CITY OF EL PASO DE ROBLES

Master Plan of Sustainable Opportunities at the Paso Robles Landfill

MAY 2010

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CLEMENTS
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PREPARED FOR:
CITY OF EL PASO DE ROBLES
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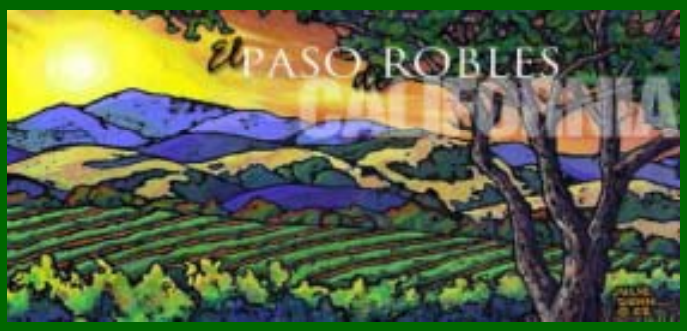

TABLE OF CONTENTS

TABLE OF CONTENTS

SECTION		PAGE
EXECUTIVE SUMMARY		**EX-1**
1.0	**INTRODUCTION/OVERVIEW**	**1-1**
1.1	Master Plan of Sustainable Opportunities	1-1
1.2	Reaching the Master Plan Goals	1-1
1.3	Renewable Energy from Wind, Solar, Biomass and Waste	1-1
1.4	Zero Waste Programs (Diversion)	1-3
1.5	Landfill Operations Recommendations	1-5
1.6	Greenhouse Gas Emissions	1-6
1.7	Economic Considerations	1-7
1.8	Next Steps	1-8
2.0	**RENEWABLE ENERGY POTENTIAL**	**2-1**
2.1	City's Energy Needs	2-1
2.2	Renewable Energy Potential	2-1
2.3	Conversion Technologies (CT) Assessment	2-2
2.4	Waste-To-Energy (WTE) Assessment	2-9
2.5	Conversion Technology and Waste-To-Energy Summary	2-11
2.6	Landfill Gas-To-Energy (LFGTE) Assessment	2-13
2.7	Solar, Wind, and Biomass Assessment	2-17
3.0	**ZERO WASTE PROGRAMS**	**3-1**
3.1	City's Existing Solid Waste Management System and Zero Waste Programs	3-1
3.2	Who Picks Up the Waste? And Where Does it Go?	3-2
3.3	What is the City Mandated to do About Diversion? How Does the City Plan for Solid Waste Programs?	3-2
3.4	Diversion Rates and Goals	3-3
3.5	City's Waste Generation	3-5
3.6	Compacted Versus Uncompacted Wastes	3-6
3.7	Waste Composition	3-7
3.8	Recommendations for the City's Zero Waste Programs	3-9
3.9	Other Options to Consider	3-17
3.10	Summary Recommendations for All Waste Streams	3-18

TABLE OF CONTENTS

SECTION		PAGE
4.0	**ZERO WASTE INFRASTRUCTURE**	**4-1**
4.1	Existing Waste Handling Summary	4-1
4.2	Summary of Facility Capacity Requirements	4-9
4.3	Assessment of Additional Facility Infrastructure Needs	4-11
4.4	Methodology	4-16
4.5	Summary of Key Findings, Conclusions, and Recommendations	4-16
5.0	**OPTIMIZATION OF LANDFILL OPERATIONS**	**5-1**
5.1	Landfill Operations Evaluation (Private vs. Public Landfill Operations)	5-1
5.2	Landfill Optimization Techniques	5-10
5.3	Potential Additional Landfill Capacity	5-21
5.4	Landfill Reclamation	5-26
5.5	Use of Sludge at the Paso Robles Landfill	5-26
5.6	Household Hazardous Waste Facility	5-29
5.7	Regulatory Compliance Inspections by the California Integrated Waste Management Board (CIWMB)/Local Enforcement Agency (LEA)	5-32
6.0	**PASO ROBLES LANDFILL GREENHOUSE GAS (GHG) EMISSIIONS**	**6-1**
6.1	Background	6-1
6.2	Comparison with Draft PMC Report	6-5
6.3	Yearly GHG Emissions Calculator	6-7
6.4	Conclusion	6-7
7.0	**FINANCIAL/ECONOMIC OPPORTUNITIES AND CONSTRAINTS**	**7-1**
7.1	Solid Waste Fees Received and Paid by the City	7-1
7.2	Alternative Revenue Generating Mechanisms	7-2

TABLE OF CONTENTS

LIST OF TABLES

Table 1-1 Disposal Quantities *(within text)*
Table 1-2 Recommended Priorities and Projected Diversion

Table 2-1 Paso Robles Citywide Electrical Usage 2006-2008

Table 3-1 Waste Generation, Diversion and Disposal Data
Table 3-2 Recommended Priorities and Projected Diversion

Table 4-1 Summary of Infrastructure Facilities and Needs Analysis/Recommendations
Table 4-2 Recyclable Material Processing Facilities
Table 4-3 Transfer Facilities
Table 4-4 Construction & Demolition Processing Facilities
Table 4-5 Composting Facilities
Table 4-6 Food Waste Composting Facilities
Table 4-7 Disposal Facilities
Table 4-8 Facility Capacity Requirements by Waste Stream

Table 5-1 City Owned Landfill in California *(within text)*
Table 5-2 Staffing Needed at Paso Robles Landfill *(within text)*
Table 5-3 Equipment Needed at Paso Robles Landfill *(within text)*
Table 5-4 Capital Cost Planning Estimates *(within text)*
Table 5-5 Available Airspace from Soil Surcharging
Table 5-6 Airspace Consumed by Daily Soil Cover (Current Working Face)
Table 5-7 Airspace Consumed by Daily Soil Cover (Recommended Working Face)
Table 5-8 Estimated Cost of Using Tarps
Table 5-9 Labor and Equipment Costs to Use Soil as Daily Cover
Table 5-10 Airspace Consumed by Side of Working Face Daily Soil Cover (Current Working Face and Intermediate Cover)
Table 5-11 Tonnage Report and Remaining Capacity

Table 6-1 2008 Green House Gas Emissions – Indirect Emissions from Electricity Use
Table 6-2 2008 Green House Gas Emissions – Landfill Vehicle Emissions
Table 6-3 2008 Green House Gas Emissions – Landfills with Collection System
Table 6-4 2006 Green House Gas Emissions – Landfills with Collection System
Table 6-5 Paso Robles Landfill Annual Green House Gas Emissions Calculator

Table 7-1 Summary of Fees Assessed on the Hauler

TABLE OF CONTENTS

Table 7-2 Summary of Development Impact Fee Survey
Table 7-3 Summary of Vehicle Impact Fees
Table 7-4 Summary of Street Sweeping Fees
Table 7-5 Facility Host Fees
Table 7-6 Tip Fees *(within text)*

LIST OF FIGURES

Figure E-1 Potential Diversion and Energy Production

Figure 1-1 Potential Diversion and Energy Production

Figure 3-1 Waste Generation, Diversion and Disposal Percentages
Figure 3-2 Waste Generation, Diversion and Disposal Percentages by Waste Stream
Figure 3-3 Waste Composition by Waste Stream – Waste Streams Controlled by Franchised Hauler
Figure 3-4 Waste Composition by Waste Stream – Uncompacted Waste Stream Delivered to Landfill
Figure 3-5 Waste Composition by Major Business Types

Figure 4-1 Solid Waste Management Facilities
Figure 4-2 Recyclable Material Processing Facilities
Figure 4-3 Transfer Facilities
Figure 4-4 Construction and Demolition Processing Facilities
Figure 4-5 Composting Facilities
Figure 4-6 Food Waste Composting Facilities
Figure 4-7 Disposal Facilities

Figure 5-1 Site Plan
Figure 5-2 2007 Aerial Survey to 2009 Ground Survey Volumes
Figure 5-3 Final Grading Plan
Figure 5-4 Cross Sections
Figure 5-5 Excavation Plan

TABLE OF CONTENTS

LIST OF APPENDICES

Appendix A: Conversion Technologies and Waste-To-Energy Feasibility Assessment
Appendix B: Landfill Gas-To-Energy Feasibility Assessment
Appendix C: Solar, Wind, and Biomass Feasibility Assessment
Appendix D: Existing Zero Waste Programs
Appendix E: Data Sources
Appendix F: Operations at Paso Robles Landfill
Appendix G: Landfill Reclamation

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The City of Paso Robles generates 45,000 tons of solid waste annually. It dumps this waste into its own landfill. Rather than just bury trash and manage the effects of its decay, this Plan identifies options to use waste beneficially.

Ideally, the City could achieve a state of "zero waste" wherein all collected solid waste is put to beneficial use and none is buried in a landfill. Such an approach (illustrated in Figure E-1) presents economic and environmental benefits:

WASTE-TO-ENERGY

Energy generating opportunities include:

Landfill Gas-to-Energy As buried trash decomposes, it releases gases (methane and other). A gas collection and microturbine system could generate 1,100 - 5,500 MWh/yr of electricity.

Solar Energy Twenty acres of land are available for solar panels. In addition, it may be possible to install a flexible solar module (landfill cap with flexible solar covers) on the southern exposed face of the inactive portion of the landfill.

The total energy production could amount to 8,300 MWh/yr. Every additional 8 acres dedicated to solar panel installation may generate an additional 2,200 MWh/yr.

Thermal Conversion Technology A thermal conversion technology facility (50 ton per day gasification plant) could produce 9,855 MWh/yr.

In summary, some energy production is possible – to what degree is a function of technology, cost and impact on other possible beneficial uses.

ZERO WASTE PROGRAMS (DIVERSION)

An estimated 28 percent of all solid waste is now diverted (recycled). This could potentially increase to over 50 percent.

The single largest material type in Paso Robles' residential waste stream is food waste. Food waste could be used in composting or harvested in an anaerobic digester (see Figure E-1). Paso Robles could arrange for a composting program, or pursue anaerobic digestion of its estimated 100 tons per day of food waste, green waste, etc. Anaerobic digestion at this scale could generate 5,500 MWh/yr.

Recycling, making use of food waste, and other solid waste programs all depend on sorting trash. Paso Robles needs the means to separate recyclables from construction debris, roll-off and self-haul loads.

LANDFILL OPERATIONS

What is the best way to achieve zero waste? – should the City operate its landfill, diversion, and/or energy generation programs? Operational control should be determined based on consideration of public benefit, cost control, value of self-determination/independence, and liability.

ECONOMIC CONSIDERATIONS

Revenues are declining while mandates and regulations are increasing costs. More revenue is needed to implement and run the programs outlined herein. Potential revenue generating mechanisms include:

- Sale of energy
- Hauler fees
- Sale of carbon credits
- Grant opportunities
- Host fees assessed on solid waste facilities
- Vehicle impact fees to recover street maintenance costs resulting from waste collection
- Landfill tipping fees
- Sale of recyclables and compost
- Solid waste development impact fees
- Street sweeping fees
- Extended producer responsibility fees and advanced disposal or advanced recycling fees

NEXT STEPS

1. Promote recycling programs, particularly to commercial and multi-family residential accounts. Establish a recyclables material sorting facility at the landfill;
2. Prepare an updated landfill capital improvement program and operations budget. Proceed with a financial analysis and proposed amended fee structure;
3. Once a sufficient revenue stream is approved, proceed with the solar project;
4. Improve the efficiency of the landfill gas collection system, then make a decision regarding the landfill gas-to-energy projects;
5. Establish feasibility of waste-to-energy conversion technology for the Paso Robles Landfill;
6. Proceed with anaerobic digestion or composting of food waste, green waste, etc.; and
7. Acquire more property as both a buffer and potential solar panel installation.

Prepared by Project Manager Christine Halley, PE

CITY OF PASO ROBLES
MASTER PLAN OF SUSTAINABLE OPPORTUNITIES

RENEWABLE ENERGY

LANDFILL GAS TO ENERGY (LFGTE)
(In Place Waste)

5,545 MWH/YR POTENTIAL ENERGY

2 MW

SOLAR
(20 Acres at the North End of the Landfill)

8,300 MWH/YR POTENTIAL ENERGY

3.8 MW

THERMAL CONVERSION TECHNOLOGY (CT)
(Gasification 50 TPD)

9,855 MWH/YR POTENTIAL ENERGY

1.5 MW

TOTAL POTENTIAL RENEWABLE ENERGY PRODUCTION
23,700 MWh/Yr

14% of Current Citywide Energy Consumption

TOTAL
7.3 MW

Enough Energy for Approximately 1,800 Single Family Homes

DIVERSION BY WASTE STREAM

(IF ZERO WASTE PROGRAMS SHOWN ON TABLE 2 ARE IMPLEMENTED)

SINGLE FAMILY
DIVERSION INCREASE 14%

COMMERCIAL/ MULTI-FAMILY
DIVERSION INCREASE 19%

CONSTRUCTION & DEMOLITION (C&D)
DIVERSION INCREASE 18%

SELF HAUL
DIVERSION INCREASE 25%

CITY WASTE
DIVERSION INCREASE 11%

INCREASE IN WASTE DIVERSION
13.5%

City of Paso Robles Potential Diversion Rate = 41.5%

FEB. 2010

FIGURE E-1 - POTENTIAL DIVERSION AND ENERGY PRODUCTION - PASO ROBLES LANDFILL

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SECTION ONE

INTRODUCTION/OVERVIEW

1.0 Introduction/Overview

1.1 MASTER PLAN OF SUSTAINABLE OPPORTUNITIES

The City of Paso Robles (City) is a community of about 29,500 residents, which is expected to grow to 44,000 by 2025 (City of Paso Robles, 2009). Located close to mountains, beaches, and deserts, it is home to one of the United States' greatest wine growing areas and an increasing number of hot springs resorts. In addition, the City owns a valuable resource, a fully permitted Class III non-hazardous solid waste landfill, the Paso Robles Landfill, which is estimated to have sufficient airspace capacity to year 2051. In developing a Master Plan for its landfill, the City was not interested in a traditional plan that focuses on continued landfilling and maximizing airspace capacity. The City's forward-thinking approach was to evaluate potential sustainable options, including renewable energy opportunities, for their solid waste management system.

The City's Master Plan of Sustainable Opportunities (Master Plan), was prepared by Bryan A. Stirrat & Associates (BAS), in partnership with the R3 Consulting Group, Clements Environmental, and Dan Predpall Consulting (the BAS Team). The purpose of the Master Plan was to develop potential sustainable options for the City's solid waste management system and recommend those that have merit for future implementation. The options identified in the Master Plan include programs, practices, operations, and infrastructure that can improve the sustainability and operations of the City's solid waste management system. These options also take into account current and future regulatory requirements, and environmental and economic factors. The proposed options, once implemented, are anticipated to generate renewable energy, increase the City's diversion rate, reduce greenhouse gases (GHG), and optimize landfill operations.

1.2 REACHING THE MASTER PLAN GOALS

After analyzing several options for the City's solid waste management system, a few priorities and programs came to light as those that would help the City accomplish its Sustainable Master Plan Goals. It is important to note that waste system components are interconnected and a decision in one area has implications for another. For example, implementing a diversion program in the commercial recycling sector would reduce waste tonnages delivered to the landfill, which in turn would reduce gate fee revenues and landfill gas production. The recommended options identified in this Executive Summary are the ones that are most viable among those evaluated for the Master Plan effort.

1.3 RENEWABLE ENERGY FROM WIND, SOLAR, BIOMASS AND WASTE

An evaluation of potential renewable energy resources at the landfill is summarized below and graphically in Figure 1-1. The Renewable Energy Potential, Section Two

of the Master Plan provides an extensive discussion and analyses of these potential renewable energy opportunities at the landfill.

TOTAL POTENTIAL RENEWABLE ENERGY PRODUCTION

The Citywide (residential, municipal and commercial) electrical consumption for the years 2006 to 2008 averaged about 172,000 mega watt hours per year (MWh/yr) or about 470 MWh/day. The United States Environmental Protection Agency (EPA) estimates that on average a single-family home consumes approximately 13 MWh/yr (EPA, 2009).The total potential energy generation from the above listed options is estimated at 23,700 MWh/yr; or 14 percent of the current Citywide energy consumption. It is estimated that the landfill could generate enough energy to provide electricity to approximately 1,800 single family homes.

LANDFILL GAS TO ENERGY

Utilizing landfill gas (LFG) for the production of energy is not a new or novel concept. There are approximately 425 landfill gas-to-energy (LFGTE) projects operating in the United States. To pursue a LFGTE project at the Paso Robles Landfill, the first step is for the City to improve the quantity and quality of LFG that is being collected at the site. This can be done by adequately tuning the existing system and the installation of additional gas collection wells. Once this is achieved, there will be two system options the City may choose to employ at the landfill as identified below.

> Option #1 – If the quality of LFG in the existing collection system is improved above the threshold of 35 percent methane, the City should next determine if it is cost effective to operate two Capstone Micro turbines (CR65) to generate electricity.
>
> Option #2 – If the LFG collection system quality is improved above 40 percent methane and the collection system expanded, LFG modeling indicates that sufficient landfill gas should be available in the future to operate a General Electric Jenbacher internal combustion engine (GE J312).

Traditional LFGTE projects using micro turbines or internal combustion engines could provide up to 2 mega watts (MW) of power. Two CR65 micro turbines could produce about 1,138 (MWh/yr). The alternative GE J312 internal combustion engine is estimated to produce about 5,545 MWh/yr but requires 5.8 times the amount of gas as compared to the CR65 micro turbine. Thus, an expansion of the LFG collection system would be needed to run the turbine.

SOLAR ENERGY POTENTIAL

There are approximately 20 acres of gently sloping land at the northern end of the landfill parcel that could be used for a ground mount solar project. In addition, it may be possible to install/adhere a flexible solar module (landfill cap

with flexible solar covers) on the southern exposed face of the inactive portion of the landfill. This proposed area would require a partial closure report submitted to CalRecycle and an Alternative Cover demonstration for the use of the liner system. The flexible solar modules make use of flexible, laminate-type photovoltaic (PV) solar collection strips developed by United Solar.

The ground mount system is estimated to produce about 6,100 MWh/yr, with a rated power output of 2.5 MW. The liner membrane system is estimated to produce about 2,200 MWh/yr. The total energy production from the two systems would be about 8,300 MWh/yr, with a rated power output of 3.8 MW.

THERMAL CONVERSION TECHNOLOGY

With the landfill's current tonnage at about 120 tons per day, there are few potential options to convert waste into renewable energy. It is recommended that the City conduct a specific analysis of the two vendors identified in Section Two of the Master Plan who can develop a commercial scale plant at 50 tons per day. The two promising thermal technologies include GEM America and Adaptive ARC. The Thermal Conversion Technology (CT) facility (50 ton per day gasification plant) could produce up to 1.5 MW of net power, or about 9,855 MWh/yr.

Planning ahead, the City should consider the following:

- Conduct a specific analysis of the two potential vendors,
- Monitor the development of ongoing CT projects in other jurisdictions,
- Pursue discussions with other local jurisdictions related to a regional CT project, and
- Consider development of a "demonstration" scale project.

1.4 ZERO WASTE PROGRAMS (DIVERSION)

In anticipation of pending legislation, stricter environmental controls and associated costs created by solid waste disposal, it is imperative to begin planning to increase diversion of solid waste currently being landfilled. Assembly Bill (AB) 479 is anticipated to require that each City and County divert 60 percent of all solid waste on and after January 1, 2015 and divert 75 percent by January 1, 2020. Also, in November 2008, the California Air Resources Board adopted the AB 32 Scoping Plan, which included a provision for mandatory commercial recycling. In response, the California Integrated Waste Management Board (now known as CalRecycle) is scheduled to adopt draft regulatory language on mandatory commercial recycling in January 2011, with final regulations anticipated to be in place by January 2012. Concerns with impacts of disposal, notably greenhouse gas emissions, should be an additional noteworthy motivator.

Before beginning to evaluate existing diversion programs for the City, the BAS Team first assessed actual and projected refuse generation and disposal tons

from residents and businesses in Paso Robles. Table 1-1 below conservatively estimates future disposal quantities using a historic, reported three-year average of 28 percent diversion for all the City's waste streams combined.

TABLE 1-1
DISPOSAL QUANTITIES

	ACTUAL (TONS)			PROJECTED (TONS)			
YEAR	**2006**	**2007**	**2008**	**2010**	**2015**	**2020**	**2025**
DIVERSION	9,872	13,092	14,632	12,693	14,038	16,345	18,692
DISPOSAL	39,188	31,884	26,734	33,022	36,519	42,522	48,627
GENERATION	49,060	44,977	41,365	45,715	50,556	58,867	67,318
PERCENT DIVERSION	20%	29%	35%	28%	28%	28%	28%

The Zero Waste Programs, Section Three of the Master Plan discusses the waste streams that were evaluated, which included single family, commercial/multi-family, construction & demolition, self-haul, and City waste. The Master Plan includes options for the City to increase its diversion rate in each waste stream category including the enhancement of existing programs and development of new programs using existing facilities. Table 1-2 in this Executive Summary provides a description of the recommended priorities and projected diversion for each waste stream (See Figure 1-1).

The estimated additional increase in diversion would be approximately 13.5 percent over the currently projected rate of 28 percent, for a projected average of 41.5 percent if all of the options shown on Table 1-2 could be implemented. This would be a big step in getting the City closer to a diversion rate of 75 percent by 2020, if the pending legislation passes.

It is also recommended that the City consider implementing purchasing policies that support the City's zero waste objectives. For example, a Source Reduction and Recycled Content Purchasing Policy should do the following:

- Recognize the need for strengthening markets for materials collected in local recycling collection systems;
- Maximize reduction of discarded materials;
- Ensure that every City department purchases environmentally-preferred products and services (without compromising overall budgetary or performance requirements);
- Serve as an example for other agencies and organizations in the community; and

- Comply with California state law, which requires local agencies to buy recycled products and allows local agencies to adopt purchasing preferences for recycled products.

It is also recommended that the City continue its legislative efforts to support Extended Producer Responsibility legislation at the State and national level. At the local level the City may wish to consider disposal bans for those materials covered by the County's "take back" ordinances.

1.5 LANDFILL OPERATIONS RECOMMENDATIONS

OPERATIONS REVIEW

The City requested a review of efficiencies in the landfill operations utilization of airspace. Improvements in soil use and compaction would help preserve long-term capacity at the site and are recommended in the operations discussion. The airspace utilization analysis conducted by the BAS Team determined that the data available was insufficient to make a definitive analysis on how airspace was utilized by existing operations. To that end it is recommended that in the future a third-party annual aerial or ground survey be conducted to better estimate the site's in-place density and airspace utilization factor from year to year. It is also recommended that the operator keep daily records of any soil used for daily and intermediate cell construction in order to better estimate existing in-place waste density, waste-to-cover ratios, and the airspace utilization factor for the landfill.

The site operator has historically had a few "areas of concern" violations, which are typically minor issues at the site. It is recommended that the City monitor and coordinate with Pacific Waste Services (PWS) to address violations in a timely manner. The City may wish to conduct its own periodic review of the site's compliance during the opening hours of the site and also at the closing of site operations. Keeping the landfill in compliance on an ongoing basis reduces the chance of having to pay fines or performing emergency repairs.

INCREASE LANDFILL GAS QUANTITY AND QUALITY

Upon review of the existing landfill gas collection system, the BAS Team recommends the inclusion of horizontal collectors in order to collect LFG earlier and avoid surface mounted pipes. Horizontal collectors can be installed as new cells are filled. The current composition of the landfill gas collected at the landfill is about 33 percent methane. Additional tuning of the collection system is necessary to improve the quality to a target of 40 to 45 percent. Once the target methane capture rate is achieved, the feasibility of a LFGTE facility increases.

PRIVATE VERSUS PUBLIC LANDFILL OPERATION

The Master Plan report also evaluated a private versus public operation and concludes that a decision as to whether the City should take over the operation

of its landfill should include consideration of whether or not the City can do a better job than a private contractor at:

1. Controlling costs;
2. Managing available airspace; and
3. Controlling and/or limiting potential liabilities.

Municipal operation of publicly-owned landfills is well established in California with the majority of both City- and County-owned landfills being operated by municipalities. While there are potential benefits to be gained by converting to a municipal operation, including greater control of the City's landfill asset and associated airspace, and greater control of and ability to limit potential liabilities, the realization of any such benefits is by no means guaranteed.

Should the City decide that it does not wish to pursue municipal operations at this time or is unable to do so until the term of the existing operating agreement expires, it is recommended that the City consider the following:

- Opportunities to restructure the current operating agreement to provide incentives for the contract landfill operator to operate in accordance with the City's best interests (e.g., increasing effective density and material diversion); and

- Undertake an Operations Review to identify opportunities for improved contractor performance, including an in-field optimum waste density evaluation. A third-party should be hired to oversee the current landfill operator, since there is no Public Works staff to conduct this for the City.

1.6 GREENHOUSE GAS EMISSION

The State of California has taken the initiative to reduce GHG emissions in order to minimize the States' impact on global warming and climate change. On September 27, 2006 Governor Arnold Schwarzenegger signed the milestone Assembly Bill No. 32 (AB 32), the Global Warming Solutions Act, which was intended to reduce emissions associated with climate change. Landfills were recognized as a source of these emissions and were included as part of the early action item list of emitters.

Environmental Protection Agency Administrator Lisa Jackson announced on December 7, 2009 that after reviewing science and public comments EPA has determined that greenhouse gases threaten the public health and welfare of the American people (EPA, 2009). This decision threatens to pave the way to new emissions regulations.

Methane is 21 times more potent as a GHG than carbon dioxide (CO_2). A one metric ton reduction in methane is equivalent to a 21-metric ton reduction in CO_2. Landfill gas utilization offers the promise for reducing GHG emissions. The EPA estimates that a 3 MW landfill gas fired power plant can reduce methane

emissions by 125,000 tons of carbon dioxide equivalent (CO_2E) per year while displacing an additional 16,000 tons of CO_2E of fossil fuel generation. Disposal of solid waste produces landfill gas that contains methane (a greenhouse gas), improving the collection efficiency of the landfill gas system can help minimize such emissions.

Solar photovoltaic projects are indirectly beneficial regarding greenhouse gas emissions. The emission factor for traditional electric generation project is 1.64 pounds of CO_2 per kilowatt hour. Similarly all of the conversion technologies included in the Master Plan report will achieve significant GHG reductions compared to landfilling. Waste diversion (zero waste practices) will also reduce GHG by reusing existing resources.

The carbon footprint or total GHG emissions from the Paso Robles Landfill was calculated to be the sum of the indirect emissions from electricity use, the on-site landfill operations vehicle emissions, the direct flare emissions, and the fugitive surface emissions. The 2006 and 2008 emissions totals are as follows:

Total GHG Emissions at the Paso Robles Landfill
2006 = 3,629.5 metric tons (CO_2E)
2008 = 3,147.5 metric tons (CO_2E)

As emissions are based on collected flow, a decline in the landfill gas flow from 2006 to 2008 resulted in a proportional decline in GHG emissions. The LFG flow rate in 2006 was 72.2 million standard cubic feet per year (MM SCFT/YR) and 62 MM SCFT/YR in 2008.

The greenhouse gas emissions from the landfill are far below the 25,000 metric tons of CO_2E reporting thresholds established by the California Air Resources Board (CARB). Therefore, the landfill is not required to report GHG emission to CARB. Improvements in the landfill gas collection system will serve to help reduce the landfill's carbon footprint (GHG emissions).

1.7 ECONOMIC CONSIDERATIONS

FUTURE PROGRAM FUNDING

The City of El Paso de Robles' financial needs and certain financial issues associated with the landfill operations and closure were reviewed. Specific items that were reviewed included: fees section of the existing agreement with PWS, franchise agreement with Paso Robles Waste Disposal, and opportunities for alternative revenue generating mechanisms.

The City currently receives the following solid waste related fees from Paso Robles Waste Disposal:

- Residential and commercial collection franchise fee of 9.34 percent, and

- Roll-Off franchise fee of 10 percent of gross receipts.

The City funds the San Luis Obispo Integrated Waste Management Authority (IWMA) from the following sources:

1. The City pays the IWMA directly $3.00 per ton of waste disposed at the landfill. The total amount paid in 2008 was $100,727.
2. Paso Robles Waste Disposal pays an AB 939 fee to the IWMA consisting of two parts: 1) a fee of $0.30 per household per month for single-family waste, equivalent to approximately $32,000 per year, and 2) two percent of gross receipts on all other lines of business (commercial, multi-family and roll-off).

The Financial/Economic Opportunities and Constraints, Section Seven of the Master Plan discusses the following nine potential revenue generating mechanisms that the City may wish to consider to fund programs/recommendations in the Master Plan:

1. Fees Assessed on the Hauler.
2. Solid Waste Development Impact Fees.
3. Vehicle Impact Fees.
4. Street Sweeping Fees.
5. Host Fees Assessed on Solid Waste Facilities.
6. Extended Producer Responsibility (EPR) Fees and Advanced Disposal or Advanced Recycling Fees.
7. Grant Opportunities.
8. Revenues from the Sale of Carbon Credits.
9. Re-Structuring Landfill Tip Fees.

The City is planning to implement a second phase (Phase 2) of the Master Plan that would include a financial/economic analysis of how to fund programs, practices, operations, and infrastructure improvements that are ultimately pursued by the City.

1.8 NEXT STEPS

Planning ahead, the BAS Team recommends that the City consider the following action items:

1. Promote recycling programs, particularly to commercial and multi-family residential accounts. Establish a recyclables material sorting facility at the landfill;
2. Prepare an updated landfill capital improvement program and operations budget. Proceed with a financial analysis and proposed amended fee structure;
3. Once a sufficient revenue stream is approved, proceed with the solar project;

4. Improve the efficiency of the landfill gas collection system, then make a decision regarding the landfill gas-to-energy projects;
5. Establish feasibility of waste-to-energy conversion technology for the Paso Robles Landfill;
6. Proceed with anaerobic digestion or composting of food waste, green waste, etc.; and
7. Acquire more property as both a buffer and potential solar panel installation.

SECTION ONE

TABLES

TABLE 1-2
EL PASO DE ROBLES LANDFILL MASTER PLAN

RECOMMENDED PRIORITIES AND PROJECTED DIVERSION

Waste Stream	Recommended Action	Existing or New Program / Facility	Material Types	Potential Additional Waste Stream Diversion Percentage	
				Percentage	Assumptions
Commercial/ Multi-Family	Develop Commercial and Multi-Family Residential Account Profile	Enhance Existing Program	NA	NA	
	Implement comprehensive commercial and multi-family outreach program	Enhance Existing Program	All existing commercial and multi-family residential diversion program materials	10% - 20%	Assumes general compliance with Mandatory Recycling Ordinance
	Implement commercial food waste collection program	New Program	Vegetative material or combined with meat scraps (depends on the processing facility)	4%	Estimate based on data from existing programs
	Establish Franchise Agreement incentives for increased diversion	Enhance Existing Program	NA	NA	
Construction and Demolition Debris/ Self-Haul	Revise roll-off rates if appropriate to increase diversion	Enhance Existing Program	Construction and demolition materials (e.g., concrete, soil, asphalt, wood, metal)	NA	
	Dedicate additional labor at working face to recover materials	Enhance Existing Program		3%	Assumes 5% recovery of C&D tonnage currently disposed
	Construct a "Recycling Pad" at the landfill	New Facility		15%	Assumes 25% recovery of C&D tonnage currently disposed
	Pre-sort area for self-haul loads	New Facility		25%	Assumes 25% recovery of Self-Haul tonnage currently disposed
City Waste	Evaluate waste stream and implement diversion programs to comply with Mandatory Recycling Ordinance	Enhance Existing Program	All existing commercial diversion program materials	11%	Assumes 25% recovery of 2,465 City Waste tons divided by 5,379 total generation
Single Family	Increase effectiveness of existing curbside recycling and green waste collection programs (additional variable waste bin rate incentives, adding new materials, contract incentives etc.)	Enhance Existing Program	All existing single-family residential diversion program materials plus potential additional curbside materials	10%	Assume 10% increase in curbside recycling tonnage
	Add food waste to existing green waste collection program	Enhance Existing Program	Vegetative material only or combined with meat scraps (depends on the processing facility)	4%	Assumes capture of ~25% of the food waste (16.7%) currently being disposed at 50% current waste stream diversion rate

SECTION ONE

FIGURES

CITY OF PASO ROBLES
MASTER PLAN OF SUSTAINABLE OPPORTUNITIES

RENEWABLE ENERGY

LANDFILL GAS TO ENERGY (LFGTE)
(In Place Waste)

5,545 MWH/YR POTENTIAL ENERGY

2 MW

SOLAR
(20 Acres at the North End of the Landfill)

8,300 MWH/YR POTENTIAL ENERGY

3.8 MW

THERMAL CONVERSION TECHNOLOGY (CT)
(Gasification 50 TPD)

9,855 MWH/YR POTENTIAL ENERGY

1.5 MW

TOTAL POTENTIAL RENEWABLE ENERGY PRODUCTION
23,700 MWh/Yr

14% of Current Citywide Energy Consumption

TOTAL
7.3 MW

Enough Energy for Approximately 1,800 Single Family Homes

DIVERSION BY WASTE STREAM

(IF ZERO WASTE PROGRAMS SHOWN ON TABLE 2 ARE IMPLEMENTED)

SINGLE FAMILY
DIVERSION INCREASE 14%

COMMERCIAL/ MULTI-FAMILY
DIVERSION INCREASE 19%

CONSTRUCTION & DEMOLITION (C&D)
DIVERSION INCREASE 18%

SELF HAUL
DIVERSION INCREASE 25%

CITY WASTE
DIVERSION INCREASE 11%

INCREASE IN WASTE DIVERSION
13.5%

City of Paso Robles Potential Diversion Rate = 41.5%

FEB. 2010

FIGURE 1-1 - POTENTIAL DIVERSION AND ENERGY PRODUCTION - PASO ROBLES LANDFILL

BAS A TETRA TECH COMPANY

SECTION TWO

RENEWABLE ENERGY POTENTIAL

2.0 Renewable Energy Potential

This section of the report provides an overview of the City's potential renewable energy resources at the Paso Robles Landfill and provides recommendations for further analysis of those resource opportunities and justification for such recommendations.

The BAS Team members who contributed to this evaluation included Chip Clements (Clements Environmental) who assessed Conversion Technologies (CT) and Waste to Energy (WTE), Keith Johnson (BAS) who evaluated Landfill Gas-to-Energy (LFGTE) and Dan Predpall Consulting who evaluated the Solar, Wind and Biomass renewable energy options for the Paso Robles Landfill.

2.1 CITY'S ENERGY NEEDS

PG&E's records of the City's total electrical usage from 2006 to 2008 averaged 172,000 MWh/yr for residential, municipal, and commercial usage. With a population of 29,500 for year 2007 which is projected to increase by 50 percent by year 2025 to 44,000, the electrical usage was likewise projected to increase by 50 percent. The electrical usage needs for 2025 are estimated to be 258,000 MWh/yr. See Table 2-1.

CITY SECTOR	Three-Year Average Annual Electrical Usage (2006-2008) – (MWh/yr)	Projection of Annual Electrical Needs – Year 2025 (MWh/yr)
Residential	74,021	111,000
Municipal	553	850
Commercial	97,627	146,400
Total Citywide – Annual	172,200	258,300
Total Citywide - Daily	472	708

2.2 RENEWABLE ENERGY POTENTIAL

A discussion of Conversion Technologies (CT), Waste to Energy, Landfill Gas to Energy, Solar, Wind and Biomass potential at the landfill follows. A potential renewable energy production diagram summarizes this analysis and is shown as Figure 1-1. The estimated potential renewable energy from current landfill resources ranges from 4 to 7 MW of net power.

2.3 CONVERSION TECHNOLOGIES (CT) ASSESSMENT

Conversion Technologies (CT) include a wide array of thermal, biological, chemical, and mechanical technologies capable of converting municipal solid waste (MSW) into useful products and chemicals, fuels such as hydrogen, natural gas, ethanol and biodiesel, and energy in the form of steam and/or electricity. CT's are currently used to manage solid waste in Europe, Israel, Japan and Australia, but are not yet in commercial operation in North America with the exception of MSW composting which is operation in several locations in the U. S. as discussed in Appendix A.

Public sector interest in CT has increased in the United States (U.S.) in recent years, based on the desire to enhance recycling and beneficial use of waste, reduce dependence on landfilling and imported fossil fuels, and reduce greenhouse gas (GHG) emissions.

There have been pilot demonstrations of biological and thermal CT in the U.S., but the absence of larger-scale commercial facilities in North America has been an obstacle to demonstrating the capabilities and benefits of these technologies for processing MSW. Currently, the first such commercial thermal demonstration plant (Plasco – plasma arc gasification) is now in full operation in Ottawa, Ontario, Canada after an extensive two-year start-up and retrofit period.

Several jurisdictions in California (i.e., City of Los Angeles, County of Los Angeles, City of San Diego, City and County of Santa Barbara, the Salinas Valley Solid Waste Authority, and the County of Orange) are either undertaking feasibility studies or developing CT projects; so much information was gleaned from these other studies by the BAS Team. CTs were evaluated to determine if renewable energy from these technologies is feasible for the City's waste stream. An assessment was made to determine if such technologies are generally practical and feasible for the City. Key issues that were evaluated in this Phase I assessment for CT included:

1. Site Evaluation
2. Waste Stream Flow Control
3. Permitting
4. Waste Diversion Credits
5. Support for CT in the Community
6. Risk
7. Power Generation/Value of Electricity
8. Alternative fuels
9. Pilot, Demonstration, or Commercial Scale CT
10. AB 32 Greenhouse Gas (GHG) Reductions
11. Cost/Benefit of CT versus Disposal at the Paso Robles Landfill

A comprehensive discussion regarding these issues is included in Appendix A, *Conversion Technologies and Waste to Energy Feasibility Assessment.* Also included in Appendix A is extensive background information on CTs and the vendors and projects associated with these technologies. A summary of these 11 issues associated with CT are discussed below.

1. Site Evaluation

The potential for a CT project at the northern portion of the Paso Robles Landfill property is "good" overall. A "small" modular CT (or WTE) plant of roughly 100 tons per day (TPD) will require approximately two to four acres of native land. There are 20 acres available at the northern portion of the landfill property; more than enough not only for the CT plant but also for composting residue from digesters, if a biological technology is selected. The proposed CT site would also be well-buffered visually from State Route 46 and the site is also well removed from residential areas. Water supply is available, but restricted with one well producing roughly 10,000 gallons per day (gpd) and another located on the southern boundary of the site. For those CTs that would generate electricity, a substation would need to be constructed and an interconnection with the PG&E grid established.

2. Waste Stream Flow Control

The City has full control over the City-generated waste stream, which is roughly 75 percent of the material received at the landfill. The other 25 percent comes from other County sources, which the City does not control.

Both the City's and the landfill's overall annual disposal tonnage has been falling dramatically over the past few years as shown below:

Year	Annual City-Disposed Tonnage
2006	39,671 tons
2007	33,844 tons
2008	26,248 tons

For a complete discussion regarding population information, waste generation, disposal, and diversion see Section 3.5 and Table 3-1.

Based on the 2008 tonnages, the City would have control of approximately 85 TPD available for a CT plant, assuming a 310 day per year operation. Initial indications from the substantial wine industry in the Paso Robles region are that all organic waste material (vines, pumice, etc.) is not landfilled, but either processed and reused as soil amendment at the vineyard, or shipped to one of the local composting operations. It is assumed for this study that this material would not contribute to the MSW waste stream.

Although waste stream projections predict that disposal tonnages will increase to 48,627 tons by 2025 (156 TPD), it is difficult to forecast whether this will occur or not given the impact of the current economic recession and increasing recycling mandates. This is an important consideration, as an available waste stream below 100 TPD which would fall within an uncertain growth pattern is too small for the vast majority of the CT vendors active in the market today. The situation is somewhat improved with an upward trend in disposal at the 150 TPD range, this falls within the lowest commercial range for a few CTs.

A regional approach could be beneficial, wherein the City, the County Integrated Waste Management Authority and some of the other cities in the region could form a Joint Venture and combine their waste streams. Transportation costs to bring additional MSW to the facility would also need to be factored into the economics. At 250 to 300 TPD, the many more CT vendors would be interested in a plant and their economics improved substantially.

However, the BAS team has identified two vendors who provide smaller scale units applicable to the existing waste stream in Paso Robles: GEM America and Pyromex. Gem America has a 50 TPD (expandable to 150 TPD) plant in start-up operations in England; and Pyromex likewise a 25 TPD standard commercial unit in Munich, Germany. Performance information for these two plants should be available by the end of the year. If successful, both of these technologies could offer viable options for Paso Robles.

3. Permitting

The permitting pathways will be challenging but do-able for any CT project developed in Paso Robles, not only because of the stringent regulatory requirements, but also because no commercial CT project (processing MSW) has been permitted in California to date. This leads to a level of uncertainty that will not be alleviated until the first projects are developed. Permits that would be required of a CT are as follows:

Assuming the CT facility will receive post-recycled, mixed MSW, the following permits and approvals will likely be required:

- A Conditional Use Permit (CUP): either revision of the existing landfill CUP, or a new CUP as a stand-alone facility.
- California Environmental Quality Act (CEQA) clearance: either a full Environmental Impact Report (EIR), focused EIR, or Mitigated Negative Declaration (MND).

- Permits to construct and operate from the San Luis Obispo County Air Pollution Control District (District) non-attainment for Ozone and PM 10.

  The District follows both the State of California Implementation Plan (SIP) and local District Rules. Because the landfill is "large" as defined in NSPS/EG and has a Title V Air Permit, the addition of a CT project would require a revision to the current permit. The type of permit revision would be dependent upon the size and type of the CT project being permitted and the associated emissions. Lastly air emission offset requirements would need to be evaluated.
- Construction and General Industrial Stormwater Permits from the Central Coast Regional Water Quality Control Board.
- Industrial Wastewater Discharge Permit (if wastewater is discharged to the sanitary sewer).
- Amendment of the County Non-Disposal Facility Element (NDFE) or Countywide Siting Element.
- Solid Waste Facility Permit (SWFP), either a revision of the existing landfill SWFP or a new SWFP as a stand-alone facility.

Given the good site conditions and the support of City elected officials, a CT project could be permitted at the landfill. The process may take at the minimum two years and may require an Environmental Impact Report (EIR) and a very comprehensive public outreach and education program.

4. Waste Diversion Credits (AB 939)

The implementation of a CT facility in Paso Robles would have a profound effect on diversion credits for the City. Under the new AB 939 accounting method, all calculations of diversion are based on the actual tonnage disposed at a landfill. Given the conversion of 85 percent to 99 percent of incoming landfill-bound MSW tonnage through a CT facility, diversion in the City of Paso Robles could be expected to soar even though the existing CIWMB's fractured and convoluted regulatory framework for diversion credit. . The current state of affairs related to CT permitting and diversion credit is summarized in Table 6 of Appendix A and is taken from the CIWMB guidance document.

5. Support for CT in the Community

It is beyond the scope of this Phase I study to gauge the support for CT in the Paso Robles community. However, it can be said that both the City Manager and Public Works Director are very interested in the feasibility of this technology both now and in the future to convert the City's MSW from landfill disposal to renewable electricity or fuel.

It is difficult to anticipate what the general support or opposition in any community until a project is actively proposed. From recent experience around the State, it can be said that the biological technologies are generally supported by the environmental groups, while the thermal technologies are opposed due to unfounded, but perceived concerns regarding air emissions and public health.

6. Risk

The 69 CT vendors listed in Table 1 of Appendix A represent a range of development from pilot to demonstration plant to fully commercial facilities. The majority fall in the first two categories, while a minority is fully-proven – but only overseas, with the exception of MSW Composting, which is proven in the U.S. Some are on the cusp of transitioning from one category to another such as Plasco just recently achieving full operation of their 100 TPD demonstration plant, or ArrowBio recently reaching 100 percent operational status of their first commercial plant at 300 TPD in Sydney, Australia.

The technological and economic risks will likewise vary depending on the vendor selected and the City's ability to assume higher risks for lower cost; by participating in project financing, for example. Conversely, the City can lower its risk by requiring the CT vendors to fully finance the facility themselves, with nothing more than a waste stream guarantee (and perhaps a site location contribution by the City).

The CT industry is maturing and each year more vendors enter the arena, and those already established at one level or another make progress. At this point, it is an emerging industry with attractive up-side benefits that may make it worth the risk for communities to develop a CT project now if the funding can be obtained.

7. Power Generation/Value of Electricity

There is a significant difference in power generation per ton of feedstock between the biological and the thermal processes. The biological processes generate approximately 200 kWh per ton, while the thermal processes generate close to 800 kWh. Therefore, a 50 TPD anaerobic digestion plant, if one could be economically built that small, would generate 400 kilowatts (kW), while a thermal process of this size would generate approximately 1.5 megawatts (MW) of net power.

A rule of thumb used by one of the thermal CT vendors is that a typical community can generate roughly one-third of their electricity needs by converting its MSW to power.

Pacific Gas & Electric (PG&E) payments for renewable energy are relatively robust at roughly $0.13/kWh, which will help offset the higher initial cost of CT.

A recent sensitivity analysis performed by Clements Environmental for the County of Orange, California showed that for each $0.01/kWh increase in electricity value, the tipping fee could be dropped $5 to $10 per ton for the thermal processes. The change is less dramatic for the biological technologies as they generate much less power per ton per ton of incoming waste.

8. Alternative Fuels

There has been a recent shift in focus by CT vendors to production of transportation fuel as their primary product as opposed to electricity. This shift has been driven primarily by legislation such as the "low carbon fuel standard," the complications of permitting power generating facilities (e.g., air emission offsets), and the misperception in the public and among environmental groups that thermal CTs are "incinerators in disguise." It is difficult to characterize a CT facility as an incinerator when the plant is producing vehicle fuel.

Biological CTs can process their methane-rich biogas into compressed natural gas (CNG) or liquified natural gas (LNG), while thermal CTs can convert their hydrogen and carbon monoxide (CO) syngas into diesel fuel via the Fischer-Tropsch process. If the City converted its City fleet to CNG, the City would require about 10,000 gallons per year. Clearly, other much larger users would need to be enrolled in the area to justify a CNG CT plant, or the product would need to be trucked to a large urban center.

9. Pilot, Demonstration, or Commercial Scale CT

With less than 100 TPD of an available and guaranteed waste stream at this time, the City will have a difficult time attracting much interest from the CT vendor community that is presently chasing projects all over the world, let alone the U.S. and California. In California alone, there are numerous projects and competitions already occurring for much larger, high-profile projects. The vendors are spread thin, and are marshalling their resources and targeting their efforts on fewer, high potential projects.

That being said, there is a segment of the CT community that to this point has not progressed beyond the pilot plant stage that might be interested in a demonstration project in Paso Robles. These demonstration projects tend to fall in the 50-100 TPD range that matches the Paso Robles waste stream tonnages, and are meant to prove the technology at a small, but commercial pilot scale. Often, these take the form of one commercial-scale module (when a true commercial plant would have at least two such lines). Such a project was recently proposed in Santa Cruz County.

However, even these companies are successful one would expect to see the demonstration plant expand into a commercial project with a doubling, tripling, or quadrupling in size of the waste stream. This is not likely to be sustainable by

the Paso Robles waste stream. Moreover, without a demonstration plant already in operation, these more nascent companies are more vulnerable to attack by environmental groups and local opposition, as was proven recently in Santa Cruz, California.

On the commercial scale, two CT vendors are able to provide a commercial plant as small as 100 to 150 TPD. A couple of examples are GEM America and Adaptive ARC. Others could accommodate the 100 TPD site by constructing only one module, when their typical smallest plant would preferably be two modules for redundancy and better economies of scale. Other vendors, such as, ArrowBio, could build a plant at the slighter higher 150 TPD range, but caution that the cost is significantly higher than for a 300 TPD, two line plant. The City would need to partner with other entities in the region to support a larger waste stream.

10. AB 32 Greenhouse Gas (GHG) Reductions

Another driving factor for development of CTs in California is AB 32 requirements to reduce GHG emissions. It is beyond the scope of this feasibility study to provide a detailed analysis of the type of GHG reductions achievable with the various CT technologies; however, all the major types of technologies included in this report will achieve significant GHG reductions compared to landfilling. These reductions come in the following areas:

- Avoidance of landfill methane emissions that would have occurred had the waste been landfilled.
- Offsetting of the GHG emissions that would have occurred to generate the equivalent amount of electricity from fossil fuels, or to produce the equivalent amount of fossil fuel for those technologies making transportation fuel.
- GHG reductions for front end recycling at the CT plant.
- GHG reductions for composting of residual material from anaerobic digestion facilities.

11. Cost/Benefit - CT versus. Disposal

On strictly a tipping fee basis, CT is currently more expensive than landfill disposal. As shown in the table below, the current Paso Robles Landfill tipping fee is approximately $40 per ton whereas CT tipping fees for smaller size plants range from $70 to $140 per ton. The small size of the waste stream in Paso Robles eliminates economies of scale that are critical for some of the CT technologies. With such a small waste stream, costs for CT can be expected to be in the higher portion of the range rather than the lower. On the other hand, the tipping fee at the landfill has not been increased in seven years and is overdue for a review and possible adjustment; a $5 per ton increase is shown in

the table. Any such increase will narrow the gap between the landfill and CT gate fees.

Technology Type	Current Tipping Fees ($/Ton)
Landfilling	$45(*)
Anaerobic Digestion	$70-100
Thermal Conversion	$70-140

(*) assumes a $5 per ton increase over current $40 tipping fee

However, just comparing the tipping fees does not provide a complete picture of the economics of a project. Further evaluation of CTs for Paso Robles would require consideration of benefits such as the value of increased diversion, GHG reductions, carbon credits, and generation of renewable energy and fuels to offset the higher cost.

Given these results, sufficient economic viability may warrant further analysis through a more in-depth, site-specific feasibility study of selected technologies. Through such a feasibility study, the City could solicit direct CT vendor input on capital and operating costs, revenues, and performance, which would result in more project and technology specific information. Ultimately, through a formal procurement process which creates a competitive environment, technology suppliers would provide their best pricing and guaranteed performance.

Based on the economic analyses presented herein, all of the conversion technologies present higher tipping fees than does continued landfilling in the City. Alternative project configurations may mitigate these differences. For example, CT projects would become more competitive with landfill tipping fees if 30-year financings and higher electric power prices were assumed. Also, other considerations that may be applicable in the future, such as State or Federal grants, would improve project economics. For example the American Recovery and Reinvestment Act and the California Energy Commission have various grant programs that should be explored for potential funding of a CT or WTE project for Paso Robles.

2.4 WASTE–TO-ENERGY (WTE) ASSESSMENT

There are currently 87 WTE plants operating in the U.S. They process a significant portion of the total MSW waste stream for the U.S. The plants tend to be large in size, with the average being about 1,000 TPD.

In contrast to CT, which is an emerging industry, the WTE industry is mature and proven and the U.S. is among the world leaders in this arena. California has three WTE plants; all built over 20 years ago:

- Commerce (1987, 350 TPD, 10 MW)
- SERRF, Long Beach, (1988, 1,380 TPD, 37.5 MW)
- Stanislaus County (1989, 800 TPD, 22 MW)

Over the years, there have been significant upgrades to the pollution control systems at WTE plants, including control of mercury, dioxin and furan emissions. Ash residue is either landfilled or mixed with concrete and used for road base, typically at the landfills.

Of the 87 plants operating in the U.S., only a handful are designed in the 100 TPD range appropriate for a waste stream the size of Paso Robles'. These plants typically produce steam as their primary product and are often coupled with a large steam user. The average tipping fee for WTE plants in this capacity range is about $100 per ton.

As was the case with CT, the smaller size of the plants and their throughput capacities increases costs dramatically compared to larger plants. This is why most WTE facilities are at least 500 TPD, and many are as large as 2,000 or 3,000 TPD.

Other issues with WTE in Paso Robles include:

- Diversion versus Disposal: WTE plants are defined as "Transformation" facilities in California. As such, they are classified as "Disposal" not "Diversion" and all waste processed in them is counted as *disposal* for AB939 reporting purposes. (The exceptions are the three existing WTE plants in the State that are grandfathered in as "Diversion" up to 10 percent of a jurisdiction's total diversion.).
- Public Opposition: The greatest challenge to developing a new WTE plant in California is the overwhelming and sometimes brutal opposition from environmental groups and the public at large (especially in the local area of the proposed plant). This opposition has become so organized and mobilized that it has been virtually impossible to site a new facility for years. This is particularly true in California where the environmental groups are very powerful, particularly in Sacramento.
- Permitting: Due to the opposition stated above, permitting would be extremely arduous and perhaps impossible. Any California Environmental Quality Act (CEQA) analysis could be expected to be attacked and challenged in court. Although these plants have proven that they can meet all air quality requirements, there is still a perception that WTE plants are hazardous to public health. In addition, because WTE plants are classified as "Disposal", jurisdictions must amend their Countywide Siting Element to include such a facility; this is a daunting process.

- Electricity versus Fuel: Unlike CTs that can produce either electricity or fuel, WTE can only produce electricity. This could be a disadvantage in non-attainment areas (such as Paso Robles) where emissions from power generation may require expensive offsets.
- Best and Highest Use: There is a judgment in the environmental community that material should be recycled or composted and that WTE plants destroy the material, even though energy is produced. Energy production is deemed a lower use, and should only be applied after all efforts at recycling have been exhausted. This argument is also used against CTs.

2.5 CONVERSION TECHNOLOGY AND WASTE-TO-ENERGY SUMMARY

Key findings regarding CT and WTE for the City of Paso Robles Landfill are as follows:

1. The Paso Robles Landfill offers a good site location for a CT or WTE project.
2. Tipping fees for CT or WTE can be expected to be substantially higher than landfill tipping fees unless offset in the future by increased payments for renewable electricity or low-carbon fuels and/or sales of carbon credits in a cap and trade system or State and Federal grants (California Energy Commission, U.S. Department of Energy). The 2008 MPR (current) is about $0.13/kWh which is a positive factor that will make tipping fees for CT or WTE more competitive with landfilling. Tip fees for WTE in the Paso Robles required range (100 TPD) are approximately $100 per ton. CT tip fees run $70 to $100 for Anaerobic Digestion CT and $70 to $140 per ton for Thermal Conversion CT.
3. The small volume of the City of Paso Robles waste stream is an impediment in that it offers little economy of scale and falls at the very lowest range of commercial feasibility for both CT and WTE. In fact, for most of the technologies on the market today to be cost effective; a waste stream of 150 to 200 TPD is needed at a minimum. However, there are two promising thermal technologies that are designed for smaller communities with waste streams as low as 25-50 TPD that are appropriate for Paso Robles. Each of these has their first commercial facilities in start-up mode. At 50 TPD, these technologies could generate about 1.5 MW of net power.
4. To increase the CT project to a more feasible scale, the City could consider formation of a Joint Venture with the County Solid Waste Authority and other nearby jurisdictions to aggregate their waste streams.
5. The existing waste stream is of the size that could support a “demonstration” facility. However, a CT vendor may be hesitant to propose such as plant without the possibility of expansion to a commercial size in the future (e.g., a 100 TPD demonstration facility expanding to a 200 TPD commercial plant).

6. Permitting will be arduous with any project, as no CT projects processing MSW have been permitted in California to date. The development pathway is expected to be easier for biological technologies as these do not attract the same level of opposition as thermal CTs. A WTE project should anticipate severe and targeted opposition from both environmental groups and the public.

All this being said, for the first time in history, there is a nexus of forces driving the development of CT projects forward in California, including:

- Climate Change and AB32 GHG reduction
- Renewable Portfolio Standard (RPS)
- Low Carbon Fuel Standard
- Proposed increases in mandatory diversion rates
- Public and elected official sentiment against continued landfilling
- Public support for renewable, domestic energy and fuel

CONVERSION TECHNOLOGY AND WASTE-TO-ENERGY NEXT STEPS

CT and WTE may be feasible at the Paso Robles Landfill. If the City wants to pursue a project in the near future, these are the recommended next steps:

1. Monitor the development of ongoing CT projects in Los Angeles, Santa Barbara, Salinas and other areas of California and Nevada.
2. Monitor and support legislation in Sacramento that would support development of CTs in California, such as AB 222.
3. Pursue discussions with other local jurisdictions related to aggregating their waste streams for a potential regional CT project. Need to consider transportation costs.
4. Conduct a landfill tipping fee study which is long overdue.
5. Conduct a specific analysis of the following:

    a. WTE: Modular combustion units generating steam or electricity.
    b. CT: The two vendors that can develop a commercial scale plant at 50 TPD.
    c. CT: Vendors that would be willing to develop a “demonstration” 50 TPD plant.

2.6 LANDFILL GAS-TO-ENERGY (LFGTE) ASSESSMENT

According to the Environmental Protection Agency’s (EPA) Landfill Methane Outreach Program (LMOP), there are approximately 425 landfill gas-to-energy (LFGTE) projects operating in the United States (U.S.); 307 projects that are

generating electricity generation and 118 that are direct use projects. These projects have demonstrated that using LFG for energy can be a win/win opportunity. Landfill gas (LFG) utilization projects can involve citizens, non-profit organizations, local governments, and industry in sustainable community planning and create partnerships. These projects go hand-in-hand with a community's commitment to cleaner air, renewable energy, economic development, improved public welfare and safety, and reductions in greenhouse (global warming) gases.

The Phase I feasibility assessment involved the following tasks:

- Overview of Available Credits and Incentives
- Landfill Gas Use Options
- Site Evaluation
- Applicable Regulatory Requirements, and
- Landfill Gas Quality and Quantity at the Paso Robles Landfill

The detailed assessment can be found in Appendix B, *Landfill Gas-to- Energy Feasbility Assessment.* A summary of the findings is presented herein.

The BAS Team has evaluated the site logistics and believes that a landfill gas to electricity project may be viable at the Paso Robles Landfill if these two key issues can be addressed:

1) Improve LFG quality to a range of 40 to 45 percent methane and
2) Increase the quantity of LFG collected.

LFG is being generated within the landfill with a composition of 55 percent methane and 45 percent carbon dioxide. The methane content of the LFG reaching the flare station is reduced as a result of dilution with ambient air. An inspection of the collection system to locate any ambient air leaks is advisable. In addition, more frequent tuning of the LFG wells may be necessary to increase gas quality. Gas flow will increase with time as the collection system is expanded.

Appendix B, Attachment 2 includes a gas generation model and gas quality estimate for the Paso Robles Landfill. The projected gas flows evaluated were based on waste flow projections contained in Pacific Waste Services' May 31, 2008 Landfill Emissions Estimate. Assuming a collection efficiency of 75 percent and using the lower value of 102 scfm results in a methane flow rate of 76.5 scfm of methane. Actual methane collected by the existing system is 39 scfm.

POTENTIAL USE OF LFG FROM THE PASO ROBLES LANDFILL

The simplest and most cost-effective use of LFG is as a medium BTU fuel. Based on preliminary research, there are no medium BTU users within an economic distance from the landfill. However, the existing flare can be retrofitted to destroy condensate or leachate produced at the landfill. This would be a beneficial use of the LFG, if the City is incurring a cost to dispose of the condensate or leachate.

Methane flow will continue to increase over the 30-year term of a potential LFG to energy project at Paso Robles. Modeling indicates that sufficient LFG should be available to operate a Jenbacher J312 internal combustion engine in the future which requires 93 scfm of methane. This would be possible if and when if the LFG collection system is expanded. There could be sufficient LFG to operate two CR65 micro turbines, if LFG quality can be increased above the threshold value of 35 percent methane.

Electricity for on-site use or sale to the PG&E grid can be generated using a variety of different technologies, including internal combustion (IC) engines, turbines, microturbines, Stirling engines (external combustion engine), Organic Rankine Cycle engines, and fuel cells. BAS evaluated the viability of these options and analyzed the most viable technologies; reciprocating IC engines and gas microturbines.

A General Electric Jenbacher J312 (GE J 312) internal combustion engine with a gross output of 633 kW requires LFG with a methane content in the range of 40 to 45 percent. Currently the collection system is producing gas below this range. Internal combustion engines are the least cost option for electrical generation on a $/kW basis. The minimum fuel flow for a GE J312 is 93 scfm of methane.

A Capstone Microturbine requires a minimum of 35 percent methane, which is also above the concentration currently produced by the collection system. The minimum fuel flow for a Capstone CR65, with a gross output of 65kW, is 14 scfm of methane.

Based on the most recent source test, the existing flare is nearing its maximum design capacity of 2.8 MMBtu/hour (currently 2.36 MMBtu/hr). Diverting some or all of the LFG from the flare will defer the need to add a second flare as LFG flows continue to increase. It is anticipated that methane generated will double between now and the year 2026, based on a consistently increasing flow of waste to the landfill. Additional flare capacity will, therefore, be required. The avoided cost of not purchasing a flare would offset some of the capital cost electrical generation equipment.

The LFGTE project having the most merit would be an electrical generation project that takes advantage of PG&E's Feed-in Tariff program. The AB 2466 Self

Generation program may be advantageous if the City is paying more than $0.093 per kWh.

Typically, publicly developed LFGTE projects have a higher net present value. The four primary differences between public and private projects are 1) for a private project the rate of return on capital invested is relatively high due to the risk associated with LFGTE projects (private developers must make a large profit), 2) some key incentives (such as Feed-in Tariffs) are only available to public entities, 3) the interest rate on capital for public projects is lower, and 4) a personal property tax expense exists for private project developers. For these reasons the City may want to be the owner of the project.

The City is currently negotiating with PG&E related to locating a transformer and switchyard near the landfill. The new PG&E substation could be built with provisions to allow easy interconnection of a LFG to electricity project. This could significantly reduce the interconnect cost and improve the viability of a project.

OVERVIEW OF APPLICABLE CREDITS AND INCENTIVES

Various incentives and subsidies may provide some economic support for a potential LFG to energy project. Some of these incentives and subsidies relate to a project's green attributes and others, such as tax credits, do not. A discussion of the various incentives and subsidies is included in this evaluation, along with an analysis of their potential applicability.

One of the most viable of these incentives and subsidies is the sale of Renewable Energy Certificates (RECs). RECs are available if a product of the LFGTE project is electricity. RECs can be sold in the Compliance REC Marketplace or the Voluntary REC Marketplace. Because the state of California has adopted a Renewable Energy Standard for electricity producers, a Compliance REC Marketplace exists. The RECs have a greater value in the Compliance REC Marketplace.

Another viable subsidy would be the Federal Renewable Energy Grants. A renewable electrical energy project would be eligible for a Section 1603 Grant under the American Recovery and Reinvestment Act of 2009. A Section 1603 Application "Payments for Specified Renewable Energy Property in Lieu of Tax Credits" would need to be completed to obtain grant funding. Generally, a tax paying entity is not eligible; therefore the City would have to structure the project such that a private company developed the LFG resource. Projects that begin construction between January 1, 2009 and December 31, 2010, and are placed in service before the Credit Termination Date are eligible. The Credit Termination Date for a LFGTE project is January 1, 2014. All grant applications must be received before October 1, 2011. Grants for LFG projects are 30 percent of the project's eligible construction costs.

A project developed by the City would qualify for the California Feed-in Tariff program or the AB 2466 Self Generation Program. The decision regarding which program to apply for would be based on what price the City is currently paying for electricity. If the City is paying less than $0.093 per kWh than the Feed-in Tariff program would be more advantageous.

Other incentives and subsidies, such as greenhouse gas credits, renewable energy production incentives, and emission reduction credits may not be available for the Paso Robles Landfill. Because the landfill has an existing LFG collection system and flare station, there would be limited opportunity for GHG credits at this site. The California Climate Action Registry Landfill Protocol requires that the methane that could be combusted in the existing flare (the flare's maximum capacity) be subtracted from the total amount of methane collected at the site. The "additional" methane available for credits would be the difference between the two. Further, installation of the LFG collection system must have been voluntary. If the LFG collection system was installed as a result of federal, state or local regulations, the site is not eligible for GHG credits. Based on a review of an August 7, 2009 email from Mr. Jim Wyse (Pacific Waste Services) to Mr. Doug Monn, the installation of the LFG system was required; therefore it is BAS' opinion that the Paso Robles Landfill is not eligible for GHG credits.

LANDFILL GAS-TO-ENERGY (LFGTE) NEXT STEPS

In order to pursue a LFGTE project at the Paso Robles Landfill, the City needs to focus on the quantity and quality of LFG that is being collected at the site.

1. To increase the quantity of the LFG collected, the BAS Team recommends expanding the existing LFG collection system to include horizontal collectors not just the vertical wells that are currently in place. Horizontal collectors can be installed as new cells are filled. Installation of horizontal collectors will allow earlier collection of LFG, and will not inhibit equipment traffic on the surface of the fill.
2. Conduct an inspection of the LFG collection system for ambient air leaks.
3. Tune the LFG system to minimize air intrusion into the LFG collection system and improve the methane content of the LFG being collected.
4. If the quality of the LFG is improved above a threshold of 35 percent methane, determine if it is cost effective to operate two CR65 micro turbines to generate electricity.
5. If the LFG collection system is expanded, modeling indicates that sufficient landfill gas should be available in the future to operate a GE Jenbacher internal combustion engineer (GE J312) since it only requires 93 scfm of methane. This should be evaluated at the appropriate time.

2.7 SOLAR, WIND, AND BIOMASS ASSESSMENT

The purpose of this evaluation was to determine if wind, solar or biomass renewable energy is feasible at the Paso Robles Landfill. Opportunities for these renewables were examined in terms of resource availability, siting, technology selection and feasibility, performance, economics, and environmental impacts and benefits. The detailed assessment can be found in Appendix C*, Solar, Wind and Biomass Feasibility Assessment*.

WIND

The wind data for the vicinity of the landfill was evaluated from maps published by the California Energy Commission. Our assessment of the data indicates that the landfill site lies within an area with minimum wind resources, or Class 1. The wind speed data for Paso Robles Airport is an average of 7.1 miles per hour, measured at 10 meters from the ground surface. Typically, an area with a Wind Class of at least "3" is needed for the economical production of wind energy.

The evaluation of the potential wind energy at the Paso Robles Landfill demonstrated the least promise for the landfill. Wind speeds are insufficient to generate electricity at an economic level, even considering wind turbines designed for lower wind regimes.

SOLAR

There are two broad types of solar energy technologies: solar thermal (also called concentrated solar), and solar photovoltaic (PV). The opportunity for solar energy at the landfill is summarized as follows:

- The Paso Robles area has excellent global horizontal irradiance levels and moderate levels of direct normal irradiance.

DIRECT NORMAL IRRADIANCE AND GLOBAL HORIZONTAL IRRADIANCE FOR THE CITY OF EL DE PASO ROBLES COMPARED TO OTHER LOCATIONS IN CALIFORNIA

Location	Direct Normal Irradiance (DNI) ($kWh/m^2/day$)	Global Horizontal Irradiance (GHI) ($kWh/m^2/day$)
Paso Robles	6.18	5.14
Los Angeles	5.16	4.95
Sacramento	5.35	4.75
Bakersfield	5.60	5.21
Daggett (Riverside)	7.54	5.78

- There are approximately 20 acres of gently sloping land at the northern end of the landfill parcel that could be used for a ground mount solar project. In addition, it may be possible to install/adhere a flexible solar module on the southern exposed face of the closed portion of the landfill.
- The DNI at Paso Robles is about 6.18 kWh/m^2/day. This DNI is border line to low for efficient operation of a solar thermal project. In addition, the area of the site is too small for an economic facility. As a result, solar thermal is not a feasible technology for the Paso Robles Landfill.
- With regard to technology, crystalline or thin-film modules could potentially work on the ground mount system. A detailed study would be needed to compare these technologies, and the types of modules available within each broad technology, to determine the most cost-effective technology for the site. Calculations for solar energy potential were based upon the SunPower 305 crystalline module with tracking for the ground mount system. The Uni-Solar PV-136 flexible module was selected for the closed landfill portion of the project.
- When these projects were modeled, the results indicated that 6100 MWh/yr would be generated by the ground mount system, and 2200 MWh/yr would be generated by the thin-film system attached to the closed portion of the landfill.
- The levelized cost of energy for a solar project was estimated to be $0.18/kWh based upon current, approximate costs for modules, inverters, and balance of system components. Considering that module prices are rapidly decreasing, which will lower installed cost; a solar project at the landfill could be feasible.

There are two ways for the City to earn revenues from a solar project at the landfill: negotiate a Power Purchase Agreement with PG&E to sell the electricity, or obtain energy credit through the Local Government Renewable Energy Self Generation Program (LGR).

The City could develop a solar project at their landfill and earn the revenues from the project. The City would need to negotiate a power purchase agreement with PG&E. The price for the energy would be close to the Market Price Referent (MPR), the price of a long-term contract for a combined-cycle natural gas power plant levelized to a cent-per-kWh basis. The MPR is set by the California Public Utility Commission (CPUC) annually. The 2008 MPR (current) is about $0.13/kWh (the MPR is a function of project commission date and term of the loan). The actual price paid by PG&E modifies the MPR by adding a Time of Day (TOD) rate to account for the value of renewable energy at different times of the day. The “all-in” price likely would be in the range of $0.14/kWh; however, the actual price must be negotiated with PG&E.

If the City develops the solar project, they will be responsible for the equity and debt financing. Currently, solar projects are being financed by the private sector at roughly a 50-50 equity-debt level. The cost of a 2.5 MW project at $5,000/kW would be about $13 million.

Alternatively, the City could pursue a one MW project through the LGR program. While no power purchase agreement would be needed, the City would still need to fund the installation, which would be about $5 million.

In either case, the City should seek funds to support the project. The key potential source for funds is the ARRA, and the funds that will be available through this program in California, under the California Energy Commission (CEC) State Energy Program (SEP). The following opportunities may help make a solar project financially viable for the City:

- Section 106 of the American Recovery & Reinvestment Act of 2009, Payment for Specified Renewable Energy Property in Lieu of Tax Credits, provides a cash payment equal to 30 percent of the installed cost of the project. To qualify, the project must be in construction by the end of 2010.
- The CEC SEP Municipal Financing District Program will provide loan guarantees and other support for renewable energy projects. The program will be announced in the fall of 2009.
- The CEC SEP Municipal & Commercial Building Targeted Measure Retrofit Program may provide support. The program will be rolled out in the fall of 2009.
- The CEC Clean Energy Systems program will provide incentives for combined heat & power, distributed energy systems, and bioenergy projects. This program will be rolled out later in 2009.
- The CEC's Energy Efficiency & Conservation Block Grant Program may offer opportunities for support. This program will be rolled out later in 2009.

BIOMASS

The opportunity for generating renewable energy from biomass is summarized as follows:

- Resource availability is a questionable for a biomass project. Approximately 2000 tons of green waste is delivered to the landfill annually. The composition of the green waste is not well known. The possibility of receiving wastes from vineyards or wineries in the area was investigated. There is a possibility that some pomace could be routed to the landfill from co-ops.
- Two processes appear feasible for the biomass waste stream at the landfill. First, gasification of woody wastes can be performed with a small, modular

gasification system. One such system has a throughput of about 500 tons/year. However, to be economical, the capacity factor must be at least 70 percent, so a sufficient quantity of waste must be available throughout the year. Second, an anaerobic digestion (AD) system could be feasible, particularly if sufficient quantities of pomace were obtained from winery operations. AD systems, however, also produce liquid and solid waste streams of their own that must be managed.

- The levelized cost of energy for gasification could be attractive. A calculation indicated that the cost could be about $0.13/kWh. While further analysis would be needed to more accurately determine waste characterization and prepare a specific equipment design, gasification could be a viable solution, particularly if additional biomass can be obtained.
- The levelized cost of energy for AD is about $0.24/kWh. This higher cost is reflective of the fact that AD produces only a small amount of renewable energy in comparison to gasification. Unless the amount of biomass is increased significantly, this technology will not be economical method to produce renewable energy.

As with solar energy, the ARRA may provide opportunities to receive funding for a bioenergy project.

NEXT STEPS

Using the results of this analysis of potential methods for generating renewable energy at the Paso Robles Landfill, the following actions are suggested to continue the development of a solar PV project:

1. Inspect the twenty-acre site on the north end of the landfill parcel. Hold discussions with the City of Paso Robles and Pacific Waste Systems to determine more precisely how much land would be available for solar development.
2. Work with a supplier(s) to obtain a more precise array design and configuration for the site, and estimate the energy production and installed cost.
3. Hold discussions with PG&E regarding interconnection to the grid (following the Small Generator Interconnection Program) and sale of the electricity to PG&E.
4. Monitor the funding and loan guarantee programs under the ARRA, including those coming from the CEC's State Energy Program.
5. Finally, if the actions above indicate a feasible project, write a brief business plan for presentation to the City.

Using the results of this analysis of potential methods for generating renewable energy at the Paso Robles Landfill, the following actions are suggested to continue the development of a biomass project:

1. Obtain a better picture of the green waste composition at the landfill, and discuss the possibility of diverting the green waste now sent to Madera to a biomass project at the landfill.
2. Contact wineries and co-ops, and discuss the possibility of diverting pomace to the landfill.
3. With an estimate of future green waste volumes, examine the feasibility of anaerobic digestion versus gasification and select the best technology based upon both technical and cost considerations.
4. For the selected technology, talk to at least three vendors and obtain the technical and cost data required to compare operational and cost issues. Select the best vendor and ask for a system quote.
5. Finally, if the actions above indicate a feasible project, a brief business plan should be prepared for presentation to the City Manager.

SECTION TWO

TABLES

TABLE 2-1
PASO ROBLES CITYWIDE ELECTRICAL USAGE 2006-2008

RATE DATA ANALYSIS: DR3712 ELECTRIC GHG SUMMARY FOR PASO ROBLES
Provided by PG&E (only provides electrical service to Paso Robles)
Tom Lorish 10/21/09

Total City	YEAR	CATEGORY	RESIDENTIAL and MUNICIPAL					COMMERCIAL				
			ELEC AVG(KWH)	ELEC USE(KWH)	ELEC CO2(metric	ELEC CLIM USE	ELEC CLIM(lbs)	ELEC AVG(KWH)	ELEC USE(KWH)	ELEC CO2(metric	ELEC CLIM USE	ELEC CLIM(lbs)
2006 Data												
PASO ROBLES	2006	NONGOVENT	538	72,969,682	15,093			3,327	71,025,004	14,691		
PASO ROBLES	2006	(3) COUNTY						2,026	399,164	83		
PASO ROBLES	2006	(4) CITY	22,675	544,200	113			4,933	12,552,537	2,596		
PASO ROBLES	2006	(5) DISTRICT						8,833	6,828,240	1,412		
2007 Data												
PASO ROBLES	2007	NONGOVENT	532	73,935,769	21,330	38,098	19,963	3,596	78,631,034	22,684		
PASO ROBLES	2007	(3) COUNTY						1,937	409,781	118		
PASO ROBLES	2007	(4) CITY	23,275	558,600	161			5,020	13,483,167	3,890		
PASO ROBLES	2007	(5) DISTRICT						9,072	7,104,269	2,049		
2008 Data												
PASO ROBLES	2008	NONGOVENT	538	75,156,939	17,864	269,787	141,368	3,698	81,601,408	19,395	18,910	9,909
PASO ROBLES	2008	(3) COUNTY						2,009	458,252	109		
PASO ROBLES	2008	(4) CITY	23,200	556,800	132			4,653	13,064,389	3,105		
PASO ROBLES	2008	(5) DISTRICT						9,373	7,322,280	1,740	575,214	301,412
			23,738	75,713,739				19,733	102,446,329			
3-Year Avg Electrical Use =			536	KWH per resid customer per month				19,492	KWH per commercial customer per month			
3-Year Avg Annual Electrical Usage =			74,020,797	KWH per year residential				97,626,508	KWH per year commercial			
3-Year Avg Electrical Use =			23,050	KWH per month municipal								
3-Year Avg Annual Electrical Usage =			553,200	KWH per year municipal								
Citywide Electrical Usage =		**172,200,505**	**KWH per year from 2006 to 2008**									

SECTION THREE

ZERO WASTE PROGRAMS

3.0 Zero Waste Programs

The Master Plan is intended to provide a "big picture" view of how the City can increase its waste diversion by enhancing existing or implementing new programs and facilities. Rather than providing an exhaustive list of all the potential programs, policies, and legislation that the City could consider, the BAS team focused its evaluation on specific programs that the City can implement or develop now and over the next five years to increase diversion and set the foundation for a sustainable zero waste system.

The terms "diversion" and "zero waste" programs are interchangeable descriptions of programs that assist in the reuse, recovery, and recycling of solid waste resources. For consistency, these activities will be referred to as zero waste programs in this report.

This section of the report provides the following information: 1) an overview of the City's existing solid waste management system, 2) a description of the City's existing zero waste programs, and 3) recommendations for improvements that will assist the City in becoming more sustainable by reducing the landfilling of its waste.

The programs and facility options that the BAS Team recommends are those that are cost-effective, are relatively easy to implement, and provide the greatest opportunity to realize meaningful increases in the diversion rate for each of the City's major waste streams. In essence, those that will help make the City make great strides on the road to zero waste.

3.1 CITY'S EXISTING SOLID WASTE MANAGEMENT SYSTEM AND ZERO WASTE PROGRAMS

To provide recommendations on how to increase the City's waste diversion rate, it is important to understand the City's existing solid waste management system. A comprehensive review of the City's system is provided below. Also, included are projections of the City's population, associated waste projections to year 2025, and the types of wastes currently disposed of at the landfill by the City's residents and businesses.

In addition, an analysis of the City's existing zero waste programs and policies was completed in order to provide recommendations for improvements or additions to the existing framework. A detailed discussion of these programs is presented in Appendix D - *Existing Zero Waste Programs.*

A summary of the data, documents, and people consulted for this effort are included as Appendix E - *Data Sources*.

The BAS Team also provided recommendations on addressing vineyard waste. This waste stream is discussed in the biomass discussion of Section Two, Renewable Energy Potential.

3.2 WHO PICKS UP THE WASTE? AND WHERE DOES IT GO?

CITY FRANCHISE AGREEMENTS

The City has an exclusive franchise agreement with Paso Robles Waste Disposal for waste collection services for residential and commercial solid waste, recycling, and green waste that expires on December 31, 2014. The City has a separate exclusive franchise agreement with Paso Robles Roll-Off (a related party of Paso Robles Waste Disposal) for Roll-Off services within the City. That agreement expires on August 31, 2013.

