# City of Everett

# Strategic Plan for Biosolids Management

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Project: 142050

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## List of Acronyms

| | |
|---|---|
| ATAD | autothermal thermophilic aerobic digestion |
| BTU | British Thermal Unit |
| BUFs | Beneficial Use Facilities |
| CFR | Code of Federal Regulations |
| CFU | Colony-Forming Unit |
| CWA | Clean Water Act |
| EPA | US Environmental Protection Agency |
| EQ | Exceptional Quality |
| MPN | Most Probable Number |
| NAS | National Academies of Science |
| NBMA | Northwest Biosolids Management Association |
| NEBRA | North East Biosolids and Residuals Association |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resources Conservation Service |
| O&M | Operations and Maintenance |
| PC | pollutant concentration |
| PEC | Pathogen Equivalency Committee |
| PFRP | Processes to Further Reduce Pathogens |
| PFU | Plaque-Forming Unit |
| PSRP | Process to Significantly Reduce Pathogens |
| TF/SC | Trickling Filter/Solids Contact |
| TS | Total Solids |
| USEPA | US Environmental Protection Agency |
| VAR | Vector Attraction Reduction |
| VS | Volatile Solids |
| WERF | Water Environment Research Foundation |
| WPCF | Water Pollution Control Facility |
| WSS | Water Secondary Sludge |
| WWTP | Wastewater Treatment Plant |

# 1.0 Introduction and Background

The City of Everett, Washington has contracted with HDR Engineering, Inc. to develop a strategic plan for the biosolids management program in order to identify needs, risks, and adaptations to improve the existing program. This plan will include the examination of possible interim treatment expansion at the existing facilities, along with integration with the currently planned construction of future treatment processes.

Presently the City's processing of biosolids generates an end product that is managed by recycling to improve soil tilth and fertility. Five approaches have been used to recycle biosolids:

- Class B land application on agricultural sites (referred to as land application)
- Forest fertilization with Class B biosolids (silvicultural application)
- Creating a Class A compost for use in landscaping
- Using Class B biosolids for landscaping at the City's Water Pollution Control Facility (WPCF)
- Using Class A and B biosolids for land reclamation projects

A desirable approach may be to continue to diversify end use products.

This section provides basic background information on the City of Everett's sewer utility, the facilities and processes currently used to treat wastewater at the City's Water Pollution Control Facility (WPCF), and the City's current and historic biosolids management practices. A discussion of biosolids regulations and trends in Section 1.0 will lay a foundation for development of the strategic plan.

## 1.1 City of Everett Wastewater Program

The City of Everett owns and operates 345 miles of sewers and 29 pump stations that convey domestic, commercial, and industrial wastewater to the Everett WPCF (City of Everett, 2008). Some sections of the City's sewer system collect both wastewater and stormwater runoff, and are referred to as combined sewers. The City operates combined sewage storage and treatment facilities to manage the excess stormwater collected in the sewer system.

## 1.2 Everett Water Pollution Control Facility

The Everett WPCF is located in north Everett, just east of Interstate 5 adjacent to the Snohomish River. The WPCF serves the City of Everett as well as other purveyors outside the City including: the Mukilteo Water and Wastewater District, the Alderwood Water and Wastewater District, the City of Marysville, and the Silver Lake Water and Sewer District. The City is also considering accepting and treating wastewater from the City of Snohomish.

The WPCF has a design capacity of 36.3 million gallons per day (MGD), with a 2008 average annual flow of 18.6 MGD.

### 1.2.1 Treatment Process

The Everett WPCF was constructed as a lagoon system in the 1960's (Carollo, 2009). The WPCF now has two parallel treatment trains: an aeration/oxidation pond system (North plant) and a trickling filter/solids contact (TF/SC) process (South plant). The TF/SC process treats the

base wastewater flow, and excess quantity is routed to the lagoon process, which also provides peak flow storage (City of Everett, 2008). The Headworks serves both trains and provides screening and grit (rocks and other dense materials) removal. Both treatment trains provide secondary treatment with biological processes and disinfection of the treated wastewater. Currently, the two parallel treatment trains have the following processes downstream of the Headworks:

1. Aerated lagoon system (North plant):
    a. Two facultative (partially aerated) lagoons, each with a volume of about 33.5 million gallons.
    b. Oxidation Pond: shallow (4-6 ft deep) ponds where anaerobic and aerobic degradation of the wastewater takes place, facilitated by microorganisms.
    c. Polishing Pond: provide final clarification of the water after degradation takes place in the oxidation pond.
    d. Disinfection: sodium hypochlorite is added to the treated water.
2. The “mechanical” (South) plant:
    e. Primary Sedimentation: large tanks that allow organic solids to settle by gravity.
    f. Trickling Filters: large tanks with filter media supporting the growth of bacteria for biological (secondary) treatment.
    g. Solids Contact Basin: tanks that are aerated to improve the settling characteristics of the trickling filter outlet water.
    h. Secondary Sedimentation: large circular tanks that allow biological solids from the solids contact basin to settle by gravity.
    i. Disinfection: sodium hypochlorite is added to the treated water.

Solids accumulated in the primary sedimentation tanks, called primary sludge, are pumped to the facultative lagoons (AC-1 and AC-2). Excess solids from the secondary sedimentation tanks, called waste secondary sludge (WSS), are also pumped to these lagoons.

Everett currently removes biosolids from the lagoon system every one or two years. A contractor is hired to dredge and dewater the biosolids, which are then temporarily stored on an asphalt pad at the east side of lagoon system prior to beneficial use.

### 1.2.2 Treated Water Reuse and Discharge

Treated wastewater from the “mechanical” (South) plant train is discharged through a marine outfall to Port Gardner Bay. This outfall is shared with the Kimberly Clark Corporation and the City of Marysville. Another outfall to the Snohomish River serves the lagoon (North) plant train, which treats excess flows that exceed the capacity of the “mechanical” (South) plant train. A small portion of the treated water can be reused as cooling water at the Kimberly Clark mill.

### 1.2.3 Proposed Solids Handling Improvements

Since 2007, there has been an increase in organic loading to the Everett WPCF, which requires adding treatment capacity to remain in compliance with the City’s National Pollutant Discharge Elimination System (NPDES) permit. In April 2010, the City completed an extensive planning process for future expansion of the WPCF to accommodate expected growth through the year 2030. The 2010 Engineering Report recommended a number of upgrades to the WPCF including separate anaerobic digestion of all solids generated from the treatment process. The

anaerobic digestion process is currently under design with construction anticipated by 2016. A mechanical solids dewatering process was recommended for construction in 2030.

## 1.3 Biosolids Quantity Estimates

The 2010 Engineering Report presented biosolids quantity estimates through the year 2030. Two projections are made, with and without the City of Snohomish discharging wastewater to the City of Everett in the future. The estimated biosolids quantities are shown in Table 1. The projections are conservative and represent the upper range of expected future biosolids quantities.

**Table 1: Projected Average Biosolids Quantities With and Without City of Snohomish Contribution (2010 Engineering Report).**

| Without City of Snohomish | Dry Tons/Year |
|---|---|
| 2010 | 5,749 |
| 2020 | 7,063 |
| 2030 | 7,884 |
| **With City of Snohomish** | **Dry Tons/Year** |
| 2010 | 5,749 |
| 2020 | 7,665 |
| 2030 | 8,486 |

Dewatered biosolids are currently produced at the Everett WPCF on a batch basis (e.g. cyclic dredging and dewatering). A continuously-operating solids dewatering facility was recommended in the Engineering Report (Carollo Engineers, 2010), and was projected to be constructed in 2022. The timing of this construction will depend on actual growth in the City's wastewater flows and loads.

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# 2.0 Biosolids Management Trends and Drivers

## 2.1 General Overview

Biosolids have many characteristics that make them a valuable fertilizer: plant nutrients (nitrogen, phosphorus, and other micronutrients), carbon, and water. Table 2 presents the typical characteristics of biosolids. When used as an agricultural fertilizer, biosolids provide essential nutrients and improve soil tilth. Biosolids are typically less expensive than commercial fertilizers, with much of the biosolids in the US being provided at no cost to the end user. Biosolids nutrients release slowly, a desirable characteristic in many fertilizer applications. Biosolids and biosolids mixtures can enhance the water holding capacity of soil, which is particularly valuable in erosion control, landscaping, and disturbed land reclamation applications.

**Table 2: Typical Nutrient Concentrations in Biosolids**

| Element | Typical Range in Municipal Biosolids (%)[1] | Everett Biosolids (%)[1,2] |
|---|---|---|
| Nitrogen (N) | 1-7 | 2.8-3.7 |
| Phosphorus (P) | 0.5-4 | 1.1-1.6 |
| Potassium (K) | 0-1 | NA |
| Sulfur (S) | 0-1 | 0.6 |
| Iron (Fe) | 0-3 | 2.5 |
| Copper (Cu) | 0 – 0.15[3] | 0.05 |
| Zinc (Zn) | 0-0.28[3] | 0.07-0.18 |
| Water Content (%) | 5-99 | 60-70 |

1. Dry weight basis.
2. Data from 2008-2010.
3. Upper end of the range is the regulatory limit.

Many scientific studies have demonstrated the benefits of biosolids and biosolids mixtures in agriculture, forestry, reclamation, erosion control, landscaping, and other applications. Biosolids research has been ongoing at local universities for decades, producing valuable information to farmers and other biosolids users on proper application rates, effective application practices, and in proving the safety and utility of biosolids. The Northwest Biosolids Management Association (NBMA) has a large library of research on biosolids (http://nwbiosolids.org/library.htm).

Figure 1 and Figure 2 show the positive impact that biosolids has had in agricultural and forestry applications, respectively. The figures demonstrate that biosolids provides a visible growth response in agriculture and forestry.

**Figure 1: Photo Showing Crops Grown with Biosolids (left) and without Biosolids (right) (courtesy of King County, Washington)**

**Figure 2: Photo of Tree Showing Increase in Growth after Biosolids Application (courtesy of King County, Washington)**

The US Environmental Protection Agency (USEPA) and the Northeast Biosolids and Residual Association (NEBRA) have published reports that provide the most wide-ranging look at trends in biosolids management in the US (USEPA, 1999; NEBRA, 2007). Figure 3 shows the breakdown of biosolids use/disposal in the US in 2004. Land application and advanced treatment (Class A or similar processing) represent over half of the biosolids use in the US.

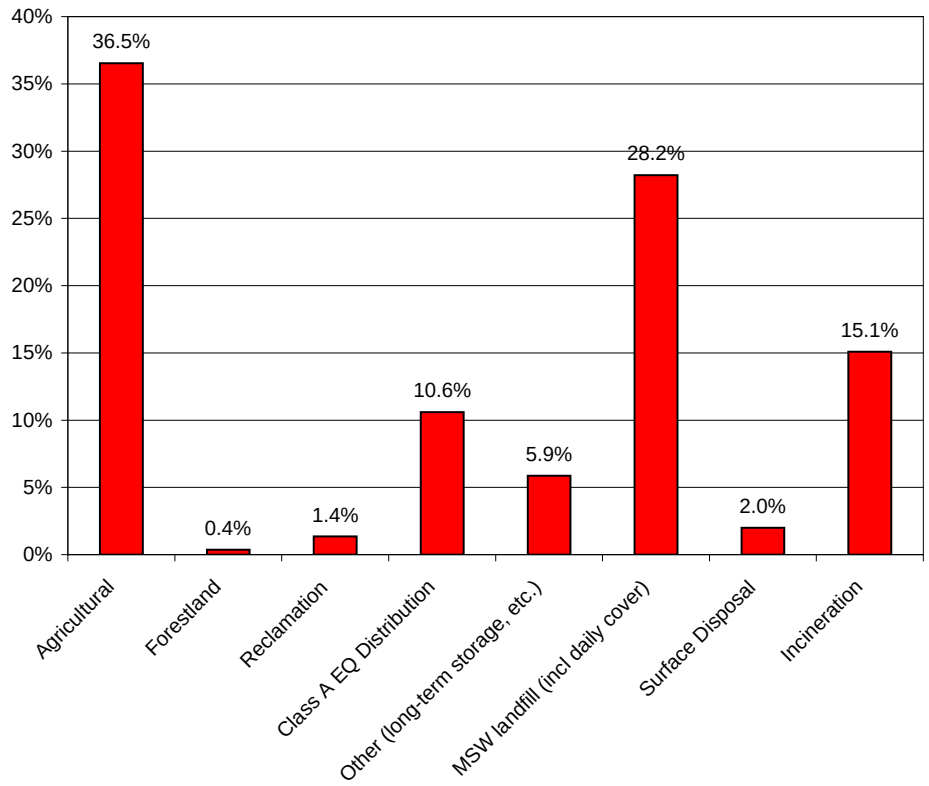


**Figure 3: North East Biosolids and Residuals Association Estimate of Biosolids Use/Disposal in the US in 2004 (NEBRA, 2007; EQ = Exceptional Quality, MSW = Municipal Solid Waste).**

In Washington, a number of utilities produce Class A biosolids including Everett (composting). Most biosolids in Washington are applied on agricultural land as Class B biosolids, as shown in Figure 4.

## 2.2 Washington State Regulations

Washington State regulates biosolids under Chapter 70.95J of the Revised Code of Washington (RCW). Washington does not have fully delegated authority from the EPA, but has the authority to issue separate state permits for biosolids management. Chapter 70.95J recognizes biosolids as a valuable commodity, and specifies implementation of a program that maximizes beneficial use. The state requirements are found in Chapter 173-308 of the Washington Administrative Code (WAC). The state program meets federal minimum requirements and has added requirements including, but not limited to, the following:

- Biosolids must not contain a significant amount of manufactured inerts (e.g. plastics, debris) [Typically, this requirement is met by screening the wastewater at the municipality's treatment plant]
- As mentioned previously, federal Class A alternatives 3 and 4 are not allowed under state regulations

- For all practical purposes, the state rule does not allow biosolids to be disposed of (e.g. landfill) on a long-term basis
- Biosolids generators and all entities managing biosolids must obtain a state permit and pay permit fees
- The state rule has certain exemptions for research

The City must submit an annual report to the Department of Ecology. The City's 2010 annual report is included in Appendix A.

