105 and \$140 per wet ton would need to be realized in order to break even with higher tipping fees required for any positive net revenues to be realized. As this rate is greater than the current cost of municipal solid waste disposal in the Commonwealth and significantly greater than organics disposal rates in other parts of the country, the development of a facility of this size would not be financially viable without significant external funding incentives.
- Alternative B: Development of a larger facility which would be capable of processing 94,000 wet tons per year would likely cost on the order of \$85M to develop and would translate to a break even tip fee between \$40 and \$60 per wet ton. Though these fees appear to be more in line with the potential market rates for this material, this option does carry with it significant risk related to waste availability. The quantity assumed here translates to 50% of the estimated organic waste within a 30 mile radius, which encompasses much of the heavily developed metro west region of Massachusetts. The likelihood of separating this waste from the solid waste stream and consolidating it at any single facility may not be a sustainable assumption due to the developing competition for this waste. Therefore, pursuit of a facility approaching this size could be financially viable, but would carry with it significant risk and uncertainty.

Despite the unfavorable finances associated with the smaller of the options evaluated and the waste availability risks associated with the larger of the options, it may be possible to select a facility size somewhere within the range evaluated here which would balance these concerns. This selection would likely be driven by whether any substantial external funding may be able to be secured as well as proper determination of the risk tolerance of the Town. Based on experience in other similar municipalities, it is anticipated that the significant capital cost and risk associated with developing a project of this nature may not be bearable exclusively by a municipal ownership option. For this reason, if the Town believed that development of this facility was a priority and in the Town's best interest, private development or a public private partnership (see Section 5) should be evaluated further through discussions with local private organics facility developers.

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Section 1

Introduction and Background

1.1 Introduction

The Massachusetts Department of Environmental Protection (MassDEP) has announced plans to impose a ban on source-separated organics (SSO), with the goal of diverting an additional 350,000 tons per year of SSO by 2020. MassDEP expects to have the proposed ban on disposal of SSO go into effect in the summer of 2014. As a result, feasibility studies are being completed to determine the ability of existing wastewater treatment facilities to incorporate co-digestion and co-generation into their treatment process as well as the feasibility of development of new facilities specifically designed for the digestion or composting of organic wastes. Due to the availability of land which formerly supported its wastewater treatment facility, the Town of Millbury is completing this study to determine the viability of the development of a new organics processing facility at that site.

The issues to be addressed and organization of the study will be as follows:

- Section 1: Introduction and Background;
- Section 2: Organics Quantities and Characteristics;
- Section 3: Conceptual Organics Processing Facility (including conceptual site layout);
- Section 4: Impacts to Existing Parcel and Surrounding Area;
- Section 5: Ownership Options;
- Section 6: Regulations and Permitting;
- Section 7: Funding and Financing;
- Section 8: Report on Community Engagement; and
- Section 9: Project Findings.

1.2 Project Drivers, Goals and Objectives

The Town is interested in exploring the technical feasibility of implementing an organics-to-energy program at the site of its former Wastewater Treatment Facility (WWTF) located at 131 Providence Street (Route 122A). The goal of this facility would be to provide a sustainable outlet for source separated organics produced within Millbury and potentially the metro west region of Massachusetts. An additional goal of the facility would be to provide energy savings to the town by offsetting current energy and heat demands from the exiting wastewater pump station and Department of Public Works (DPW) facilities which the site currently supports.

Due to the proximity of Millbury to sources of organic waste as well as its relative location with respect to major highways, several vendors have expressed interest in the development of an organics

handling and digestion facility in the town. The study of this site within the Town is intended to determine its viability for public or private development of this potential facility.

The overall goal of this study is intended to address the following items:

- Identify the potential sources and quantities of organic waste which could be processed by a facility at this site;
- Determine the conceptual size of a processing facility which could be supported by the site and by the available waste sources;
- Evaluate the costs and benefits of the conceptual facility;
- Consider any positive or negative impacts this development would have on the parcel and surrounding land owners; and
- Describe the ownership options which are available to the Town.

1.3 Massachusetts Clean Energy Center (MassCEC) Grant

Funding opportunities currently available to assist in achieving the goals of the Commonwealth of Massachusetts 2010-2020 solid waste master plan include the following:

- MassDEP Recycling Loan Fund
- MassDEP Municipal Grants; and
- MassCEC Organics to Energy program.

This study has been funded under the Organics to Energy Program which is administered by the MassCEC. The goal of the MassCEC Organics-to-Energy Program is to “increase knowledge about and support the development of facilities that convert source-separated organic materials into heat and electricity, as well as create additional products of value in agriculture, horticulture or landscaping.” The program is further designed to “advance the Commonwealth’s goal of substantially increasing the diversion of source-separated organics away from landfilling or incineration.”

Following an application process to MassCEC, the District was selected for a grant related to this study and has entered into an agreement dated January 31, 2013 for its funding.

1.4 Summary of Millbury DPW Facilities

The Town-owned facility, located at 131 Providence Street (Parcel Map 65, Block 5), consists of 16 acres of land near the southern extremity of the Town. The site is generally bounded by the Blackstone River to the North, Providence Street (Route 122A) to the South and undeveloped industrial parcels to the east and west. The site is situated approximately 1,600 feet north of the Sutton town boundary and approximately 5 miles from Interstate 90 (Massachusetts Turnpike) via exit 11.

The Town’s ownership of this land dates back to the 1960s and was developed into a DPW garage and wastewater treatment facility during the early 1970s. A brief description of these two uses of the site is detailed below.

1.4.1 Former Wastewater Treatment Plant Site

The wastewater treatment plant which was constructed on the site was used to treat wastewater from the Town of Millbury and a portion of Sutton prior to discharge to the Blackstone River for over three decades. An aerial photo showing the layout of the former WWTF is shown in Figure 1-1. Following a review of available options to address necessary upgrades to the facility, the Town voted in early 2000 to abandon the existing facility and pursue a new connection to the nearby Upper Blackstone Water Pollution Abatement District facility. This new connection, consisting of a 4-mile force main and a pump station located at the site of the former WWTF, was completed in January of 2005. The pump station currently contains three 280 horsepower pumps which have a total pumping capacity of 10 million gallons per day (MGD).

Following construction of this pump station, the existing treatment facility was ultimately decommissioned in 2006. At the time of decommissioning, most process structures were demolished

to below existing grade and backfilled. However, two existing operations and maintenance buildings, totaling approximately 6,000 sf of space, were updated for use by the Town Sewer Department. As part of the pump station design, two of the existing WWTF process tanks were also maintained for use as emergency wastewater storage in the event the pump station were to experience operational issues. The layout of the current site conditions is shown in Figure 1-2.



Figure 1-1
Former Millbury WWTF Site Layout

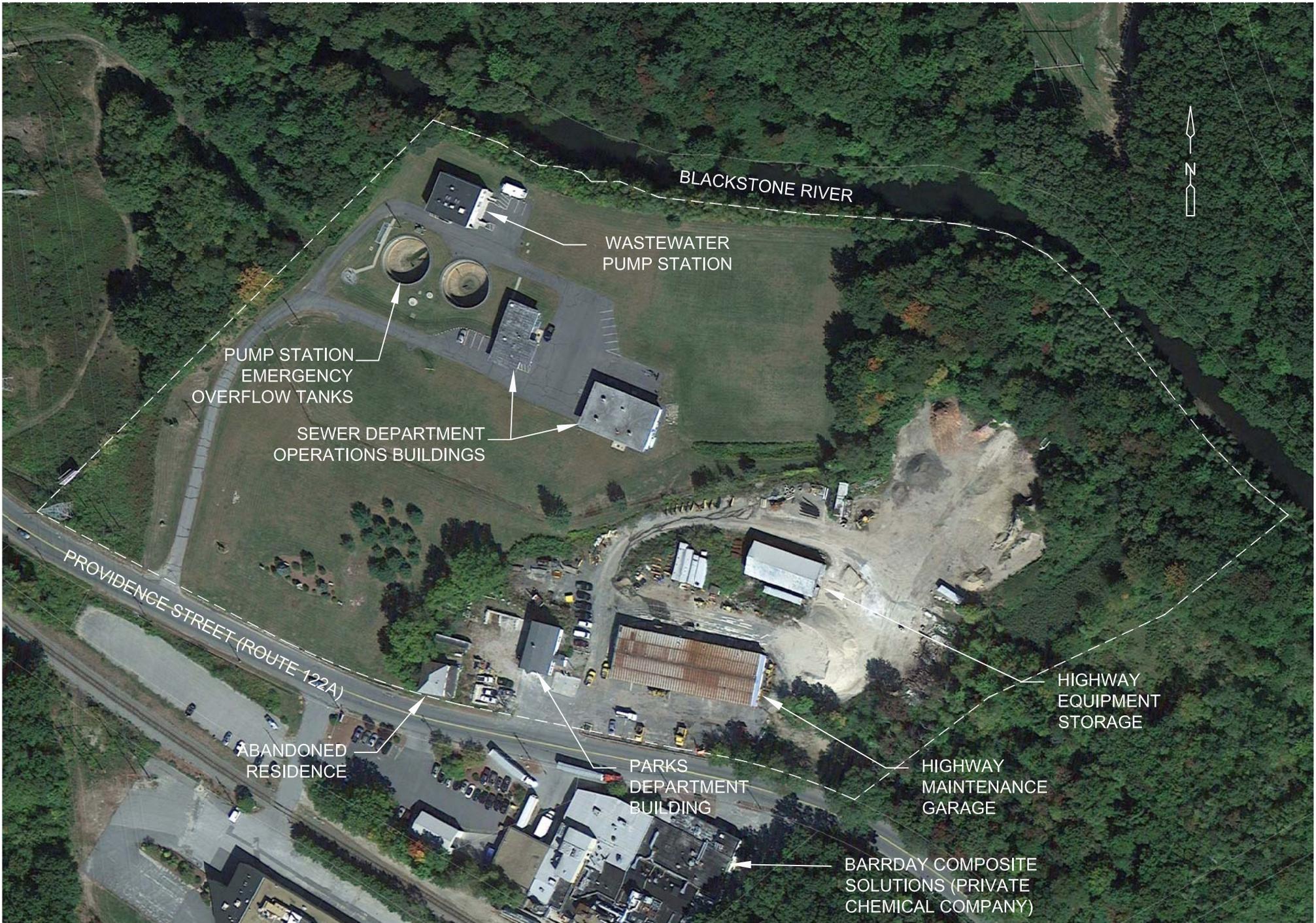
1.4.2 Existing DPW Site

As can be seen in Figure 1-2, the eastern half of the site currently supports an active DPW highway maintenance facility and related operations. Included in this area are the following site structures:

- Highway maintenance garage (10,000 sf);
- Highway equipment storage structure (3,400 sf);
- Former residence (currently abandoned and in disrepair) (2,000 sf); and
- Former barn which is currently used by the Millbury Parks Department (3,800 sf).

Both the residence and barn were constructed circa 1920 and pre-date the Town's ownership of the property. CDM Smith understands that the Town intends to demolish the former residence so as to improve traffic flow around the site once available funding for this work has been identified.

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1.5 Summary of Existing Energy Usage

Recent energy use data for the existing site was collected from the Town for use in assessing the potential for onsite use and/or net exporting of power from any future cogeneration system at the site. The data was generally available for the period between November 2011 and June of 2012 and was averaged to provide an estimate of annual demand.

Though this data will be further analyzed and compared in later sections of this report, a summary of recent electricity and natural gas energy use has been included in Table 1-1. It is important to note in this data that though the electric demand from the structures (especially the pump station) is a relatively constant demand, the heat (natural gas) demands from all points of use is seasonal with limited to no demand experienced during the warmer months of the year.

Electric (National Grid)	Pump Station	Highway Garage	Parks Garage	Total
Average Annual (kWh)	420,000	2,700	3,400	426,000
Equivalent kW	48	0.3	0.4	49
Natural Gas (NSTAR)				
Average Annual (Therms)	29	319	121	469
Average Annual (MMBtu/hr)	0.004	0.04	0.02	0.064

Table 1-1
Summary of Existing Site Energy Usage

1.6 Site Assignment Determination

In preparation for the 2014 ban on disposal of organics in landfills, regulatory changes to the solid waste regulations (310 CMR 16.00 and 19.00) and the wastewater regulations (314 CMR 12.00) were recently developed. These changes were adopted in late November 2012, and now the solid waste rules allow for streamlined siting of facilities that process SSO (e.g. compost or anaerobic digestion facilities). The wastewater rules have been changed to allow for wastewater treatment facilities with anaerobic digesters to accept and process SSO. The change to the wastewater treatment facility regulations is a simple rule change that was widely supported while the solids waste changes (siting of new facilities) received opposition from those representing local boards of health.

According to the new regulations, a site assignment under the solid waste regulations and laws (310 CMR 16.00 and MGL ch.111 § 150A, respectively) is only required for an area of land where solid waste uses can occur. Since SSO material is not considered a solid waste under the new regulations, a solid waste site assignment would not be required for the acceptance of SSOs at an existing wastewater treatment facility.

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Section 2

Organics Quantities and Characteristics

2.1 MassDEP Proposed Ban on Organics Disposal

As previously noted, the 2010-2020 Massachusetts Solid Waste Master Plan proposes a goal of reducing the quantity of waste disposed of in the Commonwealth by 30% by 2020. To accomplish this goal, the Draft Plan proposes adoption of a number of strategies for increasing the diversion of organic material from the solid waste stream. Among the alternatives for handling the diverted organics is utilization of anaerobic digestion facilities for treating organics. This initiative is creating a new demand for use of existing digesters for co-digestion and encouraging the development of new organics digestion facilities.

Currently private-sector solid waste transporters and disposal companies (referred to herein as “haulers”) direct approximately 100,000 tons per year of food wastes to organics processing facilities in Massachusetts. There are approximately two dozen such facilities currently operating. The typical processing facility is a small-scale composting facility. MassDEP estimates that approximately 400 businesses and institutions are currently diverting organic wastes. The typical waste generator is a supermarket, large restaurant, college or university, or food producer.

MassDEP expects to have the proposed ban on disposal of SSO go into effect in the summer of 2014. Initially the ban will only impact generators of more than one wet ton per week of organic wastes. The current focus on diverting SSO is also driven by the interest of MassDEP and the Governor’s Office in expanding renewable energy production, including through biogas.

2.2 Types and Characteristics of Organic Wastes

The new regulations provide the following definitions pertaining to SSO and related materials:

- Food Material means source separated material produced from human or animal food production, preparation and consumption activities which consists of, but is not limited to, fruits, vegetables, grains, and fish and animal products and byproducts;
- Compostable Material means an organic material, excluding sanitary wastewater treatment residuals, that has the potential to be composted and which is source separated from waste;
- Organic Material means vegetative material, food material, agricultural material, biodegradable products, biodegradable paper, and yard waste; and
- Source Separated means separated from solid waste at the point of generation and kept separate from solid waste.

The MassDEP intends to ban SSO wastes from landfills and municipal solid waste (MSW) incinerators. These wastes typically include food wastes from supermarkets, institutions, food producers, and other large generators. However, there are other organic wastes such as fats, oils and greases (FOG), or airport deicing fluid that could also be considered.

The highest purity FOG wastes (e.g. fryolater grease) are typically collected from restaurants and other food establishments and recycled through rendering companies. These high quality wastes are a tradable commodity since they can be used directly in the manufacturing of biodiesel fuels. Other FOG wastes, with greater levels of contamination, have good properties for co-digestion with municipal biosolids, but may present potential issues for separate organics digestion as is being considered for Millbury since contamination with chemicals or wastewater biosolids could reduce the potential marketability and perceived quality of the digestate. However, since FOG has an extremely high energy content and nearly 100 percent conversion to biogas, if FOG wastes are a component of an organic food waste, they will improve the biodegradability of the mixture.

2.3 Potential Sources of Organic Feedstocks

2.3.1 State-Wide Sources

MassDEP published a 2002 survey (updated in 2011) titled “Identification, Characterization, and Mapping of Food Waste and Food Waste Generators In Massachusetts” (completed by Draper/Lennon, Inc). The report separated Massachusetts food waste generators into the following categories:

- Manufactures/Processor
- Distributors/Wholesalers
- Hospitals
- Nursing Homes (and related facilities)
- Colleges and Universities
- Independent Preparatory School
- Correctional Facilities
- Resorts/conference facilities
- Supermarkets
- Restaurants

The study also provided a database which included the location and anticipated organic food waste generation in (tons/year) for each source. Though details as to the method of development of estimated quantities can be found in the study, it generally used the methodology shown in Table 2-1. The exception to this is that the producers within the Manufactures/Processor and Distributors/Wholesalers sectors were estimated on a state-wide basis due to the variability between each specific source location. It should also be noted that these sectors which were not specifically located are estimated to account for nearly 60 percent of the total waste as shown in Table 2-2. Further, Table 2-3 shows that most of the wastes are generated by a relatively small number of generators with approximately 80 percent of the annual tonnage being generated by only 30 percent of the total number of generators.

The results of this recently updated survey continue to serve as a basis for much of the organics diversion planning efforts throughout the Commonwealth and will be considered during the current Millbury feasibility study.

Generator Sector	Food Waste Generation Estimates by Generator Category
Hospitals	Food waste (lbs/yr) = N of beds * 5.7 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Nursing Homes and Similar Facilities	Food waste (lbs/yr) = N of beds * 3.0 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Colleges, Universities, and Independent Preparatory Schools	<i>Residential Institutions</i> Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 405 meals/student/yr
Residential Institutions	<i>Non-Residential Institutions (e.g., community colleges)</i> Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 108 meals/student/yr
Correctional Facilities	Food waste (lbs/yr) = 1.0 lb/inmate/day * N of inmates * 365 days/yr
Resorts / Conference Properties	Food waste (lbs/yr) = 1.0 lbs/meal * N of meals/seat/day ² * N of seats * 365 days/yr
Supermarkets	Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr
Restaurants	Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr

Table 2-1
Quantity Estimate Methodology for Source Separated Organics Generators

Generator Sector	Estimates Tons/Year	Percent
Food and Beverage - Manufacturers and Processes	550,000	58
Restaurants	165,000	17
Supermarkets and Grocery Stores	105,000	11
All Other Sectors	130,000	14
Total	950,000	100

Table 2-2
Source Separated Organic Generators by Industry Sector

Tons Per Year Per Organics Generator	Number of Generators	Percent by weight
Greater than 400	860	59
200 - 400	295	8
100 - 200	930	14
Less than 100	4,775	19
Total	6,860	100

Table 2-3
Source Separated Organics Generator Size Distribution

2.3.2 Regional and Local Sources

Generally, the feasibility of collection and hauling of waste is evaluated on the basis of a 30 mile radius around the disposal destination. As a starting point for this evaluation, the quantity of anticipated waste in this 30 mile region was extracted from the organic waste survey data. The spatial distribution of the anticipated sources in this region is shown on Figure 2-1 while Table 2-4 provide a summary of the distribution of these expected sources between the various industry sectors.

	Quantity	Generation (Tons Per Year)
Food and Beverage Manufacturers/Processors	150	100,000 ¹
Restaurants	873	37,000
Supermarkets and Grocery Stores	162	25,000
Wholesale Distributors	82	12,000 ¹
Institutions-Healthcare Facilities	176	7,000
Institutions-Colleges/Universities	24	4,000
Institutions-Correctional Facilities	10	1,000
Resorts and Conference Facilities	32	1,000
Institutions-Independent Schools	6	200
TOTAL	1,515	187,200

Notes: 1. Estimated based on statewide total to percent of generators within regional area.
2. "Regional" is considered to be within a 30-mile radius of the site

Table 2-4
Regional Organic Waste Source Distribution

More locally, there are a large number of food waste generators in Millbury and the surrounding areas that could contribute food waste to the Millbury facility. In addition to restaurants and grocery stores in the Town of Millbury, there are multiple agricultural centers including Stowe Farm, Pearson's Elmhurst Dairy Farm, Greystones Farm, and Roger's Farm & Garden Supply that could serve as industrial partners for this project either on the supply side or digestate (solids remaining after digestion) side. Nearby, the City of Worcester contains over 200 food waste generators that could also contribute to the organics-to-energy system. The spatial distribution of the anticipated sources in this region is shown on Figure 2-2 while Table 2-5 provides a summary of the distribution of these expected sources between the various industry sectors. Table 2-6 provides further detail on some of the larger potential local sources of organic waste in the vicinity of Millbury.