PROCESSING AND DISPOSAL FACILITIES (ZERO WASTE INFRASTRUCTURE)

Recyclable Material Processing Facilities, Transfer Stations, Construction and Demolition (C&D) Debris Processing Facilities, Composting Facilities, Food Waste Composting Facilities, and Disposal Facilities (including the Paso Robles Landfill) are discussed in detail in Section Four, *Zero Waste Infrastructure*, of this Master Plan report.

PASO ROBLES LANDFILL

The City owns its own landfill, the Paso Robles Landfill, and contracts the operation of the landfill to Pacific Waste Services; the operating agreement with Pacific Waste Service expires on July 31, 2020. All waste collected by both Paso Robles Waste Disposal and Paso Robles Roll-Off, other than that which is diverted, is required to be delivered to the City's landfill. Pacific Waste Services diverts clean loads of materials delivered to the City landfill to onsite stockpiles. Recovery of materials from mixed loads is limited to the picking that occurs at the landfill working face. The Paso Robles landfill operations are discussed in Section Five, Optimization of Landfill Operations.

3.3 WHAT IS THE CITY MANDATED TO DO ABOUT DIVERSION? HOW DOES THE CITY PLAN FOR SOLID WASTE PROGRAMS?

CALIFORNIA INTEGRATED WASTE MANAGEMENT ACT - AB 939

In 1989, the State legislature passed the California Integrated Waste Management Act (commonly known as AB 939). This Act imposed far-reaching changes in solid waste management practices and placed responsibility for implementation and funding of these changes on cities and counties under regulatory authority of the newly created California Integrated Waste Management Board (CIWMB). Among other things, AB 939 stipulated preparation and adoption of numerous planning documents and established solid waste reporting requirements and methodologies in an attempt to quantify the amount of waste being generated, disposed, and diverted within each of the 450 or so local jurisdictions in California. Based on this information, AB 939 required that each jurisdiction demonstrate a waste diversion rate of 25 percent by the year 1995 and 50 percent by the year 2000.

INTEGRATED WASTE MANAGEMENT AUTHORITY

The City is a member of the San Luis Obispo County (County) Integrated Waste Management Authority (IWMA). The IWMA is an agency created by the County in 1994 to facilitate the attainment of solid waste reduction mandated by the State of California in AB 939. The IWMA is a joint powers agency comprised of the County and its seven incorporated cities. It is governed by a 13-member board consisting of the five County supervisors and council members from the incorporated cities. The Board members are as follows:

President:	Bruce Gibson, San Luis Obispo County
Vice President:	John Hamon, City of Paso Robles
	Ed Arnold, City of Arroyo Grande
	Ellen Beraud, City of Atascadero
	Robert Mires, City of Grover Beach
	Carl Borchard, City of Morro Bay
	Ted Enring, City of Pismo Beach
	Jan Marx, City of San Luis Obispo
	Katcho Achadjian, San Luis Obispo County
	Adam Hill, San Luis Obispo County
	Frank Mecham, San Luis Obispo County
	Jim Patterson, San Luis Obispo County
	Dave Brooks, Authorized Districts

3.4 DIVERSION RATES AND GOALS

IWMA DIVERSION RATE

According to the procedures developed by the CIWMB, cities in regional agencies do not have individual diversion rates for each City. The diversion rate is determined for the agency as a whole. The IWMA's combined diversion rate was 67 percent for 2008. The IWMA diversion rate was 64 percent in 2007 and 63 percent in 2006.[1]

CITY DIVERSION RATE

The City's 2008 diversion rate for the franchised residential and commercial waste streams and the other waste streams received at the City's landfill (City Waste, self-haul, C&D, and roll-off loads) was 35 percent for 2008, with a three year average of 28 percent.

[1] 2007 and 2008 IWMA diversion rates are as reported by the IWMA.

ZERO WASTE GOALS

A detailed discussion of the City's existing zero waste programs is included in Appendix D. The City has the following priorities for determining whether or not to implement new diversion programs:

- Compliance with AB 939, i.e., maintaining a diversion rate above the required 50 percent level, or remaining within the maximum per capita disposal limit, under the new system that went into effect for the 2007 compliance year (SB 1016).
- Selecting programs that are feasible and fundable within the community's tolerance for new rate increases.
- In developing its diversion goals, the City may wish to consider both its State-mandated diversion requirements, as well as specific diversion targets for the:
- The waste streams (residential and commercial) controlled by Paso Robles Waste Disposal; and
- The waste streams entering the City's Landfill.

In considering its future diversion goals and associated priorities, the City should be aware that there is pending legislation that proposes to increase the State-mandated diversion level from 50 percent to 60 percent by 2015 and 75 percent by 2020. This legislation (AB479) is discussed below.

AB 479

The California Legislature is currently considering Assembly Bill (AB) 479 which requires that:

- Each City and County divert 60 percent of all solid waste on and after January 1, 2015;
- The CIWMB adopt policies, programs, and incentives to ensure that 75 percent of solid waste is diverted by January 1, 2020;
- The operator or owner of a business that generates at least four cubic yards of total solid waste and recyclable material per week arrange for recycling service; and
- That each local jurisdiction with a population of at least 200,000 adopts a commercial recycling ordinance by January 1, 2011.

The bill would increase state solid waste fees from $1.40 per ton to $3.90 per ton. The additional $2.50 per ton would be apportioned to local jurisdictions on a per capita basis for the purpose of funding the expansion of source reduction, recycling, and composting programs.

3.5 CITY'S WASTE GENERATION

POPULATION INFORMATION

The City's population is projected to increase by almost 50 percent over the next 15 years, with associated increased waste generation, diversion, and disposal.

YEAR	2007	2010	2015	2020	2025
POPULATION	29,500	29,800	33,044	38,476	44,000
GROWTH RATE	N/A	1.3 %	12.0 %	30.4 %	49 %

Source: City Of Paso Robles, 2009

WASTE GENERATION, DIVERSION AND DISPOSAL

The waste generation, diversion, and disposal information presented in this section is an average of the data for the City's waste stream for the three-year period from 2006 through 2008. The data was provided by Paso Robles Waste Disposal, Paso-Robles Roll-Off, and Pacific Waste Services. The information is summarized in Table 3-1 for the waste streams listed below:

- Single-Family Residential
- Commercial/Multi-Family Residential
- City Waste (Sludge, Grit, and Other City Waste)
- Uncompacted Landfill Waste Stream (self-haul, construction and demolition debris, and other roll-off loads)

Waste Generation

As shown in Table 3-1 and illustrated in Figure 3-1, the Commercial/Multi-Family Residential waste stream is the largest waste stream in the City accounting for 38 percent of the total waste generated over the last three years, followed by Single-Family Residential at 29 percent, the uncompacted Landfill Waste Stream at 21 percent (with self-haul/minimum loads comprising just under half of this total at 10 percent and uncompacted loads and C&D loads comprising the remaining 11 percent), and City Waste at 12 percent.

Note: Pacific Waste Services records loads as "C&D" loads where the customer advises the scale house that the material is C&D when loads are visually identified as such, or in instances when County permit that requires verification of recycling as a "C&D" load. It is assumed that a substantial portion of the remaining Uncompacted Landfill Waste Stream is also comprised of construction and demolition debris.

Waste Diversion

As presented in Table 3-1, the City's overall diversion rate has averaged 28 percent over the last three years, reaching a high of 35 percent in 2008. Looking at the City's waste stream as a whole (Table 3-1 and Figure 3-2), 53 percent of the City's total diversion tonnage is from the Single-Family Residential waste stream, 21 percent from the City Waste stream, 13 percent is from the uncompacted Landfill Waste Stream (self-haul, construction demolition debris, and other roll-off loads) recovered at the landfill, and 13 percent from the commercial/multi-family residential waste stream.

Diversion rates for the City's waste streams are discussed below and shown in Figure 3-2.

- **Single-Family Residential.** Diversion has relatively steady at approximately 50 percent. See Figure 3-2.
- **Commercial /Multi-Family.** Diversion has averaged 10 percent over the last three years, although it has been steadily increasing (7 percent in 2006 to 9 percent in 2007 and 13 percent in 2008). This increase is due largely to the implementation of a commingled commercial recycling program. According to Paso Robles Disposal (correspondence dated April 9, 2010) over 60% of the commercial and multi-family residential customers are participating in the recycling program. See Figure 3-2.
- **City Waste.** Diversion has averaged 49 percent, with all of this diversion attributed to waste water sludge used for on-site beneficial use at the City landfill. See Figure 3-2.
- **Uncompacted Landfill Waste Stream.** Diversion of self-haul, construction demolition debris, and other roll-off loads has averaged 17 percent over the last three years. Figure 3-2.

Waste Disposal

The Commercial/Multi-Family Residential waste stream is the largest portion of the waste disposed in the City, representing 47 percent of the total waste disposal tonnage, followed by the Uncompacted Landfill Waste Stream at 24 percent, Single-Family Residential at 20 percent and City Waste at eight percent (see Table 3-1 and Figure 3-2).

3.6 COMPACTED VERSUS UNCOMPACTED WASTES

For purposes of diversion planning the distinction between compacted and uncompacted is important as opportunities and approaches to diverting material from these waste streams vary. In general, once the material is compacted in the collection vehicle (or on-site compactor), it is destine for landfill disposal, unless there is "dirty MRF"[2] capacity or other means for processing the compacted

[2] A dirty MRF is a facility that is designed to process mixed solid waste, including compacted waste from solid waste collection vehicles.

waste streams (e.g., conversion technologies). Therefore, any recovery of compacted waste streams must occur through source separation programs. Alternatively, the uncompacted waste stream provides opportunities for material recovery at the landfill prior to disposal.

WASTE STREAMS MANAGED BY PASO ROBLES WASTE DISPOSAL (COMPACTED WASTE STREAMS)

- Single-Family Residential
- Multi-Family Residential
- Commercial

UNCOMPACTED WASTE STREAMS

- Construction and Demolition Debris
- Self-Haul (Landfill Self-Haul and Minimum Loads)

3.7 WASTE COMPOSITION

Specific waste composition data for the City is not available. Therefore, for purposes of this review, we relied on Statewide data from the CIWMB's *2004 Statewide Waste Characterization Study* to represent the composition of the City's various waste streams[3].

The following sections summarize the composition of the Single-Family Residential, Multi-Family Residential, Commercial, Construction and Demolition Debris, and Self-Haul waste streams based on the statewide sampling conducted by the CIWMB. This information is also shown in Figure 3-3 for the compacted waste streams (Single-Family Residential, Multi-Family Residential, and Commercial), and in Figure 3-4 for the uncompacted waste streams (C&D Debris and Self-Haul Waste Streams).

SINGLE-FAMILY RESIDENTIAL WASTE STREAM (Figure 3-3)

The largest portion of the Single-Family Residential waste stream is comprised of Organic material (43.9 percent), followed by Paper (21.4 percent), C&D (10.5 percent) and Plastics (9.8 percent). With respect to specific material types, the major waste type is Food 16.7 percent) followed by Leaves and Grass (9.4 percent), with Prunings/Trimmings (5.1 percent) also comprising major recoverable portions of the waste stream.

[3] While the CIWMB waste composition data is not specific to the City's waste streams it is assumed to provide a reasonable representation of the relative percentages of the various material types for planning purposes. The City may wish to perform City-specific waste composition analysis to support program planning. Any such analysis could involve physical sorting of loads and/or visual observations.

MULTI-FAMILY RESIDENTIAL WASTE STREAM (Figure 3-3)

Like the Single-Family Residential waste stream, the largest portion of the Multi-Family Residential waste stream is comprised of Organic material (39.3 percent) followed by Paper (24.6 percent), C&D (11.5 percent) and Plastics (8.5 percent). The major waste type is Food (18.9 percent), with Prunings/Trimmings (5.8 percent), and Lumber (5.0 percent) also comprising major recoverable portions of the waste stream.

COMMERCIAL WASTE STREAM (Figure 3-3)

The largest portion of the Commercial waste stream is also comprised of Organic material (29.2 percent), followed by Paper (26.5 percent), C&D (14.0 percent), and Plastics (11.9 percent). The major waste types are Food (18.8 percent), followed by Uncoated Corrugated Cardboard (8.3 percent), and Lumber (7.9 percent).

Figure 3-5 provides a breakdown of the composition of the Commercial waste stream by major business types. As shown, restaurants comprise the largest waste generator business type with Food being 56 percent of this waste stream.

CONSTRUCTION AND DEMOLITION DEBRIS

The largest portion of the Construction and Demolition Debris waste stream is comprised of C&D material (86.7 percent), followed by Metal (4.0 percent), Paper (3.2 percent), and Organics (3.0 percent). The major waste type is Composition Roofing (21.5 percent), with Large Asphalt w/out Rebar (9.5 percent), Dirt and Sand (7.1 percent), and Other Aggregates (6.2 percent) also comprising major recoverable portions of the waste stream.

SELF-HAUL WASTE STREAM

The largest portion of the Self-Haul waste stream is comprised of C&D material (54.6 percent), followed by Organics (14.0 percent), Special Waste (10.6 percent), and Metals (8.0 percent). Lumber (21.5 percent) is the major waste type with Bulky Items (10.2 percent), Asphalt Roofing (7.1 percent), and Concrete (6.2 percent) also being major recoverable portions of the waste stream.

IMPACTS ON WASTE GENERATION FROM WATER CONSERVATION

On June 2, 2009, the City adopted a water conservation and water shortage contingency plan. The ordinance prohibits excessive water flow or runoff: *"Watering or irrigating of any lawn, landscape or other vegetated area in a manner that causes or allows excessive water flow or runoff onto an adjoining sidewalk, driveway, street, alley, gutter or ditch is prohibited."* There are also Level 1 - Voluntary Reductions, Level 2 – Mandatory Reductions, and Level 3 –

Critical Condition Requirements that limit landscape irrigation to minimum days depending on the alert level for water conservation.

As of August 2009, the City was under Level 2 water conservation restrictions and is undertaking public outreach efforts; overall, the City is reporting a reduction in water use of about 25 percent from previous years. This will likely have a significant impact on the generation of green waste to the landfill this year and in future years.

In addition, the City will be developing a landscape ordinance for adoption by the end of the year that may incorporate such features as:

- Limitations on new turf landscaping for commercial areas (e.g., maximum of 10 percent of landscape area), multi-family, and residential development (e.g., limiting turf in front yards),
- Prohibitions on turf in thin strips of roadway parkways within public ROWs,
- Incorporate certain aspects of the State's model landscape ordinance that requires climate-based irrigation controllers for certain new landscapes and establishment of maximum annual water allotment.

In the long-term, this will likely contribute to a reduction in plant growth and green waste generation in the City. There is limited published data correlating the percent reduction in green waste resulting from the implementation of reduced watering on landscapes. One published source is from the City of Santa Monica's garden\garden comparison of a traditional garden to a native plant garden in a residential setting. The study can be found at www.sustainablesites.org. The study compared water use, green waste generation, and maintenance cost between the two gardens as follows:

Type of Garden	Water Use (gallons/year)	Green Waste Generation (pounds/year)	Maintenance Labor (US dollars/year)
Traditional Garden	283,981	647.5	223.22
Native Garden	64,396	219.0	70.44
Difference	219,585 (77% less)	428.5 (66% less)	152.78 (68% less)

Reductions in green waste generation are anticipated from a reduction in watering the landscaped areas. In addition, as the City transitions to reduced turf landscaping, this should also reduce the volume of green waste generated in the City. The City may wish to explore promoting native gardens versus traditional gardens to its residents.

3.8 RECOMMENDATIONS FOR THE CITY'S ZERO WASTE PROGRAMS

The City, through its franchise hauler, Paso Robles Waste Disposal, offers residents and businesses a range of source separated zero waste programs that provide the opportunity for diversion of a substantial portion of the single-family

and commercial/ multi-family waste streams. The effective implementation of these programs by the franchised hauler, and participation in those programs by residents and businesses, is supported by the County's Mandatory Recycling Ordinance. That ordinance requires that occupants of single-family residences that receive solid waste collection service from a franchised hauler separate recyclable materials from garbage. Multi-family and commercial facilities that receive solid waste collection services from a franchised hauler are required to be provided on-site recycling services, and the residents and businesses are required to participate in the recycling program. If it is determined that the waste being disposed contains more than 20 percent recyclable material, multi-family and commercial accounts may be subject to civil penalties. For single-family violations, the fine is to be determined by the City. While the City supports the diversion objectives of the County's Mandatory Recycling Ordinance, it is not supportive of the civil penalties and enforcement mechanisms.

In considering the City's options for increasing diversion, the first priority should be to maximize the effectiveness of the existing programs. This is generally the most cost- effective means for increasing diversion. Efforts to improve the effectiveness of existing programs should then be coupled with the evaluation of opportunities for new diversion programs and/or facilities. These efforts should also be supported with public education, appropriate public policies (e.g., purchasing policies), legislation (e.g., take back ordinances, disposal bans), and contractual requirements (e.g., franchise agreement and landfill operation agreement diversion incentives and/or requirements).

For purposes of zero waste planning, the distinction between compacted and uncompacted waste is important as opportunities and approaches to diverting material from these waste streams vary. In general, once the material is compacted in the collection vehicle (or onsite compactor) it is destined for landfill disposal, unless there is "dirty" Material Recovery Facility (MRF)[4] capacity or other means for processing the compacted waste streams (e.g., conversion technologies). Therefore, any recovery of these waste streams must occur through source separation programs prior to compaction. Alternatively, the uncompacted waste stream provides opportunities for material recovery at the landfill prior to disposal.

Key findings are provided for the following waste streams:

- Compacted Waste Streams: Single-Family Residential and Commercial/Multi Family Waste,
- Uncompacted Waste Streams: Self Haul, Construction & Demolition (C&D), Roll-Off Wastes, and
- City Waste.

[4] A dirty MRF is a facility that is designed to process mixed solid waste, including compacted waste from solid waste collection vehicles.

In addition, recommendations are provided for potential purchasing policies and legislation that the City may wish to consider.

SINGLE-FAMILY RESIDENTIAL

Existing Programs

Fifty (50) percent of the single-family residential waste stream is currently diverted through the City's curbside recycling and green waste collection programs. While this diversion rate falls within what is considered to be a reasonable range for these types of programs, there is likely still potential for increasing diversion through these programs which should be explored. The type of recycling program (single stream), the frequency of collection of recyclables and green waste (weekly service), the types of materials collected (e.g., mixed plastics), and the variable rate structure provide support for maximizing diversion. The City may, however, wish to consider renewed or increase public education, possibly in conjunction with a more aggressive variable can rate (e.g., a volume based rate), as well as other steps (e.g., adding new materials) in an effort to increase diversion through these programs.

New Programs

The single largest material type in the single-family residential waste stream being disposed of is food, which accounts for 16.7 percent of the single-family residential total. If we consider leaves and grass (9.4 percent) and prunings/ trimmings (5.1percent), the total portion of the single-family residential waste stream disposed of that could potentially be diverted through the existing green waste curbside collection program (enhanced to include food waste) is more than 31 percent. Therefore, the City may wish to consider the potential for incorporating food waste into the residential green waste program as part of a medium-term (five-year) planning horizon. The ability of the City to implement such a program is currently limited by the lack of available local processing capacity and the lack of transfer capacity that could allow for the use of out-of-County permitted food waste facilities.

Short of a fully permitted food waste composting program, the City should consider the potential for adding vegetative food waste to the existing green waste collection program similar to the veggie food scrap recycling program that is in place in Sonoma County. It may be possible to incorporate vegetative food waste "vegan" (no meat, fish, or dairy products) into existing green waste collection and composting programs with less stringent permitting requirements than required for programs that include meat, dairy, and fish, although this should be reviewed with the Local Enforcement Agency (LEA)[5].

[5] The California Integrated Waste Management Board (CIWMB) is the LEA for the City and County. The current 2009 State budget eliminates the CIWMB after December 31, 2009. Beginning January 1, 2010, the CIWMB functions will be pulled under the Natural Resources Agency in the Department of Resources, Recycling and Recovery (DRR&R).

Suggested Priorities

- Evaluate options to increase the capture rate of materials through the existing curbside recycling and green waste collection programs including:
  - Additional variable can rate incentives;
  - Adding new materials (e.g., textiles to the curbside recycling program, vegetative food waste to the green waste collection program), increased public education, and
  - Contractual diversion incentives for Paso Robles Waste Disposal.
- Evaluate the potential for incorporating food waste into the existing green waste collection program over the medium-term planning horizon.

COMMERCIAL / MULTI-FAMILY RESIDENTIAL

The commercial/multi-family residential waste stream accounted for almost half (47 percent) of the total City waste disposed in 2008. While the diversion rate has increased each of the last three years from 8 percent in 2006 to 15 percent in 2008, there is clearly an opportunity for increased diversion from this waste stream. Although diverting material from the commercial and multi-family residential waste streams tends to be much more challenging than the single-family waste stream, the opportunity for substantial increases in the amount of material diverted exists and should be systematically and aggressively pursued.

From the manner in which this waste stream data is currently reported, there is no way of knowing or estimating the portion of this waste stream that is commercial and the portion that is multi-family residential. As a first step in efforts to increase diversion from these waste streams, we recommend that Paso Robles Waste Disposal provide an accounting of the weekly volume of solid waste, recyclables, and green waste attributed separately to commercial accounts and multi-family accounts (a Commercial and Multi-Family Residential Account Profile). This will provide the City with a better understanding of the relative size of each of these waste streams and the extent to which commercial and multi-family residential accounts are participating in available recycling programs and help to prioritize efforts. The Commercial and Multi-Family Residential Account Profile should also include a complete list of residential and multi-family accounts by name with the associated weekly solid waste and diversion program service levels identified. This will provide a clear picture of those accounts that have access to available recycling programs and those that do not.

Existing Programs

Paso Robles Waste Disposal currently provides a comprehensive range of services to commercial and multi-family accounts, including single-stream recycling, which was started in August 2007; office paper and cardboard

recycling programs; and green waste collection. The opportunity for increasing diversion from these waste streams, therefore, is in no way hindered by the lack of comprehensive options. The issue that needs to be addressed is whether or not Paso Robles Waste Disposal is effectively marketing the available programs to all accounts and/or if the accounts are effectively utilizing the programs that are provided.

The County's Mandatory Recycling Ordinance requires that all commercial and multi-family accounts be offered and participate in the available recycling services. The "leverage" provided by this ordinance is something that most jurisdictions do not have and provides the City and Paso Robles Waste Disposal with an effective tool for aggressively pursuing additional diversion within the commercial and multi-family residential waste streams. We recommend that the City and Paso Robles Waste Disposal develop a systematic outreach process to assure that all commercial and multi-family accounts are complying with the ordinance.

A first priority should be those accounts that do not currently have recycling service (as identified through the Commercial and Multi-Family Residential Account Profile). Those accounts should be contacted and provided assistance with the implementation of appropriate recycling services. Periodic follow-up should be provided to assess progress and compliance with the Mandatory Recycling Ordinance.

Once recycling services are established at those accounts that do not currently have any recycling service, attention should shift to those accounts that do have service to assess the effectiveness of their in-house programs and offer appropriate assistance to assure that those efforts comply with the requirements of the Mandatory Recycling Ordinance. The recommended approach is simple and straight forward but may require additional dedicated staffing if it is to be effectively and aggressively implemented.

New Programs

Commercial and multi-family accounts currently have access to a comprehensive range of diversion programs. The City's short- and medium-term focus for this waste stream should be on maximizing participation and capture rates through these programs. The one substantial new commercial program the City may wish to consider is food waste diversion. The largest portion of the commercial waste stream is food waste (18.8 percent), with the majority typically generated by restaurants. The City may wish to consider participating in a pilot commercial food waste pilot program currently being planned by North San Luis Obispo County Recycling[6]. Paso Robles Waste Disposal should be involved in the planning of such a pilot project. Should the pilot program be successful, the City

[6] North San Luis Obispo County Recycling is seeking authorization for a food waste composting operation that would accept food waste at its facility at La Cruz Way in Templeton. This material would then be transferred to the B. Goodrow site in Creston for composting. A company representative reported that it is looking to secure a food waste stream for their pilot program.

may wish to expand the program to include additional commercial accounts and potentially the residential waste stream.

The City is also considering a fats, oil, and grease program at the wastewater treatment plant as fuel for co-generation. That would involve accepting such loads from pumper services that now dispose of fats, oil, and grease out-of-County. A separate residential and/or commercial food waste collection program would be needed to make beneficial use of that waste stream.

Suggested Priorities

- Work with Paso Robles Waste Disposal to develop a Commercial and Multi-Family Residential Account Profile.
- Evaluate current commercial and multi-family participation and diversion rates by program type.
- Develop and implement comprehensive and systematic outreach program to ensure that all commercial and multi-family accounts are provided with appropriate recycling containers and actively participate in the available programs as required by the County's Mandatory Recycling Ordinance.
- Explore the possibility of developing a pilot commercial food waste collection program in conjunction with the planned food waste composting pilot project being considered by North San Luis Obispo County Recycling.
- Evaluate the potential for a full- scale commercial food waste program in the medium-term planning period.
- Consider opportunities for contractual incentives for Paso Robles Waste Disposal to increase diversion (e.g., contract extensions for meeting certain diversion requirements, tying allowed operating ratio (profit) to diversion)[7].
- Establish terms and conditions of any future franchise agreements that are consistent with the City's zero waste objectives and provide the City with the necessary control over the franchisee and its waste streams. Alternatively, the City may wish to consider taking over solid waste collection operations at some point in the future (i.e., operating a municipal solid waste collection system) to provide it with direct control of the solid waste collection system.

SELF HAUL, CONSTRUCTION & DEMOLITION DEBRIS, AND OTHER ROLL-OFF WASTES

The self-haul, construction and demolition debris, and other roll-off waste streams received at the Paso Robles Landfill present a significant opportunity for increased diversion. PWS is currently recovering portions of these waste streams by directing clean source-separated loads to onsite stockpiles. Recovery of material from mixed, un-compacted loads, however, is limited to removal that occurs at the working face. While this provides some opportunity for recovery of

[7] Funding for any such financial incentives could be provided for through the collection rates (e.g., setting a higher profit level for Paso Robles Disposal that would be covered through the approved collection rates).

materials from these waste streams, it is very limited. If the City wishes to significantly increase the recovery of material from mixed loads of self-haul, construction and demolition debris, and other roll-off loads, it should develop a separate, dedicated area within the landfill (Recycling Pad) where those materials can be unloaded and processed for recovery.

To better track diversion of material from the uncompacted waste streams received at the Paso Robles landfill, it is suggested that the City work with Pacific Waste Services to enhance current landfill tonnage data tracking and reporting systems including, but not limited to the following:

1. Providing the City with electronic copies of all landfill tonnage reports, including
   - rolling quarterly totals on all quarterly reports and annual totals on the fourth quarter report (Annual Report); and
   - Historical data on each Annual Report.
2. Tracking and reporting the diversion associated with clean loads delivered to the landfill that are directed to onsite stockpiles separately from material recovered from mixed waste loads at the working face;
3. Calculating and reporting diversion rates for the uncompacted waste stream in total and separately for clean stockpiled loads (100 percent diversion) and mixed waste loads; and
4. Tracking of incoming City waste by City department and associated diversion of clean, stockpiled loads.

Alternatively, dedicating additional staff at the landfill working face for material recovery activities may provide for additional cost-effective diversion, although the level of diversion achieved would likely be at a much lower rate than could be achieved through a dedicated Recycling Pad operation.

In conjunction with, or as an alternative to a Recycling Pad, the City should consider an approach similar to that used at the Cold Canyon Landfill for increasing recovery of material from the self-haul waste stream. That facility requires each self-hauler using the facility to first stop at the "Resource Recovery Park" at the entrance to the landfill (adjacent to the scale house). There are several roll-off boxes and bins located at the Resource Recovery Park, so that each self-hauler can unload all recyclable items before entering the site. Self-haulers unwilling to stop at the Resource Recovery Park and separate their materials for recycling might be required to pay an additional $20.00 fee to the landfill.

Suggested Priorities

- Review roll-off rate schedules to assure that they provide appropriate financial incentives for segregated materials. Revise rates, if appropriate, to increase financial incentives.
- Evaluate the cost benefit of dedicating additional staffing at the landfill working face specifically for the recovery of recyclable materials. Implement a pilot program, if appropriate.
- Consider the potential for constructing a low-tech Recycling Pad operation at the landfill to allow for segregation and processing of targeted C&D and self-haul loads.
- Consider requiring self-haul loads to pre-sort recoverable materials at a Recycling Pad or Resource Recovery Park prior to disposal. This option is supported by the County's Mandatory Recycling Ordinance that states: "*A person electing to haul solid waste to a landfill instead of using the Franchisee shall comply with the recycling requirements of this Ordinance by recycling those items that can be recycled at the landfill.*"
- Work with Pacific Waste Services to enhance current landfill tonnage data tracking and reporting systems.

CITY WASTE

Other than the sludge and grit generated by the City's wastewater plant, there is a lack of information on what the other portions of the City's waste stream is comprised of and where it is being generated. For the City to develop an effective strategy for diverting material from this waste stream it needs to know what materials are being generated and from what facilities and/or operations. The City should then ensure that it is making appropriate use of all available opportunities to divert material from this waste stream, complying with the Mandatory Recycling Ordinance and setting a "zero waste" example for its residents and business.

Suggested Priorities

- Determine the individual sub-waste streams that comprise the City Waste tonnage and the specific City facilities/functions that generate those waste streams;
- Determine what existing recycling programs exist or can be accessed by the specific City facilities/functions generating those waste streams;
- Take the necessary steps to assure that the diversion of the City Waste stream complies with the Mandatory Recycling Ordinance.

3.9 OTHER OPTIONS TO CONSIDER

PURCHASING POLICIES

In addition to the program and facility recommendations presented in this technical memorandum, another recommendation is for the City to develop and implement City purchasing policies that support the City's "zero waste" objectives. Without strong, reliable (and preferably local) markets for diverted materials, it is not possible to develop a sustainable zero waste system. A Source Reduction and Recycled Content Purchasing Policy for the City should do the following[8]:

- Recognize the need for strengthening markets for materials collected in local recycling collection systems;
- Maximize reduction of discarded materials;
- Ensure that every City department purchases environmentally-preferred products and services (without compromising overall budgetary or performance requirements); and
- Serves as an example for other agencies and organizations in the community; and complies with California state law, which requires local agencies to buy recycled products and which allows local agencies to adopt purchasing preferences for recycled products.

Ideally, one of the City's objectives should be, to the extent practical, to use materials recovered at the City's landfill for City-related projects or at City properties in place of virgin materials (e.g., compost and mulch at City parks and properties, aggregate for road base, chipped tires for erosion control, etc.).

LANDSCAPING ORDINANCE

In conjunction with the City's adoption of its water conservation ordinance, the City plans to adopt a landscaping ordinance by the end of 2009. In addition, the City will be developing a landscape ordinance for adoption by the end of the year that may incorporate such features as:

- Limitations on new turf landscaping for commercial areas (e.g., maximum of 10 percent of landscape area), multi-family and residential development (e.g., limiting turf in front yards);
- Prohibitions on turf in thin strips of roadway parkways within public right-of-way; and
- Incorporates certain aspects of the State's model landscape ordinance that requires climate-based irrigation controllers for certain new landscapes and establishment of maximum annual water allotment.

[8] Taken from the City of Vacaville Source Reduction and Recycled Procurement Policy presented as an example policy by the CIWMB.

In the long-term, this will likely contribute to a reduction in plant growth and green waste generation in the City. There is limited published data correlating the percent reduction in green waste resulting from the implementation of reduced watering on landscapes. One published source is from the City of Santa Monica's garden\garden comparison of a traditional garden to a native plant garden in a residential setting. The Santa Monica study reported a 66 percent reduction in green waste generation from a native residential garden versus a traditional residential garden and a 77 percent reduction in water use. The complete study can be found at www.sustainablesites.org.

Reductions in green waste generation are anticipated from a reduction in watering the landscaped areas. In addition, as the City transitions to reduced turf landscaping, this should also reduce the volume of green waste generated in the City. The City may wish to explore promoting native gardens versus traditional gardens to its residents.

LEGISLATIVE EFFORTS

The County of San Luis Obispo Integrated Waste Management Authority (IWMA) and its member agencies, including the City, have done a very good job establishing a legislative framework for a sustainable solid waste management system. The County's "take back" ordinances for fluorescent tubes and household batteries, sharps, and paint are believed to be the first such ordinances for these materials in the nation. The County's Mandatory Recycling Ordinance also provides the City with a very effective tool to help promote and maximize diversion that most jurisdictions do not have. Going forward, the IWMA and its member agencies should continue to provide support for Extended Producer Responsibility[9] legislation at the State and national levels. At the local level, the City may wish to consider disposal bans for those materials covered by the County's "take back" ordinances.

3.10 SUMMARY RECOMMENDATIONS FOR ALL WASTE STREAMS

In conclusion, the BAS Team recommends that the City focus on the following programs for these four waste streams:

1. Commercial/Multi-Family: Maximize the effectiveness of the existing commercial diversion programs. Consider implementing a commercial food waste diversion program;
2. Construction & Demolition Debris/Self Haul: Develop additional unloading and processing capacity at the City landfill for recovering other portions of

[9] Extended Producer Responsibility (EPR) and Product Stewardship are terms used interchangeably to describe a long-term solution to manage waste products by shifting the responsibility for collection, transportation, and management for those products away from local governments and general taxpayers to the manufacturers. There are many different levels of responsibility that manufacturers can assume for their products on the path to taking full responsibility for their products. Any movement on the path to manufacturers taking full responsibility is in keeping with EPR.

the uncompacted waste streams received at the landfill (self-haul, construction and demolition debris, and other roll-off waste streams);

3. City Waste: Evaluate waste stream and implement diversion programs to comply with Mandatory Recycling Ordinance; and
4. Single-Family: Consider developing a residential food waste collection program. This is the most effective new program the City could pursue to increase diversion from the residential sectors.

Table 3-2 attached, *Recommended Priorities and Projected Diversion*, summarizes the recommended priorities and the projected diversion from these programs.

SECTION THREE

TABLES

Table 3-1
PASO ROBLES MASTER PLAN
WASTE GENERATION, DIVERSION AND DISPOSAL DATA
BY WASTE STREAM

Material	Tons			3-Year Average		Projections			
	2006	2007	2008	Tons	Percent of City's Total	2010	2015	2020	2025
SINGLE-FAMILY RESIDENTIAL									
Diversion	6,682	6,690	6,507	6,626	*53%*	6,712	7,422	8,642	9,883
Disposal	6,582	6,537	6,411	6,510	*20%*	6,594	7,292	8,491	9,710
Generation	13,264	13,227	12,917	13,136	*29%*	13,305	14,714	17,133	19,593
Single-Family Residential Diversion Rate	50%	51%	50%	50%		50%	50%	50%	50%
COMMERCIAL / MULTI-FAMILY RESIDENTIAL									
Diversion	1,294	1,517	2,092	1,634	*13%*	1,655	1,830	2,131	2,437
Disposal	16,581	15,530	14,234	15,448	*47%*	15,647	17,304	20,149	23,041
Generation	17,874	17,047	16,326	17,082	*38%*	17,302	19,134	22,280	25,479
Commercial (Including Multi-Family Residential) Diversion Rate	7%	9%	13%	10%		10%	10%	10%	10%
CITY WASTE (Sludge, Grit & Other City Waste)									
Diversion	1,674	3,064	3,310	2,683	*21%*	2,717	3,005	3,499	4,001
Disposal	3,008	2,347	2,926	2,760	*8%*	2,796	3,092	3,600	4,117
Generation	4,682	5,411	6,236	5,443	*12%*	5,513	6,096	7,099	8,118
City Waste Diversion Rate	36%	57%	53%	49%		49%	49%	49%	49%
UNCOMPACTED LANDFILL WASTE STREAM									
Incoming Tonnage									
Self-Haul Waste	*4,631*	*3,009*	*1,679*	*3,106*	*7%*	*3,146*	*3,480*	*4,051*	*4,633*
Minimum Loads	*1,506*	*1,364*	*949*	*1,273*	*3%*	*1,289*	*1,426*	*1,660*	*1,898*
Uncompacted Loads	*6,803*	*4,736*	*3,139*	*4,893*	*11%*	*4,956*	*5,481*	*6,381*	*7,298*
C&D Loads	*300*	*183*	*120*	*201*	*0%*	*204*	*225*	*262*	*300*
Total Incoming Uncompacted Landfill Tonnage	*13,240*	*9,292*	*5,887*	*9,473*	*21%*	*9,595*	*10,611*	*12,355*	*14,129*
Diversion	222	1,821	2,723	1,589	*13%*	1,610	1,780	2,073	2,370
Disposal	13,018	7,470	3,164	7,884	*24%*	7,985	8,831	10,283	11,759
Generation	13,240	9,292	5,887	9,473	*21%*	9,595	10,611	12,355	14,129
Uncompacted Landfill Waste Stream Diversion Rate	2%	20%	46%	17%		17%	17%	17%	17%
Total Diversion	**9,872**	**13,092**	**14,632**	**12,532**	***28%***	**12,693**	**14,038**	**16,345**	**18,692**
Total Disposal	**39,188**	**31,884**	**26,734**	**32,602**	***72%***	**33,022**	**36,519**	**42,522**	**48,627**
Total Generation	**49,060**	**44,977**	**41,365**	**45,134**	***100%***	**45,715**	**50,556**	**58,867**	**67,318**
Total Diversion as a Percentage	**20%**	**29%**	**35%**	**28%**		**28%**	**28%**	**28%**	**28%**

TABLE 3-2
EL PASO DE ROBLES LANDFILL MASTER PLAN

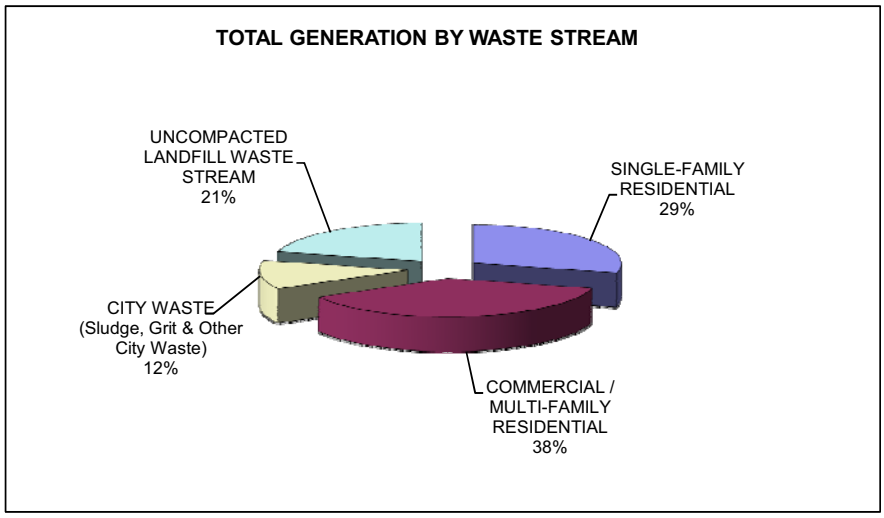
RECOMMENDED PRIORITIES AND PROJECTED DIVERSION

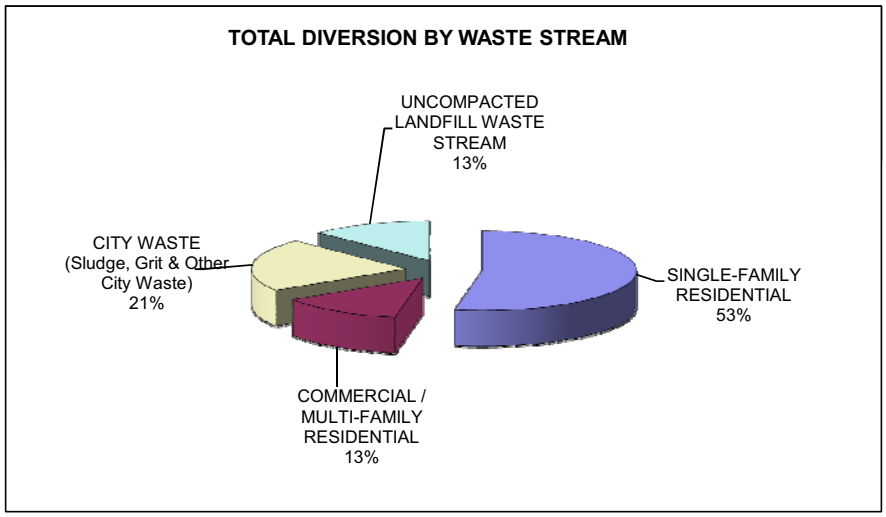
Waste Stream	Recommended Action	Existing or New Program / Facility	Material Types	Potential Additional Waste Stream Diversion Percentage	
				Percentage	Assumptions
Commercial/ Multi-Family	Develop Commercial and Multi-Family Residential Account Profile	Enhance Existing Program	NA	NA	
	Implement comprehensive commercial and multi-family outreach program	Enhance Existing Program	All existing commercial and multi-family residential diversion program materials	10% - 20%	Assumes general compliance with Mandatory Recycling Ordinance
	Implement commercial food waste collection program	New Program	Vegetative material or combined with meat scraps (depends on the processing facility)	4%	Estimate based on data from existing programs
	Establish Franchise Agreement incentives for increased diversion	Enhance Existing Program	NA	NA	
Construction and Demolition Debris/ Self-Haul	Revise roll-off rates if appropriate to increase diversion	Enhance Existing Program	Construction and demolition materials (e.g., concrete, soil, asphalt, wood, metal)	NA	
	Dedicate additional labor at working face to recover materials	Enhance Existing Program		3%	Assumes 5% recovery of C&D tonnage currently disposed
	Construct a "Recycling Pad" at the landfill	New Facility		15%	Assumes 25% recovery of C&D tonnage currently disposed
	Pre-sort area for self-haul loads	New Facility		25%	Assumes 25% recovery of Self-Haul tonnage currently disposed
City Waste	Evaluate waste stream and implement diversion programs to comply with Mandatory Recycling Ordinance	Enhance Existing Program	All existing commercial diversion program materials	11%	Assumes 25% recovery of 2,465 City Waste tons divided by 5,379 total generation
Single Family	Increase effectiveness of existing curbside recycling and green waste collection programs (additional variable waste bin rate incentives, adding new materials, contract incentives etc.)	Enhance Existing Program	All existing single-family residential diversion program materials plus potential additional curbside materials	10%	Assume 10% increase in curbside recycling tonnage
	Add food waste to existing green waste collection program	Enhance Existing Program	Vegetative material only or combined with meat scraps (depends on the processing facility)	4%	Assumes capture of ~25% of the food waste (16.7%) currently being disposed at 50% current waste stream diversion rate

SECTION THREE

FIGURES

Figure 3-1
PASO ROBLES MASTER PLAN
WASTE GENERATION, DIVERSION AND DISPOSAL PERCENTAGES BY WASTE STREAM
(3 Year Average 2006-2008)





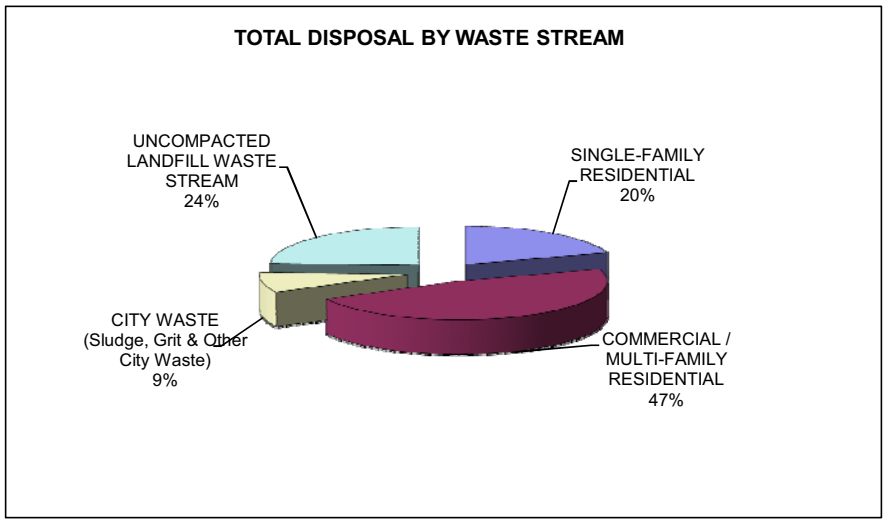
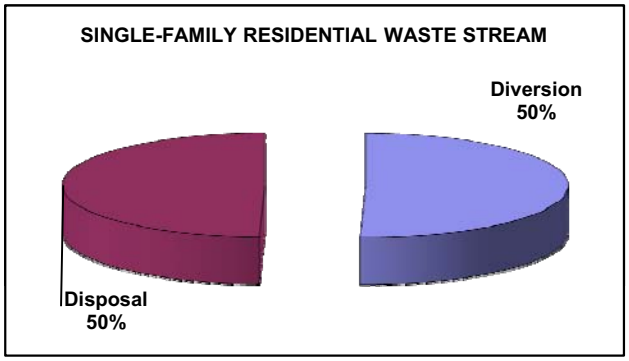
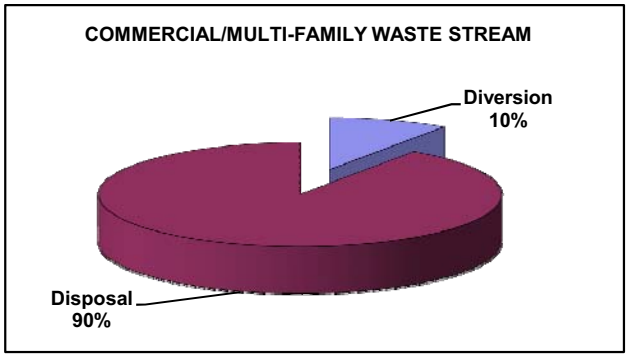


Figure 3-2
PASO ROBLES MASTER PLAN
WASTE GENERATION, DIVERSION AND DISPOSAL PERCENTAGES
BY WASTE STREAM
(3 Year Average 2006-2008)





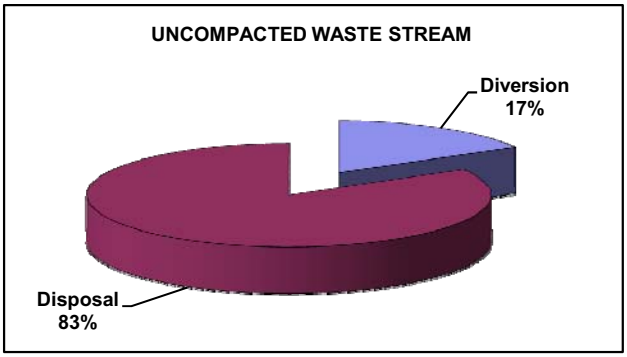
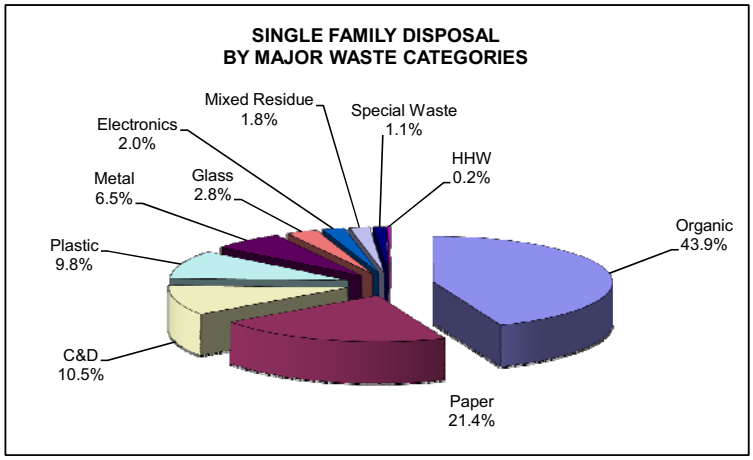
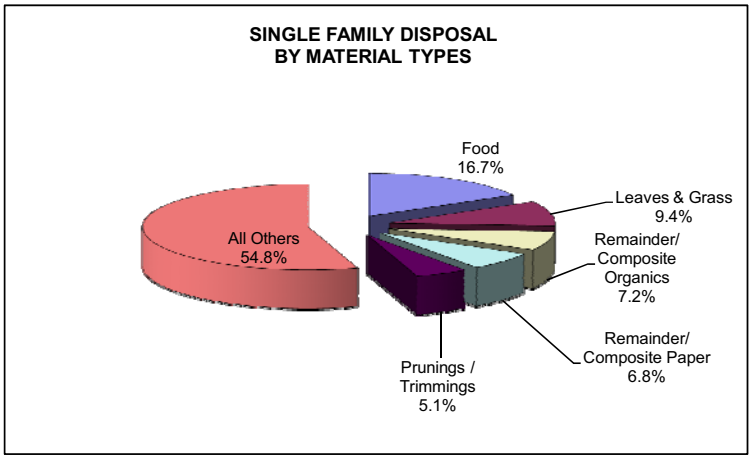
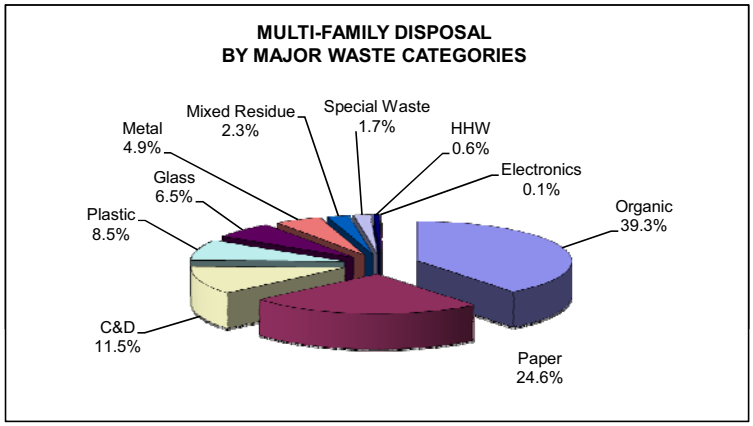


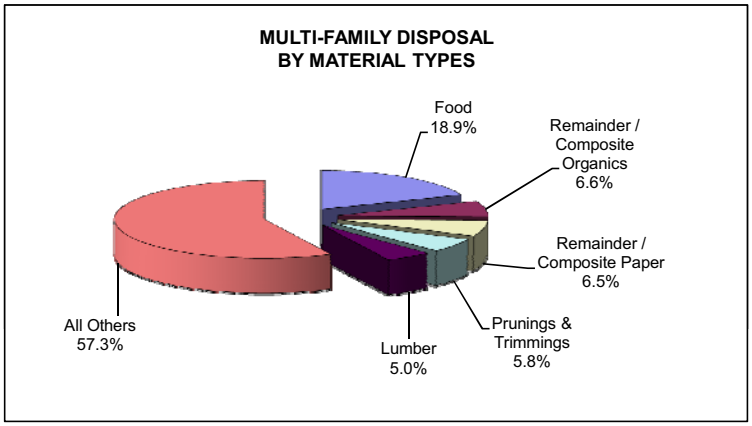
Figure 3-3

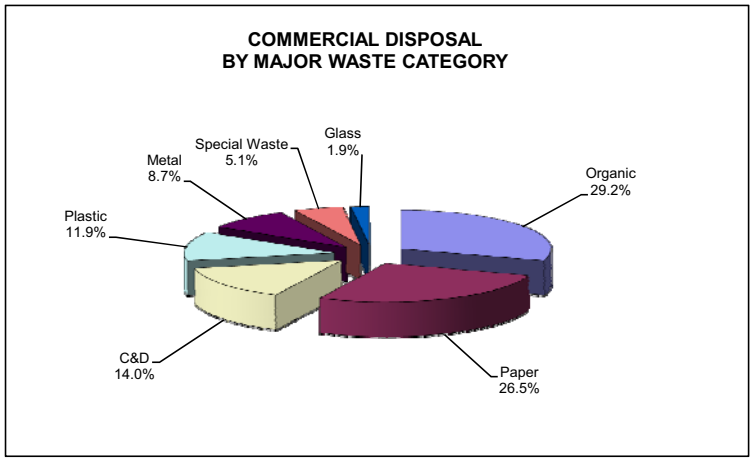
PASO ROBLES MASTER PLAN
WASTE COMPOSITION BY WASTE STREAM
WASTE STREAMS CONTROLLED BY FRANCHISED HAULER
(3-Year Average 2006-2008)











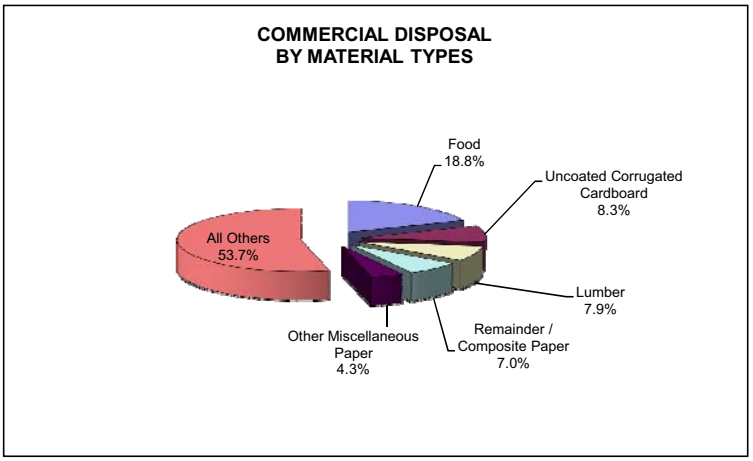
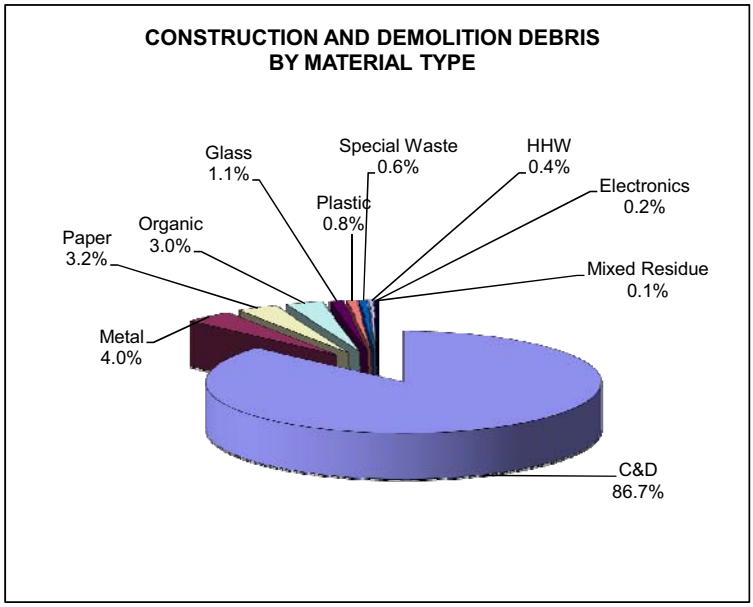
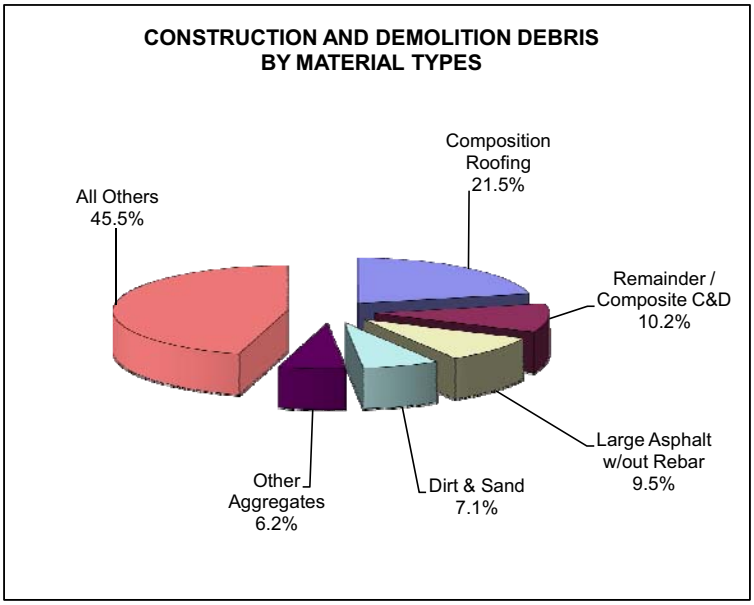


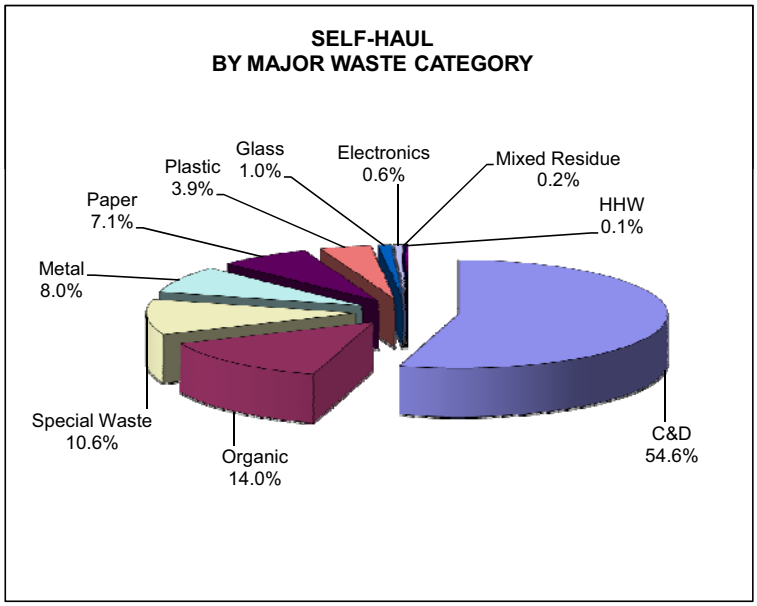
Figure 3-4

PASO ROBLES MASTER PLAN
WASTE COMPOSITION BY WASTE STREAM
UNCOMPACTED WASTE STREAMS DELIVERED TO LANDFILL

(3-Year Average 2006-2008)







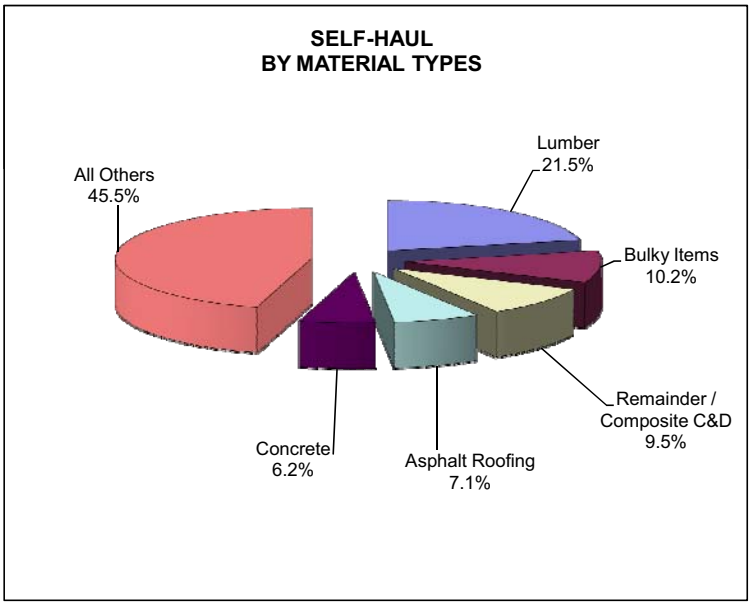
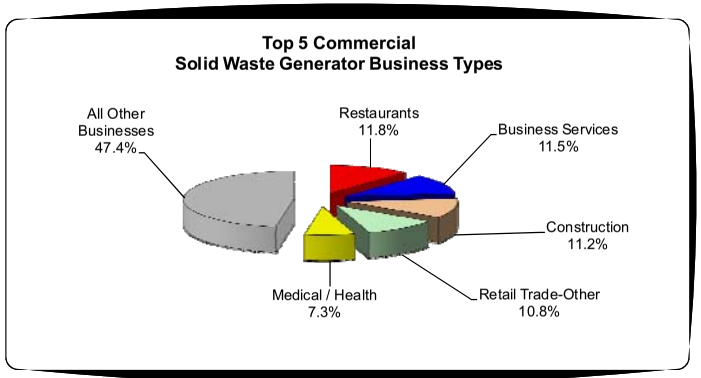
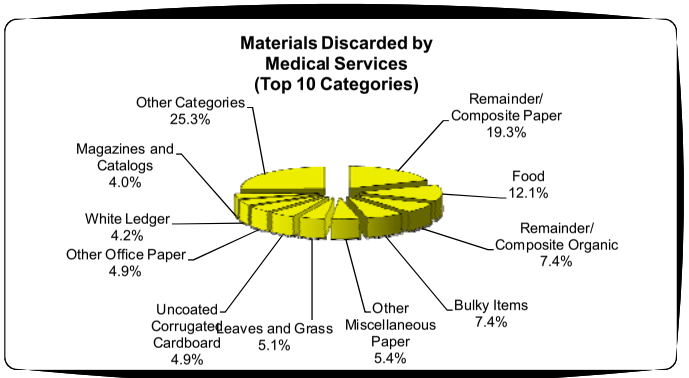
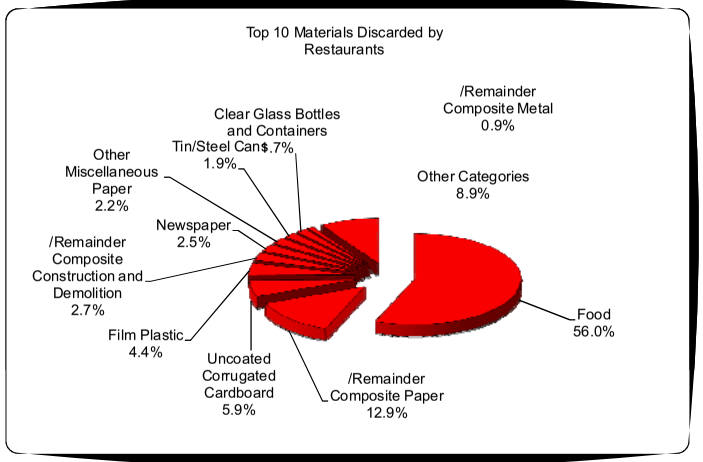
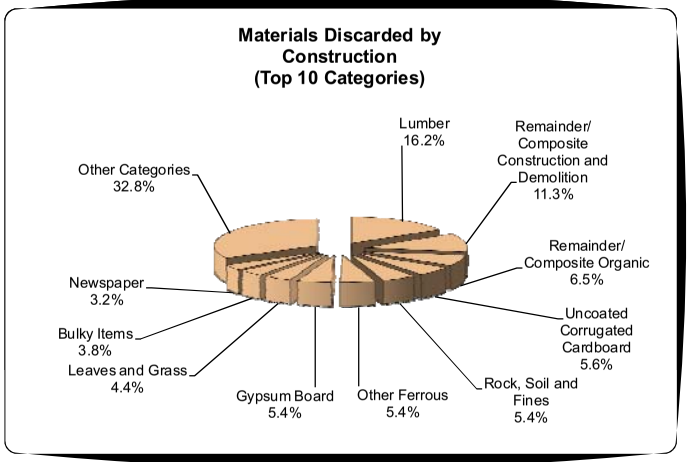


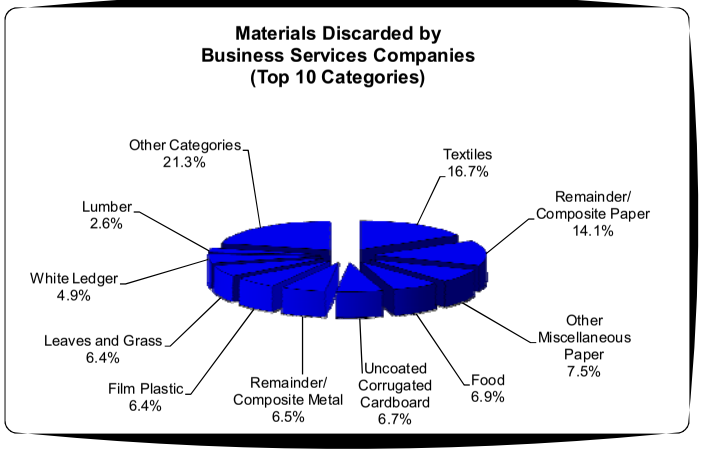
Figure 3-5
PASO ROBLES MASTER PLAN
WASTE COMPOSITION
BY MAJOR BUSINESS TYPES

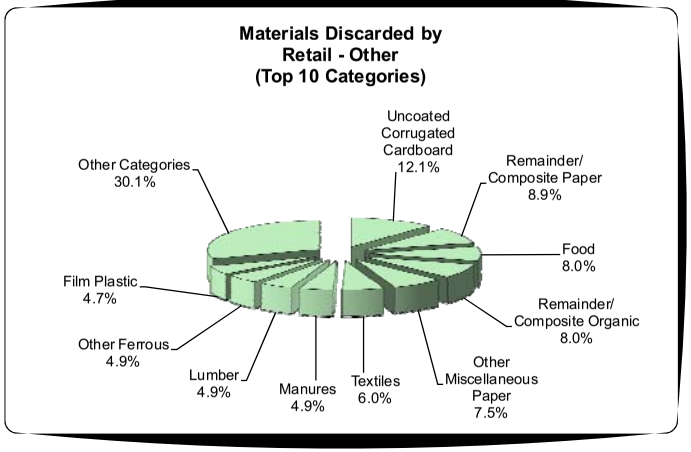












SECTION FOUR

ZERO WASTE INFRASTRUCTURE

4.0 Zero Waste Infrastructure

This section provides a snapshot of the existing solid waste management infrastructure facilities in San Luis Obispo County. Only facilities that are capable of handling and processing a primary City waste stream (e.g., mixed residential, mixed commercial, food waste, yard waste, and commingled recyclables) were included. A map showing all of these facilities is included in this section as Figure 4-1. Information on existing facilities is presented followed by an assessment of additional facility capacity needs based on the City's current waste streams.

The following types of solid waste management infrastructure facilities were reviewed:

- Recyclable Material Processing Facilities;
- Transfer Stations;
- Construction and Demolition (C&D) Debris Processing Facilities;
- Composting Facilities (Green Waste/Wood Waste);
- Food Waste Composting Facilities; and
- Disposal Facilities.

For each facility identified, information presented includes:

- Location;
- Types of Materials Accepted;
- Permitted Daily Capacity (if available);
- Available Capacity (if available);
- General Description of Facility Operations; and
- Expansion Plans (if known).

There are smaller volume facilities throughout the region that fall below the permit required threshold such as Standard Industries, McCoy Resources, SA Recycling LLC, and Viborg. While these provide a solid waste handling benefit, they may not currently be set up to accept municipal waste.

4.1 EXISTING WASTE HANDLING SUMMARY

The City's waste and recyclables are currently collected by Paso Robles Disposal who has exclusive rights to collect all residential and commercial waste in the City. The various waste streams are currently taken to the following facilities:

- **Franchised Hauler Solid Waste**
  - Residential and Commercial Waste – The City's franchise agreement with Paso Robles Disposal requires that all solid waste collected in the City

under the franchise (excluding roll-off box services) be delivered to the City's landfill (City of Paso Robles Landfill).

- Roll-Off Waste – The City's franchise agreement with Paso Robles Roll-Off requires that all solid waste collected within the City under the franchise be delivered to the City's landfill.

- **City Facility Waste** – City facility waste, sludge, and grit from the wastewater treatment plant are delivered to the City's landfill for diversion and disposal;
- **Self-Haul Waste** – Self-haul waste from the City is delivered to the City's landfill. Portions of this waste stream are taken to the Chicago Grade Landfill for diversion and disposal;
- **Residential Green Waste** – Residential green waste is delivered for diversion to the Buckeye Enterprises Chip and Grind Facility, which is owned by San Miguel Garbage;
- **Commercial Green Waste** – Commercial green waste is also delivered for diversion to the Buckeye Enterprises Chip and Grind Facility;
- **Residential Recyclables** – Residential recyclables are delivered for diversion to the Paso Robles Recycling facility on Riverside Avenue in Paso Robles, which is owned by Waste Management. Waste Management then transfers the recyclables to their facility in Santa Maria for processing;
- **Commercial Recyclables** – Commercial recyclables are taken to two (2) different recycling facilities. Source-separated cardboard is taken to the Waste Management Paso Robles Recycling facility. Commingled commercial recyclables are direct-hauled by Paso Robles Disposal to the recyclables processing facility at the Cold Canyon Landfill; and
- **Construction and Demolition Debris** – Paso Robles Roll-Off is required to take all debris box loads, including C&D debris, to the City's landfill where material is diverted and disposed.

RECYCLABLE MATERIAL PROCESSING FACILITIES

There are four (4) facilities in the County that can process single-stream recyclables like those collected by the City's curbside recycling program. These facilities are listed in Table 4-2 of this section. Figure 4-2 provides a map with the location of these facilities. A brief description of each of these facilities is provided below.

1) Paso Robles Recycling Facility[1] – This facility is located on Riverside Avenue in the City of Paso Robles and is owned by Waste Management. It serves as a buy-back center for bottles and cans, and also receives other source-separated recyclables such as source-separated cardboard from the City's

[1] This facility should not be confused with Paso Robles *Recycle* Facility which accepts asphalt and concrete.

commercial customers. This facility does not have a solid waste facility permit.

2) Buckeye Material R&P Facility [40-AA-0047] – Buckeye Enterprises recently constructed a Material Recovery Facility (MRF) at Buckeye's site at 6625 Benton Road, which is reported to have the ability and available capacity to process commingled recyclables. The City's residential commingled recyclables are currently delivered to Buckeye Material R&P.

3) North San Luis Obispo County Recycling Facility [40-AA-0039][2] – This facility is located at 3360 La Cruz Way in Templeton, which is seven (7) miles south of Paso Robles. The facility has the ability to process commingled recyclables and has reported that it has sufficient capacity available to process the City's recyclable materials. The facility currently receives an average of 500 tons per month and has a reported (April 2010) design capacity of 1,000 tons per month. The commingled recyclables currently being received meet the less than 10 percent residual and less than 1 percent putrescible waste which allows the facility to operate a Transfer/Processing Facility without a permit.

4) Cold Canyon Landfill (Material Recovery Facility) [40-AA-0017] – This facility is located at 2268 Carpenter Canyon Road in San Luis Obispo, which is about 37 miles from Paso Robles. The facility accepts municipal commingled recyclables for sorting and processing. It has a maximum throughput capacity of approximately 150 tons per day and is currently accepting approximately 3,000 tons per month. This means it is operating at, or near, the capacity of its current equipment.

TRANSFER STATIONS

There is only one (1) permitted Transfer Station in the County, the Santa Maria Transfer Station, which could provide solid waste transfer capacity for the City. That facility is listed in Table 4-3 of this section and Figure 4-3 provides a map with the location of the facility. A brief description of each of the facilities is provided below.

1) Santa Maria Transfer Station [40-AA-0022] – This facility is located at 325 Cuyama Lane in Nipomo, which is 58 miles from Paso Robles. The facility is permitted to accept metals, mixed municipal waste, and tires. It has a maximum permitted throughput capacity of 500 tons per day. This facility floor sorts tires, household hazardous waste, metals, and wood utilizing a CAT 32DL Excavator with grapple. Metals are hauled to market while wood, green waste, and tires are used as Alternative Daily Cover. Waste is reloaded into transfer trailers and transferred to the Chicago Grade Landfill.

[2] Number and letter codes following facility names represent CIWMB Facility Solid Waste Information System (SWIS) number.

CONSTRUCTION & DEMOLITION DEBRIS PROCESSING FACILITIES

There are eight (8) Construction and Demolition Waste Processing Facilities in San Luis Obispo County, including those that accept mixed C&D loads and those that accept more limited material types. The major C&D debris processing facilities are listed in Table 4-4 and their locations are shown on Figure 4-4. A brief description of each of these facilities is provided below.

1. City of Paso Robles Landfill - The City's landfill operator recovers C&D debris by directing clean loads of wood and inert material to on-site stockpiles and recovering material from mixed loads at the landfill working face. There is no dedicated area for processing C&D debris or other materials (e.g., self-haul loads) at the landfill. The City's landfill is an IWMA Certified C&D facility[3], but is not permitted by the CIWMB as a Construction Demolition and Inert (CDI) Debris Processing Facility.
2. Paso Robles Recycle Facility[4] – This facility is located 425 Volpi Ysabel within the City limits. The facility accepts asphalt and concrete. This facility is a large concrete batch plant, with CalPortland Cement and Hanson Aggregates on adjacent/contiguous properties. The site accepts concrete and asphalt for recycling. They re-crush asphalt to make new asphalt, called RAP (Recycled Asphalt Product). They have a large mobile machine on-site called a "portable crushing and screening plant" that crushes large concrete blocks. The site does not accept mixed C&D debris for recycling. The facility is not permitted by the CIWMB as a CDI Debris Processing Facility.
3. North San Luis Obispo County Recycling Facility [40-AA-0039] – This facility is located at 3360 La Cruz Way in Templeton, which is 7 miles south of Paso Robles. The facility accepts C&D and inert materials including appliances, asphalt, brick, concrete, drywall, metal, cardboard, pallets, and wood. This site has a sorting line for C&D debris. This facility is an IWMA Certified C&D facility, and is permitted as a Medium Volume CDI Debris Processing Facility.
4. Chicago Grade Landfill [40-AA-0008] – This facility is located at 2290 Homestead Road in Templeton, which is 17 miles from Paso Robles. The posted gate rate for C&D debris with a "recycle certificate" is $47.00 per ton. This facility is an IWMA Certified C&D facility and is permitted as a Large Volume CDI Debris Processing Facility. The maximum permitted throughput capacity is 175 tons per day.

   At the recycle area, also know as the C&D facility, tires, clean wood, green waste, and commingled recyclables are deposited into designated areas. Metals, wood, tires, and household hazardous waste pulled from the waste stream at the working face are hauled to recycle areas to be processed and/or transported off-site. The facility has expansion plans to develop a

[3] The IWMA has certified that the facility recycles 50 percent of the waste it receives.

[4] This facility should not be confused with "Paso Robles Recycling" which is Waste Management's clean MRF facility.

covered, two-acre facility with an elevated picking line, baler, and recyclables storage. No material is composted. The volume of material processed at the MRF is expected to be 100 to 200 tons per day. The loads sorted at the MRF will include both C&D and self-hauled waste (i.e., the uncompacted waste stream). Approximately 50 to 75 percent of the uncompacted waste stream would be directed to the MRF; at present, only about 20 percent of the incoming waste is "processed" for recovery.

5. Negranti Construction – This facility is located at 1424 Old Creek Road in Cayucos, which is 21 miles from Paso Robles. The facility accepts asphalt.
6. Cold Canyon Landfill [40-AA-0017] - This facility is located at 2268 Carpenter Canyon Road in San Luis Obispo, which is about 37 miles from Paso Robles. The facility has an open, uncovered, paved pad for accepting and sorting C&D debris. The material is sorted manually and with small loaders. There are no conveyors or other equipment for material sorting. The facility (overall site) does not have separate permit limits for the C&D part of the facility. Cold Canyon Landfill is in the process of preparing an Environmental Impact Report for a new C&D processing facility. The proposed new facility would be under a roof and would include more sorting equipment for C&D debris. This facility is an IWMA Certified C&D facility.
7. Gator Crushing & Recycling – This facility is located at 2363 Willow Road in Arroyo Grande, which is 52 miles from Paso Robles. The facility accepts asphalt and concrete.
8. Troesh Supply Company [40-AA-0044] – This facility is located at 2290 Hutton Road in Nipomo, which is 58 miles from Paso Robles. The facility accepts asphalt, concrete, and sand.

ADDITIONAL RECOVERY/REUSE FACILITY

- There is a Habitat for Humanity "ReStore" in Templeton. It is a building materials thrift store that carries a wide variety of used building materials. If the City of Paso Robles adds a "deconstruction" requirement to its C&D debris ordinance, ReStore will be a valuable resource.
- R&R Roll-Off in Arroyo Grande is permitted as a Small Volume CDI Debris Processing Facility with a maximum permitted throughput of 25 tons per day.

COMPOSTING FACILITIES (GREEN WASTE/WOOD WASTE)

There are ten (10) active permitted composting facilities in San Luis Obispo County that accept a variety of materials. These facilities are listed in Table 4-5 and Figure 4-5 provides a map with the location of these facilities. A brief description of these facilities is provided below.

1. Paso Robles Composting Company [40-AA-0032] – This facility is located at 934-B Paso Robles Street within the City limits. The facility is permitted to

accept green materials and has a maximum permitted throughput capacity of 200 tons per day. The business sells loose compost and other landscaping materials such as gravel, rock, bark, and mulches to landscapers and gardeners. The materials are stored on-site in bunkers. The facility is located in the center of the City and has stopped composting operations on-site, due to odor complaints. The site is currently receiving approximately only a few tons per day and, therefore, has an abundance of remaining, unused capacity. The facility does not have a scale to weigh waste. The charge is approximately $12.00 per load to dump a small truck-load of green waste. Currently, green materials are unloaded on the ground at the back of the site and stored in an open pile until the site receives a delivery of finished compost from its compost vendor, Kochergan Farms in Avenal. When the finished compost is unloaded, the green waste is then loaded (using a wheel loader) into the same truck and is back-hauled to the composting site.

2. Buckeye Enterprises Chip & Grind Operation [40-AA-0045] – This facility is located at 6625 Benton Road within the City limits. The facility is permitted to accept green materials and has a maximum permitted throughput capacity of 200 tons per day. This facility chips green waste but does not compost the material. Residential and commercial green waste from the City is delivered off-site to Buckeye Enterprises for chipping. Buckeye Enterprises also produces mulch products from its operation.

3. North San Luis Obispo County Recycling (Chip and Grind Facility) [40-AA-0040] – This facility is located at 3360 La Cruz Way in Templeton, which is 7 miles away from Paso Robles. The facility is permitted to accept green materials and wood waste and has a maximum permitted throughput capacity of 199 tons per day. This facility handles all of the City of Atascadero's green waste but still has significant available capacity. Materials accepted at the facility are transferred to the B. Goodrow composting site in Creston (see below).