## 2.3 Federal Regulations

The policy of the US Environmental Protection Agency (EPA) is to promote the beneficial use of biosolids while maintaining environmental quality and protecting public health (EPA, 2003). The Clean Water Act (CWA) Amendments of 1987 required the EPA to develop new regulations pertaining to sewage sludge/biosolids. In February of 1993, EPA published 40 CFR Part 503 (i.e., Part 503). The Part 503 Rule is a complex, risk-based assessment of potential environmental effects of pollutants that may be present in biosolids (USEPA, 1995). These guidelines regulate pollutant and pathogen concentrations as well as vector attraction reduction (VAR). The guideline defines biosolids as Class A or Class B, depending on the potential level of pathogens. Class A biosolids must meet strict pathogen standards and can be used with no restrictions, while Class B biosolids must meet less stringent pathogen requirements, with application restricted to crops with limited human and animal exposure. Biosolids in both classes must meet VAR requirements.

The Part 503 Rule applies to biosolids applied to agricultural and non-agricultural land, biosolids placed in or on surface disposal sites, or biosolids that are incinerated. Biosolids that are disposed of in a landfill or used as a cover material at a landfill are subject to federal requirements in 40 CFR Part 258. The general provisions of the Part 503 Rule provide basic requirements for biosolids applied to land including pollutant limits, management practices, operational standards, monitoring, record keeping, and reporting. This section will not discuss requirements for surface disposal, disposal in a landfill, or incineration. Washington State requires "beneficial use" of biosolids pursuant to the requirements of WAC 173-308, which is typically interpreted by the Department of Ecology as recycling. The City has moved forward with design of an anaerobic digestion system and will continue to produce biosolids suitable for recycling.

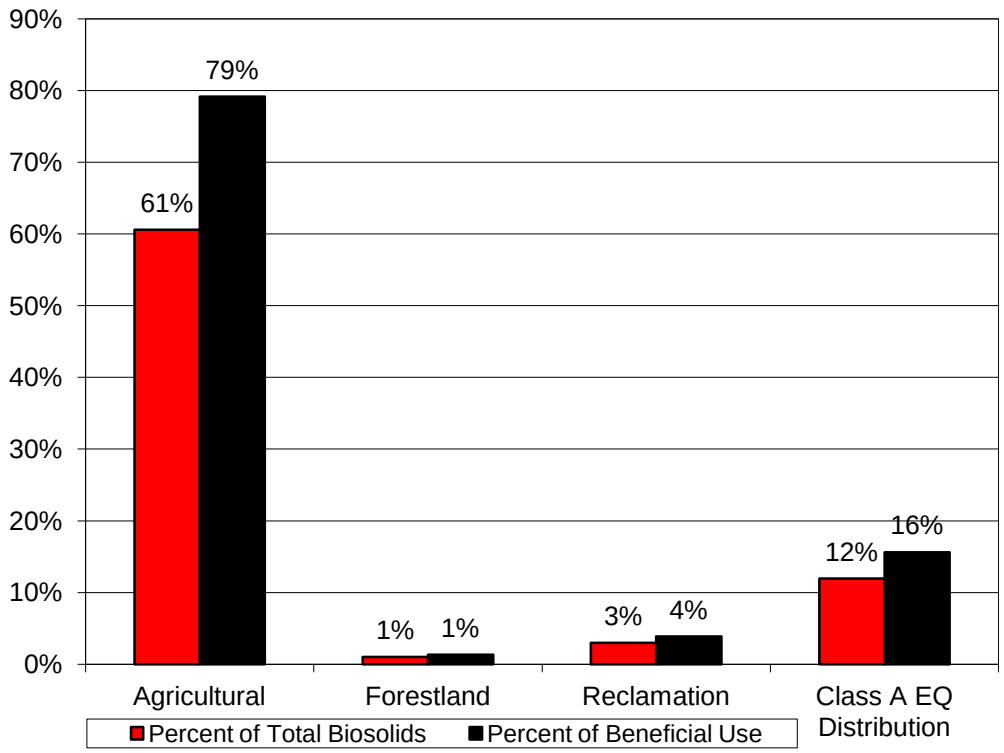


**Figure 4: NEBRA Estimate of Biosolids Use/Disposal in Washington in 2004 (NEBRA, 2007).**

### 2.3.1 Pollutants

Part 503 also requires that limits for certain pollutants, such as metals, not be exceeded. Two approaches to meeting the Part 503 metals limits are allowed: 1) a maximum concentration must be met, or 2) a maximum cumulative amount of metals added to the soil via biosolids must be met. Biosolids meeting the Part 503 requirements by maximum concentration levels are called pollutant concentration (PC) biosolids, and limits are shown in Table 3. If biosolids metals meet these concentrations, no record keeping of cumulative loading to soils is required. If PC biosolids also meet Class A pathogen reduction standards, they are considered exceptional quality (EQ), and may be distributed to the public. The City currently meets all maximum allowable concentration limits for PC biosolids. USEPA is considering lowering the limits of some of these pollutants and close scrutiny of the City's biosolids is strongly suggested so that the City will be prepared if regulatory changes occur.

Technologies to process biosolids generally do not decrease concentrations of metals in biosolids, unless other material is mixed with biosolids such as amendment material for composting.

An effective industrial pretreatment program is the key to complying with Part 503 metals limits, as industrial inputs into the collection system are usually the primary source of metals. EPA is currently considering adding 15 additional chemicals to the list of regulated pollutants. Those include acetone, anthracene, barium, beryllium, carbon disulfide, 4-chloroaniline, diazinon, fluoranthene, manganese, methyl ethyl ketone, nitrate, nitrite, phenol, pyrene, and silver. Given that the City of Everett is planning to anaerobically digest solids, it is not expected that any proposed nitrate or nitrite limits would be a concern.

**Table 3: Pollutant Concentration Biosolids Limits**

| Pollutant | Allowable Concentration (mg/kg monthly average)[1] | Everett 2009 Average Concentration (mg/kg) |
|---|---|---|
| Arsenic (As) | 41 | 11.3 |
| Cadmium (Cd) | 39 | 8.3 |
| Copper (Cu) | 1,500 | 526 |
| Lead (Pb) | 300 | 116 |
| Mercury (Hg) | 17 | 2 |
| Molybdenum (Mo) | 75 [2] | 31.9 |
| Nickel (Ni) | 420 | 47 |
| Selenium (Se) | 100 | 7 |
| Zinc (Zn) | 2,800 | 1,558 |

1. *Source: Table 3 of 40 Code of Federal Regulations (CFR) 503.13 Ceiling concentration.*
2. *Source: Table 1 of Washington Administrative Code (WAC) 173-308*

The EPA conducted an extensive sampling program of representative biosolids across the country in 2009. The City of Everett was one of the 74 municipal wastewater treatment plants surveyed in the study. The City's biosolids were sampled and analyzed for the compounds being considered for future regulation, providing a baseline for the City.

### 2.3.2 Pathogens

As described above, two classes of biosolids suitable for land application are defined by EPA, Class A and Class B. Class A biosolids are pathogen-free for all practical purposes and can be used without any additional public contact restrictions. Class B biosolids may have low levels of pathogens, and restrictions are imposed on public access and crop harvesting after land application, which are described in the following sections. It should be noted that the restrictions and limits for Class A and Class B biosolids provide equal public health protection.

#### 2.3.2.1 Class B

Class B biosolids are the predominant class of biosolids produced in the US (USEPA, 1999; NEBRA, 2007). Common treatment technologies, such as aerobic and anaerobic digestion, are used at many municipal wastewater treatment plants to inactivate the vast majority of potential pathogens in sludge. However, the sludge is not considered "pathogen-free," and EPA requires that specific management practices be employed to protect the public. Class B biosolids must also meet the same vector attraction reduction requirements as Class A biosolids.

Class B biosolids must meet one of several pathogen destruction alternatives including the following:

- Alternative 1: Meet monitoring requirements for fecal coliform.
- Alternative 2: Employ a process to significantly reduce pathogens (PSRP), or
- Alternative 3: Employ a process equivalent to a PSRP.

PSRPs include the following:

- Anaerobic digestion between 15 days at 35 $^{o}$C (95 $^{o}$F) to 60 days at 20 $^{o}$C (68 $^{o}$F).
- Aerobic digestion between 40 days at 20 $^{o}$C (68 $^{o}$F) to 60 days at 15 $^{o}$C (59 $^{o}$F).

- Air drying for at least 3 months.
- Composting – temperature of the sludge must be 40 $^{o}$C (104 $^{o}$F) or higher for at least five days. For four hours of that period, the temperature must be 55 $^{o}$C (131 $^{o}$F) or higher.
- Lime stabilization – the pH of the sludge must be raised to 12 for at least two hours, and must remain above 11.5 for 24 hours.

Alternative 3 for Class B biosolids requires approval of the USEPA or state regulatory agency. The regulating authority makes the decision on whether or not a process should be considered as equivalent to a PSRP. Both equivalent processes and PSRPs must meet specified pathogen requirements as well.

Biosolids treatment must include a method for reducing the attraction of vectors. Alternatives depend on the method of treatment and include 38 percent volatile solids (VS) destruction, a specific oxygen uptake rate of less than 1.5 mg oxygen per hour per gram total solids and other methods. Anaerobic digestion typically complies with the 38 percent VS destruction criteria.

Management practices are required to limit public and animal contact after Class B biosolids are applied and to allow natural processes to further inactivate potential pathogens. The management practices for Class B biosolids are in addition to the general management requirements specified in Subpart A of the Part 503 regulations, and are summarized in Table 4.

**Table 4: Site Restrictions for Class B Biosolids Application**

| Land/Crop | Regulation |
|---|---|
| Land with a high potential for public exposure | Public access restricted for 1 year after biosolids application |
| Land with a low potential for public exposure | Public access restricted for 30 days after biosolids application |
| Food crops, feed crops or fiber crops | Not harvested for 30 days after biosolids application; in practice, 90 days is preferred if biosolids are incorporated due to cropping cycles. |
| Food crops with harvested parts that touch the biosolids/soil mixture and are totally above the land surface (e.g., melons, cucumbers) | Not harvested for 14 months after biosolids application |
| Food crops with harvested parts below the land surface (e.g., root crops such as potatoes, carrots, radishes) | Not harvested for 20 months after biosolids application |
| Animal grazing on a site | Restricted for 30 days after biosolids application |
| Turf placed on land with high potential for public exposure or a lawn unless otherwise specified by the permitting authority | Restricted for 1 year after biosolids application |

#### 2.3.2.2 Class A

Producing Class A biosolids may provide significant cost savings and flexibility for biosolids management depending on the treatment process and the quality of the final product. In some cases, Class A biosolids can generate revenue. However, Class A solids treatment technologies generally require increased capital and operations and maintenance (O&M) costs for processing. As discussed previously, the land application of Class B biosolids is subject to a variety of restrictions not required of Class A biosolids.

Class A pathogen reduction requirements include fecal coliforms of less than 1000 MPN/gram Total Solids (TS) or Salmonella of less than 3 MPN per 4 grams TS. The Most Probable Number (MPN) method is commonly used in microbiology. Alternatives for meeting Class A pathogen requirements are shown in Table 5**.** Pasteurization systems meet both Class A Alternative 1 and Alternative 5 (PFRP) of the Part 503 regulations.

Thermal treatment means that specific time-temperature requirements must be met as specified by the Part 503 regulations. Figure 5 shows the time-temperature curve for sludge with a solids concentration less than seven percent and a contact time of at least 30 minutes (Regime D). Several regimes are specified in the regulations, but Regime D is most applicable to Everett's treatment process. Other time-temperature curves apply at different solids concentration and contact time regimes. All biosolids particles processed using this alternative must be subjected to the USEPA specified time-temperature regime, which means that batch or plug-flow processing must be employed – continuous flow processes with a detention time on or above the time-temperature curve are not acceptable.

A high pH-high temperature process is defined as the three following conditions: elevating the pH to more than 12 for at least 72 hours, maintaining the temperature of the sludge above 52°C for at least 12 hours while the pH is above 12, and air drying to over 50 percent solids after the 72-hour period of elevated pH.

**Table 5: Alternatives for Meeting Part 503 Class A Requirements**

| Alternative | Description |
|---|---|
| Alternative 1 | Thermally treated (must meet specific time-temperature requirements depending on solids concentration) |
| Alternative 2 | High pH-high temperature (lime stabilization followed by air drying) |
| Alternative 3[1] | "Other Processes" – sampling required |
| Alternative 4[1] | "Unknown Processes" – sampling required |
| Alternative 5 | Use of a Process to Further Reduce Pathogens (PFRP) |
| Alternative 6 | Process equivalent to PFRP (requires approval of EPA's Pathogen Equivalency Committee) |

1. Alternative is not allowed under Washington state regulations.

Figure 6 shows a breakdown of how wastewater utilities are producing Class A biosolids in the US. By far, the most common method is to employ an EPA-prescribed technology (Alternative 5, Processes to Further Reduce Pathogens, or PFRPs). Alternatives 1 and 2 are the next most common methods for meeting Class A requirements.

Other processes can meet Class A criteria through Alternative 3. Biosolids must have enteric virus levels less than 1 Plaque-Forming Unit (PFU) per 4 g TS and viable helminth ova levels less than 1 per 4 g TS.

Treatment processes that do not meet the requirements of the three previously described methods ("unknown processes," Alternative 4) can be considered Class A biosolids if they meet the pathogen requirements already mentioned. Since this alternative relies on testing rather than an established process, the regulations stipulate that frequent sampling must be undertaken, but do not specify the number of samples to be taken.