	Quantity	Generation (Tons Per Year)
Food and Beverage Manufacturers/Processors	26	18,000 ¹
Restaurants	121	5,000
Supermarkets and Grocery Stores	21	3,000
Institutions-Healthcare Facilities	39	2,000
Institutions-Colleges/Universities	8	2,000
Wholesale Distributors	6	1,000 ¹
TOTAL	221	31,000

Notes: 1. Estimated based on statewide total to percent of generators within local area.
2. "Local" considered to include Millbury, Worcester, Auburn, Grafton and Sutton

Table 2-5
Local Organic Waste Source Distribution

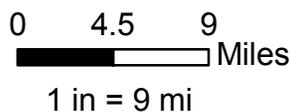
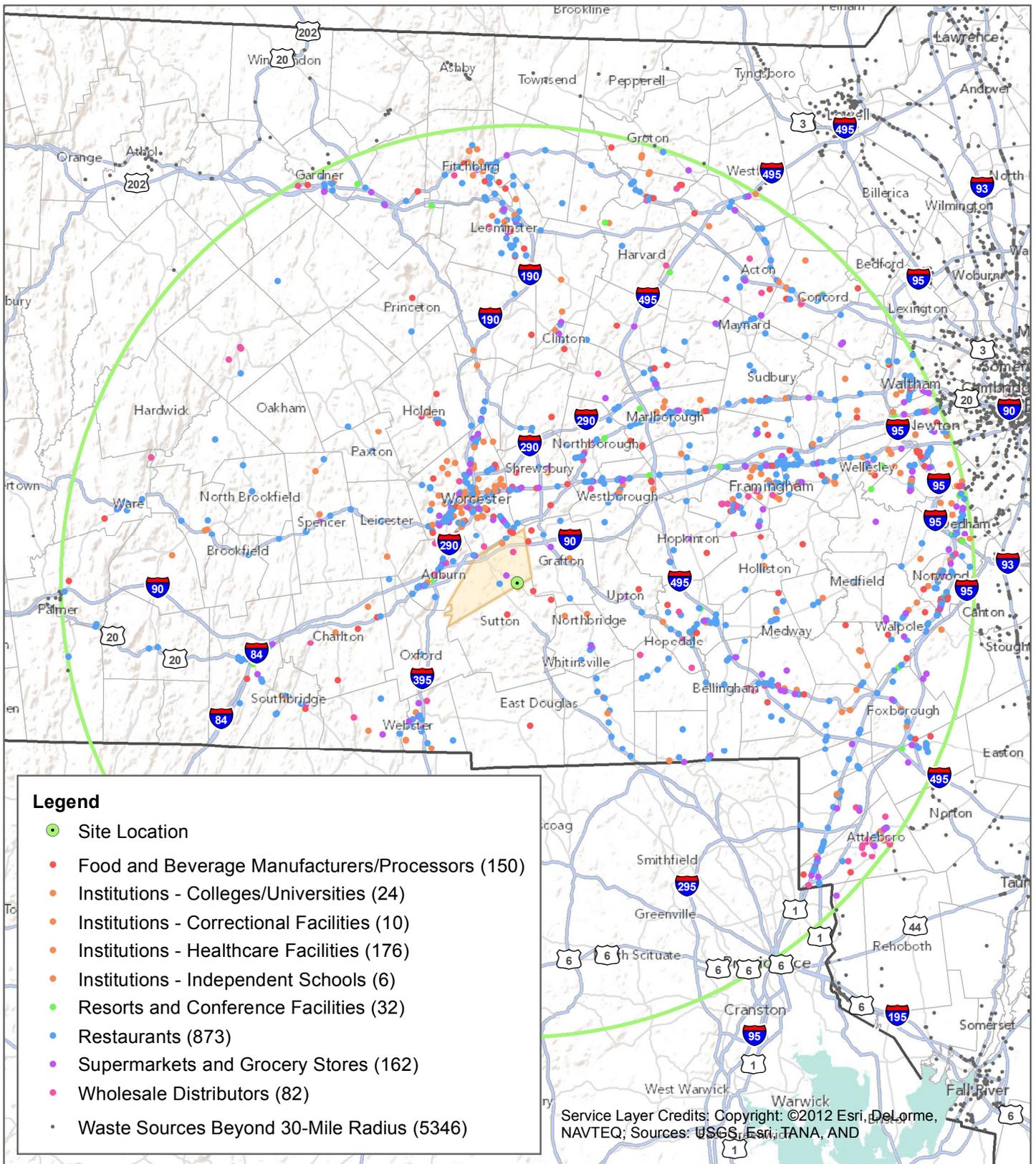
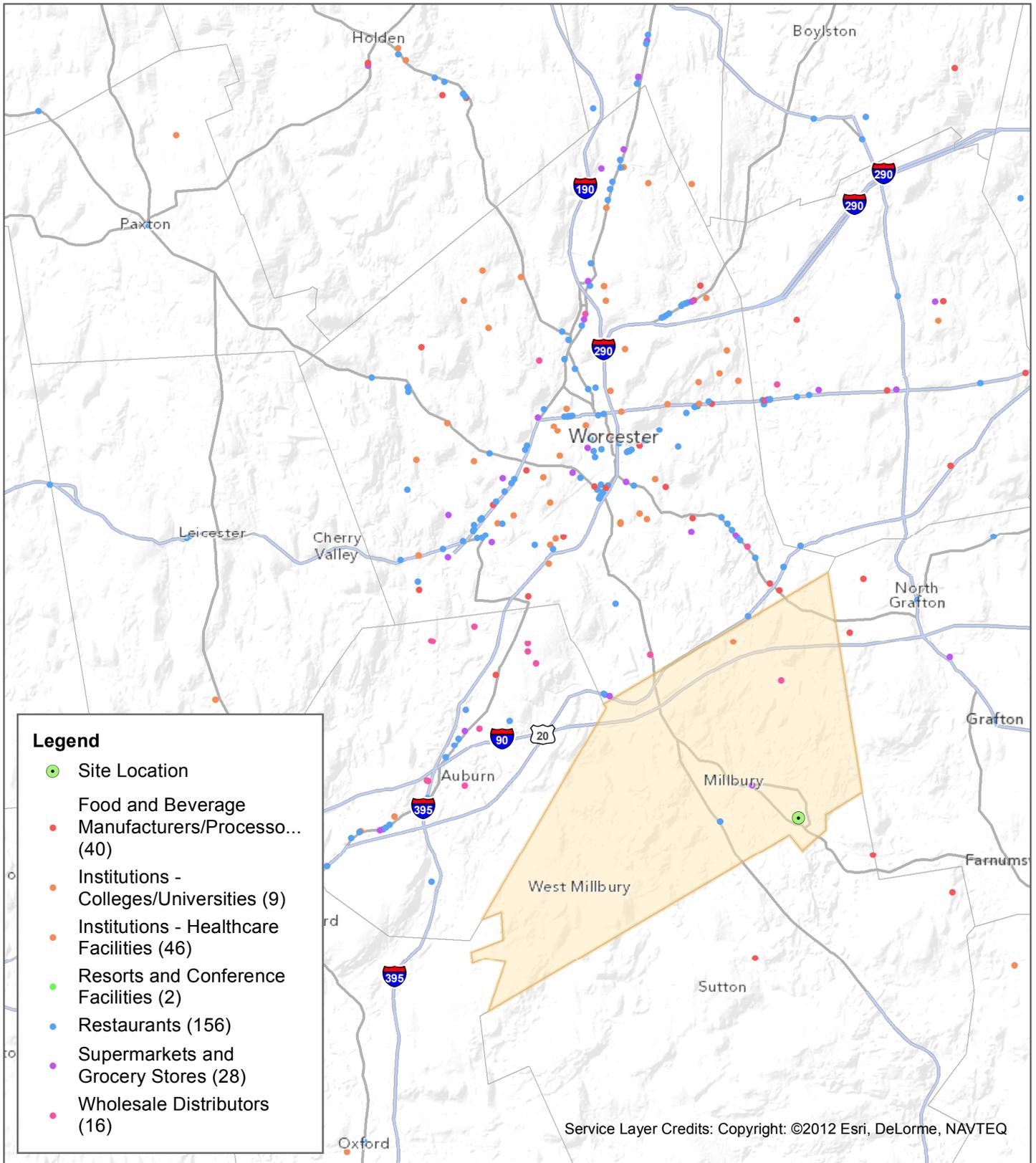


Figure 2-1
Regional Organic Waste Sources
within a 30 Mile Radius of Site
Millbury Organic Waste to Energy Facility
April, 2013

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 Miles
 1 in = 2 mi

Figure 2-2
Regional Organic Waste Sources
in the Vicinity of Worcester and Millbury
 Millbury Organic Waste to Energy Facility
 April, 2013

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No.	Generator Name	Street Address	Town/City	Generation (Tons Per Year)
1	Worcester State College	486 Chandler Street	Worcester	388
2	Stop & Shop	949 Grafton Street	Worcester	348
3	Stop & Shop	100 Worcester St.	Grafton	317
4	Stop & Shop	940 W Boylston Street	Worcester	279
5	UMASS Medical Center (University Campus)	55 Lake Avenue North	Worcester	260
6	Worcester Polytechnic Institute	100 Institute Road	Worcester	259
7	Big Y	100 May St	Worcester	254
8	Big Y	50 SW Cutoff Suite 2	Worcester	254
9	Super Shaws	113 Gold Star Blvd	Worcester	225
10	St. Vincent Hospital	123 Summer St.	Worcester	200
11	College of the Holy Cross	One College Street	Worcester	200
12	UMASS Medical Center (Memorial Campus)	119 Belmont St.	Worcester	199
13	Stop & Shop	541 Lincoln St	Worcester	198
14	Assumption College	500 Salisbury Street	Worcester	196
15	Goretis Supermarket	1 Providence St FL 2	Millbury	195
16	Price Chopper	221 Park Ave 223	Worcester	188
17	Quinsigamond Community College	670 W Boylston Street	Worcester	169
18	Tatnuck Country Club	1222 Pleasant St	Worcester	152
19	Maxine's	25 Carbon St	Worcester	150
20	Clark University	950 Main Street	Worcester	150
21	Price Chopper	195 Mill St	Worcester	143
22	Becker College	61 Sever Street	Worcester	123
23	111 Chophouse	111 Shrewsbury St	Worcester	120
24	Price Chopper 151	29 Sunderland Rd	Worcester	113
25	99 Restaurant & Pub	793 Southbridge St	Auburn	105
26	Outback Steakhouse	771 Southbridge St	Auburn	105
27	Worcester State Hospital	305 Belmont St	Worcester	104
28	Park n Shop	711 Southbridge St	Auburn	102
29	Applebee's	680 Southbridge St	Auburn	98
30	Pizza Works	456 Grove St	Worcester	98

* Table does not include Food and Beverage Manufacturers/Processors or Wholesale Distributer sector sources.

**Table 2-6
Significant Local Potential Organic Waste Sources**

As previously noted, the 2002 survey and the tables and mapping presented herein which are based on this data, do not include tonnage from Food and Beverage/Processors and Wholesale Distributors. For this conceptual analysis, quantities available from this sector were determined using a ratio of the total estimated sector quantities compared to a percentage of the generators within the referenced area. In the event that the project is deemed viable following the feasibility phase of the project, local and regional industries should be contacted directly to further refine the locations and quantities of available organic waste within these sectors.

2.4 Current Organics Diversion Efforts

MassDEP estimates that there are approximately 950,000 wet tons of such organics in the waste stream, and that currently only about 100,000 wet tons of pre-consumer food wastes are diverted, mostly by supermarkets, institutions, and other large generators. The SSO that is currently diverted is managed in any of the following ways:

- Edible food is provided to food banks – this is the highest priority use, if appropriate;
- Animal feed (e.g. at pig farms);
- Commodity processors, such as Baker Commodities (recycles high value grease and oil);
- Anaerobic digestion – a very limited amount is processed in anaerobic digesters at food production facilities or stand-alone commercial operations, such as the Jordan Dairy Farm digester (details below); and
- Composting – at municipal composting sites or the several commercial and/or on-farm composting operations in Massachusetts or in neighboring states.

Figure 2-3 depicts the general location and relative size of the existing permitted food waste processors throughout the Commonwealth. For comparison, the largest of these (located in Marlboro) is currently permitted to accept 100 TPD of waste while the majority of the smaller processors are generally local leaf and yard waste facilities permitted for up to 15 TPD of SSO co-composting.

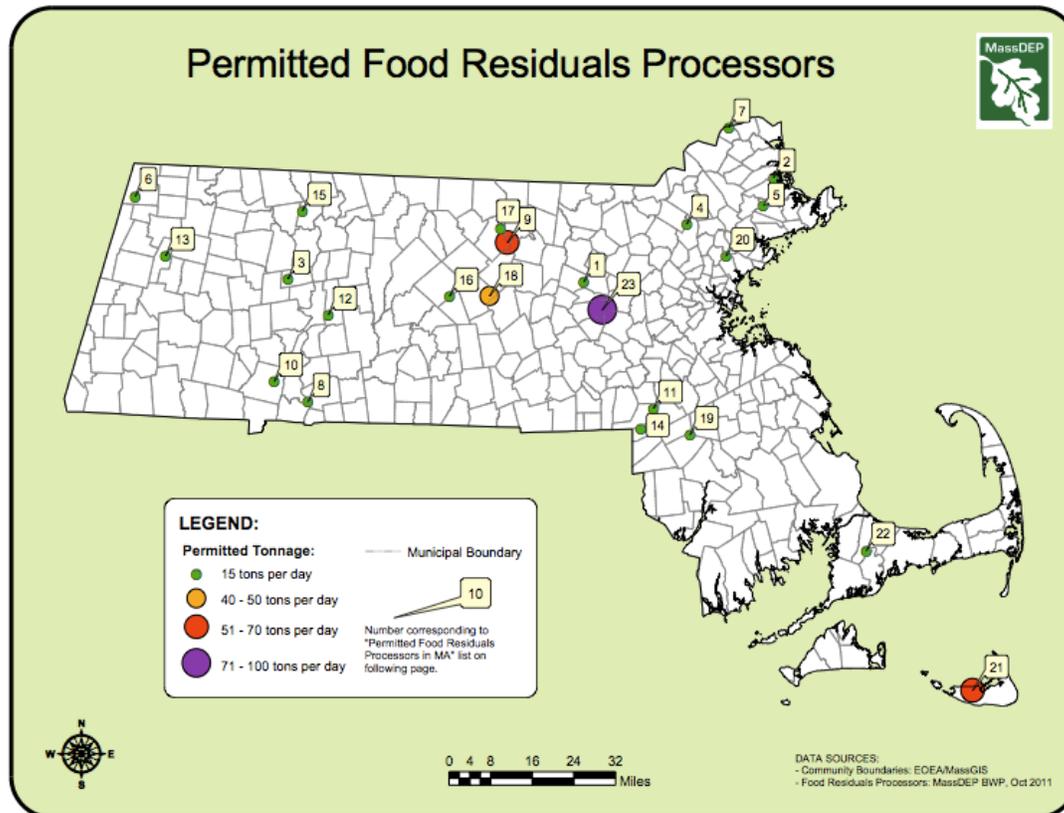


Figure 2-3
 Permitted Food Residuals Processors throughout MA (courtesy of MassDEP)

2.5 Organics Digestion Experience and Initiatives

In conjunction with the organics ban, MassDEP is concurrently promulgating regulations intended to streamline the siting of facilities that can process the additional diverted SSO, including anaerobic digestion and composting facilities, and taking other steps to encourage such development. Another significant regulation change has also allowed for wastewater treatment plants to accept SSO for processing in existing anaerobic digesters with minimal permitting requirements.

MassDEP and the Governor's office are promoting the development of new or expanded anaerobic digestion capacity around the state. Recently, they have supported and applauded the creation of the "five farm" project proposed by AGreen Energy LLC that involves construction of new anaerobic digesters and CHP at five farms around the Commonwealth. In addition, there are a number of public and private initiatives currently focused on evaluating and/or developing separate organics digestion or co-digestion project.

2.5.1 Experience

The Jordan Dairy Farm in Rutland, MA – northwest of Worcester – is the first of the five farm-based anaerobic digesters that will process a mixture of farm manures and SSO. The Jordan Farm's digester has been in operation since summer 2011 and treats a mixture of dairy manure and SSOs. The single digester has a capacity of approximately 25,000 gallons per day. The biogas produced is fed to an internal combustion engine, which is designed to produce 2280 MW hours of electricity a year (260 kW average power production). Heat from the engine jacket is run through a heat exchanger to maintain digester temperature. Electricity generated by the facility provides 100 percent of the electricity needs of the farm; excess power is sold to the grid. The digestate residual is pumped to the farm's liquid manure pit, where it is stored until the farmer applies it to soils to support the growth of corn silage and hay crops.

The next phase of the "five farm" project will involve the installation of digestion and cogeneration facilities at farms in Hadley and South Deerfield with financing for the project expected to be in place before the end of 2013. Planning for future facilities at farms in Granville and Shelburne is also underway.

Though unassociated with the five farms project, it should also be noted that co-digestion of organic waste with animal waste is also currently occurring at Pine Island Farm in Sheffield, Massachusetts. In November 2011, Pine Island Farm began using the manure as feedstock for its new anaerobic digester. Though the feedstock to the digester consists primarily of animal waste, approximately 10% of the capacity is currently used for digestion of excess whey from a local dairy processor. Biogas from the digestion system is currently used in a Combined Heat and Power (CHP) system to generate an average of 225 kilowatts of electricity for the farm and provide heat to the digester and for hot water heating needs. Excess power from the CHP system is fed back to the local electrical grid.

2.5.2 Initiatives

When the organics waste ban for pre-consumer food waste is instituted in 2014, MassDEP expects that approximately 3,000 businesses and institutions will be impacted – or nearly ten times the present number. Approximately 350,000 tons per year or approximately 1,000 tons per day of organic wastes will need to be recycled. To service these customers, many private companies and municipalities are evaluating the feasibility of developing organics digestion, organics co-digestion and co-composting facilities. In addition, private haulers are making plans to establish new or

modified transfer stations throughout the Commonwealth to serve as collection and processing points for organics.

It should also be noted that, beyond the farm digesters noted above, there are active organics digestion projects under development throughout Massachusetts. CDM Smith is currently aware of multiple initiatives in the metro west region and one specific site under investigation by a private party in the Town of Millbury.

2.6 Ongoing Organics Characterization and Digestion Studies

CDM Smith has been conducting organics digestion research for several years. As part of these efforts, a laboratory treatability study was completed to evaluate the feasibility of an anaerobic digestion to process food wastes from Department of Defense (DOD) installations. This work was conducted on food wastes generated at the U.S. Air Force Academy in Colorado with the goal of quantifying food waste digestibility and energy yield, identifying potential nutrient limitations, and determining appropriate specific energy loading rates (SELR) for these wastes. These evaluations were completed in the absence of waste activated sludge (i.e., separate food waste digestion rather than co-digestion), similar to that being considered under this study. The results have provided estimates of expected volatile solids (VS) reduction and biogas production from SSO digestion which form the basis of this technical analysis.

It should also be noted that, as part of a project for the MWRA involving CDM Smith, Fay, Spofford & Thorndike (FST) and Dr. Chul Park at the University of Massachusetts/Amherst (MWRA project 7274A), an evaluation of the co-digestibility of food waste and wastewater solids is being completed. The following steps are currently being taken:

- Conduct a bench-scale digestibility study of SSO from various sources;
- Assess the biochemical methane potential (BMP) for these SSO;
- Review the sidestream impacts from co-digestion of these SSO (toxicity, nutrient load);
- Quantify volatile solids reduction; and
- Compare various mix ratios of food waste to sludge.

The bench scale digestibility research is being conducted with the help of graduate students at Dr. Park's lab. The information from this research will assist in estimating biogas production (BMP) and residual solids (volatile solids reduction) experienced from the digestion of SSOs. Though these analyses are being conducted specifically pertaining to a potential co-digestion program at the MWRA's Deer Island Treatment Plant (DITP), the results are likely to provide some value as to the digestibility of various types of organic wastes in Massachusetts.

2.7 Conceptual Facility Sizing

As outlined in this section, based on a review of available data, it is estimated that there may be approximately 190,000 wet tons per year (wt/yr) of organic waste within a 30-mile radius (regional) of the Providence Street site. However, it is unlikely that a facility built at the Providence Street site would be able to attract this full quantity of waste as a result of a few factors, including:

- The waste generation estimates provided in the MassDEP study are conceptual in nature and include an estimate of total theoretical organic waste production. It is unlikely that all generators considered will be able to completely separate organics and some percentage will continue to be included in their solid waste stream;
- Concurrent with this study, there are a number of private and public entities studying the feasibility of developing source organics processing facilities as a result of the pending organics disposal ban in the Commonwealth of Massachusetts. As shown on Figure 2-1, the assumed 30-miles radius encompasses the majority of the metro-west region of Massachusetts and extends to points within the I-95 corridor. Based on recent discussions and planning within the industry, it appears likely that other facilities will be developed in the commonwealth that will compete with the potential Millbury facility for the sources within this area.

As a result of the above factors, the current study will conceptually analyze two loading/sizing scenarios which are intended to represent the lower and upper bounds of waste acceptance. For the purpose of this study, those scenarios are assumed to include:

- Lower limit of feasible acceptance volumes = 10% of regional organic waste = 19,000 wt/yr;
and
- Upper limit of feasible acceptance volumes = 50% of regional organic waste = 94,000 wt/yr.

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Section 3

Conceptual Organics Processing Facility

3.1 Selection of Anaerobic Digestion Technology

The production of energy from organic waste is most commonly accomplished through the use of an anaerobic digestion process. In this process, volatile organic materials within the waste are broken down by microorganisms in the absence of oxygen. This biological process produces biogas which is principally composed of methane and carbon dioxide and can be used to produce energy.

Anaerobic digestion systems are generally categorized based on the solids content of the waste they are able to process. “Wet” digestion systems typically receive waste with solids concentrations of 15% or less which is driven by the need to pump into and mix the waste within a digestion tank. Wet anaerobic digestion technology has been in use for centuries and is considered a highly proven and reliable means of reducing organic waste volume while producing biogas. There are currently 34 municipal wastewater treatment facilities within New England which utilize this technology in addition to a number of private industrial food processing and agricultural facilities which use wet anaerobic digestion for treatment of their organic waste stream.

“Dry” digesters (also referred to as High Solids Anaerobic Digesters (HSAD)) are generally designed to receive waste with between 20% and 50% solids. The HSAD process relies on the feedstock being of a quality that is able to be stacked into a digester tunnel and generally requires a bulking material (generally yard waste) to be added to a pure SSO stream to ensure permeability. Though this technology has been used commercially in Europe for over 20 years, there are only two facilities of this nature currently operating in the United States, each with an average processing capacity of between 5 and 10 wet tons per year (less than half of the smallest option being evaluated in this study).

For the purpose of this feasibility study, and as discussed further in this section, it has been assumed that wet digestion technology would be employed at the potential Millbury facility. In addition to the proven nature of the process and significantly larger experience base of wet digestion as compared to a dry process, additional advantages and reasons for this assumption include:

- Dry digestion is generally employed for feed rates of 50,000 wet tons per year or less which is approximately half of the larger of the two sizing options being evaluated for Millbury;
- The wet digestion process provides more opportunity for process monitoring and control;
- Dry digestion requires additional safety concerns and mitigation requirements due to the need to purge the tunnels of biogas following each batch;
- Dry digestion is inherently less efficient in volatile solids reduction and biogas production;
- Dry digestion provides minimal opportunity for processing of liquid organic waste (i.e. food processing wastes); and

- Significant volumes of yard waste (or other organic bulking material) are typically required as part of the waste stream on a continuous basis to ensure suitable pile stability, low bulk density and proper percolation within the digester.

The following section will review the estimated infrastructure and associated cost associated with the use of wet digestion technology for each of the acceptance scenarios outlined in Section 2.

3.2 Organics Receiving and Pre-Processing

Though few facilities presently exist nationwide for the pre-processing of source separated organic food waste, there are some operational facilities in Canada and Europe. A facility of this nature would include equipment to process in-coming wastes in order to produce a product that can be easily digested. Processing is expected to include machinery to screen and pulp the wastes, remove contaminants (e.g., glass, plastics, metals, and cardboard), and produce a uniform pumpable material that is readily digestible.

3.2.1 Pre-Processing System Sizing

It has been assumed, based on industry research, that the food waste would be delivered to the facility at a solids percentage of 31% (69% water). At this high percentage of solids, even following pre-processing, the resultant product is not conducive to pumping to or mixing within anaerobic digestion tanks. As a result, it has been assumed that the waste would be diluted to approximately 13% solids content prior to being introduced to the digestion facility. This resultant product is sometimes referred to as Engineered Food Waste (EFW). As shown in Table 3-1, this would translate to approximately 30,000 and 148,000 gal/day of EFW being fed to digestion with between 18,000 and 86,000 gal/day of dilution water being required. It should also be noted that, though public water supply is a potential source for this dilution water, rain water and/or other liquid organic wastes can also be used for this purpose and would be more cost effective. Installation of a water supply well for this water could also be considered. Though use of untreated wastewater is another technically viable solution, this would have a potentially significant negative impact on the future ability to reuse the digestate as it would then be considered a Class B biosolid and would be regulated under federal biosolids reuse regulations.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Potentially Available SSO Waste (wet tons/year)	19,000	94,000
Potentially Available SSO Waste (wet tons/day)	52	258
SSO Pre-Processing Rate (8 hrs/day, 6 days/wk) (wet tons/hr)	7.6	37.7
Assumed as-collected SSO water content	69%	69%
Dry Solids Content (dry ton/day)	16	80
Dry Solids Content (dry lbs/day)	32,000	160,000
EFW Diluted to 13% (gal/day)	30,000	148,000
EFW Storage Volume (2 days) (gal)	60,000	296,000
Water Required for Dilution (gal/day)	18,000	86,000

Table 3-1
SSO Receiving and Pre-Processing

It should also be noted that use of dewatering filtrate for dilution water is not considered feasible at this time due to the recirculation of ammonia that would occur which could create the potential for ammonia toxicity within the digestion process. For conceptual costs purposes, it is assumed that municipal drinking water will be used for this purpose and costs will be carried accordingly.