4. Chicago Grade Landfill [40-AA-0008] – This facility is located at 2290 Homestead Road in Templeton, which is 17 miles from Paso Robles. There are several operations at the site, which is why this facility also appears in other categories in this memorandum. Wood and green waste are ground on-site using a tub grinder. Ground wood is hauled off-site to be used as fuel at a co-generation plant, used as mulch, used on landfill slopes for erosion control, or used as Alternative Daily Cover material. The facility currently accepts approximately 3,900 tons of green waste per year and 6,000 tons of wood waste per year. Wastes accepted for recycling are not included in the facility's daily permit limit. The Chicago Grade expansion plans include adding a Material Recovery Facility and a Waste Transformation Facility (an ethanol plant or biomass-to-energy plant.)

5. Cagliero Ranches, Inc. Composting [40-AA-0031] – This facility is located at 8625 North River Road in San Miguel, which is 11 miles from Paso Robles.

The facility is permitted to accept agricultural waste, green materials, and manure. It has a maximum permitted throughput capacity of 9,000 tons per year.

6. Morro Bay - Cayucos POTW Composting [40-AA-0036] – This facility is located at 160 Atascadero Road in Morro Bay. The facility is permitted to accept green materials and sludge (biosolids) and has a maximum permitted throughput capacity of 1,500 cubic yards per year.
7. B. Goodrow, Inc. Composting [40-AA-0037] – This facility is located at 3730 Calf Canyon Highway in Creston. This is about 33 miles from Paso Robles. The facility is permitted to accept agricultural waste and green materials. It has a maximum permitted throughput capacity of 999 cubic yards. This facility is affiliated with and receives material from the North San Luis Obispo County Recycling chip and grind facility listed above.
8. Alpha Produce [40-AA-0038] – This facility is located at 6525 O'Donovan Road in Creston, which is 33 miles away from the City. The facility is permitted to accept agricultural waste and has a maximum permitted throughput capacity of 5,500 cubic yards per year.
9. Winsor Woodyard [40-AA-0042] – This facility is located at 1022 San Simeon Creek Road in Cambria, which is 34 miles away from Paso Robles. The facility is permitted to accept green materials and wood waste and has a maximum permitted throughput capacity of 800 tons per year.
10. Cold Canyon Landfill (Composting Operation) [40-AA-0017] – The facility is located at 2268 Carpenter Canyon Road in San Luis Obispo, which is 37 miles from Paso Robles. The facility is permitted to accept agricultural waste, C&D waste, green materials, and wood waste. It has a maximum permitted throughput capacity of 350 tons per day and the current throughput for green waste is 120 tons per day, indicating that the site has available capacity of 230 tons per day of green waste. The facility has a large area for open windrow composting and all of the necessary accompanying mobile equipment to operate the composting facility. (See this facility also listed under "Disposal Facilities.") The facility's gate rate for "clean brush" or green waste is $20.00 per ton.

FOOD WASTE COMPOSTING FACILITIES

San Luis Obispo County Facilities

There are no active permitted Food Waste Facilities in San Luis Obispo County. The nearest permitted food waste composting facility is located in Avenal in Kings County, approximately 60 miles from the City. However, the North San Luis Obispo County Recycling chip and grind facility in Templeton is attempting to obtain authorization for a food waste composting operation that would accept food waste that would then be transferred to the B. Goodrow site in

Creston for composting. A company representative reported that it is looking to secure a food waste stream for a pilot program.

Out-of-County Facilities

There are currently no permitted food waste *composting* facilities inside San Luis Obispo County. Food waste *processing* capacity statewide is limited with only 12 facilities permitted in California. While developing a facility in the County is an option, two of the permitted facilities may represent viable options for the City's waste stream, although that material would need to be transfer-hauled. These two facilities were identified as options based on being located within 100 miles of Paso Robles. A brief description of each of these facilities is provided below.

1. Kochergan Farms Composting [16-AA-0022] – This facility is located at 33915 Avenal Cutoff Road in Avenal, Kings County, which is 60 miles north of the City. The maximum permitted throughput (including food waste along with other green materials) is 1,000 tons per day.
2. Liberty Composting Inc. (San Joaquin Composting) [15-AA-0287] – This facility is located at 12421 Holloway Road in Lost Hills, Kern County, which is 65 miles east of Paso Robles. The maximum permitted throughput capacity [including food waste along with sludge (biosolids) and agricultural waste] is 786,000 tons per year.

These facilities are listed in Table 4-6 and their location is shown on Figure 4-6.

DISPOSAL FACILITIES

There are a total of three (3) active permitted Disposal Facilities in San Luis Obispo County. These facilities are listed in Table 4-7 and shown on Figure 4-7. A brief description of each of these facilities is provided below.

1. City of Paso Robles Landfill [40-AA-0001] – This is the primary site that receives waste from the City of Paso Robles. All waste that is collected by the City's franchise hauler is delivered to the City's landfill. The landfill is located on Highway 46, 8 miles east of Paso Robles, but within the City limits. The facility is permitted to accept agricultural waste, C&D waste, green materials, industrial waste, metals, mixed municipal waste, sludge, tires, and wood waste. It has a maximum permitted throughput capacity of 450 tons per day. The site receives an average of 200 to 400 tons per day. Recent waste tonnages are approximately 20 percent lower than in recent years, due mainly to the downturn in the economy.
2. Chicago Grade Landfill [40-AA-0008] – This facility is located at 2290 Homestead Road in Templeton, which is 17 miles from Paso Robles. The facility is permitted to accept agricultural waste, asbestos, C&D waste,

contaminated soil, dead animals, food wastes, green materials, industrial waste, inert materials, metals, mixed municipal waste, other designated waste, sludge, and tires. The facility has a maximum permitted throughput capacity of 500 tons per day (plus recyclables), and is currently receiving approximately 277 tons per day. The facility accepted approximately 2,200 tons of waste from the City of Paso Robles in 2008. The posted gate rate is $41.00 per ton for compacted waste from franchised haulers and $47.00 per ton for uncompacted waste.

3. Cold Canyon Landfill [40-AA-0004] – This facility is located at 2268 Carpenter Canyon Road in San Luis Obispo, which is about 37 miles from Paso Robles. The facility is permitted to accept agricultural waste, C&D waste, contaminated soil, dead animals, industrial waste, inert materials, mixed municipal waste, sludge, and tires. It has a maximum permitted throughput capacity of 1,200 tons per day and is currently accepting approximately 600 tons per day.

   The landfill also has a diversion program for self-hauled waste. Each self-hauler that uses the facility must first stop at the "Resource Recovery Park" at the entrance to the landfill (adjacent to the scale house.) There are several roll-off boxes and bins located at the Resource Recovery Park, so that each self-hauler can unload all recyclable items before entering the site. Those self-haulers that are unwilling to stop at the park and separate materials for recycling must pay an additional $20.00 fee to the landfill.

4.2 SUMMARY OF FACILITY CAPACITY REQUIREMENTS

Table 4-8 provides projections of the various City waste stream tonnages and associated facility capacity requirements expressed as tons per day of required capacity. The facility capacity projections, which are based on the Waste Generation, Diversion and Disposal projections presented in the Section Three – Zero Waste Programs, are summarized below.

RECYCLABLE MATERIAL PROCESSING CAPACITY

The projected tons per day of Residential and Commercial recyclables in Table 4-8 assume a straight line increase in 2006-2008's three-year average tonnage:

- Without any change in diversion rates; and
- With "Increased Diversion" - Assuming a 50 percent increase in the current Single-Family Residential curbside recyclables diversion rate and an approximately 500 percent increase in the Commercial/Multi-Family Residential recyclables diversion rate.

As shown, 17 tons per day of processing capacity is required to process the three-year average recyclable tonnages generated by the residential and

commercial waste streams, increasing to 25 tons per day in 2025, assuming no change in diversion rates. This number jumps to 91 tons per day for the Increased Diversion scenario described above.

CONSTRUCTION & DEMOLITION DEBRIS PROCESSING CAPACITY

An average of 36 tons per day of uncompacted material was received at the City's landfill over the last three years, with an average 6 tons per day diverted. The uncompacted City tonnage is projected to increase to 54 tons per day by 2025 assuming a straight line increase in the 2006-2008 three-year average tonnage. Additional non-City uncompacted tonnage is also received at the landfill and would also be available for processing.

COMPOSTING CAPACITY (GREEN WASTE/WOOD WASTE)

The projected tons per day of Residential and Commercial green waste/wood waste in Table 4-8 assume a straight line increase in 2006-2008 three-year average tonnage:

- Without any change in diversion rates; and
- With "Increased Diversion" - Assuming a 50% increase in the current Single-Family Residential green waste diversion rate and an approximately 500% increase in the Commercial / Multi-Family Residential green waste diversion rate.

As shown, 15 tons per day of processing capacity is required to process the 3-year average recyclable tonnages generated by the residential and commercial waste streams, increasing to 22 tons per day in 2025, assuming no change in diversion rates. This number increases to 40 tons per day for the Increased Diversion scenario described above.

FOOD WASTE PROCESSING CAPACITY

Food waste comprises approximately 20 percent of the material disposed by residential and commercial generators. If all of this material was recovered, it would be equivalent to 17 tons per day in 2010 and 25 tons per day in 2025, assuming a straight line increase in the 2006-2008 three-year average tonnage.

DISPOSAL CAPACITY

The City disposed of an average of 125 tons of waste per day over the last three years. Assuming no change in the City's three-year average diversion rate, by 2025 that rate is projected to increase to 187 tons per day, assuming a straight line increase in the 2006-2008 three-year average tonnage.

4.3 ASSESSMENT OF ADDITIONAL FACILITY INFRASTRUCTURE NEEDS

RECYCLABLE MATERIAL PROCESSING FACILITIES

Summary Needs Analysis
There appears to be sufficient single stream recycling capacity within the County, including the North San Luis Obispo County Recycling Facility, Paso Robles Recycling Facility (which transfers recyclables to a companion processing facility), the MRF at Cold Canyon Landfill (transfer or direct-haul), and the recently constructed Buckeye MRF.

Our understanding is that Paso Robles Disposal is under contract to deliver the City's residential commingled recyclables to Waste Management's Paso Robles Recycling Facility. These materials are then transfer-hauled from that facility to Waste Management's facility in Santa Maria where they are processed.

The City's commercial commingled recyclables, however, are reported to be direct-hauled over the Chicago Grade to Cold Canyon Landfill's recyclables processing facility. There appear to be two (2) other local processing options for the City's residential and commercial commingled recyclables:

- North San Luis Obispo County Recycling accepts mixed recyclables at their facility in Templeton. A company representative stated that the facility has available capacity and could process the City's commingled recyclables. The company representative also stated that it would be interested in an agreement to accept recyclable materials (as well as green waste) for processing in exchange for directing facility waste residue to the City's landfill. The residue is currently being delivered to Chicago Grade Landfill.
- Buckeye Enterprises recently constructed a MRF and is reported to have the ability and available capacity to process commingled recyclables. The City's residential commingled recyclables are also delivered to Buckeye Material R&P.

TRANSFER STATIONS

Summary Needs Analysis
There is no need for transfer station capacity for solid waste given the location of the City's landfill.

Transfer capacity for curbside recyclables is currently available through Waste Management's facility for the transfer of the City's recyclables to the processing facility in Santa Maria. However, there also appears to be viable local alternatives that do not require transfer capacity.

Transfer capacity for the City's green waste is not required, given the availability of local options, although should the City wish to access more distant processing sites (e.g., Cold Canyon Landfill's composting operation) transfer capacity would be highly desirable, if not required.

Transfer capacity for food waste as part of a potential future food waste diversion program would be required to access currently permitted food waste processing facilities out-of-County. The development of local food waste processing capacity, which is currently being explored by at least one local business that we are aware of (North San Luis Obispo County Recycling) would, however, preclude the need for such food waste transfer capacity.

Should the City need transfer capacity, such capacity could potentially be provided through the development of a direct transfer facility at the City's landfill, which requires less capital investment than a traditional transfer station and has lesser permitting requirements.

There is currently limited transfer capacity available for the City's waste stream. As discussed above, the only permitted solid waste/food waste transfer station in the County is located in Nipomo, more than 50 miles from the City. For transfer facilities to provide efficiencies, they must be located within a reasonable distance from the waste centroid, so this facility does not represent a viable transfer option.

While there is no need for solid waste transfer capacity for the foreseeable future, given the location of the City's landfill and its remaining capacity, transfer capacity for transferring single-stream recyclables and/or green waste to more distant processing facilities would be necessary, although it does not appear to be required given the availability of local options. Additionally, should the City wish to pursue food waste composting, which represents a potential significant opportunity for achieving additional diversion, and no local facility is developed, the City will need to transfer food waste to an existing permitted facility out-of-County.

Short of developing a fully-permitted transfer station, the City may wish to consider the potential for developing a direct-transfer facility at the City's landfill. A direct-transfer facility, as defined by the CIWMB, is a transfer facility that receives at least 60 cubic yards or 15 tons but less than 150 tons per day. The waste must be transferred only once from one covered container to another so the waste is never outside the confines of a container. Special transfer trailers exist for this function which can accept waste directly from route trucks. A transfer area (preferably paved) with grade separation to allow the route trucks to dump their loads into the transfer trailer would be required.

C&D DEBRIS PROCESSING FACILITIES

Summary Needs Analysis

The City currently has limited C&D processing capacity at its landfill. Providing for more effective processing of C&D debris and self-haul materials entering the City's landfill (i.e., the uncompacted waste stream) represents the most significant facility infrastructure need for the City at this time. The City should consider developing enhanced on-site recovery capacity for both the C&D waste stream and self-haul waste stream entering the landfill. Alternatively, the City could consider directing mixed C&D loads to the North San Luis Obispo facility, although it should verify the effectiveness of any such non-City processing capacity.

The C&D debris recovery operations at the City's landfill are certified by the IWMA for diversion of 50 percent. Those operations involve the directing of clean loads of green waste/wood waste and inert materials to on-site stockpiles. Recovery of materials from mixed C&D loads is largely limited to recovery of materials from the working face. There is no dedicated area for processing of mixed C&D loads or other loads that offer high-recovery potential (e.g., uncompacted self-haul loads).

There are two (2) major options for the City to increase diversion from mixed C&D loads:

- Deliver loads to a facility that has the ability to more effectively process mixed C&D loads (both the Chicago Grade Landfill and Cold Canyon Landfill have plans for enhanced C&D recovery operations, including mechanized sorting lines, and the North San Luis Obispo County Recycling Facility already has mixed C&D processing capacity); or
- Develop enhanced mixed C&D recovery capacity at the City's landfill.

This second option could involve increased labor to recover materials from the working face. A relatively low-tech "recycling pad" could also be constructed where uncompacted loads (C&D loads and self-haul loads) would be tipped in a dedicated area for manual and mechanical processing and recovery, similar to Cold Canyon Landfill's existing C&D sorting facility. Below-grade bins would enhance recovery efforts. Self-haul loads could also be required to pre-sort material at a designated area, similar to the "Resource Recovery Park" at the Cold Canyon Landfill. A more mechanized system could also be developed. Further analysis is needed to site these ancillary facilities at the Paso Robles Landfill. The addition of these types of facilities would require an amendment to the Joint Technical Document (JTD).

COMPOSTING FACILITIES (GREEN WASTE/WOOD WASTE)

Summary Needs Analysis
There appears to be sufficient local capacity for the City's green waste/wood waste, although composting options, as opposed to mulching, are more limited.

The City's residential and commercial green waste is currently delivered to Buckeye Enterprises where it is processed and mulched; it is not composted. Buckeye Enterprises has reported that it is well below capacity and could accept more green waste from the City.

North San Luis Obispo County Recycling Facility operates a composting operation for green waste materials and has expressed that it has capacity and would be eager to accept the green waste stream from the City.

The City could consider the following options for its green waste stream:

- Continue to deliver residential and commercial green waste to Buckeye Enterprises where mulch is the final product;
- Deliver green waste to the North San Luis Obispo County Recycling Facility for transfer and composting;
- Arrange for delivery (e.g., direct-transfer facility at the City's landfill) of green waste to Cold Canyon Landfill's composting operation; or
- Construct on-site composting capacity at the landfill.

FOOD WASTE COMPOSTING FACILITIES

Summary Needs Analysis
Determine City's interest in implementing food waste diversion program. If such a program is of interest:

- *Explore the potential for a pilot program in conjunction with North San Luis Obispo County Recycling company's planned food waste composting pilot project;*
- *Determine potential for coordinated regional food waste composting facility; and/or*
- *Evaluate potential for direct-transfer of food waste at the City's landfill to an existing out-of-County permitted facility.*

Diversion of food waste from both the residential and commercial sectors represents perhaps the most significant opportunity for the City to divert additional materials from these waste streams through a new program. There are, however, no active permitted food waste composting facilities in the

County. The North San Luis Obispo County Recycling Chip and Grind facility in Templeton, however, is attempting to obtain authorization for a food waste composting operation that would accept food waste at its facility. This material would then be transferred to the B. Goodrow site in Creston for composting. A company representative reported that it is looking to secure a food waste stream for a pilot program. Alternatively, there are a number of permitted food waste processing operations within a reasonable transfer haul distance of the City that could provide the necessary processing capacity, although transfer capacity would need to be developed to access these sites.

If the City is interested in exploring food waste composting, we suggest that it contact North San Luis Obispo County Recycling Facility and explore the potential for participating in its planned food waste composting pilot project. Paso Robles Disposal would also have to be involved in any such planning efforts.

DISPOSAL FACILITIES

Summary Needs Analysis
No additional disposal capacity is required.

The County's three (3) permitted landfills currently have substantial capacity available to handle the County's disposal needs for many years to come as shown in the table below:

Landfill	Remaining Capacity (Cubic Yards)	Date Reported	Anticipated Closure Date
Paso Robles LF	5,327,500	5/1/07	2051
Cold Canyon	2,800,000	7/1/06	2012 (1)
Chicago Grade	8,329,699	5/1/07	2042

(1) Cold Canyon Landfill is currently seeking an expansion that would give it an estimated 25 years of additional capacity.

Source: CIWMB SWIS Database

The City's landfill has more than 40 years of projected disposal capacity available to handle the City's disposal needs. As such, the City has no need for additional disposal capacity at this time. The main landfill capacity related issue for the City at this time is to assure that landfill operations are geared toward most effectively utilizing the available disposal capacity that exists at this landfill by determining and achieving the optimal density of material that is landfilled and maximizing the recovery of materials to minimize the quantity of waste requiring landfilling.

The City could consider directing certain loads to Chicago Grade Landfill to conserve its landfill capacity (certain types of material that Chicago Grade

Landfill may be better able to manage and/or waste from certain areas of the City that may be more effectively hauled to Chicago Grade Landfill).

4.4 METHODOLOGY

Information was gathered from the following sources to prepare this memorandum:

- Facility data available on the website of the California Integrated Waste Management Board (CIWMB);
- Personal visits to facilities;
- Telephone interviews with facility operators;
- Telephone interviews with other parties including staff from IWMA, the Local Enforcement Agency (LEA), Paso Robles Disposal, Pacific Waste Services; and
- Reviews of facility websites.

4.5 SUMMARY OF KEY FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The following provides a summary of the key findings, conclusions, and recommendations for the solid waste infrastructure facilities in the County. The information is also presented in Table 4-1 – *Summary of Infrastructure Facilities and Needs Analysis/Recommendations.* Additional information is provided in the *Assessment of Additional Facility Infrastructure Needs* portion of this report.

- **Facility capacity** currently exists in the County within a reasonable direct haul[5] distance that is sufficient to handle the City's current and projected future needs to 2025 for:
    - Processing of residential and commercial recyclables;
    - Green waste and wood waste processing; and
    - Solid waste disposal.
- **Transfer capacity** for solid waste is not necessary given the proximity of the City's landfill. For delivering food waste to out-of-County food waste processing, facilities would need to be developed if the City decides to pursue a food waste diversion program and local processing capacity is not developed. Transfer capacity would be desirable, if not required to access certain C&D processing and green waste/wood waste processing capacity in the County, although alternative facility capacity exists within a reasonable direct haul distance.

[5] "Direct haul" refers to route collection vehicles directly hauling material to a facility rather than delivering the material to a transfer station where it is then "transfer-hauled" to a facility.

Any City required transfer station capacity could potentially be provided through the development of a "direct" transfer facility[6] at the City's landfill. Direct transfer facilities require less capital investment than a traditional transfer station and have less permitting requirements.

- The City currently has limited **C&D processing capacity** at its landfill. Providing for more effective processing of C&D debris and self-haul materials entering the City's landfill (i.e., the uncompacted waste stream) represents the most significant facility infrastructure need for the City at this time. The City should consider developing enhanced on-site recovery capacity for both the C&D waste stream and self-haul waste stream entering the landfill. Alternatively, the City could consider directing mixed C&D loads to the North San Luis Obispo facility, although it should verify the effectiveness of any such non-City processing capacity.

- **Food waste processing capacity** does not currently exist in the County, although one local facility operator is pursuing a pilot food waste composting operation. If local food waste processing capacity is not developed, the City could access out-of-County facilities provided the necessary transfer station capacity is developed, as discussed above.

Available facility capacity changes over time as a result of changes in facility permit conditions, incoming tonnages, and contractual obligations. As the City moves forward with the enhancement of its solid waste management system, it should consider the pros and cons of entering into contracts with facilities to secure necessary processing capacity. It should also consider changes to its franchise agreements (as part of any contract extensions or competitive procurements) to, among other things, provide the City with the right to direct the various waste streams to specific facilities, if it desires, and/or require the franchisee to guarantee and secure necessary facility capacity. Alternatively, the City may wish to consider taking over solid waste collection operations in the future to provide it with direct control of its waste streams and diversion programs.

In addition to the traditional solid waste management facility capacity discussed in this section, alternative technology capacity may also serve the future needs for some of the City's waste streams (e.g., using food waste as fuel for a co-generation facility along with fats, oil, and grease from the City's wastewater treatment plant).

[6] A direct-transfer facility, as defined by the CIWMB is a transfer facility that receives at least 60 cubic yards or 15 tons but less than 150 tons per day. The waste must be transferred only once from one covered container to another so the waste is never outside the confines of a container. Special transfer trailers exist for this function which can accept waste directly from route trucks.

LIMITATIONS

This analysis is based on information obtained from the CIWMB Solid Waste Information System, site visits, and interviews with facility operators and other sources. We have not verified all of the information reported by the various sources contacted. The City should conduct appropriate additional due diligence related to any potential facility options that it may wish to consider (e.g., regulatory status, facility capacity and long-term commercial viability).

SECTION FOUR

TABLES

TABLE 4-1
SUMMARY OF INFRASTRUCTURE FACILITIES AND NEEDS ANALYSIS/RECOMMENDATIONS

ZERO WASTE INFRASTRUCTURE	NO. OF FACILITIES IN COUNTY	NEEDS ANALYSIS/RECOMMENDATIONS
Recyclable Material Processing Facilities;	4	Sufficient single stream recycling capacity available within the County, including the North San Luis Obispo County Recycling Facility, Paso Robles Recycling Facility, MRF at Cold Canyon Landfill and recently constructed Buckeye MRF.
Transfer Stations;	1	There is no need for transfer station capacity for solid waste given the location of the City's landfill. Transfer capacity for food waste as part of a potential future food waste diversion program would be required to access currently permitted food waste processing facilities located out-of-County.
Construction and Demolition (C&D) Debris Processing Facilities;	8	The City currently has limited C&D processing capacity at its landfill. Providing for more effective processing of C&D debris and self-haul materials entering the City's landfill represents the most significant facility infrastructure need for the City at this time.
Composting Facilities (Green Waste/Wood Waste);	10	There appears to be sufficient local capacity for the City's green waste/wood waste although composting options, as opposed to mulching, are more limited.
Food Waste Composting Facilities; and	0	Determine City's interest in implementing food waste diversion program. If such a program is of interest: Explore the potential for a pilot program in conjunction with North San Luis Obispo County Recycling company's planned food waste composting pilot project; Determine potential for coordinated regional food waste composting facility; and/or Evaluate potential for direct-transfer of food waste at the City's landfill to an existing out-of-County permitted facility.
Disposal Facilities (Landfills).	3	No additional disposal capacity is required.

TABLE 4-2

RECYCLABLE MATERIAL PROCESSING FACILITIES

Map # (Figure 1)	County	Facility Name	Location	Distance from Paso Robles (miles) [1]	Permitted Daily Capacity
1	San Luis Obispo	Paso Robles Recycling Facility	Riverside Drive Paso Robles, CA	1	NA
2	San Luis Obispo	Buckeye Material R&P Facility	6625 Benton Road Paso Robles, CA	5	NA
3	San Luis Obispo	North SLO County Recycling Facility	3360 La Cruz Way Templeton, CA	7	174 tons
4	San Luis Obispo	Cold Canyon Landfill	2268 Carpenter Canyon Road San Luis Obispo, CA 93401	37	1,200 tons

[1] Distances are based on GoogleMaps determination of location of Paso Robles which is near the intersection of 24th and Spring Streets.

Note: Facilities currently used by City are shaded green.

Note: NA = Not a CIWMB permitted facility.

TABLE 4-3

TRANSFER FACILITIES

Map # (Figure 2)	County	Facility Name	Location	Distance from Paso Robles (miles) [1]	Permitted Daily Capacity
1	San Luis Obispo	Santa Maria Transfer Station	325 Cuyama Lane, Nipomo, CA	58	500 tons

[1] Distances are based on Googlemaps determination of location of Paso Robles which is near the intersection of 24th and Spring Streets.

TABLE 4-4

CONSTRUCTION & DEMOLITION PROCESSING FACILITIES

Map # (Figure 3)	County	Facility Name	Location	Distance from Paso Robles (miles) [2]	Permitted Daily Capacity
1	San Luis Obispo	Paso Robles Landfill [1]			
2	San Luis Obispo	Paso Robles Recycle Facility	425 Volpi Ysabel Paso Robles, CA 93446	6	NA
3	San Luis Obispo	North SLO County Recycling Facility [1]	12421 Holloway Rd Los Hills, CA 93249	7	174 tons
4	San Luis Obispo	Chicago Grade Landfill [1]	2290 Homestead Road Templeton, CA 93465	17	NA
5	San Luis Obispo	Negranti Construction	1424 Old Creek Road Cayucos, CA 93430	21	NA
6	San Luis Obispo	Cold Canyon Landfill [1]	2268 Carpenter Canyon Road San Luis Obispo, CA 93401	37	NA
7	San Luis Obispo	Gator Crushing & Recycling	2363 Willow Rd. Arroyo Grande, CA 93420	52	NA
8	San Luis Obispo	Troesh Recycling, Ind. Dba RoXsand	2280 Hutton Road Nipomo, CA 93444	58	NA

[1] IWMA Certified C&D Facility - means the Integrated Waste Management Authority has certified that the facility recycles 50% of the waste it receives.

[2] Distances are based on Googlemaps determination of location of Paso Robles which is near the intersection of 24th and Spring Streets.

Note: Facilities currently used by City are shaded green.

Note: NA = Not a CIWMB permitted facility.

TABLE 4-5

COMPOSTING FACILITIES

Map # (Figure 4)	County	Facility Name	Location	Distance from Paso Robles (miles) [1]	Permitted Daily Capacity
1	San Luis Obispo	Paso Robles Composting Co.	934-B Paso Robles St. Paso Robles, CA 93446	1	200 tons
2	San Luis Obispo	Buckeye Enterprises Chip & Grind	6625 Benton Road Paso Robles, CA 93446	5	200 tons
3	San Luis Obispo	North SLO Co. Recycling Chip and Grind	12421 Holloway Rd Los Hills, CA 93249	7	199 tons
4	San Luis Obispo	Cagliero Ranches Inc. Composting	8625 North River Rd. San Miguel, CA 93446	11	9,000 tons
5	San Luis Obispo	Chicago Grade Landfill	2290 Homestead Road Templeton, CA 93465	14	500 tons
6	San Luis Obispo	Morro Bay - Cayucos POTW Composting	160 Atascadero Rd. Morro Bay, CA 93442	29	1,500cy
7	San Luis Obispo	B. Goodrow, Inc. Composting	3730 Calf Canyon Hwy Creston, CA 93432	33	999cy
8	San Luis Obispo	Alpha Produce	6525 O'Donovan Road Creston, CA 93432	33	5,500 cy/year
9	San Luis Obispo	Winsor Woodyard	1022 San Simeon Creek Rd Cambria, CA 93428	34	NA
10	San Luis Obispo	Cold Canyon Landfill	2268 Carpenter Canyon Rd San Luis Obispo, CA 93401	38	5,000cy

[1] Distances are based on GoogleMaps determination of location of Paso Robles which is near the intersection of 24th and Spring Streets.

Note: Facilities currently used by City are shaded green.

Note: NA = Not a CIWMB permitted facility.

TABLE 4-6

FOOD WASTE COMPOSTING FACILITIES

Map # (Figure 5)	County	Facility Name	Location	Distance from Paso Robles (miles) [1]	Permitted Daily Capacity
NA	San Luis Obispo	North SLO Co. Recycling Chip and Grin	3360 La Cruz Way Templeton, CA 93465	7	199 tons
2	Kings	Kochergen Farms Composting	33915 Avenal Cutoff Rd. Avenal, CA 93204	60	1,000 tons

[1] Distances are based on Googlemaps determination of location of Paso Robles which is near the intersection of 24th and Spring Streets.

Note: NA = Not a CIWMB permitted facility.

TABLE 4-7

DISPOSAL FACILITIES

Map # (Figure 6)	County	Facility Name	Location	Distance from Paso Robles (miles) [1]	Permitted Daily Capacity
1	San Luis Obispo	Paso Robles Landfill	Hwy 46; 8 Mi E of Paso Robles Paso Robles, CA 93446	9	450 tons
2	San Luis Obispo	Chicago Grade Landfill	12421 Holloway Rd Los Hills, CA 93249	14	500 tons
3	San Luis Obispo	Cold Canyon Landfill	2268 Carpenter Canyon Road San Luis Obispo, CA 93401	37	1,200 tons

[1] Distances are based on Googlemaps determination of location of Paso Robles which is near the intersection of 24th and Spring Streets.

Note: Facilities currently used by City are shaded green.

TABLE 4-8

FACILITY CAPACITY REQUIREMENTS BY WASTE STREAM

Material	3-Year Average (Tons)	Projections (Tons)				Projections (Tons per Day)[1]					Increased Diversion	Food Waste (Tons per Day)[1][2]			
	Tons	2010	2015	2020	2025	3-Year Average	2010	2015	2020	2025	2025	2010	2015	2020	2025
SINGLE-FAMILY RESIDENTIAL															
Diversion	6,626	6,712	7,422	8,642	9,883	25	26	29	33	38	57				
Curbside Recyclables	*2,962*	*3,000*	*3,317*	*3,863*	*4,417*	*11*	*12*	*13*	*15*	*17*	*25*				
Green Waste	*3,665*	*3,712*	*4,105*	*4,780*	*5,466*	*14*	*14*	*16*	*18*	*21*	*32*				
Disposal	6,510	6,594	7,292	8,491	9,710	25	25	28	33	37		5	6	7	7
Generation	13,136	13,305	14,714	17,133	19,593	51	51	57	66	75					
Single-Family Residential Diversion Rate	50%	50%	50%	50%	50%						75%				
COMMERCIAL / MULTI-FAMILY RESIDENTIAL															
Diversion	1,634	1,655	1,830	2,131	2,437	6	6	7	8	9	49				
Commercial Recyclables	*1,452*	*1,471*	*1,627*	*1,894*	*2,166*	*6*	*6*	*6*	*7*	*8*	*44*				
Green Waste	*182*	*184*	*204*	*237*	*271*	*1*	*1*	*1*	*1*	*1*	*5*				
Disposal	15,448	15,647	17,304	20,149	23,041	59	60	67	77	89		12	13	15	18
Generation	17,082	17,302	19,134	22,280	25,479	66	67	74	86	98					
Commercial (Including Multi-Family Residential) Diversion Rate	10%	10%	10%	10%	10%						50%				
CITY WASTE (Sludge, Grit & Other City Waste)															
Diversion	2,683	2,717	3,005	3,499	4,001	10	10	12	13	15					
Disposal	2,760	2,796	3,092	3,600	4,117	11	11	12	14	16					
Generation	5,443	5,513	6,096	7,099	8,118	21	21	23	27	31					
City Waste Diversion Rate	49%	49%	49%	49%	49%										
UNCOMPACTED LANDFILL WASTE STREAM															
Incoming Tonnage															
Self-Haul Waste	*3,106*	*3,146*	*3,480*	*4,051*	*4,633*	*12*	*12*	*13*	*16*	*18*					
Minimum Loads	*1,273*	*1,289*	*1,426*	*1,660*	*1,898*	*5*	*5*	*5*	*6*	*7*					
Uncompacted Loads	*4,893*	*4,956*	*5,481*	*6,381*	*7,298*	*19*	*19*	*21*	*25*	*28*					
C&D Loads	*201*	*204*	*225*	*262*	*300*	*1*	*1*	*1*	*1*	*1*					
Total Incoming Uncompacted Landfill Tonnage	*9,473*	*9,595*	*10,611*	*12,355*	*14,129*	*36*	*37*	*41*	*48*	*54*					
Diversion	1,589	1,610	1,780	2,073	2,370	6	6	7	8	9					
Disposal	7,884	7,985	8,831	10,283	11,759	30	31	34	40	45					
Generation	9,473	9,595	10,611	12,355	14,129	36	37	41	48	54					
Uncompacted Landfill Waste Stream Diversion Rate	17%	17%	17%	17%	17%										
Total Diversion	**12,532**	**12,693**	**14,038**	**16,345**	**18,692**	**48**	**49**	**54**	**63**	**72**					
Total Disposal	**32,602**	**33,022**	**36,519**	**42,522**	**48,627**	**125**	**127**	**140**	**164**	**187**					
Total Generation	**45,134**	**45,715**	**50,556**	**58,867**	**67,318**	**174**	**176**	**194**	**226**	**259**					
Total Diversion as a Percentage	**28%**	**28%**	**28%**	**28%**	**28%**	**28%**	**28%**	**28%**	**28%**	**28%**					
				Total Residential and Commercial Recyclables		17	17	19	22	25	69				
				Total Residential and Commercial Green Waste		15	15	17	19	22	37				
											Total Residential and Commercial Food Waste	17	19	22	25

(1) Based on 5-day per week operations (i.e., annual tons divided by 260 days per year).

(2) Food waste projections assume that food waste represents 20% of the Single-Family Residential and Commercial / Multi-Family Residential and that 100% of the material is captured.

SECTION FOUR

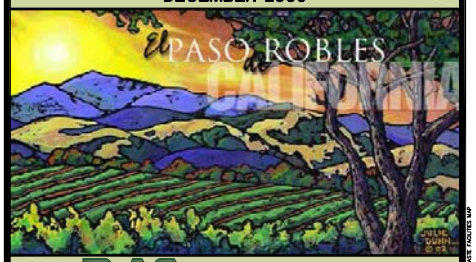
FIGURES

Facility Name	Type of Facility					
	Recycling	Transfer	C & D	Composting	Food Waste Composting	Disposal
Alpha Produce				●		
B. Goodrow, Inc. Composting				●	●	
Buckeye Enterprises Chip & Grind Op.				●		
Buckeye Material R&P Facility	●					
Cagliero Ranches Inc. Composting				●		
Chicago Grade Landfill			●	●		●
City of Paso Robles Landfill			●			●
Cold Canyon Landfill Solid Waste DS	●		●	●		●
Gator Crushing & Recycling			●			
Habitat for Humanity "ReStore"	●					
Kochergen Farms Composting					●	
Liberty Composting Inc.					●	
Morro Bay - Cayucos POTW Composting				●		
Negranti Construction			●			
North S.L.O. County Recycling Facility	●		●	●	●	
Paso Robles Composting Co.				●		
Paso Robles Recycle Facility	●					
Paso Robles Recycling Facility			●			
R&R Rolloff	●					
Santa Maria Transfer Station		●				
Troesh Supply Company			●			
Winsor Woodyard				●		
TOTAL	6	1	8	10	4	3

CITY OF EL PASO DE ROBLES LANDFILL MASTER PLAN

SOLID WASTE MANAGEMENT FACILITIES

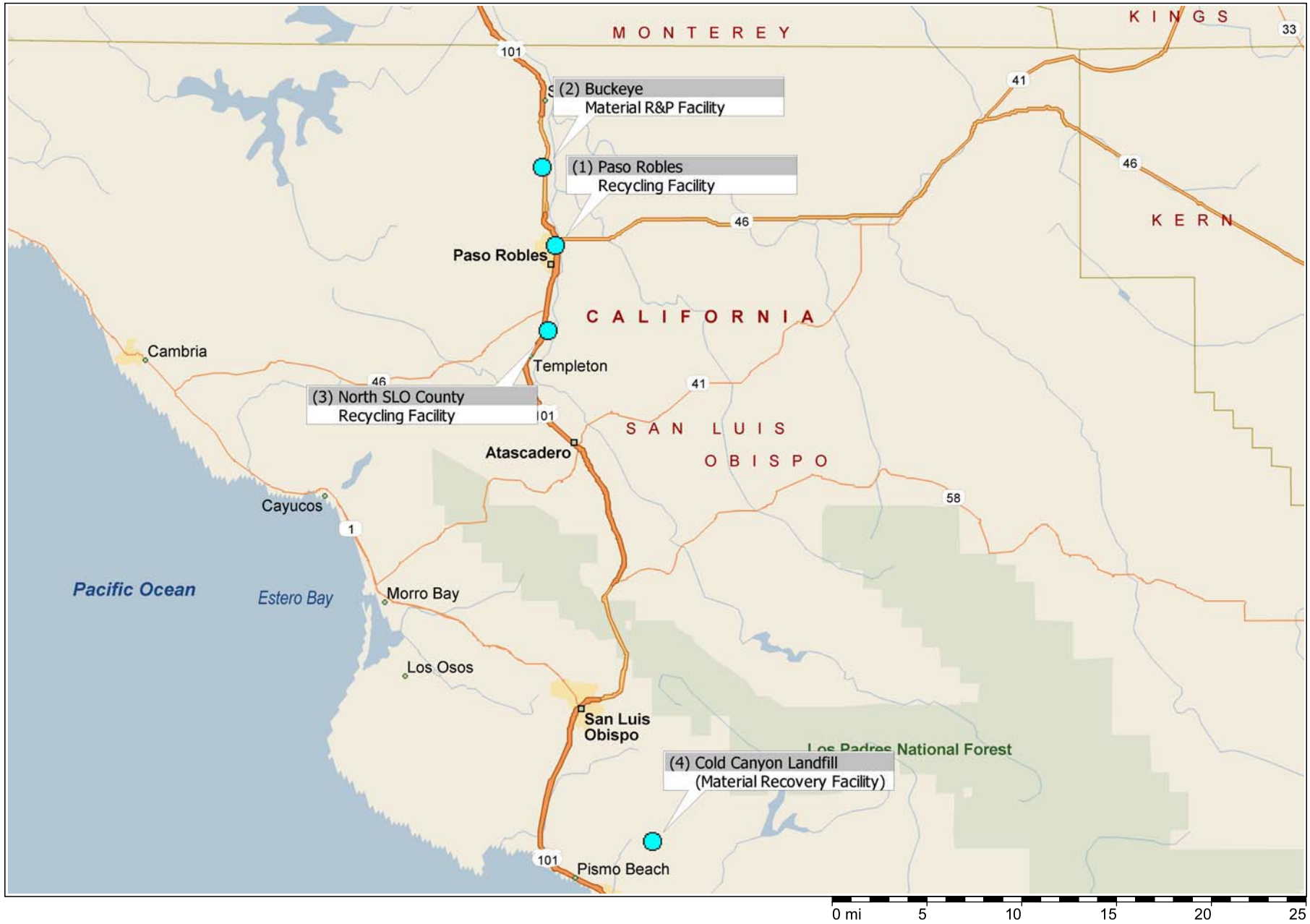
DECEMBER 2009



BAS, A TETRA TECH COMPANY
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
(909) 860-7777

10/30/09 SOLID WASTE FACILITIES MAP

El Paso de Robles Landfill Master Plan - Zero Waste Infrastructure
Figure 4-2 - Recyclable Material Processing Facilities



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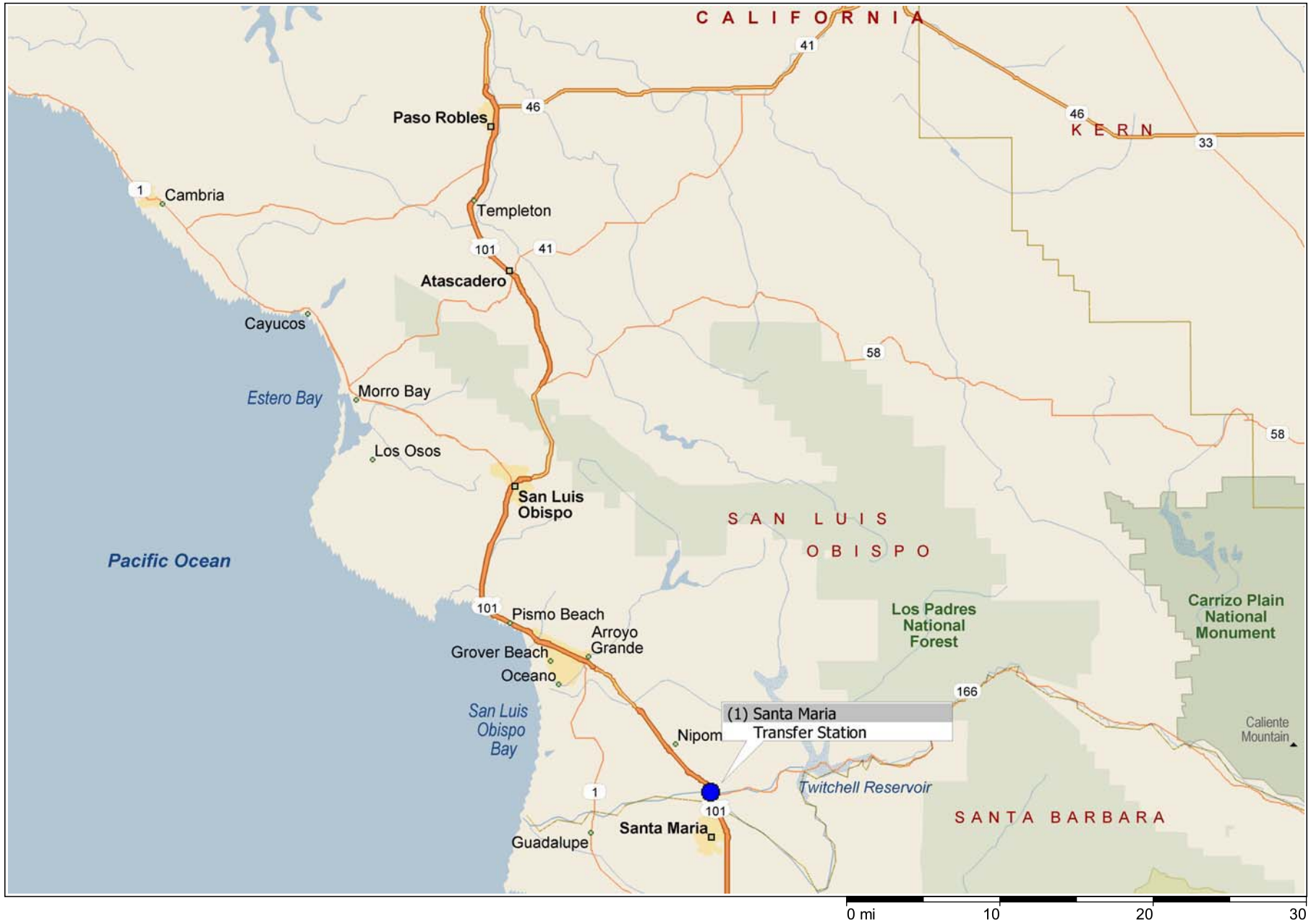
El Paso de Robles Landfill Master Plan - Zero Waste Infrastructure
Figure 4-3 - Transfer Facilities



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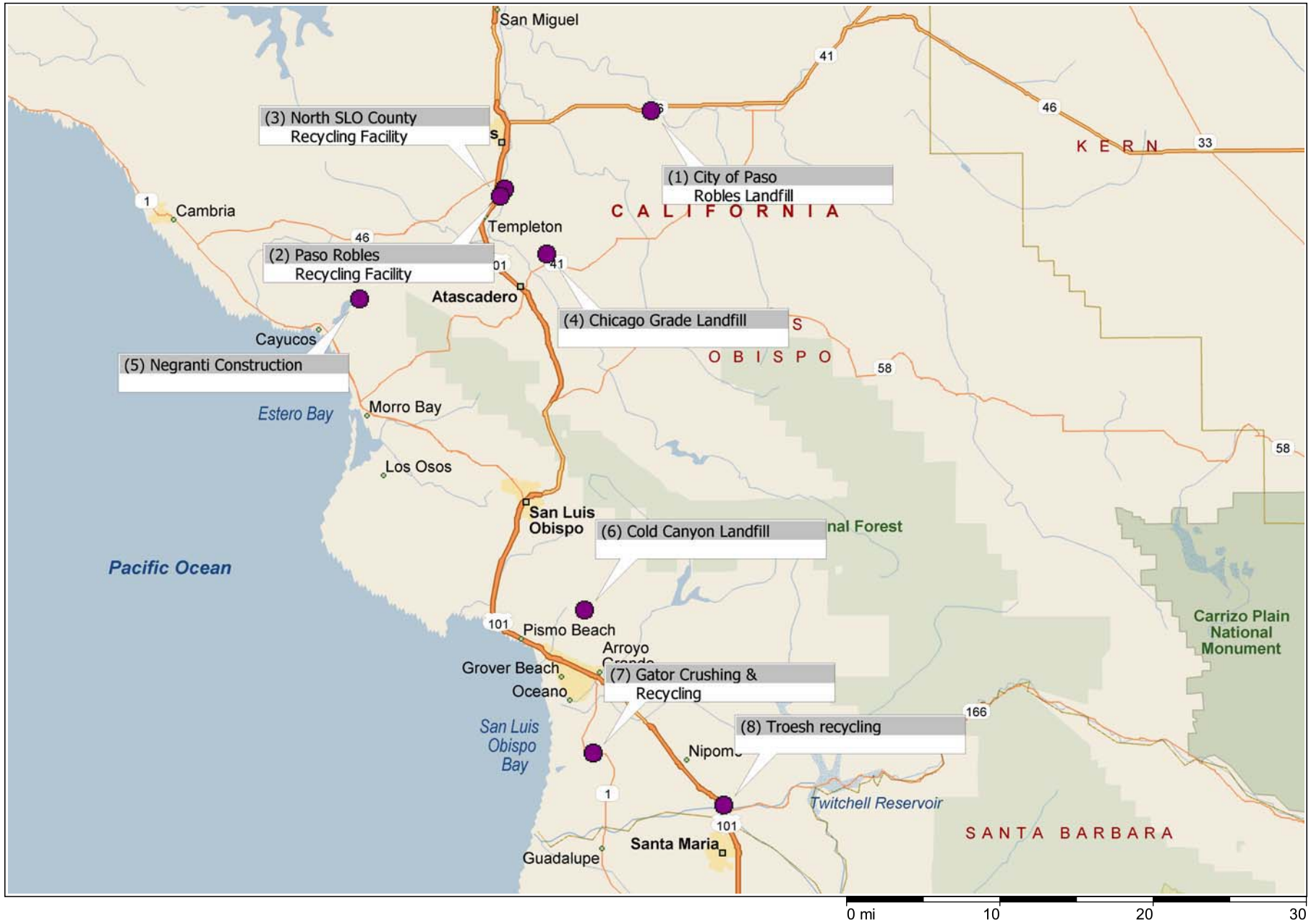
El Paso de Robles Landfill Master Plan - Zero Waste Infrastructure
Figure 4-4 - Construction and Demolition Processing Facilities



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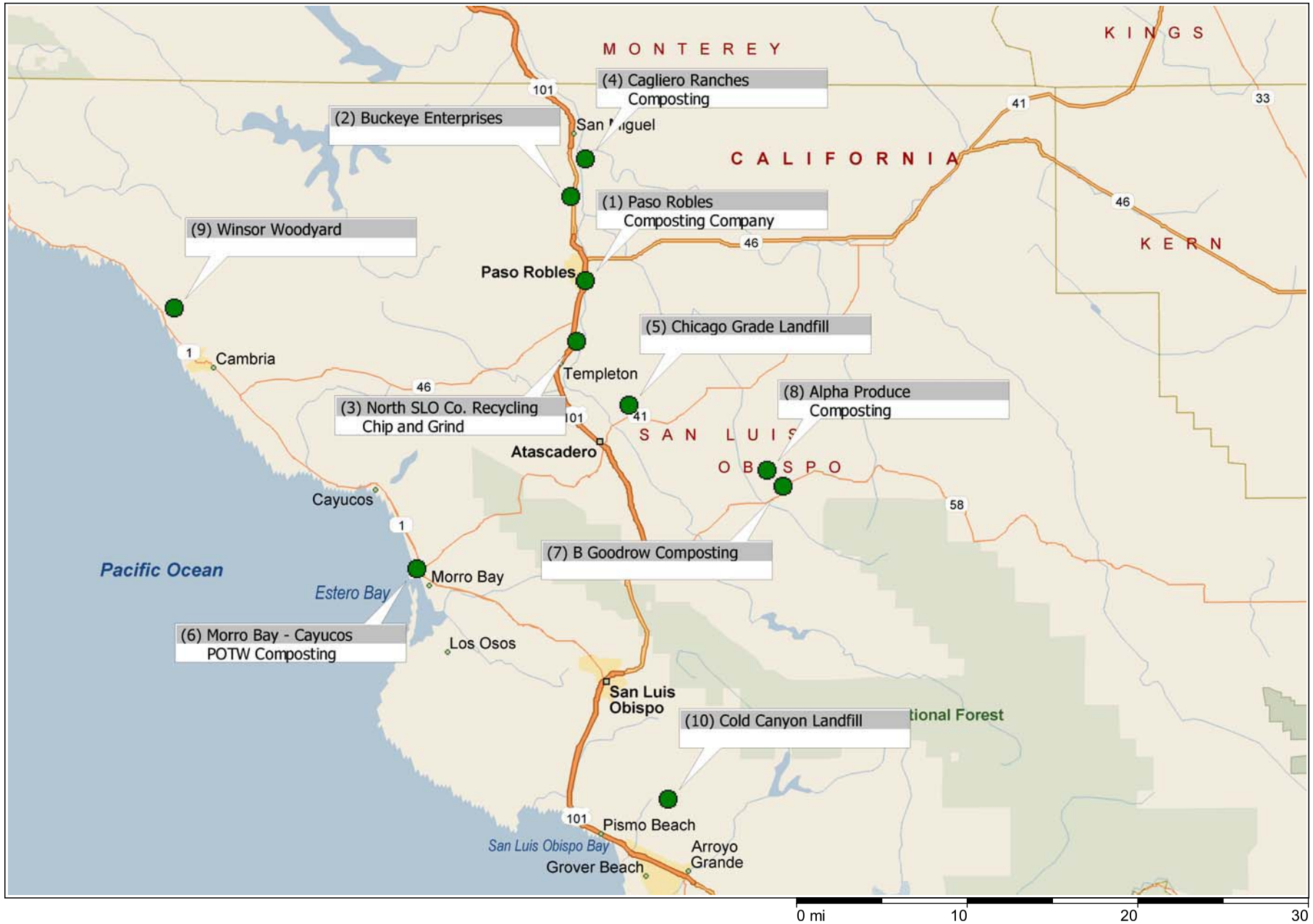
El Paso de Robles Landfill Master Plan - Zero Waste Infrastructure
Figure 4-5 - Composting Facilities



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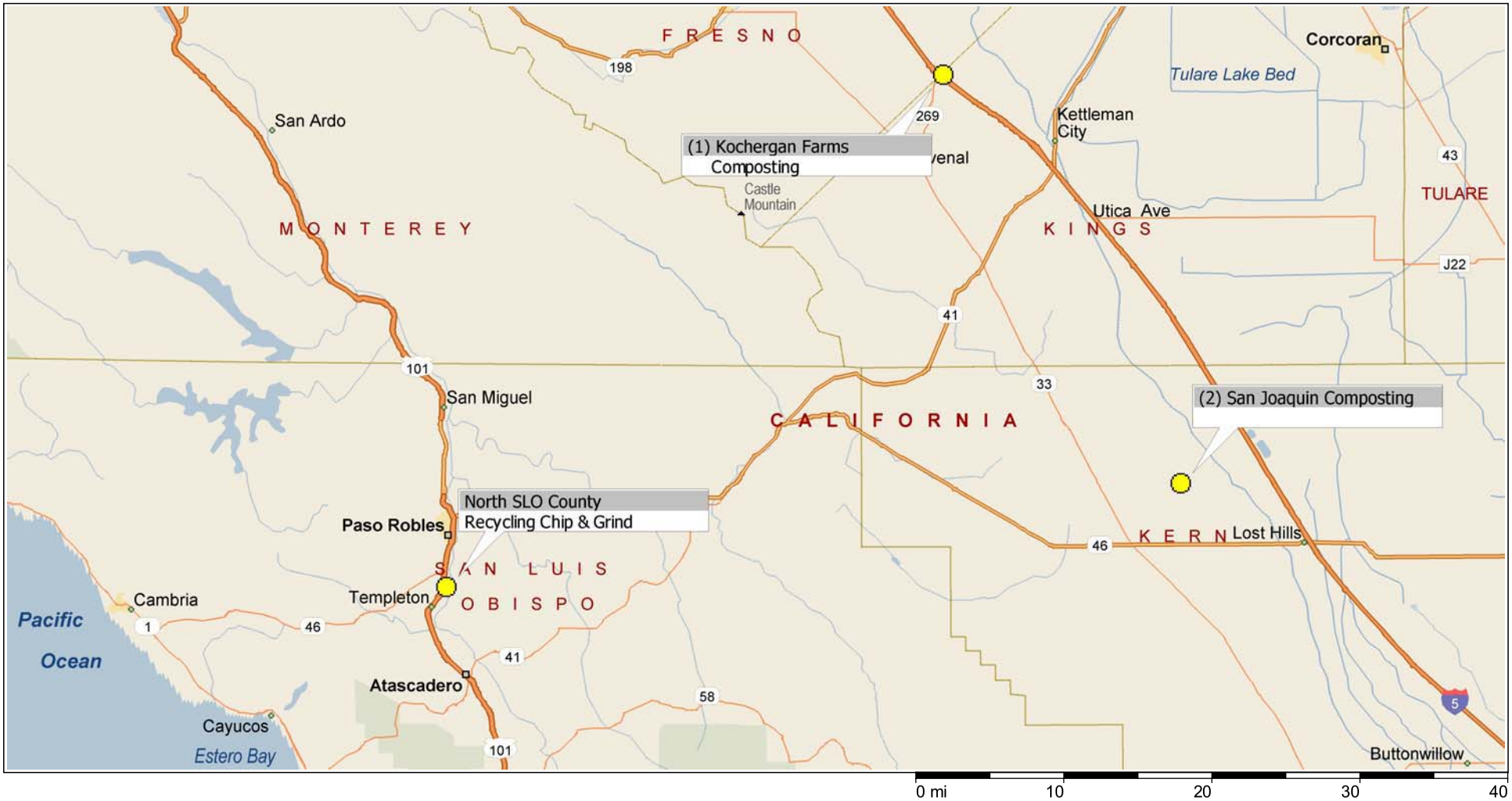
El Paso de Robles Landfill Master Plan - Zero Waste Infrastructure
Figure 4-6 - Food Waste Composting Facilities



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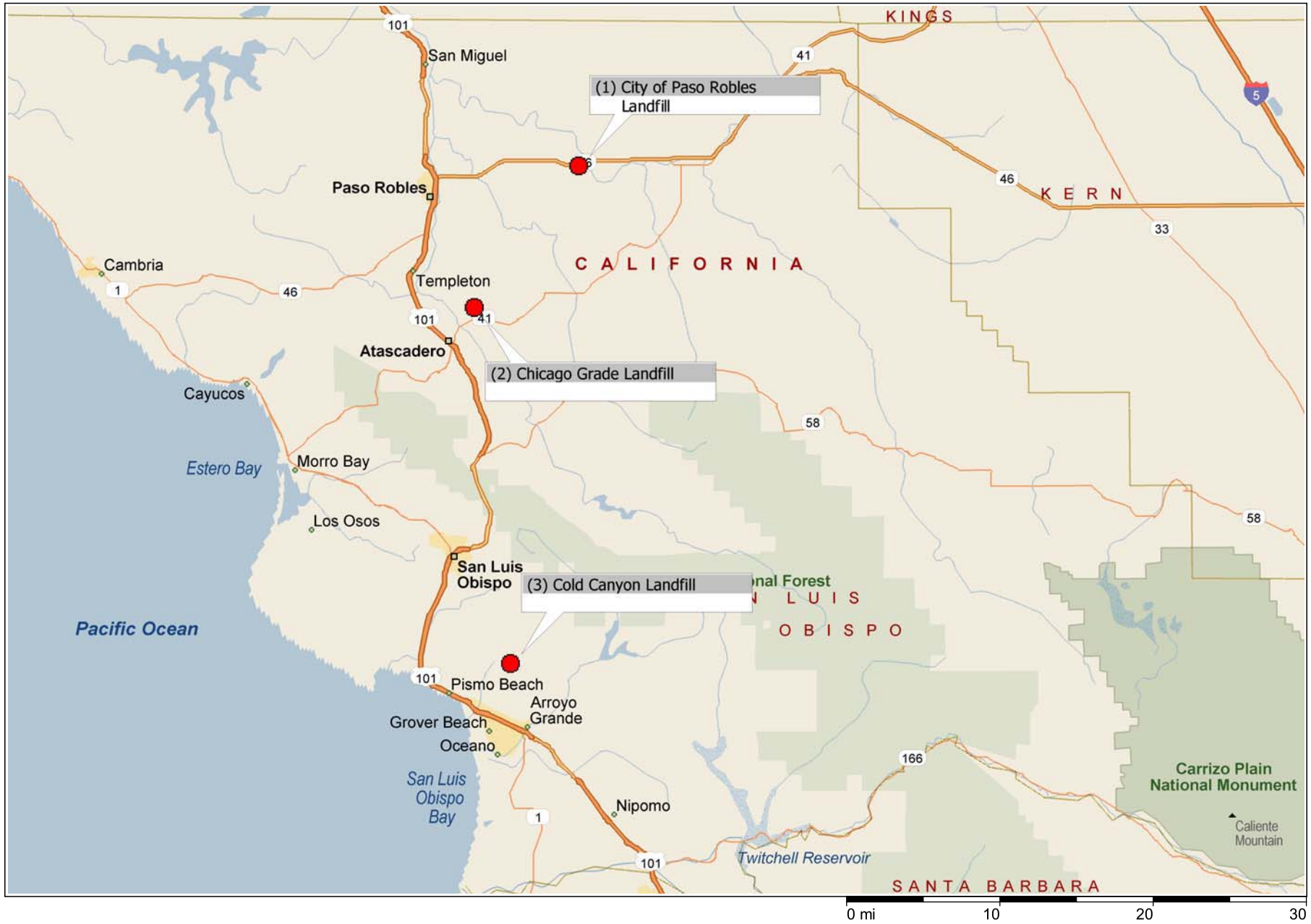
El Paso de Robles Landfill Master Plan - Zero Waste Infrastructure
Figure 4-7 - Disposal Facilities



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SECTION FIVE

OPTIMIZATION OF LANDFILL OPERATIONS

5.0 Optimization of Landfill Operations

Several areas at the Paso Robles Landfill were evaluated to determine if operations were being conducted in an optimal manner. The following areas were reviewed and this section of the report presents an analysis and key findings for the following subject areas:

- **Landfill Operations Evaluation (private versus public landfill operations)**
- **Landfill Optimization Techniques**
  - Compaction Techniques
  - Existing Equipment Utilized
  - Soil Surcharging
  - Alternative Daily Covers
    - Soil vs. Tarps: Airspace and Cost Analysis
    - Processed Green Material
- **Potential Additional Landfill Capacity**
  - Analysis of Current Airspace Utilization Factor
  - Analysis of Final Grading Plan
  - Landfill Reclamation
- **Use of Sludge at the Paso Robles Landfill**
- **Household Hazardous Waste Facility**
- **Regulatory Compliance Inspections by the California Integrated Waste Management Board (CIWMB)/Local Enforcement Agency (LEA)**

5.1 LANDFILL OPERATIONS EVALUATION (PRIVATE VERSUS PUBLIC LANDFILL OPERATIONS)

Pacific Waste Services, Inc. (PWS) has been the Paso Robles Landfill operator since August 1, 2000, and has a twenty (20) year contract ending July 31, 2020. Appendix F – *Operations at Paso Robles Landfill*, provides general information regarding the site's operations.

A decision as to whether the City should take over the operation of its landfill requires consideration as to whether or not the City can do a better job than a private contractor at:

1. Controlling costs;
2. Managing available airspace; and
3. Controlling and/or limiting potential liabilities.

PREVALENCE OF MUNICIPALLY-OWNED AND OPERATED LANDFILLS IN CALIFORNIA

Municipal operation of City-owned landfills is well established in California. Of the 12 cities identified in California that own active landfills (not including the City of Paso Robles)[1], ten (10) of those cities operate the landfill themselves, while the other two (2) contract with a private company, see Table 5-1 below. There is a similar prevalence of municipal operation of County-owned landfills in California.

TABLE 5-1
CITY-OWNED LANDFILLS IN CALIFORNIA

Name	County	Operator	Property Owner	TPD
City Owned & Operated Landfills				
City Of Clovis Landfill	Fresno	City of Clovis	City of Clovis	600
Scholl Canyon Sanitary Landfill	Los Angeles	Los Angeles County	City of Glendale	3,400
Burbank Landfill Site No. 3	Los Angeles	City of Burbank	City of Burbank	240
Savage Canyon Landfill	Los Angeles	City of Whittier	City of Whittier	350
City Of Paso Robles Landfill	San Luis Obispo	City of Paso Robles	City of Paso Robles	250
Santa Maria Landfill	Santa Barbara	City of Santa Maria	City of Santa Maria	740
City Of Lompoc Sanitary Landfill	Santa Barbara	City of Lompoc	City of Lompoc	400
City of Palo Alto Waste Disposal Site	Santa Clara	City of Palo Alto	City of Palo Alto	200
City Of Santa Cruz Sanitary Landfill	Santa Cruz	City of Santa Cruz	City of Santa Cruz	535
City Of Watsonville Landfill	Santa Cruz	City of Watsonville	City of Watsonville	275
California Street Landfill	San Bernardino	City of Redlands	City of Redlands	829
City-Owned / Private-Operated Landfills				
Avenal Regional Landfill	Kings	Madera Disposal Systems	City of Avenal	6,000
Pebbly Beach (Avalon) Disposal Site	Los Angeles	Seagull Sanitation Systems	City of Avalon	49

Source: California Integrated Waste Management Board (CIWMB) Solid Waste Information Systems (SWIS) List.

MUNICIPALLY-OWNED LANDFILLS - CHANGES FROM PUBLIC OR PRIVATE OPERATION

While many of the municipally-owned landfills in California have historically been operated by the jurisdiction, two municipalities have recently changed their operations:

- The City of Avenal switched from a municipally-operated landfill to a privately-operated landfill in 2002. It currently handles only the City's waste (50 tons per day) but it is actively seeking to import waste. A City representative stated that there were significant financial issues associated with the landfill when it was municipally operated.
- The County of Butte switched from a privately-operated landfill (Waste

[1] Source: California Integrated Waste Management Board (CIWMB) Solid Waste Information System (SWIS) database.

Management, Inc.) to a municipally-operated landfill in 2003. A phone interview was conducted with the County and the *following were cited as realized benefits of public takeover:*

- ***Improved Relationship*** - Since the operation is now publicly-operated, the relationship between the landfill and Board of Supervisors has improved dramatically. Rate increases are more transparent and public opinion of rate increases is more favorable than before.
- ***Improved Quality*** - The general public has made observations that the facility is cleaner overall and run more professionally. The County cited the absence of profit motivation as the reason for the improvement in quality.
- ***Increased Diversion*** - Diversion has increased since the takeover. The private contractor had been paid for disposal and, thus, diversion efforts were overshadowed by a profit incentive. The inclusion of preferential rates for source-separated materials has helped to divert some materials for recycling or even reuse (inert materials for County road projects).

SURVEY OF MUNICIPALLY-OPERATED LANDFILLS

A survey was conducted of those jurisdictions in California that have publicly-operated landfills. Representatives from those jurisdictions cited the following as *advantages of municipal operation versus contracting out for private operation:*

- ***Quality Control*** – Since a public operation does not need to earn a profit, tip fees can be set to match operating costs. This also means that a public operation has no financial incentive to "cut corners" and can focus on doing the job correctly and safely.
- ***Politics*** - Landfills can potentially be a politically-charged issue. Direct control over the landfill allows the City to bypass the possible conflict of interest between the public and a private operator.
- ***Transparency*** – Tip fee requests from a private operator can be clouded by suspicion of inaccuracy. Public reception of tip fee increases can be much smoother with the assurance that there is no profit motivation.
- ***Diversion*** – The inclusion of a materials recovery facility or compost facility with the landfill is easier when under public operation. Each facility is better suited to work in conjunction with the other when both have the same operator; however, this is true for either a complete private or public operation.

Representatives of those jurisdictions identified the following items as *the biggest challenges facing a public operation of a landfill*:

- ***Financial*** – Operating a landfill is a capital-intensive undertaking. The initial capital outlay is substantial. This requires a major commitment on the part of the City.
- ***Permitting*** – The City will need to focus attention on maintaining, updating, acquiring, and adhering to many permits from various agencies, such as the California Integrated Waste Management Board.
- ***Regulatory Oversight*** – Efforts must be made to comply with the requirements of the LEA and Air Quality Pollution District.
- ***Equipment*** – Selecting the right type and quantity of equipment, securing financing, and proper maintenance are critical to the success of the operation.
- ***Staff*** – Experienced, well-trained, and attentive personnel must be acquired. This is critical for both performance, as well as safety.

ADVANTAGES AND DISADVANTAGES OF PUBLIC OPERATION

In *The Handbook of Landfill Operations,* Neal Bolton, identified the following:

Reasons to Hire a Private Operator/Contractor

- ***May Save Money*** – Many landfill owners hire a contractor thinking that an experienced landfill contractor can operate the site more economically than the owner's staff. A general rule of thumb is that the more specialized the operations of the landfill are, the more compelling the expertise of a private contractor become.
- ***Avoid Liability*** – Contracting out the landfill operation will not absolve an owner of all liability. Indemnification clauses, however, can shift some degree of liability to a contractor. In some cases, certain liabilities may be passed on to the contractor. Unfortunately, if there is a problem (i.e., groundwater contamination), the owner will still be standing in the front of the liability lineup.
- ***Minimize Staff Increases*** – A private operator may be able to attract higher qualified employees due to the lack of restriction on wages that can be offered to a landfill staff. In some cases, as with some municipalities, owners may be limited in terms of the wages they can offer their own staff. In a few isolated instances, it may be difficult for a municipality with this type of limitation to hire qualified landfill staff.
- ***Reduce Capital Costs*** – One of the advantages of hiring a contractor is that it may cost less in the short term for the owner to hire a contractor than to pay for all the up-front capitalization costs. Operating a landfill is a capital-intensive undertaking, especially at the beginning. However, in the long term the owner probably will not save any money by hiring a contractor and

requiring him to cover all of the capital costs. In fact, in cases where the owner is a municipality, it could likely purchase the equipment for less than the contractor.

- ***Provide Superior Service*** – There is common general perception that the private sector can provide services more effectively than the public. If the owner does not have experience in operating a landfill, it is likely that an experienced contractor could provide a higher level of service.
- ***Avoid Political Criticism*** – In some cases, municipal owners of landfills may face comments of "competing with the private sector" or "trying to build a public works empire" by attempting to operate the landfill themselves. Whether or not these charges are true may not be relevant in terms of the political effect they have. This perception can cause political criticism despite efficient operations, which can be avoided by contracting operations.

Reasons Not To Hire a Contractor

- ***May Cost More Money*** – In contrast to public operation, a private contractor is in the business of landfill operations for profit. The amount of money an owner pays the contractor includes the cost of operating the site, plus his profit. Depending on the situation, the profit margin might range from 10 to 40 percent, with an average profit margin of 20 to 30 percent being typical. Also, an owner may have other in-house costs associated with contract management. A sound contract can limit this peripheral cost, but a loose contract with open-ended terms may require extensive oversight resulting in exhausting peripheral administrative costs.
- ***Administrative Costs*** – Hiring a contractor does not absolve the owner of all administrative responsibilities. The owner is still responsible for making sure that the site is in compliance with all Federal, State, and local regulations. Additionally, the owner must administer the contract with the contractor.
- ***Potential Liability*** – Depending on the capabilities and/or willingness of a private contractor to operate the landfill properly, the owner has forfeited some control. In some cases, the owner's liability actually increases as a result of a negligent contractor who is unable or will not do a proper job of operating the landfill.
- ***Build More Independence*** – When operated properly and efficiently, a landfill can be a tremendous asset to a municipal agency. Many owners elect to operate their own landfill, knowing that even if it costs them a little more in the short term, they will have more control of their site in the long run. Owners who operate their own landfills are typically more knowledgeable in terms of the overall landfill operation. Finally, even if the owner decides to contract out the operation at some later date, he will be more knowledgeable by having operated the site.

STAFFING AND EQUIPMENT

If the City decides to pursue municipal operations, it will need to hire qualified staff and purchase the necessary equipment. Landfill staffing and equipment needs for the landfill as reported in the Joint Technical Document (JTD) are provided in Tables 5-2 and 5-3 below:

TABLE 5-2: STAFFING NEEDED AT PASO ROBLES

Number	Staff Position
1	Site Manager
2	Equipment Operators
1	Part-Time Seasonal Equipment Operator
1	Scale Attendant
1	Mechanic
1	Spotter/Laborers/Material Reclamation Specialist
7	**Total**

TABLE 5-3: EQUIPMENT NEEDED AT PASO ROBLES LANDFILL

Number	Equipment Type
1	Komatsu D65X crawler
1	Caterpillar (CAT) 826 compactor
1	CAT 953 track loader with 3 in 1 bucket
1	CAT 623B scraper
1	Ford 8000N, 4,000-gallon water truck
1	Ford 700 utility truck
2	Roll-off chassis utility truck
1	Kenworth 10-wheel dump truck
9	**Total**

Note: During the BAS Team site visit on June 10, 2009 to the landfill, Pacific Waste Services (PWS) reported that:

- It does not have a dedicated mechanic. Routine maintenance is handled by the equipment operators; and
- Weekend staffing consists of one operator, one laborer, and one scale house attendant.

Staff

Having qualified and trained site personnel (supervisor, equipment operators, and laborers) is critical to the success of any landfill operation. Up to 90 percent of the cost of any landfill is related to the day-to-day operations, as opposed to engineering design and construction costs. The City may be able to realize a number of staffing options not available to a private contractor, including:

- Using Sheriff's Work Release staff for litter control and other non-skilled positions; and
- Utilizing an onsite landfill engineer/superintendent to provide day-to-day management of the facility and reduce the need and cost associated with current monitoring and reporting consultants (The City currently has a contract with SCS Engineers for $125,000 per year to provide landfill monitoring and reporting services).

Equipment

The following table provides planning level capital costs for potential landfill equipment stock, along with a comparison to the equipment listed in the Paso Robles JTD. As shown, to essentially replace the equipment listed in the JTD (with the addition of a CAT Backhoe Loader and the removal of one roll-off chassis) with the same or comparable new equipment would require a capital outlay of approximately $2.4 million. This does not include non-rolling stock equipment items (e.g., roll-off bins, landfill tarps).

The cost of buying similar equipment is shown below in Table 5-4:

TABLE 5-4: CAPITAL COST PLANNING ESTIMATES

JTD-Listed Equipment		CAPITAL COST PLANNING		
Number	Equipment Type	Number	Equipment Type	Cost New
1	Komatsu D65X crawler	1	CAT D6T	$ 320,000
1	Caterpillar (CAT) 826 compactor	1	CAT 826 compactor	$ 680,000
1	CAT 953 track loader with 3 in 1 bucket	1	CAT 953D track loader	$ 235,000
1	Cat 623B scraper	1	CAT 623G scraper	$ 620,000
1	Ford 8000N, 4,000-gallon water truck	1	4,000-gallon International water truck	$ 97,000
1	Ford F700 utility truck	1	Ford F700 utility truck	$ 55,000
2	Roll-off chassis utility truck	1	Used roll-off chassis	$ 100,000
1	Kenworth 10-wheel dump truck	1	Kenworth T300, 12 yd box dump	$ 124,000
		1	CAT backhoe loader 430E	$ 137,000
9	**Total**	**9**		**$ 2,368,000**

The equipment observed during our site visit differed from that reported in the JTD as follows:

- BAS observed no Komatsu D65X crawler or equivalent equipment type (e.g., CAT D6T) present; and
- There was a CAT backhoe loader 430E onsite.

CAT D6T

CAT 826C Compactor

CAT 953C Track Loader

CAT 623B Scraper

Ford 8000N 4,000 gallon water truck

Ford F700 Utility Truck

Roll-off Chassis Utility Truck

Kenworth 10-Wheel Dump Truck

CAT Backhoe Loader

Key Findings - Landfill Operations Evaluation (private versus public landfill operations)

A decision as to whether the City should take over the operation of its landfill should include consideration of whether or not the City can do a better job than a private contractor at:

1. Controlling costs;
2. Managing available airspace; and
3. Controlling and/or limiting potential liabilities.

Municipal operation of publicly-owned landfills is well established in California with the majority of both City- and County-owned landfills being operated by municipalities. While there are potential benefits to be gained by converting to a municipal operation, including greater control of the City's landfill asset and associated airspace and greater control of and ability to limit potential liabilities, the realization of any such benefits is by no means guaranteed. If the City is to develop an effective municipal operation, it must:

- Hire qualified and experienced staff;
- Provide appropriate staff training;
- Assure effective daily, short-, medium- and long-range planning, and site management;
- Commit the necessary capital resources; and
- Have the support of City management and political commitment.

Based on our discussions with City staff it appears that both the necessary management support and the political commitment exist. Provided the City can effectively translate that support and commitment into the components necessary for a successful landfill operation, the City stands to realize the associated benefits of municipal operation.

Should the City decide to pursue municipal operation of its landfill, we strongly recommend that it enlist the services of a qualified landfill operations consultant to support the City's efforts in:

- Equipment selection;
- Establishing operational benchmarks (e.g., optimal density);
- Budgeting;
- Planning; and
- Employee training.

Should the City decide that it does not wish to pursue municipal operations at this time or is unable to do so until the term of the existing operating agreement expires, it should consider the following:

- Opportunities to restructure the current operating agreement to provide incentives for the contract landfill operator to operate in accordance with the City's best interests (e.g., increasing effective density and material diversion); and
- Undertake an Operations Review to identify opportunities for improved contractor performance, including determining an in-field optimum waste density evaluation.

5.2 LANDFILL OPTIMIZATION TECHNIQUES

After a landfill is permitted and open to accept waste, the two most important element of the landfill are 1) the excavation and grading plans and 2) efficient landfill operations to conserve airspace. Just as "location, location, location" is the golden rule of real estate, the golden rule for landfills is "airspace, airspace, airspace." Conserving airspace via good landfill design and operations is the key to a successful and revenue-generating landfill.

According to the Paso Robles Landfill's Solid Waste Facility Permit No. 40-AA-0001, dated January 23, 2008, the landfill consists of 80 acres with 65 acres permitted for disposal operations. The permitted maximum design capacity is 6,495,000 cubic yards (cy) with a maximum elevation of 1,226 feet above mean sea level (amsl) and a maximum depth of 1,000 feet (amsl). The permitted maximum tonnage is 450 tons per day, with a maximum of 75,000 tpy. The estimated closure year is 2051.

Two of the most expensive costs involved in the operation of a landfill are associated with compacting the waste and covering the waste. The City's requirements for its operator, PWS, as regards to waste compaction are found in the document *"Agreement For Operation of Solid Waste Landfill, Paso Robles Municipal Landfill."* In Exhibit D, Items 2 and 3, of said Agreement, it states:

> *"2. Maximum densification of disposed refuse shall be accomplished by CONTRACTOR in accordance with RDSI [Report of Disposal Site Information, now called a Joint Technical Document], as same may be amended from time to time.*
>
> *3. Cell compaction and refuse cover will be performed by CONTRACTOR in accordance with RDSI, as same may be amended from time to time. If CONTRACTOR fails to comply with RDSI cover requirements, City shall have the right to back charge CONTRACTOR $150.00 for each 24-per hour non-compliance."*

The BAS Team evaluated the following landfill optimization techniques for preserving capacity at the landfill:

1. Compaction Techniques: Equipment Utilization and Soil Surcharging, and
2. Alternative Daily Cover.

COMPACTION TECHNIQUES

Neal Bolton, in *Handbook of Landfill Operations,* stresses that waste compaction is one of the most important components of operating a landfill. Compaction is the process of compressing a material so that it takes up less space. Because a landfill has limited permitted airspace, the more compacted the waste, the longer the site will last. In addition to increasing site life, good compaction will reduce the amount of cover needed. If refuse is well compacted, less soil will seep through between the waste minimizing the amount of soil needed for daily cover. If using tarps, tighter refuse compaction will allow for a smoother front-face surface that will make it easier to place the tarps and not rip them.

Factors governing compaction include the following:

1. **Weight of compactor:** The load that a compactor can exert on the waste is directly related to the weight of the compactor;
2. **Speed of compactor:** The higher the speed, the greater the compaction;
3. **Waste layer thickness:** The depth of each compacted refuse layer is perhaps the most important controllable factor influencing density. To obtain maximum density, waste should be spread and compacted in layers not exceeding a depth of two feet;
4. **Design of compactor (wheels and teeth):** Wheel diameter, width, and tooth design will affect a compactor's performance in several ways;
5. **Number of passes made over the waste:** Regardless of the type of machine use, the unit should make three to four passes to achieve optimum density;
6. **Slope:** Maximum compactive effort by a track type unit is achieved by working the waste on a slope of 3:1; and
7. **Moisture Content:** It is believed that water tends to weaken the bridging characteristics of waste, particularly paper such as large pieces of cardboard.