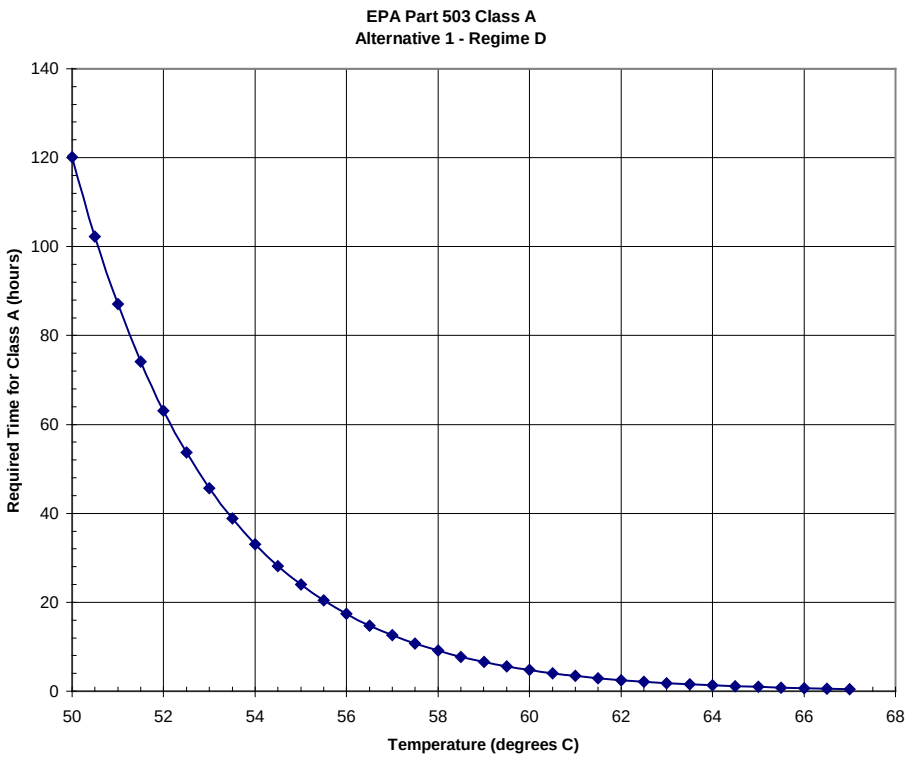


**Figure 5: Class A Alternative 1, Regime D**
**(solids concentration less than 7 percent, at least 30 minutes contact time)**

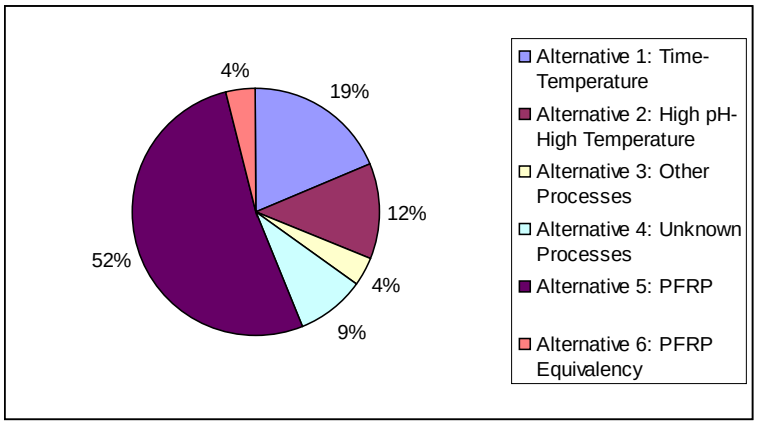


**Figure 6: USEPA Estimate of the Production of Class A Biosolids in the US (USEPA, 1999)**

Processing under Class A alternatives 3 and 4 rely on enteric virus and helminth ova testing, which can be expensive and time-consuming (4 weeks for helminth ova, and 2 weeks or longer for enteric viruses). There are also a limited number of accredited laboratories capable of

performing these analyses. Washington has eliminated Alternatives 3 and 4 under state regulations.

PFRPs include composting, heat drying, heat treatment, thermophilic aerobic digestion (also known as autothermal thermophilic aerobic digestion or ATAD), beta ray irradiation, gamma ray irradiation, and pasteurization. Detailed descriptions of the requirements for these processes can be found in USEPA (2003).

New processes not specified by the USEPA can be considered equivalent to a PFRP. The permitting authority is responsible for determining if a process is equivalent, and this is generally the Pathogen Equivalency Committee (PEC) of the USEPA.

### 2.3.3 Vector Attraction Reduction

Vector attraction reduction (VAR) requirements minimize the likelihood of environmental transport by vectors. These requirements are the same for Class A and Class B biosolids. Alternatives depend on the method of treatment and include 38 percent volatile solids (VS) destruction, a specific oxygen uptake rate of less than 1.5 mg oxygen per hour per gram TS, and other more complex methods. In general, pathogen reduction must be achieved prior to or at the same time as vector attraction reduction for biosolids to be considered Class A. Problems with pathogen re-growth led EPA to include this provision. This means that pasteurization must be upstream of digestion to meet the regulatory requirements.

### 2.3.4 Management Practices

A number of management practices are required by the Part 503 regulations and apply to bulk application of both Class A and Class B biosolids.

#### 2.3.4.1 General

General management practices required for land application include providing buffer zones around wells, surface water, and property boundaries; not causing any adverse impact to threatened or endangered species; and not applying biosolids to flooded, frozen, or snow-covered land.

#### 2.3.4.2 Agronomic Application Rate

Biosolids must be applied at an agronomic rate, and nitrogen is most commonly used to determine the agronomic rate for biosolids application.

As defined in 40 CFR 503: “Agronomic rate is the…application rate (dry weight basis) designed: To provide the amount of nitrogen needed by the food crop, feed crop, fiber crop, cover crop, or vegetation grown on land; and to minimize the amount of nitrogen that passes between the root zone of the crop or vegetation grown on the land to the groundwater.”

Excess nitrogen applied to land could result in nitrate contamination of groundwater. The agronomic rate must be determined by considering total and available nitrogen in the biosolids and the expected yield of the crop or vegetation.

In some states the application rate of nitrogen “shall not exceed the agronomic rate for the particular cultivar grown,” with agronomic rate defined as “a rate of biosolids or domestic septage which matches *nutrient* requirements for a specific crop on an annual basis.” Rates also must be applied so that runoff, erosion, leaching, nuisance conditions, or groundwater contamination are prevented.

Changing policy in the preparation of NPDES permits has resulted in inclusion of conditions that specify agronomic rates of phosphorus. USEPA may follow what many states have adopted - a

Phosphorus Index to manage phosphorus loading on land application sites. The Phosphorus Index is a risk management-based approach that takes into account transport and source factors to estimate the potential for off-site movement of phosphorus from a given site. The Natural Resources Conservation Services (NRCS) developed Phosphorus Indices for states (*NRCS Agronomy Technical Note No. 26 – Revised, October 2001*). This guidance document was developed as an assessment tool to help land managers assess the risk of offsite phosphorus migration for an individual site, but was not designed to determine compliance with water quality regulations.

The Phosphorus Index includes worksheets for agricultural land application sites to generate a site rating based on transport and source factors, and use the site rating to assign a vulnerability class (low, medium, high, very high) indicating the potential for offsite transport. This process uses the transport and source factors shown in Table 6.

**Table 6: Phosphorus Index Transport and Source Factors**

| Transport Factors | Source Factors |
|---|---|
| Soil erosion (sheet and rill, wind) | Soil test phosphorus (P) concentration |
| Irrigation-induced erosion | Commercial P fertilizer application rate |
| Runoff class | Commercial P fertilizer application method |
| Flooding frequency | Organic P source application rate |
| Distance to surface waters/buffer width | Organic P source application method |
| Subsurface drainage | |

Additional research is being conducted regarding the use of phosphorus indices. Agronomic phosphorus loading limitations have the potential to increase land requirements two to three times beyond that required based on agronomic nitrogen loadings. In general, the agronomic phosphorus loading rates would place more severe restrictions on wastewater treatment plants (WWTPs) that employ phosphorus removal, whereby significant amounts of phosphorus leave the plant site as stored phosphorus in biosolids, or land apply biosolids in phosphorus-limited watersheds. This could impact WWTPs, since phosphorus may be a critical issue in the future for certain watersheds throughout the US and in Washington where biosolids are currently applied. Washington State does not currently require that a Phosphorus Index be used.

In practice, tracking crop yields on almost all commodities require additional monitoring of nitrogen, phosphorus, potassium, and salts when applying biosolids.

### 2.3.5 Monitoring

Microbiological monitoring for either fecal coliforms or Salmonella sp. is required for all Class A biosolids alternatives and all Class B biosolids except Class B Alternative 2. Monitoring must be at the time of biosolids use, at the time the biosolids are prepared for sale or give away in a bag or other container for land application, or at the time the biosolids or material derived from the biosolids (e.g. compost) is prepared.

Monitoring requirements vary by the size of the wastewater utility and the method of sludge processing as shown in Table 7. Since Everett only produces biosolids on a periodic basis, the City monitors biosolids by taking samples throughout the lagoons twice per year. In addition, the Waste Secondary Sludge (WSS) is sampled on a quarterly basis.

**Table 7: Frequency of Monitoring Required by Part 503 Regulations**

| Amount of Biosolids Per 365-Day Period | | Minimum Frequency |
|---|---|---|
| Dry Metric Tons | Dry English Tons | |
| 0-290 | 0-320 | Once per year |
| 290-1,500 | 320-1,654 | Once per quarter (four times per year) |
| 1,500-15,000 | 1,654-16,540 | Once per 60 days (six times per year) |
| 15,000 or greater | 16,540 or greater | Once per month (12 times per year) |

*Reprint of Table 3-4 from USEPA, 2003*

## 2.4 Other Regulatory Issues

The National Academies of Science (NAS) completed an assessment of the science that supports the Part 503 Rule, and concluded that there is no evidence that current biosolids management practices under existing regulations are not safe, but that more research is required to update the science behind the regulations (National Research Council, 2002). NAS concerns included the synergistic effects of chemical pollutants and pathogens, and pathogens and chemical pollutants not considered in the risk assessment of the Part 503 Rule. As a result of NAS recommendations, USEPA may begin a review of the Part 503 Rule every five years, as is done for other USEPA-promulgated rules. USEPA is currently reviewing the Part 503 regulations and is expected to issue an updated version in the near future.

### 2.4.1 Pathogen Re-growth and Reactivation

Recent Water Environment Research Foundation (WERF) research has shown that fecal coliform, the indicator organism commonly used for pathogens, sometimes reactivates and/or re-grows after mechanical dewatering of solids. This has occurred with a variety of anaerobic digestion processes, both Class B and Class A. Research is ongoing to further understand the mechanisms and causes of this phenomenon. Research to date has shown that high solids centrifuges have the most potential to reactivate or re-grow fecal coliform. The City's contractors typically use high-solids centrifuges to dewater biosolids removed from the lagoon.

### 2.4.2 Trace Organic Compounds

Pharmaceuticals, personal care products, their intermediates, and other organic compounds have been found at very low levels in the environment, including in biosolids. Risks from current biosolids management practices are not completely known, but to date no increased risk from current biosolids management practices has been demonstrated. A recent Water Environment Research Foundation report (WERF, 2010) addresses the status of the science, risks, and public perception surrounding this complex issue.

## 2.5 Local Drivers

Increasing urbanization and development of agricultural land are making it increasingly difficult to find and permit sites for land application of biosolids. Although land application is still a relatively economical method, the availability of suitable local agricultural land is decreasing. Also, use of biosolids products have come under increasing regulatory restrictions in recent years and what once was considered best practice may not now be allowed.

Development around the Everett WPCF is causing increased scrutiny and the potential for increased odor complaints from activities at the WPCF. However, capital improvements over the past few years have reduced odors from the facility and complaints from neighbors. There have been no odor complaints directly attributed to the WPCF in the last two years.

## 2.6 Public Perception

Political divisions and conflicts have emerged over the management of biosolids around the US, particularly in California, Virginia, and Pennsylvania, but most recently in Washington State. Local ordinances have been passed banning either Class B or all biosolids land application. Growing and more organized opposition to current biosolids management practices are forcing some utilities to apply biosolids in more remote areas or further process solids in order to manage biosolids in alternative ways. In contrast, the City of Everett has an excellent biosolids management program. The City of Everett has a public education program including a brochure and a website, but increased stakeholder involvement and a larger campaign would be beneficial.

## 2.7 Biosolids Management Program Review

### 2.7.1 Overview

Historically, most of the dewatered biosolids have been hauled and applied to farmland in Snohomish and Douglas counties. The City currently maintains permits for some sites in Snohomish County and is permitted to send biosolids to private land application facilities, called Beneficial Use Facilities (BUFs), in Douglas, Snohomish, and Yakima counties.

A small portion of Everett's biosolids are composted for use in local areas including the Snohomish County PUD Right-of-Way land reclamation project and landscaped areas at the WPCF.

Historically, the City has used biosolids to fertilize local forest land and in land reclamation projects. In addition, the City has applied biosolids to a City-owned poplar farm adjacent to the WPCF.

### 2.7.2 Regulatory Compliance

The City meets the most stringent criteria for regulated pollutants (discussed in Section 2.3.1). Vector attraction reduction (discussed in Section 2.3.3) criteria is met by bench-scale testing to simulate anaerobic digestion as no anaerobic digesters are currently at the plant.

The majority of the City's biosolids meet Class B pathogen standards (discussed in Section 2.3.2.1), and the remainder meet Class A pathogen standards through composting. Class A biosolids are produced to provide additional management options to Class B reuse in agriculture and silviculture.

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# 3.0 Strategic Planning

A stakeholder committee was formed to assist Everett with the strategic planning process for biosolids management. The City solicited participation from neighborhood groups, local wildlife and environmental associations, local industries, the local agricultural community, biosolids regulators, and sewer purveyors for participation in the strategic planning process. A member of the Everett WPCF staff was also on the committee.

On November 5, 2010, an introductory workshop was held to educate the stakeholder committee on biosolids management. Topics included general wastewater treatment, Everett's wastewater and biosolids management operations, biosolids regulations, and trends.

A strategic planning workshop was held on January 13, 2011 at the Everett Water Pollution Control Facility (WPCF). In attendance were members of the stakeholder committee, the consultant team, and City staff.