3.2.2 Pre-Processing Equipment

One of the limited examples of preprocessing systems that has been utilized to-date is the “CORe” (Centralized Organics Recycling equipment) system developed by Waste Management. This system is a source separated food waste processing and blending system designed to remove the non-degradable contaminants from source separated food waste streams. The major components of this system include an organic material feed hopper, hopper auger feed, bio-separator (cylindrical screen) and bio-slurry tanks. It is intended to utilize a small footprint and provide a totally enclosed solution for SSO preprocessing at a WM transfer station(s), landfill, or on a partner’s property. Using this system, the received material is blended into a consistent feedstock. Pilot testing of the CORe system was completed at Victor Valley Water Reclamation Authority in CA with reportedly positive results. However, it is noted that this system is currently proprietary and costs for installation in Millbury are not currently available.

A second known example of a pre-processing system is that currently offered by Komptech USA of Westminster, Colorado (though headquartered in Germany). The pre-processing system that they offer includes shredding, pulping, screening/pressing, sand separation and hygienisation stages. Though they do not currently have any US installations, the equipment they offer has been used extensively in Europe.



SystemFigure 3-1
Example Receiving and Pre-Processing Equipment
(Courtesy of Komptech)

Costs evaluated later in this section include costs for this type of pre-processing system as well as the required dilution water at the Millbury site. For the purpose of equipment sizing, it has been assumed that waste would be received 8 hrs/day, 6 days/wk.

3.2.3 Pre-Digestion Storage and Feed

The efficiency of an anaerobic digestion system is contingent upon the ability to feed it at a relatively constant rate. Highly variable loading or ‘slugs’ of feed material being introduced into the process creates a potential for upsets (significant decrease in biogas production), foaming and/or an overall reduction in volatile solids destruction efficiency.

As a result of the continuous feeding needs in comparison with the receiving schedule noted previously, it is expected that pre-digestion engineered food waste storage tank(s) would be required. In addition, this storage would serve to address variations in SSO supply and potential system operational issues. For the purpose of this study, it is assumed that a total of 2 days of EFW storage would be required. As shown in Table 3-1, this equates to 60,000 and 300,000 gallons for the two options being evaluated.

Though there currently exist two former process tanks at the site that could be considered for pre-digestion storage, they were maintained in the design of the existing wastewater pumping station to provide for emergency wastewater storage in the event of an operational issue with the pumping system. As such, for the purpose of the conceptual cost analysis, it has been assumed that a new pre-digestion storage tank would be required to be constructed and reuse of these tanks is not possible. In addition, a new feed pump vault would be constructed adjacent to the new tanks to convey the EFW through the required influent heat exchangers (discussed later in this section) and ultimately to the digestion tank(s).

It should be noted, however, that conversion of the existing tanks from pump station overflow storage to pre-digestion storage could be considered during later stages of project implementation. As the current use of these tanks was part of a MassDEP approved plan associated with the pump station construction, discussions with the appropriate MassDEP departments would be required in order to convert them from their current use.

3.2.4 Pre-Processing Odor Control

Due to the nature of the waste which would be received and handled within the pre-processing system, and despite the relatively remote nature of the Millbury site, it is expected that odor control treatment of the exhaust air from this area of the process would be required. There are several types of odor control technologies that would be suitable for use at this facility, which could include:

- Biofiltration (conveyance of air upward through an organic or inorganic media that supports a population of microorganisms that consume odor forming compounds);
- Wet Scrubbing (treatment of air through a scrubbing chemical solution which oxidizes and neutralized the odor forming compounds); or
- Carbon Adsorption (use of a carbon impregnated with caustic or a catalytic carbon with an enhanced affinity for hydrogen sulfide is generally used to absorb the odor forming compounds).

Though the exact technology used at this location would need to be refined during future stages of design, an allowance will be carried in the cost evaluation to address this need.

3.3 Anaerobic Digestion

As previously noted, wet anaerobic digestion has been practiced for decades and is one of the most common technologies used for the stabilization (pathogen and odor reduction) of wastewater treatment residuals (biosolids) utilized in the United States. Some of the major benefits of this process include the following:

- Biosolids quantity reduction can commonly exceed 40 percent;
- Digester gas produced (biogas) can be converted to electricity;
- Digested biosolids produced exhibit less odor; and
- The carbon footprint of facilities with anaerobic digestion is significantly less than competing biosolids management technologies.

Previous and continued research in the area of anaerobic digestion has generally focused on improved solids pre-treatment, improved digestion efficiency and maximization of digester gas production. In addition, there are many technologies that are being developed to improve sludge quality, making it more amenable to digestion. These technologies disrupt the cell membranes with chemical, heat or pressure to accelerate the digestion process and improve biogas production. There are also several variations of the anaerobic digestion process itself which have been employed by some municipalities. These include staged systems (acid-phase digesters followed by gas-phase digesters), high temperature thermophilic digesters (140°F) and other combinations which are also intended to improve the efficiency of the digestion process.

More recently, as discussed in Section 2, there has been a significant increase in the emerging area of organics digestion and co-digestion or organics with biosolids. There are a number of ongoing studies in this area including work with the Department of Defense and the Massachusetts Water Resources Authority to help refine data pertaining to the expected volatile solids (VS) reduction and biogas production from organics digestion.

3.3.1 Digester Tank Sizing

Anaerobic digesters are sized based upon solids retention time (SRT) and hydraulic retention time (HRT). For the conceptual Millbury digestion facility, it has been assumed that the process would utilize a conventional mesophilic process (95°F process temperature) and would be sized for an average SRT of 20 days. This retention time is industry standard and is based on allowing adequate time for the biological process within the digester to optimize the volatile solids destruction and associated biogas production. It is further assumed that this high rate digester system will not include supernatant decant and therefore, the HRT is equivalent to the SRT and the terms may be used interchangeably.

Table 3-2 summarizes the recommended basis of design used to size the digester system under each acceptance alternative. As shown below, it is anticipated that required digestion volume would range from 0.6 Mgal to 1.5 Mgal.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
EFW Diluted to 13% (gal/day)	30,000	148,000
Equivalent digestion tank volume for 20 day HRT (gal)	600,000	2,960,000
Digester Feed Rate (gal/min)	21	103
Dry Solids Content (dry lbs/day)	32,000	160,000
Volatile Solids (85% VS/TS) (lbs/day)	27,000	136,000
Volatile Solids Reduced (82% VSR) (lbs/day)	22,000	112,000
Digestate Solids Remaining (lbs/day)	10,000	48,000
Digestate Solids Concentration (%)	4%	4%
Number of Tanks	1	2
Volume Per Tank (Mgal)	0.6	1.5
Approximate Diameter (ft)	60	80
Approximate Height (ft)	30	40

Table 3-2
Anaerobic Digestion Conceptual Sizing

It should also be noted that the materials of construction for digestion tanks under municipal ownership and operations is commonly cast-in-place or pre-stressed concrete. This selection of material is typically made due to considerations including service life and reduced maintenance costs when compared to other options. It also provides the most flexibility with respect to biogas pressures and cover options. However, in industrial settings, steel digestion tanks tend to be selected more commonly due to the associated capital cost savings. Steel tanks can be provided with welded or bolted steel and coated with epoxy coatings or fused glass materials. For the purpose of this conceptual analysis, it has been assumed that the tanks(s) will be constructed of cast-in-place concrete.

3.3.2 Biogas Production Estimate

Based on recent studies¹, it has been shown that the ratio of volatile solids to total solids and the biogas production per pound of volatile solids reduced for source separated organic (SSO) waste is relatively similar to that of municipal biosolids. However, it was also shown that the reduction of the volatile solids in the SSO stream within an anaerobic digester is significantly greater than is typically seen with municipal sludge (82% VS reduction for SSO vs. 55% VS reduction of municipal sludge). This, combined with the fact that SSO is generally fed to digesters at higher solids concentrations, enables the biogas yield from a gallon of SSO to significantly exceed that of from a gallon of municipal sludge. When this difference in gas production is considered on a unit basis, the yield from SSOs is approximately four times that of municipal sludge (10 cf biogas/gal SSO vs. 2.5 cf biogas/gal sludge).

As previously noted, this study evaluated two scenarios to represent the potential bounds for potential facility SSO acceptance volumes. It was determined that the average available SSO acceptance capacities under each of these scenarios would be 30,000 gal/day and 148,000 gal/day. Using these values, along with theoretical digestion performance parameters for digestion of SSO, the total anticipated biogas yield under each of these scenarios was calculated. As shown in Table 3-3, the total theoretical biogas production under these loading conditions would be between approximately 300,000 and 1,500,000 cf/day.

It should also be noted that heating value of digester biogas typically ranges from 500 to 650 BTU/cubic foot, with 600 BTU/cf being used in this estimate. For comparison, natural gas typically contains an average heating value of approximately 1,000 BTU/cf.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Volatile Solids Reduced (82% VSR) (lbs/day)	22,000	112,000
Biogas Production (13 cf/lb VSR) (cf/day)	299,000	1,523,000
Biogas Production (scfm)	208	1,058

Table 3-3
Biogas Production Estimate

¹ Anaerobic Digestion and Energy Recovery from Food Waste, J. Amador, D. Nelsen, C. McPherson, P. Evans and D. Parry (CDM Smith), H. Stensel (University of Washington), and T. Hykes, (U.S. Air Force Academy), WERF, 2012.

3.4 Ancillary Equipment

Anaerobic digestion systems require a significant amount of ancillary equipment to ensure proper process operations and safety. The following includes a brief discussion on each of the four major ancillary systems, which include:

- Heating system;
- Mixing system;
- Digester covers;
- Digester biogas handling equipment;
- Biogas storage system; and
- Biogas treatment and boosting systems.

3.4.1 Digester Heating

Anaerobic digesters are heated to maintain an environment conducive to methane forming microorganisms and to ensure greases and fats within the digester remain in an emulsified state so they can be broken down biologically.

There are two main types of heating systems: internal and external.

- **Internal:** With an internal arrangement, heat is applied to the sludge while it remains in the digester tank. Older digester heating arrangements included mounting pipes to the interior of the digester wall in which hot water circulates and draft tube mixers equipped with hot water jackets. In recent years, these arrangements have become less popular due to operational issues, including the buildup of sludge on the heating surface and access restrictions. Because all internal heating systems rely on the digester mixing system to circulate heat within the digester, the mixing system must be operated on a continuous basis. Without continuous mixing, heat gradient will develop in the tank and create biologically inactive zones.
- **External:** Newer digesters typically use external heating systems that recirculate sludge through external heat exchanger(s) using a recirculation pump. Most external heating systems incorporate means to heat the sludge before it enters the digester (i.e. influent heat exchanger). The feed sludge is typically interlocked with the sludge recirculation pumps, allowing the blending and preheating of the feed and active digester sludge before it enters the digester.

Hot water for the digester heating systems is typically supplied by either waste heat from a cogeneration system and/or a boiler that utilizes biogas from the anaerobic digester. Natural gas can be used as a supplemental fuel when not enough biogas is produced to heat the digester or if all of the digester gas is used in cogeneration and the waste heat is not sufficient to meet heating demands.

For the Millbury conceptual analysis, it has been assumed that external heat exchangers will be utilized and cogeneration waste heat will serve to supply the process heating needs. The energy balance and cogeneration sizing will be discussed later in this section.

3.4.2 Digester Mixing

Mixing in high rate digestion systems is important to maintain uniformity within the digester and to prevent scum accumulation in the digester tank. Digester mixing is a crucial component and poor mixing typically results in lower volatile solids destruction and decreased biogas production. Presently, the most common mixing systems are: recirculation pumps, compressed biogas and mechanical mixing.

- **Recirculation Pumps:** Pump systems use external pumps to recirculate the sludge for mixing. Sludge is pumped from the digester tank and is typically reintroduced through several ports located around the circumference of the digester or discharged through nozzles. Depending on tank diameter, pumping rates typically turn over the contents of the digester every 3 to 12 hours.
- **Compressed Biogas:** The four major gas mixing systems are gas discharged lances, floor-mounted diffusers, confined draft tubes, and “bubble-gun” gas mixers. On each of these systems, the gas compressor and control valves are the major mechanical pieces of equipment. In each system, biogas is taken from the headspace of the digester tank, compressed, and distributed to multiple mixing devices.
- **Mechanical Mixing:** These systems consist of a propeller, drive shaft and drive. Most mechanical mixing systems are mounted in a draft tube to direct sludge flow within the digester, while others are simply installed through tank wall penetrations with the motor and gear end external from the tank and with the propeller shaft penetrating through and generally perpendicular to the tank wall. When installed in a draft tube, drives are typically reversible, allowing the sludge to discharge at the top or bottom of the draft tube. Mixer/draft tube assemblies may be located at the center of the digester tank, at the mid-radius point or outside the digester tank.

A pump recirculation mixing system is recommended for Millbury based primarily on operation and maintenance considerations. With these systems, pumps are located inside a building along with other equipment and are easily accessed. In comparison, mechanical draft tube motors are located on top of the digester tanks creating a difficult maintenance environment especially during winter conditions. In addition, due to the inability to grind the recirculation flow with a draft tube mixer, rags and other fibrous materials could tend to accumulate within the digesters and create a maintenance concern. Further, due to the configuration of draft tube mixers, a crane would be required for any significant maintenance procedures. Gas mixing systems were removed from consideration due to cost and the historical maintenance concerns associated with the biogas compressor systems and general safety concerns associated with biogas handling. It should also be noted that a mixing system will also be required for the sludge storage tank discussed later in this section.

3.4.3 Digester Covers

Digester tanks require covers to maintain anaerobic conditions in the tank, contain and assist in collecting biogas produced during the digestion process, reduce odors, retain heat to maintain internal temperatures, and support some types of mixing equipment (e.g. internal draft tube mixers supported from fixed covers). There are four basic types of digester covers: floating, fixed, submerged fixed, and gas membrane.

- **Floating Covers:** Floating covers have been widely used throughout the wastewater industry for years. They have typically been used to provide for some liquid storage (conventional floating covers), as well as some gas storage (gas holding covers). Conventional floating covers float directly on the sludge surface, which provides for fluctuations of the liquid sludge level with minimal change in biogas pressure.
- **Fixed Covers:** Fixed concrete and steel covers are also widely used throughout the wastewater industry. They have historically been the option with the lowest cost and least potential for operation and maintenance problems in comparison to floating covers. However, fixed covers offer minimal biogas storage and limited flexibility with regard to sludge liquid level. One variation on the fixed concrete cover design is the submerged fixed cover (SFC). Compared to flat fixed cover designs, the submerged fixed cover is effective at utilizing the upper portion of the tank volume by inhibiting the buildup of floating foam and scum and directs mixing energy for better efficiency.
- **Submerged Fixed Covers (SFC):** These are similar in costs to flat roof digesters and less costly to construct than domed roofs. The key to the submerged fixed cover digester is a sloped roof that leads to a centrally located gas dome. In a SFC design, the liquid level is allowed to rise into the gas dome above the side wall, submerging the underside of the cover. Submerging the cover provides a gradual transition at the cover side wall connection, directing mixing patterns more effectively. Operating the liquid level in the gas dome minimizes the gas to liquid interface. By minimizing this interface, foam and scum can be removed more effectively. With minimal gas storage volume, a fixed cover system must either rely on storage spheres, piping, flares, vacuum and pressure relief valves, or some other means of gas storage to keep the pressures consistent inside the tank.
- **Gas Membrane Covers:** Gas membrane covers are a relatively new product that was first used in the U.S. in the early 1990s. They provide a large volume of digester gas storage using a double-membrane design and may be installed on digester tanks or sludge storage tanks. The outer membrane maintains a consistent dome shape, while the inner membrane moves up or down depending upon gas storage requirements. Ambient air fans and valves add or release air from the space between the inner and outer membranes to maintain the consistent outer membrane shape and constant biogas pressure. This also allows for substantial changes in the depth of sludge in the digester.

It has been assumed that SFCs will be used at the Millbury facility as fixed covers tend to be less costly than floating covers or gas holder membranes and SFCs minimize foaming, which is often expensive and difficult to control and contain. It is further recommended that the digested sludge storage tank, as discussed further below, be installed with a gas membrane cover to store excess biogas before it is used in cogeneration.

3.4.4 Gas Handling Equipment

Gas handling equipment consists of gas storage, conveyance and safety equipment. The conveyance system brings biogas at the rate it is produced in the digesters to equipment for consumption, storage, or wasting (combustion prior to release to atmosphere). Most biogas conveyance systems are low pressure and operate at approximately 12 inches of water column (< 0.50 psig). Biogas may be stored based on production and utilization demands of the boiler or cogeneration equipment. Storage devices include digester tank gas holder covers which are part of the digester itself and membrane gasholders that are external to the digester and are typically located in close proximity to the digester on a concrete pad.

Similar to natural gas, biogas is explosive at low concentrations of approximately 1 volume of gas to 15 volumes of ambient air. As such, it is of the utmost importance that the biogas handling system be fitted with appropriate gas-safety equipment, to protect against the risk of ignition and a potentially catastrophic explosion.

Any source of ignition, such as waste gas burners, engines, or boilers must be protected against flashback through the piping with a flame arrestor or flame traps. A flame arrestor works to quench the flame by dissipating any heat from a potential explosion in the piping. A flame trap is a combination of a flame arrestor and a thermal shutoff valve. If a propagating flame is stopped by the arrestor but continues to burn in the piping, a thermal element in the thermal shutoff valve will melt and seal off the remainder of the upstream piping from the fuel source.

Anaerobic digesters are provided with pressure/vacuum relief valves, typically mounted directly on top of the digester tank. These valves release any biogas to the atmosphere when the pressure rises above a set-point to protect from over-pressurization of the tank. Additionally, a vacuum relief valve will allow entry of ambient air into the tank during any vacuum conditions, to protect the tank from imploding. Costs for these systems have been incorporated into the project lifecycle evaluation included later in this section.

3.4.5 Biogas Storage Systems

As previously noted, because digesters do not produce biogas at a constant rate, nor is gas usage always constant, biogas storage is often recommended to maximize the biogas capture rate and increase the efficiency of the overall system. The most likely and viable alternative for providing storage capacity in this application would be the use of a double membrane gas holder.

Gas membrane covers were first used in the U.S. in the early 1990s. They provide a large volume of digester gas storage



Figure 3-2
Typical Gas Membrane Storage System
 Figure Courtesy of WesTech

using a double membrane design. The outer membrane maintains a consistent dome shape while the inner membrane moves up or down depending upon gas storage requirements. Ambient air fans and valves add or release air from the space between the inner and outer membranes to maintain the consistent outer membrane shape and constant biogas pressure. The exterior membrane is typically made out of polyester fiber fabric that is coated with PVC that is microbial and abrasion resistant. The internal membrane is also typically manufactured from PVC coated polyester fiber fabric, which is microbial, abrasion and biogas resistant. Some of the key drivers for this technology have been the need for large gas storage volumes and/or large fill and draw capacity in the tank.

There are several suppliers of membrane covers in the U.S. including WesTech, Ovivo, Siemens and JDV. WesTech, Siemens and JDV have several installations in the U.S. and most of the JDV and WesTech membrane systems are standalone on a concrete pad as opposed to on top of a tank.

Membrane covers have proven to be reliable systems with the older installations having a life expectancy of 10 years. However, suppliers indicate that the technology has improved in recent years and newer membranes should have a service life of approximately 15 years.

It is conceptually estimated that a total biogas storage volume equating to 8 hrs of average production would provide adequate storage capacity to enable a high biogas capture percentage. As such, the additional storage required to be supplied by this new storage system would range from approximately 100,000 to 500,000 cf.

3.4.6 Biogas Treatment and Boosting Systems

Biogas Treatment

Prior to being utilized in a cogeneration system, some level of treatment for biogas derived from wastewater or animal manure is typically required to remove contaminants. The level of treatment depends on the concentrations of contaminants in the biogas and end use of the gas. Contaminants often found in digester gas produced from wastewater treatment residuals include hydrogen sulfide (H_2S) and siloxanes.

Hydrogen sulfide (H_2S) in biogas is formed by the reduction of sulfates by anaerobic bacteria within the digester. Sulfates occur naturally in wastewater from the decomposition of urine and protein in the influent sludge. Siloxanes are often used in the manufacture of personal hygiene, health care and industrial products and eventually end up in wastewater. Siloxanes volatilize into the biogas during the digestion process and when this biogas is combusted, siloxanes are converted to silicon dioxide (SiO_2), which is then deposited in the combustion or exhaust stages of the equipment. In reciprocating engines, the presence of hydrogen sulfide and/or siloxanes can lead to premature deterioration and excessive maintenance of the equipment components.

As noted above, this experience with biogas quality and treatment is based on biogas from wastewater biosolids. In the case of an exclusively food waste feedstock, there is limited data relative to biogas quality. However, based on the limited data and experience that exists, this biogas is likely of much higher quality than with typical wastewater or manure derived biogas and likely contains very low levels of the above constituents. As such, for this analysis, it has been assumed that no biogas treatment beyond moisture and sediment removal will be required.

Biogas Pressure Boosting

Biogas pressure boosting is generally required in CHP applications due to the relatively low gas pressures which anaerobic digesters are typically operated at. The pressure of the biogas from anaerobic digesters is generally 12 inches of water column (< 0.50 psig) or less. This head space pressure is not sufficient for internal combustion engines which generally require an inlet pressure of between 2–5 psi of inlet gas pressure. As a result, the biogas utilization system at this facility would require a biogas booster system. In this system, the digester gas would first enter through a blower inlet moisture/particulate filter to remove any free moisture and particulates prior to being compressed with a blower. The blower would compress the gas to about 5 psig prior to entering a heat exchanger which would reduce the dew point of the gas to 40°F and reheat the gas to 80°F. All condensed moisture would be removed inside the heat exchanger and drained through a no-gas-loss drain. The heat exchanger would be supplied with cold glycol from a remote mounted glycol chiller.



Figure 3-3
Representative Biogas Booster

3.5 Energy Recovery

Digester biogas is commonly used to heat the digester and facility buildings by using the biogas in hot water boilers. However, in recent years, the prevalence of biogas fueled cogeneration systems have increased in popularity due to their ability to produce electricity and heat simultaneously. These systems which produce both electricity and recovered heat energy are commonly referred to as Combined Heat and Power (CHP) systems.

Though the electrical efficiency of an engine generator is significantly less than the overall efficiency of a boiler system, when coupled with a waste heat recovery system, the combined efficiency of the cogeneration system can be competitive with that of a boiler. As is the case in Millbury, a CHP system is often preferable to a boiler system due to the lack of sufficient heat demand to fully utilize the thermal output from a boiler system.

The following includes a brief description of available CHP technologies, and a conceptual evaluation as to the anticipated heat and electrical balance between production and on site use.

3.5.1 CHP Technology Alternatives

Currently, the most common technologies used for cogen are microturbines and reciprocating engines. In addition, other innovative technologies may become competitive in the future by reducing the need for biogas cleaning prior to use, therefore reducing overall complexity and equipment cost. For general background and potential future consideration, both established and innovative CHP technologies are briefly described below.

Internal Combustion Engines

Internal combustion (IC) engines are the most widely used CHP technology. They are often the most economical CHP technology and have combined electrical and heat recovery efficiencies higher than

any other currently available CHP technology. Heat can be recovered from the engine jacket water and from the exhaust gas. The technology is reliable and available from a number of reputable manufacturers. IC engines are less sensitive to biogas contaminants than most other CHP technologies, reducing the gas cleaning performance requirements; however, cleaning is often recommended to remove moisture, hydrogen sulfide, and siloxanes as discussed above.