Compaction Equipment

Equipment weight. Equipment weight is a critical variable once equipment type is selected. Within broad limits, increasing machine weight results in higher densities. Calculations to determine this data are based on five (5) passes by the vehicle over waste on a horizontal surface.

In-place density initially rises rapidly with machine weight and then tapers off until a plateau value is reached at around 60,000 pounds of equipment weight. The in-place density can be calculated from the regression line through the data:

$$Y = a / (1 + be^{-cX})$$

where *a*, *b*, and *c* are constants, and e is the base of natural logarithms. As X (weight of equipment) becomes very large, Y (density of refuse) approaches *a*.

The constant *c* affects the curvature of the graph. For the existing data, *a* = 1,250, *b* = 3.5, and *c* = 6.3 x 10^{-5}. That is, if Y is in-place density and X is vehicle weight in pounds,

$$Y = 1{,}250 / (1 + 3.5e^{-0.000063\,X})$$

This suggests that as vehicle weight becomes large, in-place density (assuming five passes and zero slope) approaches 1,250 pcy.

Speed of the compactor. The speed of the equipment has an effect on the amount of compactive effort it exerts on the refuse. The higher the speed, the greater the compactive effort, as a result of the impact of the teeth. A compactor that is moving faster will strike the refuse harder (with more momentum), and, as a result, achieve better compaction than a slow moving compactor. A compactor that works on a steep slope will work slowly, often in first gear; on a flatter slope, the compactor may be able to work faster, perhaps in second gear. In first gear, the average velocity of the compactor is approximately 1.5 mph, and in second gear, it is approximately 3 mph.

Number of tooth penetrations. Another benefit of higher compactor speed is a greater number of tip or tooth penetrations. The teeth perform most of the crushing and demolition necessary for good compaction, so more tooth penetrations means better compaction. With respect to the example given in the previous paragraph, where a compactor working in second gear can move twice as fast as in a slope, the fast-moving compactor will have two times as many tooth penetrations than the compactor working in first gear. Changing to flatter slopes can add an additional 500,000 to 1 million tooth penetrations per day (Bolton, 1995).

Tooth design. Tooth design controls how well a machine shreds and compacts waste. In most cases, a large tooth will be more aggressive than a small tooth, particularly on bulky waste, which can be difficult to compact. Also, a larger tooth will penetrate deeper into each lift, thus ensuring better compaction.

The tooth design also plays an important role in the finish of the cell. Machines with a tapered tooth design typically provide a smoother, more contained finish on the cell. The tapered tooth exits the refuse cleanly, without lifting any material with it. On the other hand, a straight tooth lifts refuse as it exits, leaving the cell fluffed up and leaving large pockets where cover soil can be lost. In terms of cover soil usage and litter control, the tapered design is usually superior.

Finally, the durability of a tooth is controlled to a great extent by the tooth design. All teeth will eventually wear out; however, the goal should be to have teeth which are designed to last as long as possible and can be quickly and cost effectively replaced when they wear out.

The tooth pattern – how the teeth are placed on the wheel – also plays an important role in compactor performance. If teeth are spaced too close

together, they may tend to plug up. Spacing the teeth may help reduce wheel plugging in some conditions. The tooth pattern will affect how aggressive a wheel is in terms of shredding and compacting waste. Since the greatest ground pressure occurs at the tips of the teeth, increasing the number of teeth will increase a machine's demolition ability. In general, it is worthwhile to have as many teeth on the wheel as possible, without causing plugging.

Refuse layer thickness. The depth of each compacted layer is perhaps the single most important controllable factor influencing density. To obtain maximum density, waste should be spread and compacted in layers not exceeding a depth of 2 feet. Thicker layers will reduce the density that a machine can develop in a given number of passes.

Slope. Maximum compactive effort by a track-type unit is achieved by working the waste on a slope of 3:1. Track-type machines achieve higher densities by grinding and shredding the refuse into smaller pieces as they climb a slope. Just the opposite is true for the landfill compactor. The flatter the slope, the better the compaction. This is because the weight of the landfill compactor is more efficiently utilized and concentrated when working on a flat surface. Modeling of the effect of slope is a simple matter of physics. On a level surface compaction depends on vehicle weight, as described above. However, on a slope, the effective weight of the compacting vehicle (i.e., the weight exerted in a direction perpendicular to the working face of the landfill) is reduced.

Compaction passes. The number of passes of the equipment over a given section of waste has been shown in the literature to affect density up to approximately five (5) passes. Beyond five passes, it is likely that the impact and the cost of the passes by the equipment are not offset by the incremental increases in in-place density. A regression line fitted to the data with Y = index of in-place density (5-pass density = 100), and X = number of passes yields the equation:

$$Y = 116 / (1 + 3e^{-0.6\,X})$$

The limit as the number of passes becomes large is 116 percent of the 5-pass density.

Moisture content. The field experience compiled by Caterpillar (2003) has shown that moisture content of the refuse has a significant effect on compacted density. Apparently water weakens the bridging characteristics of refuse, particularly large pieces of cardboard, thereby allowing tighter consolidation. The optimum moisture content for maximum compaction of household refuse appears to be around 50 percent by weight, but even a minimum amount of moisture can increase refuse compaction density by 10 percent. Wetting the refuse prior to daily covering may increase compaction and aid in biodegradation

Waste Densities

Generally, loose residential and commercial waste weighs about 250 to 300 pounds per cubic yard (pcy). Placement of waste in a refuse collection vehicle will increase this density to 400 to 700 pcy. In-place landfill density can vary from 1,000 to 1,500 pcy depending on the compactive effort applied to the waste. Landfill sites that accept a high percentage of demolition waste can have densities up to 2,500 pcy. PWS uses a conservative average landfill industry density factor of 1,250 pcy for in-place density to determine remaining capacity. However, PWS has to our understanding not conducted an optimum density evaluation for the landfill.

Existing Equipment Utilized

Landfills that place and compact waste using bulldozer-type equipment typically achieve the lowest in-place density because of the low-bearing pressure exerted by the equipment. Track dozers are designed to avoid sinking in soft soils by distributing the load of the equipment over a large surface area. A medium size track dozer can achieve compaction densities of 800 to 1,000 pcy. Maximum compaction is achieved when it works on a 3:1 slope, permitting the grousers (bulldozer track) to rip and tear while pushing and compacting waste up-slope. The economic limit of cover or waste movement by a track-type dozer is normally less than 300 feet[3].
Alternatively, landfills that employ wheeled compactors with tips (designed to achieve high bearing pressures) generally achieve higher in-place densities than do those that use only track-rolled dozers. Tips are designed to apply high pressure at the point of contact with the waste. According to the Caterpillar, Performance Handbook[4], landfill compactors with an operating weight over 45,000 pounds achieve the highest compaction levels, from 1,200 to 1,600 pcy.

As shown in Section 5.1.5, PWS operates bulldozer-type tracked equipment and a CAT 826C compactor capable of handling significantly more than the permitted peak daily tonnage. The compactor at the landfill is used for waste compaction while the bulldozer is used for moving the waste on the working face and the applying of daily soil cover needed to supplement or frame soil for tarp placement.

Key Findings - Landfill Optimization Techniques

The equipment fleet currently used by PWS at the landfill is capable of handling in excess of 750 tons per day on an ongoing basis. Therefore, with an inflow waste stream averaging about 147 tons per day (2006-2008) the equipment being used at the site is more than adequate.

[3] Neal Bolton, Handbook of Landfill Operations.
[4] Caterpillar Performance Handbook, Edition 34.

SOIL SURCHARGING

Soil surcharge loading, another compaction technique, is the loading over a landfill with a stockpile of soil that results in compaction by waste compression (or vertical squeezing together of waste particles) and lateral yielding of the waste under the loaded area. Surcharging causes the underlying waste to compress, therefore, creating additional airspace. The average settlement of the waste beneath the stockpile will vary depending on site conditions such as:

- Age of Waste;
- Depth of Waste;
- Climate;
- Surcharge Period; and
- Initial (compacted density).

Previous demonstration projects for waste depths of about 40 feet have averaged up to five feet of settlement[5]. A surcharge density that greatly exceeds the ultimate density which the waste would naturally reach should not be expected; surcharging will only accelerate the settlement rate.

Soil Availability. Based on an analysis of cut volumes needed to achieve the designed base liner elevations for the Paso Robles Landfill, there are approximately 1,900,000 cy of remaining excavation as of January 1, 2007[6]. The on-site soil needed for cell construction, final cover, daily and intermediate cover, is estimated to be approximately 900,000 cy. This estimate assumes a 6:1 waste-to-soil volume ratio achieved by PWS. Based on this data, the site has an excess of approximately 1 million cy of soil. Therefore, there is significant amount of soil that may be used to surcharge areas of the landfill that are reaching maximum elevation.

Figure 5-1 identifies an area recommended by BAS for soil surcharging. This area was selected because it is fairly flat and did not have vertical landfill gas wells installed in the area. Per the LEA inspection report of August 20, 2008, it was noted that PWS had installed horizontal collectors in the area north of gas collection Well EW-C1. This is the same area that we identified as a potential area for soil surcharging.

Table 5-5, *Available Airspace from Soil Surcharging,* provides the calculation regarding the potential airspace that could be reclaimed from soil surcharging and the value of said airspace. Surcharging the approximately 116,925 square feet (2.68 acres) with a 20-foot lift of soil (approximately 60,000 cy), could potentially result in recovering about 22,000 cy of airspace. The assumption is all the soil is stockpiled at once and that the volume will be less if stockpiled over a period of time. Using a waste to cover ratio of 6 to 1 and a tip fee of $40 per

[5] Bolton, Neal, *Handbook of Landfill Operations.*
[6] SCS Engineers, August 2007, Joint Technical Document, City of Paso Robles Sanitary Landfill.

ton, this equates to about $464,000 of gross revenue from the recovered airspace.

Waste densities can vary throughout the depth of a landfill depending on the type and vertical location of waste. Waste at the bottom of a landfill is under a much higher vertical load and is, therefore, denser, typically around 1,600 pounds per cubic yard (pcy). Waste near the top of the vertical profile is not under any surcharge and is typically around 1,200 pcy. When calculating the site life of a landfill, 1,200 pcy is usually used for near-term planning purposes but when calculating the remaining site life for the landfill, an average density of 1,400 pcy is more appropriate.

Key Finding – Soil Surcharging

The total airspace that could be recovered by soil surcharging would be approximately 22,000 cy with a potential gross revenue of approximately $464,000 based on a waste tipping fee of $40 per ton and a waste to cover ratio of 6 to 1. Coordination with PWS will be required to determine if the area identified in Figure 5-1 is available for soil surcharging.

ALTERNATIVE DAILY COVERS (ADC)

Alternative daily covers (ADC) have proven beneficial to many landfill operators in minimizing the cost of having to use either imported or on-site soil as a daily cover. Another important cost saving produced by using ADCs is the reduction in airspace consumed. The cost savings in airspace are typically quite significant, resulting in savings of millions of dollars over the site life. The capacity optimization afforded by ADCs is the reason why so many landfills are using ADCs at their sites.

CIWMB Approved ADC Material Types

The CIWMB promulgated regulations in 27 CCR for the use of ADC at Class III Landfills. Site-specific demonstration projects have shown that specific ADC materials can be used as a suitable daily cover (e.g., in lieu of soil) if used in accordance with the ADC standards established in 27 CCR. Site-specific demonstration projects are generally no longer required for the following eleven (11) ADC materials, if used as specified in 27 CCR:

1. Geosynthetic Fabric or Panel Products[7]
2. Foam Products
3. Processed Green and Wood Material
4. Sludge and Sludge-Derived Materials[8]
5. Ash and Cement Kiln Dust Materials

[7] Currently being used by PWS at the landfill.
[8] Currently being used by PWS at the landfill.

6. Treated Auto Shredder Waste
7. Contaminated Sediment, Dredge Spoils, Foundry Bonds, Energy Resource Exploration, and Production Wastes
8. Compost Materials
9. Processed Construction and Demolition Wastes and Materials
10. Shredded Tires
11. Spray Applied Cementitious Products

The above listed, approved materials may be used at the Paso Robles Landfill in accordance with 27 CCR and as approved by the LEA and RWQCB. If additional approved ADCs are desired to be used at the landfill, the standard operating procedures for those ADCs would be added to the JTD and submitted to the regulatory agencies as an amendment. Additionally, other ADC materials may be approved by the CIWMB on a case-by-case basis. All types of ADC must be approved by the LEA in writing prior to use. ADC materials are not recorded as waste disposed. Public Resources Code (PRC) Section 41781.3 establishes that ADC use is considered diversion through recycling[9]. Therefore, the use of ADCs is likewise considered a sustainable practice for landfills.

Tarps at the Paso Robles Landfill

Daily cover tarps have been proven as an industry standard for protection of the waste fill from litter production and from vectors and birds. The Paso Robles Landfill has been approved to use tarps as an ADC since the late 1990's. According to Jim Wyse, PWS, THOR tarps, manufactured by Odin International, Inc., Oconomowoc, Wisconsin, are used for the Paso Robles Landfill. They are 46 feet by 50 feet wide – Dura Shield 12,000 FR, with seat belt perimeter webbing and other reinforcement. The approved long-term tarping procedures for the Paso Robles Landfill as described in the 2007 JTD are as follows:

- Tarps are used only when site conditions allow;
- Soil cover is used during periods of excessively high winds;
- Tarps are placed across the working face each day;
- Tarps are placed and overlapped to promote drainage off the working face;
- Typical overlaps will be two feet during periods when rain is forecast and one foot all other times;
- Tarps lap a minimum of two feet on to adjacent soil cover;
- Tarps are held in-place using waste tires or other manageable inert objects.

The general procedures for use of tarps at the landfill is as follows: 1) waste spreading, grading, and compaction is completed at the end of the day; 2) outer

[9] Public Resources Code Section 41781.3 (a) The use of solid waste for beneficial reuse in the construction and operation of a solid waste landfill, **including use of alternative daily cover**, which reduces or eliminates the amount of solid waste being disposed pursuant to Section 40124, shall constitute diversion through recycling and shall not be considered disposal for the purposes of this division.

edges (slopes of the horizontal lift) are covered with soil cover; 3) tarps are positioned as described above using landfill equipment assisted by landfill staff labor; 4) tarps are anchored by placing tires or other heavy objects around the perimeter; and 5) additional soil cover is placed on the active face as necessary to cover all waste.

Tarps are used mainly on the horizontal area of the working face. Soil cover is applied to the outer (3:1) edges of the active fill area. Typically, soil cover is applied to the outer slopes on a daily basis; however, this schedule may vary with the actual working-face location and configuration. In some cases the slopes may be covered by tarps.

Tarps are removed in the morning and are folded to half their size then pulled off the waste fill using landfill equipment. When not in use, the tarps are kept on the ground near the working area out of the way of traffic. In addition, about 12 inches of interim cover soil is placed on the top each finished cell.

Areas at the site that will not receive waste for at least 180 days are required to have at least 12 inches of interim soil cover.

SOIL VERSUS TARPS AIRSPACE AND COST ANALYSIS

The cost of using soil versus tarps as daily cover was undertaken to provide the City with information that will confirm that the tarps are a valuable component of landfill operations at the Paso Robles Landfill.

Airspace Lost from Use of Soil as Daily Cover

From July 1, 2006 to June 30, 2009, the Paso Robles Landfill received an average of 45,181 tons of waste per year or approximately 147 tons per day at 307 operating days per year. The site's current operator stated that they are using a working face of approximately 50 feet by 100 feet. Using this information we calculated how much airspace would be lost if the operator was using only soil as daily cover to determine the value of using tarps as an ADC.

Table 5-6 - *Airspace Consumed by Daily Soil Cover (Current Working Face of 50′ x 100′)* gives the calculation for the current PWS working face of 50 feet by 100. If the landfill operations were to use soil cover only (no tarps), this larger working face results in approximately 46,000 cy per year. This results in a loss of 1,934,000 cy of airspace loss over the remaining 42 years of landfill life with an associated gross revenue loss of 54 million dollars.

Because the working face seems rather large for the average daily inflow, we also calculated the value of the airspace consumed by daily soil cover using a smaller working face of 40 feet by 40 feet. In Table 5-7 - *Airspace Consumed by Daily Soil Cover (Recommended Working Face of 40′ x 40′),* the calculations associated with this working face are presented; the annual airspace consumed by using soil as daily cover is approximately 17,000 cy per year. Applying the

annual soil airspace consumption rate over the landfill's remaining site life of 42 years, the total airspace consumed is 717,000 cy and the value of the loss airspace is approximately 20 million dollars. Therefore, regardless of the working face size, the savings in airspace capacity is quite obvious.

Operational Costs of Using Tarps vs. Soil

According to PWS, the cost of the tarps purchased for the Paso Robles Landfill is $1,400 per tarp. The tarps have an operating life of about three to four months. The site uses about five to six tarps daily and PWS purchases approximately 20 tarps per year. The cost of using the tarps including the equipment and labor costs has been estimated by the BAS Team at approximately $83,000 per year, using Caltrans equipment unit rates and assuming an on-site borrow source (see Table 5-8, *Estimated Cost of Using Tarps)*.

Soil handling and placement associated with the use of soil as daily cover is estimated to be $174,000 annually. See Table 5-9, *Labor and Equipment Costs to Use Soil as Daily Cover.* The use of tarps results in an operational savings of approximately $91,000 per year. The savings could potentially be increased if a smaller working face were to be evaluated for the site.

Key Finding – Soil vs. Tarps as Daily Cover

The airspace capacity savings of using tarps versus soil is about 46,000 cy on an annual basis. The annual cost of using only soil for daily cover is about $174,000. The cost of using tarps and limited soil is estimated to be $83,000 per year. Thus the use of tarps saves the operator approximately $91,000 in annual operational costs.

The added benefit of utilizing tarps as an ADC is not only seen in the operational cost savings but also in the value of the airspace saved by the tarps. Over the life of the landfill, the loss in potential revenue from airspace consumed from using soil as daily cover material is over $54 million dollars. Therefore, the utilization of tarps as ADC at the landfill has long-term benefits that will increase potential future revenues and site life. The site should definitely continue to use tarps as an ADC.

PROCESSED GREENWASTE MATERIAL (PGM) AS ALTERNATIVE DAILY COVER

Since PGM is organic, it was originally believed that it would eventually break down over time and not have a significant impact on landfill airspace capacity. BAS recently conducted an evaluation in Southern California of the degradation and settlement of PGM. It was determined that PGM responds to compaction loading very similar to municipal solid waste (MSW) due primarily to the high lignin content of PGM. The biodegradation modeling conducted by BAS estimated that the loss in mass of the PGM ranged from approximately 1.6 percent to 6.7 percent over an eight-month period. The study concluded that

PGM does not degrade very much nor can it be compacted more than MSW. Therefore, the use of PGM as an ADC does not optimize airspace at a landfill.

The landfill receives an average of 3,847 tpy of Processed Green Materials (PGM) collected through residential and commercial curb-side recycling programs. As reported in Appendix D, Single-Family Residential Collection Volumes (2006 to 2008) account for an average of 3,665 tpy while Commercial/ Multi-Family Residential Collection Volumes (2006 to 2008) account for an average of 367 tpy for total of 3,847 tpy of PGM. PGM may include varying proportions of wood waste from urban and other sources and if considered an ADC, it would need to be ground, chipped, shredded, screened, or processed to meet the required specifications for ADC. The PGM would then be placed over the waste and compacted to provide a cover with a minimum compacted thickness of 6 inches and an average compacted thickness no greater than 12 inches. PGM as ADC applied at significantly higher thicknesses could increase the threat of landfill fires with drying and could cause unacceptable odors with decomposition.

The current use of PGM at the landfill is as follows:

> *PWS has implemented a permanent program to divert clean green, yard, and wood wastes from the working face to a stockpile area. Grinding of the wood waste materials is subcontracted to a company with portable grinding equipment. Processed wood waste is ground, loaded into trucks, and hauled off-site to biomass fuel facilities in the Central Valley of California. Such grinding and material removal typically occurs two to three times each year. The excess material not used as biomass is used on-site as soil erosion mitigation material and on-site interim cover for side slopes.*

Key Finding – Processed Green Material (PGM) as Alternative Daily Cover

After reviewing the potential of using PGM as an additional ADC at the Paso Robles Landfill, BAS concludes that it is not a viable ADC due to the low volume of PGM received at the site and the fact that PGM does not degrade very much so it would consume as much airspace as soil for cover. The operator's current use is acceptable until such time as a viable composting or anaerobic project can be implemented at the landfill.

PROCESSED CONSTRUCTION AND DEMOLITION (C&D) AS ALTERNATIVE DAILY COVER

On September 10, 2009 PWS obtained approval from the CIWMB to conduct a Demonstration Project utilizing ground and screened construction and demolition debris (C&D) "fines" to be utilized as Alternative Daily Cover (ADC).

PWS purpose is demonstrate that the use of C&D fines as an alternative daily cover material will control vectors, fires, odors, blowing litter and scavenging without presenting a threat to human health and the environment, as required by Title 27 California Code of Regulations.

PWS's desire is to put to beneficial use by products from recycling activities. They wish to evaluate the use of C&D fines as either a partial of full supplement or exchange for use of ADC tarps.

Key Finding – Construction & Demolition (C&D) Debris as an ADC

After reviewing the potential of using processed C&D as an alternative daily cover at the Paso Robles Landfill, BAS concludes that the City would need to weigh the short- term benefits of increased revenue from taking in additional C&D material versus the long-term loss in airspace capacity. Because the C&D material if recycled would not be subject to the AB 939 fee to the CIWMB, the total revenue from the gate fee could be realized. In addition, the fines that would be used as alternative daily cover would count toward diversion credit.

The C&D use would be similar to using soil as it has similar characteristics and would likely consume as much airspace as soil for cover. The volume of C&D fines to be used appears to be fairly minimal and may not have a significant impact on long-term airspace usage. Therefore a short-term pilot for six months with good recordkeeping of tonnages and usage is recommended in order to properly evaluate the cost benefits of this proposed use.

5.3 POTENTIAL ADDITIONAL LANDFILL CAPACITY

DEFINITIONS

In-place Waste Density. [Pounds of waste per cubic yard of waste (pcy)]. The in-place waste density is the estimated or measured density of in-place waste material achieved by mechanical or other means in the development of the current lift of the current operating waste cell.

Waste-to-Cover Ratio. (volume: volume). The waste-to-cover ratio estimate is a unit-less expression of the proportion of the volumes of waste and cover that comprise a volume of compacted fill material, e.g. 4:1. The cover portion of the waste-to-cover ratio estimate should include only soil or approved daily or intermediate alternative cover that is not considered a waste material, for which payment of fees to the CIWMB is not required. The waste portion of the waste-to-cover ratio estimate should include only waste material for which payment of fees to the CIWMB is reported.

Airspace Utilization Factor (AUF). [(Tons of waste per cubic yard of landfill airspace (tons pcy)]. The AUF is the effective density of waste material in the landfill. The AUF is recorded as the total weight of waste material passing over the landfill scales that is placed in a known volume of landfill airspace in a given period of time. The waste portion of the AUF should include only waste material for which payment of fees to the CIWMB is reported.

ANALYSIS OF CURRENT AIRSPACE UTILIZATION FACTOR

The 2007 Joint Technical Document (JTD) for the landfill identifies the various assumptions made by PWS and SCS Engineers (consultant that prepared 2007 JTD), regarding operational procedures such as compaction and waste-to-cover ratio. PWS used a conservative average landfill industry density factor of 1,250 pcy for in-place density to determine remaining capacity. Regarding waste-to-cover ratio, PWS assumed a 6:1 waste-to-cover ratio to determine the amount of on-site soil used for cell construction, final cover, daily and intermediate cover.

PWS uses tarps for daily cover at the landfill. Soil was not reported by PWS to be used at 21-day increments, now are scraper loads of soil used to construct the landfill recorded by PWS. The JTD does not provide any information regarding the estimated airspace utilization factor.

The BAS Team attempted to identify existing in-place waste density, waste-to-cover ratio, and the airspace utilization factor for the landfill. Data use evaluates the landfill operations, including the latest tonnage report and ground and aerial surveys provided by PWS. As previously stated, PWS uses tarps as alternative daily cover; therefore, assumptions regarding the amount of soil needed for typical cell construction were as follows:

- Working face (30-foot advance, 10-foot lift (see Table 5-10).

Reported monthly tonnages for the period from June 1, 2007 to June 31, 2009 are shown on Table 5-11 – *El Paso de Robles Landfill Master Plan Tonnage Report and Remaining Capacity* (provided by PWS). Waste landfilled during the two-year review period was 84,816 tons.

A stratum of the 2007 surface [aerial survey, June 13, 2007, Aero-Geodetic] and the 2009 surface [ground survey, June 26, 2009, PWS] was created to determine how many cubic yards between these two surfaces exists (see Figure 5-2). AutoCAD Civil 3D was used to perform the volume calculations to determine the cubic yards between the stratum (layers) created. The net cubic yards result was a gross total of 123,867 cy.

It was estimated that the amount of soil utilized for the side of working face for the two-year review period is about 6,822 cy. Unfortunately, an assumption regarding the use of intermediate soil cover was not possible because soil loads used for landfill construction are not currently recorded at the site by PWS.

A comparison between the recorded landfilled tons (84,816 tons) and the airspace from the topographic analysis (123,867 cy) resulted in the following:

Airspace Utilization	Paso Robles Landfill	Industry Averages
Waste Landfilled (June 1, 2007 to June 31, 2009)	84,816 tons or 135,705 cy @ 1,250 pcy	
Volume Calculation Airspace (2007 Aerial Topo to 2009 ground survey)	123,817 cy	
Daily Soil Cover Assumption (side of landfill cell)	6,822 cy	
Intermediate Soil Cover	Not Available	
Effective In-Place Waste Density	Greater than 1,450 pcy	1,250 to 1,800 pcy
Refuse-to-Cover Ratio	6:1	3:1 to 7:1
Airspace Utilization Factor	Greater than 0.725 tons/cy	

Key Finding – Airspace Utilization Factor

The airspace utilization analysis conducted by the BAS Team determined that the data available was inadequate to make a definitive conclusion. It would be useful in the future to have a third-party aerial or ground survey to better estimate the site's in-place density and airspace utilization factor. It is also recommended that the operator keep daily records of any soil used for daily and intermediate cell construction in order to better estimate existing in-place waste density, waste-to-cover ratios, and the airspace utilization factor for the landfill.

ANALYSIS OF FINAL GRADING PLAN

The intent of this task was to review the existing permitted final grading plan for the Paso Robles Landfill to determine if there is a potential for additional airspace within the existing permitted limits. The BAS Team will determine if a Solid Waste Facility Permit (SWFP) amendment or revision is needed or if additional purchase of land for long-term landfilling capacity is cost-effective based on projected waste in-flow rates.

Many factors can affect the ultimate site capacity of a given landfill including variations in the use of ADCs, recycling programs, and/or the annual tonnage delivered to the landfill. The design of a landfill can significantly affect potential airspace availability. The goal is to optimize the site's capacity.

In addition, long-term landfill settlement can also have an impact on site capacity. The total effect of settlement will depend on various factors or processes such as the types of waste placed and their corresponding moisture content, the waste placement density, consolidation of the waste under loads imposed by overlying fill, and biological and chemical decomposition. It is estimated that much of this total settlement will occur during the operating life of the landfill and will be accounted for in periodic topographic surveys.

Permitted Final Grading Plan

The current final grading plan[10] (see Figure 5-3) was developed to provide waste disposal capacity within the property boundary of the landfill by incorporating the following:

- Waste fill slopes of 3:1 (H:V) along the perimeter of the landfill.
- Balance soil needed for landfill operations and final cover needs with available soil from proposed excavations.
- Final proposed maximum elevation of the landfill at 1,226 feet amsl.
- Provide for a perimeter landfill access road outside of existing and future waste fill areas.

The final grading plan also shows proposed surface water drainage improvements, permanent detention basins and the proposed landfill gas control system extraction well layout at final build-out. Upon closure, the final waste fill slopes will be graded no steeper than 3:1 (H:V), with 20-foot wide drainage benches installed for every 50 feet of elevation gain. The waste fill slopes will rise from the landfill perimeter to a maximum elevation of 1,226 feet amsl, to form a top deck. To maintain positive drainage, the top deck will be sloped at a grade of 5 percent.

The final landfill configuration will use a drainage system that includes lateral benches on side slopes, v-ditches, down chutes, drop inlet structures, and rip-rap for energy dissipation. Runoff from the top deck and down vegetated slopes will be directed to the site perimeter via v-ditches and down chutes. These will in turn discharge to five permanent sedimentation basins around the site perimeter.

Review of Final Grading Plan

The final grading plan for the landfill, Figure 5-3, provides a detailed schematic of the permitted final grades. A review of the final grading plan indicates that the current design has two top decks: the southern deck with a maximum elevation of 1,224 feet amsl and the northern deck with a maximum elevation of 1,183 feet amsl. The northern deck is 43 feet below the maximum permitted elevation of 1,226 feet amsl. Therefore, potential additional capacity exists in the northern deck area.

The landfill property totals 80 acres of which 65 acres are permitted for waste disposal. The remaining 15 acres are used for ancillary facilities, perimeter drainage, ponds, and a perimeter road. There is, therefore, little or no opportunity for a lateral expansion without acquiring adjacent property.

A review for a potentially deeper landfill in future phases was completed and included a review of the groundwater constraints at the site. The landfill is

[10] Final Grading Plan prepared by Pacific Waste Services (current landfill operator), February 2003.

located within the Paso Robles Hydrologic Area of the Salinas Hydrologic Unit. The primary groundwater aquifer beneath the landfill occurs in the Paso Robles Formation at a depth of about 265 to 300 feet below the ground surface at about 790 feet amsl and generally flows from southeast to northwest. The groundwater contours are shown on Figure 5-3 – *Final Grading Plan*.

First encountered groundwater beneath the landfill occurs in perched zones. Groundwater monitoring well, MW-V4, shows perched groundwater at about 180 feet below ground surface or about 930 feet amsl. Well MW-V5 shows perched groundwater at about 75 feet below ground surface or about 932 feet amsl. The City is currently working to define the lateral extent of the perched groundwater beneath the landfill.

Figure 5-4 - *Cross Sections*, provides information regarding the landfill's various surfaces including from bottom to top: the uppermost saturated zone groundwater levels, perched zone groundwater levels, excavation levels, 2002 topography, and final grading.

Key Finding – Airspace Potential from Modifying Master Grading Plan

As shown on Figure 5-3, there is no available area for a horizontal expansion at the landfill. The limits of waste are currently permitted to an average of 70 feet from the property boundary which is not sufficient area to support a lateral expansion. Only by acquiring adjacent property could the horizontal limits be expanded. It should be noted, however, that the acquisition of adjacent property for a buffer zone could be beneficial in the long-term for the City in the event that residential or commercial development occurs around the landfill.

The current Excavation Plan shows the maximum design depth at 1,000 feet amsl (see Figure 5-5). The highest perched groundwater point measured by well MW-V5 is 932 feet amsl. The difference between the lowest point of the design depth and the highest point of perched groundwater is 68 feet. The Waste Discharge Requirements allow for waste to be placed a minimum of five feet above the groundwater table, therefore, there is a potential for excavating a deeper landfill and creating additional landfill capacity. Steeper excavation slopes (greater than 3:1) are also an option to be considered.

The Final Grading Plan shows that the northern top deck (undeveloped area) does not reach the permitted maximum elevation of 1,226 feet amsl. To reach the maximum elevation, the City would have to procure additional land to the north, west, and east if 3:1 slopes are to be maintained. Another option is to design and permit steepened slopes (2:1); the steeper slopes would require a slope stability analysis and regulatory permit modifications such as revised waste discharge requirements and a modification or revision of the site's solid waste permit based on a revised final grading plan.

Because the site's current site life is estimated to be 2051, this revised grading plan can be revisited at a future date since there is sufficient landfill capacity at

the present time. A revised grading plan would also trigger the need for environmental documentation.

5.4 LANDFILL RECLAMATION

A brief discussion of landfill reclamation is also included herein because the City recently informed the BAS Team that it would like to see the *"use of any and all waste, included what is currently landfilled, as a potential source of renewable energy."*

Landfill reclamation or the excavation of the existing waste and potentially recycling the materials or processing them through a conversion technology for energy recovery is a potential avenue that could be explored. The Paso Robles Landfill as of July 2009 has 1,104,643 tons in-place of waste. Typically, these are the following elements that are needed for a feasibility study.

1. Site Characterization - how much and what kind of waste is in-place, what portions of the waste should be reclaimed?
2. Potential Economic Benefits.
3. Regulatory Requirements.
4. Health and Safety Plan.
5. Project Costs Evaluation.

Key Finding - Landfill Reclamation

A Feasibility Study would be needed to determine if such a project might be viable for the landfill. This is currently beyond our Phase I scope of work and would require further discussion with the City. General information regarding landfill reclamation is included as Appendix G, *Landfill Reclamation.*

5.5 USE OF SLUDGE AT THE PASO ROBLES LANDFILL

Sludge is a by-product of wastewater treatment and is not to be confused with biosolids which are the end product after treating sewage sludge with anaerobic digestion in combination with heat.

The Paso Robles Landfill is a Class III landfill and is permitted to accept sludge and either landfill it, use it as an ADC, or as a soil amendment. The site's solid waste facility permit states the following:

> "*Discharge of de-watered waste water treatment plant sewage sludge or water treatment sludge shall be conducted in accordance with governing waste discharge requirements. Use of de-watered sewage sludge and water treatment sludge to control erosion or promote vegetative growth is authorized provided this practice is conducted in accordance with Regional Water Quality*

Control Board requirements. Disposed sludge shall count towards tonnage limits."

Waste Discharge Requirements (WDR) Order Number R3-2008-0050 has the following requirements regarding sludge acceptance and disposal at the landfill. The City is required to record the following information for all dewatered sewage and water treatment sludge discharged at the landfill:

1. *Source and type of sludge {e.g., primary (at least 20% solids by weight) or secondary (at least 15% solids by weight) wastewater, water treatment}.*
2. *Volume and weight;*
3. *Percent moisture;*
4. *Location where sludge was discharged at the landfill and the waste solids to sludge ratio (at least 5 to 1 waste to sludge) by weight.*

According to the CIWMB (2004), alternative uses for sludge in California include the following:

Use	Percentage
Land Application	54%
Composting	16%
Alternative Daily Cover	12%
Disposal at a Landfill	4%
Incinerated or Stored	8%

The use of sludge is limited to up to 25 percent of landfill cover materials or landfill cover extenders. In 2005, after the City's wastewater plant was improved and consequently sludge capacity was increased, the annual sludge deliveries to the landfill increased from an average of 300 tpy to an average of 2,683 tpy for years 2006 to 2008.

CURRENT USE OF SLUDGE

Given PWS' historic application of sludge as an interim cover soil amendment at a rate of around 50 tons per acre over an average area of up to four acres annually (200 tpy), PWS is not able to keep up with current annual sludge deliveries from the City to be used as ADC.

The City's operator, PWS, on July 16, 2009 sent a letter to the City advising them that due to the higher deliveries of sludge that is being experienced at the site, use of sludge of an ADC needs to be expanded.

PWS has recently notified the City that due to the large amounts of sludge being delivered to the landfill and the minimal sludge being used for interim cover, there is a need to consider options for its beneficial use at the site. PWS is

interested in developing a one-year pilot test project that will consist in the land application of the City's sludge to a small, 2.5-acre portion of the landfill. Their intent is to grow a winter grain crop to be cut and baled for future beneficial use at the landfill. If the pilot is successful, a full-scale project would be developed, consisting of the land application of 3,000 tons of City sludge over a 60- to 80-acre area for such operation. For this to be feasible adjacent property would need to be procured for such purpose and appropriate environmental documentation and permitting would be needed.

PWS has not disposed of any of the City's sludge within the waste fill. However, PWS is mixing some sludge with borrow area soil for use as periodic daily cover on non-interim cover slopes. The balance of the sludge is currently in a stockpile area that drains to a basin in the soil borrow area where there is no direct surface drainage discharge opportunity. This use of the sludge offsets soil usage and this use is considered as "beneficial" reuse of the sludge and counts towards diversion credit for the City. The use of sludge in this manner has a neutral effect on optimization of capacity, it doesn't improve it and it doesn't make it worse.

SLUDGE AS LANDFILL GAS PRODUCER

There are benefits to disposing sludge in the landfill. The moisture and nitrogen in the sludge will enhance landfill gas (LFG) production and enable the landfill to have a landfill gas-to-energy project earlier than if the landfill did not have sludge as part of the waste mass. The downside to disposing of sludge in the landfill is that the City cannot count this tonnage as diversion and in addition, must then pay the CIWMB disposal fee for those tonnages that are landfilled.

POTENTIAL USE OF SLUDGE AS ADC

Although the site's SWFP does not clearly prohibit the use of sludge as an ADC, it could be used as such. If the City wanted to use sludge as an ADC at the landfill, a modification to the JTD would be needed. A consultation with the LEA is also recommended in order to determine if a minor revision to the SWFP should be made. Using sludge as an ADC would enable the City to count the sludge tonnage as diversion; however, the airspace consumption would be very similar to soil.

WHAT OTHERS ARE DOING WITH SLUDGE

The Orange County Sanitation Districts (Fountain Valley) is not currently "disposing" of any of its biosolids. They are managing their approximate 650 wet tons per day of biosolids by utilizing three beneficial use options as follows:

1. Direct land application of Class B cake on agricultural land in Arizona.
2. Composting at two different sites; one in Kern County for the majority of the compost and one in Arizona for one to two trucks per day.

3. A new process managed by EnerTech (Rialto, California) where they produce a synthetic coal through heat and pressure for utilization as a fuel supplement in the Cement Kiln industry.

Some of the sludge received at the landfill can be used for ADC, yet there is an excess amount that requires other beneficial uses. There are benefits to disposing sludge in the landfill. Due to the increased moisture associated with the sludge, landfill gas generation, as well as waste decomposition within the landfill increases. Ultimately, with increased landfill gas production, a landfill gas-to-energy facility may prove to be very productive. Disposing of the sludge does not allow the City the ability to count the landfilled sludge towards diversion credits but use of the sludge as an alternative daily cover will not only count towards diversion credit but also eliminates the need to pay the AB 939 fee if it is used for daily cover.

If the sludge were to be used to grow a winter grain, the land needed for the project would take away land that could potentially be used for a solar project at the northern most end of the landfill site. If the proposal is to grow a winter grain crop by acquiring additional land, then the cost of acquiring the land, the additional water needed to grow the crop, and cost to spread the sludge on the crop would need to be evaluated. Also, as discussed in Section Two, a solar project on adjacent property may also be viable; therefore, the winter crop/sludge project would be competing with a solar project on adjacent property.

Other compatible uses for the sludge such as composting with green waste, wood waste or municipal solid waste as a potential feedstock for a biomass facility are discussed in Section Two of this report. The difficulty with composting the sludge and the municipal solid waste is lack of markets for the end product. Typically, it has been difficult to convince users that the compost process results in a "safe" product.

Key Finding – Use of Sludge at the Paso Robles Landfill

Use of the sludge as a co-mingled ADC with the C&D fines or soil so that the sludge tonnage can count toward diversion appears to be a viable solution that will need to be discussed with PWS.

Using the sludge to grow a winter crop appears to need a more thorough evaluation to determine the volume of water that would be needed. The cost of obtaining that water should be factored in the overall project cost along with the labor and equipment needed for such an endeavor.

5.6 HOUSEHOLD HAZARDOUS WASTE FACILITY

The BAS Team was to provide a review of sustainable practices at the Paso Robles Household Hazardous Waste facility (HHWF). The facility operates according to the procedures outlined in the Operational Procedures

(Appendix F) and is under direct control of the San Luis Obispo County Integrated Waste Management Association (IWMA).

The IWMA operates a regional household hazardous waste collection program for all of San Luis Obispo County that provides for collection of household hazardous waste. The IWMA was established by a voluntary joint power agreement (JPA) on May 10, 2004 under California Government Code, Section 6500. The IWMA is a continuation of a State-mandated Solid Waste Program established by the County of San Luis Obispo and cities located within San Luis Obispo County. The IWMA has the power to acquire, construct, finance, operate, regulate, and maintain a solid waste landfill, transfer station, material recovery facility, composting facility, household hazardous waste facility, or a joint facility. The JPA also has the power to plan, study, and recommend proper solid waste management and implement programs within San Luis Obispo County.

The City contributes a fee of $3 per ton of their waste disposed at the Paso Robles Landfill to the IWMA. In 2007, the City contributed $137,303 for the IWMA programs and in 2008 the City contributed $100,727.

Appendix D identifies the various household hazardous waste related services provided by the IWMA. Some of these services include the following:

1. Public Education Programs

    a. City Website
    b. Paso Robles Disposal Website
    c. IWMA Website
    d. Advertising in Phone Books, Television, and Newspaper
    e. IWMA Hotline
    f. IWMA Speakers Bureau
    g. Presentations and Field Trips for School Children
    h. School Food Waste Diversion
    i. "Zero Waste in the Classroom" Program

2. Ordinances and Other Programs Available Countywide

    a. Mandatory Recycling Ordinance
    b. Battery, Fluorescent Lamp and Fluorescent Tube Collection "Take-Back" Ordinance
    c. Used Paint Collection at Retail Stores "Take-Back" Ordinance
    d. Home-Generated Sharps Waste Collection at Pharmacies and Retailers "Take-Back" Ordinance
    e. Other Household Hazardous Waste Collection at Permanent Collection Sites

The facility is open Saturday, 11:00 AM to 3:00 PM and accepts the following materials:

- Televisions or computer screens;
- Paints, pesticides, solvents, oil;
- Hazardous waste; and
- Batteries.

During regular landfill hours, PWS does allow the public to place TV, CRT and batteries at locations on the HHW area.

A chart listing hazardous wastes and their appropriate method of disposal is provided by the IWMA at their website (iwma.com/householdhaz).

SUSTAINABILITY REVIEW OF THE HHWF PRACTICES

The current variety of programs offered by the HHWF is fairly substantial and is contributing to the reduction of toxic material from the waste stream entering the Paso Robles Landfill. An inventory of their programs is included in Section Three of this report.

The numerous recycling and take back programs offered by the HHWF is contributing significantly to the City's sustainability effort just from the mere fact that they collect and recycle of household hazardous material. The educational outreach programs that the IWMA provides for the City also contributes to educating residents about sustainability as it relates to solid waste.

Collection and storage of materials at the HHWF is limited to household hazardous materials. Some of household hazardous materials brought to the HHWF are reusable; therefore, BAS reviewed the option of a potential Materials Exchange Program (MEP), also known as a "Stop and Swap" for the IWMA facility at Paso Robles Landfill.

Only certain types of common household maintenance products would be made available to the public through the MEP. This includes latex paint and non-lead-based paint products, some automotive products, household cleaners and polishes, registered pesticides, herbicides, pool chemicals, certain fertilizers, hobby and craft supplies, propane tanks, and unused household batteries. To be considered "reusable" products must be appropriately labeled, uncontaminated, and appear to be as originally manufactured. Contractor staff would need to examine materials brought into the HHWF to determine suitability for the MEP using criteria specified in a Quality Assurance Plan (QAP) developed for the HHWF.

In discussing this program with Bill Worrell of the IWMA, he said that such a program existed in the past but was terminated due to the liability associated with taking potentially unknown substances and giving them out to the public.

In addition, the IWMA's past experience with storing unknown substances was that a fire occurred at one of their facilities due to having stored two unknown reactive substances in close proximity to one another.

Key Finding - Household Hazardous Waste Facility

The Household Hazardous Waste Facility was found to be well run and operated by the IWMA. The IWMA implements many cost-effective recycling programs that contribute to the City's sustainable goals for its solid waste management system. The facility should continue to operate and the physical size of the facility appears adequate at this time. The IWMA as part of its outreach efforts should begin to integrate the word, "sustainability" in their outreach efforts regarding reducing, reusing and recycling material.

It may be possible, if a conversion technology (CT) plant is build on site to process some of the hazardous materials in the CT, however additional analysis of the waste stream would be needed to determine their potential use as a feedstock in a CT.

5.7 REGULATORY COMPLIANCE INSPECTIONS BY THE CALIFORNIA INTEGRATED WASTE MANAGEMENT BOARD (CIWMB)/LOCAL ENFORCEMENT AGENCY (LEA)

PWS, under its current operating agreement (First Amendment), has the following responsibility for regulatory compliance at the landfill:

> *"Contractor shall be fully responsible for all permit compliance and engineering requirements including development of landfill design plans and permit documents, groundwater and surface water monitoring and reporting, landfill gas monitoring and reporting, construction management and regulatory agency liaison and reporting, commencing July 1, 2005 and continuing through the term of this Agreement, this work shall be performed by an independent third-party (the Independent Party) selected by the City."*

The results of regulatory compliance inspections performed by the CIWMB since 2005 are summarized below:

2005 – 4 Violations; 1 Area of Concern
2006 – 4 Violations; 8 Areas of Concern
2007 – 0 Violations; 1 Area of Concern
2008 – 0 Violations; 7 Areas of Concern
2009 – 0 Violations; 2 Areas of Concern-(April 2009) Litter Control and Alternative Daily Cover (tarps not being weighted down sufficiently).

When asked about the general regulatory performance of the current contractor, a contact at the LEA stated that *"They do a good job generally but little things here and there take them several months to fix."* The City may wish to conduct its own inspections at other times of the day (e.g., during opening and closing times at the site) to ensure overall site compliance.

Key Finding - Regulatory Compliance Inspections by the California Integrated Waste Management Board (CIWMB)/Local Enforcement Agency (LEA)

The site operator has a few "areas of concern" violations which are typically minor issues at the site. According to the LEA, these are not typically corrected immediately and some time elapses before the area of concern issues are corrected. The City should point this matter out to PWS so that the violations are addressed in a timely manner. The City may also wish to accompany the LEA on these inspections and/or conduct its own review of the site's compliance during the opening hours of the site and also at the closing of site operations.

SECTION FIVE

TABLES

TABLE 5-5
EL PASO DE ROBLES LANDFILL MASTER PLAN

AVAILABLE AIRSPACE FROM SOIL SURCHARGING

ASSUMPTIONS		
Parameter	**Quantity**	**Unit**
Stockpile Footprint (2.68 acres)	116,925	sf
Average Compaction	5	ft
Waste Density	1,250	lb/cy
Tipping Fee	40	$/ton

Regained Airspace from Soil Surcharging = 22,000 cy

$$116{,}925\ sf \times 5\ ft \times \frac{1\ cy}{27\ cf} = \mathbf{21{,}653}$$

Potential Gross Revenue from Soil Surcharging = $464,000

$$\frac{6}{7} \times 21{,}653\ cy \times \frac{1{,}250\ \text{lb}}{1\ cy} \times \frac{1\ \text{ton}}{2{,}000\ lb} \times \frac{\$40}{1\ ton} = \mathbf{\$463{,}993}$$

TABLE 5-6
EL PASO DE ROBLES LANDFILL MASTER PLAN

AIRSPACE CONSUMED BY DAILY SOIL COVER
(CURRENT WORKING FACE OF 50' X 100')

ASSUMPTIONS		
Parameter	**Quantity**	**Unit**
Waste Density	1,400	lb/cy
Tip Fee (online)	40	$/ton
Operating Days	307	days/yr
Years Remaining	42	yr
Working Face (approximately 50' x 100')	5,000	sf
Soil Cover Thickness (6" effective)	9	in/day
Side of Working Face (30' advance, 10' lift)	150	sf
Soil Cover Thickness (Side of Working Face)	24	in/day
2006-2008 Refuse Inflow (average)	45,181	tons/yr

Annual Airspace Consumption from using Soil as Daily Cover): 46,000 cy/yr

$$\left(9\frac{in}{day}\ x\ \frac{1\,ft}{12in}\ x\ 5{,}000\,sf\ x\ \frac{1\,cy}{27\,cf}\ x\ \frac{307\,days}{1\,yr}\right)+\left(24\frac{in}{day}\ x\ \frac{1\,ft}{12in}\ x\ 150\,sf\ x\ \frac{1\,cy}{27\,cf}\ x\ \frac{307\,days}{1\,yr}\right)=46{,}050\,cy/yr$$

Total Airspace Consumption (Soil Daily Cover) over Site Life: 1,934,000 cy

$$46{,}050\ cy\ /\ yr\ \ x\ 42\ \ yrs\ = 1{,}934{,}100\ cy$$

Total Potential Revenue Loss from use of Soil for Daily Cover: $54,000,000

$$1{,}934{,}100\ cy\ x\ \frac{1{,}400\,lb}{1\,cy}\ x\ \frac{1\,ton}{2{,}000\ lb}\ x\ \frac{\$40}{1\ ton}=\$54{,}154{,}800$$

TABLE 5-7
EL PASO DE ROBLES LANDFILL MASTER PLAN

AIRSPACE CONSUMED BY DAILY SOIL COVER (RECOMMENDED WORKING FACE OF 40' X 40')

ASSUMPTIONS		
Parameter	**Quantity**	**Unit**
Waste Density	1,400	lb/cy
Tip Fee (online)	40	$/ton
Operating Days	307	days/yr
Years Remaining	42	yr
Working Face (approximately 40' x 40')	1,600	sf
Soil Cover Thickness (6" effective)	9	in/day
Side of Working Face (30' advance, 10' lift)	150	sf
Soil Cover Thickness (Side of Working Face)	24	in/day
2006-2008 Refuse Inflow (average)	45,181	tons/yr

Annual Airspace Consumption (Soil Daily Cover): 17,000 cy/yr

$$\left(9\frac{in}{day}\ x\ \frac{1\,ft}{12in}\ x\ 1{,}600\,sf\ x\ \frac{1\,cy}{27\,cf}\ x\ \frac{307\,days}{1\,yr}\right)+\left(24\frac{in}{day}\ x\ \frac{1\,ft}{12in}\ x\ 150\,sf\ x\ \frac{1\,cy}{27\,cf}\ x\ \frac{307\,days}{1\,yr}\right)=17{,}056\,cy/yr$$

Total Airspace Consumption (Soil Daily Cover) over Site Life: 717,000 cy

$$17{,}056\ cy\ /\ yr\ x\ 42\ yrs\ =\ 716{,}352\ cy$$

Potential Revenue Loss from use of Soil for Daily Cover: $20,000,000

$$716{,}352\ cy\ x\ \frac{1{,}400\,lb}{1\,cy}\ x\ \frac{1\,ton}{2{,}000\,lb}\ x\ \frac{\$40}{1\,ton}=\$20{,}057{,}856$$

TABLE 5-8
EL PASO DE ROBLES LANDFILL MASTER PLAN

ESTIMATED COST OF USING TARPS

ASSUMPTIONS		
Parameter	**Quantity**	**Unit**
Working Face per PWS: 50 ft x 100 x by 10 ft (height)		
Operating days	307	days/yr
Cost of each tarp with shipping	1,400	$/tarp
Life of Tarp (3-4mos, assume 3)	3	mos
Number of Tarps Used for ADC (5-6 tarps, assume 5)	5	tarps
Laborer (1)	15.35	$/hr
Operator (1)	57.11	$/hr
Dozer (CAT D6) (2)	89.74	$/hr
Placement Time (3)	1	hr
Estimated Soil Usage for Framing (300' x 1' x 9")	300	sf
Side of Working Face (30' advance, 10' lift)	150	sf
Soil Cover Thickness (Side of Working Face)	24	in/day

Annual Material Cost (4) = $28,000 /yr

$$\frac{5\ tarps}{3\ mos} \ x\ \frac{12\ mos}{1\ yr} \ x\ \frac{\$\ 1,400}{1\ tarp} = \$\ 28\ ,000\ \ /\ yr$$

Annual Labor and Equipment Cost to frame soil and place tarps = $55,000 /yr

$$\left[\left(1\ dozer\ x\ \frac{\$89.74/hr}{1\ dozer}\right)+\left(1\ operator\ x\ \frac{\$57.11/hr}{1\ operator}\right)+\left(2\ laborers\ x\ \frac{\$15.35/hr}{1\ laborer}\right)\right] x\left(\frac{1\ hr}{1\ day}\ x\ \frac{307\ days}{1\ yr}\right) = \$54,508/\ yr$$

$$\$55,000\ /\ yr + \$28,000\ /\ yr = \$83,000/\ yr$$

Total Annual Operations Cost = $83,000 /yr

(1) Prevailing wage from the California Department of Industrial Relations
(2) Equipment prices are based on Caltrans Equipment Rental Rates. Cost may be lower if the equipment is owned by the operator.
(3) Estimated time to place the Tarp, Soil Frame, and Soil Cover on the Side of the Working Face
(4) There is no purchase cost associated with using on-site soil for framing and for the cover of the side of the working face.

TABLE 5-9
EL PASO DE ROBLES LANDFILL MASTER PLAN

LABOR AND EQUIPMENT COSTS TO USE SOIL AS DAILY COVER

ASSUMPTIONS		
Parameter	**Quantity**	**Unit**
Operating Days	307	days/yr
Scraper (CAT 623B)*	167.63	$/hr
Dozer (CAT D6)*	88.74	$/hr
Water Truck (4,000 gal)*	40.61	$/hr
Compactor (CAT 825B)*	153.73	$/hr
Equipment Total*	450.71	$/hr
Operator** ($57.11/hr/operator x 2 operators)	114.22	$/hr
Estimated Time Required to place soil daily cover	1	hrs

Annual Operations (Labor and Equipment) Cost = $174,000 /yr

$$\left(\frac{\$450.71 / hr}{equipment} \; x \; \frac{\$114.22 / hr}{operators} \right) x \; \frac{1 \; hr}{1 \; day} \; x \; \frac{307 \; days}{1 \; yr} = \$173,434 / yr$$

*Equipment prices are based on Caltrans Equipment Rental Rates. Cost may be lower if the equipment is owned by the operator.

TABLE 5-10
EL PASO DE ROBLES LANDFILL MASTER PLAN

AIRSPACE CONSUMED BY SIDE OF WORKING FACE DAILY SOIL COVER (CURRENT WORKING FACE OF 50' X 100') AND INTERMEDIATE COVER

ASSUMPTIONS		
Parameter	**Quantity**	**Unit**
Waste Density	1,400	lb/cy
Operating Days	307	days/yr
Years Remaining	42	yr
Working Face (approximately 50' x 100')	5,000	sf
Soil Cover Thickness (6" effective)	9	in/day
Side of Working Face (30' advance, 10' lift)	150	sf
Soil Cover Thickness (Side of Working Face)	24	in/day
06/2007-06/2009 Refuse Inflow (average)	42,408	tons/yr

Annual Airspace Consumption from using Soil as Daily Cover): 46,000 cy/yr

$$\left(24 \ \frac{in}{day} \ x \ \frac{1 \ ft}{12 \ in} \ x \ 150 \ sf \ x \ \frac{1 \ cy}{27 \ cf} \ x \ \frac{307 \ days}{1 \ yr} \right) = 3,411 \ cy \ / \ yr$$

TABLE 5-11
EL PASO DE ROBLES LANDFILL MASTER PLAN
TONNAGE REPORT AND REMAINING CAPACITY

Month	Gate Tonnage	Recycled Tons	Landfilled Tons During Month	Tons, Remaining Landfill Capacity	Tons, In-Place	Annual Totals, Tons
12/31/2002				1,932,970.00	803,111.00	See Note 1 Below
Jan. 2003	4066.12	0	4066.12	1,928,903.88	807,177.12	
Feb.	3411	0	3411	1,925,492.88	810,588.12	
Mar.	3746	0	3746	1,921,746.88	814,334.12	
Apr.	3985.12	0	3985.12	1,917,761.76	818,319.24	
May	4300.57	0	4300.57	1,913,461.19	822,619.81	
June	4667.31	434.42	4232.89	1,909,228.30	826,852.70	
July	4661.36	0	4661.36	1,904,566.94	831,514.06	
Aug.	4687.16	37.97	4649.19	1,899,917.75	836,163.25	
Sept.	4115.61	415.79	3699.82	1,896,217.93	839,863.07	
Oct.	4523.8	667.68	3856.12	1,892,361.81	843,719.19	
Nov.	4953.05	80.15	4872.9	1,887,488.91	848,592.09	
Dec.	4093.28	45.44	4047.84	1,883,441.07	852,639.93	49528.93
Jan. 2004	4221.57	94.98	4126.59	1,879,314.48	856,766.52	
Feb.	4588	78.4	4509.6	1,874,804.88	861,276.12	
Mar.	5098.57	145.79	4952.78	1,869,852.10	866,228.90	
Apr.	4381.14	125.38	4255.76	1,865,596.34	870,484.66	
May	4096.32	128.03	3968.29	1,861,628.05	874,452.95	
June	4452.6	155.15	4297.45	1,857,330.60	878,750.40	
July	4493.03	150.16	4342.87	1,852,987.73	883,093.27	
Aug.	4184.69	88.11	4096.58	1,848,891.15	887,189.85	
Sept.	3784.12	43.62	3740.5	1,845,150.65	890,930.35	
Oct.	3646.38	0	3646.38	1,841,504.27	894,576.73	
Nov.	3984.17	0	3984.17	1,837,520.10	898,560.90	
Dec.	3725.87	0	3725.87	1,833,794.23	902,286.77	49646.84
Jan. 2005	3828.61	0	3828.61	1,829,965.62	906,115.38	
Feb.	3472.72	41.8	3430.92	1,826,534.70	909,546.30	
Mar.	4628.76	1975.66	2653.1	1,823,881.60	912,199.40	
Apr.	4021.3	509.85	3511.45	1,820,370.15	915,710.85	
May	4109.47	23.46	4086.01	1,816,284.14	919,796.86	
June	4454.09	98.76	4355.33	1,811,928.81	924,152.19	
July	4167.17	13.56	4153.61	1,807,775.20	928,305.80	
Aug.	4574.29	0	4574.29	1,803,200.91	932,880.09	
Sept.	4511.24	1041.4	3469.84	1,799,731.07	936,349.93	
Oct.	4113.21	0	4113.21	1,795,617.86	940,463.14	
Nov.	4108.44	0	4108.44	1,791,509.42	944,571.58	
Dec.	4021.3	509.85	3511.45	1,787,997.97	948,083.03	45796.26
Jan. 2006	4663.55	223.81	4439.74	1,783,558.23	952,522.77	
Feb.	3865.84	124.69	3741.15	1,779,817.08	956,263.92	
Mar.	4710.17	0	4710.17	1,775,106.91	960,974.09	
Apr.	4012.33	207.07	3805.26	1,771,301.65	964,779.35	
May	4885.6	0	4885.6	1,766,416.05	969,664.95	
June	4877.77	129.64	4748.13	1,761,667.92	974,413.08	
July	4477.16	874.87	3602.29	1,758,065.63	978,015.37	
Aug.	4824.44	380.67	4443.77	1,753,621.86	982,459.14	
Sept.	4317.46	0	4317.46	1,749,304.40	986,776.60	
Oct.	4580.09	0	4580.09	1,744,724.31	991,356.69	
Nov.	4272.68	388.58	3884.1	1,740,840.21	995,240.79	
Dec.	3886.23	361.55	3524.68	1,737,315.53	998,765.47	50682.44
Jan. 2007	3861.19	772.13	3089.06	1,734,226.47	1,001,854.53	
Feb.	3563.18	0	3563.18	1,730,663.29	1,005,417.71	
Mar.	4213.11	0	4213.11	1,726,450.18	1,009,630.82	
Apr.	3929.09	184.58	3744.51	3,300,310.00	1,013,375.33	Capacity Adjusted (See Note 2)
May	4298	0	4298	3,296,012.00	1,017,673.33	
June	4216.21	0	4216.21	3,291,795.79	1,021,889.54	
July	4233.03	1052.38	3180.65	3,288,615.14	1,025,070.19	
Aug.	4173.46	0	4173.46	3,284,441.68	1,029,243.65	
Sept.	3626.48	137.59	3488.89	3,280,952.79	1,032,732.54	
Oct.	3991.89	0	3991.89	3,276,960.90	1,036,724.43	
Nov.	3829.99	132.21	3697.78	3,273,263.12	1,040,422.21	
Dec.	3211.51	0	3211.51	3,270,051.61	1,043,633.72	44868.25
Jan. 2008	3551.98	0	3551.98	3,266,499.63	1,047,185.70	
Feb.	3555.74	163.07	3392.67	3,263,106.96	1,050,578.37	
Mar.	3459.42	0	3459.42	3,259,647.54	1,054,037.79	
Apr.	3649.63	124.63	3525	3,256,122.54	1,057,562.79	
May	3,733.46	-	3733.46	3,252,389.08	1,061,296.25	47376.51
June	3874.43	120.84	3753.59	3,248,635.49	1,065,049.84	
July	3932.86	0	3932.86	3,244,702.63	1,068,982.70	
Aug.	3333.57	87.67	3245.9	3,241,456.73	1,072,228.60	
Sept.	3416.15	452.26	2963.89	3,238,492.84	1,075,192.49	
Oct.	3298.59	1237.72	2060.87	3,236,431.97	1,077,253.36	
Nov.	3117.33	55.58	3061.75	3,233,370.22	1,080,315.11	
Dec.	3352.08	39.13	3312.95	3,230,057.27	1,083,628.06	39994.34
Jan. 2009	3131.78	62.76	3069.02	3,226,988.25	1,086,697.08	
Feb.	2734.36	43.31	2691.05	3,224,297.20	1,089,388.13	
Mar.	3053.27	44.98	3008.29	3,221,288.91	1,092,396.42	
Apr.	3351.8	61.36	3290.44	3,217,998.47	1,095,686.86	
May	3170.92	74.31	3096.61	3,214,901.86	1,098,783.47	
June	3767.21	61.24	3705.97	3,211,195.89	1,102,489.44	37439.6
July	3285.03	1131.06	2153.97	3,209,041.92	1,104,643.41	

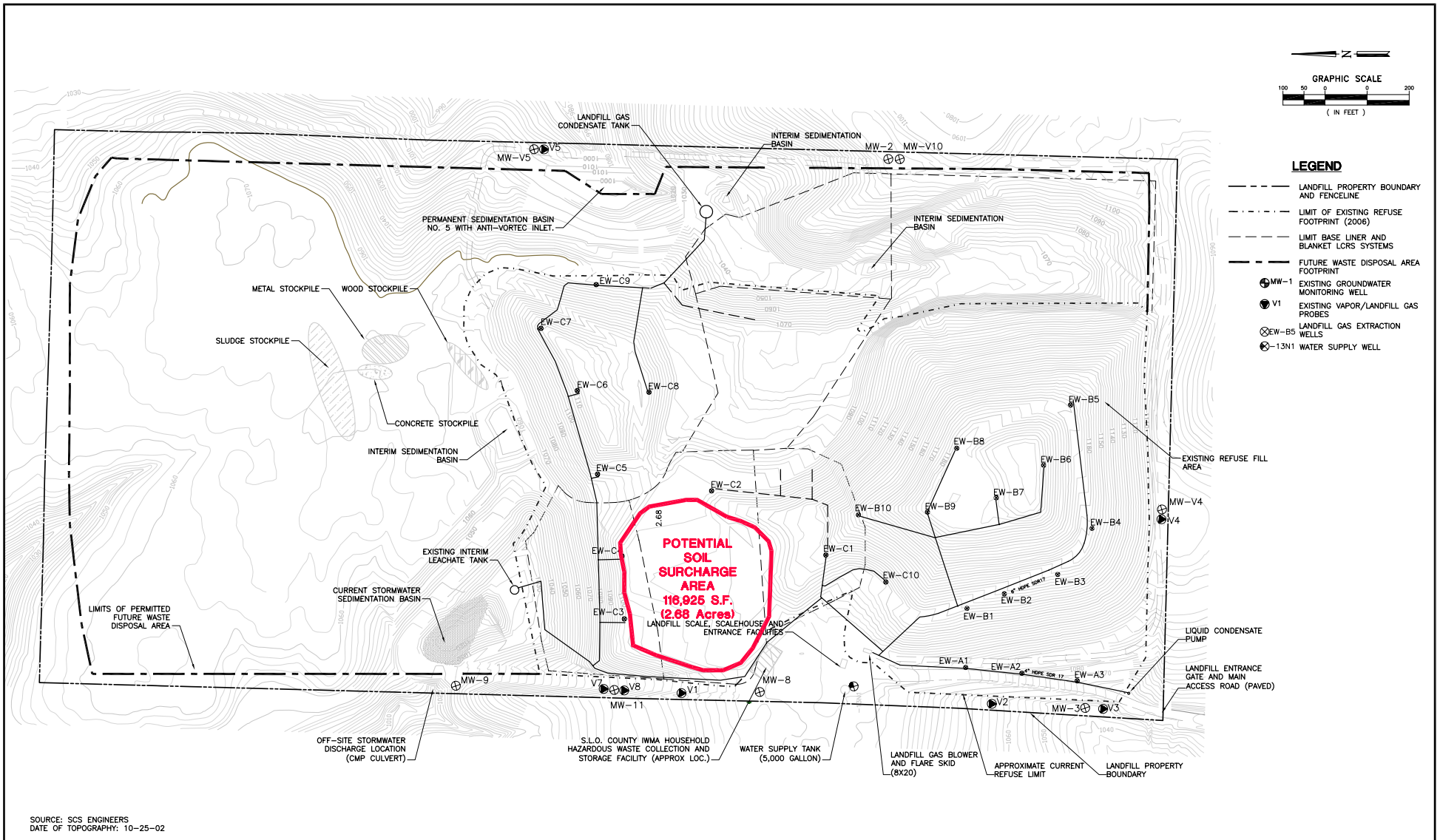
July 1, 2008 through June 30, 2009 Landfilled Tonnage =	37,439.60
July 1, 2007 through June 30, 2008 Landfilled Tonnage =	43,160.30
July 1, 2006 through June 30, 2007 Landfilled Tonnage =	52,224.59
July 1, 2005 through June 30, 2006 Landfilled Tonnage =	53,863.18
July 1, 2004 through June 30, 2005 Landfilled Tonnage =	45,401.79
July 1, 2003 through June 30, 2004 Landfilled Tonnage =	51,897.70

Notes:
1. Source of December 31, 2002 Landfill Capacity is the September 4, 2003 JTD Update Ground Surveys have been conducted on October 25, 2002 and November 14, 2003.
2. Landfill Capacity was changed in the 2007 JTD and referenced in the 8/24/07 Revised Solid Waste Facility Permit Application form. 5,327,500 cubic yards on May 1, 2007. Conversion to Tons uses 1245 #/cy equals 3,300,310 tons capacity on May 1, 2007.

April 2008 through September 2008 =	**21154.7 tons**	**Landfilled tons**
April 2008 through September 2008 =	**785.4 tons**	**recycled tons (wood, metal, cardboard, concrete)**

SECTION FIVE

FIGURES



SOURCE: SCS ENGINEERS
DATE OF TOPOGRAPHY: 10-25-02

NO.	REVISION DESCRIPTION	BY:

BAS
BRYAN A. STIRRAT & ASSOCIATES
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE
DIAMOND BAR, CALIFORNIA 91765
(909) 860-7777

PASO ROBLES LANDFILL

SITE PLAN

DESIGNED BY : [redacted]	SCALE : AS SHOWN		
DRAWN BY : J.M.L.	DATE : 8-2009	FILE NO.: 023300B	
CHECKED BY : [redacted]	DATE : 8-2009	FIGURE 5-1	
APPROVED BY : [redacted]	DATE : 8-2009		

N

GRAPHIC SCALE

100 50 0 100 200

(IN FEET)

LEGEND

LANDFILL PROPERTY BOUNDARY AND FENCELINE

LIMIT OF EXISTING REFUSE FOOTPRINT (2006)

SITE VOLUME TABLE: UNADJUSTED

SITE:	PASO ROBLES LANDFILL
STRATUM:	2007 AERIAL SURVEY TO 2009 GROUND SURVEY VOLUMES
SURF1:	2007 AERIAL SURVEY
SURF2:	2009 GROUND SURVEY VOLUMES
CUT:	610 cu.yds
FILL:	124,427 cu.yds
NET:	123,827 cu.yds (F)
METHOD:	GRID

NO.	REVISION DESCRIPTION	BY:

BAS

BRYAN A. STIRRAT & ASSOCIATES
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
1360 VALLEY VISTA DRIVE
DIAMOND BAR, CALIFORNIA 91765
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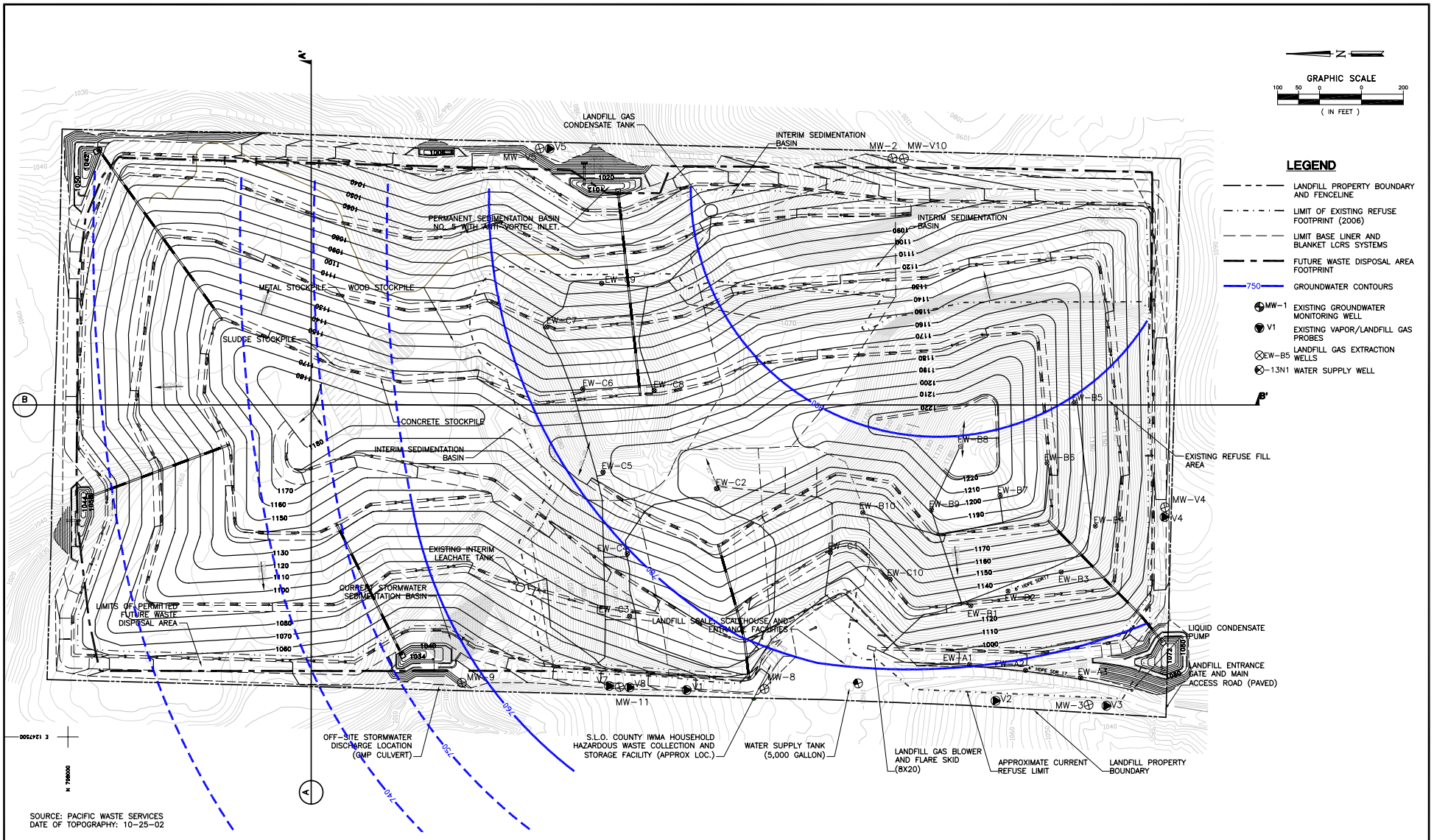
PASO ROBLES LANDFILL

2007 AERIAL SURVEY TO 2009 GROUND SURVEY VOLUMES

DESIGNED BY : NAME	SCALE : AS SHOWN	
DRAWN BY : J.M.L.	DATE : 9-2009	FILE NO.: 173831DB
CHECKED BY : C.A.L.	DATE : 9-2009	FIGURE 5-2
APPROVED BY : NAME	DATE : 9-2009	



SOURCE: PACIFIC WASTE SERVICES
DATE OF TOPOGRAPHY: 10-25-02

NO.	REVISION DESCRIPTION	BY:

BAS
BRYAN A. STIRRAT & ASSOCIATES
CONSULTING CIVIL & ENVIRONMENTAL ENGINEERS
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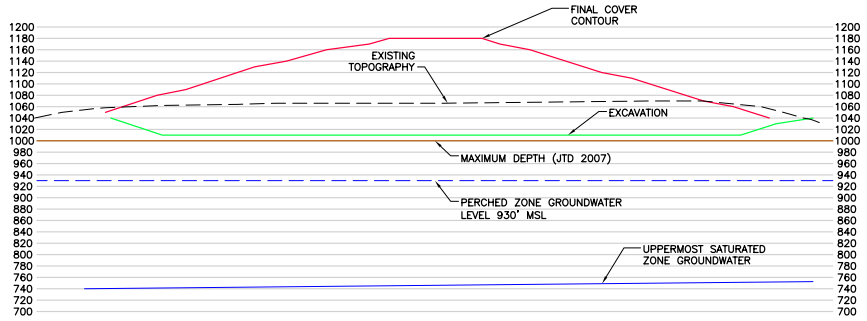
PASO ROBLES LANDFILL

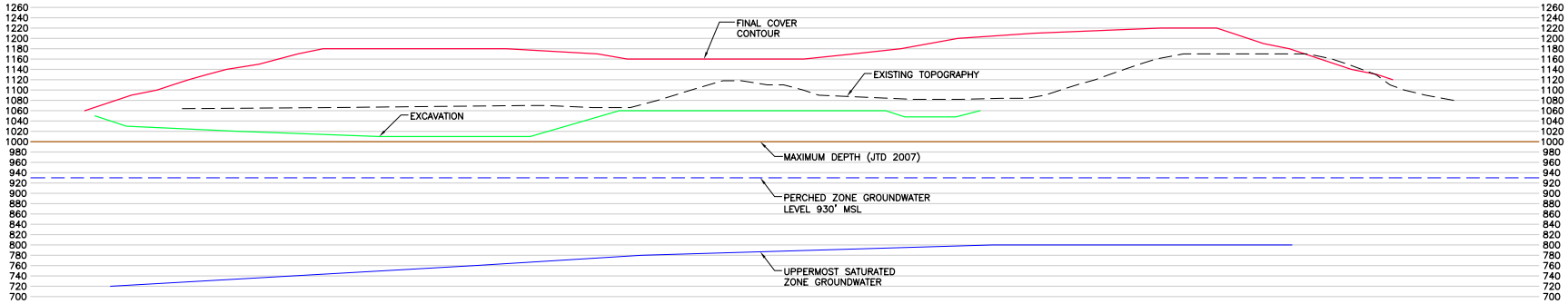
FINAL GRADING PLAN

DESIGNED BY : C.A.L.	SCALE : AS SHOWN	
DRAWN BY : J.M.L.	DATE : 8-2009	FILE NO.: 271390DB
CHECKED BY : C.A.L.	DATE : 8-2009	FIGURE 5-3
APPROVED BY : C.A.L.	DATE : 8-2009	



SECTION A-A

SCALE: 1"=100'



SECTION B-B

SCALE: 1"=100'

NO.	REVISION DESCRIPTION	BY:

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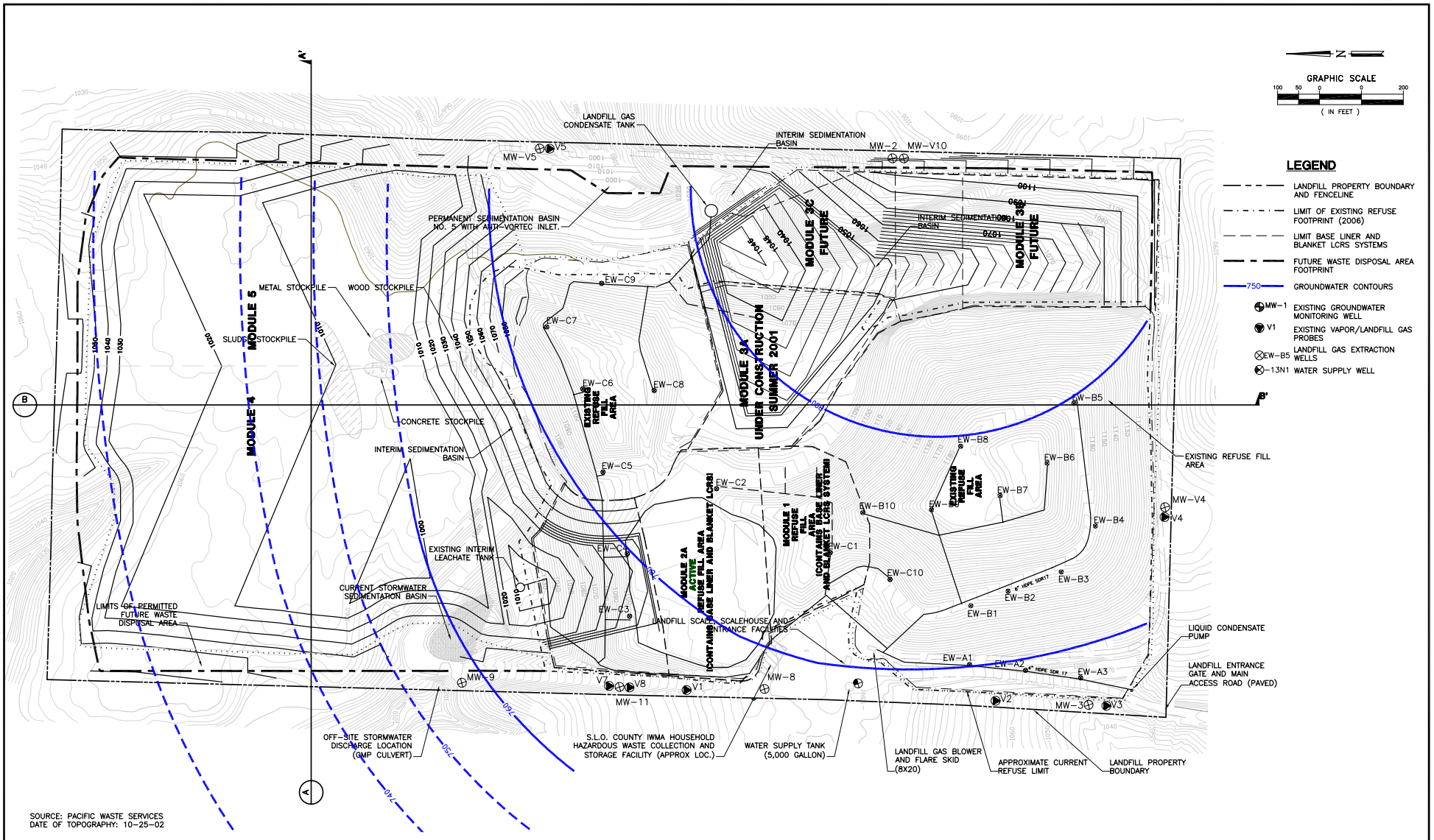
PASO ROBLES LANDFILL

CROSS SECTIONS

DESIGNED BY : C.A.L.	SCALE : AS SHOWN	
DRAWN BY : J.M.L.	DATE : 8-2009	FILE NO.: 383410B
CHECKED BY : C.A.L.	DATE : 8-2009	FIGURE 5-4
APPROVED BY : C.A.L.	DATE : 8-2009	



SOURCE: PACIFIC WASTE SERVICES
DATE OF TOPOGRAPHY: 10-25-02

NO.	REVISION DESCRIPTION	BY:

BAS
BRYAN A. STIRRAT & ASSOCIATES
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DIAMOND BAR, CALIFORNIA 91765
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PASO ROBLES LANDFILL

EXCAVATION PLAN

DESIGNED BY : C.A.L.	SCALE : AS SHOWN	
DRAWN BY : J.M.L.	DATE : 8-2009	FILE NO.: 285300B
CHECKED BY : C.A.L.	DATE : 8-2009	FIGURE 5-5
APPROVED BY : C.A.L.	DATE : 8-2009	

SECTION SIX

PASO ROBLES LANDFILL

GREENHOUSE GAS (GHG) EMISSIONS

6.0 Paso Robles Landfill Greenhouse Gas (GHG) Emissions

The City, as part of their Master Plan project, is committed to identifying the sources of GHG emissions at the Paso Robles Landfill (Landfill) in order to minimize their impact on global warming and climate change.