A workshop to discuss the market analysis and biosolids products evaluation was also held on July 1, 2011.

## 3.1 Biosolids Management Program Vision and Mission

In the January 13, 2011, workshop, a collaborative discussion on the current program responsibilities was undertaken. Brainstorming on the goals, vision, and mission of the biosolids management program going forward resulted in many constructive ideas from workshop participants. After the workshop, the consultant team drafted vision and mission statements for the biosolids management program, incorporating ideas that were discussed in the workshop. The vision and mission statements were finalized as follows:

Vision: To provide environmentally responsible stewardship of the City's biosolids in a cost-effective manner, providing open communication with all stakeholders, innovative thinking, and seeking strategic partnerships with other organizations to facilitate a sustainable program.

Mission: The Everett Biosolids Management Program cost-effectively manages the City's biosolids, protects public health and the environment, is supportive of the local community, and seeks the public's trust by providing education and open communication.

The vision and mission statements will guide the program and form the basis of the evaluation of biosolids product alternatives as the strategic planning process moves forward.

## 3.2 Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

A strengths, weaknesses, opportunities, and threats (SWOT) analysis was undertaken after discussing the vision and mission of the program. A SWOT analysis is a common strategic planning tool to identify positive and negative attributes and capabilities of an organization as well as external factors that could positively or negatively affect the organization. The elements identified in the workshop are shown in Table 8. There was general agreement amongst the workshop participants that the current biosolids management program is successful and has many strengths.

**Table 8: SWOT Analysis Summary**

| | Positive | Negative |
|---|---|---|
| Internal | Strengths:<br>• Cost-effective<br>• Well managed<br>• Regulatory compliant<br>• Diversified<br>• Responsive to public<br>• Flexibility in operations<br>• Proactive, solution-oriented<br>• Environmentally responsible<br>• Protective of public health<br>• Good morale<br>• Professional staff<br>• Ownership of program<br>• Greenhouse gas mitigation potential<br>• Good reputation<br>• Close proximity to end uses<br>• Existing infrastructure conducive to expansion<br>• Neutral to good community relations | Weaknesses:<br>• WPCF is space constrained<br>• Funding is limited<br>• Non-continuous biosolids production<br>• WPCF is close to neighbors<br>• All biosolids management operations are contracted out<br>• Scheduling/logistics constraints<br>• Staffing limited<br>• Limited control of product quality<br>• Limited storage<br>• Contracting constraints<br>• Greenhouse gas generation |
| External | Opportunities:<br>• Increasing uses/markets<br>• Many potential partners<br>• Local farming community<br>• Co-management of other residuals<br>• Regionalization/economy of scale<br>• Local use<br>• Improving the environment<br>• Creating alternative soil amendment<br>• Public education<br>• Potential optimization of WPCF operations<br>• General environmental ethic in community | Threats:<br>• Public perception<br>• Product not well known<br>• Dependent on weather/seasonal uses<br>• Limited field storage<br>• Regulatory constraints and potential future changes<br>• Mismanagement by other entities or end users<br>• Greenhouse gas regulations<br>• Illegal discharges/contamination at WPCF |

Weaknesses identified were generally related to the Water Pollution Control Facility's (WPCF) treatment processes, its size and space, and other factors common to municipal agencies such as budget constraints. Opportunities discussed were generally focused on partnerships with other entities, along with possible changes to WPCF processes. Threats included possible negative public perception and constraints such as lack of field storage.

## 3.3 Conclusion

In conclusion, the workshops provided a collaborative environment for discussion of the City of Everett's biosolids management program strategy. Vision and mission statements were developed to guide the biosolids management program in the future.

# 4.0 Market Analysis

This section presents the findings of the market analysis. Markets for four biosolids products were evaluated:

1. Class B dewatered biosolids
2. Class A lime stabilized biosolids
3. Class A compost
4. Class A thermally dried pellets

These four products cover the spectrum of proven biosolids products in use in Western Washington and across the US. Two the products evaluated are currently produced by the City.

Capital improvements would be necessary for lime stabilized biosolids, expansion of the City's composting process, and thermally dried pellets. These improvements will be discussed in the next section.

Markets were selected for evaluation based on their current use by the City and their proven use by other municipalities. Statistics from reliable sources, such as Washington State University Extension Service, and personal correspondence with key individuals and firms were used to perform the analysis.

## 4.1 Class B Dewatered Biosolids

Several markets were evaluated for Class B dewatered biosolids including agriculture, forestry, and reclamation.

### 4.1.1 Agriculture

Historically, most of the City's Class B dewatered biosolids have been hauled and applied to farmland in Snohomish and Douglas counties. The City currently maintains permits for some sites in Snohomish County and is permitted to send biosolids to private land application facilities, called Beneficial Use Facilities (BUFs), in Douglas, Yakima, and Snohomish counties.

An analysis of statistics provided by the US Department of Agriculture (USDA) is presented in Table 9. The market data shown in Table 9 overstates the actual total agricultural biosolids market due to the following factors:

- Total acreage for crops do not account for setbacks from roads, wells, surface water, property lines; excessive slopes; high groundwater; or other conditions that would limit Class B biosolids application.
- Crop and soil restrictions, such as USDA organic farming, wet weather, harvesting restrictions, and soil nutrient concentrations, may not allow all acreage to be fertilized with Class B biosolids.
- Other biosolids producing agencies are using some of the areas under consideration for land application, in particular Douglas County. King County alone land applied biosolids to approximately 5,200 acres in Douglas County (King County, 2009).
- Some property owners may not be willing to go through the permitting process to apply biosolids onto their land.

**Table 9: Summary of Agricultural Market for Everett Class B Dewatered Biosolids**

| County/Crop | Total Acres | Potential Everett Biosolids Market (dry tons/year)[1] | Percentage of Total Acres, All Everett Biosolids[2] |
|---|---|---|---|
| *Snohomish County* | | | |
| Corn | 5,200 | 78,000 | 11% |
| Hay | 6,500 | 33,400 | 25% |
| Wheat | 1,700 | 10,900 | 78% |
| *Skagit County* | | | |
| Corn | 4,500 | 67,500 | 13% |
| Hay | 8,500 | 43,700 | 19% |
| Wheat | 4,500 | 22,900 | 37% |
| *Douglas County* | | | |
| Hay | 4,500 | 23,140 | 37% |
| Wheat | 167,900 | 1,099,300 | 0.8% |

1. Assumes an application rate of 15, 5.1, and 6.4 dry tons/acre for corn, hay, and wheat, respectively.
2. Assumes projected year 2030 annual average biosolids production of 8,486 dry tons per year (with Snohomish).

Discussions were also held with local and regional farmers about the agricultural market for Class B biosolids. The farmers indicate that there is strong demand for this product, especially in Douglas County (Ruud, 2011). Based on these discussions and the results shown in Table 9, there is a significant market in the local and regional agricultural sector for the City's Class B biosolids.

### 4.1.2 Forestry

Approximately 900,000 acres of Snohomish County is considered forested, representing approximately 68 percent of the total County area (Snohomish County, 2011). Most of the acreage is in the eastern portion of the County. The largest local forest products company in the area has indicated that they do not own any of the forested land in the County or in nearby Counties. Land ownership, outside of public agencies, could not be determined without a details analysis of individual parcels. Identification of individual parcels of forested land for biosolids application is beyond the scope of this study and such data is not typically available for public or commercial use. If other Class B biosolids cake markets are not sufficient in the future, it is recommended that a more detailed study of forested land be undertaken.

Typical limitations to forest application include:

- Limited access roads
- Steep slopes and difficult terrain
- Mature trees block access and limit application capabilities
- Limited availability and cost of specialized equipment

Therefore, it is recommended that other markets be used for Class B dewatered biosolids before considering forest markets in more detail.

### 4.1.3 Reclamation

Snohomish County Public Utility District (PUD) No. 1 is involved in right-of-way disturbance reclamation projects. The City has given on average 350 cubic yards (cy) per year to the County PUD for these purposes and intends to continue providing biosolids over the next few years.

Other local reclamation projects may be available but no specific projects were identified at this time.

### 4.1.4 Summary

Currently there is a strong demand for Class B dewatered biosolids in the local agricultural market as described in Section 4.1.1. There is expected to be continued demand for Class B dewatered biosolids in local reclamation markets.

## 4.2 Lime-Stabilized Biosolids

The market for Class A lime-stabilized biosolids is similar to the market for Class B dewatered biosolids, but there are several advantages over Class B dewatered biosolids. Primary markets include agriculture, reclamation, and forestry. Some City departments, such as forestry, parks, and streets, could potentially use the product. However, lime stabilized biosolids are generally not as desirable as compost for these applications due to the increased potential for odor and less desirable aesthetic properties.

### 4.2.1 Agriculture

Lime is used by some farmers in Western Washington due to the benefit of raising the pH in the areas relatively low pH soils to better grow some crops. It is used less frequently by farmers east of the Cascades due to relatively neutral soil pH levels there. Additional benefits to meeting Class A requirements include fewer requirements for record-keeping, certifications, and obtaining binding written agreements from land owners; and potentially less restrictions on public access, site management, harvest restrictions, and requirements for land application plans depending on specific application sites.

Table 10 summarizes the potential agricultural market for lime stabilized biosolids in the three counties evaluated. The potential market in Skagit County for Class A lime stabilized biosolids is significantly more than for Class B dewatered biosolids due to the additional crops that could benefit from the product, in particular potatoes. Washington State University's Skagit County Extension Service indicates that Skagit farmers growing potatoes and other vegetables use a significant amount of lime and would likely be very interested in Class A lime stabilized biosolids (McMoran, 2011). It is likely, however, that a significant portion of the food crop acreage shown in Table 10 is used for organically-grown crops, which would significantly reduce the market as biosolids are specifically not allowed on organic farms.

**Table 10: Summary of Agricultural Market for Class A Lime Stabilized Biosolids**

| County/Crop | Total Acres | Potential Everett Biosolids Market (dry tons/year)[1] | Percentage of Total Acres, All Everett Biosolids[2] |
|---|---|---|---|
| *Snohomish County* | | | |
| Corn | 5,200 | 41,600 | 27.5% |
| Hay | 6,500 | 33,400 | 34.3% |
| Wheat | 1,700 | 10,900 | 105% |
| *Skagit County* | | | |
| Blueberries | 1,200 | 3,100 | 371% |
| Bulbs | 1,100 | 8,800 | 130% |
| Carrots | 300 | 2,600 | 446% |
| Corn | 4,500 | 36,000 | 31.8% |
| Grass Seed | 700 | 3,600 | 318% |
| Hay | 27,000 | 138,900 | 8.3% |
| Potatoes | 11,500 | 59,100 | 19.4% |
| Raspberries | 1,300 | 5,600 | 206% |
| Strawberries | 500 | 1,700 | 668% |
| Vegetable Seed | 2,500 | 6,433 | 89.0% |
| Wheat | 5,500 | 34,700 | 33.0% |
| *Douglas County* | | | |
| Hay | 4,500 | 23,140 | 49.5% |
| Wheat | 167,900 | 1,099,300 | 1.0% |

1. Assumes an application rate of 5.1, 8, and 6.4 dry tons/acre for hay, corn, and wheat, respectively. Application rates for Skagit County crops other than hay, corn, and wheat, were determined based on WSU (2010) and McMoran (2011) and limited to 8 dry tons/acre based on local experience (Bartelheimer, 2011).
2. Assumes projected year 2030 annual average biosolids production of 8,486 dry tons per year (with Snohomish). It should be noted that the total production of lime stabilized biosolids is estimated to be 11,500 dry tons/year due to the increase in solids from lime addition.

A local soil consultant estimated the market value of the nitrogen, phosphorus, potassium, and lime in a Class A lime-stabilized product at approximately $23 per wet ton of biosolids, or approximately $90 per dry ton at 25 percent solids concentration. However, to date there are no local agencies that have been able to sell lime stabilized biosolids for that price.

In summary, the market for lime-stabilized biosolids is slightly better than the market for Class B biosolids in western Washington and the product could potentially generate more revenue than Class B biosolids. It should be noted, however, that the lime stabilization process creates more biosolids to be managed.

### 4.2.2 Forestry

The forestry market for Class A lime stabilized biosolids is similar to Class B dewatered biosolids.

### 4.2.3 Reclamation

Reclamation opportunities for Class A lime stabilized biosolids may be slightly better than Class B dewatered biosolids due to their high pH. Many sites needing reclamation have low pH soils from previous industrial activities.

### 4.2.4 Summary

There would likely be a strong demand for Class A lime stabilized biosolids in the local agricultural market. There is also expected to be demand for Class A lime stabilized biosolids in local reclamation markets, especially if reclaiming low pH soils.

## 4.3 Composted Biosolids

The City currently produces approximately 200 to 500 cubic yards of compost every year from biosolids that are dredged from the lagoons, dewatered, and stored. Biosolids are composted using covered aerated static piles. Amendment from other City uses including wood waste, turf thatch, grass clippings, and animal bedding is mixed with biosolids in varying ratios depending on the moisture content and desired porosity, which is determined at the time of pile creation.

Local and regional markets for compost are extensive and there are several large local compost producers near Everett. It is difficult to assess the true market for the City's biosolids without considering pricing structures due to the level of competition from local for-profit compost producers. This market analysis focuses on City and other local uses assuming that the City's biosolids compost would be provided at low or no cost to customers.

### 4.3.1 City Uses

Various City departments use compost in a variety of applications. Extensive discussions were held to determine the quantity and quality of compost desired. Table 11 summarizes the City's compost uses by department. Mulch and similar products are not listed as biosolids compost serves a different purpose than mulch. The City uses various mulch and compost products, and each use has a specific product quality need.

Discussions with some City Departments revealed that biosolids compost has been used in the past. Some individuals have found its characteristics to be not suitable for their application (e.g. too clumpy, too much compaction), with the City's horticultural uses requiring the most strict product quality. Careful consideration of the requirements of each specific application are required if the City's biosolids are to be marketed to the departments listed in Table 11. As shown in the table, there is a limited market for biosolids compost for City uses.