One disadvantage of IC engines is their relatively high emissions, as compared to other CHP technologies, such as microturbines and fuel cells. IC engine emissions can cause permitting difficulties in areas with strict air quality limits and may require additional emissions control, such as selective catalytic reduction to meet emission requirements. However, most IC engines installed since 2005 are lean-burn engines, with higher fuel efficiency and lower emissions than rich-burn engines which were more commonly used before the 1970s.

Combustion Gas Turbines

Combustion gas turbines are often a good fit for very large biogas production rates. Like IC engines, combustion gas turbines are a reliable, well-proven technology available from several manufacturers. Large Waste Water Treatment Plants (WWTPs) in the US use biogas-fueled combustion gas turbines or CHP. Heat can be recovered from the exhaust gas. Combustion gas turbines are relatively simple, containing few moving parts and consequently requiring little maintenance. While infrequent, the maintenance of combustion gas turbines requires specialized service.

Microturbines

As the name suggests, a microturbine is a much smaller version of a combustion gas turbine. Microturbine capacities range from 30 kW to 250 kW and are often a good fit for smaller WWTPs with anaerobic digestion. Microturbines are relatively new, introduced about 15 years ago. Despite their somewhat recent development, microturbines have become the second most widely used technology at WWTPs for harvesting electricity and heat from biogas energy due to their small capacity and clean emissions. However, microturbine electrical efficiency is considerably lower than that of IC engines. Microturbines require relatively clean fuel, increasing the performance requirements and cost of biogas treatment, but their exhaust emissions are among the lowest of all CHP technologies. Microturbines are currently available from two manufacturers.

Fuel Cells

Fuel cells are unique in that they do not combust biogas to produce power and heat. Instead, fuel cells convert chemical energy to electricity using electrochemical reactions. Their benefits include high electric efficiency and extremely clean exhaust emissions. However, fuel cells are one of the most expensive CHP technologies in terms of both capital and operation and maintenance (O&M) costs. In addition, they are extremely sensitive to impurities in the biogas, requiring the highest level of biogas cleaning of all CHP technologies. For these reasons, fuel cell installations are typically limited to locations with strict air quality regulations and fuel cell-specific grants or incentives.

Stirling Engines

While Stirling engine technology is well established, their application to biogas is innovative. There has been increased interest in this CHP technology in recent years due to its reduced biogas cleaning requirements. A Stirling engine is an external combustion process. Biogas is combusted outside of the prime mover. The heat generated by the combustion process expands a working gas (generally helium), which moves a piston inside a cylinder. Because combustion occurs externally to the cylinder and moving parts, very little biogas cleaning is required.

Pipeline Injection

Pipeline quality biogas has extremely low concentrations of contaminants and must be compressed to match the natural gas transmission line pressure. Biogas contaminants that must be removed include foam, sediment, water, siloxanes, hydrogen sulfide, and carbon dioxide. Following cleaning, biogas must be compressed for pipeline injection. Biogas cleaning to pipeline quality has high capital and O&M costs. In most situations, generation of pipeline quality biogas is not cost-competitive with CHP. This biogas use is a better fit for large biogas producers (to take advantage of economies of scale) that near a natural gas pipeline. If financial incentives are available, pipeline injection can become attractive. There are currently only a few facilities cleaning biogas to pipeline quality in the US.

CNG or LNG Vehicle Fuel

Biogas can be upgraded to displace CNG or liquid natural gas (LNG) in vehicles capable of using these fuels. In Europe, upgrading biogas to fuel vehicular fleets is a well-established practice. In the US, there are only a few installations. Purity requirements for vehicular fuel are lower than those for pipeline injection. The biggest barriers to CNG or LNG conversion are the lack of a widespread infrastructure for gas filling stations and the cost of vehicle conversion for CNG or LNG use. Small scale packaged CNG conversion systems and filling station equipment are available from a single manufacturer and includes sulfur removal in a vessel with proprietary media, siloxanes removal in an activated carbon vessel and membrane carbon dioxide removal. There are currently three biogas CNG installations in the US, two at landfills and one at the Janesville, WI WWTP.

Cogeneration Technology Selection

As previously noted, reciprocating internal combustion engines are the most widespread, economical and efficient of all CHP technologies currently used for biogas cogeneration. Though the selection of CHP technology should be revisited during later stages of development for this project, internal combustion engines were selected for use in the following system sizing as well as the economic evaluation included later in this section.

For the purpose of engine sizing, it was assumed that engine selection would be based on ensuring that the average biogas production rate under each alternative would be capable of being utilized by the selected engine(s).

Biogas feed rate to the engine less than the total rated capacity would be utilized by either running the engines at a reduced rate or running less than the total number of installed units. It was further assumed that a parasitic load of 5% of the total electrical output is needed to provide energy for compression, gas boosting and gas treatment. For example, a 400 kW unit will produce 380 kW assuming 5% of the power produced is consumed by the parasitic load of the equipment used to operate the cogeneration system.



Figure 3-4
GE Jenbacher 850 kW IC Engine

3.5.2 Projected Energy Balance

As noted previously, the digestion of organics yields biogas production and associated energy recovery opportunities. However, the processing of solids yields energy consumption in the following areas:

- Heat required for preheating of incoming waste;
- Heat to replace energy lost to the environment through tank walls, cover, etc;
- Electrical energy for the digestion system components (pumps, mixers, etc); and
- Electrical energy for the downstream processing of digestate (effluent from the digester).

The above demands need to be considered along with the anticipated CHP energy production in order to yield a realistic estimate of net energy which would be available for other purposes.

CHP Energy Production

As noted above, in order to realize an environmental and financial benefit from this biogas, it would need to be utilized in a CHP cogeneration system. The internal combustion engine assumed for this analysis would have an average electrical generation efficiency generally between 30- and 40-percent. However, when the waste heat produced by this equipment is recovered and reused for process or facility heating requirements, an overall system efficiency of over 80% can generally be realized.

Table 3-4 summarizes the amount of power and heat produced if the biogas is utilized in a reciprocating engine. As shown, the total estimated electrical output using average biogas production rates and assuming a 95% capture rate is estimated to range from 840 kW to approximately 4,900 kW. In addition, based on engine manufacturer data, the total recoverable heat from these engines would equate to between approximately 3.6 and 18.4 MMBtu/hr, respectively.

Heat Balance

In this application, the waste heat from the CHP equipment would be recovered and applied to influent preheating and to maintain mesophilic digestion tank temperatures. The theoretical energy use for these heating needs was calculated and included in Table 3-4. As shown, the influent preheating requirements are currently estimated to range from 0.4 to 1.8 MMBtu/hr while the conductive process heat loss was estimated to be between 0.3 and 1.1 MMBtu/hr. It should be noted that these heat demand values are based on the noted temperatures and could be significantly less during the warmer seasons and/or with warmer incoming waste temperatures.

In addition to process heat, the new buildings required to house the equipment are assumed to utilize CHP waste heat for facility heating demands. Based on a conceptual estimate of 25 Btu/sf, this would equate to between 0.6 and 1.0 MMBtu/hr under peak (winter) conditions. It was additionally assumed that the existing building at the site (Pump Station, Highway Garage and Parks Garage) would be heated with CHP waste heat and values for these facilities were derived from recent utility bills provided by the Town. The energy balance included in Table 3-4 takes into account these heating demands. It should also be noted that conceptual cost allowances have been included in the financial analysis to cover the heat recovery loop (likely glycol circulation system) which would be required to distribute heat to these existing buildings.

As shown in the table, during the peak heat demand season (winter), after accounting for the anticipated heat demands, the lower bound estimate (10% of regional SSOs) yields a conceptually equal heat balance while the larger acceptance scenario (50% of regional SSOs) yields an excess of 12 MMBtu/hr. During the summer months, there appears to be an excess heat recovery capacity of between 3 and 16 MMBtu/hr for the two respective options.

Electricity Balance

The expected electrical production from the CHP system is currently estimated to range from 1 to 5 MW, depending on the waste acceptance quantity. Conceptual estimates of electrical demand from the new systems were also completed. This demand would originate from the equipment required for the pre-processing equipment, digestion process, biogas treatment, dewatering systems and side stream treatment (discussed later in this section). In addition, it was assumed that the electrical demands of the existing facilities at the site (from recent Town utility information) would be satisfied by the CHP electrical production. As noted in Table 3-4, after satisfying these estimated and actual demands, the net available electrical energy from the system is estimated to range between 690 and 4,300 kW.

3.6 Solid and Liquid Products and Byproducts

Though the potential benefits of accepting and processing organics can be significant due to the biogas production potential, the digestate flow from the process is roughly equivalent to the hydraulic input and contains significant inert and undigested solids that must be dealt with. In certain applications, this digestate can be beneficially reused so as to improve facility economics and environmental impact. Some potential methods of digestate solids reuse include the following:

- Land apply liquid digestate as a Class B fertilizer: This is generally relegated to applications where hauling of liquid digestate is not required, there is sufficient on-site storage for digestate during any non-growing season and there is sufficient established demand for the product (i.e. on-farm digestion facilities);
- Dewater digestate for use as Class B fertilizer: In other applications where there is limited space to store significant quantities of liquid digestate or hauling of liquid would be cost prohibitive, the product is first dewatered, stored temporarily and then land applied as a fertilize/soil amendment;
- Dewater and compost for use as a Class A fertilizer: The addition of a properly designed composting facility to process dewatered solids would create a higher quality product with additional reuse opportunities. However, the composting process is space intensive and would add significant capital and operational costs to the project; or
- Dewater and thermal dry for use as a Class A fertilizer: It should be noted that the excess heat from the cogeneration engines could also be used to dry the dewatered digestate and, in turn, produce a potentially marketable dried fertilizer product. Due to the temperatures of the heat that is recovered, this would likely be relegated to transferred of heat via hot oil or water to a belt dryer system. Assuming an average overall dryer efficiency of approximately 1300 Btu/lb of water evaporated and using Millbury Alternative B where there is estimated to be 11.7 MMBtu/hr available, there appears to be the potential to evaporate 9,000 lb water/hr in belt dryer(s) which, when operated full time, would be sufficient to dry the 25% solids dewatered digestate to 90% solids. However, the above calculations assume that the dryer and cogeneration system heat recovery are operated simultaneously and continuously.

Biogas Production and CHP Sizing	Alternative A (10% of Regional SSO)		Alternative B (50% of Regional SSO)	
	Summer	Winter	Summer	Winter
Volatile Solids Reduced (82% VSR) (lbs/day)	22,000	22,000	112,000	112,000
Biogas Production (13 cf/lb VSR) (cf/day)	299,000	299,000	1,523,000	1,523,000
Biogas Production (scfm)	208	208	1,058	1,058
Average Biogas Captured (95%)(scfm)	197	197	1,005	1,005
Equivalent reciprocating engine size (kW at full load)	1X1,000	1X1,000	2X2,500	2X2,500
Total Recoverable Heat (MMBtu/hr at full load)	4.33	4.33	18.7	18.7
CHP Capacity Utilization with Average Biogas (%)	84%	84%	98%	98%
Heat Balance				
Recoverable Heat from Average Biogas (MMBtu/hr)	3.63	3.63	18.4	18.4
Design Temperatures				
Minimum Ambient Design Temperature (deg F)	60	0	60	0
Incoming EFW Temperature (assumed) (deg F)	60	60	60	60
Internal Digester Temperature (deg F)	95	95	95	95
EFW Feed Heat Requirement				
Flow Rate (gpm)	21	21	103	103
Total Feeding Heat Required (MMBtu/hr)	0.36	0.36	1.80	1.80
Maximum Conductive Heat Loss (MMBtu/hr)				
Cover (Insulated, U=0.28)	0.026	0.072	0.098	0.266
Wall (Insulated Above Grade, U=0.14)	0.026	0.072	0.098	0.266
Wall (Below grade, Uninsulated, U=0.25)	0.047	0.128	0.175	0.475
Bottom (Uninsulated, U=0.50)	0.047	0.128	0.175	0.475
Total Maximum Conductive Heat Loss	0.15	0.40	0.55	1.48
Building Heat Requirements (MMBtu/hr)				
New Process Buildings (~25 Btu/sf)	-	0.57	-	1.04
Pump Station	-	0.023	-	0.023
Highway Garage	-	1.85	-	1.85
Parks Garage	-	0.51	-	0.51
Total Building Heat Demand	0	2.95	0	3.42
Total Potential Heat Demand (MMBtu/hr)	0.51	3.72	2.34	6.70
Net Remaining Heat Energy (MMBtu/hr)	3.1	0.0	16.0	11.7
Electricity Balance				
CHP Electrical Output at Average Biogas (kW)	840	840	4,900	4,900
Electric Demand (kW)				
New Process Equipment	60	60	300	300
Biogas Boosting (5% of Production)	42	42	245	245
Pump Station	48	48	48	48
Highway Garage	0.3	0.3	0.3	0.3
Parks Garage	0.4	0.4	0.4	0.4
Total Demand	151	151	594	594
Net Remaining Electrical Energy (kW)	690	690	4,300	4,300

Table 3-4
CHP Sizing and Energy Balance

In the event the dryer operation were reduced to the previously assumed 6 days per week, 8 hours per day staffing of this facility, there would be insufficient heat recovery during those periods to dry the digestate. It should also be noted that the quality of product from a belt dryer system is significantly less than the granular products produced by a rotary dryer (as produced at the MWRA and GLSD facilities) and would likely yield a lower market value. It is currently estimated that inclusion of this type of system in the current project could add somewhere between \$20M and \$40M to the overall Alternative B facility capital cost.

Reuse of digestate through any of the above means would also be contingent upon securing a viable and consistent outlet for the product. As the organics reuse market within the region is not well developed at this time, it is not currently known whether, and to what extent, this opportunity exists. In addition, the seasonal nature of the agricultural fertilize demands in this region would likely necessitate the shipping of the product to other parts of the country during certain parts of the year and the demand and market rates for purchasing of this potential product are not currently known.

As a result of the above considerations, it was assumed that expansion of the current project for the purpose of digestate reuse would not be pursued as part of the initial facility development. Instead, it was assumed that, as discussed further below, the digestate would be dewatered and transported to an offsite location for disposal.

3.6.1 Digestate Storage

The dewatering system for the conceptual facility (discussed below) would likely be operated on a similar daily schedule as the receiving and pre-processing system. As the digester(s) would be fed and would discharge continuously, digestate storage volume would be required during the hours when the dewatering system is not in operation. At average day conditions, the digester would provide a continuous output of between 73 and 360 gpm for the options evaluated in this study. If 2 days of storage were provided, this would equate to between approximately 60,000 gallons and 300,000 gallons of digestate tank volume.

With the use of submerged fixed covers over the digestion tank(s) and the need for biogas storage volume (discussed previously), the digestate storage tanks provides a good opportunity to cover this tank(s) with a biogas membrane and use the headspace of the tank as the storage mechanism. This also enables any additional biogas production resulting from methanogenesis within the storage tank to be captured and utilized. Costs included below incorporate this concept of dual purpose storage.

3.6.2 Dewatering Technology Selection and Sizing

There are a variety of technologies available for the dewatering of digestate. A brief description of the leading and most proven technologies is as follow:

- **Belt Filter Press:** A conventional belt filter press (BFP) is a dewatering device that applies mechanical pressure to a chemically conditioned digestate, which is sandwiched between two (2) tensioned porous belts. By passing those belts through a serpentine of decreasing diameter rolls, the digestate is gradually compressed by increasing pressure which presses water out while leaving a moist “cake” behind. This material typically has the consistency of damp soil. Belt filter presses offer numerous advantages over comparable dewatering technologies including: Rapid start-up and shut-down of equipment; less noise and low electrical power consumption compared to centrifuges; low polymer consumption; relatively low maintenance to operate; and low staffing requirements. Conversely, major disadvantages of a belt filter press

unit include; odor release during dewatering requires high rate ventilation and odor control; require extensive manual cleaning at the end of an operating cycle for wash down, moderate to high water demands for belt wash system.

- **Rotary Press:** Rotary presses offer moderate to high degree of dewatering with minimal equipment foot print, minimize odor control and room ventilation requirement by fully enclosing the dewatering process, and provide a fully automated cleanup cycle minimizing staffing needs for cleanup. The basic operating principal of a rotary press is to feed digestate between twin perforated plates that simultaneously compress and dewater it. Major advantages of rotary presses over belt filter presses and centrifuges include automated wash down cycle, low housekeeping maintenance requirements and minimal odor generation; major disadvantages include poor dewatering performance on thin, low-fiber digestates and considerably variable operating performance amongst existing installations.
- **Centrifuge:** Centrifugal solids dewatering is a high speed process that utilizes the centrifugal forces generated during high speed rotation of a cylindrical bowl assembly to physically separate and dewater solids from liquid in wastewater sludge. Liquid digestate is pumped into a stainless steel bowl that is spun at very high speeds producing gravity accelerations between 2,500 -3,500 G. The heavier digestate solids accumulate at the bowl wall and are then discharged by means of a helicoidally shaped screw known as a scroll, which pushes the solids from the cylindrical section of the bowl, up through the conical section and towards the discharge ports. The liquid phase of the digestate, known as the centrate, finds its way back down the centrifuge bowl where it flows out to the discharge pipe. Centrifuges offer numerous advantages including high loading capacity, smaller equipment footprint, minimal operator attention and minimal odor emissions disadvantages include high energy costs, lengthy shut-down period and generally require special structural considerations due to weight and dynamic loading concerns.

For the purpose of this analysis, it has been assumed that belt filter press technology will be used as a result of its low energy cost and proven reliability in dewatering non-fibrous digestate as is likely to be discharged from an exclusively organics digester.

Table 3-5 summarizes the assumed operating parameters and anticipated performance of this system under the two loading scenarios.

3.6.3 Side Stream Treatment Considerations

As noted above, the dewatering process would concentrate the digested solids while producing a side stream flow that would require further management. The amount of side stream to be managed is estimated to range between 25,000 and 125,000 gal/day. Though limited data is available pertaining to the quality of this flow from an exclusively SSO digester, it is known that typical dewatering side stream downstream of anaerobic digestion (with or without biosolids) can have significant ammonia concentrations. Though this high level of ammonia may not be a problem when the digestate is used directly (without dewatering) as a fertilizer, when separated by dewatering, the concentration of ammonia nitrogen in the dewatering sidestream would likely require treatment prior to being discharged to a wastewater sewer.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Flow to Dewatering (gal/day)	30,000	148,000
Flow to Dewatering (8 hrs/day, 6 days/wk) (gpm)	73	360
Solids to Dewatering (lb/day)	10,000	48,000
Solids to Dewatering (8 hrs/day, 6 days/wk) (lb/hr)	1,500	7,000
Digestate Storage Volume (assuming 2 days) (gal)	60,000	296,000
Dewatering Feed Concentration (%)	4%	4%
Assumed Dewatered Cake Solids (%)	25%	25%
Assumed Dewatering Solids Capture (%)	95%	95%
Dewatered Cake (wet tons/day)	19	91
SSO Waste Received (wet tons/day)	52	258
Overall Solids Remaining (%)	37%	35%
Dewatered Cake Water Content (gal/day)	4,800	23,000
Side Stream Requiring Disposal (gal/day)	25,000	125,000

**Table 3-5
Digestate Dewatering**

The presence of ammonia in wastewater can significantly increase secondary wastewater treatment process oxygen requirements along with the associated aeration costs. This results from the biological nitrification process where approximately four times the oxygen is required to treat one pound of ammonia as compared to one pound of typical BOD. For this reason, many municipal treatment facilities enforce ammonia pretreatment limits which must be achieved prior to discharge to the municipal collection system.

Though the Upper Blackstone Water Pollution Abatement District does not currently have such limits, it is our understanding that they are currently evaluating this situation and developing new pretreatment standards. As such, this conceptual analysis assumed that an onsite pretreatment system would be required to reduce the side stream ammonia concentrations whether or not the facility was to accept biosolids along with SSO. The costs for this system have been included in the financial analysis later in this section.

3.7 Funding and Financing

Financing of this project could be based on one or a combination of state grants, low interest loans, tipping fees for accepting SSOs and/or cogeneration electrical benefits as described further below.

3.7.1 Grants and Loans

Funding opportunities currently available to assist in achieving the goals of the Commonwealth of Massachusetts 2010-2020 solid waste master plan include the following:

- MassDEP Recycling Loan Fund
- MassDEP Municipal Grants; and
- MassCEC Organics to Energy program.

In addition to the funding provided by the MassCEC for the current study, additional funding may be available for development of this facility. Depending on the efficiency of the CHP system, the project may be eligible for support from National Grid. Favorable funding opportunities through MassDevelopment may also be available as a result of the projected capital cost of this project.

In addition, the Clean Water State Revolving Fund (CWSRF) Loans may also be an avenue for low interest loans to fund the project. Though the CWSRF program has historically concentrated on water-related projects, the based on recent discussions with MassDEP, it has been noted that organic diversion projects are also being looked upon favorably within their current project prioritization system. As such, if selected for CWSRF funding, this project would be eligible for low interest loans as well as any potential principal forgiveness which the program may have to offer at that time.

3.7.2 Production Incentives

Production Incentives associated with the project could include one or more of the following:

- In 2012, legislation was passed in Massachusetts, which is currently being developed into regulation, allowing AD facilities to avail themselves of the “net-metering” provisions of the Green Communities Act. While the final details are not known, it is likely that incentives from providing the renewable energy from this facility into the local power grid will be promoted with incentives that could exceed the current cost of power at the site. If more power is generated than can be used onsite, excess credits may be applied to other Town accounts or the accounts of other local customers of National Grid. However, it should be noted that both options being evaluated exceed the current (2012) municipal account average electrical usage of 500 kW;
- Millbury may be able to take advantage of markets for renewable portfolio standards (RPS) and, if sufficient heat from the process is put to productive use, the Massachusetts Alternative Energy Portfolio Standard. The values of the credits associated with these programs fluctuate with market conditions. National and private market incentives may also come to play a significant role in the future; and
- In the event development of this project were to be funded by the private sector (discussed in more detail in Section 5), there are likely additional tax incentives that could be considered.

3.7.3 Other Potential Operating Revenue

Operating revenue associated with the project may include:

- As discussed further below, fees for disposal of SSOs at the facility could serve as a source of revenue to fund the project; and
- In the event a market for the final digestate product were identified, theoretically, the sale of the product for its remaining nutrient content could yield additional operating revenue. However, as discussed previously, this market is not well developed within the Commonwealth and the demand for such a product is not currently known.

Additional discussion related to funding and financing will be provided later in this report.

3.8 Preliminary Economic Lifecycle Evaluation

Determining the economic feasibility of an organics digestion facility requires an understanding of the cost of the improvements that would be required to accept and process the SSO materials, the infrastructure necessary to process the material and harness the energy value of the additional biogas produced along with the impact to ongoing operations costs. To compare relative costs and benefits of the alternatives, estimates of probable project cost were developed for each of the acceptance scenarios and the associated operations cost impacts were also conceptually quantified.

3.8.1 Summary of Process Performance and Infrastructure Needs

Two SSO acceptance conditions were evaluated during this study to evaluate a wide range of potential cost and benefits. Table 3-6 summarizes some of the key expected process performance values under average annual conditions associated with each of these options. Figure 3-4 provides an overview of the capital infrastructure required and operational impacts under each scenario.