The City retained BAS Team in May 2009 to quantify the landfill's GHG emissions based on the most recent emissions data available at that time (2008). In August 2009, BAS was advised that the local air pollution control district on behalf of the City had engaged a consultant, PMC, to prepare a community-wide and government operations baseline GHG emissions inventory for 2005 for the City. One portion of PMC's scope was to determine what percentage of the GHG can be attributed to the solid waste generated by the City. PMC grouped the solid waste GHG emissions as part of the City government operations.

In order for the City to have something to compare the 2008 GHG estimate developed by BAS, we also developed a 2006 baseline for the Landfill. The 2006 baseline GHG inventory uses 2006 data for the landfill surface and flare emissions, since source tests at the Landfill are performed every other year and one was not available for 2005. The other emission sources (electricity and vehicular emissions) that were calculated with 2008 data were subsequently not recalculated with 2006 data because 1) the data was not readily available and 2) electricity usage and landfill equipment usage did not significantly change from 2006 to 2008 at the Landfill.

It is important to note that there are different methodologies to calculate GHG generation and emissions and the use of different models and assumptions may produce different results.

6.1 BACKGROUND

The State of California has taken the initiative to reduce GHG emissions in order to minimize the States' impact on global warming and climate change. On September 27, 2006, Governor Schwarzenegger signed the milestone Assembly Bill No. 32 (AB 32), the Global Warming Solutions Act, which was intended to reduce California's global warming gas emissions. Landfills were also recognized as a source of these emissions and were included as part of the early action item list of emitters. The early action items are the first to receive attention and the first sectors subject to greenhouse gas regulations. Reporting of GHG emissions is the first requirement to be promulgated and implemented under AB 32.

Under the early action legislation, a reporting threshold emission limit of 25,000 metric tons of carbon dioxide equivalent (CO_2E) was established by the California Air Resources Board (CARB). Even though the Landfill's estimated

emissions are far below the CARB reporting threshold, the City has recognized the importance of calculating GHG emissions to identify potential sources of GHG reductions.

The primary GHG emissions from the landfill include carbon dioxide, methane and oxides of nitrogen (NOx). The International Panel on Climate Change (IPCC) established global warming potentials for each of the GHGs. The global warming potential (GWP) factor is a measure of a gas's potential impact as compared to carbon dioxide. The GWP is based in part on a gas' infrared absorption and atmospheric life. Methane (CH_4) was determined to have a GWP of 21, whereas nitrous oxide (NOx) was determined to have a GWP of 310. Even small emissions of methane or nitrous oxide can have a significant impact on the environment. The methane and nitrous oxide emissions are converted to their CO_2E by multiplying the emissions by the GWP.

GHG emissions estimates calculated herein by BAS were developed based on the Local Governments Operations Protocol, Version 1.0, (originally "International Council for Local Environmental Initiatives", or ICLEI protocol.) The ICLEI protocol includes a methodology for the calculation of direct and indirect emissions.

For the Landfill, the GHG emissions include direct and indirect emissions. Emissions are also categorized as Scope 1, 2, and 3 emissions. For compatibility with the PMC report, the scope category is also used in this report. Scope 1 emissions are caused by activities within the City and emitted within the City (fuel combustion), while Scope 2 emissions are caused by activities within the city, but most likely are emitted outside the city (electricity). Scope 3 emissions are indirect emissions such as waste decomposition.[1]

INDIRECT EMISSIONS (SCOPE 2 EMISSIONS)

- Electricity emissions (indirect contribution from the use of electricity).

DIRECT EMISSIONS (SCOPE 1 AND 3 EMISSIONS)

- Landfill vehicle emissions (direct mobile sources) – Scope 1 emissions;
- Fugitive methane emissions from the Landfill's surface and incomplete combustion of methane in the flare – Scope 3 emissions; and
- Flare emissions of NOx caused by combustion (direct emissions) – Scope 1 emissions.

[1] PMC, City of Paso Robles, Administrative Draft – Community-Wide and Government Operations 2005 Baseline Greenhouse Gas Emissions Inventory , August 2009

ELECTRICITY EMISSIONS

The Landfill does not generate electricity on-site. However, the use of electricity at the Landfill causes emissions at the point-of-power generation. The ICLEI protocol addresses these emissions as Source 2 emissions and provides a recommended approach for calculating them. This approach includes the use of third-party verified emission factors specific to each utility for carbon dioxide emissions and area-specific emission factors for methane and nitrous oxide. Per Pacific Waste Services (PWS), the electricity usage at the Landfill in 2008 was 42,634 kilowatt hours.

See attached Table 6-1 - *2008 Greenhouse Gas Emission, Indirect Emissions from Electricity Use*. This amount was also used for the 2006 baseline emissions.

2008 Electricity Emissions 8.9 metric tons (CO_2E)

LANDFILL VEHICLE EMISSIONS

The emissions from the landfill's fleet of operations vehicles (e.g., compactor, dozer, and water truck) were calculated using the ICLEI protocol for mobile combustion sources. These are direct emissions which are generated and emitted at the landfill site. *The emissions were calculated using the recommended ICLEI approach which uses site-specific fuel usage and fuel-specific emission factors.* Per PWS, the Landfill operator, the 2008 fuel usage at the Paso Robles Landfill was 20,062 gallons of diesel fuel.

The emissions from employee vehicles used to commute to the landfill were not included. The main reasons are that the landfill staff is minimal (seven PWS employees) and they are not under the City's direct control.

The methane and nitrous oxide emissions were converted to their CO_2E and summed with the carbon dioxide emissions for the total environmental impact. See attached Table 6-2 - *2008 Greenhouse Gas Emissions, Landfill Construction/Vehicle Emissions*.

2008 – Landfill Operations Vehicles – 205.6 metric tons CO_2E

LANDFILL GAS EMISSIONS – CONTROLLED AND FUGITIVE SOURCES

Methane gas emissions include two sources, the methane gas escaping through a landfill's surface and the methane gas which is collected but not completely destroyed in the combustion flare. The Landfill conducts routine performance

tests on the flare, the last of which was conducted in August 2008. The Landfill gas collection flow rate is recorded and gas samples are taken at the inlet and exhaust of the flare during controlled conditions. The destruction efficiency of the organics, the methane content, and the NOx concentration are determined from these samples. The destruction efficiency was demonstrated to be 98%; therefore, the emissions from the flare are 2% of the collected methane gas. The collection efficiency is the default value of 75%. The total gas generated is then calculated to be (1/0.75) of the collected gas. The emitted gas is assumed to be 25% of the calculated generated gas. For the calculation of surface methane emissions, the calculation methodology accounts for the oxidation of methane through the Landfill's cover. The calculation uses a factor of 10% oxidation.

The GHG emissions for the Landfill were calculated using Equation 9.2 for Landfills with Partial LFG Collection Systems, of the ICLEI protocol. The Equation 9.2 is as follows:

$$CH\ 4\,Emitted = LFGCollect\ ed \times CH\ 4\% \times \left\{ (1 - DE) + \left[\left(\frac{1}{CE} \right) \times (1 - OX) \right] \times [AF + (1 - CE)] \right\} \times UCF \times GWP$$

Where:

CH_4 Emitted	=	Metric tons of CO_2 Equivalent
LFG Collected	=	Annual flow, MMSCFY, (average 118 SCFM)
CH_4%	=	Fraction of CH_4 in LFG, site specific
DE	=	Destruction Efficiency, Default of 99%
CE	=	Collection Efficiency, Site Specific, 93.7%
OX	=	Oxidation Factor, Default of 10%
AF	=	Uncollected Area Factor, Site Specific 0%
UCF	=	Unit Conversion Factor from MMSCFY to metric tons CO2E
GWP	=	Global Warming Potential, Default 21

The total carbon equivalent for the landfill gas methane emissions was calculated to be 2,933 metric tons of CO_2E, 2,750 of which are from fugitive emissions and 183 from controlled sources.

Because this equation uses default collection efficiency, which is conservative by nature, these emissions could be considerably lower.

During the combustion process, small amounts of NOx are generated. During the August 2008 source test, the flare discharge was sampled and tested for the presence of NOx. The laboratory results indicated an emission rate of 0.98 pounds of NOx per day, or 0.163 metric tons of NOx per year. Given the NOx

GWP of 310, the impact is 50.5 metric tons of CO2E annually. See attached Table 6-3 - *2008 Greenhouse Gas Emission, Landfills with Collection System.*

2008 - Flare Station = 183 metric tons (CO_2E)
2008 Total Fugitive or Surface Emissions = 2,750 metric tons (CO_2E)

Total GHG Emissions Paso Robles Landfill 2006 vs. 2008

Source	2006 metric tons of C02E	2008 metric tons of C02E
Electricity	8.9	8.9
Landfill Operations Vehicles	205.6	205.6
Landfill Flare	213*	183
Landfill Surface	3,202*	2,750
Total	3,629.5*	3,147.5

*See Table 6-4 - *2006 Greenhouse Gas Emissions, Landfills with Collection System.*

6.2 COMPARISON WITH DRAFT PMC REPORT

The BAS Team reviewed the draft PMC report regarding their GHG emissions inventory for the City's solid waste stream and determined that PMC and BAS used very different methodologies. The primary differences are summarized below:

PMC August 2009 Administrative Draft Report	BAS
2005 City's solid waste tonnage data was used to estimate GHG emissions as reported by the San Luis Obispo Integrated Waste Management Authority (IWMA). Used California Integrated Waste Characterization Study from 2004. Total City Waste Tonnage 37,574.55 Paso Robles Landfill = 34,042.76 tons Chicago Grade = 3,514.61 Cold Canyon= 17.18 tons	All waste landfilled in the Paso Robles Landfill was used to estimate the GHG emissions (City and non-City waste) as indicated in the source test data report. Data used was provided by PWS. 2006 total in-place tons 998,765 total tons disposed 39,188 2008 total in-place tons 1,083,628 Total tons disposed 26,734
Calculated LIFETIME (lifecycle emissions) impact of a single year's waste, 2005.	Used the "waste in–place method" which calculates emissions generated by all the in-place waste. Calculated one year's impact of all deposited waste at the landfill for years 2006 and 2008.
Calculated impact for just City's waste (does not include waste from unincorporated areas or sludge) for one year, including waste going to two other landfills in the area.	Calculated impact of waste and sludge deposited at the Paso Robles Landfill.
Clean Air and Climate Protection 2009 software (CACPS) package developed by ICLEI in partnership with the National Association of Clean Air Agencies (NACAA) and Torrie Smith Associates.	ICLEI, Local Government Operations Protocol, Chapter 9 Solid Waste Facilities. Quantification done using Equation 9.2 for landfills with Partial LFG Collection Systems.
2005 GHG emissions estimate = 13,433 metric tons (CO2E) At three separate landfills PRL, CGL, and CCL.	2006 GHG emissions estimate = 3,629.5 metric tons (CO2E) 2008 GHG emissions estimate = 3,147.5 metric tons CO2E
Used 50% collection efficiency for City's portion of total waste (waste tons per the San Luis Obispo Integrated Waste Management Authority).	Used ICLEI default collection efficiency of 75%. The Landfill reported values as high as 94%.

The differing methodologies produced different results. PMC calculated the *lifetime* GHG impact from solid waste disposed of by the City's residents and businesses for the base year of 2005. BAS calculated the *annual* GHG emissions from all solid waste in-place to date for the years 2006 and 2008 regardless if it came from within or outside the city's limits.

The difference in the results from the lifetime versus annual emissions is quite significant: PMC's estimate was13,433 metric tons of carbon equivalents (CO2E), while BAS estimate was 3,630 metric tons CO2E for 2006; a difference of 73 percent.

The approach PMC used is valid for analyzing the impact of today's deposits as a means of determining a baseline from which future reductions can be forecasted.

The BAS approach is appropriate for quantifying the landfill's actual emissions and to identify the landfill's capacity for actual reductions. The BAS approach addresses the calculation of the day-to-day GHG emissions as described in the Master Plan scope of work.

6.3 YEARLY GHG EMISSIONS CALCULATOR

BAS developed a GHG Calculator that can be used to quantify GHG emissions associated with the landfill. A sample output sheet is included as Table 6-5.

Five parameters will need to be input in the GHG Calculator to determine the total GHG emissions for the landfill. The five data parameters that the City can provide to BAS for the annual update are the following:

1. Annual electrical usage at the Landfill;
2. Annual fuel usage at the Landfill;
3. Annual LFG Collected = Annual flow, MMSCFY, (average 118 SCFM)*;
4. Percent methane (CH_4) in LFG = Fraction of CH_4 in LFG, site specific*;
5. DE = Destruction Efficiency, Default of 99%*.

* From routine source performance tests on the flare.

6.4 CONCLUSION

The total emissions from the Paso Robles Landfill was calculated to be the sum of the indirect emissions from electricity use, the on-site landfill operations vehicle emissions, the direct flare emissions, and the fugitive surface emissions. The 2006 and 2008 emissions totals are as follows:

Total GHG Emissions Paso Robles Landfill

2006 = 3,629.5 metric tons (C02E)

2008 = 3,147.5 metric tons (CO2E)

As emissions are based on collected flow, a decline in the landfill gas flow from 2006 to 2008 resulted in a proportional decline in GHG emissions. The LFG flow rate in 2006 was 72.2 million standard cubic feet per year (MM SCFT /YR) and 62 MM SCFT/YR in 2008.

This decline is consistent with the landfill's waste acceptance rate. The landfill accepted 50,682 tons in calendar year 2006 and 39,994 tons in calendar year 2008, a decrease of 21 percent.

SECTION SIX

TABLES

Table 6-1 - 2008 Greenhouse Gas Emissions - Indirect Emissions from Electricity Use

Equations

CO_2 Emitted [1]	=	Electricity Us	X	Emission Factor	/	2,204.62				
CH_4 Emitted [1]	=	Electricity Us	X	Emission Factor	/	2,204.62				
N_2O Emitted [1]	=	Electricity Us	X	Emission Factor	/	2,204.62				
Total CO_2 Equivalent[2]	=	CO_2 Emissions	+	CH_4 Emissions	X	CH_4 GWP	+	N_2O Emission	X	N_2O GWP

Term Definitions :

CO_2 Emitted [1]	=	Total CO_2 emitted over period, metric tons
CH_4 Emitted [1]	=	Total CH_4 emitted over period, metric tons
N_2O Emitted [1]	=	Total N_2O emitted over period, metric tons
Emission Factor[3]	=	Utility Specific Factor, third party verified, lb CO_2/MWh
GWP[4]	=	Global Warming Potential, to convert metric tons of CH_4 or N_2O into metric tons of CO_2

Term Values

CO_2 Emission Factor	=	455.81	lbs/MWh
CH_4 Emission Factor	=	0.029	lbs/MWh
N_2O Emission Factor	=	0.011	lbs/MWh
CH_4 GWP	=	21	
N_2O GWP	=	310	
Electricity Use	=	42.634	MWh/year

CALCULATIONS

CO_2 Emitted	=	Electricity Us	X	Emission Factor	/	2,204.62				
	=	43	X	456	/	2,204.62				
	=	9	Metric Tons of CO_2 per year							
CO_2 Equivalent from CH_4 Emitted	=	Electricity Us	X	Emission Factor	X	CH_4 GWP	/	2,204.62		
	=	43	X	0.029	X	21	/	2,204.62		
	=	0.01	Metric Tons of CO_2 Equivalent per year							
CO_2 Equivalent from N_2O Emitted	=	Electricity Us	X	Emission Factor	X	N_2O GWP	/	2,204.62		
	=	43	X	0.011	X	310	/	2,204.62		
	=	0.1	Metric Tons of CO_2 Equivalent per year							
TAL CO_2 Equivalent Emissions from from Indirect Utility Use	=	CO_2 Emissions	+	CO_2 Equivalent from CH_4 Emissions	+	CO_2 Equivalent from N_2O Emissions				
	=	8.8	+	0.01	+	0.1				
	=	***8.9***	**Metric Tons of CO_2 Equivalent per year**							

NOTES:

(1) Equation 6.8, Calculating Indirect Emissions from Electricity Use, "Local Governments Operations Protocol", Version 1.0 September 2008

(2) Equation 6.9, Calculating Indirect Emissions from Electricity Use, "Local Governments Operations Protocol", Version 1.0, September 2008

(3) Emission factors are Specific for Pacfic Gas & Electric Company, 2006 for CO_2 (Table G. 5) and the 2004 values for the California Grid Average Electricity for CH_4 and N_2O, Table G. 6.

(4) The GWP is per the Intergovernmental Panel on Climate Change, Table E.1 of "Local Governments Operations Protocol", Version 1.0, Sept 2008.

Table 6-2 - 2008 Greenhouse Gas Emissions - Landfill Vehicle Emissions

Equations

CO_2 Emitted [1]	=	Fuel Consumed	X	Emission Factor	/	1,000			
CH_4 Emitted [2]	=	Fuel Consumed	X	Emission Factor	/	1.E+06			
N_2O Emitted [2]	=	Fuel Consumed	X	Emission Factor	/	1.E+06			
Total CO_2 Equivalent[3]	=	CO_2 Emissions	+	CH_4 Emissions	X	CH_4 GWP	+ N_2O Emissions	X	N_2O GWP

Term Definitions :

CO_2 Emitted	=	Total CO_2 emitted over period, metric tons
CH_4 Emitted	=	Total CH_4 emitted over period, metric tons
N_2O Emitted	=	Total N_2O emitted over period, metric tons
Emission Factor	=	Published emsssion factor by fuel type or by equipment type
GWP[4]	=	Global Warming Potential, to convert metric tons of CH_4 or N_2O into metric tons of CO_2

Term Values

CO_2 Emission Factor[5]	=	10.15	kg/gallon fuel
CH_4 Emission Factor[6]	=	0.74	g/gallon fuel
N_2O Emission Factor[6]	=	0.26	g/gallon fuel
CH_4 GWP	=	21	
N_2O GWP	=	310	
Fuel Consumed	=	20,062	gallons

CALCULATIONS

CO_2 Emitted	=	Fuel Consumed	X	Emission Factor	/	1,000			
	=	20062	X	10.15	/	1,000			
	=	204	Metric Tons of CO_2 per year						
CO_2 Equivalent from CH_4 Emitted	=	Fuel Consumed	X	Emission Factors	X	CH_4 GWP	/	1.E+06	
	=	20062	X	0.7400	X	21	/	1.E+06	
	=	0.3118	Metric Tons of CO_2 Equivalent per year						
CO_2 Equivalent from N_2O Emitted	=	Fuel Consumed	X	Emission Factors	X	N_2O GWP	/	1.E+06	
	=	20062	X	0.2600	X	310	/	1.E+06	
	=	1.617	Metric Tons of CO_2 Equivalent per year						
TOTAL CO_2 Equivalent Emissions from Vehicle Use	=	CO_2 Emissions	+	CO_2 Equivalent from CH_4 Emissions	+	CO_2 Equivalent from N_2O Emissions			
	=	203.6	+	0.312	+	1.617			
	=	***205.6***	**Metric Tons of CO_2 Equivalent per year**						

NOTES:

(1) Equation 7.2, Calculating CO_2 Emissions from Mobile Combustion, "Local Governments Operations Protocol", Version 1.0, September 2008

(2) Equation 7.6 & 7.7, Calculating CH_4 and N_2O Emissions from Mobile Combustion, "Local Governments Operations Protocol", Version 1.0, September 2008

(3) Equation 7.8, Converting to CO_2 Equivalent and Determiing Total Emissions, "Local Governments Operations Protocol", Version 1.0 September 2008

(4) The GWP is per the Intergovernmental Panel on Climate Change

(5) Default CO_2 Emission Factor for Transport Fuels, Table G.9, "Local Governments Operations Protocol", Version 1.0 September 2008.

(6) Default CH_4 and N_2O Emission Factor for Non- Highway Vehicles by Model Year, Table G.12, "Local Governments Operations Protocol", Version 1.0, September 2008.

Table 6-3 - 2008 Greenhouse Gas Emissions - Landfills with Collection System

Equations

CH_4 Emitted [1] = LFG Collected X CH_4 % X {(1-DE)+{(1/CE) X (1-OX)] X [AF +(1-CE)]} X Unit Conversion X GWP

Term Definitions

LFG Collected [2]	=	Annual LFG Collected by the collection system, MMSCF
CH_4%[2]	=	Fraction of CH_4 in LFG
DE [2]	=	CH_4 Destruction Efficiency
CE[3]	=	Collection Efficiency (Collected LFG/Total LFG)
OX[3]	=	Oxidation Factor
AF	=	Uncollected Area Factor
Unit Conversions	=	19.125, MM SCFT of CH_4 to metric tons of CH_4
GWP[3]	=	Global Warming Potential, metric tons of CH_4 into metric tons of CO_2

Term Values

LFG Collected	=	118	X	525600	min, /	1.E+06	=	62 MM SCFT/YR
CH_4%	=	36.8%	,	Average over monitoring perio				
DE	=	98.0%	,	Site Specific, based on 2008 Performance Test				
CE	=	75.0%	,	Default, per EPA Protocol				
OX	=	10%	,	Default, per ICLEI Protocol				
AF	=	0	,	Ratio of Areas with decomposable waste without a collection system/ with a collection system				
Unit Conversions	=	19.125	,	Default, per ICLEI Protocol				
GWP	=	21	,	Default, per ICLEI Protocol				

CALCULATIONS

CH4 Emitted = LFG Collected X CH4 % X {(1-DE)+{(1/CE) X (1-OX)] X [AF+(1-CE)]} X Unit Conversion X GWP

= 62 X 37% X {(0.02)+{(1.33) X (90%)] X [0 +(25%)]} X 19.125 X 21

= ***2933 Metric Tons of CO_2 Equivalent per year***

***183* Metric Tons of CO_2 Equivalent per year from Controlled Sources**

***2750* Metric Tons of CO_2 Equivalent per year from Fugitive Sources**

NOTES:

(1) Equation 9.2, Landfills with Partial LFG Collection Systems, *"Local Governments Operations Protocol,"* Version 1.0, September 2008

(2) As recorded duiring 2008 Source Test, performed on August 26, 2008, by Best Environmental

(3) Default value, per "Local Governments Operations Protocol." Version 1.0 September 2008.

Table 6-4 - 2006 Greenhouse Gas Emissions - Landfills with Collection System

Equations

CH_4 Emitted [1] = LFG Collected X CH_4 % X {(1-DE)+{(1/CE) X (1-OX)] X [AF +(1-CE)]} X Unit Conversion X GWP

Term Definitions

LFG Collected [2]	=	Annual LFG Collected by the collection system, MMSCF
CH_4% [2]	=	Fraction of CH_4 in LFG
DE [2]	=	CH_4 Destruction Efficiency
CE [3]	=	Collection Efficiency (Collected LFG/Total LFG)
OX [3]	=	Oxidation Factor
AF	=	Uncollected Area Factor
Unit Conversions	=	19.125, MM SCFT of CH_4 to metric tons of CH_4
GWP [3]	=	Global Warming Potential, metric tons of CH_4 into metric tons of CO_2

Term Values

LFG Collected	=	137.4	X 525600 min, / 1.E+06 = 72.2 MM SCFT/YR	
CH_4%	=	36.8%	,	Average over monitoring perio
DE	=	98.0%	,	Site Specific, based on 2008 Performance Test
CE	=	75.0%	,	Default, per EPA Protocol
OX	=	10%	,	Default, per ICLEI Protocol
AF	=	0	,	Ratio of Areas with decomposable waste without a collection system/ with a collection system
Unit Conversions	=	19.125	,	Default, per ICLEI Protocol
GWP	=	21	,	Default, per ICLEI Protocol

CALCULATIONS

CH4 Emitted = LFG Collected X CH4 % X {(1-DE)+{(1/CE) X (1-OX)] X [AF+(1-CE)]} X Unit Conversion X GWP

= 72 X 37% X {(0.02)+{(1.33) X (90%)] X [0 +(25%)]} X 19.125 X 21

= ***3416 Metric Tons of CO_2 Equivalent per year***

***213* Metric Tons of CO_2 Equivalent per year from Controlled Sources**

***3202* Metric Tons of CO_2 Equivalent per year from Fugitive Sources**

NOTES:

(1) Equation 9.2, Landfills with Partial LFG Collection Systems, *"Local Governments Operations Protocol,"* Version 1.0, September 2008

(2) As recorded during 2006 Source Test.

(3) Default value, per "Local Governments Operations Protocol." Version 1.0 September 2008.

BAS BRYAN A. STIRRAT & ASSOCIATES CIVIL AND ENVIRONMENTAL ENGINEERS	**Paso Robles Landfill - Paso Robles, CA** **GREENHOUSE GAS EMISSIONS CALCULATION**	Job N 2009.0042. Date: 9/11/2009 By: DMM Checked: KJ

TABLE 6-5
PASO ROBLES LANDFILL
ANNUAL GREENHOUSE GAS (GHG) EMISSIONS CALCULATOR

Input Values

Update all 6 highlighed areas to calculate CO2E per year

Data Year =	2008						
Electricity Use =	42.634	MWh/year					
Fuel Consumed =	20062	gallons					
LFG Collected =	118	X	525600	min/yr	1.E+06	= 62.0	MM SCFT/YR
Percent Methane (CH4%) =	36.8%	,	Average over monitoring period				
Destruction Efficiency (DE) =	98.0%	,	Site Specific, based on 2008 Performance Test				

Total GHG Emmission:

Electricity = 8.9 Metric Tons of CO2 Equivalents per year

Fuel = 205.6 Metric Tons of CO2 Equivalents per year

Landfill Gas = 2933.3 Metric Tons of CO2 Equivalents per year

2008

Total Landfill GHG 3147.7 Metric Tons CO2E

Calculated by:

ASSOCIATES	Paso Robles Landfill - Paso Robles, CA GREENHOUSE GAS EMISSIONS CALCULATOR	Job No.: 2009-0042 Date: 11/20/2009 By: JL Checked: SN

SECTION SEVEN

FINANCIAL/ECONOMIC OPPORTUNITIES AND CONSTRAINTS

7.0 Financial/Economic Opportunities and Constraints

The City financial needs and certain financial issues associated with the landfill operations and closure were reviewed by the BAS Team. Specific items that were reviewed were as follows:

1. The fees section of the existing agreement with Pacific Waste Services (PWS), the current landfill operator, to determine what types of fees are remitted to the City, such as franchise fees and AB 939 fees.

2. A review of the franchise agreement with Paso Robles Waste Disposal was also conducted to determine fees that the City receives from this agreement.

3. A review of opportunities for alternative revenue generating mechanics was also completed.

7.1 SOLID WASTE FEES RECEIVED AND PAID BY THE CITY

Solid Waste Fees Received

The City currently receives the following solid waste related fees from Paso Robles Waste Disposal:

- Residential and commercial collection franchise fee of 9.34%[1]; and
- Roll-off franchise fee of 10% of gross receipts.

In 2008 the City received $675,490 from Paso Robles Waste Disposal. The landfill operations agreement between the City and PWS provides for the sharing of revenue between the City (35%) and PWS (65%) in the event that gross revenues received from operation of the landfill exceed the Revenue Sharing Point identified in the agreement.[2] In 2007 the City received $707,781 and in 2008 the City received $675,490 from the landfill revenue sharing agreement with Pacific Waste Services.

Solid Waste Fees Paid

The San Luis Obispo Integrated Waste Management Authority (IWMA) receives funding from the City from the following sources:

[1] Source: Paso Robles Waste Disposal [Note: The original 11/24/93 Franchise Agreement specified 3% of gross receipts (pg. 6). The current franchise fee is now 9.34%.

[2] In the event that total gross revenues received from the operations at the landfill in any year increase by an amount greater than four (4) percent (the "Revenue Sharing Point") the City and PWS share all revenues above the Revenue Sharing Point.

- The City pays the IWMA directly $3.00 per ton of waste disposed at the landfill. The total amount paid in 2008 was $100,727[3]; and
- Paso Robles Waste Disposal pays an AB 939 fee to the IWMA consisting of two parts:
  - A fee of $0.30 per household per month for single-family waste, equivalent to approximately $32,000 per year[4] and
  - Two percent of gross receipts on all other lines of business (commercial, multi-family and roll-off).

7.2 ALTERNATIVE REVENUE GENERATING MECHANISMS

This section summarizes various revenue generating mechanisms that are not currently being used by the City and/or are in place but could be modified to generate additional revenues. Many of these mechanisms are being used in various cities throughout California, and we have provided examples of these practices.

The alternative revenue generating mechanisms included in this report are listed below and are followed by more detailed descriptions:

1. Fees Assessed on the Hauler. This fee type includes a group of various fees that are assessed on haulers, including franchise fees, AB 939 fees, public education fees, billing fees, administrative fees, etc.
2. Solid Waste Development Impact Fees. These fees are designed to help a municipality recover the initial capital costs associated with expanding its solid waste operations to accommodate and serve new developments.
3. Vehicle Impact Fees. Vehicle impact fees are fees that are charged to collection service providers to recover street maintenance costs associated with the collection of solid waste, recycling, and yard waste.
4. Street Sweeping Fees. These are designed to recover costs of street sweeping by applying a portion of the street sweeping cost to each user, either on a per-account basis, or on a percentage basis.
5. Host Fees Assessed on Solid Waste Facilities. Host fees are fees charged to solid waste facility operators. Such facilities include landfills, transfer stations, or material recovery facilities ("MRFs"). Host fees are designed to recover street maintenance, litter abatement, code enforcement, or other costs resulting from the impacts of the facility.
6. Extended Producer Responsibility ("EPR") Fees and Advanced Disposal or Advanced Recycling Fees. EPR is a policy approach that extends the

[3] Source: IWMA.
[4] Based on Department of Finance estimate of approximately 9,000 homes.

responsibility of producers for their products throughout the products' lifecycles. There are generally no governmental fees associated with EPR. Governmental fees are more likely to take the form of an Advanced Recycling Fee, where the government collects a fee at the point of sale for a particular product, and uses the fee revenue to fund recycling programs for that type of product.

7. Grant Opportunities. Grants available from various State or Federal agencies.
8. Revenues from the Sale of Carbon Credits. Carbon credits may be available for sale if they are allowed for recycling programs through a future "cap-and-trade" system for greenhouse gas emissions, which may be established in California or the entire United States in the next few years.
9. Re-Structuring Landfill Tip Fees. Opportunities for changing the currently landfill rates to generate additional revenue.

1. Fees Assessed on the Hauler

Franchise fees, AB 939 fees, and other administrative fees are assessed on refuse collection contractors in the majority of cities in the State of California. The various fees can include franchise fees, AB 939 fees, public education fees, billing fees, administrative fees, environmental mitigation fees, etc. There are a variety of methods for fees assessed on the hauler, including:

- An annual flat fee, either a fixed flat fee, or a base amount that is either fixed in some cases, or adjusted annually by changes in the Consumer Price Index (CPI). Cities that have fixed flat franchise fees include Oakland, Las Gallinas, Novato, West Bay Sanitary District, and Sunnyvale.
- The most common franchise fee and AB 939 fee assessment method is a percentage fee based on gross receipts, or receipts net of disposal costs. Hundreds of cities in California assess fees using this method, and the fees are required by either municipal code language or contract language. The percentage amounts of the fees range from 2% to 24%. Many cities assess franchise fees and AB 939 fees.
- Specific dollar amount per ton or per cubic yard.
- Fees per account, such as an amount per account per year or per month.

In general, these fees are included in the rates that customers pay, and are not shown on the customers' bills.

The City could consider increasing its franchise fee and/or including a City-specific AB 939 fee separate from that paid to the IWMA, to cover City-specific AB 939 related costs.

See Table 7-1 for a sample of the fees assessed on the hauler by various cities.

2. Solid Waste Development Impact Fees

Solid waste development impact fees are designed to help a municipality recover the initial capital costs associated with expanding its solid waste operations to accommodate and serve new developments. Expansion costs that need to be recovered may include the costs of purchasing solid waste and recycling collection vehicles and collection containers, building new facilities or expanding current ones, and occasionally include the costs of recruiting new staff. These fees are specifically related to one-time expansion costs, as opposed to on-going operating costs.

Residential impact fees are typically calculated on a per unit basis, while commercial impact fees are typically calculated on the basis of waste volume. Cities may re-calculate the fees every few years, or increase the fee each year by the Consumer Price Index (CPI), or other escalation factor.

We have identified eight cities in California that assess or are considering assessing such fees on new developments: Clovis, Redlands, Merced, Hanford, Lompoc, Hemet, Fresno and Roseville.

Table 7-2 provides a summary of solid waste development impact fees charged by a number of cities.

3. Vehicle Impact Fees

Vehicle impact fees are fees that are charged to solid waste collection service providers to recover street maintenance costs associated with the collection of solid waste, recycling, and yard waste. In addition, some cities have imposed vehicle impact fees on construction vehicles as well. A vehicle impact fee can be determined by analyzing the impacts of the vehicles on the jurisdiction's streets as a percentage of total vehicle impacts and allocating a proportional share of street maintenance cost requirements to those vehicles.

There are over 30 cities in California that have studied refuse vehicle impact fees and/or construction vehicle impact fees. We have included details for seven cities in California that have assessed a vehicle impact fee: Alameda, Modesto, Menlo Park, Rolling Hills Estates, Tiburon, Twenty-nine Palms, and Woodside.

Once the vehicle impact fee amount is calculated, it can be assessed in a variety of ways. For refuse vehicle impacts, a flat fee can be charged to the hauler, with or without an annual escalator, or a fee can be calculated as a percentage of gross receipts.

For construction vehicle impacts, the fee can be assessed as a percentage of permit valuation, on a per-square-foot of construction basis, or in other ways, as determined by the City.

Table 7-3 lists a number of jurisdictions that charge vehicle impact fees. A preliminary analysis of the City's street maintenance costs indicates that it may be able to generate significant revenue for street maintenance repair through the implementation of such a fee.

4. Street Sweeping Fees

Street sweeping fees are included in refuse collection rates in cities throughout California. In many cities, street sweeping fees are designed to simply recover costs of street sweeping by applying a portion of the street sweeping cost to each user, either on a per-account basis, or on a percentage basis. In addition to street sweeping, some cities also recover costs for tree trimming and/or median island maintenance through the solid waste fund as well. Eight cities in California that assess or are considering assessing such fees on new developments are Calabasas, Claremont, Culver City, Glendale, Merced, Santa Monica, Sacramento and Whittier. Table 7-4 summarizes cities implementing street sweeping fees and the fees charged by the cities.

5. Host Fees Assessed on Solid Waste Facilities

Host fees are fees charged to the solid waste facility operators. Facilities may include landfills, transfer stations, or MRFs. Host fees are designed to recover street maintenance, litter abatement, code enforcement, or other costs resulting from the impact of such facilities. A host fee can be determined by analyzing the cost impacts related to vehicles on the jurisdiction's streets, potential litter abatement costs, and staff costs for inspections. Host fees are sometimes calculated by allocating a proportional share of those costs to each ton of material that the facility receives.

Hosts fees may be assessed on the following materials or other bases:

- All tons disposed (may exempt tons diverted);
- All tons received;
- Out of City/County tons;
- A percentage of gate revenue; or
- A fixed amount per year.

Host fees are authorized through various mechanisms, including municipal code, Conditional Use Permits, Franchise Agreements, Memorandums of Understandings (MOUs), or Business Permits. Host fee requirements are typically listed as a clause in the contract between the host city and the facility operator, and/or the contract may reference the municipal code. For the City,

new host fees could be imposed at the time that new solid waste or recycling facilities are developed or existing solid waste or recycling facilities are expanded.

Host fees may be considered either unrestricted revenue or revenue to be used for a defined purpose. Many cities consider host fee revenues as unrestricted revenues and are host fees that are generally deposited into a City's general fund.

Table 7-5 provides a sample of the Host fees assessed on various solid waste facilities in California.

6. Extended Producer Responsibility Fees and Advanced Disposal/Recycling Fees

Extended Producer Responsibility ("EPR") is a policy approach that extends the responsibility of producers for their products throughout the products' lifecycles. There are generally no governmental fees associated with EPR. The original definition by Professor Thomas Lindqvist emphasized "total life cycle environmental improvement of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product."[5] EPR can include programs that emphasize the end-of-life management of products, after consumers discard them. Alternatively, the definition used by the California Integrated Waste Management Board (CIWMB) emphasizes reducing environmental impacts:

> *"Extended Producer Responsibility (EPR) is the extension of the responsibility of producers, and all entities involved in the product chain, to reduce the cradle-to-cradle impacts of a product and its packaging; the primary responsibility lies with the producer, or brand owner, who makes design and marketing decisions."*[6]

The vast majority of EPR systems are established at the country or state level. EPR systems would be difficult to establish for an individual city, because if a manufacturer refused to participate, that manufacturer could still offer their products for sale in neighboring jurisdictions. In addition, it is difficult and costly for a jurisdiction to establish enforcement systems with manufacturers and retailers, because, unlike state governments, these are not pre-existing enforcement relationships. State governments are already in the business of imposing sales taxes and regulating products sold by retailers, for example. There may also be issues of consistency with state law.

[5] Lindhqvist, Thomas. (2000) *Extended Producer Responsibility in Cleaner Production*. IIIEE Dissertations 2000:2. Lund: IIIEE, Lund University.

[6] California Integrated Waste Management Board, EPR Framework Policy.

Advanced Disposal/Recycling Fees

An alternative policy to EPR is one that uses "Advanced Disposal Fees" or "Advanced Recycling Fees" collected when products are purchased. When using an Advanced Recycling Fee, the government collects a fee at the point of sale for a particular product, and uses the fee revenue to conduct recycling programs for that type of product. This approach generally has higher administrative costs than EPR systems because it involves a third party, the government, in the process.

An example of an Advanced Recycling Fee (ARF) is California's Electronic Waste Recycling Act, which went into effect in 2005. In this system, consumers pay an advanced recycling fee when they purchase a product covered by the act, such as a computer monitor or television. The fees paid by consumers are deposited into a fund that is managed by the State of California. The State then pays recyclers for collecting and processing electronics that are collected under the Act. One of the goals of the Act was to relieve local governments of the costs of collecting and recycling electronic wastes, which are banned from landfill disposal.

San Francisco's Litter Reduction Efforts with Businesses

The City of San Francisco has been exploring new ways to deal with litter production in the city. San Francisco conducted a survey of litter and found some of the top components of litter were cigarette butts and items related to fast food (napkins, containers, etc.) It then began a dialogue with fast food retailers. Ideas have been explored to have retailers provide additional litter containers and to "adopt-a-block" to clean-up the entire block rather than cleaning limited to their own property. While such an approach would not bring fees directly to the City, if the businesses take on direct responsibility for more litter clean-up activities, the City's cost of litter clean-up would be reduced.

Single-use Carryout Bag Reduction Initiative

A number of cities are currently reviewing its options for reducing single-use carryout bags. These options may involve levying a fee on plastic and/or paper carryout bags. That fee could be used by the City for litter-related education and/or litter reduction related to single-use carryout bags. Such a fee should be carefully coordinated with the City Attorney to ensure compliance with State law. Some jurisdictions, such as the County of Los Angeles, have investigated assessing a fee on plastic carryout bags.

Existing law requires large grocery stores to have on-site containers for collection of plastic bags for recycling. Recently proposed (but not approved) statewide legislation (AB 2058 and AB 2769) would have imposed a $0.25 fee

on single-use carryout bags at large grocery stores. A portion of the fee would have been remitted to the CIWMB and monies would have been expended to administer and enforce the provisions of the single-use carryout bag law. The remainder of the fee would have been used for grants to cities and counties, to implement single-use carryout bag recycling, and pollution prevention and outreach programs. The law would have required stores to develop public education materials related to single-use carryout bag recycling.

Takeout Food Packaging

In recent years, more than a dozen cities in the State of California have begun to regulate takeout food packaging. Several of them have banned foamed polystyrene from City facilities and others have banned foamed polystyrene from use for takeout food packaging at local restaurants. To date, these programs have not included a fee component; however, a fee or fine could be a component of these programs. Fees could be used for recycling education or litter reduction. Fees or bans on non-biodegradable or non-compostable take out food containers are being considered as an option for reducing litter under that program.

7. Grant Opportunities

California Integrated Waste Management Board (CIWMB)

- **Local Government Waste Tire Cleanup and Amnesty Event Grants –** Covers cost of cleanup, abatement, or other remedial actions related to the disposal of waste tires.
- **Tire-Derived Product Grants –** Funding for tire-derived products (for example, playground covers, tracks, recreational surfaces, sidewalks, etc.) made with 100 percent recycled California waste tires.
- **Waste Tire Enforcement Grants –** Funding for waste tire enforcement activities.
- **Rubberized Asphalt Concrete (RAC) Grants and Tire-Derived Aggregate (TDA) Grants –** Funding assistance for RAC and TDA projects.
- **Targeted Rubberized Asphalt Concrete Incentive (TRI) Grants –** Funding for rubberized asphalt concrete projects.
- **Used Oil Block Grants –** Used to establish and maintain used oil and used oil filter collection programs. Grants calculated at approximately $0.27 per capita. Jurisdictions may also apply regionally to pool funds. About $10 million is available annually.
- **Opportunity Grants –** Supplemental funding for used oil and used oil filter collection or equipment/facility modifications to facilitate collection. Must be used to enhance Used Oil Block Grant programs already in place.

- **Farm and Ranch Clean-up Grants –** For clean-up of illegal solid waste sites on farm or ranch property.
- **Solid Waste Disposal Site and Illegal Disposal Site Cleanup Grants –** Can be used to finance a wide range of remediation projects at solid waste disposal sites and illegal disposal sites where a threat exists to public health and safety or the environment.
- **Reuse Assistance Grants –** Used to provide incentives to promote and apply the concept of reuse to business communities.
- **Household Hazardous Waste (HHW) Grants –** Used for collection and management of HHW. Annual awards total $4.5 million for programs that reduce the amount of HHW disposed at landfills.
- **Landfill Closure Loan Program –** Approximately $640,000 is awarded in competitive, low, or interest-free loans for each annual funding cycle. Applicants are operators of older-technology, unlined landfills who desire to close early to avoid or mitigate potential environmental problems caused or threatened by continued operation of the site.
- **Local Government Matching Grants –** Provides financial assistance in the form of reimbursement grants up to $750,000 in matching funds for eligible costs to assist public entities requiring financial assistance, and committed to accelerating the pace of cleanup, restoring sites, and protecting public health and safety and the environment.
- **Liquefied Natural Gas from Landfill Gas Demonstration Grant –** Funding to businesses wanting to develop renewable energy technologies utilizing available California biomass resources.

California Department of Conservation (DOC)

- **Beverage Container Recycling Grants –** Up to $1.5 million may be awarded annually. Typically there is a specific grant focus each year such as sporting venues, multi-family housing, or education and outreach.
- **City/County Payment Program –** Each year, the DOC makes a total of $10.5 million available to eligible cities and counties for beverage container recycling and litter clean-up activities.
- **Market Development and Expansion Grants** - Program will encourage the development and expansion of markets for beverage container materials.
- **California Farmland Conservancy Program –** Provides agricultural conservation easement grants that are used to compensate landowners who voluntarily sell their land's development rights.

United States Environmental Protection Agency (US EPA)

- **Brownfields Assessment Grants** – Provides funds to inventory, characterize, assess, and conduct planning (including clean-up planning) and community involvement related to brownfield sites (e.g., real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant).
- **Brownfields Revolving Loan Fund (RLF) Grants** – Provides funds for a grant recipient to capitalize a revolving fund, to make loans, and provide subgrants to carry out cleanup activities at brownfield sites.
- **Brownfields Cleanup Grants** – Provides funds to carry out clean-up activities at a specific brownfield site owned by the applicant.

8. Revenues from the Sale of Carbon Credits

While there is widespread agreement that an industrial "cap-and-trade" system for greenhouse gas ("GHG") emissions[7] will be established in the United States in the next few years, there is a great deal of speculation and uncertainty about the exact details of that system. A "cap-and-trade" system would establish an overall upper limit, a cap, on the total amount of GHG emissions allowable nationwide. Within that overall cap, portions of the total allowable emissions would be allotted to various businesses and organizations within the country (or state, if a state system).

An individual business or organization is termed an "operator." Each operator would have an allowance of carbon credits. A carbon credit is a permit that allows the holder to emit one ton of carbon dioxide[8]. If their actual emissions were below the allowance, that operator would have excess carbon credits that could be sold. In contrast, if an operator chooses to exceed their allowance, that operator would have to purchase carbon credits from another operator. In this way, the market system seeks to reduce carbon emissions at the lowest possible cost. For example, in certain cases, it will be cheaper for an operator to purchase carbon credits from another operator than it will be to install new equipment to reduce emissions. Credits can be bought and sold and can be widely traded in open markets, as is currently the case in many Countries that signed on to the Kyoto Protocol.[9]

Legislation has been introduced in the United States Congress to implement a cap-and-trade system, but the legislation did not pass into law. In California,

[7] The major greenhouse gases which affect the climate include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, and others. They are generally expressed in terms of carbon dioxide equivalents (eCO2.)

[8] One ton of carbon dioxide emissions is the standard unit of measurement for greenhouse gases. Emission of other greenhouse gases, such as methane, are expressed in "carbon dioxide equivalents," based upon their relative global warming potential.

[9] The Kyoto Protocol was adopted at the United Nations Framework Convention on Climate Change in 1997. It contains legally binding commitments for countries to reduce their anthropogenic emissions of greenhouse gases.

AB 32 became law in 2006. As a result of AB 32, the State's Air Resources Board is charged with establishing a program to reduce statewide GHG emissions. "The Act caps California's GHG emissions at 1990 levels by 2020. The Act authorizes the state board to adopt market-based compliance mechanisms including cap-and-trade."[10]

9. Restructuring Landfill Tip Fees

The City's landfill rates are similar to those at Chicago Grade Landfill (nearest landfill to the City other than Paso Robles Landfill), as shown in the Table 7-6 below. In terms of restructuring the landfill tip fees, there are two basic options:

- Increase tip fee to generate additional revenue per ton (with a potential lose in tonnage to Chicago Grade Landfill); or
- Reduce tip fee to capture tonnage currently going to Chicago Grade Landfill (although it is not clear what level of price break would be required to capture additional tonnage such that the City would realize a net revenue increase).

Given the value of the City's landfill capacity, we would not suggest that the City consider reducing the tip fee without some reasonable assurances that there would be a positive net impact to the City. Any such assurances may not be possible given the lack of control over what steps Chicago Grade Landfill might take in response. Rather we would suggest that the City either maintain the current relative rate structure or increase rates to be consistent with Chicago Grade Landfill.

TABLE 7-6
TIP FEES

Type of Load	Price per Ton		Variance (Paso Robles v. Chicago Grade)
	Paso Robles Landfill	Chicago Grade Landfill	
Minimum Load	$ 20.00	$ 20.00	$ -
Compacted Refuse	$ 38.85	$ 41.00	$ (2.15)
Uncompacted Refuse	$ 46.85	$ 47.00	$ (0.15)
Concrete, Brick & Asphalt	NA	$ 15.00	

[10] As taken from the web site of the Pew Center on Global Climate Change, regarding the California Global Warming Solutions Act of 2006.

SECTION SEVEN

TABLES

TABLE 7-1 Summary of Fees Assessed on the Hauler							
City	**Population, 2008**	**Exclusive or non-Exclusive Commercial Collection**	**Fee Name**	**Fee Methodology**	**Annual Escalator**	**Annual Amount / Percentage**	**How Are Fees Assessed?**
Elk Grove [1]	139,542	Permit System	Commercial Refuse Hauler Fees	% of Gross Revenue	No	Amount Ranges from 8% to 35% based on Diversion Amounts	Included in rates
Las Galinas Sanitary District	48,383	Yes	Franchise Fee	Flat Fee	No	$25,000	Included in rates
City of LA [2]	4,045,873	Permit System	AB 939	% of Gross Revenue	No	10%	All Customers
Novato	52,737	Yes	Franchise Fee	Flat Fee	No	$45,000	Included in rates
Oakland	420,183	Yes	Franchise Fee	Flat Fee	Yes, 80% of CPI	$4,320,000	All Customers
			Other Fees	Flat Fee	Yes, 80% of CPI		All Customers
Rancho Santa Margarita	49,764	Yes	Franchise Fee	5%			Included in rates
			Outreach Fee	Flat Fee	Yes, CPI	$60,000	Included in rates
San Francisco	824,525	1 Hauler with 2 permits	Impound Account	Calulated Amount	Based on City Solid Waste Budget	$6,000,000	Residential Only
Sunnyvale	137,538	Yes	Franchise Fee	Flat Fee	Yes, 100% of CPI	$1,535,737	All Customers
San Diego	1,336,865	Permit System	AB 939 Fee [3]	$7.00 Per ton	Set by Council Resolution	$10,100,000	Included in rates
			Franchise Fee [3]	$12.00 per ton			Included in rates
			Refuse Collector Business Tax [4]	$8.00 per ton			Included in rates
West Bay Sanitary District	3,000	Yes	Franchise Fee	Flat Fee	No	$5,000	Included in rates

[1] Fee is based on diversion requirement of 30% or greater = 8% fee, Under 21% diversion = 14% fee, Less than 3% diversion = 35% fee
[2] Applies to haulers collecting over 1,000 tons per year
[3] Applies to haulers generating over 75,000 tons per year
[4] Applies to self haul tons over two ton loads and all out-of-City waste

TABLE 7-2
Summary of Development Impact Fee Survey

City	Fee Amount Per Building Type					Fee Methodology	
	Single- Family ($/unit)	Multi-Family ($/unit)	Mobile Home ($/unit)	Com.	Ind.	Res.	Com.
Redlands	$650	$325	N/A	$52/ppd		N/A	Waste Generation
Hemet Container	$59	$59	$59	$225 - $520		Per Unit	Waste Volume
Equip.	$53	$37	$53	$0.033/ gsf	$0.027/ gsf		
Clovis	$306	$114	N/A	$114/unit		Per Unit	Fixed Rate/ Waste Volume
Lompoc	60 gal -$67.41 90 gal - $68.48 350 gal - $271.68 450 gal - $341.57	No Standardized Fee. Dependent on the number and size of containers at the project site.				Per Unit	Waste Volume
Merced	$299.55	$207.55	$299.55	All non-residential cost of bin + proportion of truck used		Per Unit	Waste Volume
Hanford	$215.46	$119.79	N/A	All non-residential cost of bin + proportion of truck used		Per Unit	Waste Volume

ppd = pounds per day
gsf = gross square foot

TABLE 7-3 Summary of Vehicle Impact Fees						
City	**Population, 2008**	**Does City charge a Vehicle Impact fee on refuse? On construction?**	**When was VIF established?**	**Is the fee charged to the hauler only, or is it visibly shown on the customer's bill?**	**If charged to hauler, how? Annual lump-sum payment to City?**	**How much does the City collect annually from this fee?**
Alameda	75,823	Yes	2002	Fee is charged to customer, but was reimbursed to the customer by the City for the first two years		N/A
Modesto	209,936	Yes Refuse		10.5% of gross receipts passed through on the garbage rates charged to customers	N/A	$1.7 million
Menlo Park	31,490	Yes Construction	2005	Fee is charged to contractor	0.58% of the total construction project value and exempting residential alterations, residential repairs, and all projects less than $10,000 in value	varies
Rolling Hills Estates	8,185	Yes Refuse	2005	Hauler Only	Annual lump-sum in advance	$131,250 4/1/08 $150,000 4/1/09
Tiburon	8,917	Yes Refuse & Construction	2005		Construction - 1% of permit valuation	Refuse - $70,000
Twentynine Palms	27,966	Yes Refuse	2004	Hauler Only	15% franchise fee to offset costs of impacts to streets	N/A
Woodside	5,625	yes Construction	1991	Fee is charged to contractor / hauler	$1 / cubic yard, for everything over 30 cubic yards	varies

TABLE 7-4 Summary of Street Sweeping Fees								
City	**Population, 2008**	**Street Sweeper**	**Dept/Fund Cost is Acctd**	**Are Fees Assessed to Customer?**	**How Are Fees Assessed**	**In refuse rates or as separate rate?**	**Allocation Method (Res/Com)**	**Do you conduct protest hearings?**
Calabasas	23,725	Yes	AB 939 Regulatory Fees	Per Ton, sliding scale	No	Approx. $230,000 per year	Fees are charged on a per-ton basis, with the dollar amount of the fee dependent on the quarterly diversion rate of the hauler, ranging from $12.50/ton for 50% diversion, to $10/ton for 75% diversion.	AB 939 fund
Claremont	37,242	Contracted Out	Sanitation Fund	Yes	Com. - by bldg. $10/month/owner Single Family - $10.31 per qtr per/home	Separate charge on refuse bill	N/A	No. On bills prior to 1996
Culver City	40,694	Clean Street	SW Acct	Yes	N/A	In refuse rate	By curb mile, 48% residential, 52% commercial	Yes for Residential Rates
Glendale	207,157	City Crews	Integrated Waste Mgmt Fund	Yes	N/A	in "refuse base rate" but not itemized	By curb mile, 80% residential, 20% commercial	N/A
Merced	80,608		Solid Waste Rates	Yes	$1.53 per month per customer	In refuse rate	N/A	N/A
Santa Monica	91,439	City Crews	Solid Waste Ent. Fund	Res - no Comm - yes	Water meter size (1", 11/4", 2")	Res - Included Comm - separate fee	N/A	Pre 1996
Sacramento	475,743	City Crews	Public Works Ent. Fund	Yes	Variable from $1.24 to $4.06 per month, based on type of service account	Fees on Utility Bills	N/A	N/A
Whittier	86,945	City Crews	Public Works Ent. Fund	Yes		Separate charge on refuse bill	N/A	N/A

TABLE 7-5
Facility Host Fees

Facility	Facility Location	Owner	Operator	Permitted Tons/Day	"Host" Fee	Authorization	Adjustment	Based on	Equivalent Fee/Assessed Per Ton	Recipient/ Use
Transfer Stations & Recycling Facilities										
Downey Area Recycling & Transfer - DART	Downey	Los Angeles County Sanitation Districts	Los Angeles County Sanitation Districts	1,500	$1.32 per ton	Development Agreement	Based on tipping fees and sale of recyclables	Disposal tons and recycling sales	$1.32	General Fund
Rainbow Transfer Station & MRF	Huntington Beach	JBST Properties	Rainbow Disposal	2,800	2% of gross receipts	Franchise Agreement	None	Public dumping charges ("paid disposal")	$0.64	General Fund
Waste Management Transfer Station	South Gate	Waste Management	Waste Management	2,000	$400,000 per year	Operating Agreement	CPI	Flat fee	$0.64 or more, depending on actual throughput	General Fund
South Gate Transfer Station	South Gate	Los Angeles County Sanitation District	Los Angeles County Sanitation District	1,000	$1.26 per ton	Permit Fee	CPI	All inbound tons	$1.26	General Fund
Interior Removal Specialist - MRF	South Gate	Interior Removal Specialist	Interior Removal Specialist	3,000	$1.25 per ton	Permit Fee	$.05 per ton per year	All inbound tons	$1.25	General Fund
Hanson Aggregate C&D Recycling	South Gate	Hanson Aggregate C&D Recycling	Hanson Aggregate C&D Recycling	1,000	2% of gate revenue	Permit Fee	Based on gate revenues	All inbound tons	$.14 (3)	General Fund
Landfills										
Olinda Alpha Sanitary Landfill	Brea	County of Orange	County of Orange	8,000	$1.50 per ton (1)	MOU	Adjusts to $1.50 per ton on 2014	All Out-of-city tons	$1.50 per ton (1)	City of Brea Sanitation and Streets Fund
Colton Sanitary Landfill	Colton	City of San Bernardino	City of San Bernardino	3,100	$1.00 per ton (2)	MOU	No	Disposal tons	$1.00	City Of Colton
Scholl Canyon Landfill	Glendale	City of Glendale	Los Angeles County Sanitation Districts	3,400	25% of Gate Fee	City Ordinance	Based on Tipping fee	All Out-of-city tons	$10.02	City of Glendale General Fund
Frank R. Bowerman Sanitary Landfill	Irvine	County of Orange	County of Orange	8,500	$1.50 per ton (1)	MOU	Adjusts to $1.50 per ton on 2014	All Out-of-city tons	$1.50 per ton (1)	City of Irvine Sanitation and Streets Fund
Puente Hills Landfill	Los Angeles County - Unincorporated Area (Whittier)	Los Angeles County Sanitation District	Los Angeles County Sanitation District	13,200	$1.00 per ton	CUP	No	Disposal tons	$1.00	Los Angeles County Community Enhancement Fund
					$1.00 per ton	CUP	No	Disposal tons	$1.00	Puente Hills Native Habitat Land Trust
					10% of Gate Fee	County Ordinance	Based on tipping fee	Disposal tons	$2.94	Los Angeles County General Fund
San Timoteo Sanitary Landfill	Redlands	County of San Bernardino	County of San Bernardino	1,000	$1.00 per ton (2)	MOU	No	Disposal tons	$1.00	City of Redlands
Mid-Valley Landfill	Rialto	County of San Bernardino	County of San Bernardino	7,500	$4.98 per ton	Development Agreements	Yes	Disposal tons	$2.49 to each city	City of Rialto and City of Fontana
Victorville Sanitary Landfill	Victorville	County of San Bernardino	County of San Bernardino	1,600	$.50 per ton (2)	MOU	No	Disposal tons	$0.50	City of Victorville and City of Hesperia

(1) The Host fee is a fixed amount until 2014. Then the fee converts to $1.50 per ton.
(2) Landfill Mitigation Fund - for mitigation of hosting landfill, road repair, illegal dumping
(3) Source - Estimated amount per ton by Public Works Director

Table 7-6 LANDFILL TIP FEES			
Type of Load	**Pirce per Ton**		**Variance** (Paso Robles v. Chicago Grade)
	Paso Robles Landfill	Chicago Grade	
Minimum Load	$ 20.00	$ 20.00	$ -
Compacted Refuse	$ 38.85	$ 41.00	$ (2.15)
Uncompacted Refuse	$ 46.85	$ 47.00	$ (0.15)
Concrete, Brick & Asphalt	NA	$ 15.00	

APPENDICIES

APPENDIX A

CONVERSION TECHNOLOGIES AND WASTE-TO-ENERGY FEASIBILITY ASSESSMENT

CONVERSION TECHNOLOGIES AND WASTE-TO-ENERGY FEASIBILITY ASSESSMENT

CONVERSION TECHNOLOGIES

Conversion Technologies (CT) include a wide array of thermal, biological, chemical, and mechanical technologies capable of converting municipal solid waste (MSW) into useful products and chemicals, fuels such as hydrogen, natural gas, ethanol and biodiesel, and energy in the form of steam and/or electricity. CT are currently used to manage solid waste in Europe, Israel, Japan and Australia, but are not yet in commercial operation in North America with the exception of MSW composting which is operation in several locations in the U. S. as discussed later in this report.

Public sector interest in conversion technologies has increased in the United States (U.S.) in recent years, based on the desire to enhance recycling and beneficial use of waste, reduce dependence on landfilling and imported fossil fuels, and reduce greenhouse gas (GHG) emissions.

There have been pilot demonstrations of CT in the Canada and the U.S., but the absence of larger-scale commercial thermal, biological (anaerobic), chemical and mechanical facilities in North America has been an obstacle to demonstrating the capabilities and benefits of these technologies for processing MSW. Currently, the first such commercial thermal demonstration plant (Plasco – plasma arc gasification) is in start-up mode in Ottawa, Ontario. There are however, thirteen MSW composting facilities (biological -aerobic digestion) in operation the United States.

Feasibility studies or actual project procurements are underway in such locations as: Nashville, Tennessee; Huntsville, Alabama; New York City, New York; Los Angeles, California (CA) (City and County); Santa Barbara, CA (City and County); San Jose, CA; Salinas County, CA; St. Lucie County, Florida, and Taunton, MA (MA). Some of these public-sector initiatives include consideration of demonstration facilities, while others intend to proceed directly to procurement for a commercial facility. Requests for facilities range in size from 200 tons per day (TPD) in the City of Los Angeles (the "Emerging Technology" track) to a facility as large as 1,800 TPD in Taunton, MA.

An example of the range of vendors proposing on these projects is illustrated by the project in the City of Los Angeles. Vendors that have made the short list there are:

- Arrow Ecology and Engineering/CR&R (Anaerobic Digestion)
- Community Recycling (MRF, Anaerobic Digestion, Composting, Biomass Power)
- Plasco Energy (Plasma Arc Gasification)
- Interstate Waste Technologies (Pyrolysis, Gasification)
- Wheelabrator (Waste-to-Energy)
- Covanta (Waste-to-Energy)
- WRSI (Anaerobic Digestion)
- Urbasser (Anaerobic Digestion, WTE, Gasification)
- Zia Metallurgical (Thermal)

Of particular interest for smaller communities is the fact that most CT's are modular in nature, with individual modules in the 100-150 TPD range. This means that a plant with the minimum of two lines can effectively be developed in the 200-300 TPD range, a size appropriate for many smaller cities or groups of rural towns throughout the U.S. This is not necessarily true of the traditional Waste-To-energy (WTE) facilities that are typically uneconomical below about 500 TPD. This ton per day or sizing issue is addressed at length in this report.

CATEGORIES/TYPES OF CONVERSION TECHNOLOGIES

Table 1 lists CTs that have been identified in the most recent search efforts. Although the list may not capture all possible technologies and corporate sponsors, it represents a broad spectrum of CTs, including the companies that are more established in the industry and that have achieved the greatest level of development.

TABLE 1. Conversion Technology Suppliers by Technology Category

Thermal Processing	Biological Processing
Gasification (22) Bioengineering Resources, Inc./New Planet Energy/Ineos Bio Dynecology Ebara Corporation Ecosystems Projects EcoTech Fuels/Victory Circle Fuels Entech Solutions Enerkem Global Alternative Green Energy Global Energy Solutions Global Recycling Group Green Energy Corporation ILS Partners/Pyromex Interstate Waste Technologies (Thermoselect) KAME/DePlano Primenergy Taylor Recycling Facility Thermogenics Waste Gasification Systems / Allan Environmental World Waste Technologies Ze-Gen Zeros Technology Holding Zero Waste Energy Systems **Plasma Gasification** (10) AdaptiveARC Alter NRG / Westinghouse [(1)] EnviroArc Technologies / Nordic American Group Global Environmental Technologies GSB Technologies InEnTec Peat International / Menlo Int. Plasco Energy Group Solena Group Startech Environmental **Pyrolysis** (7) Bioconversion Technology LLC (Emerald Power) Eco Waste Solutions Entropic Technologies Corporation GEM America International Environmental Solutions Pan-American Resources Recycled Energy Corporation/Pyrolysis Plus Technology	**Anaerobic Digestion** (9) Arrow Ecology and Engineering Canada Composting Ecocorp KAME/DePlano New Bio Orgaworld Organic Waste Systems Vagron Waste Recovery Systems, Inc. (Urbaser/Valorga) **Aerobic Digestion/MSW Composting** (6) Bedminster Civic Environmental Systems Conporec ECS (Engineered Compost Systems) Herhof Mining Organics Management **Chemical Processing** **Hydrolysis** (5) Arkenol Fuels/BlueFire Ethanol BioEngineering Resourcess (BRI) Biofine / BioMetics Genahol Masada OxyNol **Other** (1) Changing World Technologies (CWT) **Mechanical Processing (9)** CES Autoclaves Cleansave Waste Corporation Comprehensive Resources EnerTech Environmental Herhof Gmbh Recycled Refuse International Tempico WET Systems World Waste Technologies

(1) Several project developers have proposed or are engaged in projects with the Westinghouse plasma gasification technology, including Geoplasma, USST and Rigel Resource Recovery.

As shown in Table 1, CT as a whole can be grouped into several broad categories:

Thermal Processing. Thermal processing includes technologies such as gasification, plasma gasification, and pyrolysis, which use heat to convert MSW into a synthesis gas (that can be used to produce a fuel, or cleaned and combusted to generate electricity) and other usable products (e.g., vitrified aggregate, carbon-based char, metal, sulfur).

Biological Processing. Anaerobic Digestion (AD) and MSW Composting are biological technologies. AD converts the organic fraction of MSW through decomposition by microbes in the absence of oxygen and produces a biogas that can be combusted to generate electricity or converted to fuel. It also produces a solid organic residual that can

be used as a feedstock for composting. In-vessel composting of MSW features controlled oxygen, moisture, and temperature to accelerate the decomposition of organics. Each in-vessel stage is generally followed by a curing stage, which is either an aerated-static pile, or traditional windrow.

Chemical Processing. Chemical processing technologies use one or a combination of various chemical means to convert MSW into usable products, such as synthetic diesel fuel and other distillates.

Ethanol Production. Hydrolysis is a chemical reaction in which water, typically with an acid, reacts with the cellulose fraction of MSW (e.g., paper, food waste, yard waste) to produce sugars, with additional processing to convert the sugars to ethanol or other products. Hydrolysis can also be achieved using a biological process with enzymes. In addition to hydrolysis, thermal processing can be used to create a gas which microbes can then convert directly to ethanol.

Mechanical Processing. Mechanical technologies employ physical processing, such as steam classification (autoclaving), primarily to recover recyclables and separate the organic and inorganic fractions of MSW. Mechanical processing technologies are typically followed by other conversion processes.
Summary descriptions of these technology categories follow.

THERMAL PROCESSING

Thermal technologies encompass a variety of processes that use or produce heat under controlled conditions to convert MSW to usable products. The organic fraction of MSW is converted to energy, and the inorganic fraction is recovered as products (e.g., aggregate, metal). Thermal technologies can potentially convert all organic components of MSW into energy (i.e., all carbon and hydrogen-based materials, including plastic, rubber, textiles, and other organic materials that are not converted in biological processes). Thermal processing includes such technologies as gasification, plasma gasification, and pyrolysis. Distinctions between the different thermal technologies center on the processing temperature, the means of maintaining the elevated temperatures, and the degree of decomposition of the organic fraction of the MSW.

Thermal processing occurs in a high-temperature reaction vessel. Reactor temperatures range from approximately 800°F for a pyrolysis technology to as high as 8,000°F for plasma gasification. Within the reaction vessel, the organic fraction of the MSW is converted to a gas typically composed of hydrogen, carbon monoxide and carbon dioxide gases. This gas is commonly called synthesis gas or "syngas." Some thermal technologies, such as pyrolysis, produce a gas that also consists of various low molecular weight organic compounds. Thermal technologies sometimes introduce a supplemental fuel (e.g., natural gas, chipped tires, coke, etc.) to improve the quality and consistency of the synthesis gas. Plasma gasification technologies use a supplemental source of energy, most commonly electricity, to produce an electric arc to elevate the temperature and enhance dissociation of the molecules in the MSW.

With some thermal technologies, such as gasification, the inorganic fraction of MSW is commonly recovered in the forms of: vitrified "aggregate" or "slag", mixed metals, industrial salts, chemicals, and other byproducts. Some thermal technologies, such as pyrolysis, generate a char (i.e., a carbon-based solid) rather than a vitrified product. Depending upon market conditions, these byproducts may have beneficial uses, or may be usable as Alternate Daily Cover (ADC) at landfills. If no markets are available for the aggregate or char material and it must be landfilled, diversion achieved by the system can drop by as much as 20 percent.

The syngas produced by thermal conversion technologies can be combusted to generate electricity. Thermal conversion technologies can also convert the syngas to fuels. However, for MSW processing, the production of fuels is more complex than is the production of electricity and has not been proven on a commercial scale. Although some MSW technology suppliers are conducting research and development efforts on fuel production (either to augment or substitute for electricity generation), the prevailing practice in the MSW market continues to be electricity generation, with the newest focus being on the use of combined cycle power generation systems for greater efficiency.

In an overview fashion, thermal processing of MSW can be described in two primary steps: (1) pre-processing, if required, and (2) thermal conversion, including combustion of the syngas to generate electricity.

- **Pre-processing.** Pre-processing requirements are often very minimal for thermal technologies. Except for the common requirement to remove or size-reduce large,

over-sized materials such as furniture and large appliances, many thermal processing technologies do not require size reduction or separation of MSW by component. This is not always the case, though, as some thermal technologies (e.g., many pyrolysis technologies) shred and/or dry the waste prior to processing. While recyclables such as metals can be recovered in a pre-processing step, many of the thermal technologies recover the metal after the thermal conversion process.

- **Thermal Conversion and Use of Gas.** The thermal conversion process results in a syngas and other products, as described above. The gas may be chemically processed into fuels such as hydrogen or chemicals such as methanol, but currently, most technology suppliers have been or are focusing on converting the syngas to energy by using it as a fuel in traditional boilers, reciprocating engines and combustion turbines. Some of the thermal technologies pre-clean the syngas prior to combustion using standard, commercially-available technology to remove sulfur compounds, chlorides, heavy metals and other impurities. Pre-cleaning the syngas prior to combustion can be more cost-effective than post-combustion controls. Even with pre-cleaning, most technologies apply some post-combustion air pollution control technology, such as NOx control. The extent of syngas cleaning and post-combustion air pollution control varies by technology.

Some of the more advanced thermal conversion technologies, i.e., those with commercial facilities or pilot facilities processing MSW, include technologies provided by 1) Ebara, 2) Interstate Waste Technologies, 3) Entech Solutions, 4) Westinghouse Plasma Gasification, 5) Plasco Energy Group, 6) GEM America, and 7) International Environmental Solutions. These seven technology suppliers were reviewed and evaluated as part of comprehensive studies conducted by New York City and/or Los Angeles County. A summary of these thermal processing technology suppliers are discussed herein is presented below.

1) <u>Ebara</u>

Ebara Corporation (Ebara), headquartered in Tokyo, Japan, is the project sponsor for the Twin-Rec fluidized bed gasification technology (also called TIFG - twin internally revolving fluidized-bed gasifier). The technology consists of a fluidized bed gasifier coupled with a high-temperature, ash-melting furnace. The system requires shredding of MSW prior to processing. Recyclable metals (ferrous and aluminum) are recovered from the gasifier reactor. Synthesis gas created in the reactor is combusted at a very high temperature in the ash melting furnace. Steam generated from the combustion of the gas is used to generate electricity. The synthesis gas enters the ash melting furnace in a "raw" state, containing tar,

fine char, and ash residue. These materials are melted in the furnace and extracted as a vitrified, glassy slag, which is marketed to the construction industry as an aggregate.

Ebara's Twin-Rec technology has been in commercial operation in Japan since 2000, with 25 units currently in operation. Six plants (with 16 Twin-Rec units in aggregate) are in operation processing MSW. The first began commercial operation in March 2002 (Sakata Area), with two additional plants later in 2002 (Kawaguchi City, Ube City), two plants in 2003 (Chuno Union, Minami-Shinshu Wide Area Union), and one plant in 2004 (Nagareyama City). Ebara's largest MSW facility, the Kawaguchi City Asahi Clean Center (see photo), began commercial operations in November 2002.

Asahi Clean Center
Kawaguchi City, Japan

Ebara is continuing development efforts for its Twin-Rec technology, with its "second generation" unit designed to de-couple the gasification process from the ash-melting furnace (i.e., the vitrification process). This will allow for the collection and cleaning of the synthesis gas prior to its combustion, and to enable other uses for the gas. The first commercial plant to use the "second generation" of the Twin-Rec technology will be a 200-tpd facility in Chiba, Japan, which was expected to be operational in 2007. The current status of this facility is under investigation.

The Ebara gasification technology recovers recyclables (metals), and generates energy and other products as described below:

- **Recyclables.** Ferrous metal and aluminum drop by gravity to the bottom of the gasifier reactor (along with other dense inorganic materials), where they are removed intact (i.e., unmelted and unoxidized) and recovered using magnets and eddy current separators. Ebara represents that it can recover approximately 80% of the ferrous metal and aluminum present in the waste feedstock.

- **Energy.** The technology generates energy, in the form of steam and electricity, associated with the combustion of the synthesis gas. The electricity is used to meet internal needs, with the balance (net electricity) sold as a product. Energy output will depend on the characteristics of the waste. Net electricity output is estimated to be on the order of 400 kilowatt hours per ton of MSW processed (kWh/ton). The

energy conversion efficiency of the technology is estimated to be approximately 15%.

- **Other Products.** Fly ash entrained in the synthesis gas is turned into a glassy slag in the ash melting furnace. The slag is continuously discharged at the bottom of the furnace and quenched, resulting in a glassy, granulate material that is marketed as a product for civil construction uses. Approximately 7% by weight of the incoming MSW is expected to be turned into a glassy slag. If a stable market is not established for the slag, this material would require disposal as a residue.

- **Residue Requiring Disposal.** Residue requiring disposal is generated in Ebara's process from the solid output of the gasifier and the air pollution control system. An estimated 6% by weight of the MSW received for processing will be residue requiring landfill disposal. If the glassy slag product identified above requires disposal due to lack of a market, the quantity of residue requiring landfill disposal would increase to approximately 13%.

2) Interstate Waste Technologies

Interstate Waste Technologies (IWT), represented in the U.S. out of Middleburg, Virginia, and Malvern, Pennsylvania, offers the Thermoselect high-temperature gasification technology. IWT is the sole North American licensee of the Thermoselect technology. The technology is a closed-loop process based on high-temperature gasification with an extended residence time for process gases. The technology simultaneously gasifies organic materials and melts down inert materials. There is no size reduction or separation of the MSW prior to gasification, and no front-end recovery of recyclables. Rather, all MSW is input to the process and is either converted to energy or extracted as a product. Assuming all products can be marketed, which has reportedly been demonstrated at operating facilities in Japan, the technology generates no residue requiring disposal.

The Thermoselect technology is currently in commercial operation at seven locations in Japan (Chiba, Mutsu, Kurashiki, Nagasaki, Yorii, Tokushima, and Izumi). The Chiba facility, which began commercial operations in September 1999, is the longest-operating Thermoselect facility in Japan (see photo). Chiba was initially operated with MSW, but currently processes industrial waste (primarily plastic and paper, along

Thermoselect Facility
Chiba, Japan

with sludge, wood chips, oil, and miscellaneous organic waste). The Kurashiki facility is one of the newest facilities, but has the largest capacity of all the Thermoselect facilities currently in operation. Kurashiki began operations in March 2005, and has a design capacity of 612 TPD. It processes MSW from the City of Kurashiki along with industrial waste (including auto shredder residue) from area industries.

The Thermoselect gasification technology recovers metals, and generates energy and other products as described below:

- **Recyclables.** The Thermoselect technology processes MSW as received, with no pre-processing. Therefore, no recyclables are recovered at the front-end of the process. All materials input to the process are either converted to energy or extracted as a product. As described below, metals are recovered, but classified as a product rather than a recyclable.

- **Energy.** The technology generates energy in the form of electricity, associated with the combustion of the synthesis gas. The electricity is used to meet internal needs, with the balance (net electricity) sold as a product. Energy output will depend on the characteristics of the waste and the method used to generate electricity. Net electricity output is estimated to range from approximately 500 kWh/ton to as high as 850 kWh/ton, under the wide range of MSW characteristics and equipment options available for generating electricity. The energy conversion efficiency of an IWT Thermoselect facility is estimated to range from approximately 15% to as high as 21%.