**Table 11: City Compost Demand Summary**

| City Department/Use | Total Market (cy/year) | Potential Everett Biosolids Market (dry tons/year)[1] | Percentage of Total Acres, All Everett Biosolids[2] |
|---|---|---|---|
| City Parks | 10-40 | 2-7 | 0.1% |
| City Forestry | 50-100 | 8-17 | 0.2% |
| City Horticulture | 50 | 8 | 0.1% |
| City WPCF[3] | 0-100 | 0-17 | 0.2% |
| City Street Projects | 0-500 | 0-83 | 0-1.0% |

1. Assumes 3:1 amendment to biosolids ratio by volume and compost weight of 1,000 lbs/cubic yard.
2. Assumes projected year 2030 annual average biosolids production of 8,486 dry tons per year (with Snohomish).
3. Assumes 0.5 acres of landscaped area at WPCF, 3 inches of compost every other year.

### 4.3.2 Washington Department of Transportation Use

The Washington Department of Transportation (WSDOT) was contacted to discuss potential use of Everett's biosolids compost on state highway projects. There is a formal procedure for listing on WSDOT's Qualified Product List (QPL) for compost. The City would need to be certified by the US Composting Council's (USCC) Seal of Testing Assurance (STA) program. Then the City would submit a sample to WSDOT along with a QPL application.

Once on the QPL, Everett's biosolids compost would compete with other commercial compost products such as Cedar Grove and Pacific Topsoil. WSDOT's contractors select a compost product from the QPL list, and most likely base their decision on price, familiarity, product quality for the specific application, proximity to the product, and the ability of the compost producer to provide adequate quantities in a timely manner.

WSDOT indicated that near-term projects in the Everett vicinity will be limited due to budget constraints. It is difficult to quantify the future market for WSDOT projects given the lack of local projects and the competitive nature of the purchasing process. It is recommended that if the City continues to compost biosolids and could gain approval from the USCC STA program, it is worthwhile to pursue listing on the QPL.

### 4.3.3 Snohomish County Uses

Snohomish County Public Works is involved in rehabilitation projects that require compost. The County may have other uses for compost but they were not identified in this analysis. The County's Native Plant Steward Program reports that between 100 and 200 cubic yards of compost is used each year for nursery potting soil. The County's projects are typically in late fall and winter, which could provide a good opportunity for the City to donate or sell biosolids compost as this is typically a period of low demand.

As mentioned above, Everett's Class A compost and Class B dewatered biosolids continue to be used on right-of-way projects for the County PUD. The County PUD projects will continue for the next several years and Everett's composted biosolids will continue to be used.

### 4.3.4 General Public Use

Compost is an excellent product for landscaping and garden uses. For a successful composting program to market to the general public, an education and advertising campaign must be initiated to inform customers of the availability, proper use, and cost of the product. Branding the product also creates a sense of value and facilitates product marketing efforts. From previous experience at other local agencies, it may take weeks, months, or a season to develop

enough demand from the general public for the product. Most agencies that properly price the product, have sufficient storage during non-peak demand (winter), maintain adequate product quality standards, and price the product appropriately have adequate demand for all biosolids compost.

### 4.3.5 Local Landscaping Companies

Three local landscaping companies were contacted by phone to discuss the potential for use of Everett's biosolids compost. Two of the companies were unresponsive to several phone calls and the third company indicated that they primarily used mulch products for their business and did not use a significant amount of compost.

### 4.3.6 Local Composters and Fertilizer Brokers

Discussions were held by phone with two leading local composting firms. Neither firm indicated clear interest in a brokerage contract but one indicated some interest in providing a contract to accept the City's Class B biosolids and produce Class A compost for a fee.

Fertilizer brokers buy or produce fertilizers wholesale and sell or make custom fertilizer blends for specific markets. Discussions with the two leading regional fertilizer brokers indicated that they would not be interested in a contract with the City for biosolids compost at this time. The fertilizer market can change quickly, and in the future the City should continue to contact brokers for potential interest should the need arise.

### 4.3.7 Summary

Table 12 shows that City and County compost uses are relatively small compared to the City's projected biosolids production. However, demand is expected to be strong from the general public and potentially from local landscapers if the biosolids compost is incentivized by providing it at a low cost.

**Table 12: Summary of Composted Biosolids Market**

| Market | Total Market (cy/year) | Potential Everett Biosolids Market (dry tons/year)[1] | Percentage All Everett Biosolids[2] |
|---|---|---|---|
| City Uses | 110-790 | 18-132 | 0.2-1.6% |
| County Uses | 100-700 | 17-117 | 0.2-1.4% |
| General Public | Dependent on quality and price | Dependent on quality and price | Dependent on quality and price |
| Local Landscapers | Dependent on quality and price | Dependent on quality and price | Dependent on quality and price |
| Local Composters and Fertilizer Brokers | None at this time | None at this time | None at this time |

## 4.4 Thermally Dried Biosolids Pellets

A number of markets were identified and evaluated for Class A/EQ thermally dried pellets. High quality dried pellets are a very desirable fertilizer for certain types of agriculture, golf courses, and general turf applications.

### 4.4.1 Local Agriculture

Thermally dried pellets can be used in local agriculture as a Class A product. They can be applied using equipment similar to that used for synthetic pelletized fertilizers. Table 13 summarizes the local agricultural market for thermally-dried biosolids pellets. Douglas County was not included as farmers there have indicated that dewatered biosolids cake is preferred due to dryland farming practices and closer markets are available for this product. In Snohomish and Skagit Counties, biosolids pellets could be very attractive according a local farmer (Bartelheimer, 2011). It should be noted that the pellet quality is less important in the agricultural market than in other markets such as the golf course market. Therefore, a lower cost drying process could be used. Drying processes and costs will be discussed later in this report.

**Table 13: Agricultural Market for Thermally-Dried Biosolids Pellets**

| County/Crop | Total Acres | Potential Everett Biosolids Market (dry tons/year)[1] | Percentage of Total Acres, All Everett Biosolids[2] |
|---|---|---|---|
| *Snohomish County* | | | |
| Corn | 5,200 | 78,000 | 11% |
| Hay | 6,500 | 33,400 | 25.4% |
| Wheat | 1,700 | 10,900 | 105% |
| *Skagit County* | | | |
| Blueberries | 1,200 | 3,100 | 275% |
| Bulbs | 1,100 | 9,400 | 130% |
| Carrots | 300 | 2,600 | 330% |
| Corn | 4,500 | 67,500 | 12.6% |
| Grass Seed | 700 | 4,100 | 210% |
| Hay | 27,000 | 138,900 | 6.1% |
| Potatoes | 11,500 | 59,100 | 14.3% |
| Raspberries | 1,300 | 5,600 | 152% |
| Strawberries | 500 | 1,700 | 495% |
| Vegetable Seed | 2,500 | 6,400 | 132% |
| Wheat | 5,500 | 34,700 | 33.0% |

1. Assumes an application rate of 15, 5.1, and 6.4 dry tons/acre for corn, hay, and wheat, respectively. Assumes no nitrogen is lost during the drying process.
2. Assumes projected year 2030 annual average biosolids production of 8,486 dry tons per year (with Snohomish).

### 4.4.2 Local Golf Courses

There are two public golf courses in Everett: Walter Hall and Legion Memorial. The Everett Parks and Recreation Department maintains the grounds at these courses, and have indicated a potential interest in using dried biosolids pellets if there is a cost savings. Other private courses within approximately 20 miles of the City center were identified through internet searches and other publically available information sources. These courses, their size, and the estimated maximum biosolids market are shown in Table 14. Over 4,000 dry tons per year of dried biosolids could potentially be marketed to these local courses.

**Table 14: Estimated Local Golf Course Market for Dried Biosolids Pellets.**

| Name | No. Holes | Length (yards) | Area (acres)[1] | Biosolids Fertilizer Market (dry tons/yr)[2] |
|---|---|---|---|---|
| Walter Hall | 18 | 6,450 | 40 | 249 |
| Legion Memorial | 18 | 6,900 | 43 | 266 |
| Everett Golf and Country Club | 18 | 6,188 | 38 | 239 |
| Hat Island Golf Course | 9 | 2,470 | 15 | 95 |
| Mill Creek Country Club | 18 | 6,349 | 39 | 245 |
| Kenwanda | 18 | 5,336 | 33 | 206 |
| Harbour Pointe | 18 | 6,862 | 43 | 265 |
| Snohomish | 18 | 6,813 | 42 | 263 |
| The Golf Club at Echo Falls | 18 | 6,004 | 37 | 232 |
| Lynnwood Municipal | 18 | 4,741 | 29 | 183 |
| Wellington Hills | 9 | 2,735 | 17 | 105 |
| Inglewood | 18 | 6,722 | 42 | 259 |
| Ballinger Lake | 9 | 2,564 | 16 | 99 |
| Wayne Golf Course | 18 | 4,326 | 27 | 167 |
| Nile Shrine Golf Club | 18 | 5,000 | 31 | 193 |
| Flowing Lake | 18 | 4,265 | 26 | 165 |
| Island Greens | 9 | 1,358 | 8 | 52 |
| Battle Creek, Champion Course | 18 | 6,575 | 41 | 254 |
| Battle Creek, Par-3 Course | 9 | 1,113 | 7 | 43 |
| Cedarcrest | 18 | 5,811 | 36 | 224 |
| Bear Creek Country Club | 18 | 6,964 | 43 | 269 |
| Sum | | | 654 | 4,070 |

1. Assumes an average width of 30 yards.
2. Assumes an average annual application rate of 10 lbs nitrogen / 1,000 sf. Assumes 75% of the total area is fertilized. Assumes the average biosolids nitrogen content is 3.5% on a dry weight basis.

### 4.4.3 City Parks and Recreation Department

The City maintains several athletic fields and grass areas in parks throughout Everett. According to the Everett Parks and Recreation Department (PRD), approximately 1,200 pounds of commercial fertilizer is applied to these areas on an annual basis, excluding the two public golf courses discussed in the previous section.

The City PRD uses a 22:2:22 nitrogen-phosphorus-potassium ratio (N:P:K) slow release fertilizer for general grassy areas, which is higher in both nitrogen and potassium content compared to the City's biosolids. Assuming an average biosolids nitrogen concentration of 3.5 percent (dry weight basis), this would equate to approximately 7 dry tons of biosolids per year.

Athletic fields are fertilized with a 3:1:2 slow-release fertilizer and the PRD uses approximately 6 to 7 tons per year. Assuming an average biosolids nitrogen concentration of 3.5 percent (dry weight basis); this would equate to approximately 16 to 18 dry tons of biosolids per year.

### 4.4.4 General Public Use

Dried biosolids pellets are an excellent fertilizer for home lawns and gardens. As with compost, the City would need an advertising program to educate local residents and inform them of the costs and how to obtain the product. The City would need to decide on a pricing structure and when and where pellets could be either picked up or bought.

Given the limited access to the current biosolids area, it is recommended that a more accessible area at the WPCF or another location be used as the pick-up point for dried pellets. The site of a potential future biosolids drying facility will be determined later in this planning process. It is assumed that new access roads would be provided to this drying facility to allow customers to obtain biosolids pellets. Alternatively, pellets could be bagged at the drying facility and transported to another location for pick-up, either within the WPCF boundary or at another external location.

### 4.4.5 Fertilizer Brokers

Discussions with the two leading regional fertilizer brokers indicated that they would not be interested in a brokerage contract with the City at this time for biosolids dried pellets. The fertilizer market can change quickly, and in the future the City should continue to contact brokers for potential interest should the need arise.

### 4.4.6 Energy Use

Biosolids pellets can be used as a coal substitute in industrial applications. Dried biosolids have a typical thermal value of around 6,500-8,000 BTU/lb. The most viable market is cement kilns due to their high energy use and the potential for incorporating the combustion byproducts into concrete. There are several cement kilns in the Seattle area but none could be identified in the Everett area. Two large cement kilns in the Seattle area were contacted. Both facilities are located approximately 40 miles driving distance from the Everett WPCF. One of the facilities is no longer making cement, and the other has not responded to date.

A large local industry has indicated interest in purchasing dried pellets for fuel. The quantity of biosolids produced by the City would be small compared to the total energy needs of this industry.

There would be more potential revenue should a greenhouse gas cap-and-trade system be implemented in the US, with credits for alternative fuels such as dried biosolids.

### 4.4.7 Summary

There is a moderately strong local market for dried biosolids pellets as shown in Table 15. Dried pellets would need to be marketed to local golf courses and some may not want the product. There is also competition from other dried biosolids pellets regionally (SoundGRO) and nationally (Milorganite®) that will likely reduce the potential market for Everett. Biosolids pellets also compete with inorganic fertilizers with higher nitrogen content. It is expected that the general public would take the remainder not used by golf courses and the City PRD if provided at little or no cost.

A bill passed the Washington state legislation in 2011 that would ban application of fertilizer containing phosphorus to turf, which would impact dried biosolids pellet market. However, it was partially vetoed by the Governor. A nearly identical bill was recently introduced in the Washington state house. This bill reflects growing concern about phosphorus pollution from fertilizers, and an increased focus is expected from the regulatory community and other legislative efforts. It is unclear at this time what potential future regulatory and legislative

changes may take place, but the City should continue to monitor such changes as they could impact the market for dried biosolids pellets and potentially Class B biosolids cake.

**Table 15: Summary of Dried Biosolids Pellets Market**

| Market | Total Market (dry tons/year)[1] |
|---|---|
| Local Agriculture[2] | Up to 387,000 |
| City Uses | 23-25 |
| Golf Courses | 4,070 |
| General Public | Unknown |
| Local Landscapers | Minimal |
| Fertilizer Brokers | None at this time |
| Energy Use | 8,500+ |

- Assumes projected year 2030 annual average biosolids production of 8,486 dry tons per year (with Snohomish).
- For Snohomish and Skagit Counties.