3.8.2 Capital Cost Estimates

As generally reflected in Figure 3-4, the major new facility components that would be required for this facility and which serve as the basis for the conceptual capital costs summarized in Tables 3-7 and 3-8 include the following:

- **Pre-Processing Facility:** The components and design of this system would be intended to process the incoming waste into a pumpable and digestible material free from foreign objects. The equipment associated with this system is assumed to be housed inside a building with all required ancillary systems including adequate ventilation and odor control. The processing capacity of the system considered here could range between 8 wt/hr to 40 wt/hr.
- **Pre-Digestion Food Waste Storage Tanks and Pump Station:** As a result of the continuous feeding needs in comparison with the receiving schedule noted previously, it is expected that pre-digestion engineered food waste storage tank(s) would be required. The estimated size of this storage would equate to between 60,000 and 300,000 gallons for the two options being evaluated. It is further assumed that a new feed pump vault would be constructed adjacent to the tanks to convey the EFW to the digestion tank(s).
- **New Anaerobic Digester(s) and Ancillary Digestion Equipment:** The two options evaluated yield a need for between 0.6 and 3.0 million gallons of digestion capacity. It has been assumed that this would be provided inside of cast-in-place concrete tanks with submerged fixed covers. In addition, a digester equipment building would be provided to house the mixing, heating and other ancillary digestion equipment. Biogas Collection, Safety and Boosting Equipment would also be provided in the form of collection headers, foam separator, sediment trap, flame arrestors, condensate traps, emergency relief valves, as well as a waste gas burner system to combust any biogas not utilized in the CHP system. In addition, a pressure boosting system would be required to increase the gas pressure being fed to the CHP system.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Potentially Available SSO Waste (wet tons/day)	52	258
Digestion Volume (Mgal)	0.60	2.96
EFW Fed to Digester (gal/day)	30,000	148,000
Biogas Produced (cf/day)	299,000	1,523,000
CHP Electrical Production (kW)	840	4,900
CHP Net Electrical Remaining After Onsite Use (kW)	690	4,300
CHP Heat Recovered (MMBtu/hr)	3.6	18.4
CHP Net Heat Remaining after Onsite Use (MMBtu/hr)	0.0	12.0
Dewatered Cake (wet tons/day)	19	91
Dewatered Cake (cy/day)	84	405
Centrate Requiring Disposal (gal/day)	25,000	125,000

Table 3-6
Conceptual Digestion Facility Summary

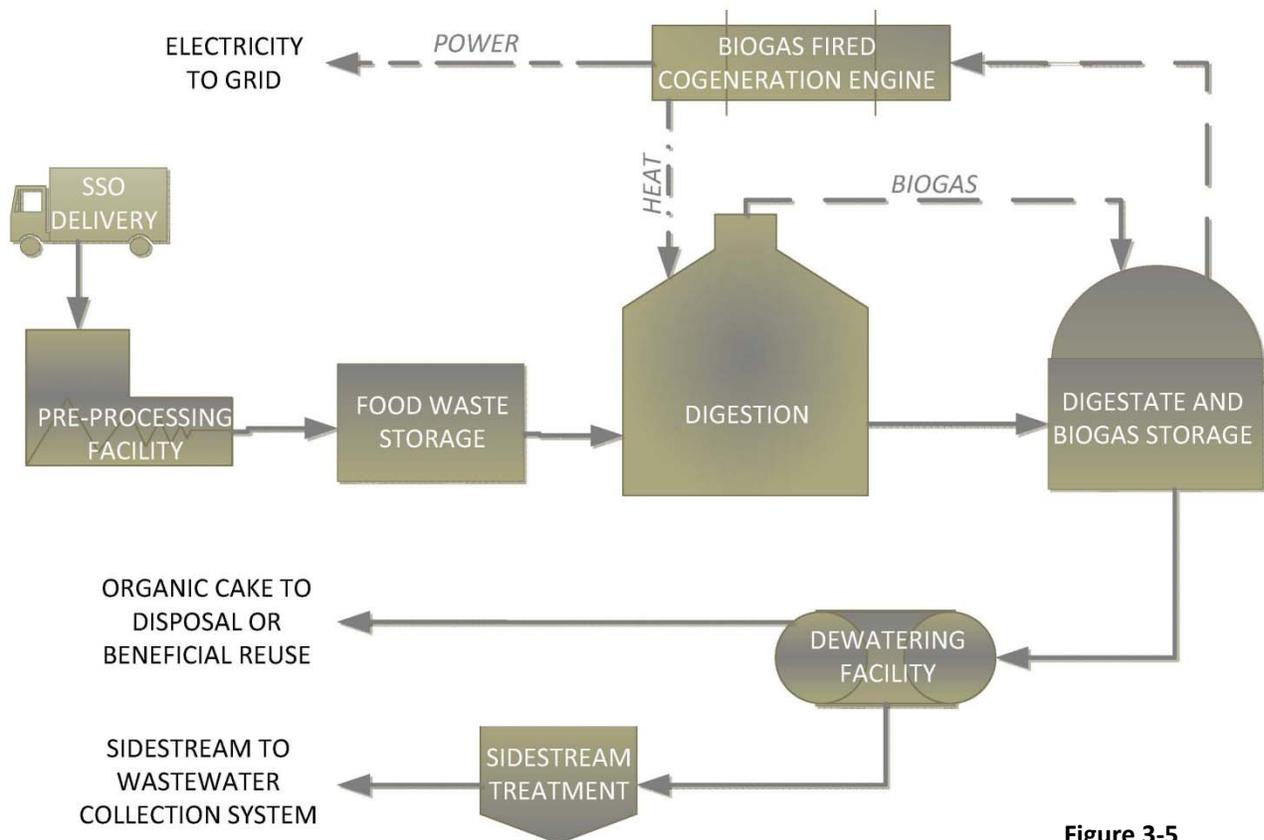


Figure 3-5
Simplified Facility Process Schematic

- **Digestate and Biogas Storage:** Due to the assumed dewatering schedule relative to the constant effluent rate from the digester, additional digestate storage volume would be required. In addition, biogas storage would be required to help maximize the CHP utilization by adsorbing fluctuations in biogas production and CHP operation. It is recommended that these two components be combined into a new concrete tank covered by a gas holder membrane and associated costs have been included.
- **New Cogeneration Engines:** As previously noted, reciprocating internal combustion engines are the most widespread, economical and efficient of all CHP technologies currently used for biogas cogeneration. Though the selection of CHP technology should be revisited during later stages of this project, internal combustion engines were selected for use in the system sizing as well as the economic evaluation included in the following tables. As shown, 19,000 wt/yr option would require a 1,000 kW engine while the 96,000 wt/yr option would require two units, each with a capacity of 2,500 kW.
- **Dewatering Facility:** Due to the low solids concentration of the digestate, a solids dewatering system would be required. The system is assumed to include feed pump system, belt filter press dewatering equipment, cake truck storage bay and other ancillary systems – all housed in an enclosed superstructure due to environmental (freezing) concerns as well as odor control considerations.
- **Sidestream Treatment Facility:** The dewatering process would concentrate the digested solids while producing a side stream flow that would require further treatment. The amount of side stream to be disposed of is estimated to range between 25,000 and 125,000 gal/day. Though limited data is available pertaining to the quality of this flow from an exclusively SSO digester, it is known that typical side stream downstream of an anaerobic digestion can have significant ammonia concentrations. Conceptual costs for a separate deammonification treatment system have been included in the analysis.
- **Rolling Stock:** Various pieces of equipment would be required for receiving of materials and maintenance of the facility. As such, an associated allowance has been included.

All capital costs include a 25% allowance for project contingencies and an additional 25% for engineering of the associated improvements. The costs for the above improvements were estimated and then amortized assuming a 20-year bond at an interest rate of 2.5 percent (which is consistent with Millbury's current bonding opportunities) to achieve an equivalent annual cost.

3.8.3 Operation and Maintenance Costs

Operation of an organics processing facility at the site would carry with it significant costs which need to be considered in the conceptual financial analysis. Tables 3-7 and 3-8 also include the following financial considerations for annual operation and maintenance (O&M) costs:

- **Labor:** Though some existing DPW employees currently have experience and certifications in wastewater treatment facility operation, it is assumed that additional staffing resources would be required to operate a facility of this nature. Though delivery is assumed to be handled and funded by outside haulers, facility maintenance and operation is assumed to require between 3 and 6 employees during core operating hours (6 days/wk, 10 hrs/day). As such, the associated total labor costs were developed based on a rate of \$50/man hour (including fringe benefits).

- **Dilution Water:** As previously noted, the dilution of incoming waste may be required and it has been assumed that this would be accomplished using domestic water purchased from Aquarian Water Company at the current rate of \$2.815/1,000-gallons for the first 9,000-gallons, then \$3.337/1,000-gallons above the first 9,000 gallons used.
- **Dewatering Chemicals:** Dewatering of digestate will require polymer for proper operation and solids capture. It was assumed that this chemical would be consumed at a rate of 50 lbs polymer per dry ton of organic solids and would cost approximately \$1.50/lb Polymer.
- **Offsite Cake Disposal:** Though there may be an opportunity for use of this material for animal bedding or agricultural fertilizer, as there have not been any specific outlets identified at this time, it has been assumed that disposal will be required at a rate of \$50/wet ton including transportation.
- **Dewatering Side Stream Disposal:** It has been assumed that the side stream treatment system would discharge to the municipal sewer system at the current Town rate of \$1.65 per 1,000 gallons.
- **General System Maintenance:** Systems and equipment of this magnitude will inherently carry with it ongoing costs for operations and maintenance. For general maintenance activities, it has been assumed that this annual cost would equate to ~2% of the equipment capital cost.

3.8.4 Summary of Financial Analysis

As shown within Tables 3-7 and 3-8, the total annual net cost of developing a digestion facility at the Millbury site is estimated to range from \$35M to \$85M. After considering the significant financial benefits of the associated combined heat and power system in addition to the operational costs of the facility, the net annual cost is estimated to range from \$2.7M to \$5.7M before accounting for tipping fee revenues. At these costs and assumed SSO quantities, the break-even tipping fee would equate to between \$140 (for the 10% of regional waste option) to \$60 (for the 50% of regional waste options) per wet ton received. In the event the preprocessing system was to be excluded from the project, the break-even tipping fees would equate to between approximately \$105 and \$40 per wet ton, respectively.

Based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of \$30 to \$40 per wet ton for pre-processed waste. Though the break-even tip fees for the larger of the conceptual Millbury facility options are on the higher end of this range, it should be noted that this conceptual analysis has included some conservative assumptions where further analysis may prove it to be more cost effective.

The most significant conservatism to be noted is the assumptions related to facility design, materials of construction and the resultant capital cost estimates. The design of this facility has been assumed to comply with redundancy standards and construction materials that are commonly applied to municipal infrastructure projects to properly protect from upset conditions and ensure adequate design life. It has been shown historically that less robust and often less costly solutions (i.e. steel tanks in lieu of concrete tanks, steel or wood in lieu of masonry buildings, less installed redundant equipment) are often employed when development is completed by a private for profit-entity. In the event this project was to be developed by a private entity, some of these savings may be able to be realized.

Capital Costs	Unit Size		Total
Pre-Processing Facility	8 wt/hr		\$11,000,000
Pre-Digestion EFW Storage Tank Covers and Feed Pump Station	60,000 gal, 25 gpm		\$800,000
Digestion Tank, Support Building and Ancillary Equipment	0.6 MG		\$13,000,000
Digestate Storage Tank and Biogas Membrane	60,000 gal, 100,000 cf		\$1,500,000
CHP Internal Combustion Engine and Electrical Infrastructure	1X1,000 kW		\$4,600,000
Dewatering Facility	1,500 lb/hr		\$2,000,000
Sidestream Treatment Facility	25,000 gal/day		\$2,000,000
Rolling Stock (Loader, Trucks, Other Equipment)	-		\$300,000
	Total		\$35,000,000
	Amortized Annual Cost¹		\$2,300,000
O&M Costs	Unit Cost	Quantity	Annual Cost
Labor	\$50/hr	120 mh/wk	\$300,000
Dewatering Process Chemicals	50 lbs/DT, \$1.50/lb Polymer		\$400,000
Offsite Cake Transportation & Disposal	\$50/wt	19 wt/day	\$300,000
Pre-Processing Dilution Water		18,000 gpd	\$20,000
Sidestream Disposal		25,000 gpd	\$15,000
General O&M	2% of equipment cost		\$200,000
	Annual O&M Cost		\$1,200,000
Combined Heat and Power	Quantity	Unit Cost	
Net Electrical Remaining After Onsite Use (Existing & New) ⁴	690 kW	\$0.13/kWh	\$(800,000)
Net Heat Remaining after Onsite Use (MMBtu/hr)	0 MMBtu/hr	-	-
	Annual CHP Cost		\$(800,000)
Total			
	Net Annual Cost		\$2,700,000
	Annual SSO Received (wt/yr)		19,000
	Break Even Tip Fee (\$/wt)		\$142
	Break Even Tip Fee without Installation of Pre-Processing (\$/wt)		\$105

¹ Based on 2.5% interest rate on 20-year bond

² Negative values in above table indicate financial credit

³ All values based on April 2013 dollars

⁴ For net metering purposes, equates to 6.0M kwh/yr, which is greater than existing town account usage of ~4.4M kwh/yr

Table 3-7
Millbury Organics to Energy Facility
Financial Feasibility at 19,000 WT/YR Acceptance Rate

Capital Costs	Unit Size	Total	
Pre-Processing Facility	40 wt/hr	\$29,000,000	
Pre-Digestion EFW Storage Tank Covers and Feed Pump Station	300,000 gal, 125 gpm	\$2,000,000	
Digestion Tank, Support Building and Ancillary Equipment	2X1.5 MG	\$23,000,000	
Digestate Storage Tank and Biogas Membrane	300,000 gal, 500,000 cf	\$5,000,000	
CHP Internal Combustion Engine and Electrical Infrastructure	1X2,500 kW	\$15,000,000	
Dewatering Facility	7,000 lb/hr	\$5,000,000	
Sidestream Treatment Facility	125,000 gpd	\$5,000,000	
Rolling Stock (Loader, Trucks, Other Equipment)	-	\$600,000	
	Total	\$85,000,000	
	Amortized Annual Cost¹	\$5,500,000	
O&M Costs	Unit Cost	Quantity	Annual Cost
Labor	\$50/hr	240 mh/wk	\$600,000
Dewatering Process Chemicals	50 lbs/DT, \$1.50/lb Polymer		\$2,200,000
Offsite Cake Transportation & Disposal	\$50/wt	91 wt/day	\$1,700,000
Pre-Processing Dilution Water	86,000 gpd		\$103,000
Sidestream Disposal	125,000 gpd		\$75,000
General O&M	2% of equipment cost		\$450,000
	Annual O&M Cost		\$5,100,000
Combined Heat and Power	Quantity	Unit Cost	
Net Electrical Remaining After Onsite Use (Existing & New) ⁴	4,300 kW	\$0.13/kWh	\$ (4,900,000)
Net Heat Remaining after Onsite Use (MMBtu/hr)	12 MMBtu/hr	-	-
	Annual CHP Cost		\$(4,900,000)
Total			
	Net Annual Cost		\$5,700,000
	Annual SSO Received (wt/yr)		94,000
	Break Even Tip Fee (\$/wt)		\$61
	Break Even Tip Fee without Installation of Pre-Processing (\$/wt)		\$40

¹ Based on 2.5% interest rate on 20-year bond

² Negative values in above table indicate financial credit

³ All values based on April 2013 dollars

⁴ For net metering purposes, equates to 37M kwh/yr, which is greater than existing town account usage of ~4.4M kwh/yr

Table 3-8
Millbury Organics to Energy Facility
Financial Feasibility at 96,000 WT/YR Acceptance Rate

Beyond capital cost estimate assumptions, a few of the additional conservatisms included herein which, upon refinement, may yield additional financial benefit include:

- Significant excess CHP heat is present for the larger scale organics receiving option. Though there does not appear to be any current ability to reuse this heat onsite, in the event an adjacent facility or other onsite use for this heat were to become available, use/sale of this heat may benefit the economics of this project;
- Organic waste volatile solids reduction (VSR) and biogas production have been shown in some studies to exceed the assumed values of 82% VSR and 13.6 cf biogas/lb VSR;
- Financial benefits available from the sale of Renewable Energy Certificates (RECs) have not been taken into account; and
- The digestate is assumed to require disposal (with an associated cost) rather than have potential as a product that may earn revenue.

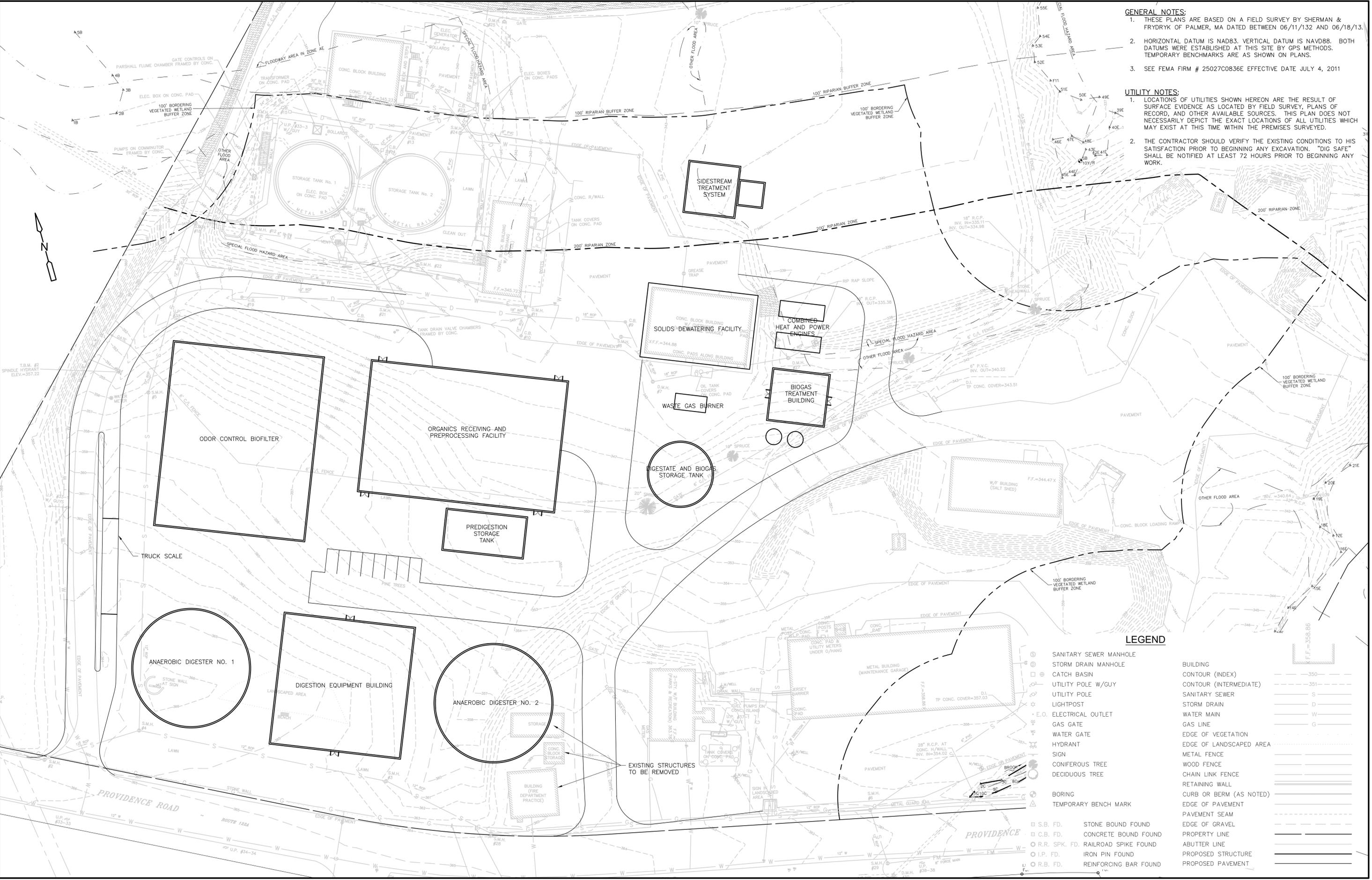
Further, though overall costs would be expected to increase in the future proportional to the rate of inflation, based on recent history, energy price escalation will likely exceed that of standard inflation indices. Therefor the net benefit of additional biogas production and net revenues from digestion are likely to be greater in future years.

All costs noted with this memorandum are in present day (April 2013) dollars.

3.9 Conceptual Site Plan

In an attempt to determine the viability of the site to support the organics to energy facility sizes evaluated in this report, a conceptual site plan of the larger of the two options (50% of regional SSO) was developed. This conceptual plan was developed based on conceptual sizing of the various facility components combined with a recent wetlands delineation and ground survey which were completed by others as part of the current project. As shown in Figure 3-6 (attached), this conceptual site plan shows that the largest of the two options evaluated herein would likely be capable of being supported by the current site.

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- GENERAL NOTES:**
1. THESE PLANS ARE BASED ON A FIELD SURVEY BY SHERMAN & FRYDRYK OF PALMER, MA DATED BETWEEN 06/11/13 AND 06/18/13.
 2. HORIZONTAL DATUM IS NAD83. VERTICAL DATUM IS NAVD88. BOTH DATUMS WERE ESTABLISHED AT THIS SITE BY GPS METHODS. TEMPORARY BENCHMARKS ARE AS SHOWN ON PLANS.
 3. SEE FEMA FIRM # 25027C0836E EFFECTIVE DATE JULY 4, 2011

- UTILITY NOTES:**
1. LOCATIONS OF UTILITIES SHOWN HEREON ARE THE RESULT OF SURFACE EVIDENCE AS LOCATED BY FIELD SURVEY, PLANS OF RECORD, AND OTHER AVAILABLE SOURCES. THIS PLAN DOES NOT NECESSARILY DEPICT THE EXACT LOCATIONS OF ALL UTILITIES WHICH MAY EXIST AT THIS TIME WITHIN THE PREMISES SURVEYED.
 2. THE CONTRACTOR SHOULD VERIFY THE EXISTING CONDITIONS TO HIS SATISFACTION PRIOR TO BEGINNING ANY EXCAVATION. "DIG SAFE" SHALL BE NOTIFIED AT LEAST 72 HOURS PRIOR TO BEGINNING ANY WORK.