- **Other Products.** Materials in the waste that are not converted to energy are recovered as products. Quantities are directly related to the characteristics of the waste. Aggregate and mixed metals are generated from the melting of inorganic material in the high-temperature gasification reactor. Both would be generated and recovered at a rate of approximately 7.5% by weight of the incoming MSW. The aggregate is silica-based, and includes encapsulated impurities that are rendered inert. The mixed metals include iron, aluminum and copper. Other products include industrial salts (sodium chloride, sodium fluoride and other minor salts), sulfur, and zinc hydroxide, which are generated during the cleaning of the synthesis gas. These other products are expected to be generated and recovered at a rate of approximately 2% or more (combined total) by weight of the incoming MSW.

- **Residue Requiring Disposal.** Assuming all products can be marketed, the technology would generate no residue requiring landfill disposal. The ability to market all of the products is supported based on performance at existing facilities in Japan. For a project in the U.S., the metals and other minor products are expected to have stable markets. Some uncertainty exists regarding the presence of stable markets for the aggregate, although, IWT has identified concrete companies in the

U.S. that would likely use the product. If the aggregate product requires disposal due to lack of a market, the quantity of residue requiring disposal would be approximately 7.5%.

3) Entech Solutions

Entech Solutions, previously represented as NTech Environmental, Ltd, headquartered in Devon, England, integrates three distinct technologies into a system. The core technology is the Entech gasifier, which consists primarily of a low temperature gasification unit and a syngas-fueled boiler. The Entech gasifier can be used to process a variety of wastes, including MSW and sewage sludge. Prior to gasification, MSW is pre-processed using the Wastec Kinetic Streamer technology, which is a mechanical system for front-end recovery of recyclables. The third component of the system is the Royco plastic-to-oil technology, a pyrolytic cracking process that converts plastics recovered from the MSW during pre-processing into diesel oil and other fuel products. The system recovers traditional recyclables and generates two primary products: electricity from syngas, and oil from plastics.

The three distinct technologies aggregated by Entech have not yet been demonstrated or developed as an integrated system. However, the individual system components are currently in commercial operation overseas. The Entech gasifier has been in commercial use since 1989. Over 100 units have been installed, and more than 20 of the installations process MSW. The largest facility processing MSW is located in Genting, Malaysia (see photo). The facility in Malaysia has a single unit with a design capacity of 67 TPD, and has been in commercial operation since 1998.

Entech Gasifier
Genting, Malaysia

Wastec Kinetic Streamer
North Yorkshire, England

The Wastec Kinetic Streamer technology was developed in 2001 based on mineral ore sorting equipment. There is one Wastec installation, located at a landfill in the United Kingdom (North Yorkshire, England). The system was initially operated on a demonstration basis from 2001-2004, processing source-separated recyclables. Beginning in 2005, the system was operated on a commercial basis processing mixed (unsorted) MSW. It has a design capacity of 220 TPD. Very recently, the Kinetic Streamer was taken out of operation to provide for system optimization; it is expected to resume continuous operations in 2008.

There are two Royco installations in commercial operation, one in North Korea and one in South Korea. These facilities have been in operation for several years, but the dates of commercial operation are not available. A third facility, also in North Korea, is currently in start-up. All three installations are small-scale, commercial units. The newest facility, which has a design capacity of approximately 6 TPD (less than 2,000 tpy), is the largest of all three installations. The photo to the right shows one of the older facilities, which has a capacity of approximately 3 TPD (1,000 tpy). A facility under development in Melbourne, Australia, has a planned capacity of 18 TPD (5,000 tpy).

Royco Plastic-to-Oil
Technology, Korea

The Entech system recovers recyclables, and generates electricity and other products, including diesel oil, as described below:

- **Recyclables.** The Wastec Kinetic Streamer and associated pre-processing equipment, supplemented with some hand picking, recovers traditional recyclables from the incoming MSW. Materials that are recovered in the process and the recovery efficiency estimated by Entech include cardboard (50% recovery), ferrous metal and aluminum (90% recovery), film plastic (95% recovery), rigid plastic (88%

recovery), and glass (98% recovery), with an overall average recovery efficiency of approximately 70% of these recyclable materials. With these recovery rates, it is estimated that approximately 30% by weight of the MSW received for processing could be recovered as recyclables.

- **Energy.** The technology generates energy, in the form of electricity, associated with the combustion of the syngas. The electricity is used to meet internal needs, with the balance (net electricity) sold as a product. Net electricity output is estimated to be on the order of 500-600 kWh/ton. The energy conversion efficiency is estimated to be approximately 17%.

- **Other Products.** The integrated Royco system generates an oil product expected to be similar in composition to a diesel product. The oil would be used for parasitic use (gasifier startup) and the excess would be sold as a product. On a mass basis, approximately 65-70% of the plastics fed to the system are converted to oil, generating approximately 200 gallons of oil (or more) for each ton of plastics processed.

- **Residue Requiring Disposal.** Residue requiring landfill disposal includes residue from pre-processing, residue from the Royco plastic-to-oil process, and air pollution control residue. In addition, ash from the gasifier and rubble and dirt from pre-processing, which are intended to be sold as products, may require disposal in a landfill due to lack of markets for these materials. Up to approximately 10% by weight of the MSW received from processing may be residue requiring landfill disposal.

4) Westinghouse Plasma Gasification

Rigel Resource Recovery and Conversion Company (Rigel) is a project development team that has previously proposed (for New York City) to engineer and build a conversion facility based on application of the Westinghouse plasma arc gasification system. Rigel team members are located in the United States (including Baltimore, Maryland) and abroad. Rigel's application of the Westinghouse plasma system to the processing of MSW is new, with no existing facilities that combine the system components as planned by Rigel. Rigel's application of the Westinghouse technology, as proposed for New York City, is designed to serve as a power plant as well as a waste management facility. The review provided herein

Plasma Gasification Facility
Utashinai, Japan

focuses on the Westinghouse plasma arc gasification system, as it was proposed to be configured by Rigel.

The Westinghouse plasma arc gasification system uses high-temperature ionized air, called plasma, to convert carbon-based materials into a synthesis gas. The technology can process various types of waste, including MSW and sewage sludge. Inorganic materials leaving the plasma reactor as molten liquid are separated into metals and a glassy slag. There is no size reduction or separation of the MSW prior to gasification (except for over-sized materials greater than approximately 3 feet, which must first be shredded), and no front-end recovery of recyclables. Rather, all MSW is input to the process and is either converted to energy or extracted as a product. Assuming all products can be marketed, the technology generates no residue requiring disposal.

Westinghouse Plasma Corporation (WPC) is a wholly owned subsidiary of Alter Nrg, a Canadian firm that acquired WPC in April 2007. Therefore, Alter Nrg is now the owner of the Westinghouse plasma gasification technology. In April 2007, Alter Nrg entered into a technology license agreement with NRG Energy, Inc., a Princeton, New Jersey-based corporation that is a distinct and separate corporate entity from Alter Nrg. The License agreement grants NRG Energy a five-year, exclusive license to use the proprietary gasification technology in the United States. Previously, the Westinghouse plasma technology was commercially available to any interested party (such as Rigel). This new ownership and license agreement impacts the ability of such companies to use the Westinghouse technology.

The Westinghouse plasma gasification system was operated at a pilot scale (5 TPD) in Yoshii, Japan, from 1999-2000. The pilot plant demonstrated the ability to process MSW, and resulted in construction of two commercial facilities in Japan, both constructed by Hitachi Metals. The largest facility, located in Utashinai, Japan, began commercial operations in 2003 (see photo). It was designed to process auto shredder residue (ASR), MSW, or a blend of the two, and generates electricity. The Utashinai facility primarily processes ASR, and has a design capacity for this feedstock of approximately 165 TPD. The facility also processes some MSW, but the quantity typically processed is not available. The design capacity for processing all MSW is approximately 300 TPD. The second and smaller commercial facility, located in Mihama-Mikata, Japan, began commercial operations in 2002. This facility processes approximately 26 TPD of MSW and 4 TPD of sewage sludge,

and generates heat for sale to a local industry. In addition to these commercial installations, WPC operates a research and development facility, called the Westinghouse Plasma Center, located near Pittsburgh, Pennsylvania. This facility houses offices and is used for pilot demonstration for customer process development for solid, liquid and gaseous feedstock.

The newest application of the Westinghouse plasma gasification technology is for the planned facility in St. Lucie County, Florida. The planned facility will process MSW, with an initial capacity of 300 TPD. The project is planned to be operational in 2011. The project developer is Geoplasma, Inc.

Rigel's design utilizing the Westinghouse technology includes the use of fossil fuels (i.e., coke, supplied to the reactor, and natural gas, supplied to the combustion turbine). Primary outputs are energy in the form of steam and electricity, recovered metals, glassy slag, chlorine and sulfur products as summarized below:

- **Recyclables.** Rigel's application of the Westinghouse technology processes MSW as received, with no pre-processing. Therefore, no recyclables are recovered at the front-end of the process. All materials input to the process are either converted to energy or extracted as a product. As described below, metals are recovered, but classified as a product rather than a recyclable.

- **Energy.** The technology generates energy in the form of steam and electricity, associated with the combustion of synthesis gas combined with natural gas. The electricity is used to meet internal needs, with the balance (net electricity) sold as a product. Net electricity output is estimated to be more than 2,200 kWh/ton. This high electric output reflects the large amount of fossil fuel input to the system (approximately 40% of the total energy input), including coke to the reactor and natural gas to the combustion turbine. The energy conversion efficiency of the Rigel facility is estimated to be approximately 37-40%.

- **Other Products.** Materials in the waste that are not converted to energy are recovered as products. Quantities are directly related to the characteristics of the waste, with the majority of materials recovered as glassy slag. Glassy slag consists of inorganic materials that do not volatilize in the gasification process and do not separate out as mixed metals after discharge from the reactor. The slag is primarily silica-based, and includes impurities that are encapsulated in the glassy material and rendered inert. Materials fed to the reactor that contain silica and contribute to the slag product are MSW, coke, and silica flux (a sand-like material used to promote vitrification). In addition, particulate matter captured in the cyclone during the cleaning of the synthesis gas is fed to the reactor, to enable encapsulation of the

particulate within the slag. Glassy slag is expected to be recovered at a rate of approximately 16% by weight of the MSW received for processing. Other products and their recovery rates are mixed metals (7%), hydrochloric acid (about 3%), and elemental sulfur (less than 0.5%).

- **Residue Requiring Disposal.** Assuming all products can be marketed, the technology would generate no residue requiring landfill disposal. For a project in the U.S., the metals and other minor products are expected to have stable markets. Some uncertainty exists regarding the presence of stable markets for the slag. If the slag requires disposal due to lack of a market, the quantity of residue requiring disposal would be approximately 16%.

5) Plasco Energy Group

PlascoEnergy Group is the parent company of the PlascoEnergy family of companies headquartered in Ottawa, Ontario, Canada. The PlascoEnergy Conversion Process (PCP) has been perfected through many years of focused research in conjunction with and supported by the Canadian National Research Council (NRC) and the Ontario Ministry of the Environment (MOE). For over a decade, Plasco has operated a pilot plant to refine the design and operational parameters for the commercial scale demonstration facility now operating in Ottawa.

The PCP is a non-incineration thermal process that converts more than 99% of the waste it processes into clean energy and marketable co-products. The PCP uses recovered heat from the process to gasify the waste and then uses the unique, advantageous characteristics of plasma to refine the gaseous products into a clean, consistent synthesis gas (syngas). The quality of the syngas is controlled so consistently that it can be fed to a combined cycle power plant (internal combustion engines, plus heat recovery steam generators). This results in substantially more power per ton of waste than mere combustion of the syngas in a boiler.

PlascoEnergy Facility
Ottawa, Canada

The conversion of one ton of MSW results in the following (will vary depending on composition and Btu value of feedstock MSW):

- 1.25 MWh of electricity
- 340 lbs of construction aggregate
- 15-30 lbs of recyclable metal
- 10-20 lbs of commercial salt
- 4 lbs of sulfur for agriculture, and
- 72 gallons of water (treatable to potable quality)

Originally designed to stabilize and optimize syngas production with the introduction of a High Carbon Fuel (i.e., plastics or tires) along with the MSW, initial runs at the Trail Road facility described below have demonstrated that this fuel additive is not necessary for optimal operations.

PlascoEnergy entered into a partnership with the City of Ottawa, Canada in April 2006 for the construction of a commercial-scale evaluation and demonstration conversion facility at their Trail Road Landfill site. The facility, as permitted, converts 100 TPD of MSW to approximately 4 MW of electrical energy. Construction was completed in June 2007 and commissioning began in July 2007, with the first Syngas produced on July 19, 2007. This facility represents the commercial size module that will merely be replicated for larger plants.

The Trail Road facility has been and continues to be extensively monitored for air emissions and other factors and to date has achieved levels well below the stringent limits set by the Ontario Ministry of the Environment. There are no emissions from the conversion process

itself, only from the power generation equipment. Vitrified slag will be purchased by a local company as an additive in concrete.

Primary outputs are energy in the form of steam and electricity, recovered metals, glassy slag, salts, and sulfur products as summarized below:

- **Recyclables.** Pre-processing consists of sorting large recyclable items off the tipping floor, grinding, and magnetic separation for ferrous metal recovery.
- **Energy.** The technology generates energy in the form of steam and electricity, associated with the combustion of synthesis gas. The electricity is used to meet internal needs, with the balance (net electricity) sold as a product. Net electricity output is estimated to be 1,000 to 1,250 kWh/ton. This high electric output reflects the efficient use of heat and steam recovery from the Syngas and the Jenbacher engines, as well as the benefits of plasma arc technology.
- **Other Products.** Materials in the waste that are not converted to energy are recovered as products. Quantities are directly related to the characteristics of the waste, with the majority of materials recovered as glassy slag. This slag is primarily silica-based, and includes impurities that are encapsulated in the glassy material and rendered inert. In addition, particulate matter captured in the baghouse during the cleaning of the synthesis gas is fed to the reactor, to enable encapsulation of the particulate within the slag. Glassy slag is expected to be recovered at a rate of approximately 17% by weight of the MSW received for processing. Other products and their recovery rates are mixed metals (12%), commercial salts (about 1%), elemental sulfur (0.2%), and potable water (30%).
- **Residue Requiring Disposal.** Assuming all products can be marketed, the technology would generate a total residual of less than 1% of the incoming MSW tonnage. This small amount of residual will require disposal at a hazardous waste landfill.

6) <u>GEM America</u>

GEM Demonstration Facility
South Wales

GEM America (GEM), located in Summit, New Jersey, is the American subsidiary of GEM International, the owner and patent holder of the GEM Thermal Cracking System. GEM's thermal technology is capable of processing MSW and other types of waste, and has been tested on a variety of waste including MSW, commercial waste, wood waste and plastics. The GEM technology

requires pre-processing to create a dried and shredded, prepared waste. The pre-processing equipment is not part of the patented GEM technology, but is included ahead of the GEM technology as part of an overall system and can be designed for the recovery of recyclables. GEM uses a pyrolysis technology, also called thermal cracking, to convert MSW into a synthesis gas that is combusted in a reciprocating engine to generate electricity. The process generates a carbon-based solid material, called char. The char may be potentially useable as a landfill cover material, but due to lack of identified markets is currently considered a process residue that requires disposal.

GEM's reference facility is a standard converter unit installed at a private landfill site in South Wales, U.K., which is the first, full-scale (commercial-sized) unit sold by GEM. While the reference facility represents a full-scale commercial installation under private ownership and operation, it operated intermittently for testing and inspection purposes, design modifications, and other reasons specific to the private facility owner and operator (e.g., to accommodate simultaneous testing and modification of an autoclave unit, intended for front-end separation of recyclables). Operation of the GEM converter was limited to four days per week, six hours per day, for a 12- to 18-month period. In this regard, GEM's reference facility is more representative of a full-scale demonstration facility of the converter unit than of a complete commercial facility capable of pre-processing and conversion.

The capacity of GEM's reference facility is approximately 40 TPD, which is the capacity of a standard GEM converter module. This capacity is the quantity of waste fed to the converter, after recovery of recyclables and drying of the waste. The owner's original plan was to expand to a total of three modules, but such expansion has not yet occurred. The demonstrated operating capacity at the reference facility is approximately 18.5 TPD, which is about half the design capacity. GEM reports that the facility has processed a total of approximately 1,375 tons of MSW over a one-year operating history. The facility is not currently operating, pending plans to re-locate the installation elsewhere.

GEM has been pursuing development of its first commercial facility in the U.S. (a private, industrial application in Ohio). This installation was scheduled to be operational in 2007, and may have recently achieved that status. The current status of this newest GEM installation is under investigation.

The primary output of the GEM technology is electricity, as described below, along with the potential recovery of recyclables:

- **Recyclables.** GEM has not completely developed a design concept for a front-end material recovery system. Only metal recovery is considered a routine part of the operation, with magnets and eddy current separators integrated with the waste shredding equipment. Glass would presumably be removed from the waste during pre-processing, but recovered glass has been considered by GEM to be residue requiring landfill disposal.

- **Energy.** Energy input to the GEM process comes from MSW. Fossil fuel (natural gas) is used during periods of startup, but is not used on a steady-state basis. Energy output is in the form of thermal energy and electricity.

  GEM proposes engines for conversion of syngas energy to electricity. For a commercial plant, the gross electricity output is stated to be 603 kWh of electricity per ton MSW received for processing. The technology requires approximately 70 kWh of electricity for internal (parasitic) use, resulting in net electricity generated for export (sale) of approximately 533 kWh per ton of incoming MSW. Additional thermal energy is reportedly also available for export (as heat, in the form of hot water). However, GEM has not sufficiently developed this concept for review and evaluation. Heat export, if viable, could provide additional revenue.

- **Other Products.** Except for energy, the GEM process does not generate products. The char, which is the solid byproduct of the pyrolysis process, may have potential use as a landfill cover material.

- **Residue.** The GEM process generates residue consisting of oversized material from pre-processing, glass, and char at an estimated rate of 28.4% by weight of the waste received for processing. The char consists of ash (inorganic material that escapes pre-processing) and residual carbon. The quantity of char will vary, depending on the characteristics of the waste processed. For example, inert material that is not removed during pre-processing (e.g., glass, stones, metal) will pass through the converter and be mixed in with the char.

7) International Environmental Solutions (IES)

IES Demonstration Facility
Romoland, California

IES, located in Romoland, California (Riverside County), is the developer of a pyrolytic gasification technology currently under development for use with a variety of feedstocks, including MSW. IES's technology centers on generation of a syngas by a retort reactor, followed by combustion of the syngas in a thermal oxidizer. The technology includes pre-drying of the waste and capture of the thermal energy using a heat recovery steam generator (HRSG). Because a dryer is integral to the process, as currently configured, the system can process sewage sludge and other organic wastes along with MSW. The process converts waste to useful energy in the form of electricity for net export. A small amount of residue, which will require disposal, is generated by the process.

IES has built a demonstration facility in Romoland, California (see photo). This facility has been used to process a variety of feedstocks since 2004. The Romoland facility has two pyrolysis units: one unit has an 8-tpd capacity, and the other has a 50-tpd capacity. The 50-tpd unit has been extensively stack-tested while operating with MRF residuals as a feedstock. Except for several case-specific allowances made by the South Coast Air Quality Management District to enable extended test durations, the 50-tpd pyrolysis unit is generally limited by permit to operate less than a full day at a time. Therefore, the IES demonstration facility does not currently operate continuously. A commercial scale (125 tpd) unit is in construction and will represent the commercial module that will simply be replicated for larger plants. It is estimated that this unit will be ready for start up in the 1st quarter of 2009.

Primary outputs of the IES process are described below:

- **Recyclables.** The IES design concept, to date, has been to accept MRF residuals, from which recyclables have already been removed. The IES technology does not include front-end recovery of recyclable materials. All of the MRF residual is processed through the retort vessel to produce syngas and char. The char has no appreciable recyclables that can be recovered.

- **Energy.** Electricity is produced by the combustion of the syngas in the thermal oxidizer for generation of thermal energy, which is then transferred to steam in the heat recovery steam generator, and finally converted to electricity by the steam turbine for both plant parasitic use and export.

- **Other Products.** The sole material product of the IES process is the syngas, produced by pyrolytic gasification. Currently, the only marketable product from the IES process is electricity. In addition to electric generation with the syngas, manufacture of fuel products, such as hydrogen, are actively under investigation by IES.

- **Residue.** The IES process generates residue requiring disposal from three sources: (1) the char from the retort vessel; (2) particulate matter collected by the cyclone; and (3) air pollution control system residues. Air pollution control system residues would include particulate matter, a caustic substance such as lime used for acid gas scrubbing, and a small amount of carbon injection used for mercury and dioxins/furans scrubbing. Approximately 5 percent by weight of the quantity of incoming MSW would need to be disposed.

BIOLOGICAL PROCESSING

Anaerobic Digestion

Anaerobic digestion is the reduction of carbon-based organic materials through controlled decomposition by microbes, accompanied by the generation of liquids and gases. In the anaerobic digestion of MSW, the biodegradable, organic components are metabolized by microorganisms in the absence of oxygen, producing a biogas (primarily methane and carbon dioxide), a solid byproduct (called "digestate", which is a compost feedstock), and reclaimed water. In an overview fashion, anaerobic digestion can be described by four primary steps: (1) pre-processing, or separation/preparation, of the MSW to obtain a prepared organic feedstock; (2) digestion of the prepared organic feedstock; (3) post-treatment of the digestate to produce compost, and (4) use of the biogas generated during the anaerobic digestion process. These primary steps are described below.

- **Pre-processing.** For mixed MSW, pre-processing or preparation/separation is necessary for separating biodegradable, organic materials from other waste components as well as for size reduction and preparation of the organic feedstock. Pre-processing can be accomplished using traditional, mechanical sorting processes, or it can employ more innovative and technology-specific approaches (e.g., the water-based preparation/separation system designed by ArrowBio.) Pre-processing will result in residue requiring disposal, generally consisting of broken glass and other inert materials

present in the wastestream. Pre-processing can be combined with recovery of traditional recyclables that are not readily biodegradable and not of value in the digestion process. Recovered recyclables from pre-processing may include ferrous metal, aluminum, plastic, and glass. Recent initiatives are underway to sort paper and cardboard as recyclables, particularly when there are high market values for these materials. In general, maximizing the recovery of recyclables and the removal of non-degradable, inert materials during pre-processing will result in higher quality compost at the end of the process.

- **Digestion.** The separation and preparation of biodegradable, organic material from the MSW results in an organic feedstock for the digestion process. The fundamental objective of anaerobic digestion is to produce a large quantity of methane-rich biogas and a small quantity of well-stabilized digestate from the organic feedstock. In all anaerobic digestion technologies, the process occurs in an enclosed, controlled environment (i.e., within the "digester", or "bioreactor"). However, different digestion technologies are available, which produce different results regarding biogas and compost quantity and characteristics. The process may be "wet" or "dry", depending on the percent solids of the organic feedstock in the digester. The process temperature may also be controlled in order to promote the growth of a specific population of microorganisms, with process temperatures ranging from approximately 35-55°C (95-131°F). The process may be conducted in a single-stage or two-stage reactor vessel, and on a continuous or batch basis. Retention times of material in the digester can also vary.

- **Post-processing.** Anaerobic digestion results in a solid byproduct, called "digestate". It consists of organic material that is not readily digestible, along with inorganic material that escaped pre-processing. The digestate is commonly dewatered, with the liquid returned to the process or managed as a wastewater. The dewatered solids may be screened to remove inorganic materials, and are then aerobically finished, if necessary, to produce stable, mature compost, for sale as a product. The extent of post-treatment required to achieve stable, mature compost, as well as the quantity of compost produced, varies based on the digestion technology used. Also, depending on the extent of separation and preparation conducted prior to digestion, some technologies require more post-processing than others (e.g., some technologies require screening of digestate prior to aerobic finishing, and/or screening of mature compost).

- **Biogas Management.** Anaerobic digestion results in a biogas, composed primarily of methane and carbon dioxide. Higher-quality biogas has a higher percentage of methane, with individual digestion technologies producing biogas with methane concentrations ranging from approximately 55% to 80%. Biogas may also include small amounts of contaminants, such as hydrogen sulfide (H_2S). The concentration of H_2S and other contaminants in the biogas generally depends on the characteristics of the MSW. Commercially available technologies may be utilized to remove contaminants and otherwise improve the quality of the biogas (i.e., achieve a higher percentage of

methane), if such a step is necessary for a particular project. Often without any cleanup steps, the biogas can be beneficially used to generate electricity.

Two of the more advanced anaerobic digestion technologies for MSW are the Arrow Ecology ArrowBio process, and the Waste Recovery Systems Valorga process. These biological processing technology suppliers were reviewed and evaluated as part of comprehensive studies conducted by New York City and/or Los Angeles County. A summary of these two vendors is presented below.

1) Arrow Ecology and Engineering

ArrowBio
Sydney, Australia

Arrow Ecology & Engineering (Arrow), with headquarters in Tel Aviv, Israel, is the technology supplier for the patented ArrowBio wet anaerobic digestion technology (ArrowBio). ArrowBio process is specifically designed to process mixed MSW, because the upfront MSW separation and preparation system is an integrated component of the ArrowBio technology. The system can process sewage sludge and other organic wastes along with MSW.

Arrow has a reference facility located at a transfer station in Tel Aviv, Israel, which has been processing MSW commercially since late 2003. Arrow's reference facility has a digestion capacity of approximately 77,000 tpy (211 TPD, based on 365 days per year). However, pre-existing space limitations within the layout of the transfer station allowed for installation of only one, rather than two, separation and preparation lines in support of the digestion process. Due to these pre-processing constraints, Arrow's reference facility can only process approximately 38,500 tpy (105 TPD) of MSW.

Arrow is actively pursuing development of its technology in other locations. Arrow was awarded two contracts by the South West Sydney Councils Resource Recovery Project for development of facilities in areas of Sydney, Australia. The first, referred to as "Jacks Gully", is now fully constructed and in start-up mode, and will process 90,000 tpy (247 TPD) of MSW. The second project is under development for another suburb of Sydney (Belrose), with development pending additional commitment of waste to the project. Also, Arrow has reportedly been awarded a contract with the City of Pachuca, Mexico, with further

development of that project pending financial due diligence, and has been awarded a project in the U.K.

The ArrowBio technology consists of two integrated subsystems: (1) physical, water-based separation and preparation, and (2) biological treatment using two-stage anaerobic digestion, including an acetogenic bioreactor and a methanogenic, Upflow Anaerobic Sludge Blanket (UASB) bioreactor. The two components are uniquely integrated. Specifically, the digestion component requires a watery slurry (3-4% solids), similar to a wastewater from municipal sewage, in which the biodegradable organics are dissolved or present as fine particulates. Therefore, water-based separation techniques are used to separate and recover recyclables and remove inorganic materials, while simultaneously preparing the biodegradable organics into a watery slurry. Likewise, the digestion process is a net generator of water. Therefore, water generated during the digestion process is recycled back to the separation and preparation component as process water, which excess water used in other ways or discharged as wastewater.

The separation and preparation subsystem of the ArrowBio technology is a water-based system, integrated with traditional mechanical sorting equipment. At the ArrowBio reference facility in Israel, incoming MSW is deposited directly into the water bath as it is received. Proposed Arrow facilities, including those currently planned for suburbs of Sydney, Australia, will likely include a receiving moving floor ahead of the water bath to allow for manual picking of bulky items from the waste as it is being moved to the water bath, and to allow for the recovery of paper and cardboard. Future facilities may also include a bag opener prior to the water bath, to allow for more efficient sorting. The need for an extended walking floor ahead of the water bath as well as the need for a bag opener is determined on a project-specific basis.

The water bath in the ArrowBio system is a flotation tank. Water streams through the flotation tank, separating materials by density. Water is continuously recirculated through the flotation tank, creating a flow current that facilitates separation of materials. The continuous recirculation of the water also keeps the organic material in suspension and reduces odors. The separation of recyclables and inorganic material in the water bath is based upon the differing buoyancy of the fractions of the MSW. Plastics float in water; organic matter tends to stay suspended or is dissolved in water, and heavy materials such as metals, glass, textiles, and inorganic matter sink in water. As the heavy materials sink,

they are removed by a submerged walking floor. Upon removal, these heavy materials proceed through a bag opener (trommel screen) followed by magnetic separation for ferrous metal recovery, eddy current separation for nonferrous metal recovery, and manual sorting for other materials such as glass and textiles. The remaining material is returned to the flotation tank for further separation. At the end of the water bath the lighter stream materials (e.g., plastics), which float, are directed by paddles on the surface of the water bath to an "air float" system, where they are removed from the water bath. Lighter materials proceed through a bag opener, and subsequently automatic and manual separation of plastic for recycling. The organic fraction that is suspended in the water is size-reduced in a hydrocrusher, followed by filtering for additional removal of plastic and inorganic residual (grit). Some of the organic fraction and water is returned to the flotation tank for hydraulic balancing (along with water from the digestion process). The remainder of the prepared organic fraction is pumped to the digestion system as a watery, organic slurry (approximately 3 to 4 percent solids).

After material separation and organic preparation, biological treatment occurs in two types of bioreactors constructed in series: an acetogenic bioreactor, followed by a methanogenic bioreactor. Arrow's design uses two acetogenic reactors (in parallel) followed by one methanogenic bioreactor. In the acetogenic reactors, a specialized population of micro-organisms converts the organic material, by fermentation, into alcohols, sugars, and organic acids, which are then readily degradable in the second stage anaerobic reactor, the methanogenic reactor. Organic material must be sufficiently digested in the acetogenic reactor in order to pass through a fine screen into the methanogenic reactor. Fibrous material that is not very susceptible to microbial attack and that is not sufficiently digested cannot pass through this fine screen and is periodically removed from the acetogenic reactor as digestate.

The second stage methanogenic digester is the Upflow Anaerobic Sludge Blanket (UASB) type. UASB digesters have successfully been used to process wastewaters generated by the food- and beverage-processing industries. ArrowBio has applied this experience to processing MSW. In the UASB methanogenic bioreactor, micro-organisms convert the alcohols, sugars, and organic acids into biogas, which consists mainly of methane and carbon dioxide, and biomass, also known as digestate. The UASB reactor has a very high solids retention time, which is the average amount of time that the micro-organisms (i.e., solids) remain in the reactor. For the ArrowBio process, the solids-retention time is

approximately 75-80 days. The high solids-retention time provides for a highly efficient digestion process, resulting in a biogas with a significantly higher percentage of methane than other anaerobic digestion technologies. Also, the higher-efficiency process results in a lower volume of digestate, which is well stabilized.

The ArrowBio technology recovers recyclables, generates biogas that can be combusted to produce electricity, and generates a compost product, as summarized below:

- **Recyclables.** The ArrowBio process recovers traditional recyclables from the incoming MSW in the water bath. Materials that are recovered in the process include ferrous metal, aluminum, mixed film plastic, and glass.

- **Energy.** The ArrowBio anaerobic digestion technology produces biogas at a rate approximately equal to 11% of the incoming MSW by weight. The biogas produced in the ArrowBio process consists of methane, typically at a concentration of 70% to 80%, and carbon dioxide at a concentration of approximately 20% to 30%. Arrow also reports that trace amounts of hydrogen sulfide (i.e., less than 100 parts per million), oxygen, and nitrogen are present in the biogas.

  Arrow combusts the biogas in a reciprocating engine to produce electricity. The Arrow Bio facility in Israel utilizes a Caterpillar engine. Supplemental fuel (e.g., natural gas) is not used. The gross energy production rate for the ArrowBio technology is reported to be 300 kWh per ton of incoming MSW. The technology requires approximately 50 kWh for internal use, resulting in net electricity generated for export (sale) of approximately 250 kWh per ton of incoming MSW.

- **Other Products.** Compost is produced from dewatered digestate, with only passive aerobic finishing, if required (i.e., further stabilization of the digestate via on-site storage, with no active management to mix, turn or otherwise mechanically aerate the material). The compost production rate is approximately 14% of the incoming MSW (on a wet weight basis). No screening is conducted on the compost, reportedly because screening is not required.

- **Residue.** During front-end separation and preparation, recyclables and biodegradable organic materials are separated from inorganic and non-biodegradable material (e.g., grit, textiles, rubber, and composite packaging or consumer materials). The fraction that is not recyclable or biodegradable is considered residue requiring disposal at a landfill. For the ArrowBio process, up to approximately 23% of the MSW received for processing will be residue requiring disposal. This residue includes 2-3% glass that could potentially be recycled with development of a stable secondary market local to the facility. Unlike some other anaerobic digestion technologies, the ArrowBio technology does not generate residue after digestion. This is because the ArrowBio technology includes an

extensive, water-based, hydro-mechanical separation and preparation process integral to, and preceding the digestion process, avoiding the need to screen the digestate or the finished compost after the digestion process.

2) Waste Recovery Systems, Inc.

Waste Recovery Systems, Inc. (WRSI) is the United States representative for the Valorga anaerobic digestion technology, developed by Valorga International of Montpellier, France. WRSI has offices in Monarch Beach, California.

The Valorga process may be used for treatment of either mixed MSW, or for the source-separated organic fraction of MSW. In addition, sewage sludge or biosolids may be processed with MSW. The Valorga process is considered a "dry" anaerobic digestion process, since it processes organic feedstock with a solids content greater than 30%.

The Cadiz Plant
Spain

The Valorga anaerobic digestion technology has been operating commercially since 1988, with the first commercial plant (located in France) processing MSW. One of the newest, and largest, Valorga facilities is located in Barcelona, Spain, and also processes MSW. This reference facility began operations in 2004, and processes approximately 264,552 tpy of waste (725 TPD, on average, based on 365 days per year). The facility processes approximately 90% MSW (greater than 240,000 tpy) together with biowaste (source-separated, organic household waste).

For processing mixed MSW, WRSI reports that the Valorga digestion system would be coupled with a traditional materials recovery facility (MRF) at the front-end of the process, to recover recyclables and separate out non-biodegradable materials. The front-end processing would also include separation and size reduction equipment, to achieve a biodegradable organic fraction suitable as feedstock for the digester.

To achieve optimal conditions for microbial degradation in the Valorga system, the prepared MSW feedstock must be diluted, inoculated and heated. The exact weight of the

material entering the digester is stated to be a critical design parameter for the Valorga process. The material to be digested is weighed on a device that is integral to the conveyor system leading to the digester. The initial moisture content of the incoming waste is also measured, and sufficient dilution water (recycled from the process) is added to achieve a solids content of 30% to 35%. The material is then heated by steam injection to raise the temperature of the mixture to operating temperature, and mixed with a small amount of digested material to inoculate it with anaerobic microorganisms. The prepared material is pumped into the digester, to begin the digestion process.

The Valorga digester is a cylindrical concrete tank, with an inner wall extending vertically across two-thirds of the digester diameter. Prepared material is injected into the digester on one side of the inner wall, and digested material is extracted on the other side of the inner wall. This design ensures sufficient residence time of the material in the digester, preventing "short circuiting", which occurs when material proceeds too rapidly on a direct path from the inlet to the outlet. Material moves through the digester, around the wall, in a plug flow manner, with an average retention time of 16 to 17 days. During digestion, pressurized recirculated biogas is injected through nozzles located in the floor of the digester, mixing the digesting material. This pneumatic mixing is used in place of mechanical mixers, which would be subject to significant wear within the digester.

The digested material is removed from the digester and is dewatered using a screw press. The liquid that is pressed from the digestate in the screw press operation is put through a centrifuge in order to separate the suspended solids from the liquid. The centrifuge centrate (liquid) is recycled back to the digester feed pump for use as dilution water. The dewatered solids from the screw press are combined with the dewatered solids from the centrifuge and are aerobically finished in order to produce a stabilized compost product. Aerobic finishing requires approximately 14 days. After aerobic finishing, the compost is screened to remove inert materials that passed through the process. These inert materials are disposed of as residue.

The WRSI/Valorga technology recovers recyclables, generates biogas that can be combusted to produce electricity, and generates a compost product, as summarized below:

- **Recyclables.** Traditional recyclables would be recovered in a front-end MRF that is coupled with the Valorga technology. WRSI reports that approximately 88% of the metal and 28% of the plastic present in the waste would be recovered. Actual

recovery rates would depend on the MRF equipment components and configuration.

- **Energy.** The Valorga anaerobic digestion technology produces biogas at a rate approximately equal to 15% of the incoming MSW by weight. The biogas produced in the Valorga process consists of methane, typically at a concentration of 55%, and carbon dioxide at a concentration of approximately 45%.

  The Valorga facility in Barcelona, Spain is equipped with gas engine generators, for purposes of generating electricity from the biogas. Supplemental fuel (e.g., natural gas) is not used. The energy production rate is reported to be 218 kWh per ton of incoming MSW. The technology requires approximately 94 kWh for internal use, resulting in net electricity generated for export (sale) of approximately 124 kWh per ton of incoming MSW.

- **Other Products.** The compost production rate is approximately 24% of the incoming MSW (on a wet weight basis).

- **Residue.** For the WRSI/Valorga process, an estimated 31% of the MSW received for processing will be residue requiring disposal. The front-end processing will generate an estimated 24% residue, and post-processing screening of compost will generate an estimated 7% residue.

MSW Composting

One alternative to landfilling that is particularly appealing due to its significant potential for waste diversion is in-vessel composting of municipal solid waste (MSW). Organic materials comprise the majority of MSW (typically 60-70%), so composting could play a role in achieving the waste reduction goals set by various States. The technology features controlled oxygen, moisture, and temperature environments to accelerate the decomposition of organics. Each in-vessel stage is generally followed by a curing stage, which is either an aerated-static pile, or traditional windrow.

Municipal Solid Waste (MSW) Composting facilities struggled in the past with financial troubles, inconsistent results, and skepticism among market end-users. Primary challenges for the earlier facilities included competing with low-cost landfill tip fees, inadequate investment in odor control systems, and quality control of the feedstock and compost end-product. During the 1980s and 1990s MSW composting facilities were not very successful, however, new facilities have began to further develop process controls and operating procedures to control odors and improve compost quality.

Cost and cost control are primary drivers with respect to solid waste management. Some of the key market influences for cost fluctuations include:

- The value and marketability of the compost and product
- Residual haul distances and disposal tipping fees
- Labor and material and the availability of funding
- Contractual arrangements
- Regulatory compliance requirements and costs

The outstanding questions regarding MSW composting are the quality and marketability of the final product, and the overall cost. This net cost is strongly impacted by the cost of residue disposal and the value and marketability of the finished compost.

Typical tip fees for MSW composting facilities vary from $40 to $75 per ton. The most significant economic advantage for composting occurs when costs for recycling are factored into the overall solid waste management program. Since composting facilities offer diversion rates of between 60 percent and 75 percent of the incoming waste, composting facilities allow solid waste managers to integrate this technology with their recycling programs to more effectively plan and control costs.

Examples of firms currently pursuing projects in the U.S. include:

Bedminster has now developed 12 projects worldwide, including six in the U.S., all handling mixed MSW and biosolids. New plants have come on line in the past few years, including the 700 TPD (designed to handle over 1,000 TPD) facility in Edmonton, Alberta. The company is now licensing the technology to others for project development. The Bedminster system is designed to handle MSW and biosolids together, usually a 2:1 mix. It is not designed to run on MSW alone.

Conporec is a French-Canadian company with a front-end technology similar to Bedminster. They operate a North American plant located north of Montreal in Tracy, Quebec that processes 35,000 TPY of mixed MSW (everything except Blue Box recyclables). They have also been awarded a 38,000 TPY facility in Delaware County, Delaware to process a mix of MSW and biosolids.

Herhof is a European technology with roughly 50 installations there. Historically, the Herhof system has focused on source-separated organics as a feedstock for production of compost. A more recent thrust has been the processing of MSW for the production of Stabilite, their patented fuel that is sold to WTE, cement kilns, and conventional

power plants. The company is proposing a modified system to process MSW and produce compost and Stabilite. Their one North American facility, in Peele, Ontario (outside Toronto) processes 16,000 TPY of MSW for sale as compost.

ECS (Engineered Compost Systems) operates a 50 TPD MSW composting facility at West Yellowstone, MT, and another 50 TPD MSW composting plant in Mariposa County, CA. The latter system features an upfront MRF followed by eight composting vessels for primary composting and an aerated static pile (ASP) system for extended curing.

Currently, there are 13 mixed MSW composting facilities operating in the United States:

- Gilroy, CA
- Mariposa, CA
- Cobb County, GA
- Marlborough, MA
- Nantucket, MA
- Truman, MN
- West Yellowstone, MT
- West Wendover, NV
- Delaware County, NY
- Medina, OH
- Rapid City, SD
- Sevierville, TN
- Columbia County, WI

Table 2 of this Appendix provides summary information on these facilities. The following sections are excerpted *verbatim* from BioCycle November 2007, Vol. 48, No. 11, p.22.

TABLE 2 – MSW Composting Facilities in the U.S.

Table 1.

MSW Composting Facilities in the US

Location	Owner/Operator	Project Start Date	System	Feedstock	Throughput (TPD)	Tipping Fee	Cost to Operate	Diversion %	Final Products
Gilroy, CA	Private/Z-Best Composting	2001	Enclosed ASP (Ag Bag, large plastic tubes)	Mixed waste, including dirty MRF screenings, residential MSW, commingled garbage and yard waste	280			70%	MSW compost only marketed to non-food related users
Mariposa County, CA	Municipal	2006	In-vessel (SV Composter - Engineered Compost Systems (ECS))	MSW from residents and businesses, and Yosemite National Park	60	$70/ton or $9.57/cy un-compacted and $19.14/cy compacted	Project totaled $8.3 million	50%	Daily Cover (ADC) at the County's landfill
Cobb County, GA	Municipal	1996	Rotating drum/aerated windrow (Bedmister)	MSW and treated biosolids	200			60%	Bio-Blend compost, offered free to residents, available for commercial sales
Marlborough, MA	Municipal/WeCare Environmental	1999	Rotating drum/aerated windrow (Bedmister with Allu turner)	MSW, biosolids, source separated organics	100 (with 5 tpd biosolids)			65%	30,000 cy of compost/year, 15% sold for $4 to $8/cy, the balance distributed at the cost of transportation
Nantucket, MA	Municipal/Waste Options, Inc.	2005	Rotating drum/aerated windrow (Bedminster) (Waste Options investigating use of pyrolysis)	Yard waste, MSW, biosolids	125 peak/30 off-peak (with biosolids)	$90/ton		80%	Topsoil and compost for sale (50% of compost sale goes to the Town), 1-6 cy is $35/cy, 7-16 cy is $30/cy, >16 cy is $25/cy
Truman, MN (Prairieland SWMB)	Municipal	1991	In-vessel (OTVD agitated bay composting system)	MSW	65	$75/ton			Portion of residuals are burned as refuse-derived fuel, rest is Class 2 compost (with a fee for trucking to haul to farmers)
West Yellowstone, MT	Municipal	2003	In-vessel (SV Composter - ECS)	MSW from Yellowstone National Park only, receive a lot of recylceable material that can't be recovered (stopped receiving biosolids in 2007) (planning to add bison road kill in 2008)	3,000 tons/year	$207/ton	$200/ton	50%	2,000 cy/year of compost sold in bulk for $15/cy
West Wendover, NV	Municipal		Rotating drum/aerated windrow	MSW and biosolids	25 (with biosolids)			70%	14 tpd of compost and 6 tpd of noncompostable garbage which is hauled to the landfill
Delaware County, NY	Municipal	2006	Rotating drum/agitated bays (Conporec/IPS - Siemens)	MSW, biosolids, select commercial/industrial organics from dairy farms	24,000 tons/year (with 6,500 tons/year biosolids)	no tipping fee	$50/ton	62%	Compost, mostly sold to a broker on a profit share basis, some direct sales from facility
Medina, OH	Municipal/Norton Environmental	1994	Windrow	Screend mixed organic waste from onsite "dirty" MRF, yard trimmings and wood	45				Compost used for landfill applications (ADC, slope cover)
Rapid City, SD	Municipal	2003	Rotating drum/agitated bays (Dano/IPS - Siemens)	MSW, biosolids	180 (with 12,000 gal biosolids)	$45/ton		27%	40 to 50 tpd of compost which is given away (may try to market to golf courses)
Sevierville, TN	Municipal	1992	Rotating drum/aerated windrow (A-C Equipment, Backhus turner)	Residential and commercial MSW, biosolids (not presently composting due to a major facility fire May 2007, plans to rebuild and expand)	250 (with 50 tpd biosolids)	$40/ton	$25.34/ton	60%	60% composted, 40% to an unlined demolistion debris landfill (in 2006 30,000 tons of compost was produced and sold to a marketing company for soil blending, topdressing and erosion control)
Columbia County, WI	Municipal	1992	Rotating drums/windrows	Residential MSW	70-80	$34/ton			3,000 tons/year of compost produced and given to local farmers at no cost

These 13 mixed MSW composting facilities are operating in the United States:

1) **Gilroy, California**: The Z-Best Composting site south of Gilroy was permitted in 1998 to accept up to 1,300 tons/day of curbside collected yard trimmings. In 2001, Z-Best was permitted to process municipal solid waste at the site as well. A sorting line was installed at the facility, which included hand sorting stations, as well as a BHS de-bagger, disc screen and a shredder. Materials passing through the 3-inch minus shredder were composted in Ag Bags. The company targeted "organics-rich" compactors, primarily from its commercial collection routes as well some residential. In addition to the compactor loads, the facility takes in screenings from a dirty MRF in Sunnyvale operated by a sister company, Zanker Material Processing Facility. "We receive about 280 tons/day of mixed waste, including the dirty MRF screenings, MSW from residential sources and commingled garbage and yard waste," says Michael Gross of Z-Best Composting.

   Z-Best is in the process of changing its operations at several of its recycling facilities in the San Jose region. As a result, it is dismantling the front-end processing plant at the Gilroy site. "All materials will go through our new MSW MRF in San Jose," adds Gross. "Processed material that has been cleaned will be hauled to Gilroy for composting. This way, we won't have to haul residuals back to our landfill. It is a better use of that composting site."

2) **Mariposa County, California**: The Mariposa County mixed waste composting plant began operating in the summer of 2006. The facility is designed to process 60 tons/day of material from residents and businesses in Mariposa County, as well as Yosemite National Park. Finished compost is used for daily cover at the county's landfill. Equipment at the plant includes a Bulk Handling Systems sorting line (including a de-bagger) and SV Composter vessels from Engineered Compost Systems (ECS). In the fall of 2006, there were some odor complaints that needed to be addressed. Part of the problem was traced to the biofilter, which wasn't functioning properly. ECS rewetted and reformed the media, added additional material and put an exhaust air humidifier that had been installed initially but wasn't in operation at that time, back in service. Odor emissions were significantly reduced both in frequency and severity, reports ECS.

3) **Cobb County, Georgia**: The Cobb County mixed waste composting plant opened in 1996 to process 300 tons/day of mixed waste with 100 tons/day of biosolids. As reported in last year's BioCycle, the facility is operating at 200 tons/day. Operations have not changed much during 2007. The compost is a mixture of MSW and treated sewage sludge, which enters rotating drums for three days, and then is screened and placed in aerated windrows for 28 days. After a second and final screening, its Bio-Blend compost is offered free to residents for individual use, and is available for commercial sales by appointment.

4) **Marlborough, Massachusetts**: Starting its eighth year of operation this fall, this 120 tons/day rotary drum co-composting facility processed 34,000 tons of mixed MSW, 12,000 tons of biosolids and 8,000 tons of source separated organics. According to Chris Ravenscroft, President of WeCare Environmental, owner and operator of the facility under contract to the City of Marlborough to process its MSW, it had to reduce the quantity of biosolids processed through the facility and have continued to identify new, clean sources of organic wastes, such as supermarkets.

   The facility produces approximately 30,000 cy of compost per year, with 15 percent sold for $4 to $8/cy, and the balance distributed at the cost of transportation. Compost is used for topdressing existing lawns and athletic fields, as well as to manufacture topsoil. The compost is screened through a 3/8-inch McCloskey trommel screen. "We find that the markets have a very low tolerance for contamination," says Ravenscroft. The residue rate from material processed through the composting system is approximately 35 percent.

5) **Nantucket, Massachusetts**: On the Island of Nantucket off the coast of Cape Cod, Waste Options, Inc. continues to operate the 125 tons/day MSW and biosolids co composting facility under a 25-year contract with the Town of Nantucket. The last two years have focused on compost marketing, and Whitney Hall, President of Waste Options, reports that demand for the compost and organic topsoil continues to grow. "Landscapers who bring in yard waste are our largest customers, and we sell more topsoil than straight compost," he says. "We also have some distributors who take bulk deliveries and market the product."

   The MSW compost is refined with a bivi-TEC screen and a de-stoner to remove glass, and then blended with ground yard trimmings for further curing. One modification to the blending recipe has been to cut back on the amount of chipped wood and brush and use more leaves and wood fines. Hall explains that this results in less wood and sticks to screen out of the final product. "Instead of using a 3/8-inch screen in the McCloskey trommel, we are using a one-half inch screen," he notes. Waste Options has a sliding scale price for the organic topsoil, with discounts for larger quantities - 1-6 cy is $35/cy; 7-16 cy is $30/cy; and >16 cy is $25/cy. Fifty percent of compost sales revenues go to the Town.

   As for possible changes at the facility, Hall says Waste Options is investigating the use of pyrolysis, a high temperature process that would extract combustible gas from the compost facility residuals, and construction and demolition debris. The gas would be used to generate electricity to power the plant. "I have looked at two operating pyrolysis facilities and have discussed it with the Town and the Massachusetts Department of Environmental Protection (DEP)," he says. "It appears that the process could be permitted by the DEP. A quick look at the economics indicates that it could be viable, so the Town is forming a committee and hiring a consultant to assist with a feasibility study."

6) **Truman, Minnesota:** The Prairieland Solid Waste District steadily processes 65 tons/day in its OTVD agitated bay composting system, with no plans to expand capacity. A portion of the residuals from the process are burned as refuse-derived fuel (RDF). According to the facility's director, Mark Bauman, if demand for RDF expands, the District might install an additional shredder to produce more fuel. It still produces 3,000 tons/year of compost, and will land spread it for no charge. A fee for trucking is charged to haul compost to farmers, and eventually, when demand increases, a small fee will be charged for the compost. In the last year, there has been growing demand for the end product to use in animal mortality composting, particularly with the swine industry. Pork producers use the compost as an amendment to process piglet mortalities, and the occasional sow.

The facility's tipping fee is currently $75/ton. A bivi-TEC is used to screen the compost to five millimeters. Due to fluctuating levels of lead, the District's compost is usually Class 2. "We landfill some residuals that could be used for fuel, but just don't have capacity in area to burn it at this time," says Bauman.

7) **West Yellowstone, Montana:** The West Yellowstone Compost Facility, operated by the Hebgen/West Yellowstone Refuse District, is designed processes 3,000 tons/year of mixed MSW. It uses an in-vessel composting system supplied by Engineered Compost Systems. "We accept mixed MSW from Yellowstone National Park only," explains Kathy O'Hern, facility manager. "The Park's waste stream includes a small amount of residential material. The remaining waste stream consists of waste generated in campgrounds, concessionaire restaurants and hotels, roadside bins and the Park's trade shops, e.g., electrical, plumbing and woodshops."

The plant opened in July 2003. Initially, it also accepted biosolids from the park. "The only change we made to our operations in 2007 was to stop accepting biosolids," adds O'Hern. "Although we are permitted to handle biosolids, we found that this material does not work well in our incline coreless auger conveyor." During 2008, the facility is planning to add a road kill composting program for the bison hit on local highways.

About 2,000 cy/year of compost are produced. It is sold in bulk for $15/cy. The facility has a bivi-TEC screen and a Forsberg de-stoner to remove contaminants from the compost. "About 95 percent of the contaminants are removed," she says. "The final compost continues to contain small flecks of colorful plastic picnic ware." Overall, residue from operations accounts for about 50 percent of the total incoming waste stream. "We receive a large amount of recyclable materials that cannot be recovered with our existing system," adds O'Hern. Tipping fee at the facility is $207/ton; cost to operate, including loan repayment, is $200/ton.

8) **West Wendover, Nevada:** The city of West Wendover's composting facility accepts up to 25 tons/day of garbage, which is mechanically sorted and combined with up to 5 tons/day of biosolids (generated by the nearby wastewater reclamation facility). The compostable mix is then loaded into cement kilns, which operate as rotary drums. The end result is 14 tons/day of compost, and 6 tons/day of non-compostable garbage such as glass and C&D debris, which is hauled to the landfill for disposal. By combining the MSW and biosolids, West Wendover is achieving a 70 percent recycling rate, notes a statement on its website.

9) **Delaware County, New York:** "This year has been a good one for our compost facility, and I have to say we are successfully producing a quality product with minimum down time," reports Susan McIntyre, Solid Waste Director for the Delaware County Department of Public Works. The facility, which is owned by the county, came on line in May 2006. Its processing line includes a Conporec rotary drum and Siemens/IPS agitated bays (14 in total). The plant is processing 24,000 tons/year of MSW, 6,500 tons of biosolids and 2,800 tons of select commercial/industrial organics from local dairy plants.

McIntyre describes a number of minor changes made in the plant over the last year as part of fine-tuning the operation. "We made some adjustments to the bioreactor's interior for better waste tumbling and mechanical separation," she says. "We also added chains and paddles to the trommel screen interior to improve organics separation and screen cleaning. A leveling bar was added to the infeed conveyor to the pulverizer that crushes glass in the final compost product." The county instituted a two-week preventive maintenance shut down, a practice it plans to continue.

Operationally, the most significant change has been a more aggressive effort to divert problematic waste items such as hose, tubing, strapping, carpet and other bulky objects that contribute to generation of large "hair balls" inside the drum. "We are working with the private haulers who collect the MSW, and are making progress," adds McIntyre. "Our crane operators have gotten more skilled at removing these materials from the tip floor prior to loading into the bioreactor. Once the operators extract a few hair balls out of the discharge end they tend to get more discriminate as to what they load in the front end!" To help with removing the hair balls that still are created, the county installed a permanent winch with custom designed logging grapples to hook onto the balls and pull them out.

Total residuals from the composting facility are 38 percent by weight, and 20 percent by volume, a more important number to Delaware County since all residuals go to its adjacent lined landfill. Landfill staff has found that disposal of wet residuals (about 55 percent moisture) has advantages over the drier MSW they used to bury since it is easier to handle and has less wind-blown litter. Recyclable materials are diverted through a separate MRF prior to MSW being

delivered to the composting facility. The MRF is located on the same site. The facility does not charge a tipping fee, but McIntyre reports that operating costs and debt service are in the low to mid $50/ton. The County sold approximately 7,500 cy of compost in the first three quarters of 2007. Most is sold to a broker on a profit share basis, with limited direct sales from the facility. Testing has repeatedly shown that the compost contains less than one percent foreign particles by dry weight. "We have a dedicated staff that is committed to what we are doing, and believe in it, and that is an important contribution to our success thus far," says McIntyre.

On the regulatory front, the New York State Department of Environmental Conservation recently determined that the facility must register as a minor air emission source due to its biofilter. Using data from comparable composting facilities and their biofilters, the county was able to demonstrate that the facility is in the state's lowest regulatory threshold for emissions of NOx and SOx. As for odor complaints, McIntyre says that when the occasional complaint comes in it is usually the adjacent landfill. "It's a different odor from the composter, and we can recognize it too," she says.

10) **Medina, Ohio:** Medina County has operated a mixed municipal solid waste processing facility ("dirty MRF") since 1993. Between 140,000 and 150,000 tons/year of MSW is tipped at its Central Processing Facility. Recyclables are removed via manual and automated sorting. Screened two-inch minus fines (the mixed organic waste fraction) are composted with yard trimmings and wood. Compost is used for various landfill applications. Recently, the facility began producing refuse derived fuel pellets from shredded paper and film plastic.

11) **Rapid City, South Dakota:** The mixed waste composting plant in Rapid City will celebrate its fifth year of operation next May. The plant has two rotary drums, followed by a nine-bay Siemens/IPS composting system. "We currently process 180 tons of MSW/day, down from 200 tons/day last year," says Mike Oyler, plant manager. "Our goal is to get a better breakdown of the organic fraction by putting less material through the drums. We are finding that by not overloading the drums, we are getting better separation of the MSW as it has more room to tumble." The facility co composts the MSW with about 12,000 gallons/day of biosolids. Retention time in the bays is 28 days, followed by secondary composting in aerated piles in an adjacent building. "We decreased the height of these piles, as well as piles of finished compost outside, to 6-feet," adds Oyler. "That eliminated a lot of odors. We think the piles were going anaerobic." On occasion, material is put back through the bays for a total retention time of 56 days. "That compost is much darker in color and when we screen it, it looks like wet coffee grounds."

The media in the biofilter was changed earlier this year; staff decided to use compost screen overs instead of wood chips only. In addition, the biofilter

sprinklers were changed from a rotating head with a 30-foot pattern to umbrella head sprinklers that cover a 10-foot area, providing better overall coverage. In addition, operators are building a screen to further refine the finished compost. "We've designed a small vibration unit with a 1/8-inch screen," says Oyler. "We'd like to market this compost for use on golf courses and to top-dress lawns." Roughly 40 to 50 tons/day of compost is produced using a 1/8-inch screen. Finished compost is given away. "We are getting great testimonials from area residents who are using the compost on their lawns and gardens," he adds.

12) **Sevierville, Tennessee:** Sevier Solid Waste Inc.'s 15 year-old MSW co composting facility, the largest operating plant in the U.S. in 2006, burned to the ground on May 31, 2007, completely destroying the 102,000 square foot building that housed the tip floor and compost hall. As fully described in the accompanying article, the five rotary drum compost vessels and their hydraulic rams were saved by the Pigeon Forge Fire Department. Pending final terms of the insurance settlement, Sevier Solid Waste Inc. plans to rebuild the facility, expanding it to 180,000 square feet and making significant changes to the materials flow process.

Prior to the fire, the facility was processing 250 tons/day of MSW and 50 tons/day of biosolids. A new Backhus windrow turner had been purchased and was being used to turn and aerate the compost piles; the forced aeration system had been turned off. According to Tom Leonard, Solid Waste Director, the aeration trenches had been a continual maintenance challenge due to clogging of the specially manufactured plastic grates developed by Bedminster Bioconversion when it built the facility. The grates were also prone to being dislodged by the loader bucket as it was turning the piles, and had to be continually replaced.

All of the residential and commercial MSW generated in Sevier County was being processed at the facility, with 60 percent of the total tons converted to compost. The remaining 40 percent residue, mostly plastic, glass and metal, goes to an unlined demolition debris landfill operated on an adjoining parcel of land, thereby diverting the residue from a lined landfill. There is no upfront sort line for recyclables, and after discharge from the digesters the recyclables are too dirty for marketing. In the early years, the facility utilized a belt magnet to pull metals off the residuals, as well as an eddy current separator to extract aluminum. Both streams were shredded and screened to remove dirt. However, neither metal product was sufficiently clean for recycling markets. In 2006, notes Leonard, the facility produced almost 30,000 tons of 1/4-inch screened compost. All of it was sold to a company that markets the materials for soil blending, topdressing and erosion control. The tip fee at the facility is $40/ton, with total costs to process MSW and biosolids, as well as dispose of residue, estimated at $25.34/ton.

13) **Columbia County, Wisconsin:** The Columbia County Recycling and Waste Processing Facility has been operating since 1992, and continues to process between 70 and 80 tons/day, although the flow is a bit higher in the summer.

> There are two rotary drums, each loaded with five yards of material at a time, with a daily capacity of 40 tons (maximum capacity of 250 tons per drum). After five days in the drum, the compost goes through a 15-foot long screen with 3/4-inch holes. The compost is then put into windrows for eight weeks, and is finally screened to 3/8-inch. About 3,000 tons/year of compost is produced. It is given away at no cost to local farmers. According to Bill Casey, the facility manager, national waste companies have been purchasing the independent haulers in the county, including those servicing municipalities. These companies also own the landfills, and with an inside market, they are able to undercut the $34/ton tip fee at the MSW composting facility, making it increasingly difficult to maintain the throughput. "We had to go out and do our own collection; we offer curbside collection in certain areas," says Casey.

MSW composting continues as a "niche" type conversion technology, gaining hold in smaller communities, by and large, and one with a certain environmental ethic. The difficulties in providing a final product of high quality, free of contamination continue to be an issue. Likewise, overcoming the negative public perception regarding products derived from MSW, has proved difficult. Economics have been adversely affected by this inability to build final product value.

However, the simplicity of these systems still continues to amaze and should stronger markets develop over time, MSW composting could realize a resurgence.

CHEMICAL PROCESSING

Chemical processing technologies use one or a combination of various chemical means to convert MSW into usable products, often uniquely encompassing aspects of other conversion processes such as digestion and gasification. An example of a chemical processing technology is depolymerization, which is the permanent breakdown of large molecular compounds into smaller, simple compounds.

Depolymerization is thermal in nature, but instead of a single thermal reaction step it involves a number of complex and interrelated processing steps, some similar to petroleum refining. In simplified terms, the process is an advanced thermal process that utilizes water as a solvent, converting the organic fraction of MSW into energy products (steam and electricity), oil and specialty chemicals. Following up-front sorting to remove recyclables and inorganics, the major steps of the depolymerization process are: (1) pulping and slurrying the MSW with water; (2) heating the slurried MSW under pressure; (3) quickly

lowering, or "flashing" the slurry pressure to release and recover gaseous products (which can be converted to light hydrocarbons or used to generate electricity); (4) reheating the slurry to drive off water and light oils from the solids; and (5) separating the light oils from the water. Further processing of the oils (e.g., distillation, solvent extraction, cracking) can be used to produce higher-value oils, equivalent to #4 and #2 oil products. The process also generates carbon solids, which could be activated and used as a filter medium or as a soil amendment.

Hydrolysis

Hydrolysis is generally a chemical reaction in which water reacts with another substance to form two or more new substances. Specifically in relation to MSW, hydrolysis refers to a chemical reaction of the cellulose fraction of the waste (e.g., paper, food waste, yard waste) with water and acid to produce sugars. The sugars are then fermented to produce an alcohol, followed by distillation to separate the water from the alcohol and recover a concentrated, fuel-grade ethanol.

Sorting of the MSW (for example in a Material Recovery Facility or MRF) must take place to first obtain the organic fraction. Glass, metals and plastic can be recovered as recyclables, while non-recyclable inorganics are removed and disposed of as residue. The organic material is then shredded and introduced into a reactor vessel. Acid is added to the reactor vessel as a catalyst, and within the reactor the material is "cooked" to convert complex organic molecules to simple sugars. Since the acid merely catalyzes the reaction and is not consumed in the process, it can typically be extracted and recycled in the process.

Byproducts of the hydrolysis conversion process include gypsum and lignin. Gypsum, which is a marketable product used in wallboard, is produced from the addition of lime slurry to the process to neutralize the sugar after hydrolysis and remove metals. Lignin, which is the organic, non-cellulose material that is not converted by the acid, can be gasified or combusted to generate steam to support process operations.

In most cases, hydrolysis is the first step in a multi-step technology. For example, the additional process steps of fermentation and distillation can be combined with hydrolysis for conversion of the sugars to fuel-grade ethanol. Fermentation of the sugars also produces carbon dioxide, which can be purified, compressed and marketed. Alternately,

the sugars can be converted to levulinic acid, which is a commonly-used chemical feedstock for other chemicals with established and emerging markets (e.g., methyl tetrahydrofuran, an oxygenated fuel additive). Two of the more promising of these technology vendors are discussed herein.

1) Masada OxyNol

Hydrolysis is not yet in commercial operation for MSW. However, at least one company (Masada OxyNol) is advancing the technology to commercial application for MSW. In the early 1990's, Masada began the Masada OxyNol™, LLC business venture, which integrated and piloted existing technologies, and advanced a project for MSW-to-ethanol processing plant in Orange County, New York. In 1996 a feasibility study was conducted and relations were developed with the Orange County municipality of Middletown, and surrounding municipalities. Subsequently, necessary legal, financial and engineering procurement work was completed by Masada, resulting in a contract for waste supply from Middletown and surrounding communities, which was signed in the summer of 2004. The New York State Environmental Quality Review Act (SEQR) Environmental Impact Statement (EIS) was completed, and the project was fully permitted by the New York State Department of Environmental Conservation.

Masada's owner, who closely managed the OxyNol business venture and the Middletown, NY plant development passed away in 2005. Further development work was suspended while the company sought strategic investors and management support. Subsequently, ownership issues were resolved and the project began to move forward. Significantly, the New York State Part 360 Solid Waste Permit and the Title V Air Operating Permit, which were obtained during project development and allow construction of the facility, were renewed. Construction of this facility is planned to start in 2008. Masada is also pursuing international projects. In November 2007, Masada entered into a joint-venture agreement with a privately-owned group of waste management companies in the Dominican Republic, and has proposed at least one project in that Country.

2) BlueFire Ethanol

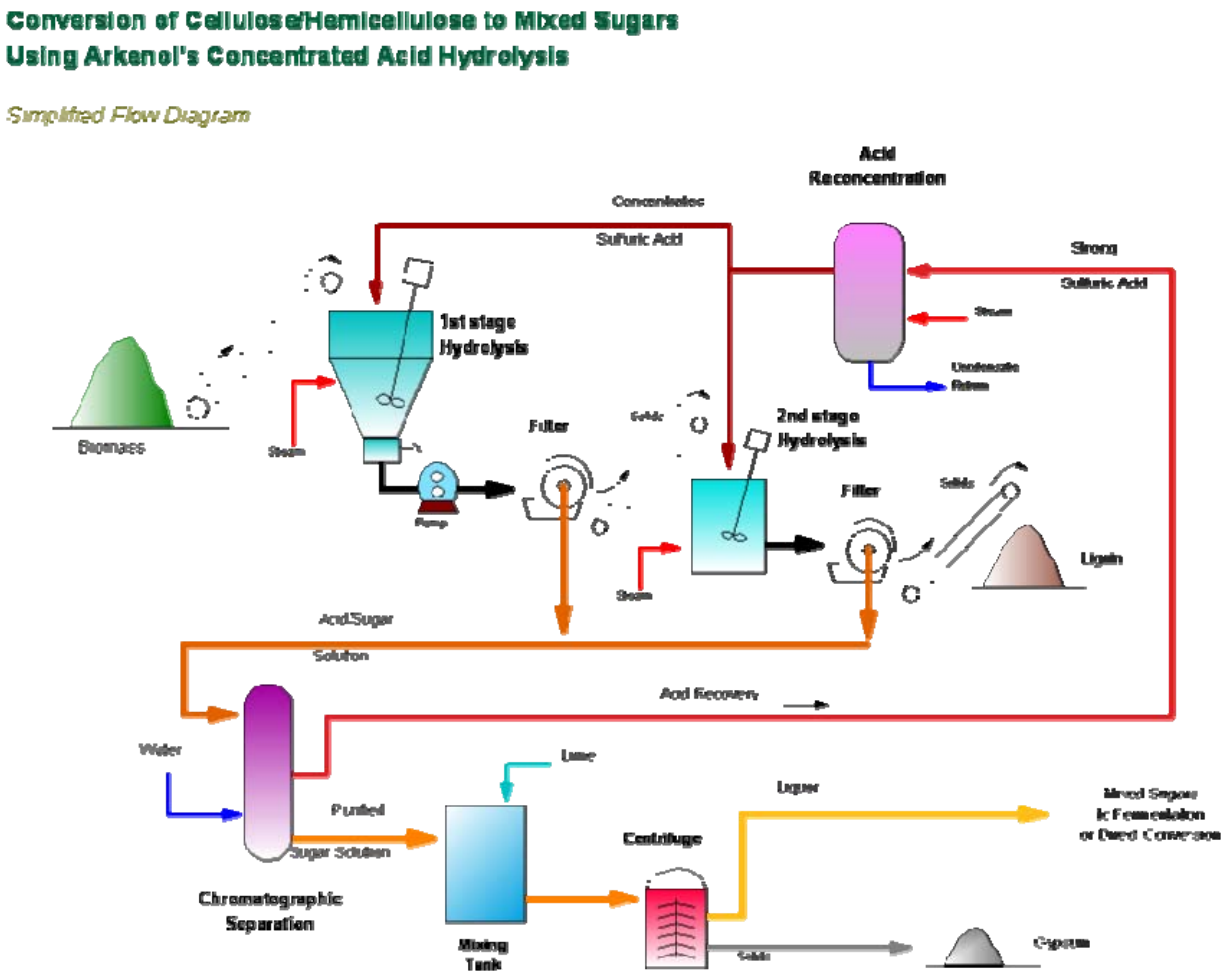
BlueFire Ethanol (formerly Arkenol) of Irvine, CA has received a grant from the US DOE for $40 million towards development of a commercial scale cellulosic ethanol plant. The facility will receive and process approximately 800 TPD of greenwaste, wood waste and MRF residuals, and will be located adjacent to the El Sobrante Landfill near Corona, CA. The Company must match funds with 60% private investment.

In advance of the large plant, BlueFire has received all permits and is due to start construction in the 1st quarter of 2009 of a similar but smaller biorefinery adjacent to the existing Lancaster, CA landfill. This biorefinery will convert roughly 250 TPD of green waste and wood waste into fermentable sugars, lignin, and gypsum using a patented concentrated acid hydrolysis technology. The sugars will then be converted to ethanol through a traditional fermentation process. The facility will be configured to produce about 3.2 million gallons per year of ethanol and several by-products including:

- 20,668 tons (55% moisture) of lignin cake
- 3,293 tons (40% moisture) of gypsum
- 329 tons (82% moisture) of animal feed will be produced from the fermentation residues
- 6,123 tons of carbon dioxide will be produced as a by-product of the fermentation process

The primary product, fuel grade denatured ethanol, will be sold to Petro-Diamond and used as a octane enhancer and oxygenate in the reformulated gasoline market. The lignin produced in the process is to be used as boiler fuel to produce steam and heat for the plant. Alternatively, it could be marketed as a soil ammendment to landscaping and farming industries due to it's highly carbonaceous nature. Gypsum, is also used in the agricultural industry as an amendment for clay soils. Lastly, protein residues from the fermentation process will be sold locally as an animal feed supplement.

The Lancaster project is expected to come on line in the last quarter of 2009, and at that time will be the first commercial scale cellulosic ethanol plant in the world.



3) <u>Bioengineering Resources, Inc. (BRI)</u>

The BRI process involves three main steps:

- Gasification
- Fermentation
- Distillation

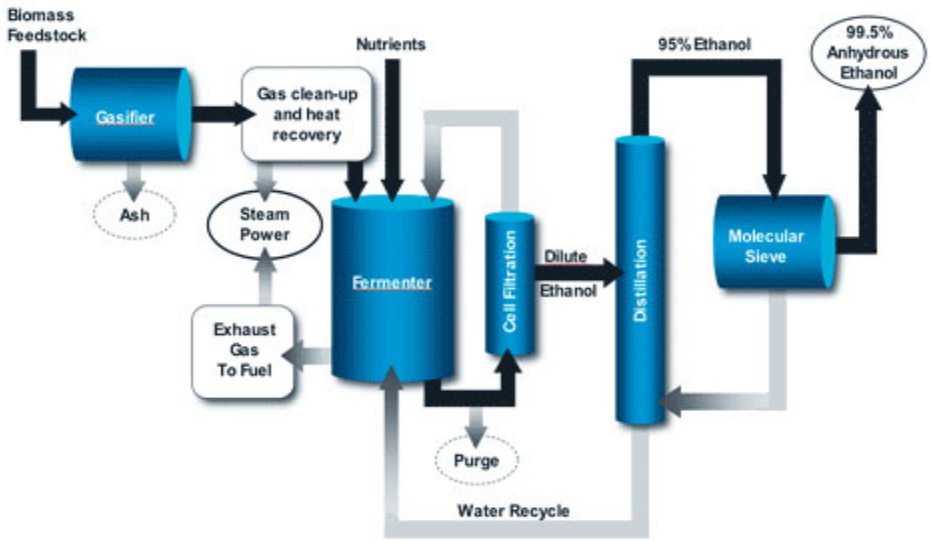
The process will normally convert more than 90% of the organic material it receives. The remaining ash is landfilled or could be recycled in products like cement blocks or paving.

As the process uses waste products that otherwise would have been placed in landfills and BRI's plants are capable of generating an excess of electricity beyond their parasitic needs, they can produce liquid and electric energy while consuming zero new BTUs in the process.

In the BRI Process, an enormous amount of waste heat is created from the cooling of the syngas before it is delivered to the bioreactor. Steam can be generated from this waste heat and introduced into a turbine to generate electricity. There is no combustion associated with this step of the electricity generation process.

In the optimum plant design, only 75% of the synthesis gas is consumed by the bacterial culture. The remaining 25% could be used to create such by-products as hydrogen or ammonia for fertilizer, or to produce additional high temperature steam.
If this residual syngas were mixed with natural gas and combusted to create additional electricity, it would burn 70% cleaner than natural gas, because it will have passed through three stages of filtration (i.e., scrubbing, activated carbon filtration and the liquid environment of the reactor tank). Due to the internal generation capabilities of the technology, these plant old the potential to be completely energy self-sufficient once they reach their normal operating temperature.

BRI Process Schematic



Other

Changing World Technologies

A company that offers thermal depolymerization is Changing World Technologies (CWT). CWT is headquartered in West Hempstead, New York, and is the developer of a conversion technology that creates renewable diesel fuel from feedstocks that are ordinarily considered to be wastes. The CWT technology was first developed to make useful energy products from animal and food processing wastes. CWT has also invested in significant research and development work to evaluate the feasibility of processing auto shredder residue and components of municipal solid waste (MSW). The system can in theory co-process sewage sludge along with other wastes, although there may be limitations on the proportionate quantity that would make technical and economic sense in a multi-waste feedstock to a CWT facility. CWT is actively pursuing development of commercial scale plants using food processing wastes as feedstocks in other locations. Concurrently, major development investment is being made to advance experience with auto shredder residue and mixed MSW.

CWT has two reference facilities. The larger facility (248 TPD) is located in Carthage, Missouri and has been operated by Renewable Environmental Solutions, LLC (RES) since the year 2005 with poultry processing waste as a feedstock. The smaller, pilot facility (7 TPD) is located in Philadelphia, Pennsylvania, and has been used for research and development activities since the year 2000. The pilot facility is operated by Thermo Depolymerization Process, LLC (TDP).

MECHANICAL PROCESSING

Mechanical processing technologies employ physical processing techniques, primarily to recover recyclables and separate the organic and inorganic fractions of MSW. Mechanical processing technologies are typically followed by other conversion processes. An example of a mechanical processing technology is steam classification of MSW in an autoclave. The steam classification process applies heat and pressure, with agitation, to sterilize waste,

reduce its volume, and facilitate the separation of waste components. Following steam classification, mechanical screening may be used to recover recyclables, remove non-recyclable inorganics, and separate the organic fraction. Some technology suppliers are developing systems that would convert the recovered cellulose to ethanol or use the recovered cellulose as a fuel (e.g., for a gasification system).

Autoclaving of medical waste for sterilization before disposal has long been practiced throughout the U.S. However, in recent years, a much broader, larger, and innovative application has emerged as a process for MSW. Mixed residential and commercial MSW or post-MRF residue is "pressure cooked" with steam in large, rotating super drums up to 25 ft in diameter and 100 ft long. This facilitates subsequent separation of organic biomass (processed paper, cardboard, foodwaste, etc.) from inorganic (glass, metal, plastic, textiles, etc.).

Autoclaving can be viewed as a "pre-processing" step for following conversion technologies (CT). The importance of producing a high-quality, homogeneous organic feedstock for CT plants, all of which focus on the organic component of MSW, should not be overlooked. In fact, one of the greatest challenges facing the application of CT to MSW and MRF residuals is feedstock preparation.

Overall diversion of 70-90% can be achieved depending on the quality of the MSW feedstock and ability to market all the products.

The process involves the following steps:

- Autoclaving of "as received" or "post MRF" MSW (no shredding or pre-processing is necessary except removal of bulky items)
- Screening to separate organic and inorganic fractions
- Sorting of traditional recyclables
- Further processing of biomass (several alternatives listed below)
    - Cleaning to recover paper fiber for recycling at paper mills
    - Anaerobic digestion for power, fuel and compost production
    - Gasification for heat and power generation
    - Hydrolysis for ethanol production
    - Wastewater treatment and discharge to sewer

Examples of firms currently active in the U.S. include:

- Comprehensive Resources (CR3) (Salinas, CA)

- CES Autoclaves (University of Alabama)
- Tempico (Hammond, LA)

A fourth developer, World Waste International (WWI), actually constructed a 500 TPD autoclave plant at the CVT Transfer Station in Anaheim, CA. This plant featured two 12-ft diameter autoclaves designed to process up to 500 TPD of mixed commercial and "post MRF" residue that was disposed at the Brea Olinda Landfill. The recovered paper fiber was dewatered to "wet lap" quality and sold to a local paper mill for manufacturing into new paper products, predominantly corrugated medium. WWI has since changed strategies and is pursuing thermal processing for power generation. The autoclaves are no longer part of their plans.

At present, there are no commercial scale MSW autoclave systems in the U.S. The one such plant that was constructed, WWI in Anaheim, CA was shut down due to a change in course for the company. The main reason given is that it was not cost effective to recover fiber for sale to paper mills, which are in decline in the U.S. However, WWI states that the autoclaves themselves worked.

From the current direction of all three autoclave companies it is clear that the focus is on production of fuels and energy from the biomass, and that the autoclave is functioning as a "feedstock processing" system. This is not to be taken lightly, as feedstock preparation is one of the critical elements for any type of MSW conversion. One issue which faces developers of the autoclave is conflicting patent claims, which have loomed in the past, and may become more obstreperous when the first commercial plants go into development.

Three of the mechanical processing technology vendors are discussed herein.

1) <u>Comprehensive Resources (CR3)</u>

CR3 ran a demonstration plant in Reno, NV for several years. This included not only the autoclave, but a biomass cleaning system to recover clean paper fiber. In 2006-2007, the autoclave was moved to the Crazy Horse Landfill in Salinas, CA for further demonstrations under the auspices of the Salinas Valley Solid Waste Authority. The autoclave started operating there in late 2007 and conducts demonstration runs approximately once a month. It is currently undergoing air emissions testing.

The 6-ft diameter rotating and articulating autoclave can process over one ton of MSW over a two hour cycle. The focus now is on processing MSW and agricultural wastes with the intent of hydrolyzing the resultant biomass to make fuel-grade ethanol. This is a change from the original strategy of pulp recovery for sale to paper mills. The autoclave team is participating in a comprehensive R&D agreement with the Department of Agriculture lab in Richmond, CA where the biomass hydrolysis work is being conducted.