## 4.5 Conclusions

This market analysis is a snapshot in time and future events may change the market outlook for potential biosolids products. Currently, there are strong markets for Class B biosolids cake and moderately strong markets for lime stabilized biosolids, composted biosolids, and dried biosolids pellets in the local area and region. The strongest market is in agriculture, which is market most used currently by the City. Dried pellets have a moderately strong market, but there is a risk that a large part of this market could be eliminated by recent legislation banning phosphorus fertilizer on turf. The compost market appears strong within the City and County, but these uses are relatively small and represent only a small portion of the City's total projected biosolids quantities. The City faces strong competition from local for-profit companies in other compost markets, and would likely need to incentivize the compost by providing it at little or no cost and develop a brand to increase visibility and facilitate marketing efforts. Large capital improvements would be necessary for lime stabilized biosolids, expansion of the City's composting process, and thermally dried pellets. These improvements will be discussed in the next section.

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# 5.0 Biosolids Products Evaluation

This section evaluates the potential infrastructure upgrades and impacts on operations and maintenance required to generate these products. All four of the biosolids products under consideration require solids dewatering and the facility costs are presented in the 2010 Engineering Report. For comparison purposes the cost of the future dewatering facility is not included in this section.

Order of magnitude capital (construction, facilities, and associated technical services) cost estimates typically range from -25% to +75% of actual project costs. The following assumptions were made in capital cost estimates:

- Annual cost escalation during construction – 3.5% of direct costs per year
- Contractor's overhead, profit, bonds, mobilization – 20% of direct costs
- Engineering, administration, legal, and permitting – 20% of construction cost

These cost markups are included in the total capital cost estimates throughout this report.

## 5.1 Class B Dewatered Biosolids

Class B dewatered biosolids are currently produced at the Everett WPCF, therefore no significant infrastructure needs are anticipated in addition to those recommended in the 2010 Engineering Report.

Most of the City's Class B dewatered biosolids have been hauled and applied to farmland in Snohomish County. The City currently maintains permits for sites in Snohomish County and is permitted to send biosolids to private land application facilities, called Beneficial Use Facilities (BUFs), in Snohomish, Douglas, and Yakima counties.

Should the City elect to haul and manage biosolids rather than use a contractor(s), possible additional equipment and staff needs include the following:

- Trucks and trailers
- Tractor(s) and spreader(s)
- Spare parts or a contract for maintenance
- Personnel to operate the equipment listed above

An example of a tractor and spreader used for Class B biosolids application is shown in Figure 7. At approximately 8,500 dry tons per year, the highest projected quantity from the 2010 Engineering Report, there will be approximately 36 truck trips per week assuming the following:

- 30 cubic yard capacity trucks
- 20 percent solids concentration
- Dewatered biosolids density of 1,500 pounds per cubic yard

**Figure 7: Tractor and Spreader Combination.**

Three truck and trailer combinations are required assuming the following:

- A round trip haul distance of 100 miles,
- Average round-trip haul time of two and a half hours including unloading
- A five day per week, eight hour per day schedule.

The estimated cost for the equipment is presented in Table 16.

**Table 16: Class B Biosolids Equipment Cost Estimate**

| Item | Cost |
|---|---|
| Truck and trailer combinations (3) [1] | $450,000 |
| Tractor (2) | $280,000 |
| Spreaders (2) | $58,000 |
| Front-end loader | $60,000 |
| Service truck with flat-bed trailer | $60,000 |
| Contingency | $91,000 |
| Sales Tax | $87,000 |
| Sum | $1,086,000 |

1. Truck and trailer combinations are assumed to be 30 cubic yard capacity each.

An alternative to a tractor and spreaders is a combination hauling and spreading unit. However, these are generally more costly than tractors and spreaders.

Field storage is recommended due to weather conditions during much of the year that prohibit biosolids application. The City has not constructed a lined field storage facility to date, but an engineered structure should be considered after the future dewatering facility is brought online.

Shared costs for storage facilities in exchange for long-term contracts with partners would benefit both parties.

The estimated annual operations and maintenance (O&M) cost is presented in Table 17.

**Table 17: Class B Biosolids Operations and Maintenance Cost Estimate**

| Item | Cost |
|---|---|
| Fuel | $250,000 |
| Labor | $386,000 |
| Maintenance Materials | $26,000 |
| Equipment Replacement [1] | $129,000 |
| Administration [2] | $187,000 |
| Sum | $977,000 |

1. Amortized depreciation of assets.
2. Including permit fees, sampling, and labor for one full-time program administrator.

## 5.2 Class A Composted Biosolids

Class A compost is currently produced at the Everett WPCF on a batch basis as described above. The City currently produces 200 to 500 cubic yards of compost per year from approximately 100 dry tons of biosolids that are dredged from the lagoons, dewatered, and stored. Biosolids are composted using aerated static piles. Amendment from other City departments and projects such as wood waste, turf thatch, grass clippings, and animal bedding is mixed with biosolids.

The City currently uses Engineered Compost Systems (ECS) equipment, which has worked well. For purposes of developing order of magnitude cost estimates, it is assumed that ECS equipment and recommended facilities would be procured.

Two options were evaluated for expanding the capacity of the existing composting process: 1) expansion to 2,000 dry tons per year (approximately 50,000 cubic yards per year) the current annual biosolids production, and 2) expansion to be capable of processing all of the City's estimated 2030 biosolids production (approximately 8,500 dry tons per year). After evaluating the required footprint, it was determined that the 2,000 dry ton per year facility (current production rate) could possibly be located on the existing biosolids pad. Expansion would be limited until after construction of the proposed dewatering facility as space for dredging and dewatering operations is still required. A potential facility to process all of the approximately 8,500 dry tons per year would need to be located elsewhere due to lack of sufficient space. ECS estimates that approximately 300,000 square feet of area would be required for such a facility. A siting analysis is beyond the scope of this study. Given the market analysis results and readily available feedstock material quantities, composting 2,000 dry tons per year of biosolids is a reasonable goal. For these reasons, only a composting facility capable of processing 2,000 dry tons per year is considered further.

The following facilities would be required for expanding the current composting system to be capable of composting 2,000 dry tons per year:

- Additional air blowers
- Additional aeration piping

- Additional compost pile covers
- Cover winding machine
- Mixer
- Site clearing, additional paving, and other site improvements
- Electrical panels, wiring, and instrumentation

Additionally, since the expanded composting facility would not be capable of processing all 8,500 dry tons per year projected in the 2010 Engineering Report, the equipment listed above for Class B dewatered biosolids would also need to be purchased. The estimated total capital cost for the composting equipment and facilities is presented in Table 18. A photo of the ECS aerated static pile piping system and covers is shown in Figure 8.

**Table 18: Estimated Capital Costs for Composting Facility Expansion**

| Item | Cost |
|---|---|
| Truck and trailer combinations (3) [1] | $450,000 |
| Tractor (2) | $280,000 |
| Spreader (2) | $58,000 |
| Front-end loader (2) | $120,000 |
| Service truck with flat-bed trailer | $60,000 |
| Mixer | $203,000 |
| Cover Winder | $101,000 |
| AC Composter Package [2] | $1,261,000 |
| End-dump Truck | $100,000 |
| Trommel Screen | $103,000 |
| Sitework | $100,000 |
| Electrical | $310,000 |
| Escalation to Construction Mid-Point | $55,000 |
| Contractor's Overhead, Profit, Bonds, Mobilization | $624,000 |
| Contingency | $936,000 |
| Engineering, Administration, Legal, Permitting | $945,000 |
| Sum | $6,767,000 |

1. Truck and trailer combinations are assumed to be 30 cubic yard capacity each.
2. ECS package includes covers, odor ducting, piping, and valves.

**Figure 8: Example Aerated Static Pile Composting Process (courtesy of ECS)**

The estimated annual operations and maintenance (O&M) cost for both land application and composting is presented in Table 19. For purposes of the cost analysis, it is assumed that any revenue from compost sales would not exceed costs for purchasing amendment material to blend with the dewatered biosolids.

**Table 19: Operations and Maintenance Cost Estimate for Expanded Composting Facility.**

| Item | Cost |
|---|---|
| Fuel | $244,000 |
| Power | $19,000 |
| Labor | $463,000 |
| Maintenance Materials | $87,000 |
| Equipment Replacement [1] | $199,000 |
| Compos Amendment Material | $76,000 |
| Administration [2] | $187,000 |
| Sum | $1,275,000 |

1. Amortized depreciation of assets.
2. Including permit fees, sampling, and labor for one full-time program administrator.

## 5.3 Class A Lime Stabilized Biosolids

Lime stabilization consists of adding lime, an alkaline agent, to either liquid or dewatered biosolids to raise the pH above 12 for more than two hours. Additional requirements must be met for Class A pathogen reduction depending on the particular process. As discussed in previous sections, the primary market for lime stabilized biosolids is agriculture. Class A lime stabilized biosolids would require an additional treatment process in conjunction with those described in the 2010 Engineering Report (Carollo, 2010), or a modification to the dewatering process described in that report. The cost estimates assume that the lime-stabilized biosolids are entirely managed on agricultural land in western Washington.

A variety of proprietary lime stabilization systems are commercially available including the following:

- RDP EnVessel Pasteurization™
- Schwing Bioset
- FKC Screw Press Dewatering and Pasteurization
- N-Viro Process™

Evaluation of the various systems, equipment, and technology, is beyond the scope of this study. This report focuses on the FKC Screw Press Dewatering and Pasteurization process for purposes of order of magnitude cost estimates. A photo of the process in Sequim, Washington is shown in Figure 9.

**Figure 9: Example Lime Stabilization Process (courtesy of FKC).**

A modified dewatering process was assumed based on the FKC process. Discussions with City staff revealed that there are plans for future expansion in the vicinity of the planned dewatering

facility, meaning that additional space for lime stabilization facilities is limited. The following facilities would be required for modifying the currently planned dewatering process to be capable of lime stabilizing all of the City's biosolids:

- Dewatering screw presses
- Boilers and ancillary equipment
- Lime silo and feed equipment
- Lime stabilized biosolids conveyance equipment
- Lime stabilized biosolids storage hopper

The FKC screw presses are generally larger than more traditional dewatering equipment, so an alternative layout or slight building expansion is likely required compared with the dewatering facility shown in the 2010 Engineering Report. It is also assumed the Class A lime stabilized biosolids would be land applied, and the equipment listed above for Class B dewatered biosolids would need to be purchased. The estimated additional cost for such a facility is presented in Table 20.

**Table 20: Estimated Capital Costs for Class A Lime Stabilization**

| Item | Cost |
|---|---|
| Truck and trailer combinations (3) [1] | $450,000 |
| Tractor (2) | $280,000 |
| Spreader (2) | $58,000 |
| Front-end loader (2) | $120,000 |
| Service truck with flat-bed trailer | $60,000 |
| Lime-stabilization equipment package | $2,430,000 |
| Lime silo and feed system | $1,013,000 |
| Mechanical and miscellaneous | $225,000 |
| Electrical | $788,000 |
| Dewatering Building Expansion | $990,000 |
| Equipment Cost Offset from 2010 Engineering Report Dewatering Facility [2] | ($2,000,000) |
| Escalation to Construction Mid-Point | $225,000 |
| Contractor's Overhead, Profit, Bonds, Mobilization | $1,283,000 |
| Contingency | $1,627,000 |
| Engineering, Administration, Legal, Permitting | $1,509,000 |
| Sum | $9,058,000 |

1. Truck and trailer combinations are assumed to be 30 cubic yard capacity each.
2. FKC screw press dewatering equipment would offset costs included in 2010 Engineering Report for Dewatering Facility.

The estimated annual operations and maintenance (O&M) cost is presented in Table 21. It should be noted that adding lime also increases the quantity of biosolids produced by the process. This is accounted for in the O&M cost estimate.

**Table 21: Operations and Maintenance Cost Estimate for Lime Stabilization**

| Item | Cost |
|---|---|
| Fuel | $271,000 |
| Power | $20,000 |
| Lime | $541,000 |
| Labor | $386,000 |
| Maintenance Materials | $19,000 |
| Equipment Replacement [1] | $224,000 |
| Revenue [2] | ($57,000) |
| Administration [3] | $187,000 |
| Sum | $1,782,000 |

1. Amortized depreciation of assets.
2. Assumes $5 per dry ton.
3. Including permit fees, sampling, and labor for one full-time program administrator.

## 5.4 Class A Dried Biosolids Pellets

Class A thermally dried pellets would require a thermal drying process in addition to those described in the 2010 Engineering Report (Carollo, 2010). A variety of proprietary thermal drying systems are commercially available. This report uses a direct rotary drum dryer, such as the Andritz DDS system, as the basis of cost estimates. A photo of this system is shown in Figure 10 and a schematic of the Andritz process is shown in Figure 11.

The most logical location for a drying facility is adjacent to dewatering equipment to minimize conveyance of dewatered biosolids. After discussions with plant staff, there are plans for the area just west of the proposed dewatering facility. If that location could not be utilized, pumping or another method of conveying dewatered biosolids to an alternate drying facility location would be required.