LEGEND

⊙	SANITARY SEWER MANHOLE	▭	BUILDING
⊕	STORM DRAIN MANHOLE	—	CONTOUR (INDEX)
⊙	CATCH BASIN	- - -	CONTOUR (INTERMEDIATE)
⊙	UTILITY POLE W/GUY	S	SANITARY SEWER
⊙	UTILITY POLE	D	STORM DRAIN
⊙	LIGHTPOST	W	WATER MAIN
⊙	E.O. ELECTRICAL OUTLET	G	GAS LINE
⊙	GAS GATE	—	EDGE OF VEGETATION
⊙	WATER GATE	—	EDGE OF LANDSCAPED AREA
⊙	HYDRANT	—	METAL FENCE
⊙	SIGN	—	WOOD FENCE
⊙	CONFEROUS TREE	—	CHAIN LINK FENCE
⊙	DECIDUOUS TREE	—	RETAINING WALL
⊙	BORING	—	CURB OR BERM (AS NOTED)
⊙	TEMPORARY BENCH MARK	—	EDGE OF PAVEMENT
⊙	S.B. FD. STONE BOUND FOUND	—	PAVEMENT SEAM
⊙	C.B. FD. CONCRETE BOUND FOUND	—	EDGE OF GRAVEL
⊙	R.R. SPK. FD. RAILROAD SPIKE FOUND	—	PROPERTY LINE
⊙	I.P. FD. IRON PIN FOUND	—	ABUTTER LINE
⊙	R.B. FD. REINFORCING BAR FOUND	—	PROPOSED STRUCTURE
		—	PROPOSED PAVEMENT

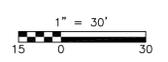


FIGURE 3-6
MILLBURY ORGANICS TO ENERGY FACILITY
CONCEPTUAL SITE PLAN
SEPTEMBER 2013

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Section 4

Impacts to Existing Parcel and Surrounding Area

4.1 Site Considerations

The installation of an organic waste processing and digestion facility at any site would carry with it substantial new infrastructure, some level of increased truck traffic and the potential for changes to noise and odor levels originating from the site. However, if properly planned and designed, these impacts can be minimized or fully mitigated through the use of proper truck routing, enclosed facilities and properly designed odor control systems. Though anaerobic digestion systems are relatively quiet and produce limited odors, organics waste receiving and preprocessing systems can produce some noise and odors. As previously discussed in Chapter 3, for this reason, this facility has been assumed to be fully enclosed and would include an odor control system to treat its exhaust air. In addition, as shown in the conceptual facility layout, this portion of the facility should be located as distant from abutting properties as possible.

The impact that the development of this type of facility would have on the parcel and surrounding areas generally depends on the current use of the parcel and the nature of land use in the general area. The fact that the Millbury parcel is a former wastewater treatment facility, currently supports a wastewater pump station and DPW operations along with the industrial nature of the abutting properties would likely limit impacts and any negative perceptions when compared to construction on a more “green field” (previously undeveloped) site.

To further evaluate any potential impacts, a review of available site data was completed as part of this study to determine whether any known hazards, sensitive receptors or other environmental may pose a concern for this potential project. A variety of data sets were acquired from the Massachusetts Office of Geographic Information (MassGIS) and used as the primary basis for this analysis.

4.1.1 Potential Environmental Impact and Hazards

Data pertaining to existing environmental features and potential hazards was collected and evaluated for the site and its immediate surrounding area. The environmental datasets reviewed included the following:

- Department of Conservation and Recreation Areas of Critical Environmental Concern (ACEC);
- Bureau of Waste Prevention (BWP) Regulated Major Facilities;
- U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory;
- MassDEP Oil and/or Hazardous Material Sites with Activity and Use Limitations (AUL);
- MassDEP Waste Site Cleanup Program Activity and Use Limitation Sites;
- Municipal Solid Waste Combustion (Resource Recovery) Facilities;
- Handling Facilities (Transfer Stations, Compost and Other Wastes Handling); and

- Natural Heritage and Endangered Species Program (NHESP) inventory, including: Certified or Potential Vernal Pools; Estimated Habitats of Rare Wildlife; Priority Habitats of Rare Species; and Natural Communities.

Figure 4-1 reflects the available data from the above sources, which showed that many of the above features or protected areas are not present at the Providence Street site. With respect to potential hazards or protected areas, the features identified in the immediate vicinity of the site were limited to:

- One hazardous material generator listed under the Bureau of Waste Prevention (Barrday Composite Solutions located across the street from the site); and
- One potential vernal pool location located on the opposite side of the river from the site.

4.1.2 Flood Hazard Area

National Flood Insurance Rate Mapping (FIRM) developed by the Federal Emergency Management Agency in the area of the Town-owned parcel was also reviewed for this study. It is apparent from the detailed mapping developed as part of this project, that the 100-year flood inundation area does include portions of the site with ground elevations between approximately 340.0 and 340.5. In general terms, this would likely include the northern quarter of the former wastewater treatment facility portion of the site. The general location of this flood hazard area is also included in Figure 4-1.

4.1.3 Environmental Justice Population

One additional dataset which was reviewed as part of this study is the Environmental Justice (EJ) population locations. This data is the focus of the state's Executive Office of Energy and Environmental Affairs' (EEA) and reflects areas across the Commonwealth with high minority, non-English speaking, and/or low-income populations. Data in this layer were compiled at the block group level from the 2010 census redistricting tables.

The United States Environmental Protection Agency (USEPA) and MA EEA office define Environmental justice (EJ) as *“the fair treatment and meaningful involvement of all people regardless of race, color, sex, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies.”* The EEA further defines its program goals as *“helping to address the disproportionate share of environmental burdens experienced by lower-income people and communities of color who, at the same time, often lack environmental assets in their neighborhoods”* and to *“promote community involvement in planning and environmental decision-making to maintain and/or enhance the environmental quality of their neighborhoods.”*

As shown in Figure 4-1, based on 2010 census data, there is one block group located in downtown Millbury which qualifies as an “Environmental Justice Population.” This qualification was made based on the area falling below 65% of the 2010 Massachusetts state median household income of \$62,133. The block group in question is generally bounded by Elm Street to the North, Henricks Lane to the south, Route 146 to the west and Providence Street to the East. The analysis of this data is generally performed at the block group level rather than a street-by-street basis, however, it is notable for this project since the area in question is immediately adjacent to the site. In addition, as discussed further below, waste hauling truck routes are likely to be required to access the site through this population. Though the issue may ultimately not be significant for the project, the Town should be cognizant of it as it may impact public acceptance of the project.

4.2 Transportation

Transportation of SSO to the site would likely occur via truck. As shown in Figure 4-2, there are two possible access routes from the Massachusetts Turnpike (I-90). Access from I-90 exit 11 would utilize Riverlin Street to Providence Street while trucks could also utilize exit 10 A would use Rt. 146 (exit 9 or 8) to Rt. 122A. The distance from the turnpike is between 4 and 5 miles and would necessitate travel through the downtown business district of Millbury. Based on the feedstock quantity assumptions detailed in Chapter 3, incoming truck traffic would likely range between 4 and 20 trucks per day assuming a 15 ton capacity. In addition, an additional 4 to 20 trucks per day hauling dewatered cake offsite would be required assuming use of a 20 cubic yard truck. These quantities may vary significantly depending on the consistency and transportation of the waste.

As previously noted, the organics diversion and hauling market within Massachusetts is in its infancy and the types of trucks that will be used to haul the material is not currently known. Much of the current diversion practice involves hauling of liquid organic waste using a sealed tanker truck while solid organic waste is hauled using traditional solids waste trucks. Odors from either of these transportation methods will depend on the design and age of the truck with the liquid tankers yielding less odor and leakage than a solid waste truck. It should also be noted that there are other types of vehicles in used in other US and foreign organic waste markets with rotating cylindrical bodies which mix collected material, distribute the load across the trailer and with reduced leakage and odors as compared to traditional waste hauling. As the organics diversion market gains momentum in Massachusetts, additional details and experience with hauling operations will become available from the haulers involved in this market.

4.3 Abutter Considerations

As shown in Figure 4-3, the parcel, and much of the Providence Street area, falls within the Town of Millbury “I-1” (industrial) zoning district. The closest non-industrial district is the “B-2” (business) district located on the opposite side of Providence Street. Upon review of the current Town of Millbury bylaws, there does not appear to be any specific prohibition against siting of an organics processing facility of this location. Though, given the available land area at the site substantially larger setbacks would likely be possible, it was also noted within the regulations that any new facility structures would be required to comply with the following setbacks:

- Front Yard setback: 30-ft;
- Side Yard Setback: 20-ft; and
- Rear Yard Setback: 20-ft.

Land use data (based on 2005 aerial photography) was also assessed and compared to current zoning districts. As shown in Figure 4-4, land use in the vicinity of the site is limited to industrial and waste disposal (due to the presence of the WWTF in 2005) with significant forested land and wetlands providing a reasonable buffer between site activities and abutters or other land uses.

As also indicated in Figure 4-4, there is significant power utility transmission land use surrounding the site which would presumably also limit future significant changes to existing zoning and land use. In addition, this utility infrastructure may prove useful for the exporting of electricity from the site.

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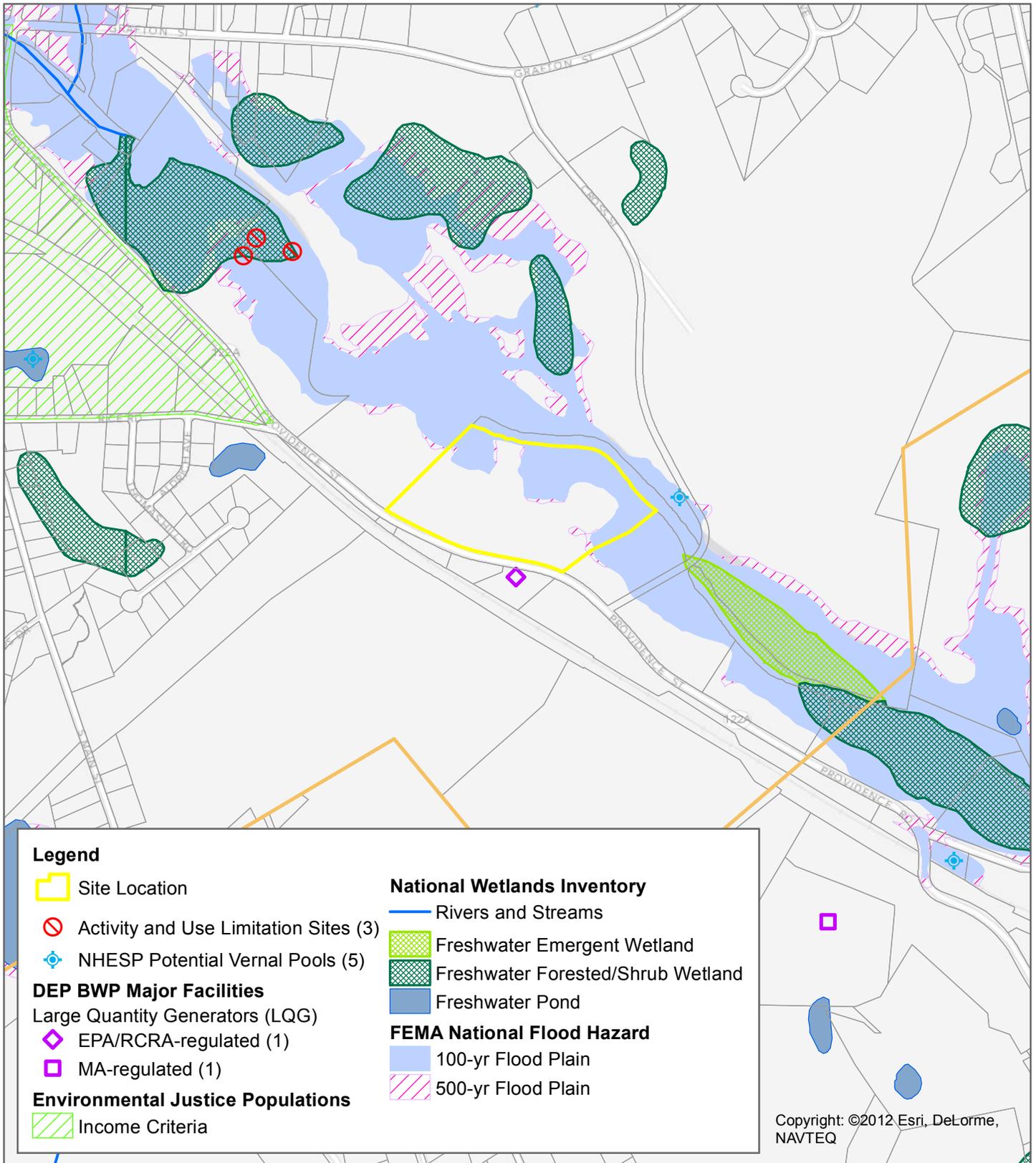


Figure 4-1
Potential Environmental Hazards
 Millbury Organic Waste to Energy Facility
 August, 2013

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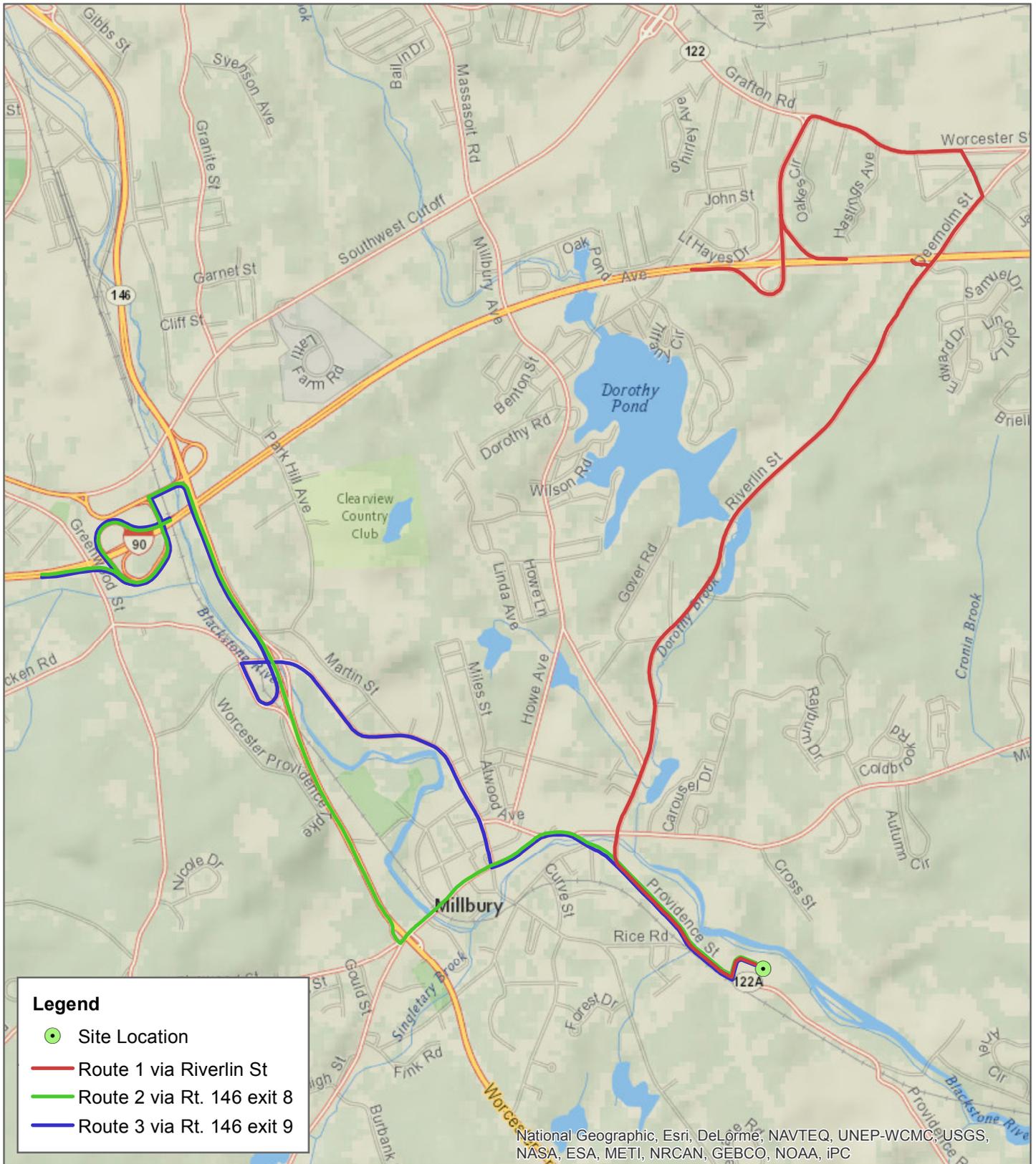


Figure 4-2
Potential Truck Routes to Site
 Millbury Organic Waste to Energy Facility
 April, 2013



0 1,750 3,500
 Feet
 1 in = 3,500 ft



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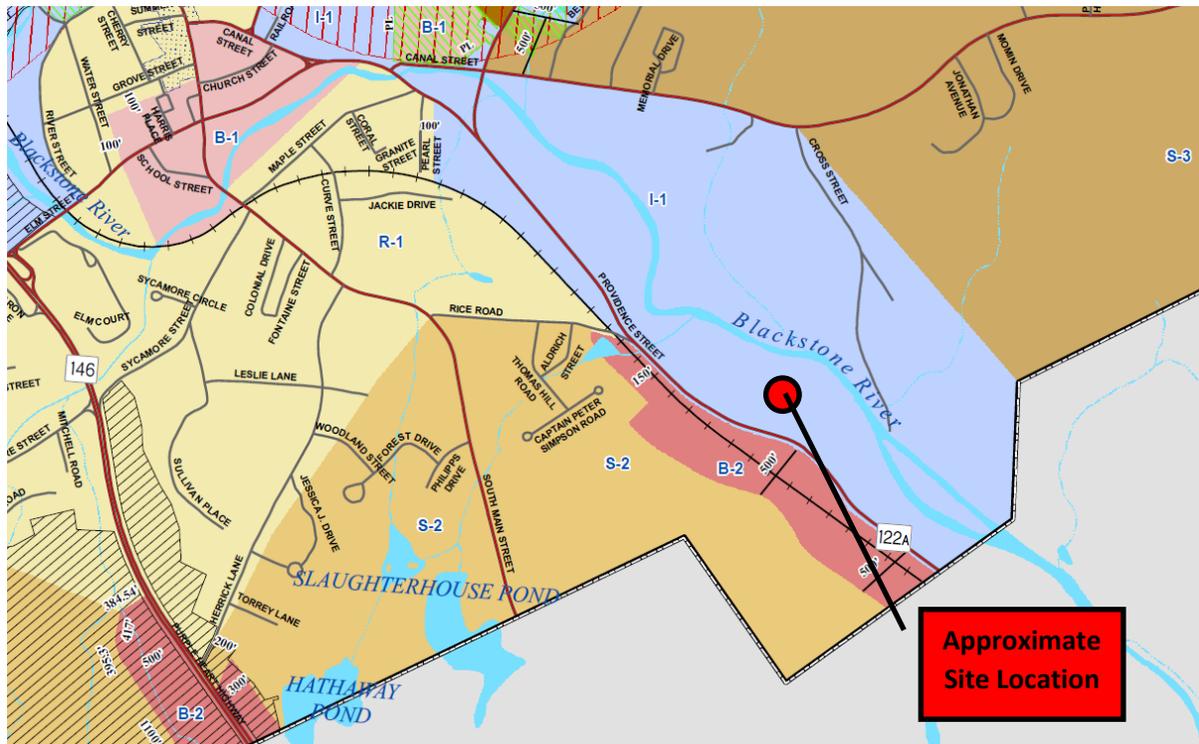
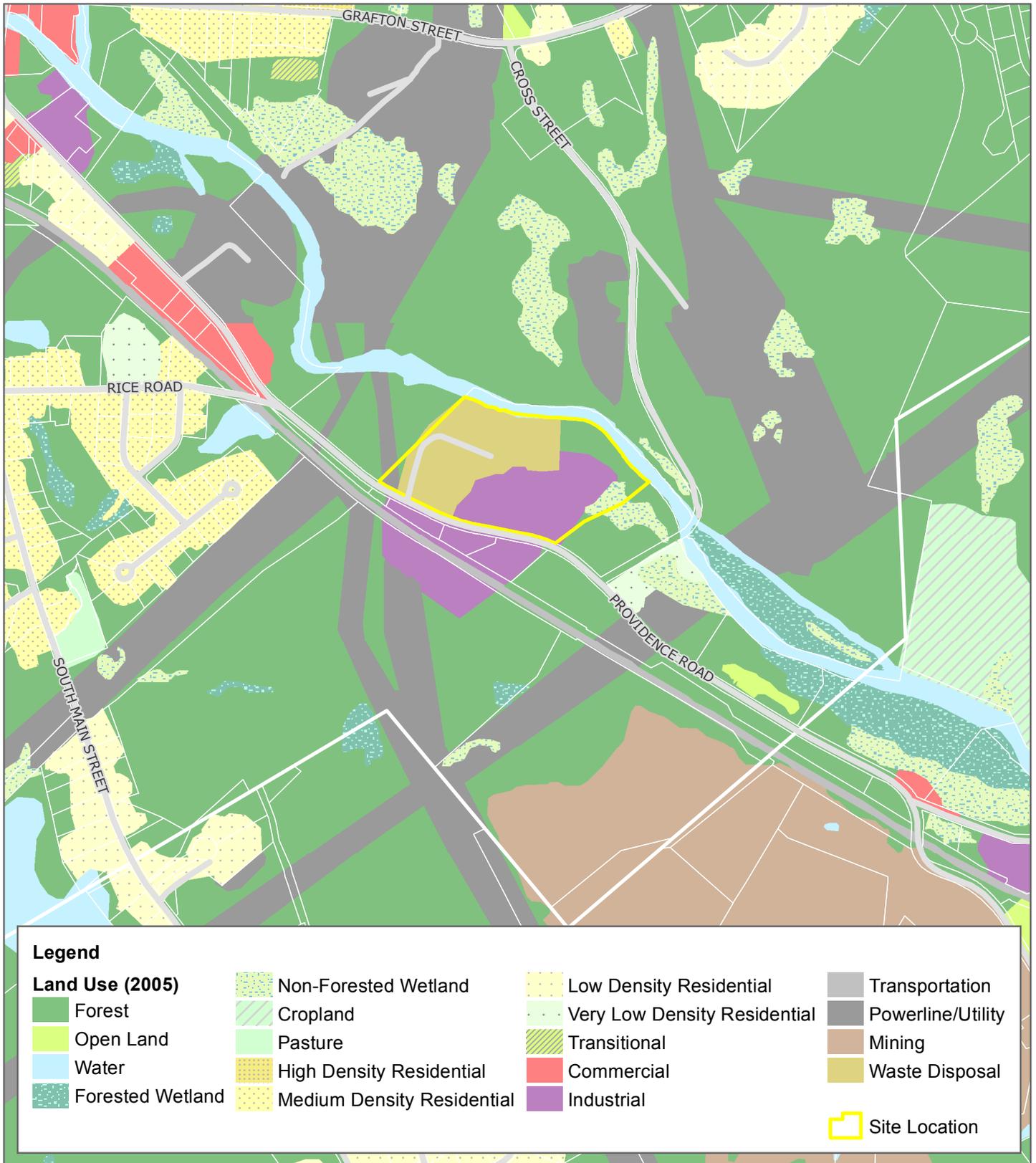


Figure 4-3
Town of Millbury Zoning
(Courtesy of Central Massachusetts Regional Planning Commission)

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0 500 1,000
 Feet
 1 in = 1,000 ft

Figure 4-4
Land Use Data
 Millbury Organic Waste to Energy Facility
 April, 2013

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Section 5

Ownership Options

5.1 Introduction

This section provides an overview and comparison of various ownership options that may be considered by the Town for implementation of the organics-to-energy center at the Town-owned project site. Issues related to project funding and financing for the ownership options will be addressed later in this report. Depending on the ownership option ultimately chosen, certain legal issues (such as Town contracting authority and applicable procurement procedures) will need to be addressed by Town legal counsel at a later date.

The ownership options reviewed here incorporate different approaches to the allocation of project responsibility, risks and economic benefits in the following key aspects of implementation:

- Design, construction and operation of project facilities;
- Collection of source-separated organics (SSO); and
- Energy savings.

With regard to certain so-called “uncontrollable risks” (such as change in law or regulations, force majeure, unknown site conditions, permitting, etc.), it generally can be expected that such risks would be allocated to the Town under each of the ownership options.