One future plan includes the development of a full-scale commercial autoclave plant (2,000 TPD) at the Johnson Landfill in Salinas County, where it would be part of a "Resource Management Park".

StereCycle was granted the CR3 license for the UK and portions of Europe. They have secured investment capital from Goldman Sachs and others totaling over 70 million British pounds. They have constructed two 9-ft diameter autoclaves and are pursuing several locations for projects in the UK. The autoclaved, screened, and dried biomass would be used for soil conditioner and boiler fuel.

2) <u>CES Autoclaves (University of Alabama)</u>

CES is a new company formed from World Waste International participants by the original MSW steam autoclave developer, Professor Michael Eley of the University of Alabama. CES is currently working with Rainbow Disposal of Huntington Beach, CA to construct a 10 TPD pilot plant at Rainbow's MRF/transfer station. The focus of the process is to convert MRF residual now going to landfill disposal into a biomass feedstock for conversion to ethanol. The latter technology will be supplied by Clean Earth Solutions, a dilute 2-stage acid hydrolysis process.

Rainbow anticipates the pilot plant will be operational in the summer of 2008.

3) <u>Tempico (Hammond, LA)</u>

Tempico, Inc. was formed in 1990 to commercialize patented technology utilizing pressure and steam within a rotating autoclave registered as the ***Rotoclave®.*** The technology is being used in the medical waste processing field currently, with other exciting applications underway. Over 110 Rotoclaves are operational worldwide processing medical waste.

The *Rotoclave®* technology offers the opportunity for volume reduction of Municipal Solid Waste (MSW) to landfills, potentially reducing the volume by approximately 50% without the need for grinding. Beyond volume reduction, the Tempico system provides the ability for further biomass processing as described earlier in this section.

The Rotoclave® system utilizes a pressure vessel with a unique rotating internal drum that accepts waste materials and subjects them to agitation, heat, and moisture. The combination of high temperature, pressure and moisture, in conjunction with the unique method of agitation ensures all materials will contact the necessary sterilizing steam. The Company is hopeful that its first system of four 12' diameter, 50' long vessels for processing MSW will be contracted for installation in the Dominican Republic sometime in the 1st quarter 2008. A project in New Jersey is also in development.

Tempico has chosen to remain "technology neutral" and is working with cellulosic ethanol, gasification, recycle fiber and cellulosic-derived specialty chemical vendors on one front while developing long term sources of MSW on another. The company has performed tests relative to recycle fiber with major paper companies since the early 1990s and more recently with other conversion technology vendors.

Tempico has a commercial dilute acid hydrolysis cellulosic ethanol facility teaming opportunity under way, and will be setting up a 1,000 pound per batch Rotoclave and associated downstream recycling equipment at a landfill in the next two or three months in order to produce MSW derived pulp for testing over a long period of time.

ECONOMIC REVIEW OF CONVERSION TECHNOLOGIES

A key consideration in determining the commercial viability of any CT, and their feasibility as alternatives to continued landfilling, will be the tipping fees that might be expected from individual technologies. Tipping fees, in turn, are highly sensitive to project-specific and site-specific factors such as site development costs, local construction market conditions, regulatory and permitting requirements, residue transportation and disposal costs, the strength and stability of electricity and local product and material markets, and transportation costs for delivery of products to final locations.

For purpose of this review, the following factors relating to economics have been considered:

- **Information Sources.** In the past few years, several studies have generated cost and revenue data regarding advanced conversion technologies (specifically, thermal processing and anaerobic digestion technologies), for both small- and large-scale demonstration and commercial facilities in the United States. Information from Alternative Resources Inc.'s (ARI) September 2004 and March 2007 studies and reports for New York City and from ARI's October 2007 study for Los Angeles County, CA (Los Angeles County Conversion Technology Evaluation Report - Phase II), which represents some of the most current information that is publicly available, is summarized here, along with other published information.

- **Planning Perspective.** Since the technologies considered in this report are not yet in commercial operation in the United States, information on capital and operating costs is generally available only on a planning-level basis. While such estimates are only at a level of detail and accuracy commensurate with planning efforts or initial feasibility studies, the information is instructive to the degree that the analyses result in order-of-magnitude cost and tipping fee estimates. Although such estimates should not be considered as definitive as those that would result a formal procurement or from in-depth project-specific feasibility studies, they are useful in providing estimates of what reasonably could be expected of individual technologies and, in the first instance, can serve as one factor in determining which technologies or categories of technologies may be appropriate for further consideration in subsequent comprehensive planning work.

- **Analytical Assumptions.** In the studies referenced above (i.e., New York City and Los Angeles County), the participating technology suppliers were asked to provide capital and operating cost estimates, as well as performance data such as net energy produced for sale and the types and volumes of materials that could be recovered and sold. The amount of electricity generated and the volume of materials recovered for each technology were confirmed through independent reviews of the mass and energy balances that were provided by technology sponsors. Based upon these analyses, the amounts of products (i.e., the energy generated and the secondary materials recovered) - - and therefore project economics - - vary between the technologies, depending upon technology-specific considerations.

- **Cost/Benefit Considerations.** In considering alternatives to landfilling, it can be expected that direct costs would be only one aspect of an overall cost/benefit analysis, which might take into account additional considerations such as:

    - statutory imperatives and local policies and objectives regarding environmental concerns, particularly regarding recycling, renewable energy generation and waste diversion from landfills;

- the long-term reliability of any advanced conversion technologies that might be considered for an identified project;
- the actual costs that might result from formal, guaranteed price proposals solicited through a procurement, when compared to planning-level estimates;
- the long-term outlook for energy and materials markets and the affect of market uncertainties on project economics; and,
- the prospect for the continuation of landfilling long-term, as influenced by regulatory, economic and policy matters.

The following subsections provide summaries of estimated project costs and resulting tipping fees, as derived from information provided by various technology suppliers. As summarized below, there is significant variation in capital and operating costs, both within individual technology types and between disparate technology types.

THERMAL PROCESSING

Economic information for thermal processing technologies has been published as a result of studies conducted by Los Angeles County (ARI, October 2007). Los Angeles County data was based on cost and revenue information in 2007 dollars, with a projected first-year tipping fee for the year 2007. This planning-level analysis is summarized in Table 3 below.

Table 3. Thermal Processing - Summary of Projected First-Year Tipping Fees Los Angeles County (2007)

Technology Supplier	Facility Capacity (TPD)	Capital Cost ($2007, millions)	Annual O&M Cost ($2007, millions)	Annual Revenues ($2007, millions)	Projected Tipping Fee ($/ton, 2007) Private Ownership and Financing
IES	242.5	$30.1	$2.7	$3.3	$56
IWT	312	$75.2	$11.0	$7.9	$131
IWT	623	$126.4	$16.9	$19.6	$71
IWT	935	$170.4	$24.6	$29.4	$59
Entech	413	$56.6	$6.8	$6.3	$55

BIOLOGICAL PROCESS

Anaerobic Digestion

Economic information for anaerobic digestion technologies has been published as a result of studies conducted by New York City (ARI, March 2007) and Los Angeles County (ARI, October 2007). New York City data was based on cost and revenue information in 2005 dollars, with a projected first-year tipping fee for the year 2014. This planning-level analysis is summarized in **Table 4**. Los Angeles County data was based on cost and revenue information in 2007 dollars, with a projected first-year tipping fee for the year 2007. This planning-level analysis is summarized in **Table 5**.

Table 4. Anaerobic Digestion - Summary of Projected First-Year Tipping Fees New York City (2014)

Technology Supplier	Facility Capacity (TPD)	Construction Cost ($2005, millions)	Annual O&M Cost ($2005, millions)	Annual Revenues ($2005, millions)	Projected Tipping Fee ($/ton, 2014)	
					Private Ownership and Financing	Public Ownership and Financing
Arrow	586	$43.3	$4.2	$7.3	$56	$43
WRSI	500	$41.0	$2.9	$3.3	$80	$65

Table 5. Anaerobic Digestion - Summary of Projected First-Year Tipping Fees for Los Angeles County (2007)

Technology Supplier	Facility Capacity (TPD)	Capital Cost ($2007, millions)	Annual O&M Cost ($2007, millions)	Annual Revenues ($2007, millions)	Projected Tipping Fee ($/ton, 2007) Private Ownership and Financing
Arrow	300	$20.9	$1.9	$3.0	$50

CHEMICAL PROCESSING

Hydrolysis

Ethanol Production

Hydrolysis technologies are not yet in commercial operation for MSW. However, the technology is advancing to commercial application in the United States, with a waste-to-

ethanol hydrolysis facility under development in Middletown, New York. A limited review of Masada's technology was provided based on information reported by Masada for the New York City Phase II Study (ARI, March 2007). The facility under development is proposed to process 230,000 tpy of MSW and 422,000 tpy of sewage sludge, along with significantly smaller amounts of other waste materials (i.e., waste paper, septage and leachate). The project delivery approach is design/build/own/operate (DBOO) with a guaranteed waste supply and tip fee provided by contracted municipalities. The negotiated tipping fee for 2004 was $65 per ton of MSW supplied, escalated at 64% of the Consumer Price Index (CPI). Masada has assumed full responsibility for the marketing of the ethanol and its quality.

The economics of the 250 TPD BlueFire Ethanol plant in Lancaster, CA are quite different because their feedstock is not MSW but source separated greenwaste and woodwaste. They typically charge no tipping fee for this material that is more like a commodity, but instead accept it at no charge and in some instances also contribute to the trucking cost to bring the material to the facility.

Changing World Technologies (CWT) is one of the more advanced chemical processing technologies pursuing applications for MSW, but its experience with MSW is limited. As previously noted, CWT has a small (7-tpd) pilot facility that has tested various feedstocks, and a 248-tpd commercial facility with poultry processing waste as a feedstock. CWT provided economic information for a conceptual, 200-tpd demonstration facility for the Los Angeles County Phase II Evaluation (ARI, October 2007), which would process a combination of MSW, auto shredder residue, and fats/oils/grease. Based on information provided by CWT ($2007), capital costs for a 200-tpd demonstration facility would be approximately $35 million, and operating costs would be approximately $9 million per year. Revenues would be derived primarily from the sale of biodiesel, the primary product, and also from the sale of recovered metal and other secondary products. CWT estimated revenues would be on the order of $8.4 million per year. CWT estimated a tipping fee of $60 per ton for MSW and sludge, and $20 per ton for fats, oils, grease and used oil. However, the company projected there would be an annual loss using the estimated tipping fee for the proposed demonstration facility. CWT projected that profitable economics would be achieved with a 1,000-tpd commercial facility.

MECHANICAL PROCESSING

Mechanical processing technologies employ physical processing techniques, primarily to recover recyclables and separate the organic and inorganic fractions of MSW. Mechanical processing technologies are typically followed by other conversion processes. An example of a mechanical processing technology is steam classification of MSW in an autoclave. The steam classification process applies heat and pressure, with agitation, to sterilize waste, reduce its volume, and facilitate the separation of waste components. Following steam classification, mechanical screening may be used to recover recyclables, remove non-recyclable inorganics, and separate the organic fraction. Some technology suppliers are developing systems that would then pulp the separated organic fraction with water to recover cellulosic-material for use in low-grade paper making (e.g., cardboard). Other technology suppliers are developing systems that would convert the recovered cellulose to ethanol or use the recovered cellulose as a fuel (e.g., for a gasification system).

PERMIT REQUIREMENTS FOR CONVERSION TECHNOLOGIES

Assuming the CT facility will receive post-recycled, mixed MSW, the following permits and approvals will likely be required:

- A Conditional Use Permit (CUP): either revision of the existing landfill CUP, or a new CUP as a stand-alone facility;
- California Environmental Quality Act (CEQA) clearance: either a full Environmental Impact Report (EIR), focused EIR, or Mitigated Negative Declaration (MND).
- Permits to construct and operate from the San Joaquin Air Pollution Control District.
- Construction and General Industrial Stormwater Permits from the Central Coast Regional Water Quality Control Board (RWQCB)
- Amendment of the County Non-Disposal Facility Element (NDFE) or Countywide Siting Element.
- Solid Waste Facility Permit (SWFP), either a revision of the existing landfill SWFP or a new SWFP as a stand-alone facility.

The permitting pathways will be arduous for any CT project developed in Paso Robles, not only because of the formidable regulatory requirements, but also because no commercial CT project (processing MSW) has been permitted in California to date. This leads to a level of uncertainty that won't be alleviated until the first projects are developed. That being said, some general conclusions can be drawn about the existing regulatory environment:

- Anaerobic Digestion projects can more easily be permitted than thermal projects because they operate at low temperatures, have no air emissions, are supported by environmental groups, are already operating in various forms at wastewater treatment plants, and are included in CIWMB plans and protocols for the future. Anaerobic digestion is classified as "composting" by the CIWMB and as such has a clearer pathway to a SWFP. Should the Anaerobic Digestion project choose to combust the gas to generate electricity, air emissions typical of landfill gas combustion may be generated.
- Conversely, thermal CT projects can anticipate a more difficult permitting environment due to their high operating temperatures. They are more complex, require more rigorous air pollution analyses, and engender opposition from environmental groups that characterize them as a form of incineration (although technically and environmentally they differ from incineration). These technologies also suffer from convoluted statutory definitions that list pyrolysis, for example, as "transformation" (a disposal method), and define gasification so narrowly that almost none of the technologies qualify in that category. This creates more uncertainty related to how some thermal technologies will be defined and what permitting process they will follow to obtain a SWFP.
- Air permitting will be difficult, but achievable.
- AB 222 (Adams) provides diversion credit and renewable energy designation for all CTs, however it has an uncertain future as a two-year bill in the Senate.

AB 939 DIVERSION CREDITS

The State regulations define CTs as well as what constitutes solid waste disposal, and, in their present form, may not allow the full amount of waste processed at a CT facility to be counted toward meeting a jurisdiction's diversion goals. Amendments to the Public Resources Code, such as AB 222 (Adams and Ma) have been proposed to clarify the regulations related to CT facilities. However, no regulations have been adopted to date that provide a comprehensive regulatory framework for the development of CT facilities.

CTs have the potential to reduce the amount of solid waste being landfilled as well as provide a source of renewable energy. However, the regulatory framework for CTs is fractured and convoluted resulting at present in the following CT diversion credit situation:

The current state of affairs related to CTs and diversion credit is summarized in the following **Table 6**, taken from the CIWMB guidance document.

Table 6
CT and California Integrated Waste Management Board (CIWMB) Requirements

Conversion Process	IWMA* Category?	SWFP* or EAN* Required? PRC 40194	Siting: NDFE or CSE Required? PRC 50001	Is it Disposal or Diversion? PRC 41780, 41781, 40192
If only handling separated material (meets 3-part test)	Excluded from definition of Transfer/Processing PRC 40200(b)(2); 14 CCR 17402.5	No	Neither	Diversion if meet 3-part test.
The requirements below only apply if the processes noted are used on waste material that does not meet the "3-Part Test".				
Transormation[1]	Transformation PRC 40201	Yes	CSE	Pre-1995 permit-up to 10 of the 50% diversion requirement, otherwise – disposal PRC 41783
Pyrolysis[1]	Transformation PRC 40201	Yes	CSE	Same as above.
Distillation[1]	Transformation PRC 40201	Yes	CSE	Same as above.
Biological Conversion	Transformation PRC 40201	Yes	CSE	Same as above.
Anaerobic Digestion[1]	Composting PRC 40116	Yes	NDFE	Diversion
Gasification[1]	Gasification PRC 40117	Yes	NDFE	Diversion
Other Processes	Transfer/Processing PRC 40200, PRC 40172	Yes	NDFE	Diversion
By definition, Biomass Conversion Facilities can only handle separated material of specific types.				
Biomass Conversion	Biomass Conversion PRC 40106, PRC 40201	No	Neither	Pre-1995 permit-up to 10 of the 50% diversion requirement, otherwise – disposal PRC 41783.1

[1] If not meeting the 3-part test.
IWMA: Integrated Waste Management Act
SWFP: Solid Waste Facility Permit
EAN: Enforcement Agency Notification
NDFE: Non-disposal Facility Element
Disposal: Tonnage going to a disposal or transformation facility requiring a Solid Waste Facility Permit.
Diversion: Tonnage would "count" as diversion if had been "counted" as disposal in the jurisdiction's base year.

AB 32 GREENHOUSE GAS (GHG) EMISSIONS

Another driving factor for development of CTs in California is AB 32 requirements to reduce greenhouse gas (GHG) emissions. It is beyond the scope of this feasibility study to provide a detailed analysis of GHG reductions achievable with the various CT technologies. However, all the major types of technologies included in this report will achieve significant GHG reductions compared to landfilling. These reductions come in the following areas:

- Avoidance of landfill methane emissions that would have occurred had the waste been landfilled.
- Offsetting of the GHG emissions that would have occurred to generate the equivalent amount of electricity from fossil fuels, or to produce the equivalent amount of fossil fuel for those technologies making transportation fuel.
- GHG reductions for front end recycling at the CT plant.
- GHG reductions for composting of residual material from anaerobic digestion facilities.

If and when a cap and trade system is implemented for GHG similar to that in place for some criteria pollutants now, the revenues from sale of GHG credits may contribute to a lowering of the CT tipping fee, or a rebate to participating jurisdictions.

RENEWABLE PROTFOLIO STANDARD

Current law requires sellers of electricity to meet 20 percent obtain 20% of their power from renewable sources. These sources include: Biomass, Solar thermal, Photovoltaic, Wind, Geothermal, Fuel cells using renewable fuels, Small hydroelectric, Digester gas, MSW conversion, Landfill gas, Ocean wave, Ocean thermal, and Tidal current.

Under current rules of the CEC, electricity derived from anaerobic digestion is defined as renewable. However, the picture is not so clear when it comes to the thermal technologies as they are restricted by definition to very onerous performance standards (i.e. zero emissions). However, this situation may be changing with legislation pending in Sacramento (AB222) that would provide renewable status for energy derived from the "biogenic" portion of the feedstock going to all CT projects, including thermal. Biogenic

meaning the non-fossil fuel derived material; thus energy derived from converting plastics in the wastestream would not count as renewable.

LOW CARBON FUEL STANDARD

The Governor's Executive Order S-01-07 sets a mandate for the development of fuels with lower carbon intensity, i.e. renewable fuels. This Order establishes a statewide goal to reduce the carbon intensity of California's transportation fuels by at least 10% by 2020. This standard is now part of the Stare Implementation Plan for alternative fuels, as well as an "early action" as defined by the ARB under AB32.

This action by the Governor has created a demand for renewable fuels produced in the State that have a lower carbon (footprint) than fossil-fuel derived gasoline or diesel fuel. CTs that prepare a fuel as their final product can receive credit for contributing to this lower fuel carbon standard.

Some of the biological CTs that produce methane as the primary component of their biogas (along with CO_2 and other compounds) are proposing to process this gas and convert it to CNG or LNG. In addition, some thermal CTs use either biological or thermo-chemical processed to convert their syngas to fuels.

In this instance, as in the RPS discussion above, it will likely be only the fuel derived from the biogenic portion of the feedstock that counts as low carbon.

CONVERSION TECHNOLOGIES FOR PASO ROBLES

This section highlights the key issues specific to developing a CT project at the Paso Robles Landfill. These issue areas are as follows:

- Cost/Benefit of CT vs. continued landfilling at the Paso Robles Landfill
- Site Evaluation
- Risk
- Flow Control and Available Wastestream
- Support for CT in the Community
- CT vs. Conventional WTE
- Value of Electricity and Cost of Residue Disposal
- Affect on Diversion

- Demand for Alternative Fuels
- Pilot, Demonstration, or Commercial Scale CT

COST/BENEFIT OF CT VS. DISPOSAL AT THE PASO ROBLES LANDFILL

On strictly a tipping fee vs. tipping fee basis, CT is more expensive than landfill disposal. As shown in the table below, the current Paso Robles Landfill tipping fee over a 20 year planning period is estimated at $53 per ton, whereas CT tipping fees for smaller size plants range from $70 to $140 per ton. The small size of the waste stream in Paso Robles eliminates economies of scale that are critical for some of the CT technologies. With such a small waste stream, costs for CT can be expected to be in the higher portion of the range rather than the lower. On the other hand, the tipping fee at the landfill has not been increased in seven years and is due for adjustment; a $5 per ton increase is shown in the table. Any such increase will narrow the gap between the landfill and CT gate fees.

Technology Type	Current Tipping Fees ($/Ton)
Landfilling	$45(*)
Anaerobic Digestion	$70-100
Thermal Conversion	$70-140

(*) assumes a $5 per ton increase as pending rate hike over current $40

However, just comparing the tipping fees does not provide a complete picture of the economics of a project. To justify further evaluation of CTs for Paso Robles will require consideration of benefits such as increased diversion, GHG reductions, carbon credits, and generation of renewable energy and fuels to offset the higher cost.

Given these results, sufficient economic viability may warrant further analysis through a more in-depth, site-specific feasibility study of selected technologies. Through such a feasibility study, the City could solicit direct CT vendor input on capital and operating costs, revenues, and performance, which would result in more project and technology specific information. Ultimately, through a formal procurement which created a competitive environment, technology suppliers would provide their best pricing and guaranteed performance.

Based on the economic analyses presented herein, all of the conversion technologies present higher tipping fees than does continued landfilling. Alternative project

configurations may mitigate these differences. For example, CT projects would become more competitive with landfill tipping fees if 30-year financings and higher electric power prices were assumed. Also, other considerations that may be applicable in the future, such as greenhouse gas emission credits and possible state or federal grants, would improve project economics.

In considering the results of the analyses, it should be noted that:

1. Project economics are technology-specific. For example, anaerobic digestion is a less capital intensive technology than are many thermal and mechanical processing and operating costs, and performance, between technology suppliers, due to both the nature of specific technologies and the experience of the supplier in the U.S.
2. Project economics are sensitive to financing assumptions, because longer financing terms result in lower annual debt service payments. Also, the ownership/development mode will affect costs. Although the DBOOT approach (Design, Build, Own, Operate, Transfer) is preferable in terms of risk allocation (given that, in the US at least, these are still new and emerging technologies), public ownership, which would avoid the added cost of private equity, would be less costly.
3. Energy pricing will be key to economic viability for many of the technology suppliers. The thermal and mechanical processing technologies are more sensitive to changes in power pricing since they generate significantly more electricity per ton of MSW processed and, therefore, are more reliant on electricity sales revenues than are anaerobic digestion technologies. The outcome of current legislative efforts to resolve questions regarding the eligibility of certain thermal conversion technologies for renewal electricity pricing will influence the ultimate economics of thermal conversion technology projects. Also, as indicated above, some of the technologies have the capability to produce fuels (e.g., compressed natural gas and/or pipeline quality natural gas, ethanol, hydrogen) which might represent viable energy product alternatives.
4. The ability to sell compost, even at a low per ton price, is important to the economics of anaerobic digestion technologies. The inability to sell compost, with the resulting need to dispose of compost as a residual would raise the tipping fees by between roughly 10% and 20%, depending upon the technology.
5. The sharing of revenues from both energy and materials sales is a common feature of conversion technology projects, and several model approaches have been developed for sharing arrangements. It should be noted, however, that revenue sharing arrangements and tipping fee levels are interrelated. Project developers will have cash flow and return targets, which will be based upon the combination of tipping fee revenues and product revenues. If sharing arrangements result in lower net product revenues to a developer, the proposed tipping fee would be increased in order to meet the targeted return. However, there are approaches that have been used for the sharing of "excess" revenues realized above certain minimum thresholds. These arrangements

enable the developer to realize its targeted cash flow and returns at a "base case" level, and enable both the developer and its public client to benefit from revenues that are in excess of those originally predicted, avoiding apparent "windfall" profits of private companies.

SITE EVALUATION

A small CT project of roughly 100 TPD, will occupy not more than 2-4 acres of land. The site for a CT project at the back of the Paso Robles Landfill is good overall. Some of the key site factors are:

- A small CT project of roughly 100 TPD, will occupy not more than 2-4 acres of land. There are 20 acres available at the landfill; more than enough not only for the CT plant but also for composting residue from digesters, if a biological technology is selected.
- The site is well buffered from the highway; in fact, not visible at all as the filled portion of the landfill lies between the CT site and the highway
- Located in a remote region, the site is well removed from residential areas (only one ranch house on the west side is in the vicinity)
- Water supply is available, but restricted with one well producing roughly 10,000 gpd and another located on the southern boundary of the site. Many CT technologies actually generate water (recovered from the MSW which is usually about 20% moisture); however, if generating electricity, they would need to use air cooling rather than water cooling, which will be more expensive.
- Although there is no sewer, most CT projects can treat their wastewater to reusable standards, and their wastewater could be reused onsite for landscape irrigation or dust control.
- A substation would need to be constructed and an interconnection with the PG&E grid established.

RISK

The 69 CT vendors in Table 1 represent a range of development from pilot plant, to demonstration plant, to fully commercial facilities. The majority fall in the first two categories, while a minority are fully-proven – but only overseas. Some are on the cusp of transitioning from one category to another such as Plasco nearing full operation of their 100 TPD demonstration plant, or Arrow Bio nearing 100% operational status of their first commercial plant at 300 TPD.

The technological and economic risk will likewise vary depending on the vendor selected and the jurisdiction's appetite for taking on risk for lower cost; by participating in project financing, for example. Conversely, a jurisdiction can lower its risk by requiring the CT vendors to fully finance the facility themselves, with nothing more than a waste stream guarantee (and perhaps a site contributed by the City).

However, the CT industry is maturing and each year more vendors enter the arena, and those already established at one level or another make progress. At this point it is an emerging industry with attractive up-side benefits that may make it worth the risk for communities to develop a project early.

FLOW CONTROL, AVAILABLE WASTES TREAM, REGIONALIZATION

The City has full control over the City-generated wastestream, which has historically comprised roughly 75% of the material received at the landfill. The other 25% comes primarily from the County Waste Authority; material which the City does not control.

Interestingly, both the City's and the landfill's annual tonnage has been falling dramatically over the past few years while diversion has increased as illustrated below with the City's tonnage:

Year	City Disposed Tonnage
2006	39,671 tons
2007	33,844 tons
2008	26,248 tons

Based on the 2008 number, the City would have roughly 85 TPD available (in total) for a CT plant, assuming a 310 day per year operation (85% availability). Although the projections in the Landfill Master Plan show this disposal tonnage increasing to 48,627 tons by 2025 (156 TPD) it is hard to forecast whether this will occur or not given the impact of the current recession and increasing recycling activity.

This is an important consideration as an available waste stream below 100 TPD with an uncertain growth pattern is too small for the vast majority of the CT vendors active in the

market today. The situation is somewhat improved at 150 TPD with an upward trend in disposal. At least this falls within the lowest commercial range for a few CTs.

This would indicate that a regional approach could be beneficial wherein the City, the County Waste Authority and perhaps some of the other cities in the region would form a Joint Venture and combine their waste streams. At 300 TPD, most of the CT vendors would be interested and their economics improved substantially.

Initial indications from the substantial wine industry in the Paso Robles regions are that all organic waste material (vines, pumice, etc.) is not landfilled, but either processed and reused as soil amendment at the vineyard, or shipped to one of the local composting operations. Therefore, it is assumed for this study that this material is not available to supplement the MSW wastestream.

POWER GENERATION

There is a significant difference in power generation per ton of feedstock between the biological and the thermal processes. The former generate approximately 200 kWh per ton, while the latter are closer to 800 kWh. Therefore, a 200 TPD anaerobic digestion plant would generate 1-2 MW, while a thermal process would generate 6-7 MW.

An interesting rule of thumb used by one of the thermal CT vendors is that a typical community can generate roughly 1/3 of their electricity needs by converting its MSW to power.

SUPPORT FOR CT IN THE COMMUNITY

It is beyond the scope of this Phase I study to gage the support for CT in the Paso Robles community. However, it can be said that both the City Manager and Public Works Director are very interested in the feasibility both now and in the future to convert the City's residual MSW not being landfilled to electricity or fuel.

This interest is similar to that seen in other communities throughout California that are investigating the feasibility of CT or actively pursuing projects. These include:

- The City of Los Angeles
- The County of Los Angeles
- The County of Orange
- The City and County of Santa Barbara
- The City of San Diego
- The City of San Jose
- The Salinas Solid Waste Authority

However, it is difficult to gage general support or opposition in any community until a project is actively proposed. From recent experience around the State, it can be said that the biological technologies are generally supported by the environmental groups, while the thermal technologies are opposed due to unfounded but perceived concerns regarding air emissions and public health.

VALUE OF ELECTRICITY AND COST OF RESIDUE DISPOSAL

PG&E payments for renewable energy are relatively robust at roughly $0.13/kWh, which will help offset the higher initial cost of CT. A recent sensitivity analysis performed by the Clements team for Orange County showed that for each $0.01/kWh increase in electricity value, the tipping fee could be dropped $5-10/ton for the thermal processes. The change is less dramatic for the biological technologies as they generate much less power per ton.

The residue disposal cost is much less important because the thermal CTs have less than 1% residual, while the biological CTs (assuming the digester residual can be composted and marketed) have a residual of less than 15%.

EFFECT ON DIVERSION

The implementation of a CT facility in Paso Robles would have a profound effect on diversion. Under the new AB 939 accounting method, all calculations of diversion are based on the actual tonnage disposed at a landfill. Given the conversion of from 85% to 99% of incoming landfill-bound MSW tonnage through a CT facility, diversion in the City of Paso Robles could be expected to soar.

DEMAND FOR ALTERNATIVE FUELS

There has been recent shift in focus by CT vendors to production of transportation fuel as their primary product as opposed to electricity. This shift has been driven primarily by legislation such as the "low carbon fuel standard", the complications of permitting power generating facilities (air emission offsets, etc.), and the misperception in the public and among environmental groups that thermal CTs are "incinerators in disguise". It is difficult to characterized a CT facility as an incinerator when the plant is producing vehicle fuel.

Biological CTs can process their methane-rich biogas into CNG or LNG, while thermal CTs can convert their hydrogen and CO syngas into diesel fuel via the Fischer-Tropsch process.

In addition, there are certain CTs that are designed to convert MSW to transportation grade ethanol including Fulcrum Energy (gasification and catalytic conversion), New Planet Energy (gasification and biological conversion), and others. Although no commercial plants of this type have been built to date in the U.S., these companies claim yields of 90-100 gallons of ethanol per ton of MSW; the equivalent of about 600,000 gallons per year for a 200 TPD CT plant. However, it should be noted that these vendors are planning much larger facilities than could be supported in Paso Robles.

If it converted it's City fleet to CNG, the City of Paso Robles would consume about 10,000 gallons per year. Clearly, other much larger users would need to be enrolled in the area to justify a CNG CT plant, or the product would need to be trucked to a large urban center.

PILOT, DEMONSTRATION, OR COMMERCIAL SCALE CT

At less than 100 TPD of available wastestream at this time, the City of Paso Robles will have a hard time attracting much interest from a CT community that is chasing projects all over the world, let alone the U.S. and California. In California alone, there are numerous projects and competitions already occurring for much larger, high-profile projects. The vendors are spread thin, and are marshalling their resources and targeting their efforts on a few important projects.

That being said, there is a segment of the CT community that to this point has not progressed beyond the pilot plant stage that might be interested in a demonstration project in Paso Robles. These demonstration projects tend to fall in the 50-100 TPD range that matches the Paso Robles wastestream, and are meant to prove the technology at a commercial, reproducible scale. Often, these take the form of one commercial-scale module (when a true commercial plant would have at least two such lines). Such a project was recently proposed in Santa Cruz County. However, even these companies with success expect to see the demonstration plant expand into a commercial project with a doubling, tripling, or quadrupling in size. This is likely not be supportable by the wastestream in Paso Robles. Moreover, without a demonstration plant already in operation, these more nascent companies are more vulnerable to attack by environmental groups and local opposition, as was proven in Santa Cruz.

On the commercial scale, a select few CT vendors may be able to provide a commercial plant as small as 125-150 TPD, by constructing only one module, when their typical smallest plant would preferably be two modules for redundancy and better economies. Arrow Bio is one who will build a plant at the 150 TPD range, but caution that the cost is significantly higher than for a 300 TPD, two line plant.

CONVERSION TECHNOLOGIES VS. CONVENTIONAL WATER-TO-ENERGY

There are currently 87 WTE plants operating in the U.S. They process a significant portion of the total MSW wastestream for the U.S. The plants tend to be large in size, with the average being about 1,000 TPD. The industry is about 35 years old in the U.S. and many of the plants are now aging, or undergoing retrofits. There have been no new WTE plants constructed in the U.S. for over a decade, as opposition from environmental groups and the public at large, and drop in the contract pricing for electricity have impacted the industry. However, with the current high energy prices, drive for development of renewable, domestic energy, WTE is getting a new look from communities across the Country.

In contrast to CT which is an emerging industry, the WTE industry is mature and proven and the U.S. is among the world leaders in this arena. California has three WTE plants:

- Commerce (1987, 350 TPD, 10 MW)
- SERRF (1988, 1,380 TPD, 37.5 MW)
- Stanislaus County (1989, 800 TPD, 22 MW)

Over the years, there have been significant upgrades to the pollution control systems at WTE plants, including control of mercury, dioxin and furan emissions. Ash residue is either landfilled or mixed with concrete and used for road base, typically at the landfills.

Of the 87 plants, only a handful are designed in the 100 TPD range appropriate for a wastestream the size of Paso Robles'. These facilities are all Modular Combustion Units, comprised of two parallel pre-fabricated combustion lines. There are another six WTE facilities in the 200 TPD range, and most of these are of the Mass Burn Water Wall type, similar to the large plants.

The "100 TPD or less" facilities include:

- Perham, MN (116 TPD)
- Polk County, MN (80 TPD)
- Alexandria, MN (80 TPD)
- Red Wing, MN (90 TPD)
- Barron County, WI (100 TPD)

All but the Perham facility focus on the sale of steam, for which there must be a large steam user in relatively close proximity. Given the site location at the landfill in Paso Robles, this is really not an option for this project. However, the Perham, MN plant is an example of a small facility retrofit in 2002 to sell power. It generates 2.5 MW, about 517 kWh per incoming ton of MSW. Tipping fees for this project range from about $60/ton for waste collected by the City to $115/ton for private hauler waste. The average tipping fee for WTE plants in this capacity range is about $100/ton. As was the case with CT, the small size of the plants and their throughput capacities increases cost dramatically over larger plants. This is why most WTE facilities are at least 500 TPD, and many as large as 2,000 or 3,000 TPD.

Other issues with WTE in Paso Robles include:

- Diversion vs. Disposal: WTE plants are defined as "Transformation" facilities in California. As such, they are classified as "Disposal" not "Diversion" and all waste processed in them is counted as disposal for AB939 reporting. (The exceptions are the three existing WTE plants in the State that are grandfathered in as "Diversion" up to 10% of a jurisdiction's total diversion.).

- Public Opposition: The greatest challenge to developing a new WTE plant in California is the overwhelming and sometimes brutal opposition from environmental groups and the public at large (especially in the local area of the proposed plant). This opposition has become so organized and mobilized that it has been virtually impossible to site a new facility for years. This is particularly true in California where the environmental groups are very powerful, particularly in the State Capitol.

- Permitting: Due to the opposition stated above, permitting would be extremely arduous and perhaps impossible. Any CEQA analysis could be expected to be attacked and challenged in court. Although these plants have proven that they can meet all air quality requirements, there is still a perception that WTE plants are hazardous to public health. In addition, because WTE plants are classified as "Disposal", jurisdictions must amend their Countywide Siting Element to include such as facility; in and of itself a daunting process.

- Electricity vs. Fuel: Unlike CTs that can produce either electricity or fuel, WTE can only produce electricity. This could be a disadvantage in non-attainment areas (such as Paso Robles) where emissions from power generation may require expensive offsets.

- Best and Highest Use: There is a judgment in the environmental community that material should be recycled or composted and that WTE plants destroy the material, even though energy is produced. Energy production is deemed a lower use, and should only be applied after all efforts at recycling have been exhausted. This argument is also used against CTs.

CONCLUSIONS AND RECOMMENDATIONS

The following preliminary conclusions can be drawn from the above discussion related to CT and WTE feasibility for the City of Paso Robles.

1. The Paso Robles Landfill offers a good site for either at CT or a WTE project. It is a remote location, distant from residential areas, and hidden from view from the highway. Limited water may be an issue for some technologies.

2. The renewable power purchase price from PG&E of approximately $0.13/kWh is a positive factor that will make tipping fees for CT or WTE more competitive with landfilling. It is likely that only the biogenic portion of the converted waste will count as renewable.

3. Tipping fees for CT or WTE can be expected to be substantially higher than landfill costs unless offset in the future by: increased payments for renewable electricity or low-carbon fuels, sales of carbon credits in a cap and trade system, grants from the CEC or USDOE, the ability to secure public financing and 30-year amortization periods, and unexpected spikes in landfill costs due to intensifying regulation of emissions.

4. The small size of the City of Paso Robles waste stream is an impediment in that it offers no economies of scale and falls at the very lowest range of commercial feasibility for both CT and WTE. In fact, for most of the technologies on the market today to be effective a waste stream of 150-200 TPD is needed at a minimum.

5. In order to increase the project to a more feasible scale, the City could consider formation of a JV with the County Solid Waste Authority and other nearby jurisdictions to aggregate their waste streams.

6. The existing waste stream is of the size that could support a "demonstration" facility. However, a CT vendor may be hesitant to propose such as plant without the possibility of expansion to a commercial size in the future (e.g. a 100 TPD demonstration facility expanding to a 200 TPD commercial plant).

7. Permitting will be arduous with any project, as no CT projects processing MSW have been permitted in California to date. The permitting pathway is expected to be easier for biological technologies as these are not opposed to nearly the level as thermal CTs. A WTE project should anticipate severe and targeted opposition from both environmental groups and the public.

8. All this being said, for the first time in history, there is a nexus of forces driving the development of CT projects forward in California, including:

    - Climate Change and AB32 GHG reduction
    - Renewable Portfolio Standard (RPS)
    - Low Carbon Fuel Standard
    - Proposed increases in mandatory diversion rates
    - Public and elected official sentiment against continued landfilling
    - Public support for renewable, domestic energy and fuel

9. Looking forward the City should:

    - Monitor the development of ongoing CT projects in Los Angeles, Santa Barbara, Salinas and other areas of California and Nevada

- Pursue discussions with other local jurisdictions related to a regional CT project
- Complete the overdue landfill tipping fee increase
- Consider development of a "demonstration" scale project

APPENDIX B

LANDFILL GAS-TO-ENERGY FEASIBILITY ASSESSMENT

LANDFILL GAS-TO-ENERGY FEASIBILITY ASSESSMENT

According to the Environmental Protection Agency's (EPA) Landfill Methane Outreach Program (LMOP), there are approximately 425 landfill gas-to- energy (LFGTE) projects operating in the U.S. (U.S.), 307 generating electricity and 118 direct use projects. These projects have demonstrated that using LFG for energy can be a win/win opportunity. LFG utilization projects can involve partnerships with citizens, non-profit organizations, local governments, and industry in sustainable community planning. These projects go hand-in-hand with a community's commitment to cleaner air, renewable energy, economic development, improved public welfare and safety, and reductions in greenhouse gases (GHG).

This initial feasibility assessment is presented as follows:

- **Available Credits and Incentives**
- **Landfill Gas Use Options**
- **Site Evaluation**
- **Applicable Regulatory Requirements, and**
- **Landfill Gas Quality and Quantity Over the Project Life**
- **Conclusion**

Various incentives and subsidies may provide some economic support to a potential landfill gas to energy project. Some of these incentives and subsidies relate to a project's green attributes and others, such as tax credits, do not. A discussion of the various incentives and subsidies is included in this evaluation, along with an analysis of their potential applicability.

AVAILABLE CREDITS AND INCENTIVES

LANDFILL GAS-TO-ENERGY (LFGTE)

A LFGTE project creates two distinct commodities: the underlying value of the electricity (or other product), and the value of the "green" attributes. The value of the underlying electricity will depend upon the negotiated price contained in a power purchase agreement between the City and Pacific Gas & Electric (PG&E). The green attributes from the project may be unbundled from the electricity and marketed separately.

Various incentives and subsidies may be available to provide some economic support to a potential LFGTE project. Some of these incentives and subsidies relate to the green attributes and others, such as the Section 45 Tax Credits, do not. Potential incentives and subsidies are listed below:

RENEWABLE ENERGY PRODUCTION INCENTIVE (REPI)

The 2005 Act includes use of landfill gas for electricity production [42 USC §13317(b)] (see Section 202(b)(2) of the Act). The Act extends the eligibility period to October 1, 2016 [42 USC §13317(c)] (see section 202(c) of the Act), which means a facility generating electricity from LFG must meet these requirements:

- Must be operational by October 1, 2016.
- Can receive payments for the first 10 years of operation, until 2026, if federal funds are available.

Appropriations are extended for fiscal years 2006 through 2026 [42 USC §13317(g)] (see section 202(g) of the Act), although no annual amount is set forth in the Act. If appropriated funds are insufficient to make full payments, 60 percent of funds will be assigned to facilities that use solar, wind, ocean, geothermal, or closed-loop biomass technologies, and the remaining 40 percent will be assigned to other projects, including those that use landfill gas [42 USC §13317(a)(4)] (see section 202(a)(4) of the Act).

REPI provides an incentive payment of 1.5 cents per kWh (1993 dollars) with annual increases for inflation for electrical power produced by qualifying energy facilities. REPI funding is prioritized by project type. Tier 1 projects are solar, wind, geothermal, or closed loop biomass technologies. Tier 2 projects include other renewable technologies, including LFG. Tier 1 projects receive first priority for 100 percent funding. Tier 2 projects typically receive partial payments on a prorated basis, and the estimated level of REPI funding for a LFG project is less than 0.5 cents/kWh. Currently the REPI is not fully funded. In addition, the funding would be year to year and not for the life of the project.

RENEWABLE PORTFOLIO STANDARD (RPS)

A Renewable Portfolio Standard (RPS) was established in California in 2002 under Senate Bill 1078. The standard was recently accelerated by the Governor and requires that all

retail sellers of electricity shall serve 33 percent of their load with renewable energy by 2020. State government agencies have been directed to take all appropriate actions to implement this target in all regulatory proceedings, including siting, permitting, and procurement for renewable energy power plants and transmission lines.

The RPS is a State of California policy that requires electricity providers to obtain a minimum percentage of their electricity from renewable energy resources. The RPS program is administered by the California Public Utilities Commission (PUC). California utilities will pay a premium for renewable electricity in order to avoid penalties and achieve the required goal.

Environmentally friendly renewable electricity is defined as geothermal, wind, biomass, small hydro, biogas and solar. The RPS forces California utilities to partially fund green power projects. The level of funding is variable, and may include an initial up front capital contribution, rather than an increase in the purchase price of the electricity above market price. Utilities receive renewable energy certificates (REC's) from green power projects.

RECs can be sold in the Compliance REC Marketplace or the Voluntary REC Marketplace. Because the state of California has adopted an RPS, a Compliance REC Marketplace exists. The RECs would also have a greater value in the Compliance REC Marketplace. Companies like Evolution Markets are brokers for certified RECs. If the RECs can be Green-e certified then they can become Tradable Renewable Certificates (TRCs).

Green-e is a nationally recognized standard that helps consumers identify environmentally superior renewable energy offerings. The voluntary certification program verifies that the TRCs (sometimes called "green tags") meet strict environmental and consumer protection standards, and provides customers with the assurance that their green purchase supports generation from new renewable resources. To qualify for Green-e certification, RECs must originate from 100 percent new renewable facilities that generate energy from eligible resources such as the sun, the wind, the heat of the Earth, low-impact hydropower, biogas, or biofuels. Certified product providers undergo an annual verification process audit to document that the provider's renewable certificate transactions were consistent with its marketing claims

GREENHOUSE GAS (GHG) CREDITS

Methane is 21 times more potent as a GHG than carbon dioxide (CO_2). A one metric ton reduction in methane is equivalent to a 21-metric ton reduction in CO_2. After accounting for the CO_2 generated in the conversion, the resulting multiplier is 18.25. The capture and combustion of LFG in a flare results in a significant net reduction in GHG emissions on a CO_2 equivalent basis (CO_2E). The nascent GHG emission credit market faces a number of uncertainties due to unresolved regulatory and institutional issues associated with the implementation of the international GHG control effort. Passage of the Waxman-Markey Bill or the EPA Mandatory Reporting Rule could potentially increase the value of GHG Credits.

There are protocols for determining the amount of GHG credits generated by a specific project. Four different programs with four slightly different protocols: Clean Development Mechanism (CDM), Regional Greenhouse Gas Initiative (RGGI), California Climate Action Registry (CCAR), and Chicago Climate Exchange (CCX).

Prices for CO_2E have been reported as high as $2 to $7 per metric ton. The buyer of GHG credits may wish to purchase an option to buy the reductions at perhaps $0.50/ton. The option would run from 2008 to 2012, the period covered by the Kyoto Protocol. Another option would be have the buyer of GHG credits invest in the Gas Collection Control System (GCCS) directly.

Landfill gas to energy projects can sell the GHG emission credits from collection and destruction of landfill gas into markets such as the Chicago Climate Exchange, the Climate Registry or can trade the future emission reduction credits for investments in the installation of the landfill gas collection systems and energy plants. In addition, carbon credits can be sold through bi-lateral trades outside the Chicago Climate Exchange.

If a landfill is forced or required by the Clean Air Act or other regulation to install and operate a collection system, then the collection system may not generate GHG credits

The Paso Robles Landfill may not be eligible for GHG credits because there is already a landfill gas collection system installed at the site. The installation of the system must be installed on a voluntary basis to qualify for GHG credits.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED) CERTIFICATION

Green buildings certified via the LEED process may qualify for State and local government incentives. Commercial buildings, such as offices, retail and service establishments, libraries, schools, museums, churches, and hotels are eligible for certification under LEED. There is a maximum of 10 points available for the category of "Optimizing Energy Performance" which would include HVAC systems and hot water service. Both of these could be powered by LFG.

FEDERAL PURCHASE REQUIREMENT

Section 203 of the Energy Policy Act of 2005 establishes a federal purchase requirement for renewable energy. To the extent economically feasible and technically practicable, the total quantity of electric energy the federal government consumes during any fiscal year must be renewable energy, according to the schedule below:

- At least 3 percent in 2007-2009
- At least 5 percent in 2010-2012
- At least 7.5 percent in 2013 and after

Under this requirement, renewable energy includes electricity generated from LFG.

CLEAN RENEWABLE ENERGY BONDS

Congress passed the Energy Tax Incentives Act of 2005 (the "Act") in July, 2005. Among a number of other tax incentives, the Act permits non-taxpaying entities such as State and local governments, cooperative electric companies, clean renewable energy bond lenders and Indian tribal governments to issue "clean renewable energy bonds" ("CREBs") to finance certain renewable energy and clean coal facilities.

CREBs are a form of tax credit bond in which interest on the bonds is paid in the form of federal tax credits by the U.S. government in lieu of interest paid by the issuer. CREBs, therefore, provide qualified issuers/qualified borrowers with the ability to borrow at a zero percent (0%) interest rate. The federal tax benefit to the holder of a CREB is greater than the benefit derived from tax exempt municipal bonds in that the tax credit derived from a

CREB can be used to offset, on a dollar for dollar basis, a holder's current-year tax liability, as opposed to excluding interest from gross income, as permitted for tax-exempt bonds.

In April 2009 the IRS issues Notice 2009-33 soliciting applications for the new CREB allocation and providing interim guidance on program rules. The expiration date for new CREB applications under this solicitation was August 4, 2009. The allocation for new CREBs was $2.4 billion.

RENEWABLE ENERGY GRANTS

The American Recovery and Re-investment Act of 2009 (H.R. 1) (Stimulus Bill) enacted in February 2009 created a renewable energy grant program that will be administered by the U.S. Department of Treasury. This cash grant is taken in lieu of the federal business energy investment tax credit (ITC). In July 2009 The Department of Treasury issued documents detailing guidelines for the grants, terms and conditions and a sample application. Grants are available for eligible projects (including LFGTE) placed in service in 2009 or 2010.

LFGTE projects fall under the "qualified facilities" category. For this category the grants are equal to 30 percent of the basis of the property. It is important to note that only tax-paying entities are eligible for this grant. Grant applications must be submitted by October 1, 2011.

QUALIFIED ENERGY CONSERVATION BONDS (QECBS)

The Energy Improvement and Extension Act of 2008 (Bailout Bill), enacted October 2008, authorized the issuance of Qualified Energy Conservation Bonds that may be used by State and local governments to finance certain types of energy projects. QECBs are qualified tax credit bonds, and in this respect are similar to new CREBs. The allocation for QECBs is $3.2 billion. The advantage of these bonds is that they are issued with a zero percent (0%) interest rate. The borrower pays back only the principal of the bond and the bondholder receives Federal tax credits in lieu of the traditional bond interest. Allocations are based on a State's percentage of the U.S. population as of July 1, 2008. IRS Notice 2009-29 contains a list of the QECB allocations for each state.

RENEWABLE ELECTRICITY PRODUCTION TAX CREDIT (PTC)

The American Recovery and Re-investment Act of 2009 (H.R. 1) (Stimulus Bill) enacted in February 2009 created the federal renewable electricity production tax credit (PTC). The federal renewable electricity PTC is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. For LFG projects the PTC is 1.1 cents/kWh. The duration of the credit is generally 10 years after the date the facility is placed in service. The credit is claimed by completing Form 8835, Renewable Electricity Production Credit, and Form 3800, General Business Credit. As with the Renewable Energy Grants, it is important to note that only tax-paying entities can take advantage of the PTC.

CALIFORNIA FEED-IN TARIFFS

Effective February 20, 2008, PG&E will purchase power from customers who install eligible renewable generation up to 1.5 MW in size. LFG is included in the definition of eligible renewable generation. Assembly Bill 1969 was originally written for public water and wastewater agencies, but the California Public Utilities Commission extended the Feed-in Tariffs to include all customers who install renewable generation up to 1.5 MW. The Feed-in Tariffs are a renewable power production incentive that is intended to encourage small, customer-owned generation up to 1.5 MW capacity. On-site generation can be net meters, which would allow PG&E customers to use the power they generate, and sell the excess to PG&E.

The purchase price of the electricity, as listed in Attachment 1, PG&E's publication *Frequently Asked Questions, PG&E Power Purchase Agreement for Small Renewable Generation "Feed-in Tariffs"* is $0.093 /kWh (adjusted by time-of-day factors). The tariffs will be available until the combined cumulative capacity of eligible generation installed equals 500 MW.

The connection to the PG&E grid would take place under Federal Energy Regulatory Commission's (FERC) Small Generator Interconnect Process. Because the sale of power to PG&E would be a wholesale transaction, the seller would need FERC authorization to make such a sale, even though the sale is consummated pursuant to a CPUC-jurisdictional

contract. There are two options to obtain such authorization, obtain Qualifying Facility (QF) status for your facility, or apply to FERC for market based rate authorization.

CREDITS AND INCENTIVES SUMMARY

The aggregate value of all the incentives and subsidies to the LFGTE project and the actual applicability of these incentives and subsidies are complex would require additional review. In any case, the City should try to maintain the rights to all of the incentives and subsidies that are applicable to the City. An example of a subsidy that the City could not take advantage of would be the Renewable Electricity Production Tax Credit (PTC) or Renewable Energy Grants because the City does not pay federal income taxes.

While maintaining the rights to all of the incentives and subsidies, the City may decide to sell the rights to the LFG and allow a private entity to develop the resource. A private entity may pay the City a royalty for the rights to the LFG. The private entity would accept delivery of the LFG at the discharge of the collection system blower (prior to the LFG being routed to a flare). The private entity would be responsible for purchasing and maintaining all of the subsequent equipment and piping.

The City may also decide to develop a LFGTE project themselves and subcontract the operation of the project to a private entity. This approach has some advantages because the City would have more control over the project, and would receive both the operating revenue and incentives/subsidies from the project. The structure of a LFGTE project should be determined after the type of LFGTE project is selected. This approach has the advantage of using low interest rate municipal bonds, or no interest CREBs, to finance the project. The cost of money plays a key role in the overall profitability of a project. In addition, the City could enter into a power purchase agreement with PG&E under the Feed-in Tariffs production incentive, which has a favorable rate structure.

On July 29, 2009 the Obama Administration announced that the Department of Energy will provide up to $30 billion in loan guarantees for renewable energy projects. This action will expand the existing Department of Energy loan guarantee program which included $2 billion in 2009 appropriations to support loans for renewable energy and electric power transmission projects. The Department of Energy's Loan Guarantee Program requires the

preparation of a proposal in response to one of the Department's solicitations, and is geared toward larger, cutting edge projects.

LANDFILL GAS (LFG) USE OPTIONS

There are several options for the beneficial use of LFG. These options include 1) electricity generation (approximately 70 percent), 2) direct use (approximately 30 percent), 3) combined heat and power applications or co-generation(less than 4 percent), and 4) the production of alternate fuels (less than 1 percent). Attached Figure 1 is a simplified decision tree based on the most common LFG use options. Each of these options is discussed next.

1) ELECTRICITY GENERATION

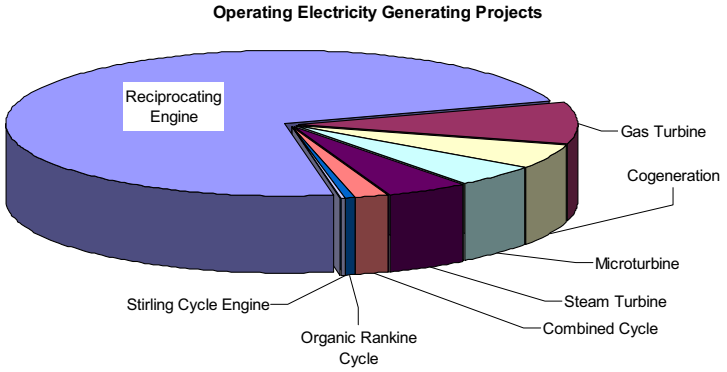
Electricity generation is the most popular use for LFG and there are many operational Landfill Gas to Energy (LFGTE) projects in the U.S. Several of these projects were developed between December 31, 1992, and June 30, 1998 to take advantage of Section 29 Tax Credits (now expired). LFGTE projects in the U.S. primarily rely on reciprocating engines to produce electricity. Table 5.4.1 lists both operational and planned LFGTE projects and the technology utilized.

TABLE 1
CURRENT LFGTE PROJECTS AND TECHNOLOGY UTILIZED

Utilization Technology	Operating Projects		Projects Under Construction		Planned Projects (Candidate LFs)	
	Count	Capacity (MW)	Count	Capacity (MW)	Count	Capacity (MW)
Reciprocating Engine*,**	225	780	25	98	29	94
Gas Turbine*	29	156	2	23	2	11
Cogeneration	16	59	4	17	3	10
Microturbine	16	10	1	<1	1	<1
Steam Turbine	14	136	-	-	-	-
Combined Cycle	6	86	-	-	-	-
Organic Rankine Cycle**	2	<1	-	-	-	-
Stirling Cycle Engine	1	<1	1	<1	-	-
Fuel Cell	-	-	-	-	-	-
TOTALS	**307**	**1,226**	**33**	**138**	**35**	**115**

Source: EPA LMOP – 07

*One combination project has reciprocating engines at one landfill and a gas turbine at another landfill; for the individual counts by utilization technology, these technologies are counted separately, but for the total, the project is counted as one project.
**One project has reciprocating engine as the original technology and organic rankine cycle as the technology for the project expansion; for the individual counts by utilization technology these technologies are counted separately, but for the total, the project is counted as one project.



In California there are several LFGTE projects in operation or under construction.

Economic Considerations

Wholesale electrical power costs have fluctuated in the past several years. However, current imbalances in the electrical wholesale market are not likely to continue and one should expect fairly stable wholesale power sale prices for the rest of the decade. Deregulation of the electrical wholesale market has meant more options for the sale of electricity exist, but these options may not increase electricity prices. However, the adoption of the State of California's Renewable Portfolio Standard (near term goal of 20 percent renewable power by 2010) will increase the value of electricity generated from renewable sources.

The two options for electrical generation are peak shaving or base load generation. Peak shaving would have a significantly higher purchase price for the electricity. Peak shaving may require routing of the landfill gas to a flare when not generating electricity because the generators would operate on an intermittent basis. This scenario would allow for continuous operation of the collection system. The peak shaving operational scenario would put the least amount of operating hours on the generation equipment, reducing O&M costs and increasing the useful life of the equipment. The total amount

of electricity generated would be less than base load operation, but the project revenue could actually equal the base load operation scenario. The use for peak power often coincides with elevated temperatures, when the need for cooling increases.

The base load generation scenario would have the advantage of generating more electricity, but at a lower price. Base load generation would allow continuous vacuum to be applied to the gas collection system, which would simplify control of surface LFG emissions. This scenario would fully utilize the power generation equipment and the available LFG, but would increase O&M costs and shorten the useful life of the generation equipment.

The decision to select peak shaving or base load generation would primarily be based on economic considerations. A power purchase agreement and an interconnection agreement would be required to sell power to a utility. The power purchase agreement would specify whether the project is peak shaving or base load generation and the purchase price of the power.

LFG Processing and Pretreatment

Some level of fuel pretreatment will most likely be required. Fuel specifications vary depending on the type of electrical generation equipment used, but the LFG processing steps are similar. Water vapor must be removed from the LFG. Water vapor in LFG will generate condensate that is highly corrosive. The steps to removing water vapor from LFG include the following:

1. Demister/moisture knockout
2. Compression
3. Cooling
4. Filtering
5. Reheating
6. Siloxane/Hydrogen Sulfide Treatment (if required)

The demister/knockout vessel removes condensate droplets and solid matter from the LFG stream.

Fuel inlet pressure requirements for electrical generation equipment vary. The type of compressor used should therefore be based on the type of electrical generation

equipment being used. The types of compressors include: centrifugal compressors (good up to 5 psi), rotary sliding vane compressors (good up to 30 psi), lobe or root type compressors (good up to 30 psi), reciprocating compressors (45 psi and above), and rotary screw/flooded screw compressors (45 psi and above). Generally, if the fuel pressure requirement falls within the range of a centrifugal compressor, a centrifugal compressor should be used.

LFG exiting the compressor will have a relatively high temperature. An insufficient amount of ambient cooling occurs in Paso Robles, so some type of LFG cooling system must be installed. An evaporative cooling tower is less expensive than a refrigerant cooling system, but has a less consistent temperature reduction capability. Refrigerant cooling would probably be selected for the Paso Robles area. LFG cooling generates additional condensate. The condensate droplets should be removed from the LFG stream at this stage with a coalescing filter in the 0.4 to 0.5-micron range.

After filtering, the LFG is reheated to reduce the LFG's relative humidity to below 80 percent. The maximum relative humidity tolerated by an IC engine is 80 percent. A heat exchanger is typically used to reheat the LFG at this stage.

Finally, if the LFG has high concentrations of siloxane or hydrogen sulfide, some form of treatment will be necessary. A pretreatment system for siloxane or hydrogen sulfide can be inserted at either the upstream or downstream end of the treatment skid. Refrigerant cooling to approximately 34 degrees Fahrenheit (°F) can be used as a method to remove a majority of the siloxane or other treatment such as granulated activated carbon. Testing the LFG at the Paso Robles Landfill would be required to determine the concentration of siloxane and hydrogen sulfide in the gas. Both siloxane and hydrogen sulfide cause additional wear and create the need for more frequent equipment maintenance.

In addition to the process mentioned above, the production alternative fuels may require the removal of nitrogen, oxygen, carbon dioxide, and volatile organics in the landfill gas.

The degree of processing adds to the vulnerability of the operation as additional equipment can increase the system's downtime. A high degree of processing will also

add to maintenance costs. The costs associated with operating the processing equipment must also be considered as a loss to the system's efficiency.

Electrical Generation Using Internal Combustion Engines

The most prevalent use of LFG is as fuel for a reciprocating internal combustion (IC) engine generating electrical power. The advantages of the IC engine option include relatively low costs, relatively high efficiency, and use of a widely used technology. Common IC engine range in size from 500 to 3,000 kW. IC engines can operate on LFG with a methane content as low as 40 percent.

Process Description: The equipment required for IC engine installations include gas compressors, interconnection piping, heat exchangers, knockout vessels, and filters. The type of equipment required depends on the composition of the LFG and the location of the project. Additional processing equipment may be required if the LFG contains excess sulfur, halide, or silicon compounds. Additional compression of the LFG may be required if the existing blowers cannot achieve the required engine intake pressure, along with a heat exchanger, and additional filtering of the LFG before it enters the IC engine.

In order to minimize up-front capital expenditures, some LFGTE developers have chosen not to pre-treat or to minimally pre-treat the landfill gas prior to combustion in IC engines. After LFG exits the exhaust side of the primary centrifugal blowers that supply vacuum to the extraction wells, the LFG may be further compressed with a second compressor to achieve necessary fuel pressure requirements. The LFG is then routed through a coalescing filter and fed directly into the IC engines. While this process is not recommended by IC engine manufacturers and will cause increased IC engine maintenance over time, the costs of the increased maintenance can be offset by the pre-treatment operating and maintenance costs.

Compression of the fuel is generally required to bring the LFG up to the pressure range of 2 to 5 psi (56 to 139 inches of water column) at the intake of the IC engine turbocharger. Other fuel specifications are a maximum relative humidity of 80 percent (LFG from the field is 100 percent), and a maximum temperature of 1,040°F.

- Heat Efficiency (Btu to kW): IC engines are approximately 35 percent efficient converting LFG BTUs to electricity. Efficiency can be increased in cogeneration applications where waste heat is recovered from the engine cooling system or exhaust system.
- Price per kW ($/kW): Installed capital costs range from $900 per kW to $1,300 per kW, depending on the size of the project.
- Emissions (One Jenbacher JGS 320 GS-B.L. rated at 1059 kw):

NO_2:	1.1 g/bhp-hr
	Less than 3.35 lbm/MWhr, 3.55 lbm/hr
CO:	3.4 g/bph-hr
	Less than 10.36 lbm/MWhr, 10.98 lbm/hr
NMHC	0.6 g/bhp-hr
	Less than 1.83 lbm/MWhr, 1.94 lbm/hr

Economics

Of the various electrical generation technologies, reciprocating engines are by far the most common. Reciprocating engines have been selected for over 75 percent of the operating LFGTE projects in the U.S. This is because the cost, on a price per installed kW basis, is low relative to the other technologies. Possible constraints include electricity quantity specifications, electricity pricing variations depending on the time the electricity is being produced, and delivery conditions (where the electricity is inserted into the grid).

Electrical Generation Using Large Turbines

Large LFG turbines are generally only economically viable for larger LFGTE projects. Large LFG turbines have advantages since they are able to operate on lower Btu LFG (down to 20 percent methane), have lower maintenance costs (more resistant to corrosion damage), and have lower nitrous oxide (NO_x) emission rates. Disadvantages include lower overall efficiency (unless the waste heat is utilized in a cogeneration application), the need to run at full load, and high parasitic losses. Common large LFG turbine units are in the 2.5 to 5 megawatt output range.

Process Description: As with IC engines, a turbine installation will require gas compressors, interconnection piping, heat exchangers, knockout vessels, and filters. Turbines require compression of the intake fuel to 250 psi compared to 2 psi for IC

engines. Fuel compression results in the majority of the parasitic loss in the overall system. Additional processing equipment may be required if the LFG has excess sulfur, halide, or silicon compounds; however some large LFG turbines have less stringent intake fuel specifications. The LFG relative humidity and inlet fuel temperature are less critical for large LFG turbines than for IC engines. Turbine efficiency is adversely impacted by elevated ambient temperatures and may require inlet air cooling.

The efficiency of a large LFG turbine can be increased by combined-cycle technology. Combined-cycle technology refers to the combined use of hot combustion gas turbines and steam turbines to generate electricity. The arrangement of the two turbine types can increase the thermal efficiency of the project beyond the efficiency of conventional turbines. Thermal efficiency of a combined-cycle plant can exceed 50 percent. However, the initial capital cost of a combined-cycle plant is proportionate to the efficiency increase.

- Heat Efficiency (Btu to kW): A Magellan OGT2500 turbine is 27.3 percent efficient converting LFG BTUs to electricity (simple cycle). Efficiency can be increased in combined-cycle configurations where waste heat is recovered from the turbine exhaust system. There is a significant amount of waste heat generated by a turbine.
- Price per kW ($/kW): Installed capital costs range from $1,200 per kW to $1,700 per kW, depending on the size of the project.
- Emissions (Magellan OGT2500):

NO_2:	25 ppm
	Less than 2.6 lbm/MWhr, 6.5 lbm/hr
CO:	100 ppm
	Less than 6.08 lbm/MWhr, 15.2 lbm/hr
NMHC:	Approximately 98% destruction efficiency

Economics: Simple cycle gas turbines are operating at approximately 13 percent of the operational LFGTE projects in the U.S. The cost, on a price per installed kW basis, is slightly higher than IC engines.

The costs of maintaining a gas turbine can be lower than for an IC engine. However, the operation and maintenance costs of the processing equipment must be included. The operating costs of the processing equipment are considered parasitic losses and reduce the overall efficiency of the system. Operations and maintenance costs for a gas turbine project include routine costs associated with the turbine and the more complex

LFG processing equipment, and non-routine costs associated with major overhauls of the turbine.

Possible constraints include stringent electricity quantity specifications, electricity pricing variations depending on the time the electricity is being produced, and delivery conditions (where the electricity is inserted into the grid). Project expenses are similar to the IC engine economic analysis. An economic analysis would include siloxane and sulfur removal, which will be required because gas turbines are more sensitive to these constituents than IC engines.

Recently, Magellan (a large gas turbine manufacturer) has stated that they will no longer supply turbines to landfill gas projects. The general reasons are high maintenance costs and poor performance on low Btu gas. However, Solar Turbine has recently introduced a new 5 MW turbine that is designed to run on low Btu LFG.

Electrical Generation Using Microturbines

Process Description: There are at least two manufacturers of microturbines that can be fueled with LFG: Ingersoll-Rand and Capstone. Microturbines are ideal for a changing gas flow design because they are small and modular. Microturbines can also be placed close to the electricity user if a LFG pipeline is less expensive to install than an electrical transmission line. Microturbines have many of the advantages of large LFG turbines. They are able to operate on lower Btu LFG, have lower maintenance costs (more resistant to corrosion damage), have lower NOx emission rates, and can run on a variety of fuels (LFG, natural gas, propane, diesel, biodiesel). Disadvantages are also similar to large turbines. They have lower overall efficiency than an IC engine (unless the waste heat is utilized), they need to run at full load, have higher parasitic losses (primarily fuel compression), and are more sensitive to the presence of silicon compounds in the LFG.

Common microturbine unit sizes are 70 kW and 250 kW for Ingersoll-Rand, and 30 kW, 65 kW and 200 kW for Capstone. For microturbines to reliably operate, the LFG needs to be compressed and processed. The amount of processing depends on the LFG quality. A microturbine installation requires gas compressors, refrigeration equipment, interconnection piping, heat exchangers, knockout vessels, and filters. Microturbines

require compression of the intake fuel to a minimum of 75 psi, based on 350 Btu/standard cubic feet (scf) of fuel.

Performance: The minimum microturbine fuel quality, per both Ingersoll-Rand and Capstone, is approximately 350 Btu/scf high heat value (HHV). This is equivalent to a landfill gas concentration of approximately 35 percent methane, by volume. Parasitic losses in compression and microturbine operation total about 30 percent of the rated electrical output.

A cogeneration option could be added in order to utilize the waste heat from the turbine to produce hot water.

- Heat Efficiency (Btu to kW): An Ingersoll-Rand 70kW microturbine is 28 percent efficient converting LFG Btu's to electricity (simple cycle).
- Price per kW ($/kW): Installed capital cost is approximately $3,000 to $3,600 per kW produced, including the fuel conditioning skid.
- Emissions (Ingersoll-Rand 70kW microturbine):

NO_2:	3 ppm at 3% O_2
	Less than 0.15 lbm/MWhr, 0.0105 lbm/hr
CO:	less than 9 ppm
	Less than 0.5 lbm/MWhr, 0.035 lbm/hr
NMHC	98.6% destruction efficiency
	Less than 0.02 lbm/MWhr, 0.0014 lbm/hr

Economics: Microturbines have been selected for less than 3 percent of the operating landfill gas to energy projects in the U.S. This is because the cost, on a price per installed kW basis, is higher relative to the other technologies.

Possible constraints include electricity quantity specifications, electricity pricing variations depending on the time the electricity is being produced, and delivery conditions (where the electricity is inserted into the grid).

Project expenses are similar to those identified in the previous options, with the exception that operations and maintenance of the microturbines and gas processing skids are higher than for IC engines. An economic analysis would include siloxane and sulfur removal, which is required for microturbines.

Recently Ingersoll-Rand has discontinued offering the gas processing skid with their microturbine, leaving potential customers to design and supply their own gas processing skid. The customer must now take the liability of processing the LFG to meet the Ingersoll-Rand fuel specifications.

Electrical Generation Using Fuel Cells

Fuel cells create electricity by combining hydrogen and oxygen in an electrochemical reaction. The electricity is produced with efficiency as high as 50 percent. The most common type of system is the phosphoric acid fuel cell (PAFC) which can use reformed methanol as a fuel source. A 200-kW PAFC plant has been tested by the EPA at the Penrose Landfill in Sun Valley, California (Swanekamp, 1995).

Nickel/Carbon fuel cells that run on LFG are currently being sold by Empire Equipment. These fuel cells are manufactured by Fuel Cell Energy in the state of Connecticut. The fuel cells have nickel plates surrounded by semi-molten carbonate. The operating temperature is 1,200^{0}F, which must be accurately regulated within a tight temperature range. Unlike PAFC's, nickel/carbon fuel cells operate directly on readily available fuels such as landfill gas. There is no need to first produce hydrogen externally and then send the hydrogen to the fuel cell. Direct fuel cells (DFCs) are the most efficient type of fuel cells. The net efficiency of the DFC 300A fuel cell is 47 percent. One drawback of the nickel/carbon DFC is that it needs a water source to regulate the cell's internal temperature.

Fuel cell advantages include modularity, high efficiency, quiet operation and low emissions. If fuel cells were used to convert LFG to electricity, the LFG would have to be cleaned before it enters the fuel cell. The specifications for LFG use in a fuel cell are restrictive and would be costly to comply with because the LFG would have to be upgraded to near pipeline natural gas quality.

- Heat Efficiency (Btu to kW): The DFC 300A is rated at 7,260 Btu/kWh.
- Cost Efficiency ($/kW): Installed capital cost is in the range of $3,000 to $4,400 per kW produced (not including the fuel conditioning).
- Emissions (Nickel/Carbon fuel cell):

NO_2:	0.03 ppmv
CO:	10 ppmv
NMOC:	10 ppmv
Fuel Flow:	0 – 44 cfm

The DFC 300A comes from the factory with a one-year warranty. The cost to extend the warranty from one year to five years is $330,000. Routine maintenance of the DFC 300A is estimated to be $20,000 per year.

2) DIRECT USE OF LFG

A summary of Direct Use Projects is presented in the following table.

TABLE 2
CURRENT LFG DIRECT USE PROJECTS AND TECHNOLOGY UTILIZED

Utilization Technology	Operating Projects	Projects Under Construction	Planned Projects (Candidate LFs)
	Count	Count	Count
Boiler	43	3	2
Direct-Thermal	37	1	8
Leachate Evaporation	20	-	-
High Btu	11	4	6
Greenhouse	4	-	1
Alternative Fuel	1	2	-
Medium Btu	1	-	1
Liquefied Natural Gas	1	-	1
Methanol Synthesis	-	-	1
Unknown	1	1	9
TOTALS	**119**	**11**	**29**

Source: EPA LMOP - 07
*One project involves LFG use in boiler and other direct thermal applications; for the individual counts by utilization technology, these technologies are counted separately, but for the total, the project is counted as one project.

3) COMBINED HEAT AND POWER

Fire Applications

It is difficult to predict future natural gas prices but it is safe to say that the price of natural gas will at least keep pace with inflation. However, if another natural gas

shortage develops the price of natural gas could increase substantially more than the rate of inflation. This would increase the value of the LFG.

The simplest and most cost-effective use of LFG is as a medium Btu fuel. Only limited condensate removal and filtration is required for medium Btu applications. The primary cost involved with a medium Btu project is the LFG transmission pipeline. The cost of the pipeline is variable depending upon its length and routing.

One direct fire application would be sending the LFG to a boiler to generate steam. The steam would power a turbine and generate electricity. Puente Hills Landfill has a water wall boiler/steam turbine that generates electricity. Boiler/steam turbine installations have a significantly higher cost per kW than either IC engines or large turbines, so only the largest landfills can support such a project. The size of the project must be at least 8 to 9 megawatts in order to make this option feasible. This would require high Btu LFG flows in excess of 3,500 SCFM for the life of the project. The Paso Robles Landfill is unable to produce this amount of LFG; therefore this option is not economically feasible.

Another application would be to use the LFG Btu's to supply an adsorption chiller with hot water to produce air conditioning.

In order for a medium Btu project to be economically viable, the medium Btu customer should be within five (5) miles of the landfill. The viable distance between a customer and the landfill is influenced by factors such as the estimated recoverable gas volumes, pipeline installation costs, competing fuel prices and the customer demand (continuous or intermittent). Medium Btu customers include rotary kilns, direct fired afterburners/fume incinerators, catalytic afterburners, asphalt pavement and asphalt products, metallurgical furnaces, dryers, incinerators, chemical processing equipment and glass production.

Boiler Retrofit

Gas fired boilers typically operate on natural gas which has a Btu content of 1,000 Btu per cubic foot. To convert a natural gas fired boiler to run on landfill gas a new fuel train must be fabricated. The fuel train would be designed to operate on gas with a Btu

content of between 330 and 350 Btu per cubic foot. The new fuel train would include new fuel control valves and new burners.

The boiler start-up and shutdown sequence would be modified as follows:

- Boiler starts on natural gas until it is up to operating temperature.
- Boiler switches from natural gas to landfill gas once the boiler is up to operating temperature.
- For abnormal shutdowns, the boiler must go through a purge cycle to remove any landfill gas condensate that may remain in the boiler.
- For normal shutdowns the boiler would first switch from landfill gas to natural gas. The boiler would run on natural gas for a period of time before normally shutting down.

After the boiler retrofit has been completed it should be recertified for operation. Factory Mutual Company performs such re-certifications on site for a cost of approximately $10,000. The recertification would include all of the boiler components that have been modified, specifically including the fuel train.

4) ALTERNATIVE FUEL

UPGRADE THE LFG FOR USE AS AN ALTERNATIVE FUEL

Low to medium Btu LFG contains significant amounts of nitrogen, carbon dioxide, and oxygen. If these gases can be selectively removed from the LFG, a high-Btu product would result. High-Btu LFG can be injected into a natural gas pipeline, used for vehicle fuel, fuel cells, and methanol production. This option, upgrading LFG, requires relatively extensive treatment of the LFG; therefore it has a relatively high capital cost and may only be cost effective for larger projects. As the price of natural gas increases, the production of high-Btu gas from LFG becomes more competitive.

Methods of separation include separation by membranes, separation by solvents, and separation by pressure swing adsorption, and separation by refrigeration.

HIGH Btu LFG

Development of high-Btu gas from LFG requires near zero air infiltration into the landfill gas well field. Air intrusion into the well field reduces the Btu content of the LFG and can cause the LFG to exceed oxygen and nitrogen content limits. Near-zero air infiltration typically requires that LFG wells only draw from the core of the landfill. Near zero air infiltration can be a concern for landfill owners due to the contradiction between the need to maintain medium-Btu LFG to support a processing plant's requirements, and the need to control surface emissions and gas migration. This is because pulling some air into the landfill reduces surface emissions and gas migration, but it also dilutes the LFG with nitrogen and oxygen. For landfills without a highly impenetrable cover, it would be difficult to maintain a LFG composition that would support a processing plant's requirements, even if the LFG came from just core wells.

The current technology has proven to be effective for the separation of carbon dioxide, membranes, and pressure swing adsorbers (PSA) have been shown to reduce oxygen by 45 percent and nitrogen by 10 percent. A small portion of the methane loss is minimal and methane recovery for a PSA is as high as 88 percent. The presence of oxygen often prohibits the processed gas from meeting the strict natural gas pipeline specifications. High Btu gas can be blended with natural gas for piping for high Btu applications if a high Btu customer is within a close proximity.

LFG TO COMPRESSED LANDFILL GAS (CLG) OR COMPRESSED NATURAL GAS (CNG)

A major advantage of compressed landfill gas (CLG) production is that LFG could be utilized as a resource to produce clean vehicle fuels that provide significantly lower emissions relative to gasoline and diesel fuels. An advantage of CLG (also referred to as CNG) is that the tanks are smaller than liquified natural gas (LNG) tanks. Five CNG tanks are required to achieve a 150-mile range. The conversion of the methane contained in LFG to CLG for vehicle fuel use or other purposes has been commercially demonstrated by the Los Angeles County Sanitation Districts (LACSD). The LACSD has been operating a LFG to compressed landfill gas (CLG) fueling facility at the Puente Hills Landfill in the City of Industry, California, since 1992. The landfill gas is dewatered, pressurized and purified using membrane technology. The feed gas flow of 250 CFM at 55 percent methane is used to produce a fuel quality CNG flow of 100 CFM at 97.5 percent methane. The gas has a diesel fuel equivalent of 1000 gallons/day. A

dedicated pipeline was installed at the Puente Hills landfill to collect gas from the interior, or core of the landfill. The landfill gas from these core wells has a higher methane content and lower nitrogen and oxygen content than other collection wells.

The need to minimize the nitrogen content in the LFG is an important consideration. A second process to remove the excess nitrogen would need to be added to the LFG to CLG plant design, which would significantly increase the cost of the plant.