The following facilities would be required for modifying the currently planned dewatering process to be capable of drying all of the City's biosolids:

- Drying equipment
- Process air treatment equipment
- Pellet screening, pulverizing, and recycling equipment
- Bagging equipment (optional)
- Digester gas piping to drying area
- Dewatered cake conveyance
    - Pumps and pipeline, or
    - Trucks and unloading bin

**Figure 10: Example Direct Drum Drying System Furnace (courtesy of Andritz)**

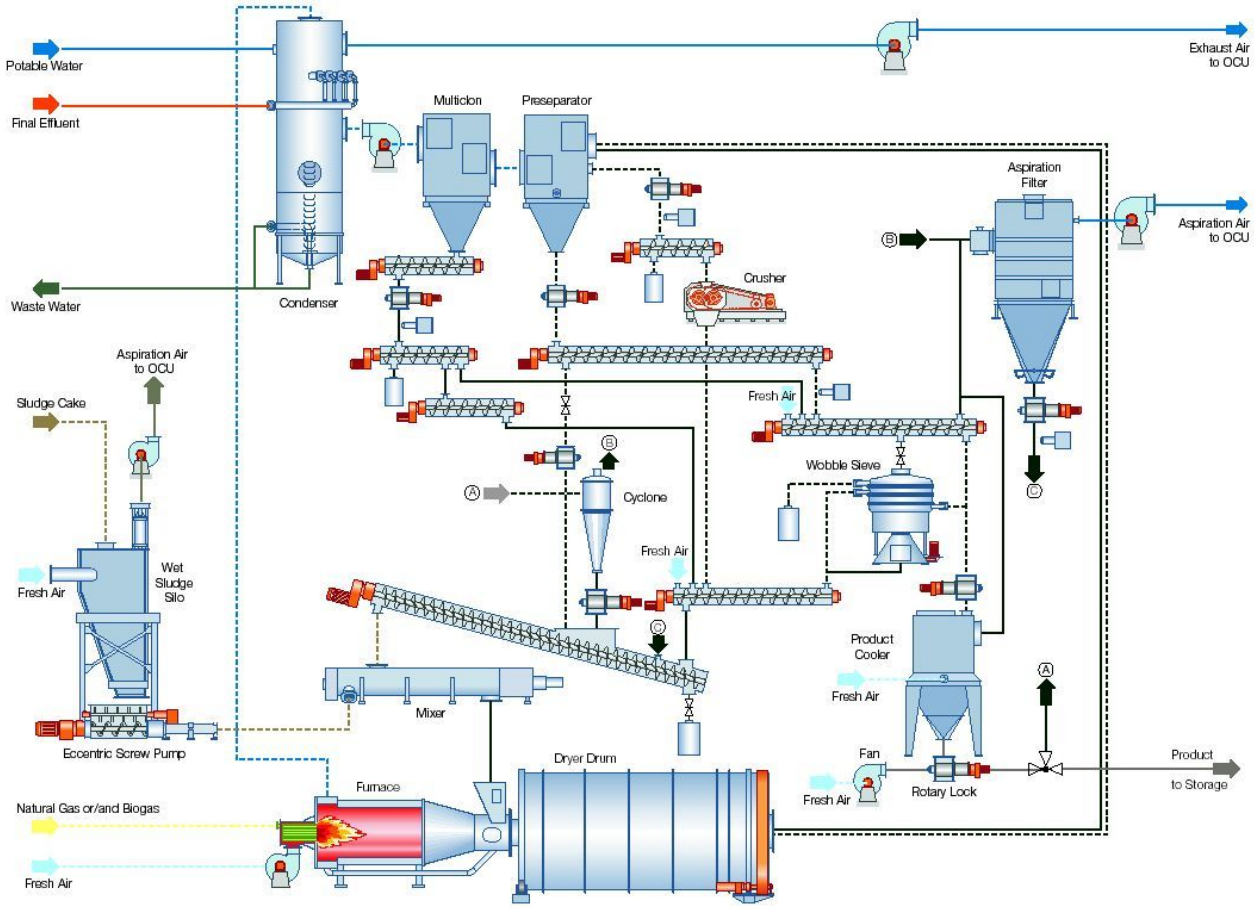


**Figure 11: Schematic of Example Direct Drying Process (courtesy of Andritz)**

The estimated additional cost for such a facility is presented in Table 22. The estimated annual operations and maintenance (O&M) cost is presented in
Table 23.

**Table 22: Estimated Capital Costs for Drying Facility**

| Item | Cost |
|---|---|
| Drying equipment package | $10,800,000 |
| Mechanical and miscellaneous | $250,000 |
| Electrical | $1,878,000 |
| Dewatering Building Expansion | $3,500,000 |
| Escalation to Construction Mid-Point | $575,000 |
| Contractor's Overhead, Profit, Bonds, Mobilization | $3,285,000 |
| Contingency | $3,878,000 |
| Engineering, Administration, Legal, Permitting | $4,833,000 |
| Sum | $28,996,000 |

**Table 23: Operations and Maintenance Cost Estimate for Dried Pellets**

| Item | Cost |
|---|---|
| Power | $173,000 |
| Natural Gas | $454,000 |
| Labor | $333,000 |
| Maintenance Materials | $108,000 |
| Equipment Replacement [1] | $400,000 |
| Revenue [2] | ($85,000) |
| Administration [3] | $194,000 |
| Sum | $1,577,000 |

1. Amortized depreciation of assets.
2. Assumes $10 per dry ton.
3. Including permit fees, sampling, and labor for 1.5 full-time equivalents.

## 5.5 Non-Cost Criteria Evaluation

A workshop was held on July 1, 2011 with the stakeholder committee, the City, and HDR. Non-cost evaluation criteria were developed and biosolids products under consideration were rated against those criteria. The following non-cost criteria were agreed to as the most appropriate for the strategic planning process:

- Environmentally Responsible
- Innovative
- Potential for Strategic Partnerships
- Sustainable

- Good Neighbor
- Flexibility
- Risk
- Public Perception
- Value Added Product

Workshop participants collaboratively weighted each criterion for its relative importance and rated each of the biosolids products for each criterion.

**Table 24: Non-Cost Criteria Weighting and Rating**

| Criteria | Weight | Class B Dewatered | Compost | Lime Stabilized | Dried Pellets |
|---|---|---|---|---|---|
| Environmentally Responsible | 3 | 3 | 2 | 2 | 1 |
| Innovative | 1 | 1 | 3 | 2 | 3 |
| Potential for Strategic Partnerships | 2 | 2 | 3 | 2 | 3 |
| Sustainable | 3 | 2 | 3 | 1 | 3 |
| Good Neighbor | 3 | 2 | 1 | 1 | 3 |
| Flexibility | 2 | 1 | 2 | 2 | 3 |
| Risk | 2 | 2 | 3 | 2 | 3 |
| Public Perception | 3 | 1 | 3 | 2 | 3 |
| Value Added Product | 1 | 2 | 3 | 2 | 3 |
| Sum of Weight and Rating | --- | 37 | 49 | 34 | 54 |

Alternatives rated 1 (worst) through 3 (best) for all criteria.

## 5.6 Summary

Table 25 summarizes the cost estimates for the four biosolids products evaluated. The following assumptions were made in the life cycle cost estimates:

- Discount rate of 6%
- Life cycle of 20 years except land application equipment, which was assumed to have a service life of 10 years

Class B cake appears to be the most cost-effective biosolids product for Everett.

**Table 25: Summary of Cost Estimates for Biosolids Products Evaluated**

| Biosolids Product | Capital Cost ($million) | Annual O&M Cost ($million) | Present Worth Cost ($million) |
|---|---|---|---|
| Class B Dewatered | $ 1.1 | $ 1.0 | $ 12.3 |
| Compost (2,000 DT/yr) | $ 6.8 | $ 1.3 | $ 21.4 |
| Class A Lime Stabilized | $ 9.1 | $ 1.8 | $ 29.5 |
| Dried Pellets | $ 29.0 | $ 1.6 | $ 47.1 |

Table 26 presents a summary of the present worth costs and the sum of non-cost criteria ratings. The alternative with the best cost/benefit ratio is Class B dewatered biosolids. Expansion of the current composting process to have a capacity of 2,000 dry tons per year ranks second. The benefit of additional composting is that the system can be expanded in phases based on demand, availability of low cost feedstock, and availability of capital funds.

**Table 26: Summary of Biosolids Products Evaluation**

| Biosolids Product | Non-Cost Criteria Rating | Present Worth Cost ($million) | Cost/Benefit Ratio ($million) | Relative Cost/Benefit Ratio[2] |
|---|---|---|---|---|
| Class B Dewatered | 37 | $ 12.3 | $0.33 | 1.0 |
| Compost (2,000 DT/yr) | 40[1] | $ 21.4 | $0.54 | 0.62 |
| Class A Lime Stabilized | 34 | $ 29.5 | $0.87 | 0.38 |
| Dried Pellets | 54 | $ 47.1 | $0.87 | 0.38 |

1. Weighted average of Class B Dewatered and Compost based on 2,000 dry tons composted out of approximately 8,500 dry tons total.
2. Cost/benefit ratio is defined as the present worth cost of an alternative divided by its non-cost criteria rating. The lowest cost/benefit ratio is the best alternative. The best alternative's cost/benefit ratio receives a value of 1.0. The cost/benefit ratios of all other alternatives are scaled to the best alternative, which results in relative cost/benefit ratios below 1.0.

# 6.0 Conclusions and Recommendations

The City of Everett has developed a strategic vision and mission for its biosolids management program. The City has been in compliance with regulatory requirements and should continue to monitor for changes in these requirements.

An extensive analysis of markets has revealed that there are several viable outlets for the City's biosolids. A formal market analysis should be repeated every few years or if regulatory constraints or conditions change resulting in impacts on the City's program. It is recommended that ongoing informal market assessment should continue through involvement in research and professional associations, communication with the local community and industry, and communication with other City departments. This is consistent with the program vision and mission. The overall biosolids management plan should also be updated every few years, with a logical interval of five years, the same as the City's permit renewal interval.

While the cost-benefit analysis showed that Class B dewatered biosolids ranks best, there is a benefit to having local outlets for biosolids and continuing the current biosolids composting operation. Composting diversifies the program and provides a beneficial local use that proves that the City is committed to supporting the local community as stated in the mission statement. It also demonstrates that the City is committed to local beneficial use and provides economical and collaborative management of wastes from other City departments.

Before expanding the current composting operation, a more detailed analysis of options for siting, equipment, and layout should be conducted in a separate study or predesign report. The analysis should examine how an expansion could be sited to avoid spaces where periodic dredging and dewatering operations occur in the interim while maximizing the efficiency of a facility once the future dewatering facility is online and the space would no longer be needed for dredging and dewatering. The study should also evaluate how the expansion could be phased in over time. The study/report should also evaluate options for alternative sites for composting operations and develop more detailed cost estimates. If growth in the service area and increases in solids production do not occur as projected, the need for an expansion of the current composting operations may be minimal in the near term. While there is no current driver for an immediate expansion of the composting operation, planning should commence as permitting, design, and construction of a composting facility at an alternative site would likely take several years.

In support of the current and potentially expanded composting program, the City should pursue certification on WSDOT's Qualified Product List once a landscaping compost mix is finalized. The City could also work with local landscaping companies to develop additional markets for its compost.

The City should also consider developing a City-wide organics management strategy, including both Public Works and other City departments, to facilitate efficient uses of City wastes and potentially develop new sources of compost feedstock.

To continue to ensure a viable local market for Class B dewatered biosolids, the City should continue to work with its end users in support of the mission. The City should consider long-term contracts and cost-sharing for field storage facilities, especially when the proposed dewatering facility is online. This would enhance the long-term viability of this key agricultural market.

Other follow-on work should include development of additional educational materials on the City's biosolids and consideration of a branding campaign to name and promote the product.

Tours of the WPCF could involve visiting the biosolids composting area if desired by visitors. Tour invitations, small discussions of biosolids program issues and activities, and notices about potential compost availability could be added to the City's Public Works Water annual report or as a separate document mailed with the City's water and sewer invoices.

The City should continue to sponsor research on Class B dewatered biosolids and biosolids compost. It is recommended that the following areas of research be sponsored directly by the City or indirectly through a professional association (such as the Northwest Biosolids Management Association (NBMA) or the Water Environment Research Foundation (WERF)) in support of the recommended biosolids management program:

- Targeted research for Class B dewatered biosolids on crops grown by the City's end users, and specific to Western Washington growing conditions.
- Evaluation of different compost mixes for different City department and public uses.
- Evaluation of biosolids quality changes in anticipation of anaerobic digestion and dewatering operations.

In summary, the City currently has a successful and cost-effective biosolids management program. The City should maintain its diversity of biosolids products; seek to strengthen existing markets; continue to assess new markets; and continue to work with other municipalities, businesses, and the public to ensure the long-term viability of the biosolids program.

# 7.0 References


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# Appendix A – Everett Biosolids Annual Report

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DEPARTMENT OF ECOLOGY
State of Washington

# Annual Biosolids Report 2010

## READ THIS PAGE BEFORE COMPLETING THIS REPORT.

### About this report

- The due date for this annual report is **March 1, 2011**. Failure to submit your report by this date is a violation of the state biosolids rule (**Chapter 173-308 WAC**) and may result in enforcement actions.
- This report is required for all facilities in Washington that treat, store, use, or dispose of biosolids, sewage sludge, or septage **and** that require a biosolids permit. This includes wastewater treatment plants, composters, septage management facilities, and biosolids beneficial use facilities (BUFs).
- You must complete a report for **each** permitted facility.
- This report form is also available online at: **http://www.ecy.wa.gov/biblio/ecy070125.html**.

### Completing this report

- All amounts must be reported in **dry tons**. Use the following **conversion factors** if your information is in **wet tons** or **gallons**.
  - Dry tons = wet tons x percent solids
  - Dry tons = gallons x 8.34 ÷ 2000 x percent solids (*for septage, you can assume 2% solids*)
- **Expand a section or provide attachments if you need additional space** anywhere on the form.
- You must **submit copies of all relevant analytical results and monitoring data** with this report.
- Do not leave whole sections blank. If a question does not apply to you enter "**N/A**". If an answer is zero enter "**0**". If a response is an estimate enter "**EST.**".
- Contact your regional Biosolids Coordinator if you need assistance in completing this report.

### Signing this report

- The certification statement in Section E **must be signed by the Responsible Official** listed in Section A or by a duly authorized representative (***usually this not the operator***).
- This is a **legally binding document**—you must read the certification statement before signing.
- The person signing this report **must verify information** provided by others before signing.

### Submitting this report

- You must **submit your report to the following persons**:
  - **Original**, in **hardcopy** form, to **Ecology headquarters.**
  - **Copy** to any **Ecology region** where your biosolids, sewage sludge, or septage will be treated, stored, disposed, or applied to the land. Please submit this copy **electronically** if possible.
  - **Copy** to any **local health jurisdiction** where your biosolids, sewage sludge, or septage will be treated, stored, disposed, or applied to the land. This is not required if the local health jurisdiction has stated that they do not want to receive the report. Ask the local heath jurisdiction if an electronic copy is acceptable.
  - **Copy** to **EPA Region 10** by **February 19, 2011**, if your facility is a "Major" or "Class I" facility. Ask EPA if an electronic copy is acceptable.
- **Mailing addresses** can be found at the end of this form or online at: **http://www.ecy.wa.gov/programs/swfa/biosolids/contacts.html**.