5.2 Municipal Ownership

Under the municipal ownership option, the Town would own the organic-to-energy center facilities and would provide financing for design and construction. Operation and maintenance could be performed by Town employees or by an outside firm under a short-term (5 years) or long-term (10 to 20 years) contract with the Town. Design and construction could be performed through

- a) A traditional design-bid-build approach (where a design engineer is retained to prepare detailed plans and specifications for public bidding and a construction contract is awarded to the lowest responsible bidder);
- b) A design-build contractor (where design and construction is performed under a single contract); or
- c) A construction management at-risk approach (where a design engineer is retained to prepare detailed plans and specifications and a construction management firm is hired at an early point in the design development process to provide pre-construction services and work with the design engineer and to provide the Town with an “open book” guaranteed maximum price to perform construction).

The design-build approach may require special legislative authority for the Town.

The municipal ownership option would have the Town undertake primary responsibility for all aspects of project implementation. The Town would thereby assume the overall profile of project risks (costs and long-term performance) and economic benefits (net revenue from SSO collection and energy savings, as discussed in Section 3 of this report). Certain income tax benefits that may be available in the case of private ownership would not be available to the Town.

5.3 Public/Private Partnership

The Public/Private Partnership option would involve ownership and financing arrangements whereby certain of the project's risks and rewards are shared between the Town and a private company. Such options might include:

- a) Town design, construction, financing and ownership of the organic-to-energy center facilities coupled with a long-term operations/concession agreement whereby the net revenues or economic benefits are shared between the Town and private operator;
- b) Town financing and ownership of the organic-to-energy center facilities coupled with a long-term design, build and operations/concession agreement whereby the net revenues or economic benefits are shared between the Town and private operator; or
- c) Private design, construction, financing, ownership and operation of the organic-to-energy center facilities coupled with a long-term site lease agreement whereby the net revenues or economic benefits are shared between the Town and private operator. Each of these approaches may require special legislative authority for the Town.

The public-private partnership option would have the Town enter into an arrangement with a private company whereby the responsibilities for project implementation are shared, the specifics of which would depend on the sub-options (a), (b) and (c) briefly described above. Under this arrangement, the Town and private company would also share the project's risks (costs and long-term performance) and economic benefits (net revenue from SSO collection and "behind the meter" energy savings). Certain income tax benefits may or may not be available to the private company in the case of the public-private partnership option.

5.4 Site Lease/Private Ownership

Under the Site Lease/Private Ownership option, the Town would turn the project site (excluding existing buildings and facilities) over to a private company via a long-term lease agreement and the company would design, construct, finance, own and operate the organic-to-energy center facilities, pay a fixed annual rent and provide certain performance guarantees to the Town, and the Town would enter into a power purchase agreement with the company and/or an agreement to buy net metering credits. In this arrangement, the risks related to the project's costs, performance and revenue associated with the implementation, ownership and long-term operation of the organic-to-energy center facilities would be allocated to the private company.

The private ownership option would have the private company undertake primary responsibility for all aspects of project implementation. The company would thereby assume the overall profile of project risks (costs and long-term performance) and economic benefits (net revenue from SSO collection). Certain income tax benefits may be available in the case of private ownership to help offset the higher cost of capital typically associated with private financing.

5.5 Preliminary Comparison of Options

Table 5-1 compares the ownership options described in Sections 5.2, 5.3 and 5.4 in terms of the following key factors:

- Design and construction risks
- Financing risks and costs
- Operation and maintenance risks
- Economic benefits and risks
- Life-cycle project costs
- Implementation time
- Private sector capabilities/interest

	Town Ownership	Public-Private Partnership	Private Ownership
Design/construction risks	Assumed primarily by the Town if design-build-build. Town can transfer these risks with design-build or design-build-operate contracting.	Allocated to the party responsible for design and construction.	Assumed primarily by the private company.
Financing risks/costs	Assumed by the Town.	Depends on source of financing.	Transaction costs and return on equity assumed by private company. Debt interest rate assumed by the Town until financial close. Cost of capital for private financing typically higher than Town financing.
Operations risks	Assumed by the Town.	Allocated to the party responsible for operation.	Assumed by the private company.
Economic benefits/risks	Allocated to the Town.	Depends on the specific arrangement.	Allocated to the private company, though lease payment is benefit to Town and PPA could provide price certainty to Town.
Life-cycle project costs	Assumed by the Town.	Depends on the specific arrangement.	Assumed by the private company and partially recovered in the service fee/charges to the Town.
Implementation time	Depends on the procurement method.	Depends on the procurement method.	Depends on the procurement method.
Private sector capabilities/interest	Should be a competitive market of capable firms.	Needs to be determined.	Needs to be determined.

Table 5-1
Comparison of Ownership Options

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Section 6

Regulations and Permitting

6.1 Applicable Regulations

As part of the current feasibility study, an initial assessment was completed related to the regulatory trends and drivers related to development of an organics to energy facility in Millbury along with the potential permitting associated with development of the facility.

6.1.1 State Regulatory Trends

As has been previously noted, MassDEP is now focusing a great deal of attention on organic residuals: especially SSO. The agency has announced its intention to ban certain large scale (e.g. commercial and institutional) SSO from landfills in 2014. In preparation for this ban on landfill disposal, two significant regulatory changes were developed in 2011, one to the solid waste regulations (310 CMR 16.00 and 19.00) and one to the wastewater regulations (314 CMR 12.00). These changes were finally adopted in late November, 2012, and now the solid waste rules allow for streamlined siting of facilities that process SSO (e.g. compost or anaerobic digestion facilities). The wastewater rules have been changed to allow for wastewater treatment facilities with anaerobic digesters to accept and process SSO. The change to the wastewater treatment facility regulations is a simple rule change that was widely supported while the solids waste changes (siting of new facilities) received opposition from those representing local boards of health.

A few specific changes in the recent promulgation include the following:

- 310 CMR 16.02 defines “source separated” as “separated from solid waste at the point of generation and kept separate from solid waste.”
- 310 CMR 16.02 (and 310 CMR 19.000) revised the definition of solid waste to exempt “organic material when handled at a Publicly Owned Treatment Works as defined in 314 CMR 12.00 and as approved by the Department pursuant to 314 CMR 12.00.”
- 314 CMR 12.00 will require written approval from MassDEP to accept SSO materials at AD units.
- A site assignment under the solid waste regulations and laws (310 CMR 16.00 and MGL ch.111 § 150A, respectively) is only required for an area of land where solid waste uses can occur. Therefore, since the SSO materials handled at WWTP’s or exclusively organics processing facilities is not considered a solid waste by definition, it would not require a solid waste site assignment.
- 314 CMR 12.00 notes that “Fish and animal material from slaughterhouses, butchering and processing facilities, pet food production facilities and supermarkets may not be accepted into anaerobic digesters operated at a wastewater treatment facility without specific written approval of such materials by the Department.”

MassDEP's focus on organics seems to be a lasting trend, driven, in large part, by the fact that organics are the last and greatest untapped potential resource in landfilled solid waste – and it can be a source of renewable energy. As long as the political will remains, it seems likely that a landfill ban will be enacted in Massachusetts in the next few years, if not by the current 2014 deadline.

In addition, whereas comprehensive energy and GHG emissions policy has stalled at the national level, Massachusetts has adopted leading programs for both. With new alternative energy production from biogas, Millbury would be able to take advantage of markets for renewable portfolio standards (RPS) (as discussed in additional detail later in this report). Planning for this potential facility should presume that these kinds of state policies will continue, making renewable energy and documented reductions in GHG emissions likely more valuable with time. National and private market incentives may also come to play a significant role in the future.

6.1.2 Local Regulatory Trends

Massachusetts local Boards of Health are also raising concerns about the proposed MassDEP regulations streamlining the siting of organics processing facilities. Their objections appear to be mostly about having their local power taken away in the siting process for smaller facilities. In general, as noted above, local control is a strong force in Massachusetts, and Boards of Health express concern about local nuisance and environmental impacts from managing organics – which can be odorous if not handled properly.

6.2 State and Local Permits Required

Development of an organics to energy facility at the Millbury Providence Street site would involve installation of substantial new infrastructure for any of the alternatives being evaluated. State and local permits are required whenever proposed work may affect certain environmentally sensitive resources, disturbs a specific amount of land and/or constructs new infrastructure subject to local building and zoning board reviews. Though a detailed permitting review would need to be conducted during later stages of project implementation, the following provides a brief description of the likely permits required for anaerobic digestion related improvements to the Millbury site.

6.2.1 MassDEP and Board of Health Approvals

Also as noted within revisions to 314 CMR 12.00, acceptance of SSO at Millbury will require a written approval to accept SSO materials at AD units from the MassDEP. However, based on the known goals for the SSO initiative, this approval is unlikely to meet resistance at the state level.

As noted above, the changes to the CMR solid waste and wastewater treatment regulations allowed for streamlining of new facility siting and eliminated the need to acquire a solids waste site assignment for SSO processing. Since Millbury SSO is not considered a solid waste, a new "site assignment" through the local board of health would not be required.

6.2.2 Air Quality Permitting

The installation of new biogas-fired boilers and cogeneration engines is expected to require a new air permit. Per 310 CMR 4.10(2), it would be necessary to apply for a Non-Major Comprehensive Plan Approval from the MassDEP, and to have this permit in hand before installing the equipment. A Non-Major Comprehensive Plan Approval application can take four to six weeks to prepare, and is required to include a Best Available Control Technology analysis, and possibly also a dispersion modeling demonstration. MassDEP approval of this permit is expected to take about six months.

In addition, all digester-gas fired engines must comply with U.S. EPA emission limits in 40 CFR 60 Subpart JJJJ, Standards of Performance for Stationary Spark Ignition Internal Combustion Engines, shown in Table 5-2, for nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC). The reciprocating biogas fired cogeneration engines investigated under this evaluation for potential use at Millbury do appear to meet the USEPA limits identified in Table 6-2.

Engine Type	Manufacture Date	Maximum Rated Engine Power	Oxides of Nitrogen	Carbon Monoxide	VOC
Digester Gas, Except Lean Burn 500≤HP<1,350	On and after 1/1/2011	HP<500	2.0 g/HP-hr or 150 ppmvd @ 15% O ₂	5.0 g/HP-hr or 610 ppmvd @ 15% O ₂	1.0 g/HP-hr or 80 ppmvd @ 15% O ₂
	On and after 7/1/2010	HP≥500	2.0 g/HP-hr or 150 ppmvd @ 15% O ₂	5.0 g/HP-hr or 610 ppmvd @ 15% O ₂	1.0 g/HP-hr or 80 ppmvd @ 15% O ₂
Digester Gas, Lean Burn	On and after 7/1/2010	500≤HP<1,350	2.0 g/HP-hr or 150 ppmvd @ 15% O ₂	5.0 g/HP-hr or 610 ppmvd @ 15% O ₂	1.0 g/HP-hr or 80 ppmvd @ 15% O ₂

Table 6-1
U.S. EPA Emissions Standards for Stationary Digester Gas Engines

6.2.3 Wetland Resources

Based on wetlands delineation completed during this project, and as shown on the conceptual facility layout developed, it is possible that the required improvements at the site may not be required to be installed within the 100-foot Buffer Zone of wetlands on the site. However, as shown on the conceptual site plan, it is possible that some new infrastructure may be required within the 200-foot Riverfront Area buffer zone. Since wetlands and riverfront areas are protected under the Massachusetts Wetlands Protection Act (WPA), authorization would be required from the municipal Conservation Commission for any work in either of these protected resource areas.

Authorization from the Conservation Commission for work within the wetlands buffer zone can be provided via two different mechanisms. Authorization can be approved via a Determination of Applicability or an Order of Conditions (wetland permit). However, work within the 200-ft riverfront area buffer would require a Notice of Intent (NOI) to be filed with the local Conservation Commission. Following submittal of a NOI, the commission would hold a public hearing to review the proposed activities subject to jurisdiction of the Wetlands Protection Act and receives input from the public before issuing a permit decision.

6.2.4 Planning Board

As noted previously, there does not appear to be any specific prohibition against siting of an organics processing facility within the current zoning regulations for this site. However, the final determination as to whether review of this project by the local Planning Board should be determined by local officials. Based on the scale of this project, it is likely that a project of this nature would be required to be reviewed and approved.

6.2.5 Local Building Permits

Local building permits are typically the responsibility of the general contractor performing the construction and are obtained during the construction phase.

6.2.6 Flood Protection

Commonly accepted design guidelines for similar waste processing facilities, suggests that infrastructure should provide for protection against structural and equipment damage from the 100-year flood level. It is assumed design of this project would likely follow similar guidance. According to the most recent FEMA flood insurance mapping (latest version dated July 4, 2011), a significant portion of the site does fall within the 100-year floodplain of the Upper Blackstone River. As such, special permitting and/or construction practices to resist flood damage would be required if any of the new infrastructure were to be located within this area.

6.2.7 Stormwater

EPA currently regulates stormwater discharges from construction sites that disturb 1 acre or more and construction dewatering activities. It is likely that facility construction would disturb greater than 1 acre of land and will therefore require a Construction Activities Permit. As part of the construction contract, the Contractor typically obtains the required NPDES Permit.

A Stormwater Pollution Prevention Plan (SWPPP) would also be prepared during final design according to the MassDEP General Permit requirements for stormwater discharges. The Plan would identify a pollution prevention team, potential pollutant sources, stormwater monitoring requirements, record keeping, reporting responsibilities, and stormwater management controls. The Plan would also include a site map showing discharge locations, stating receiving water bodies, and showing locations of materials exposed to precipitation.

6.2.8 Natural Heritage and Endangered Species

Though an initial review of this data was completed during this study, during the early stages of the project design, a more detailed review for the potential presence of “Rare and Sensitive Habitats” would be required to be completed. This process generally involves a review of the Massachusetts Natural Heritage Atlas along with correspondence with the Massachusetts Natural Heritage and Endangered Species Program (NHESP). In the event no estimated habitat of rare wildlife or priority habitat of rare species are identified within the project area or in the immediate vicinity, no additional permitting would be required.

6.2.9 Cultural Resources

During the early stages of the project, review of the Massachusetts Cultural Resource Information System (MACRIS) would be required to identify any potential historical or archaeological resources at the site. Due to the fact that the facility consists of previously disturbed land, issues with this review are unlikely.

6.3 Electrical Interconnection Requirements

The electrical interconnection of a cogeneration facility can be a significant component of the project. Cogeneration facilities capable of generating thousands of megawatt hours per year will require an electrical utility service and associated infrastructure capable of transmitting a significant electrical load to the grid. As previously noted, the existing facilities at the Providence Street site have an average annual energy consumption of approximately 50 kW while the new systems associated with the anaerobic digestion facility could add an additional average load of approximately 100 kW. Based on the alternatives evaluated here, the peak output of the cogeneration facility could be in the range of 1 to 5 MW. Since the output of the cogeneration facility scenarios exceeds the electrical demand, the facility will need to be directly connected to National Grid and net metered so as to recover the benefits of this electrical production.

Typical cogeneration facilities of this size produce power at either 480 volts or 4160 volts, three phase 60 hertz. The facility will therefore require a separate transformer that converts the produced voltage to 13.2 kV which is assumed to be the electric utility service voltage currently serving the Providence Street Site. These values would need to be confirmed during the design phase. Regardless of exact voltages, a three phase step-up transformer with utility metering on the primary (13.2 kV side) would be required. The transformer should comply with the Department of Energy (2010 compliant) for energy efficiency.

In addition, a bi-directional net meter provided by the utility (National Grid) will need to be installed to measure and record the site consumption and production when the facility is producing more power than demand. If the facility were to be municipally owned, based on the net metering concept, when the facility produces more power than consumed, the utility will record and credit other town-owned electrical accounts. It should also be noted that National Grid may also require a reclosing device to disconnect the cogeneration system from the grid, but this will not be definitely known until further discussions are conducted with the utility during design. Final design and integration of the cogeneration facility system must comply with the National Grid Standards for Integrating Distributed Generation, IEEE 1547.

Due to the direct utility tie-in, it is expected that a National Grid impact study will be needed prior to commencing construction; this has a maximum time frame of 90 day to complete. The maximum time frame for interconnection approval is 150 days through the Standard Process Interconnection Application, including the impact study. The application fee for this work should not exceed \$2,500 per National Grid standards and the Impact Study may cost approximately \$10,000 based on prior experience, but actual cost of the study will be provided by National Grid once the requirement is determined.

6.4 Permitting Implementation Plan

Though a specific permitting implementation plan would need to be developed as part of the design phase of this project, the potential permits have been listed below in their likely order of importance relative to the project schedule beginning with the lengthiest permitting process.

- **Air Quality Permitting:** As noted above, a Non-Major Comprehensive Plan Approval from the MassDEP would likely be required for this project. As the preparation of this permit could take between 4 and 6 week with permit approval taking an additional 6 months, this is likely on the critical path for permitting of this project.

- Electrical Interconnection Application: Though the duration of this process is variable, from the start of the pre-application process through to final approval of the interconnection application with National Grid, it can be assumed that a 6 month duration may be required.
- Wetland Resources: Due to the potential need for work within a wetland buffer zone and/or riverfront buffer zone, a Notice of Intent filed with the local conservation commission would likely be required. This process involves preparation of the NOI submission, commission presentation(s) and a public comment period which could take on the order of 3 to 6 months.
- Planning Board: The time period for local approval of any potential required variances is highly variable and is often tied to the level of local support (and opposition) for the project. However, a 3 month period can be assumed for planning purposes.
- Natural Heritage and Endangered Species: Submission to the Massachusetts Natural Heritage and Endangered Species Program (NHESP) is a relatively brief process, though response as to the presence of “Rare and Sensitive Habitats” can take up to 30 days to receive.
- Cultural Resources: Submission to the Massachusetts Cultural Resource Information System (MACRIS) is also a limited effort, but a 30 day turnaround time on the response should also be planned for.
- MassDEP Approvals: A letter to MassDEP requesting approval for this project would be required. Though the response time is not currently know, it can be assumed that this would be approved in a relatively short period of time given its current high level of support for the organics diversion initiatives within the Commonwealth.
- Local Building Permits: These permits would be the responsibility of the contactor and would be incorporated into their overall project construction schedule.
- Stormwater: These permits would be the responsibility of the contactor and would be incorporated into their overall project construction schedule.

Section 7

Funding and Financing

As discussed in Section 5, there are a number of project development and ownership options available for this project. In addition to the allocation of project responsibility and risks, a major driver in the decision as to the most advantageous option surrounds maximizing the affordability and economic benefits. Though financing projects of this nature can be complex and availability of assistance can vary depending on the ownership option selected, there are a number of possible programs available including state grants, low interest loans and tax incentives which could aid in the project development and financing. In addition, as noted in Section 3, tipping fees for accepting SSOs and cogeneration electrical production incentives would serve to assist in financing of the required infrastructure. A brief description of each available program is described further below.

7.1 Potential Grants and Loans

7.1.1 MassCEC Organics to Energy program

The Massachusetts Clean Energy Center (MassCEC) administers the Commonwealth's Organics-to-Energy Program. In addition to providing technical assistance related to the development of projects that convert source-separated organic materials into heat and electricity, it also provides grants for the development of related facilities. Projects must be located in the service territories of the investor-owned or municipal electric distribution companies that pay into the Massachusetts Renewable Energy Trust Fund -- administered by the Massachusetts Clean Energy Center ("MassCEC") -- and must produce 1) electricity that is eligible for the Massachusetts Renewable Portfolio Standard or 2) thermal energy that can be used outside the organics processing system itself. The principal technology supported is anaerobic digestion, although a limited number of awards may be made for projects employing other commercially available technologies.

The MassCEC provides grant funding for feasibility studies, technical studies, pilot projects and construction projects. As noted earlier, the majority of the funding for the current feasibility study was provided through the MassCEC Organics to Energy Program. The dollar cap for pilot studies is currently \$200,000 while construction project grants are capped at \$400,000.

7.1.2 MassDEP Recycling Loan Fund

As announced in July of 2013, in an effort to support the pending organic waste diversion regulations, the Commonwealth of Massachusetts has made \$3 million in low-interest loans available to private companies for construction of anaerobic digestion facilities. The low-interest loans will be administered by BCD Capital through MassDEP's Recycling Loan Fund, with monies provided by the Department of Energy Resources (DOER). The loans range from \$50,000 to \$500,000 with terms up to ten years and are intended to be used for permanent working capital, refinancing, and real estate, machinery & equipment, and acquisition financing.

7.1.3 MassDEP Sustainable Materials Recovery Grants

MassDEP Sustainable Materials Recovery Program (SMRP) Municipal Grants offer funding to cities, towns and regional entities for "recycling, composting, reuse and source reduction activities that will increase diversion of municipal solid waste and household hazardous waste from disposal."

Historically, grants were general geared toward recycling and composting equipment, Pay-As-You-Throw programs, waste reduction enforcement, school recycling and local/regional waste reduction projects. During 2012, a total of approximately \$2 million was awarded across 118 projects. MassDEP typically accepts applications for this program between early April and mid-June annually

It was also recently announced that DOER is making \$1 million available in grants for anaerobic digestion to public entities for projects on municipal or state land through the SMRG program. The grants will be awarded in amounts up to \$500,000 per project (multi-year grant). MassDEP and DOER have awarded the first AD grant of \$100,000 to the Massachusetts Water Resources Agency (MWRA) for co-digestion pilot testing at its wastewater treatment plant at Deer Island.

7.1.4 National Grid Energy Efficiency Incentives

This project may also qualify for National Grid Custom Measure Incentives Program for New Construction. Though this program has historically been geared toward providing financial assistance to energy efficiency measures, such as the use of specific high efficiency lighting fixtures or water heating systems, custom incentives also apply to more complex projects that provide energy efficient solutions – including cogeneration projects. For electrical efficiency studies, in the event the project meets a series of screening criteria and prerequisites, this program can provide up to 70% of incremental cost of higher efficiency equipment, or an amount that buys down the incremental investment to a 1.5 year simple payback. However, as the name suggests, this program is highly customized and additional technical discussions with National Grid would be required to determine project eligibility and potential funding.

7.1.5 Green Communities Competitive Grant

The “Green Communities Act” of 2008 created a Green Communities Division within the Massachusetts Department of Energy Resources (DOER). The charge of this division is to guide all cities and towns within the Commonwealth “along a path of enhanced energy efficiency and renewable energy toward zero net energy.” In general, the goal of this program is to maximize energy efficiency in public buildings, including schools, city halls, and public works and public safety buildings; generate clean energy from renewable sources; and manage rising energy costs. To achieve these goals, the Division currently provides technical assistance as well as opportunities to fund energy improvements.

In 2011, the Town of Millbury was designated as one of the 110 Green Communities in the Commonwealth of Massachusetts and made eligible for grant funding for energy efficiency measures and renewable energy projects through the Green Communities Grant Program. DOER Green Communities Competitive Grants are awarded to existing Green Communities that have successfully invested their initial designation grants. In 2013, a total of \$3.7million in competitive grants were awarded which were capped at \$250,000 per municipality. The competitive grants are funded through proceeds from Regional Greenhouse Gas Initiative auctions (RGGI).