*If you need this publication in another format, please call the Waste 2 Resources Program at (360) 407-6900. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.*

# Annual Biosolids Report 2010

## SECTION A: FACILITY INFORMATION

**Name of facility** Everett Water Pollution Control Facility **Owner** City of Everett

**Physical address** 4027 4th Street SE Everett WA 98201

**Mailing address** 3200 Cedar Street Everett WA 98201

**Primary contact name** Chris Chesson **Primary contact title** Senior Environmental Specialist

**Primary contact phone** 425 257 8878 **Primary contact email** cchesson@ci.everett.wa.us

**Responsible official name** Ray Stephanson **Responsible official title** Mayor

**Responsible official phone** 425 257 7112 **Responsible official email** rstephan@ci.everett.wa.us

**Facility type** (*check all that apply*)

- ☒ Major sewage treatment facility (design *flow of ≥1 mgd or serving a population of ≥10,000*)
- ☐ Minor sewage treatment facility (design *flow of <1 mgd and serving a population of <10,000*)
- ☐ Class I sewage treatment facility (*have a pretreatment program or designated as Class I*)
- ☐ Composting facility (*receive biosolids or sewage sludge from others for composting*)
- ☐ Septage management facility (*land apply or prepare septage for land application*)
- ☐ Beneficial use facility (*receive biosolids from others for direct land application*)
- ☐ Other—describe _____

## SECTION B: BIOSOLIDS/SEPTAGE/SEWAGE SLUDGE MANAGEMENT

**Sent to a facility for further treatment** _____ *dry tons* Facility names and subtotals _____

**Received from a facility for further treatment** _____ *dry tons* Facility names and subtotals _____

**Sent to a biosolids beneficial use facility (BUF)** 164 *dry tons* BUF names and subtotals Boulder Park Inc

**Received by a biosolids beneficial use facility (BUF)** _____ *dry tons* Facility names and subtotals _____

**Sent to a landfill for disposal** _____ *dry tons* Landfill names and subtotals _____

**Sent to an incinerator** (*include your incinerator*) _____ *dry tons* Incinerator names and subtotals _____

**Stored for less than 2 years** _____ *dry tons*—describe _____

**Stored or accumulated for more than 2 years** (*this includes lagoon facilities*) _____ *dry tons*

When was the last time you surveyed solids accumulation? _____

When was the last time you tested your solids for the pollutants in WAC 173-308-160? _____

How much capacity remains for solids accumulation (*remaining feet of space*)? _____ *feet*

When do you plan to remove solids? _____

**Land applied or sold/given away** (*do not complete for biosolids you sent to a BUF*) 3014 *dry tons*

Subtotal applied to an agricultural site 2914 *dry tons*

Subtotal applied to a forest site _____ *dry tons*

Subtotal applied to a reclamation site _____ *dry tons*

Subtotal applied to a public contact site _____ *dry tons*

Subtotal applied to a lawn or home garden _____ *dry tons*

Subtotal sold/given away in bulk, bag/other container, compost, or blended product 100 *dry tons*

# Annual Biosolids Report 2010

**Land application site information** (*do not complete for biosolids you sent to a BUF*)

Location (*unit, field name, address, or latitude/longitude*) **Cascade Materials Ag Project, 12224 92nd Street SE, Snohomish WA 98290 - South Field (85 acres) Marsh Road (175 acres) Field 1 (25 Acres) Field 2 (110 acres)** Amount applied **2480** *dry tons* Acres applied to **395** *acres*
Vegetation grown **Corn intercropped with rye grass or corn.**

**If you composted biosolids, complete the following table** (*check all that apply*)

| Feedstock | Amount (*cite units – e.g. dry tons, wet tons, cubic yards*) | County of Origin (*specify if from another state or country*) |
|---|---|---|
| ☒ Biosolids/Sewage Sludge/Septage | 95 yards | Snohomish |
| ☐ Carcasses | ____ | ____ |
| ☐ Crop Residues (*specify*): ____ | ____ | ____ |
| ☐ Food Processing Waste | ____ | ____ |
| ☐ Food Waste (*pre-consumer vegetative*) | ____ | ____ |
| ☐ Food Waste (*all other*) | ____ | ____ |
| ☐ Industrial Waste (*specify*): ____ | ____ | ____ |
| ☐ Land-clearing Debris | ____ | ____ |
| ☐ Manure (*specify type*): ____ | ____ | ____ |
| ☐ Mixed Food and Yard Debris (*residential*) | ____ | ____ |
| ☐ Sawdust/Shavings | ____ | ____ |
| ☒ Other Wood Debris | 300 yards | Snohomish |
| ☒ Yard Debris | 50 yards | Snohomish |
| ☒ Other (*specify*): Animal Bedding | 20 yards | Snohomish |

## SECTION C: BIOSOLIDS/SEPTAGE QUALITY

**Pollutants** (*see WAC 173-308-160; not applicable to septage unless required by permit*)

Number of pollutant monitoring events in the past year **2**

List pollutants exceeding the Table 3 values and explain **0**

List pollutants exceeding the Table 1 values and explain **0**

**Pathogen reduction** (*check all that apply; see WAC 173-308-170 or WAC 173-308-270[3]*)

| | |
|---|---|
| ☐ Class A—Alternative 1 (*time/temperature*) | ☐ Class A—Alternative 2 (*pH/time/temperature/% solids*) |
| ☒ Class A—Alternative 3 (*process to further reduce pathogens [PFRP]*)<br>☒ Composting ☐ Heat drying ☐ Heat treatment ☐ Thermophilic aerobic digestion<br>☐ Beta ray irradiation ☐ Gamma ray irradiation ☐ Pasteurization | |
| ☐ Class A—Alternative 4 (*PFRP equivalent*) | ☐ Class B—Alternative 1 (7 *samples*) |
| ☐ Class B—Alternative 2 (*process to significantly reduce pathogens [PSRP]*)<br>☐ Aerobic digestion ☐ Air drying ☐ Anaerobic digestion ☐ Composting ☐ Liming | |
| ☒ Class B—Alternative 3 (*PSRP equivalent*) | ☐ Septage injection |
| ☐ Septage incorporation | ☐ Septage pH stabilization |
| ☐ Did not meet requirements—explain ____ | |

Section B continued

Location (unit, field, address, lat/long) **Lowell Snohomish River Road Ag Project (see SSLAP for project location) – East Field 90 acres total** Amount applied **534** *dry tons* Acres applied to **70** *acres* Vegetation grown **Corn**

**Vector attraction reduction** (*check all that apply; see* ***WAC 173-308-180*** *or* ***WAC 173-308-270[3]***)

| | |
|---|---|
| ☒ Alternative 1 (*38% volatile solids reduction*)<br>☒ Alternative 1a (*bench test-anaerobic*) ☐ Alternative 1b (*bench test-aerobic*) | |
| ☐ Alternative 2 (*specific oxygen uptake rate*) | ☐ Alternative 3 (*aerobic process*) |
| ☐ Alternative 4 (*pH stabilization*) | ☐ Alternative 5 (*≥75% solids*) |
| ☐ Alternative 6 (*≥90% solids*) | ☐ Alternative 7 (*injection*) |
| ☐ Alternative 8 (*incorporation*) | ☐ Septage injection |
| ☐ Septage incorporation | ☐ Septage pH stabilization |
| ☐ Did not meet requirements—explain _____ | |

## SECTION D: GENERAL COMMENTS RELATED TO FACILITY OPERATION

**Please add any comments or descriptions of activities that you think are important** _____

## SECTION E: ATTACHMENTS, CERTIFICATION STATEMENT, MAILING ADDRESSES

**Attachments** (*check all that apply; include actual lab reports for analytical data*)

- ☒ Analytical data for pollutants if testing was required
- ☒ Analytical data for pathogen reduction if testing was required
- ☒ Analytical data for vector attraction reduction if testing was required
- ☒ Other—describe (*examples include soil and water sampling results, time and temperature monitoring data, pH monitoring data, and additional land application site information*) **Time and Temperature data for compost**

**Certification statement** (*must be signed by the Responsible Official listed in Section A or a duly authorized representative; see* ***WAC 173-308-310(10)(b)***)

*"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."*

Responsible Official Signature Matt E Chesser Date 2/9/11

Responsible Official Title Senior Environmental Specialist

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# Appendix B – Responses to Comments on Draft Plan

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**SNO-VALLEY FARMS INC**
**7230 89TH AVE SE**
**SNOHOMISH, WA 98290**
**snovalleyfarms@gmail.com**
**425-508-7989**

December 3, 2011

To: Chris Chesson
From: Dan Bartelheimer

RE: Strategic Plan for Biosolids Management

Comments and suggestions:

Pg 8 The 5,749 dry tons for 2010 was for one year or was it the amount recovered in 2010 and nothing was dredged in 2009?

Pg 13, table 3 Food crops, feed crops or fiber crops. I suggest the not harvested for 30 days after class B biosolids application be extended to 90 days. If Class B biosolids need to be incorporated, what can be harvested in 30 days?

Pg 16, P 2.3.4.2 When biosolids are applied at an agronomic rate, much more than nitrogen needs to be monitored. Average crop yields on almost all commodities will require additional N, P and/or K. Monitoring the crop yield as well as the crop grown is equally important. High application rates of biosolids may increase the salts in the soil and drastically reduce the productivity of the soil. Lower yields may be an indication that the soil is being overloaded with biosolids.

Pg 24, table 8 This table should be with P 4.1.1 (agriculture). If class B biosolids need to be incorporated, it should not be applied to hay or pasture fields unless it is incorporated prior to seeding. The acres of hay may need to be reduced by 75%.

Pg 26, table 9 Class A lime stabilized biosolids will be approximately 25% lime. The lime may be a finely ground oxide with a high neutralizing power. This lime when applied to the soil will be fast acting. Lower application rates of one ton of lime or four ton of the class A lime stabilized biosolids may be more practical. An upper rate may be eight ton of lime stabilized biosolids per application.

Pg 27, P 4.2.1 The summary should be P 4.2.4.

Pg 30, P 4.4.2 Reference is made to fertilizers that are applied on parks, athletic fields, golf courses but nothing is mentioned how dried biosolids would compare. 16 to 18 dry tons of biosolids applied per year does not appear to be practical but maybe dangerous.

Pg 30, 4.4.1, General public use This should be P 4.4.3. Why has the agricultural market been overlooked? This product can be easily applied with a dry fertilizer spreader. It can be easily mixed with commercial fertilizer. I have made several attempts over the last two years to have this product broadcast on 500 acres of grass.

Pg 30, 4.4.1 Fertilizer brokers This should be 4.4.4.

Pg 31, table 12 This should be inserted under P 4.4.1 Local golf courses.

Pg 31, P 4.4.2 Energy use This should be P 4.4.5.

Pg 32, P 4.4.3 Summary This should be P 4.4.6. Ag market should be included in the summary.

Pg 34, table 14 One tractor and spreader would be adequate. Two front-end loaders would be necessary, one at the dewatering site and the second in the field.

Pg 36, table 16 One tractor and spreader should be adequate.

Pg 39, table 18 This product may be dry enough for a spin spreader. The lime stabilized biosolids would be applied at a lower rate and on a greater number of acres. A truck mounted spin spreader would replace the two tractors with spreaders. The transporting equipment may also need to be revised. A belt unload trailer could be utilized that would unload into a portable belt/auger conveyer that would load the spreader. In most instances, the lime stabilized biosolids would not be dumped in the fields and spread like the class B biosolids.

Pg 40, table 19 The revenue of $57,000 for 11,500 tons of lime stabilized biosolids appears to be very conservative.

Pg 42, table 20 Foot notes to the table do not appear to be applicable.

Pg 43, table 22 The table needs a key.

Pg 46 Someplace in the document the value of the nutrients within the biosolids should be stated. Whenever biosolids utilization is discussed, the positive aspects need to be presented. What is the organic composition? How will it improve soil tilth? Where are statistics and charts displaying the advantages of the application of biosolids. If the positive is not promoted, biosolids will be perceived negatively by the public.

Changes to the associated tables, etc will need to be made to correlate with the proposed changes.

Pg47 Name is misspelled. Bartelheimer & Sno-Valley Farms Inc

*Comments were received from Dan Bartelheimer on December 3, 2011. Responses are as follows:*

1. The quantities presented are estimates taken from the 2010 Engineering Report for consistency with other City planning efforts and are not actual quantities.
2. Clarification was added to table 3.
3. Clarification was added to section 2.3.4.2.
4. Table 8 assumes that future biosolids would meet vector attraction reduction requirements, so incorporation would not be required.
5. An upper limit of 8 tons of lime stabilized biosolids per acre was added and the values were re-calculated.
6. Section number was changed.
7. The quantity of 16 to 18 dry tons refers to a total quantity, not a loading rate.
8. An analysis of the local agricultural market was added to section 4.4.
9. Section number was changed.
10. Table 12 was moved.
11. Section number was changed.
12. Section number was changed and a summary of the agricultural market was added to table 12.
13. Two tractors and two spreaders were maintained to provide a conservative cost estimate.
14. In our experience, the lime stabilized biosolids would be transported by similar trucks and likely be applied using equipment similar to the City's current Class B biosolids. Including estimated costs for tractors and spreaders is a conservative assumption as the equipment suggested would likely be less expensive.
15. Yes, the revenue assumption is conservative.
16. Table foot notes revised.
17. A key was added to this table.
18. Text was added at the beginning of section 2.1 to address these comments.
19. Changes were made to tables throughout the document.
20. Spelling was changed.

*Comments were received in hand-written form from Donna Gleisner. Comments were incorporated in the document with two exceptions:*

1. The list of acronyms was maintained for the reader's convenience; this approach is industry-standard for reports of this type.
2. Spacing of bulleted items was maintained.

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