7.1.6 Clean Water State Revolving Fund (CWSRF) Loans

Every year the Commonwealth of Massachusetts funds millions of dollars’ worth of water and wastewater projects through the Department of Environmental Protection (MassDEP) State Revolving Fund (SRF). The Clean Water State Revolving Fund (CWSRF) Loans could provide an avenue for low interest loans and principal forgiveness to fund this potential project. Though the CWSRF program has historically concentrated on water-related projects, the based on recent project examples and discussions with MassDEP, it has been noted that organic diversion projects are also being looked

upon favorably within their current project prioritization system. As such, if selected for CWSRF funding, this project would be eligible for low interest loans (2% interested rate) as well as any potential principal forgiveness which the program may have to offer at that time. During the 2012 funding process, the CWSRF program offered approximately \$300 million in financing for clean water projects across the Commonwealth.

Based on the 2013 Intended Use Plan (IUP) developed by the MassDEP, the Commonwealth was expected to receive an estimated \$47.9 million federal grant to subsidize the CWSRF program. In 2012, Congress required at least 10% of the federal grant be used to fund “green infrastructure” and it is expected that a similar requirement for 2013 will be enforced. Based on the IUP, the MassDEP intended to finance (including both grants and loans) approximately \$68 million for Green Infrastructure project components.

7.1.7 Clean Renewable Energy Bonds (IRS)

Clean Renewable Energy Bonds (CREBs) are 0% interest bonds typically issued for up to approximately \$3.0 million administered by the Internal Revenue Service (IRS). The IRS initiated the program in 2005 and accepted applications intermittently through 2010. The most recent round of funding included approximately \$2.4 billion in funding. However, the IRS is not currently accepting application for this program and it is unknown when/if additional funding will be made available. For more information, please refer to <http://www.irs.gov/Tax-Exempt-Bonds/>.

7.1.8 Qualified Energy Conservation Bonds

Qualified Energy Conservation Bonds (QECBs) are tax credit bonds, bonds which the borrower pays back the principal on the bond, and the bondholder receives federal tax credits in lieu of traditional bond interest payments. QECBs can be issued to qualified energy conservation projects, including anaerobic digestion projects. A total of \$3.2 billion of QECBs were initially authorized under the federal Energy Improvement and Extension Act of 2008 and American Reinvestment and Recovery Act of 2009 (ARRA). QECBs were allocated based on population and Massachusetts received \$67 million of the total. DOER administered a series of Program Opportunity Notice (PON) to allocate this funding, the most recent of which was dated April 18, 2013 and labeled as PON-ENE-2013-070. Based on this recent solicitation, only \$4 million of the original total Massachusetts allocation remains available for distribution.

7.1.9 Global Climate Change Mitigation Incentive Fund

The Economic Development Agency (USEDA)(part of the U.S. Department of Commerce) administers the GCCMIF to public works projects that reduce greenhouse gas emissions and creates new jobs. In FY 2012, \$16.5 million was allocated to the grant-based fund, and additional funding is expected to be allocated in FY 2013. Applications are due on a rolling basis. Private sector and or for-profit companies are not eligible for this fund.

7.1.10 Business Energy Investment Tax Credit (ITC)

A Business Energy Investment Tax Credit (ITC) is available from the U.S. Internal Revenue Service (IRS) for combined heat and power systems. The tax credit is only available for commercial, industrial or utility entities. Tax-exempt municipal entities, including the Town of Millbury, would not be eligible for this tax credit. As discussed below, the Town would be able to indirectly benefit from the tax credit by entering a long term agreement with an Energy Service Company (ESCO) for development of the facility. The credit is equal to 10% of CHP expenditures, with no maximum.

7.1.11 MassDevelopment Tax Exempt Financing

The Massachusetts Development Finance Agency (MassDevelopment) was created in 1998 under legislation which merged the Massachusetts Government Land Bank with the Massachusetts Industrial Finance Agency. MassDevelopment works with private- and public-sector clients to stimulate economic growth by creating jobs and increasing the state's housing supply. Among other financing options, they offer tax exempt financing to municipal and non-profit entities for funding of large-scale projects. Because they are exempt from federal taxes and in certain cases state taxes, tax-exempt bonds are usually the lowest interest rate option for real estate projects and new equipment purchases. In the fourth quarter of FY 2013 (April, May & June of 2013), MassDevelopment financed 84 projects totaling approximately \$800 million in investment in the Commonwealth.

7.1.12 Private Tax-Exempt Financing

Similar to traditional municipal bond financing, there are many private financial service companies that offer a myriad of options for tax-exempt financing of municipal projects. The providers of these services suggest that this capital can be offered at competitive rates in an expedited timeframe and with fewer complications when compared to traditional municipal financing methods. Though these factors would need to be compared on a case-by-case basis, the one distinct advantage to private financing on the current project would likely be the flexibility to structure payments to meet budget needs with consideration given to the terms and conditions of existing loan and/or bond agreements. For example, this mechanism could be used to limit the initial debt payments when the current bond debt is the greatest and the operations savings of the project has yet to be fully realized. It should also be noted that, in many cases, the construction and long term financing can be rolled into a single private financing agreement. Also, in some instances, equipment manufacturers have the ability to offer competitive financing terms (e.g. Siemens Financial Services Corporation), though financing from these sources is generally contingent upon a substantial portion of the project cost (~20% to 30%) being for their respective equipment.

Table 7-1 provides a summary of the general characteristics of each grant and loan program described in this study.

7.2 Potential Operating Revenue

7.2.1 Organic Waste Tipping Fees

As discussed previously, fees for disposal of SSOs at the facility would likely serve as a source of revenue to fund the project. Though this rate would be driven by the waste disposal market in the Commonwealth and would be influenced by a number of factors, based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of \$30 to \$40 per wet ton for pre-processed waste.

7.2.2 Digestate Beneficial Reuse

In the event a market for the final digestate product was identified, theoretically, the sale of the product for its remaining nutrient content could yield additional operating revenue. However, as discussed previously, this market is not well developed within the Commonwealth and the demand for such a product is not currently known. Due to the ongoing activity and discussions pertaining to the organics processing and reuse markets, additional opportunities and potential financial implications may become more clear in the coming months.

7.2.3 Net Metering

In 2012, legislation was passed in Massachusetts, which is currently being developed into regulation, allowing anaerobic digestion and cogeneration facilities to avail themselves of the “net-metering” provisions of the Green Communities Act. The premise of the program is to provide incentives to supplying renewable energy into the local power grid.

Massachusetts Net Metering Regulations, 220 CMR 18.00 et seq., defines that an Anaerobic Digestion Net Metering Facility must:

- Generates electricity from a biogas produced by the accelerated biodegradation of organic materials under controlled anaerobic conditions;
- Has been determined by the Department of Energy Resources, in coordination with the Department of Environmental Protection, to qualify under the Department of Energy Resources’ regulations as a Class I renewable energy generating source under 225 CMR 14:00: Renewable Energy Portfolio Standard – Class I and M.G.L. c. 25A, § 11F; and
- Is interconnected to a Distribution Company.

The regulations further define three classes of energy facilities eligible for net metering categorized by their rated capacity. The capacity ranges for the three classes are:

- Class I Net Metering Facility means a plant or equipment that is used to produce, manufacture, or otherwise generate electricity and that is not a transmission facility and that has a design capacity of 60 kilowatts or less.
- Class II Net Metering Facility means an Agricultural Net Metering Facility, Anaerobic Digestion Net Metering Facility, Solar Net Metering Facility, or Wind Net Metering Facility with a generating capacity of more than 60 kilowatts but less than or equal to one megawatt; provided, however, that a Class II Net Metering Facility of a Municipality or Other Governmental Entity may have a generating capacity of more than 60 kilowatts but less than or equal to one megawatt per unit.
- Class III Net Metering Facility means an Agricultural Net Metering Facility, Anaerobic Digestion Net Metering Facility, Solar Net Metering Facility, or Wind Net Metering Facility with a generating capacity of more than one megawatt but less than or equal to two megawatts; provided, however, that a Class III Net Metering Facility of a Municipality or Other Governmental Entity may have a generating capacity of more than one megawatt but less than or equal to two megawatts per unit.

Both options evaluated in this study would qualify the facility as a Class III net metering facility.

A facility’s maximum capacity will also help determine whether it is a “public” or a “private” project. If a net metering facility is designed for the private net metering cap, then the maximum total capacity is 2 MW. If a net metering facility is designed for the public net metering cap, then the maximum capacity is 10 MW. Only Class II and Class III facilities may be included in the public net metering cap.

Under the net metering program, in installations where power produced does not exceed on-site power use, the host customer is able to apply net metering credits to offset its bill from the electric distribution company. If more power is generated than can be used onsite, and as long as two basic

conditions are met, a Host Customer may apply net metering credits to other accounts, even if the other accounts are not held by the Host Customer. The Host Customer can allocate net metering credits to other accounts as long as all of the accounts are with the same electric distribution company and located within the same ISO-NE load zone. Because the facility options evaluated here would exceed the current total Town of Millbury town account electric usage, a partner electric customer would need to be secured in order to fully utilize the net metering credits that would be produced by this project. In addition, if the facility were to fall under the public net metering cap described above, any partner customer that were to receive the net metering credits from the facility would be required to be a public entity.

If a net metering facility has a capacity of 1 MW to 2 MW (making it a Class III facility), the electric distribution company may decide to pay the Host Customer for the value of any credits from excess generation, instead of applying any credits to accounts. Under state law, this decision is left entirely up to the electric distribution company, but the utility must decide before the facility becomes operational what it will do in this regard.

For the purpose of the financial analysis included in Section 3 of this study, it has been assumed that the Millbury facility would be a Class III public net metering facility and would either utilize a public net metering electric customer partner to utilize the extra credits produced or would be paid directly for the credits by National Grid.

7.2.4 Renewable Energy Certificates (RECs)

As part of the Massachusetts Renewable Portfolio Standards (RPS), electric suppliers are required to have an annually-increasing percentage of their retail sales generated by renewable energy. Electric suppliers fulfill this obligation by purchasing renewable energy certificates (RECs) from the owners of qualified renewable energy generating systems and recording these purchases with the New England Power Pool (NEPOOL) Generation Information System (GIS). One REC is created for every 1,000 kWh (1 MWh) of renewable electricity generated. The RPS, and creation of RECs, is intended to provide additional revenue flow and financial support for renewable energy projects in Massachusetts. As of April 2013, Class I RECs, which include electricity generation from wind, wave, tidal, geothermal and sustainable biomass were trading at around \$64/MWh.

An Alternative Compliance Payment (ACP) is a payment of a certain dollar amount per MWh, which a retail electricity supplier may submit to DOER in lieu of purchasing RECs. These payments are provided to the MasCEC and the revenue generated from ACPs is used to fund new renewable generation projects. In Massachusetts, this ACP is currently set at \$65.27 per MWh, which effectively sets the ceiling price for the REC purchasing market. The ACP may vary year to year but by no more than 10 percent per year.

Under current regulations, the power from a Millbury organics-to-energy system could be sold to the market as RPS Class I Renewable Energy Certificates (RECs). Though the pricing is quite strong for RECs in Massachusetts at the present time, the increase of renewable energy production systems (solar, other organics to energy facilities, etc) will impact and likely force a decrease in the pricing within this market. However, as a point of comparison, based on the alternatives evaluated in this study and at the current REC market pricing, the power could translate into between \$350,000 per year and \$2 million per year assuming 90% system availability and facility operations at full capacity.

Table 7-2 includes a summary of the potential operating revenue associated with this facility along with the associated assumption included within the Section 3 financial analysis.

	Type of Funding	Applicant Type	Recent Statewide Allocation	Dollar Cap Per Project
MassCEC Organics to Energy Program	Grants	Public & Private	Unknown	\$200,000 (Piloting) \$400,000 (Construction)
MassDEP Recycling Loan Fund	Low Interest Loans	Private	\$3M for AD	\$50,000 to \$500,000
MassDEP Sustainable Materials Recovery Grants	Grants	Public	\$1M for AD	\$500,000
National Grid Custom Measures Program	Grants	Public & Private	Unknown	70% of Incremental Cost or Buy-Down to 1.5 yr Payback
Green Communities Competitive Grant	Grants	Public	\$3.7M (2013)	\$250,000
MassDEP Clean Water State Revolving Fund (CWSRF)	Low Interest Loans & Principal Forgiveness	Public	\$68M for Green Infrastructure (2013)	None
Clean Renewable Energy Bonds (CREBs)	Not current accepting applications			
Qualified Energy Conservation Bonds	Tax Credit Bonds	Public & Private	\$4M	None
Global Climate Change Incentive Mitigation Fund	Grants	Public	\$16.5M Nationwide (2012)	Unknown
Business Energy Investment Tax Credit	Tax Credit	Private	N/A	10% of Combined Heat and Power Costs
MassDevelopment Tax Exempt Financing	Tax Exempt Bonds	Public & Private	\$800M (Q2 2013)	None
Private Tax Exempt Financing	Tax Exempt Bonds	Public & Private	None	None

Table 7-1
Summary of Grant and Loan Opportunities

	Potential Range	Current Study Assumption
Organic Waste Tipping Fees	\$30 to \$40 per Wet Ton for SSO	Solved for Break-Even Tipping Fee
Digestate Beneficial Reuse	Unknown	Offsite Disposal <u>Cost</u> of \$50/wet ton
Electrical Net Metering	Current rate of \$0.13/kWh	Included Full Credit for All Power Production
Renewable Energy Certificates (RECs)	Current rate of \$64/MWh	Not Included in Operating Revenues

Table 7-2
Potential Operating Revenues

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Section 8

Report on Community Engagement

The potential Millbury Organics-to-Energy project, as with most public works project, carries with it the need to engage the public beginning in the earliest stages of project planning and throughout project implementation. As the Town of Millbury is fully aware, these communications are essential so as to ensure broad understanding and support of the project goals. The purpose of this Section is to discuss the community engagement efforts completed to-date as part of this project development.

Despite that the goal of the potential project is related resource recovery and sustainable energy production from a renewable resource, it would involve the receipt and processing of an additional waste stream not currently received in Town. Further, as previously noted the transportation routes to and from the site are likely to involve approximately 5 miles of roads to and through the downtown area. These deliveries have the potential to have actual or perceived negative impact on odors and/or traffic volumes. For these and other reasons, communication with and education of the project stakeholders is essential.

The Town of Millbury understands the importance of community engagement and has initiated these communications prior to and concurrent with the development of this feasibility study. Specifically, the following activities have been undertaken:

8.1 Description of Activities Undertaken

8.1.1 Public Hearings

- The Director of Public Works introduced the MassCEC grant and Organic to Energy feasibility study to the local Board of Selectmen at multiple televised meetings during 2012 and early 2013;
- A presentation was made to the Board on September 10, 2013 discussing the outcome of the Phase I feasibility study and providing a status update on the project; and
- Scheduling of a special public hearing to discuss this potential project is planned for early October of 2013.

8.1.2 Written and Electronic Communications

- The Millbury-Sutton Chronicle has reported on the Selectmen presentations and described the purpose of the MassCEC grant, the proposed organics project as well as the intended location at the DPW facility on Providence Street;
- During late August 2013, the Phase I executive summary report was provided to the Board of Selectman for review and comment;

- The Phase I Feasibility Study Executive Summary and the Phase II conceptual site plan was posted to the Millbury DPW website at http://www.millbury-ma.org/Public_Documents/MillburyMA_DPW/index. In addition, comments on the study were requested and a link to the email address for the DPW director was provided prominently on the Millbury DPW website as well as the town electronic announcement board.

8.1.3 Direct Written Abutter Communications

A list of abutters is currently being developed for any parcel owner within 1,000 feet of the Providence Street parcel. The property owners within this area will then be sent a letter via certified mail briefly describing the project and the current status of planning effort and inviting them to the October 2013 public hearing. Town contact information (DPW Director) will also be provided in this mailing for these stakeholders to provide direct feedback.

8.2 Summary of Issues Addressed or Outstanding

Feedback received from the Board of Selectmen and from the public following these communications has been positive to date.

Limited responses were received to the posting of the Phase I feasibility study. However, the responses received included questions pertaining to:

- Type of trucks that would haul the SSO material to the site;
- The routing and number of trucks that would be required to make the project feasible; and
- Potential odors that could emanate from the site.

Section 9

Project Findings

9.1 Summary of Findings

As previously noted, two SSO acceptance conditions were evaluated during this study so as to analyze a wide range of potential cost and benefits. Using these waste acceptance scenarios, conceptual systems were sized to adequately process this waste. Systems included preprocessing, anaerobic digestion, digestate dewatering, sidestream treatment, biogas treatment and biogas fired cogeneration equipment. Table 9-1 summarizes some of the key expected process performance values under average annual conditions for each option.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Potentially Available SSO Waste (wet tons/year)	19,000	94,000
Potentially Available SSO Waste (wet tons/day)	52	258
Digestion Volume (Mgal)	0.60	2.96
EFW Fed to Digester (gal/day)	30,000	148,000
Biogas Produced (cf/day)	299,000	1,523,000
CHP Electrical Production (kW)	840	4,900
CHP Net Electrical Remaining After Onsite Use (kW)	690	4,300
CHP Heat Recovered (MMBtu/hr)	3.6	18.4
CHP Net Heat Remaining after Onsite Use (MMBtu/hr)	0.0	12.0
Dewatered Cake (wet tons/day)	19	91
Dewatered Cake (cy/day)	84	405
Centrate Requiring Disposal (gal/day)	25,000	125,000

Table 9-1
Conceptual Digestion Facility Process Summary

To compare relative costs and benefits of the alternatives, estimates of probable project cost were developed for each of the acceptance scenarios and the associated operations costs impacts were also conceptually quantified. As summarized in Table 9-2, the total annual net cost of developing a digestion facility at the Millbury site is estimated to range from \$35M to \$85M. After considering the significant financial benefits of the associated combined heat and power system in addition to the operational costs of the facility, the net annual cost is estimated to range from \$2.7M to \$5.7M before accounting for tipping fee revenues.

At these costs and assumed SSO quantities, the break-even tipping fee would equate to between approximately \$140 (for the 10% of regional waste option) to \$60 (for the 50% of regional waste options) per wet ton received. In the event the preprocessing system was to be excluded from the project, the break-even tipping fees would equate to between approximately \$105 and \$40 per wet ton, respectively.

	Alternative A (10% of Regional SSO)	Alternative B (50% of Regional SSO)
Initial Capital Costs	\$35,000,000	\$85,000,000
Annual Capital Costs (Amortized 20 yrs @ 2.5%)	\$2,300,000	\$5,500,000
Annual Operational Costs	\$1,200,000	\$5,100,000
Annual Combined Heat and Power Revenue	\$800,000	\$4,900,000
Net Annual Cost	\$2,700,000	\$5,700,000
Annual SSO Received (wt/yr)	19,000	94,000
Break Even Waste Tip Fee (\$/wt)	\$142	\$61
Break Even Waste Tip Fee without Installation of Pre-Processing (\$/wt)	\$105	\$40

Table 9-2
Conceptual Financial Summary

Based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of \$30 to \$40 per wet ton for pre-processed waste. Though the organics disposal market in the Commonwealth is currently in a state of flux due to the pending waste ban as well as the rapid development of various waste processing facilities, it is not currently known whether this experience in other parts of the country will be seen in Massachusetts. It is important to note, however, that the current average rate for municipal solid waste disposal in Massachusetts is in the range of \$70 per ton, so tipping fees for non-preprocessed waste less than this may be able to be initially borne by the developing organics market in the Commonwealth. Despite this, it remains to be seen how low rates for these wastes, which have an inherent energy value as well as a potential digestate reuse value, will be ultimately driven down by competing processing facilities.

With consideration of the above factors and estimated costs, the apparent financial viability of the two facility sizing options evaluated here can be summarized as follows:

- Alternative A: The development of a facility to accept and process 19,000 wet tons per year of SSO is estimated to cost on the order of \$35M. After accounting for the operations costs and energy benefits associated with the facility, an SSO tip fee between approximately \$105 and \$140 per wet ton would need to be realized in order to break even with higher tipping fees required for any positive net revenues to be realized. As this rate is greater than the current cost of municipal solid waste disposal in the Commonwealth and significantly greater than organics disposal rates in other parts of the country, the development of a facility of this size would not be financially viable without significant external funding incentives.
- Alternative B: Development of a larger facility which would be capable of processing 94,000 wet tons per year would likely cost on the order of \$85M to develop and would translate to a break even tip fee between \$40 and \$60 per wet ton. Though these fees appear to be more in line with the potential market rates for this material, this option does carry with it significant risk related to waste availability. The quantity assumed here translates to 50% of the estimated organic waste within a 30 mile radius, which encompasses much of the heavily developed metro west region of Massachusetts. The likelihood of separating this waste from the solid waste stream and consolidating it at any single facility may not be a sustainable assumption due to the developing competition for this waste. Therefore, pursuit of a facility approaching this size could be financially viable, but would carry with it significant risk and uncertainty.

9.2 Implementation Recommendations

Despite the unfavorable finances associated with the smaller of the options evaluated and the waste availability risks associated with the larger of the options, it may be possible to select a facility size somewhere within the range evaluated here which would balance these concerns. This selection would likely be driven by whether any substantial external funding may be able to be secured as well as proper determination of the risk tolerance of the Town. Based on experience in other similar municipalities, it is anticipated that the significant capital cost and risk associated with developing a project of this nature may not be bearable exclusively by a municipal ownership option. For this reason, if the Town believed that development of this facility was a priority and in the Town's best interest, private development or a public private partnership (see Section 5) should be evaluated further through discussions with local private organics facility developers.

For reference, and for future partnership opportunity considerations, a few of the private firms actively pursuing this area include the following:

- Anaergia (Burlington, ON);
- Applied Water Management (Division of Natural Systems Utilities (NSU) (Hillsborough, NJ));
- Casella Organics (Partial Owner of Agreen Energy LLC) (Portland, ME);
- Harvest Power (Waltham, MA);
- NEO Energy (Portsmouth, NH); and
- Waste Management Inc. (Houston, TX).

9.3 Procurement Approaches

Two basic approaches are available for the Town to competitively procure a lease agreement for purposes of constructing and operating a source separate organic waste processing facility at the Providence Street Site. A brief discussion of each standard approach is provided below.

9.3.1 Separate Request for Qualifications and Request for Proposals

Under this approach, the Town would prepare and issue two separate requests. The first request would be a Request for Qualifications (RFQ) which would contain minimum technical and financial criteria that would be used to prequalify a short list of respondents that the Town determines would be most advantageous to the Town. Only the prequalified respondents would receive the second request which would include a formal Request for Proposals (RFP). The RFP would include all technical, permitting and financing requirements; performance standards (e.g., odor control); proposal submittal requirements including drawings and renderings; and a draft property lease agreement. The primary advantage of this approach is that only a small number of qualified firms are selected to receive the RFP thereby ensuring that only serious proposals are received. This approach also reduces the cost and effort on the part of the Town to review proposals and select a preferred respondent. The primary disadvantage of this approach is that it lengthens the project schedule since two separate documents need to be prepared, issued and reviewed.

9.3.2 Combined Request for Qualifications and Request for Proposals

Under this approach, only one request would be prepared and issued. The combined request would include both minimum technical and financial criteria as well as a formal request for proposals. Like the first approach, the RFP portion would include all technical, permitting and financing requirements; performance standards; proposal submittal requirements including drawings and renderings; and a draft property lease agreement. The primary advantage of this approach is that it shortens the project schedule by combining the two steps. For this project the estimated time savings is two months. The primary disadvantage is that a greater number of proposals would likely be received including ones that may or may not be compliant with the minimum qualifications. The time and effort to review a larger number of proposals would offset some of the time savings that this approach is designed to achieve.

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