LFG TO LLG (LIQUEFIED LANDFILL GAS)

Another option would be to convert LFG to LLG (Liquified Landfill Gas). Technologies have been developed to produce high-purity liquefied landfill gas (LLG) and liquid CO_2 from LFG. Companies that have developed processes for treating and compressing LFG to manufacture LLG include Acrion Technologies (membrane and liquid CO_2 solvent wash), Applied LNG Technologies (proprietary process), Cryofuels Systems (proprietary process), Dow Chemical Company (Selexol solvent) and Kryos Energy Inc. (Kryosol solvent).

The Selexol process is perhaps the oldest and requires LFG compression and removal of hydrogen sulfide in a solid media bed, volatile organic compound (VOCs) in a primary Selexol absorber, and CO_2in a secondary Selexol absorber. The Kryosol technology is similar to the Selexol process but it requires the use of the Kryosol solvent. The Acrion Technologies process is also similar to the Selexol process but requires the use of liquid CO_2 as the solvent.

Much of the discussion in the LFG to CLG section relating to LFG Btu and oxygen/nitrogen content also applies to converting LFG to LLG. The LFG purification processes mentioned in the previous section to produce high-Btu CLG could be used as the “front end” of a LFG to LLG plant. However, the nitrogen content of the LFG may be less critical for converting LFG to LLG, because during the final liquefaction process the nitrogen can be separated from the methane.

Two companies, Applied LNG Technologies and Cryofuels Systems, have operated pilot-scale plants demonstrating that LFG can be directly converted to LLG. Because only pilot plants have been operating on LFG, this technology is considered to be an

emerging technology or a Category 2 technology. Only general cost information on this option would be released by the companies.

APPLIED LNG TECHNOLOGIES

- A 5,000 gallon per day LFG to LNG plant would have a capital cost $5 million dollars.
- Required flow rate of 1,600 scfm of LFG at 40 percent methane.
- O&M on the plant would be approximately $0.10 per gallon of LNG.
- LFG contaminates and LNG product would be used to power the LNG manufacturing plant; total power requirement is estimated to be 3,000 horsepower.
- Approximately half of the energy from the LFG would be used to power the plant or lost in the LFG to LNG process.
- One LFG-powered 750 kW electrical generator would be required to run the plant (fueled by LFG that was partially cleaned but not liquefied).
- LNG product would have an approximate composition of 97 percent methane and 3 percent nitrogen (assuming total nitrogen in the LFG can be held below 10 percent).

Applied LNG Technologies (now Prometheus Energy Company) has a large scale plant at the Frank R. Bowerman Landfill in Orange County, California to convert LFG to LLG. The plant started producing LLG in January 2008. Information about plant operation is proprietary. The plant is designed to produce 5,000 gallons per day of LLG. Although the plant is now operational, startup issues caused the operational date to be delayed for one year. The plant is currently operating at near full capacity.

The cost of producing LLG from LFG could be as high as $0.65/gallon, depending upon the type and amount of contaminates that needed to be removed from the LFG. LNG has a diesel equivalent of 1.7 gallons LNG = 1 gallon diesel on an energy equivalent basis, therefore the diesel equivalent price of LNG could be $0.65/gallon x 1.7 = $1.11/gallon. This assumes that the LFG is provided at no cost to the project.

Economic Analysis Results: Production of LLG from LFG is not currently being done on a large scale in the U.S. Two pilot scale plants have proved that the technology is viable. Because only pilot plants have been operating on LFG, this technology is considered emerging and is still undergoing research and development.

The theoretical yearly LNG production for the Cryofuels System's plant would be the same as the Applied LNG Technologies plant (1,825,000 gallons). Only a very general economic analysis of a Cryofuels Systems plant has been performed. The economic analysis is general because information on this process is proprietary or because very little actual operating information is available. However, the resulting LNG cost should be within ±25 percent of the actual cost to produce LNG from LFG.

The economic analysis assumes that LLG is sold at a price of $0.51/gallon. In addition, because the project would be generating electricity to power the LLG plants, the project also receives revenue of $0.02/kW-hr from the sale of renewable energy certificates (RECs). The project customer for both the LLG and the electricity produced by this project would be the City. There would not be any operational constraints placed on the project because the City would be both the developer and the customer for this project. This project structure may allow an expedited construction schedule since agreements would not have to be obtained from outside parties.

Project expenses are segregated into two categories, operating expenses and general business expenses. Operating expenses include operations and maintenance of both the LLG plants and the electrical generation equipment, and engineering services. General business expenses include the following: insurance, interest payments on capital, and equipment depreciation.

ORGANIC RANKINE CYCLE POWER PLANT

Closed loop organic rankine cycle technology uses a temperature differential to evaporate a process fluid (pentane). The heat source could be exhaust gases from a simple cycle gas turbine, low pressure steam, medium temperature liquid found in the process industry, or heat generated by flaring landfill gas. In all cases, a heat exchanger is used to transfer the waste heat to the closed loop of the plant. The plants working fluid is vaporized and feed through a turbine to generate electricity. After the fluid exits the turbine it is cooled until it condenses back into a liquid. The process will work with temperature differentials as low as 125°F.

Currently, closed loop organic rankine cycle plants are only economic is sizes ranging from 15 to 20 MW. However, Ormat Technologies is developing a "standard unit" plant that has an output of 2 MW. The cost of this standard unit plant has not been announced. Published costs of this technology range from $2,000 to $4,000 per kilowatt.

ETHANOL FUEL FROM GREEN WASTE/GRAPE POMACE

At least two pilot plants are currently being constructed, a $30 million plant beside a landfill near Lancaster, California and a $20 million plant in Perry, Florida. The pilot plants are being designed by BlueFire Ethanol Fuels and Myriant Technologies, respectively. Both plants would produce cellulosic ethanol fuel from shredded wood waste. Neither plant is currently operational. The process does require that heat or steam be supplied, therefore being adjacent to a landfill would be advantageous if the heat or steam can be supplied by landfill gas. BAS considers the production of ethanol fuel from cellulose to be an emerging technology.

UTILIZATION PRIORITIZATION & OPTION REQUIREMENTS

LFG utilization technologies can be grouped into three categories based on how close the technology is to being commercialized. Category 1 technologies are currently being used commercially, Category 2 are emerging technologies that are undergoing research and development, and bench-scale demonstrations or field-scale pilot tests. Category 3 includes technologies that would be considered as potentially applicable for use with LFG. For this study BAS has only considered Category 1 and Category 2 technologies. The following sections discuss these technologies. A list of each technology along with its designation as a Category 1 or Category 2 technology is provided below.

Internal Combustion Engines	Category 1
Large Gas Turbines & Combined Cycle	Category 1
Medium Btu (boiler/steam turbine)	Category 1
Microturbines	Category 1
LFG to Liquified Landfill Gas (LLG)	Category 2
LFG to Compressed Landfill Gas (CLG)	Category 2
Fuel Cells	Category 2
Stirling Cycle Engine	Category 2

Organic Rankine Cycle Plant (Ormat Industries Equipment)	Category 2
Ethanol Fuel from Green Waste	Category 2

SITE EVALUATION

The landfill is situated on an 80 acre parcel, of which 65 acres is permitted for waste disposal. There is an existing landfill gas collection system which includes 23 vertical gas extraction wells, piping and an LFG&E Triton Model GF-200 enclosed ground flare with a capacity of 2.8 MMBtu/hour. The landfill has a Title V Air Quality Permit to Operate No. 70-6. The existing landfill gas collection system, and any future landfill gas to energy project, is subject to the terms of this Title V Permit. Diversion of landfill gas from the existing flare to any other end use would require a minor modification to the sites Title V Permit.

At the time of the August 26, 2008 source test the system was collecting 118 standard cubic feet per minute of landfill gas with a methane content of between 32.5 percent and 33.2 percent methane. This equates to a heat rate of 2.36 MMBtu/hour, which is close to the maximum rated capacity of the flare. However, the current methane content of the gas is relative low for a LFGTE project, limiting end use options.

If an electrical generation project is selected, the location of the connection to the PG&E grid is critical. Options would be connecting to the 12 kV distribution line located along Route 46 or connecting at a substation several miles from the site. Up to 2 MW can be delivered to the 12 kV distribution line. Beyond 2 MW the power must be delivered to a substation. Based on the current landfill gas flow rates less than 2 MW is anticipated to be generated, therefore connecting to the 12 kV distribution line is feasible. The connection to the PG&E grid would take place under Federal Energy Regulatory Commission's (FERC) Small Generator Interconnect Process.

APPLICABLE REGULATORY REQUIREMENTS

FEDERAL LANDFILL REGULATIONS

Under the Resource Conservation and Recovery Act (RCRA), enacted by Congress in 1976 and amended in 1984, landfills that accept MSW are primarily regulated by state, tribal, and

local governments. The Environmental Protection Agency (EPA), however, established criteria for Municipal Solid Waste Landfills (40 CFR Part 258) under RCRA on October 9, 1991 that municipal solid waste landfills must meet in order to stay open. The criteria contain location restrictions, design and operating standards, groundwater monitoring requirements, corrective actions, financial assurance requirements, LFG migration control, closure requirements, and post closure requirements. Under the design standards new landfills and lateral expansions that occur on or after October 9, 1993, are required to line the bottom and sides of the landfill prior to waste deposition. In addition, all landfills operating after October 9, 1991, must place a final cap over the landfill surface. The placement of liners and caps reduces the potential for subsurface and surface LFG migration and groundwater contamination.

While additional federal, state, and local landfill rules and regulations are in place, RCRA represents the primary laws covering land disposal of municipal solid waste.

FEDERAL LANDFILL AIR EMISSIONS REGULATIONS

Because of the benefits of collecting and controlling LFG, the 1996 EPA Standards of Performance for New Stationary Sources (NSPS) and Emission Guidelines (EG) for Control of Existing Sources, and the National Emission Standards for Hazardous Air Pollutants (NESHAP) require "large" MSW landfills to collect LFG and combust it to reduce NMOC by 98 percent (or to an outlet concentration of 20 ppmv). Landfills are meeting these gas destruction standards using flares or energy recovery devices including reciprocating engines, gas turbines, and boilers.

A "large" landfill is defined as having a design capacity of at least 2.5 million metric tons and 2.5 million cubic meters and a calculated or measured uncontrolled NMOC emission rate of at least 50 metric tons (megagrams) per year. The Paso Robles Landfill exceeds the capacity limit of 2.5 million metric tons (4.17 metric tons of permitted capacity) and is therefore subject to NSPS/EG regulations. NSPS and NESHAP require that gas collection systems be well designed and well operated. They require gas collection from all areas of the landfill, monthly monitoring at each collection well, and monitoring of surface methane emissions to ensure that the collection system is operating properly and to reduce fugitive emissions. Smaller MSW landfills are not required to control emissions by the NSPS or

NESHAP, but can still greatly reduce emissions of NMOC by collecting and combusting LFG for energy recovery or in a flare.

Code of Federal Regulations 40 Part 60 (40 CFR 60), Subpart WWW (Standards of Performance for Municipal Solid Waste Landfills) or (NSPS) is typically the driving force requiring the construction and installation of a LFG extraction system at landfills. However, the Paso Robles Landfill does not currently have an NMOC emission rate of at least 50 metric tons (megagrams) per year based on the EPA's LandGem model. Because the landfill is below the 50 metric ton threshold for NMOC's the installation of a comprehensive landfill gas collection system was voluntary. However, even if a collection system had not been installed the City would be required to provide an annual calculation of the site specific NMOC emission rate using the procedures specified in Section 60.754 (Tier 1, 2, and 3 calculations) of 40 CFR 60.

SAN LUIS OBISPO COUNTY AIR POLLUTION CONTROL DISTRICT (DISTRICT) AIR EMISSIONS REGULATIONS

The District follows both the State of California Implementation Plan (SIP) and local District Rules. Because the landfill is "large" as defined in NSPS/EG and has a Title V Air Permit, the addition of a LFGTE project would require a revision to the current permit. The type of permit revision would be dependent upon the size and type of LFGTE project being permitted. As an example, if an internal combustion engine was being permitted, the CO_2 emissions from the site would increase when compared with the existing flare emissions. If a microturbine was installed emissions may not change much.

POTENTIAL GREENHOUSE GAS EMISSIONS (CHG) REGULATIONS

The State of California has passed the California Global Warming Solutions Act of 2006 (AB32). Flares with emissions exceeding 25,000 metric tons per year of CO_2 will being reporting in 2009. Landfills will be required to report methane emissions. Regulations relating to the implementation of emissions reductions have not been promulgated at this time.

Landfill gas utilization offers the promise for reducing GHG emissions. The EPA estimates that a 3 MW landfill gas fired power plant can reduce methane emissions by 125,000 tons of carbon dioxide envivalents per year while displacing an additional 16,000 tons of CO_2E

of fossil fuel generation[1]. Based on this projection and on the EPA estimate that 520 additional landfills it identifies as strong candidates could generate an additional 1,200 MW of electricity, the U.S. could reduce annual greenhouse gas emissions by as much as 56.4 millions tons of CO_2E with landfill gas capture.

The Waxman-Markey bill, HR 2454, was passed by the House of Representatives on June 29, 2009. This bill would control GHG emissions and may affect the Paso Robles Landfill. The EPA is also moving ahead with its Mandatory Reporting Rule, which was released in draft form on March 10, 2009. The draft rule requires GHG emission reports to be submitted on March 31, 2011 for 2010 emissions.

LANDFILL GAS QUALITY AND QUANTITY OVER THE PROJECT LIFE

The landfill gas (LFG) generation estimate is an important tool in properly sizing a Landfill-Gas-To-Energy (LFGTE) project. According to the EPA Publication 430-F-01-001, Small Landfills = Untapped Energy Potential, one million tons of waste in place produces LFG that is equivalent to 1.1 MW of electrical generation. This rule of thumb assumes that a comprehensive, high efficiency collection system is in place. The Paso Robles Landfill currently has 1.13 million tons of waste in place, and therefore should be able to support a 1 MW electrical generation project.

Estimating LFG generation can be approached from three perspectives. One perspective is regulatory compliance. From this perspective, a LFG flow rate that is near the upper range of theoretically possible LFG generation is preferred to ensure that all generated LFG is being collected, that both surface and lateral LFG migration is being controlled and that system piping is adequately sized. Estimating higher LFG generation is conservative in this case. This scenario could be termed "maximum gas flow design."

Under a maximum gas flow design, LFG usage and LFGTE project output is maximized. A risk arises under this scenario when the LFG supply is insufficient to run the equipment at the rated capacity as LFG generation ultimately decreases. This may be acceptable if it is critical for the project owner to maximize early-year revenues, if there are no electrical generation shortfall penalties, and if augmented natural gas fuel supplies are available.

[1] US Environmental Progection Agency. "Frequently Asked Questions About Landfill Gas and How it affects Public Health, Safety, and the Environment." EPA, http://www.epa.gov/lmop/faq-3.htm#8, 2008.

A LFGTE project will typically use a LFG flow rate estimate that is near the lower range of theoretically possible LFG generation. This scenario could be termed "minimum gas flow design." A LFGTE project will not perform at 100 percent utilization if it is based on an over estimated LFG flow rate. To fully cover debt service and operating costs, LFGTE facilities should operate at full capacity. A disadvantage of a minimum gas flow design is that some LFG will go unused in years when LFG is plentiful.

A third scenario involves "changing gas flow design." This scenario acknowledges that actual LFG generation changes from year to year. This scenario requires installation of smaller modular equipment over time as LFG flow increases, and decommissioning of equipment as LFG flow declines. This modular scenario ensures that LFG flows are properly matched to the equipment needs. However, equipment and installation costs are generally higher for a modular approach.

Regardless of the LFG generation estimate results, the ultimate goal of a LFGTE project is to extract LFG at a rate that is close to the rate that it is actually being produced. One concern relating to the above three scenarios is the contradiction between the need to achieve near zero air infiltration so that LFG Btu content remains as high as possible, and the desire to control surface emission and lateral gas migration. This contradiction occurs because the collection system may need to operate at a higher vacuum to control surface and lateral migration. The higher vacuum may introduce some ambient air into the extraction wells through the landfill cover. Ambient air dilutes the LFG, reduces the Btu content and increases the potential for composting and initiating costly landfill fires.

A LFGTE project may require LFG with a methane content as high as 55 percent (LFG to Compressed Landfill Gas (CLG)). Reciprocating engines may tolerate methane contents as low as 40 percent. Generally, the requirement for higher Btu content LFG causes a slight decrease in LFG capture, since the landfill gas extraction system (LFGES) must operate at a lower overall vacuum. This impacts the overall collection efficiency of the LFGES. The LFGES must be carefully maintained and adjusted to ensure both regulatory compliance and a LFG Btu content as high as possible. *It is this need to balance regulatory compliance with a desire to maintain as high a Btu content as possible that brings LFG developers interested in continuous operation of the LFGTE equipment into conflict with landfill owners interested in continuous compliance.* BAS recommends that a LFGTE project

should be designed at the discharge point of the flare station blowers, so that the City is always in control of the landfill gas extraction system. The LFGTE project would then purchase the LFG at the discharge of the blowers.

Landfill Gas Generation Modeling Approach -

1. The LFG modeling approach consisted of using the Environmental Protection Agency (EPA) LandGEM model (Version 3.02, May 2005) calibrated to existing site conditions. This approach included the following steps:
    a. Partial coverage to estimate methane collection potential for a system with complete coverage.
    b. Compare methane collection rate to methane generation rate, based on assumed collection efficiency. Estimate methane generation rate based estimated methane collection rate.
    c. Calibrate model such that the modeled methane generation rate matches the current estimated methane generation rate.
    d. Use the calibrated model to forecast the future methane generation rate.

Landfill Gas Collection Flow Rate Analysis -

Current collection data from 1970 to present was analyzed to accomplish the first three steps as shown above. The results of this modeling analysis are presented on in Attachment 2.

Current Methane Collection Rate -

Methane generation is the basis of the EPA's LandGEM model. The first step to calibrate the model is to calculate the methane collection flow currently realized. Methane concentration varies inversely with the LFG flow rate, and the methane flow at a closed landfill will gradually decline. The total LFG collection rate is increased or decreased with the infiltration of air. This infiltration is adjusted during well field tuning and either dilutes or increases the methane concentration. The first step in the analysis is to remove this variability. For instance, current LFG collection rate at the landfill is 118 SCFM at an average methane concentration of 33 percent, for a methane collection rate of with 39 SCFM methane.

Methane Flow = Total LFG Flow x Methane Concentration

Methane Flow LF = (118 SCFM) x 33 Percent
Methane Flow LF = 39 SCFM Methane Collected

Estimated Methane Generation

The methane collected is only a portion of the methane being generated. Because the EPA's LandGEM model is based on the methane generated, it is necessary to relate the methane collected to the methane generated. The collection efficiency is the ratio of the collected methane to the generated methane. A high collection efficiency means the gas collected represents a larger portion of the gas generated. A collection efficiency of between 94.15 percent and 87.4 percent was calculated by Pacific Waste Services (PWS) in their May 31, 2008 Emissions Report. EPA's AP-42 "Compilation of Air Pollutant Emissions Factors" uses a default collection efficiency value of 75 percent. PWS's May 31, 2008 Emissions Report also contained a LandGEM model run for the Paso Robles Landfill.

BAS estimated the landfill's LFG generation flow rate in accordance with 40 CFR 60.755(a)(1)(ii) using the Environmental Protection Agency (EPA) LandGem model. BAS also calculated the LFG flow using our proprietary LFG generation model.

One of the input parameters the model requires is the landfill's known waste acceptance rate. Solid waste flow rates were obtained from the PWS LandGEM input file. Other input parameters were adjusted to reflect the presumed moisture content and varying rates of decomposition associated with different fractions of the waste stream. The model produced an estimate of peak methane generation rate for the last year of waste disposal, with a decline in production thereafter.

Gas production parameters were chosen to reflect the methane generation for LFG to Energy project purposes. Actual recoverable methane may be different than the predicted generation. Also, regulatory default L_o and k values may not be representative of the specific conditions at the Paso Robles Landfill, and may overestimate flow rates for system design.

Methane Generation Potential (Lo): In the landfill gas generation equation shown in Attachment 2, the methane generation potential value represents the theoretical maximum yield (expected volume of gas per unit mass of refuse). Determining the maximum theoretical yield of a unit mass of municipal solid waste can be complex. Either of two

methods can be used: 1) stoichiometric, or 2) biodegradability. Both methods require extensive sampling, time consuming lab analysis, and complex analytical procedures. Both methods rely extensively on a characteristic sample of the waste stream.

PWS used a methane generation potential value (Lo) of 100 cubic meters per megagram (m^3/Mg) for their LandGEM model run. This is based on the minimum value allowed under AP-42 and may actually underestimate the LFG generation potential of the waste in the Paso Robles Landfill because the landfill accepts predominately residential municipal solid waste. This value also assumes a small percentage of nondegradable refuse (i.e., concrete, brick, stone, glass, and metal) is contained in the waste mass. For comparison BAS used a value of 170 cubic meters per megagram (m^3/Mg) for the methane generation potential (Lo). This is the default value specified by the Clean Air Act for conventional landfills in arid climates. Using this value results in higher LFG generation values.

Methane Generation Rate Constant (k): AP-42 allows the use of a k value of 0.02 per year for arid regions that have less than 25 inches of rainfall per year. BAS reviewed its internal database of gas generation rates measured at the Paso Robles Landfill and several other arid region landfills and compared these values with the AP-42 arid region value. Since the landfill is located in the western U.S., and rainfall is less than 15 inches per year, a low LFG generation rate (k) was assigned. A k = 0.02 per year value was used for this generation estimate and reflects a dry waste mass and slow decomposition rates.

Other model inputs included the actual waste tonnage in place for Paso Robles Landfill and the estimated waste tonnage in place at closure. The results of this modeling are typically in 100 percent methane generated.

Modeled at 100 percent methane, gas generation at the Paso Robles Landfill in 2009 is between 172 scfm to 102 scfm of methane. As shown on Figure 2, PWS' generation model, using an L_o value of 100^3/Mg, yielded the lower curve. BAS' generation model, using the L_o value of 170^3/Mg, yielded the upper curve. Assuming a collection efficiency of 75 percent and using the lower value of 102 scfm results in a methane flow rate of 76.5 scfm (0.76 x 102) methane. The actual methane collected by the existing system is 39 scfm.

The percent of generated LFG that is actually collected by the LFGES is a critical parameter. Highly efficient collection of generated LFG will bring the actual LFG flow at the LFGTE project closer to the estimated LFG generation, and will affect project sizing and long-term economic performance. LFG extraction systems are not 100 percent efficient; therefore, only a portion of methane generated will be collected. A collection efficiency of 75 percent is typically assumed. Higher collection efficiencies are possible, depending on the design of the extraction system and site conditions (i.e., final cover air permeability, lined or unlined cell, etc.).

TABLE 1 - PEAK METHANE GENERATION RATES
L_o = 100 m^3/Mg & k = 0.02 ^{1}/yr

Paso Robles Landfill	Total Tons In Place*	Methane Flow in Standard Cubic Feet Per Minute (SCFM) At Peak	Peak Year
Total	3,949,000	319	2050

* Tons of waste in-place as provided by PWS

TABLE 2 - PEAK METHANE GENERATION RATES
L_o = 170 m^3/Mg & k = 0.02 ^{1}/yr

Paso Robles Landfill	Total Tons In Place*	Methane Flow in Standard Cubic Feet Per Minute (SCFM) At Peak	Peak Year
Total	3,949,000	543	2050

* Tons of waste in-place as provided by PWS

TABLE 3 - 2009 LANDFILL GAS FLOW RATES
From LandGEM Model Runs

	90% Collection Efficiency	85% Collection Efficiency	80% Collection Efficiency	75% Collection Efficiency
Input Parameters	SCFM LFG	SCFM LFG	SCFM LFG	SCFM LFG
L_o = 100, k = 0.02/yr, 33% CH_4	277	261	246	231
L_o = 170, k = 0.02/yr, 33% CH_4	470	444	418	392
Actual LFG Flow	118	118	118	118

Peak LFG SCFM flow from Paso Robles Landfill is anticipated in year 2050 and is estimated to be between 718 and 1,223 scfm (at 33 percent methane and 75 percent efficiency). Converting the average peak LFG flow in 2050 to a heat rate yields a value of approximately 19.6 MM Btu's per hour. The maximum unit LFG generation rate is estimated to be 0.06 cubic $feet_{LFG}/lb_m$-yr in 2007, declining thereafter.

Landfill Gas Quality

The composition of the LFG collected by an interior LFG well field is anticipated to be somewhat different than the composition of a perimeter LFG migration control system. On August 26, 2008 the LFG composition and flow rate were reported as follows:

CH_4: 33.04 % by volume
CO_2: 32.28 % by volume
O_2: 1.36 % by volume
N: 33.32 % by volume
Flow: 118 scfm
Heat Rate =2.3 MM Btu's per hour

This flow rate is being produced by a total of 23 perimeter and interior extraction wells.

LFG extracted from the interior of the landfill is sometimes referred to as "Core LFG." This LFG can have a higher methane content, ranging from 40 percent to 55 percent methane. Perimeter LFG is derived from wells located on the landfill slopes, at the edge of the waste cells, and in native soil adjacent to the cell boundary. To maximize the overall LFG Btu content from a combined system of interior and perimeter wells, some re-tuning of the existing perimeter wells may be necessary. If the gas quality necessary for the LFGTE project cannot be achieved by judicious re-tuning of the collection system, the LFG from the landfill can be augmented with natural gas or propane. The cost of augmenting the LFG to increase the Btu content will make a LFGTE project at the Paso Robles Landfill less economically viable.

COLLECTION SYSTEM EXPANSION

BAS suggests expanding the existing landfill gas collection system to include horizontal collectors. Horizontal collectors can be installed as new cells are filled. Installation of horizontal collectors will allow earlier collection of LFG, and will not hinder equipment traffic on the surface of the landfill.

CONCLUSION

BAS believes that a landfill gas to electricity may be viable at the Paso Robles Landfill if 1) the landfill gas quality can be increased and 2) the quantity of landfill gas can be increased. Landfill gas is generated within the landfill with a composition of 55 percent methane and 45 percent carbon dioxide. The methane content of the landfill gas reaching the flare station is reduced as a result of dilution with ambient air. An inspection of the collection system to locate any ambient air leaks may be advisable. In addition, more frequent tuning of the landfill gas wells may be necessary to increase gas quality. Gas flow will increase with time as the collection system is expanded.

This study contains a gas generation model and gas quality estimate for the Paso Robles Landfill. Figure 2 shows the projected gas flows, based on waste flow projections contained in PWS's May 31, 2008 Landfill Emissions Estimate. Assuming a collection efficiency of 75 percent and using the lower value of 102 scfm results in a methane flow rate of 76.5 scfm methane. Actual methane collected by the existing system is 39 scfm.

Methane flow will continue to increase over the 30 year term of a potential landfill gas to energy project. Modeling indicates that sufficient landfill gas should be available to operate a J312 in the future (93 scfm of methane required), if the collection system is expanded. There would be sufficient landfill gas to operate two CR65 microturbines, if landfill gas quality can be increased above the threshold value of 35 percent methane.

The simplest and most cost-effective use of LFG at the Paso Robles Landfill is as a medium Btu fuel. There are no medium Btu users within an economic distance from the landfill. However, the existing LFG&E flare can be retrofitted to destroy condensate or leachate. This would be a beneficial use of the landfill gas, if the landfill is incurring a cost to dispose of the condensate or leachate.

Electricity for on-site use or sale to the PG&E grid can be generated using a variety of different technologies, including internal combustion engines, turbines, microturbines, Stirling engines (external combustion engine), Organic Rankine Cycle engines, and fuel cells. BAS evaluated the viability of these options and performed an analyses of the most viable technologies; reciprocating engines and gas microturbines.

A GE Jenbacher J312 internal combustion engine (gross output of 633kW) requires landfill gas with a methane content in the range of 40 to 45 percent. Currently the collection system is producing gas below that range. Internal combustion engines are the least cost option for electrical generation on a $/kW basis. The minimum fuel flow for a J312 is 93 scfm of methane.

A Capstone Microturbine requires a minimum of 35 percent methane, which is also above the concentration currently produced by the collection system. The minimum fuel flow for a Capstone CR65, with a gross output of 65kW, is 14 scfm of methane.

The LFGTE project having the most merit would be an electrical generation project that takes advantage of PG&E's Feed-in Tariff program. The AB 2466 Self Generation program may be advantageous if the City of Paso Robles is paying more than $0.093/kWh.

Typically, publicly developed LFGTE projects have a higher net present value. The four primary differences between public and private projects are 1) for a private project the rate of return on capital invested is relatively high due to the risk associated with LFGTE projects (private developers must make a large profit), 2) some key incentives (such as Feed-in Tariffs) are only available to public entities, 3) the interest rate on capital for public projects is lower, and 4) a personal property tax expense exists for private project developers. For these reasons the City may want to be the owner of the project.

Based on the most recent source test, the existing flare is nearing its maximum design capacity of 2.8 MMBtu/hour (currently 2.36 MMBtu/hr). Diverting some or all of the LFG from the flare will defer the need to add a second flare as LFG flows continue to increase. It is anticipated that methane generated will double between now and the year 2026, based on a consistently increasing flow of waste to the landfill. Additional flare capacity will therefore be required. The avoided cost of not purchasing a flare would offset some of the capital cost electrical generation equipment.

The City is currently negotiating with PG&E related to locating a transformer and switchyard near the landfill. The new PG&E substation could be built with provisions to allow easy interconnection of a landfill gas to electricity project. This could significantly reduce the interconnect cost and improve the viability of a LFGTE project.

Various incentives and subsidies may provide some economic support to a potential landfill gas to energy project. Some of these incentives and subsidies relate to a project's green attributes and others, such as tax credits, do not.

One of the most viable of these incentives and subsidies is the sale of renewable energy certificates (RECs). RECs are available if a product of the LFGTE project is electricity. RECs can be sold in the Compliance REC Marketplace or the Voluntary REC Marketplace. Because the state of California has adopted a Renewable Energy Standard for electricity producers, a Compliance REC Marketplace exists. The RECs have a greater value in the Compliance REC Marketplace.

Another viable subsidy would be the Federal Renewable Energy Grants. A renewable electrical energy project would be eligible for a Section 1603 Grant under the American Recovery and Reinvestment Act of 2009. A Section 1603 Application "Payments for Specified Renewable Energy Property in Lieu of Tax Credits", would need to be completed to obtain grant funding. Renewable Energy Property owned as a sole proprietorship, joint venture, partnership, corporation, or cooperative organization as described in Section 1381 of the Internal Revenue Code (IRC). Generally, a tax paying entity is eligible, therefore the City would have to structure the project such that a private company developed the LFG resource. Projects that begin construction between January 1, 2009 and December 31, 2010, and are placed in service before the Credit Termination Date are eligible. The Credit Termination Date for a landfill gas to energy project is January 1, 2014. All grant applications must be received before October 1, 2011. Grants for landfill gas projects are 30 percent of the project's eligible construction costs.

A project developed by the City would qualify for the California Feed-in Tariff program or the AB 2466 Self Generation Program (see Attachment 3). The decision regarding which program to apply for would be based on what price the City is currently paying for electricity. If the City is paying less than $0.09271/kWh than the Feed-in Tariff program would be more advantageous.

Other incentives and subsidies, such as greenhouse gas credits, renewable energy production incentives, and emission reduction credits may not be available for Paso Robles Landfill. Because the Paso Robles Landfill has an existing LFG collection system and flare

station, there would be limited opportunity for GHG Credits at this site. The CCAR Landfill Protocol requires that the methane that could be combusted in the existing flare (flare's maximum capacity) be subtracted from the total amount of methane collected at the site. The "additional" methane available for credits would be the difference between the two. Further, installation of the LFG collection system must have been voluntary. If the LFG collection system was installed as a result of federal, state or local regulations the site is ineligible for GHG Credits. Based on the August 7, 2009 e-mail from Mr. Jim Wyse to Mr. Doug Monn, the installation of the collection system was required; therefore it is BAS' opinion that the site is not ineligible for GHG Credits.

APPENDIX C

SOLAR, WIND, AND BIOMASS FEASIBILITY ASSESSMENT

SOLAR, WIND, AND BIOMASS FEASIBILITY ASSESSMENT

INTRODUCTION

The purpose of this work effort was to conduct an analysis of solar, wind, and biomass resources available at the Paso Robles Landfill, determine if these resources can be economically converted to renewable energy, and if the answer is affirmative, estimate the potential for energy production.

This discussion is presented in seven sections.

1. Resource Availability. First, the resource is evaluated to determine if there is sufficient solar, wind, or biomass resources to utilize for energy production.
2. Siting. Opportunities. Second, if the resource is available, the landfill site will be evaluated with respect to locating an appropriate energy production facility.
3. Technology Feasibility. Third, the appropriate technology will be discussed,
4. Performance Characteristics.. Fourth, the performance characteristics of each technology is discussed.
5. Economics. Fifth, a rough order of magnitude cost analysis is discussed giving the estimated cost of installation. Comment on the feasibility of developing the facility based upon these costs.
6. Environmental Issues. Sixth, a few comments are offered about the environmental issues, including the benefits of implementing the facility on the environment.
7. Conclusions. Lastly, summary conclusions for solar, wind and biomass renewable energy at the Paso Robles Landfill are presented.

RESOURCE AVAILABILITY

In this section, the resource is evaluated to determine if there is a sufficient resource, in terms of quantity and quality, to produce energy.

Solar Resources

The solar resources at the landfill are summarized below in Figure1, Summary of Climate Data – Paso Robles Municipal Airport.

RETScreen

Country - region	United States of America		
Province / State	California		
Climate data location	Paso Robles Municipal Arp		
Latitude	°N	35.7	
Longitude	°E	-120.6	Source
Elevation	ft	797	Ground
Heating design temperature	°C	-1.7	Ground
Cooling design temperature	°C	37.1	Ground
Earth temperature amplitude	°C	15.4	NASA

	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°F	%	kWh/m²/d	kPa	mph	°C	°C-d	°C-d
Jan	45.9	77.2%	2.78	97.8	5.4	10.7	319	0
Feb	49.3	76.7%	3.58	97.6	6.0	11.6	235	0
Mar	52.5	74.1%	4.97	97.5	6.7	13.7	205	43
Apr	56.8	63.8%	6.39	97.5	8.1	16.7	126	114
May	62.6	57.4%	7.48	97.4	9.2	20.0	31	217
Jun	67.5	54.1%	7.69	97.3	9.6	23.3	0	291
Jul	71.4	52.3%	7.10	97.3	9.2	25.2	0	369
Aug	71.6	52.8%	6.38	97.3	8.1	24.6	0	372
Sep	67.8	56.5%	5.37	97.2	6.9	22.9	0	297
Oct	60.8	60.4%	4.22	97.4	5.8	19.6	62	186
Nov	51.3	70.4%	3.14	97.7	5.4	14.2	219	21
Dec	45.0	74.1%	2.54	97.8	5.4	10.7	335	0
Annual	58.6	64.1%	5.14	97.5	7.1	17.8	1,532	1,910
Source	Ground	Ground	NASA	NASA	Ground	NASA	Ground	Ground

Measured at	ft	10	0

Figure 1, Climate Data, Paso Robles Airport

The data reflects a 15-year average of data obtained at the Paso Robles Municipal Airport. The key is the global horizontal irradiance (GHI), expressed in the units of kilo Watt hours per square meter per day (kWh/m^2/day). GHI is the total irradiance on a horizontal surface, and is the sum of the diffuse irradiance and the direct normal irradiance (DNI). The diffuse portion is the light scattered by the atmosphere, and the direct normal portion is the sunlight that strikes a surface that is perpendicular to the path of the sun through the day.

Most models used to predict, or estimate, energy production from solar projects installed at a particular location calculate the diffuse and direct normal portions of the irradiance from the global horizontal irradiance. The climate data for the Paso Robles Municipal Airport provides hourly data, which are used by the models.

From Figure 1, the annual average GHI is 5.14 kWh/m^2/day, computed from data taken during the period 1991 through 2005. To put this in perspective, the following data, including DNI, used to model solar thermal performance) are presented in the following table:

TABLE 1

DIRECT NORMAL IRRADIANCE AND GLOBAL HORIZONTAL IRRADIANCE FOR THE CITY OF EL DE PASO ROBLES COMPARED TO OTHER LOCATIONS IN CALIFORNIA

Location	Direct Normal Irradiance (DNI) (kWh/m^2/day)	Global Horizontal Irradiance (GHI) (kWh/m^2/day)
Paso Robles	6.18	5.14
Los Angeles	5.16	4.95
Sacramento	5.35	4.75
Bakersfield	5.60	5.21
Daggett (Riverside)	7.54	5.78

The Paso Robles area has excellent global horizontal irradiance and moderate levels of direct normal irradiance.

Wind Resource

Wind energy systems convert the power of moving air into electricity. Aerodynamic forces act on the rotor to convert the linear motion of the wind stream into the rotational motion

needed to turn an electrical generator. The available power in the kinetic energy of the wind is given by the relation:

$$P = \frac{1}{2}\rho A V^3$$

Where ρ is the air density, A is the rotor area intercepting the wind, and V is the upstream wind velocity. Of these, wind velocity is most important. The cubic dependence of wind power on wind speed implies that energy output, and consequently the economics of a wind turbine installation, is highly sensitive to wind speed. A 50 percent change in velocity results in more than tripling available energy; doubling the wind speed increases the power by a factor of eight. Thus, wind speed is perhaps, the most critical factors in determining wind energy generation.

The wind resource is evaluated as wind power potential, expressed as power density, or power per area.

Wind is typically measured at a height of 10 meters (33 feet). Wind speed typically increases with height. Wind shear data is used to predict wind speeds at 30 meters, 50 meters and even 100 meters. Wind turbines are being built at increasing heights and blade diameters to take advantage of the higher wind speeds at higher elevations.

The relationship between wind power density and wind speed is shown in Table 2, along with the assigned wind power classes. Typically, areas with a wind class of at least three (four with turbines at lower heights) is needed for the economical production of wind energy.

TABLE 2
CLASSES OF WIND POWER DENSITY
AT HEIGHTS OF 10 M

Wind Power Class	Wind Power Density (W/m^2)	Wind Speed[(b)] m/s (mph)
1	0	0
	100	4.4 (9.8)
2	150	5.1 (11.5)
3	200	5.6 (12.5)
4	250	6.0 (13.4)
5	300	6.4 (14.3)
6	400	7.0 (15.7)
7	1,000	9.4 (21.1)

Wind data for California has been published by the California Energy Commission, and appears on their web site at www.energy.gov/maps/wind.html . The scale of these maps does not allow precise location of the landfill. The same data is available on the National Renewables Research Laboratory (NREL) National Atlas of Renewable Resources Interactive Map, which can be found at http://mapserve2.nrel.gov/website/resource_atlas/viewer.htm .

Inspection of these data sources indicates that the landfill site lies within an area with minimum wind resources, or Class 1. Wind speeds can be as high as 9.8 mph in this class. As mentioned above, somewhat higher wind speeds are needed to achieve Class 3 wind power.

Figure 1 shows a summary of the wind speed data for Paso Robles Airport. The data shows that the average wind speed for Paso Robles is 7.1 mph, measured at 10 meters from the ground surface. Wind power density is the power in watts (W), divided by the area in square meters (m^2), and is a measure of how much energy is available for conversion by a wind turbine.

Biomass Resource

Based on the information provided in Technical Memorandum #1 regarding the Paso Robles waste streams, four waste streams are delivered to the Paso Robles Landfill as follows: single-family, commercial/multi-family, City waste, and uncompacted landfill waste streams (C&D, and self-haul). For purposes of this analysis, the annual volume of green waste is needed to estimate the quantity of renewable energy that could be generated from this waste stream.

According to Technical Memorandum #1, there is limited specificity with regard to waste composition delivered to the landfill. The green waste data is summarized in Table 3 below.

TABLE 3 ANNUAL GREEN WASTE RESOURCE ESTIMATE			
Waste Stream	**2010 Disposal Volume (tons)**	**Percent Green Waste**	**Green Waste Volume (tons)**
Single Family Residential	6594	9.4	620
Commercial/Multi-Family	15,647	5.6	876
City Waste	2796	5	140
Uncompacted Waste Stream (C&D, Self-Haul)	9391	5	470
Total	**34,428**		**2106**

Notes: 1. Assume 5 percent green waste for City Waste stream.
2. Assume 5 percent green waste for Uncompacted waste stream

Based upon this analysis, it is assumed that the green waste stream will be approximately 2,100 tons in the year 2010, or about 8.5 tons per day assuming a five-day week. This estimate is consistent with the actual green waste received at the landfill during the past two years.

The extensive wine industry in the Paso Robles region, comprising roughly 30,000 acres of vineyards, may provide opportunities to obtain more biomass. There are two primary solid wastes that originate in the wine industry. First, after the harvest season, the vines are pruned. In most instances, the cuttings are chipped between the vine rows and the resulting mulch is mixed into the soil. About two to four tons of prunings are cut per acre of vineyard. Virtually all of the prunings are recycled at the vineyards.

A second source of waste, called pomace, comes from the wine-making process. Pomace includes the grape skins, stems, and seeds. About 20 percent of the grapes comprise the pomace, and two to 12 tons of grapes are harvested per acre depending upon the vineyard operation and types of vines. The larger vineyards can achieve 10 to 12 tons per acre, while smaller vineyards are in the low end of the range. Assuming an average of eight tons per acre, and 30,000 acres of vineyards, an estimate of the total amount of pomace generated is 35,000 tons. A number of wineries were contacted to determine how pomace was disposed. Many wineries indicated that they composted it on site and used it as a soil amendment. While it was not possible to determine how much pomace is sent off-site, it appears that less than a third of the total pomace produced leaves the sites.

Some wineries, however, send the material to composting operations or landfills. Based on contact with composters, it appears that the volume of pomace being disposed by winery operations is decreasing with time, indicating that more wineries are recycling pomace. Space for composting is limited at those facilities; if the tonnage exceeds the composting capacity, the remainder is landfilled. In addition, some pomace is trucked to San Joaquin Valley and used a cattle feed.

In addition, there are a few co-ops that process grapes for wineries. For example, Paso Robles Wine Services, located on Buena Vista Drive in Paso Robles, performs crushing and barrel storage services for about 40 wineries in the area. Paso Robles Waste Disposal collects the pomace and delivers it to a local composter.

SITING OPPORTUNITIES

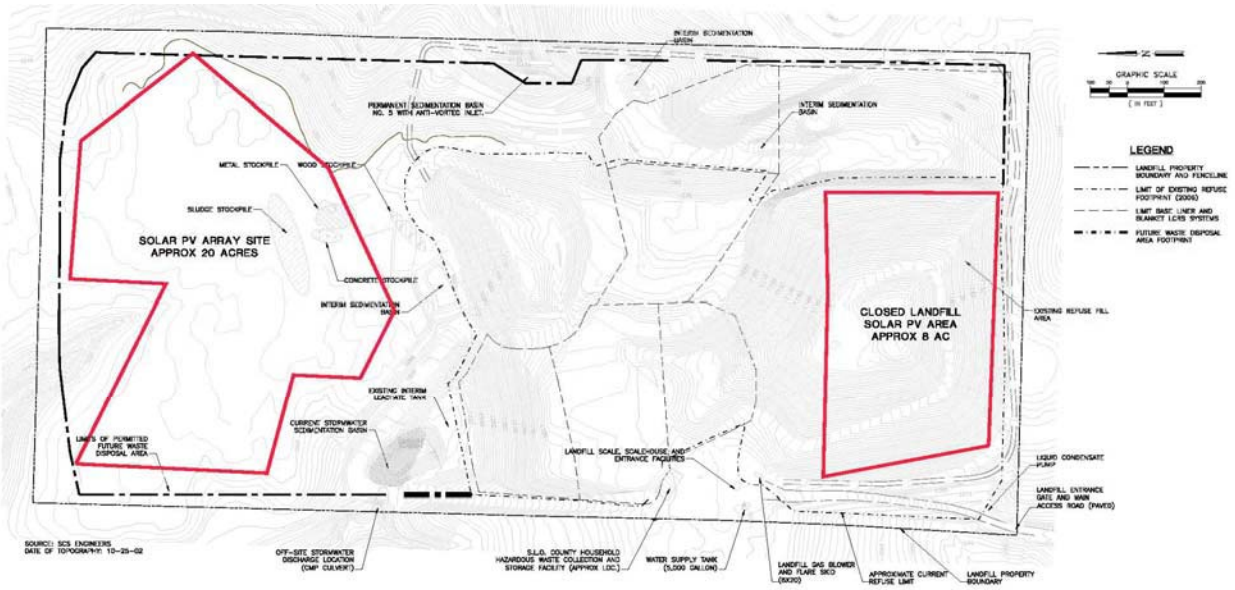
In this section, the landfill site will be evaluated to establish a suitable location for a solar, wind, or biomass facility.

Solar

Two types of solar photovoltaic (PV) projects are potentially feasible on the landfill site. The first is a common ground mount project that would be located in the undeveloped portion of the parcel. The second would be a "surface mount", whereby modules would be adhered to an HDPE cover on the closed portion of the landfill.

A proposed location for a solar PV ground mounted array is shown in Figure 2. The area is located at the northern area of the landfill property. This area is primarily flat, and the current landfill master plan is not to utilize this portion of the site for at least ten years. The approximate area of the solar PV site is twenty acres. This area would accommodate the solar array, inverters, and local substation.

The proposed location for the surface mount is on the area of the landfill that is slated to be closed. The site would comprise the southern face of the closed cell, as shown in attached Figure 2. The approximate area of this site is eight acres.



Wind

If a wind farm was to be developed on the landfill site, it is likely that the wind turbines would be located in the same area proposed for the ground mount solar array. Again, this site is about twenty acres in area.

Wind turbine siting is a complex subject. A key concern is the impact of terrain on the wind energy. The open area to the north of the active and closed portions of the landfill rises in elevation to about 1,180 feet above sea level (asl). The undeveloped portion of the landfill is at an elevation of about 1,060 feet. Therefore, there is a 120 foot differential, which will impact wind flow. Consequently, the "hub height" of the turbines would need to exceed the height of the top of the closed portion of the landfill by about 30 feet in order to efficiently capture the wind. Thus, the height of the towers would need to be about 150 feet, which is quite high for small turbine designs, but normal for large turbines.

Another siting issue is wake effects, or turbulence, when there are multiple turbines. Eddy currents, or vortices, are created by the turbine blades and the tower itself. In addition, a wind speed deficit will occur, resulting in array losses. Typical spacing for the towers is 2 to 4 rotor diameters along a row, and 5 to 10 rotor diameters between rows.

Biomass

If a biomass-to-energy facility were to be developed at the landfill, the most likely location for it would be in the vicinity of the scale house and administration office.

Electric Transmission Interconnection

There are three issues with respect to electric transmission that need evaluation:

- How the electricity produced by the renewable energy will be transported to the point where it will be injected into the Pacific Gas & Electric (PG&E) grid.
- Determination of the injection capacity.
- How the electricity can be credited to the City of El Paso de Robles.

There is a 12 kilovolt (kV) distribution line along State Route 46. This is the closest transmission line to the landfill. The landfill has an existing line that connects this line with the office at the landfill. This line cannot carry the load from the renewable energy project. Therefore, a new line will need to be constructed.

The 12 kV line will have limited ability to accept injection from the renewable energy project. Up to about 2 MW may be able to be inserted; however, a flow modeling study must be performed by PG&E to determine how much energy can be injected. The City will have to submit an application under the Small Generator Interconnection Program (SGIP) to request such a study by PG&E.

Finally, the City wants to generate renewable energy at the landfill, and obtain a credit for this energy in their monthly bill. The state actually has a process by which this is feasible. It is called the Local Government Renewable Energy Self Generation Program. PG&E will meter the energy produced by the renewable energy system and credit this energy back to the City. The limitation is that only one megawatt can be applied per “generator”. Also, the program only applies if the solar project is located within the city boundary.

TECHNOLOGY FEASIBILITY

In this section, technologies potentially suitable for generating renewable energy with solar, wind, or biomass at the Paso Robles Landfill will be discussed. Technologies that are infeasible will be noted in this section, and not carried forward in the analysis.

Solar

There are two broad types of solar energy technologies: solar thermal (also called concentrated solar), and solar photovoltaic (PV). Solar thermal technologies include parabolic trough, linear Fresnel reflectors, power towers systems, and stirling dish systems. Of course, there are also hybrids of these technologies. All of these technologies work on a similar principal: the sun's energy is captured via mirrors, and the energy is focused onto a receiver, which converts this energy to heat. Then the heat can be routed to a heat exchanger to make steam for power production. The key siting issue for these technologies is the level of direct normal solar irradiance. The DNI at Paso Robles is about 6.18 kWh/m^2/day. This DNI is borderline to low for efficient operation of a solar thermal project. In addition, the area of the site is too small for an economic facility. As a result, solar thermal is not a feasible technology for the Paso Robles Landfill.

There are three types of photovoltaic technologies today: crystalline, thin-film, and concentrated photovoltaic (CPV). CPV will not be considered because it is an emerging technology and the available technical data is very limited.

A vast majority of solar PV systems operating today utilize crystalline modules (large suppliers include SunPower and Suntech). Crystalline modules are either single or multi-crystalline, and are rated at roughly 150 to 300 Watts (W) per module. The efficiency of crystalline modules varies from 12 percent to 18 percent. The power density of crystalline modules is typically 12-15 W/sq ft.

In contrast, thin film modules, which comprise amorphous silicon (Uni-Solar is the largest supplier), cadmium telluride (First Solar is the largest supplier), and copper indium gallium diselenide (Nanosolar is a supplier of these new type of module), have efficiencies of five to

nine percent, are rated at 50 to 80 W, and have power densities of about 6 W/sq ft. The lower power rating and density requires that thin film project use significantly higher numbers of modules and larger area to attain the same output. On the other hand, thin film modules are more sensitive to diffuse light, less sensitive to cell temperature (output drops with increasing temperature), and some are very flexible rather than rigid.

Crystalline modules are typically equipped with trackers, to maximize output. Thin film modules are typically fixed at a tilt angle of about 20 degrees, to maximize output. Both types of modules suffer some output degradation at high ambient temperatures (less so for thin-film), and their output degrades at about 0.5 percent per year. Losses in the array (such as wire resistance and soiling), as well as inverter losses, will reduce the total output of an array by about 15 percent.

A solar PV system is comprised of many modules in series and parallel, connected to combiner boxes, which, in turn, are connected to inverters. The inverters transform the direct current from the modules to alternating current. Inverters come in many sizes expressed in terms of kilowatts (kW), from a few kW to 500 kW per inverter. Aside from the modules and inverters, the remainder of the system, which includes circuit breakers, fuses, combiner boxes, frames, cable runs, trackers (if needed), etc, is called balance of system (BOS).

The decision to use crystalline or thin film modules at the Paso Robles Landfill is a complex, and beyond the scope of this study. However, for purposes of further evaluating this technology, one technology will be selected and described in the next section.

Wind

In general, wind turbines come in two size categories: small systems, and utility-scale systems. The small systems cover energy production up to 100 kW per turbine, and the large-scale units typically fall in the range of one to three MW.

Small systems have rotor diameters in the range of 30 to 60 feet for power capacities of 10-100 kW. The rotor diameters for large turbines can be 250 feet and produce 2 MW of power.

The cost/kW for small turbines is considerably higher than large turbines, primarily because large turbines are more efficient, as measured by the specific yield, or kWh/m^2. For example, a typical large turbine (say, 1.5 MW) will have a specific yield of roughly 1,200 kWh/m^2, whereas a 20 kW turbine's yield is about 800 kWh/m^2 for the same wind speed.

A typical power curve for a wind turbine is shown in Figure 3. This curve relates to a 10 kW turbine; however, the curve is similar even for large turbines (500 kW and higher). The two important data points are cut-in speed and wind speed where the rated power is achieved. Note in Figure 3 that the cut-in speed is about seven miles per hour (mph) or 3.2 meters per second (m/s), which is the annual mean wind speed at Paso Robles. Then note that the wind speed where roughly 10 kW of power is reached is 25 to 30 mph (11to13 m/s).

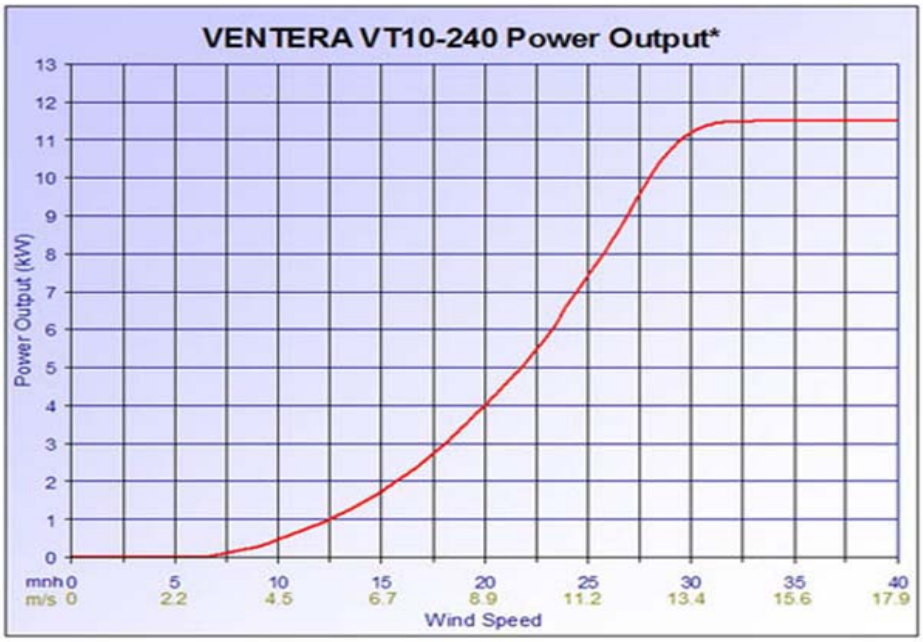


Figure 3, Wind Power Curve

Figure 4 below shows the wind rose for Paso Robles Airport. Note that the highest continuous wind speeds are about eight meters per second (18 mph). According to the power curve, 18 mph is less than halfway up the power curve, where the output is about 4 kW, or less than 50 percent of the turbine's rated power.

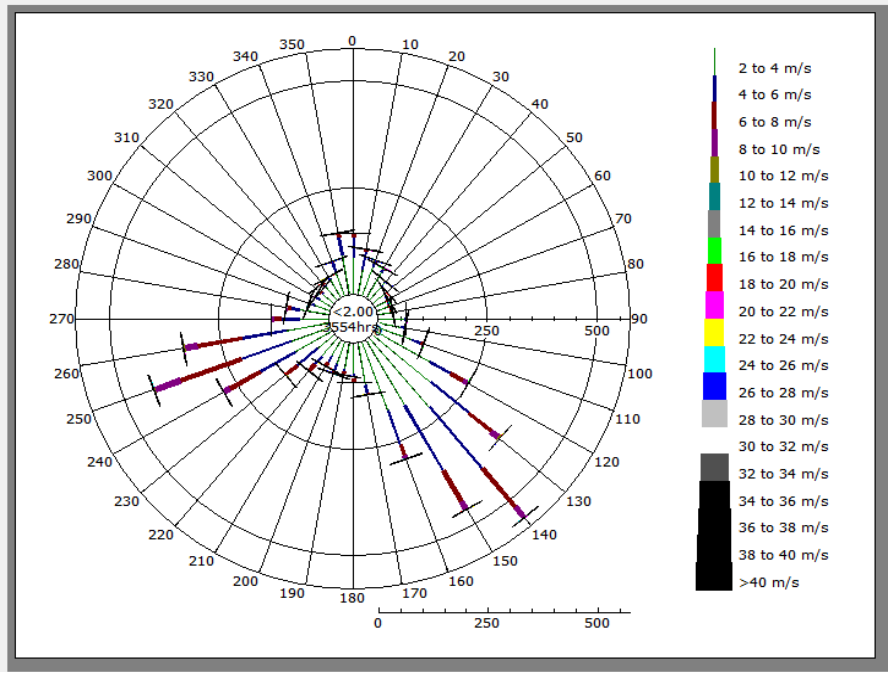


Figure 4, Wind Rose, Paso Robles Airport

Finally, wind turbine performance was modeled using the RETScreen model published by the National Renewable Energy Laboratory (NREL). The Gamesa G58-850 turbine was design specifically for lower wind speeds and has the following features:

- Rotor Diameter: 190 ft (58 m)
- Swept Area of Blades: 28,500 SF (2642 m^2)
- Blade Length: 94 ft (28.3 m)
- Tower Height: 180 ft (55 m)
- Rated Power: 850 kW
- Cut-in Wind Speed: 7 mph (3 m/s)

The approximate model results, along with typical values are summarized in Table 4 below:

TABLE 4 MODEL RESULTS FOR PASO ROBLES USING GAMESA G58-850 WIND TURBINE		
Value	**Gamesa G58-850/ Paso Robles**	**Typical**
Energy Production (MWh/yr)	300	1,500-3,000
Capacity Factor (percent)	4	15-30
Specific Yield (kWh/m^2)	114	600-1,200

The results in Table 4 indicate that wind turbine performance at Paso Robles is infeasible.

Biomass

The green waste that is delivered to the landfill can be treated using one of the following technology groups:

- Composting
- Anaerobic Digestion (AD)
- Thermochemical Technologies
    - Direct Combustion
    - Gasification/Plasma Gasification
    - Pyrolysis
- Refuse-derived Fuel (RDF)

If additional biomass could be diverted to the Paso Robles Landfill from vineyards or wineries, this could help make certain technologies feasible. If prunings were brought to the landfill, the same technologies listed above would apply.

On the other hand, if pomace was brought to the landfill, other potential opportunities may be feasible. Pomace is comprised of about eight percent seeds, 10 percent stems, 25 percent skins, and 57 percent pulp. It is rich in nitrogen, potassium and calcium. It has a very high heating value.

Grape pomace is a lignocellulosic waste (LCW), and is composed of cellulose, hemicelluloses, lignin, and water. LCW is resistant to degradation. Extensive research is being conducted to develop more efficient and cost-effective methods to break down the LCW and provide access to useful by-products. The treatment methods currently in use and being researched, along with the by-product recovery, are as follows:

- Microbial Cultivation: Food, Fuel, and Medicines
- Transesterification: Biodiesel
- Bioconversion/Gasification: Synthetic gas, Biohydrogen
- Acetogenesis/Methanation: Biogas
- Humification: Biofertilizers
- Hydrolysis/Fermentation: Bioethanol

Grape pomace is used to produce many foodstuffs, such as grapeseed oil. Transesterification of pomace is not a commercial process today. Bioconversion, as stated above, is a commercial process for pomace. Acetogenesis and methanation are the reactions in an anaerobic digestion process, and is commercial. Humification is currently applied at composting operations in the Paso Robles region. Hydrolysis and fermentation of pomace is not yet a commercially available process for pomace.

Currently, a few wineries are investing in two ways to treat pomace to retrieve valuable by-products: anaerobic digestion and thermochemical conversion. These technologies, which are compatible with pruning waste as well, are discussed below.

<u>Anaerobic Digestion</u>: AD is a family of processes, carried out in the absence of oxygen, where microorganisms convert biomass into energy, in the form of a biogas (primarily comprised of methane) and a stable humus material. The gas can be routed to a reciprocating engine to generate electricity.

Assume the available green waste stream is ten tons per day. A typical AD system would produce about 1,000 m^3 of biogas per day with this waste stream, which could generate about 1650 kWh of electricity. On an annual basis, about 400,000 kWh of electricity would be generated, which equates to about 160 kWh/ton of feedstock. Compared to a thermal process, discussed below, this conversion efficiency is rather low, primarily due to the fact

that a large volume of solid byproduct is also produced in the AD process. The solids could be used as a soil amendment or mulch.

Unfortunately, the availability of about 2,000 tons of feedstock per year is too small for a commercial AD unit. The smallest units available run at about 5,000-10,000 tons/year. Furthermore, the feedstock stream flow at the landfill will be quite uneven, making AD operation uneconomical. If more biomass could be obtained from nearby vineyards and/or wineries, AD could be an attractive technology.

Thermochemical Processes: These processes apply heat and pressure to convert a feedstock to a biogas that can be used for energy production. The most common technologies in use today are direct combustion, gasification, pyrolysis, and plasma gasification. Combustion and gasification are more compatible with the goal of energy production, so these technologies will be discussed here.

Combustion is the rapid oxidation of fuel to obtain energy in the firm of heat. For power generation, the heat is used to produce high-pressure steam via a boiler. Today, most solid-fueled combustors are called "fluidized bed" boilers. A number of these systems burn biomass (e.g., wood wastes) operate in California. Direct combustion is not appropriate for the Paso Robles Landfill for several reasons. First, combustion is not a renewable energy source, and second, the smallest combustors require much higher feedstock throughputs.

Gasification is a process that uses air or oxygen and heat at or above 1,300°F to convert the feedstock into a synthetic gas. This gas is then used by a reciprocating engine (or small gas turbine) to generate electricity.

Gasification systems are available that process biomass. These systems are typically comprised of the following stages:

- Feedstock preparation: biomass that is primarily tree trimmings, cuttings, waste lumber, or similar material must undergo size reduction (chippers) and sorting (remove oversized material, fines).

- Feedstock Drying: the prepared feedstock enters the first section of the downdraft gasifier, where the material is dried.

- Flaming Pyrolysis: as the temperature of the material reaches the proper level, it is fed to the pyrolysis section. Air is added, and the feedstock is converted to combustion gases, char, and residual tar vapors.

- Gasification: next, the char and tar vapors are converted to hydrogen, carbon dioxide, and carbon monoxide. Some ash and char remain, and are disposed.

- Gas Cleaning: the synthetic gases contain entrained char fines and ash. A gas cleaning system quenches the gases and filters out most of the contaminants. For woody biomass, the clean fuel gas typically will have an energy content of 100 to 200 Btu/cu ft. A pound of biomass produces about 50 cu ft of fuel gas.

- Electricity Generation: finally, the clean fuel gas can be used by a gen-set (engine) to generate electricity.

- Waste Heat Recovery: The engine has two sources of waste heat that can be recovered in the form of hot air or hot water: the engine coolant, and the engine exhaust.

- The conversion efficiency will be approximately 500 kWh/ton of feedstock.

Gasification is a potentially feasible technology for renewable energy generation the Paso Robles Landfill.

Summary

The solar, wind, and biomass technologies for renewable energy production were reviewed for the Paso Robles Landfill. The potentially feasible technologies are solar photovoltaics, anaerobic digestion, and biomass gasification. Use of AD or gasification would require additional quantities of biomass to make these technologies cost-effective. These technologies are carried forward.

PERFORMANCE CHARACTERISTICS

The potentially feasible technologies, solar PV and biomass gasification, are further described in this section. For each technology, a rough conceptual design is suggested and modeled to obtain performance characteristics, from which a cost and revenue analysis can be presented in the next section.

Solar PV

For purposes of this task, it is assumed that a solar PV project will comprise two parts:

- A ground mount system on the north end of the site. The analysis here is based upon the SunPower 305 crystalline module with the SunPower T-20 trackers, and a ballasted foundation system. A photo of this system is shown in Figure 5. An advantage of the ballasted foundation is that it can easily be moved when the land is needed for a landfill cell.

Figure 5, SunPower Solar Array

- Uni-Solar PV-136 amorphous silicon modules adhered to an HDPE membrane covering the closed portion of the landfill. The PV-136 was selected because this flexible module is being applied to landfills in Germany and the U.S.

The ground mount system will occupy about twenty acres. The following design assumptions were used to model the system performance:

- Assuming eight acres per megawatt, the capacity of the site is about 2.5 MW
- Climate and solar irradiance data for the year 2005
- 9500 SunPower 305 watt modules will be used in tracking mode
- Ten Xantrex GT250 inverters rated at 250kW
- Deratement factor: 0.86
- The dc output is approximately 2,900 kW

The ground mount system will produce about 6100 MWh/yr (6,100,000 kWh/yr).

The system located on the closed landfill cell will occupy about eight acres. Note that use of flexible modules on a sloping surface has not been applied extensively as yet; however, the conditions at the landfill appear to be compatible with this approach. Further study would be required to ensure that flexible modules could be adhered to the landfill face.

The following design assumptions were used to model the system performance:

- Assuming six acres per megawatt, the capacity is about 1.3 MW
- Climate and solar irradiance data for the year 2005
- 11,000 Uni-Solar PV-136 modules rated at 136 watts
- 13 Xantrex PV-100 inverters rated at 100kW
- Deratement factor: 0.86
- The dc output is approximately 1488 kW

This PV system will produce approximately 2,200 MWh/yr.

The total energy production from the two systems would be 8,300 MWh/yr, with a rated power output of 3.8 MW.

<u>Biomass</u>

As stated above, the use of anaerobic digestion (AD) or gasification will require additional biomass, and the delivery of this biomass would need to be timed as to provide a feedstock

supply that could be utilized throughout the year. The production of renewable energy from these technologies only will be economical with near year-round operation. Batch operations are feasible, but renewable energy as a by-product would not be feasible.

For purposes of this report, it will be assumed that the minimum supply of biomass will be available. Assuming that 4,000 tons of biomass per year is available, which is almost twice the tonnage currently delivered to the landfill. If a portion of the added waste is pomace, this material would be de-watered and pelletized with a pellet mill before use for the gasification scenario.

With regard to AD, and assuming a Kompogas BW horizontal plug-flow reactor is used. A typical system is shown in Figure 6. Note that an AD system is a relatively complex industrial project.

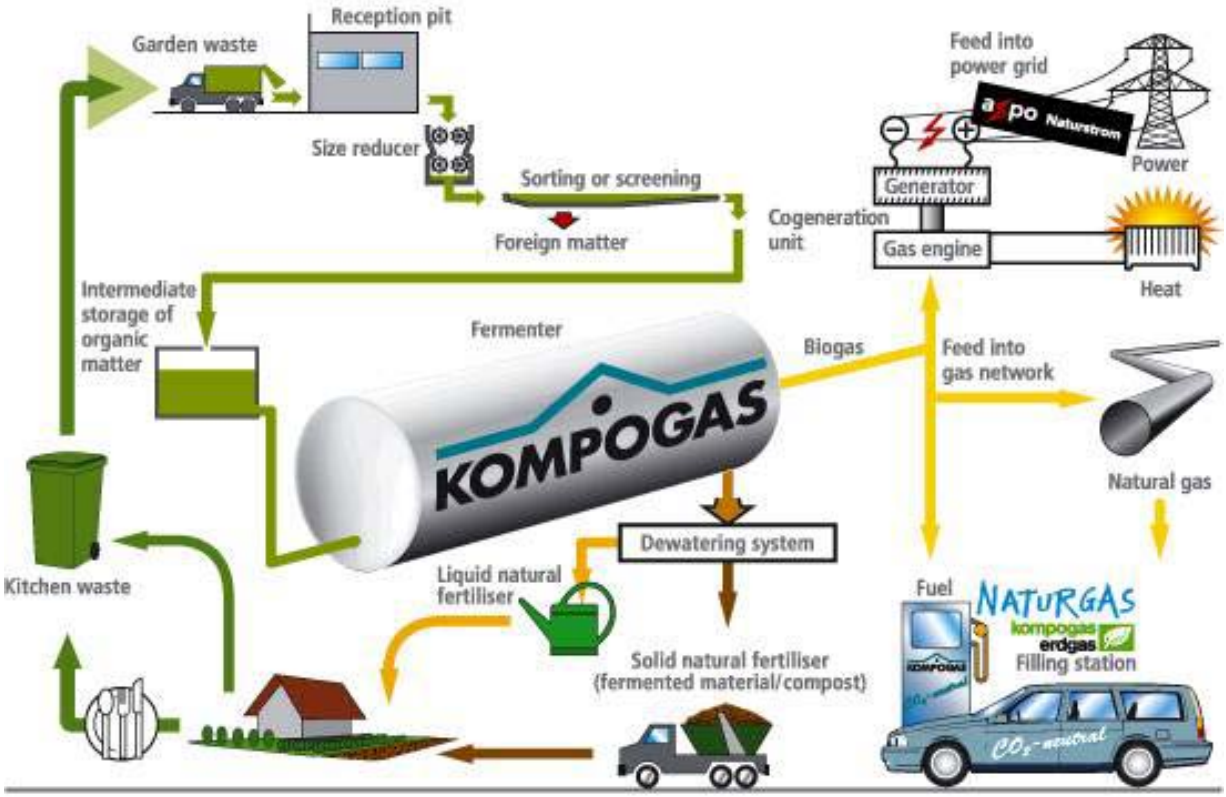


Figure 6, Kopogas Process System

This AD system would have roughly these characteristics (actual numbers will depend upon several factors, including timing of feedstock input, moisture content, and carbon-nitrogen ratio):

- Feedstock input rate: 12 tons/day
- Annual biogas production: 15 million cu ft
- Electricity production: 700,000 kWh_e/yr
- Excess heat production: 550,000 kWh_t/yr
- Digestate/compost: 1500 tons/year
- Liquid fertilizer: 1800 tons

Note that there is no use for the excess heat at the landfill; this will hurt the economics.

With regard to gasification, assume two Community Power Corporation BioMax 100 gasifiers that would treat 2000 tons of woody biomass at the landfill. These gasifiers are modular, and operate remotely (unattended). Figure 7 shows a BioMax 50 gasifier.

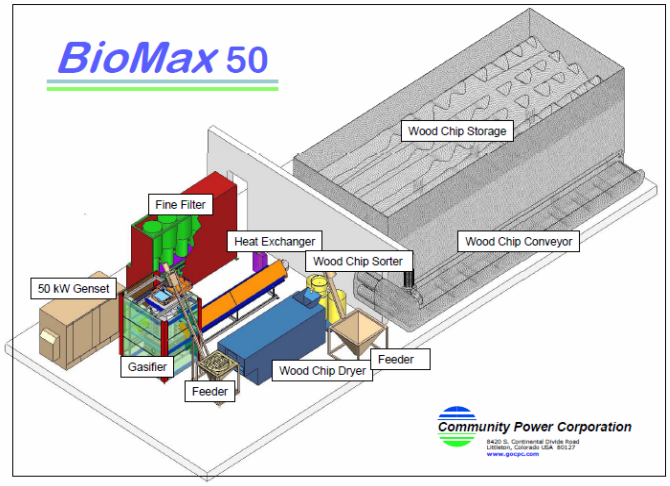


Figure 7, BioMax 50 Gasfier

The BioMax 100 gasification system would have roughly the following characteristics:

- Feedstock input rate: 2.5 tons/day
- Electricity production: 1,000,000 kWh/yr

Note that more electricity is produced by gasification when the throughput is one-half that of AD.

ECONOMICS

In this section, the economics of a solar PV system and biomass system are discussed. One way to compare the economics of diverse technologies is to use the cost of energy, as levelized value over the life of the facility. The levelized cost of energy, or LCOE, is a complex calculation that accounts for many factors over time. However, it is primarily driven by the installed cost and the annual energy production:

$$LCOE = (IC * FCR + AOM)/AkWh$$

where IC is the installed cost, FCR is the fixed charge rate per year (essentially the interest paid on a loan), AOM is the annual operations and maintenance cost, and AkWh is the annual energy production in kWh/yr. Assume that the FCR is eight percent.

The LCOE should be compared to the sale price of renewable electricity (i.e., the price the utility will pay for the electricity).

<u>Solar</u>

The following cost assumptions were used to compute the LCOE for the ground mount system:

- Installed cost: $5,000/kW
- Annual electricity generation: 6,100,000 kWh
- Annual O&M cost: $60,000 ($0.015 kWh)

The LCOE is about $0.18. However, the cost for PV modules is dropping rapidly, driven by an oversupply of modules in the recession, and the falling price of silicon. If the system cost of $5,000/kW drops to $4,500/kW, the LCOE would be about $0.15/kWh.

Similar results pertain to the solar project proposed for the closed portion of the landfill.

Biomass

The following cost assumptions were used to compute the LCOE for anaerobic digestion:

- Installed cost: $2,000,000 ($500/ton/yr)
- Annual electricity generation: 700,000 kWh
- Annual O&M cost: $80,000 ($20/ton/yr)

The LCOE is $0.24/kWh. This cost is substantially higher than the price of electricity paid by the utility for renewable energy from biomass (assumed to be somewhat lower than the price for solar energy).

The following cost assumptions were used to compute the LCOE for gasification:

- Installed cost: $1,600,000 ($800/ton)
- Annual electricity generation:1,000,000 kWh
- Annual O&M cost: $100,000 ($50/ton/yr)

The LCOE is $0.13. The gasification system appears to have a feasible cost. Note that this cost is based upon 24/7 operation for 8200 hours per year.

ENVIRONMENTAL ISSUES

The environmental issues, in terms of impacts and benefits, are discussed in this section.

Solar

The construction of solar projects has limited environmental impacts, primarily associated with air emissions from construction equipment. During operation, there would be few impacts at the landfill site.

Solar PV projects are beneficial regarding green house gas emissions. The emission factor for electricity generation is 1.64 pounds of carbon dioxide per kilowatt hour (lb CO_2 /kWh). Therefore, about 10 million pounds of CO_2 will be "saved" by solar energy per year by this project. The energy produced by this project will power about 900 homes.

Biomass

The anaerobic digesters (AD) system's primary impact is air emissions from the reciprocating engine during operation. Odors can be an issue, but not likely with grape pomace. Pathogens in the digestate also can be an issue.

Operation of the AD system will "save" about 1.1 million lb of CO_2 per year. The energy produced by the AD project will power about 60 homes.

The gasification system's primary impact is air emissions from the reciprocating engine and the gas cleaning system. Operation of the gasification system will "save" about 1.6 million lb of CO_2 per year. The energy produced by the gasification facility will power about 90 homes.

CONCLUSIONS

The purpose of conducting this evaluation was to determine if solar, wind, or biomass renewable energy is feasible at the Paso Robles Landfill. Opportunities for these renewables were examined in terms of resource availability, siting, technology selection and feasibility, performance, economics, and environmental impacts and benefits.

Wind

The production of wind energy demonstrated the least promise for the landfill. Wind speeds are insufficient to generate electricity at an economic level, even considering wind turbines designed for lower wind regimes.

Solar

The opportunity for solar energy at the landfill is summarized as follows:

- The solar resource is attractive in terms of global horizontal irradiance levels.
- There are up to about 20 acres of gently sloping land at the northern end of the landfill parcel that could be used for a ground mount solar project. In addition, it

may be possible to install/adhere a flexible solar module on the southern exposed face of the closed portion of the landfill.

- With regard to technology, crystalline or thin-film modules could potentially work on the ground mount system. A detailed study would be needed to compare these technologies, and the types of modules available within each broad technology, to determine the most cost-effective solution. Calculations were based upon the SunPower 305 crystalline module with tracking for the ground mount system. The Uni-Solar PV-136 flexible module was selected for the closed landfill portion of the project.
- When these projects were modeled, the results indicated that 6100 MWh/yr would be generated by the ground mount system, and 2200 MWh/yr would be generated by the thin-film system attached to the closed portion of the landfill.
- The levelized cost of energy for a solar project was estimated to be $0.18/kWh based upon current, approximate costs for modules, inverters, and balance of system components. Considering that module prices are rapidly decreasing, which will lower installed cost, a solar project at the landfill could be feasible.

There are two ways for the City to earn revenues from a solar project at the landfill: negotiate a power purchase agreement with PG&E, or obtain energy credit through the Local Government Renewable Energy Self Generation Program (LGR).

The City could develop a solar project at their landfill and earn the revenues from the project. The City would need to negotiate a power purchase agreement with PG&E. The price for the energy would be close to the Market Price Referent (MPR), the price of a long-term contract for a combined-cycle natural gas power plant levelized to a cent-per-kWh basis. The MPR is set by the California Public Utility Commission (CPUC) annually. The 2008 MPR (current) is about $0.13/kWh (the MPR is a function of project commission date and term of the loan). The actual price paid by PG&E modifies the MPR by adding a Time of Day (TOD) rate to account for the value of renewable energy at different times of the day. The “all-in” price likely would be in the range of $0.14/kWh; however, the actual price must be negotiated with PG&E.

If the City develops the solar project, they will be responsible for the equity and debt financing. Currently, solar projects are being financed by the private sector at roughly a 50-50 equity-debt level. The cost of a 2.5 MW project at $5,000/kW would be about $13 million.

Alternatively, the City could pursue a 1 MW project through the LGR program. While no power purchase agreement would be needed, the City would still need to fund the installation, which would be about $5 million.

In either case, the City should seek funds to support the project. The key potential source for funds is the American Recovery & Reinvestment Act of 2009 (ARRA), and the funds that will be available through this program in California, under the California Energy Commission (CEC) State Energy Program (SEP). The following opportunities may help make a solar project financially viable for the City:

- Section 106 of the American Recovery & Reinvestment Act of 2009, Payment for Specified renewable Energy Property in Lieu of Tax Credits, provides a cash payment equal to 30% of the installed cost of the project. To qualify, the project must be in construction by the end of 2010.
- The CEC SEP Municipal Financing District Program will provide loan guarantees and other support for renewable energy projects. The program will be announced in the fall of 2009.
- The CEC SEP Municipal & Commercial Building Targeted Measure retrofit Program may provide support. The program will be rolled out in the fall of 2009.
- The CEC Clean Energy Systems program will provide incentives for combined heat and power, distributed energy systems, and bioenergy projects. This program will be rolled out later in 2009.
- The CEC's Energy Efficiency & Conservation Block Grant Program may offer opportunities for support. This program will be rolled out later in 2009.

Biomass

The opportunity for generating renewable energy from biomass is summarized as follows:

- Resource availability is a question mark for biomass. Approximately 2000 tons of green waste is delivered to the landfill annually. The composition of the green waste is not well known. The possibility of receiving wastes from vineyards or wineries in the area was investigated. There is a possibility that some pomace could be routed to the landfill from co-ops.

- Two processes appear feasible for the biomass waste stream at the landfill. First, gasification of woody wastes can be performed with a small, modular gasification system. One such system has a throughput of about 500 tons/year. However, to be economical, the capacity factor must be at least 70%, so a sufficient quantity of waste must be available throughout the year. Second, an anaerobic digestion system could be feasible, particularly if sufficient quantities of pomace were obtained from winery operations. AD systems, however, also produce liquid and solid waste streams of their own that must be managed.
- The levelized cost of energy for gasification could be attractive. A calculation indicated that the cost could be about $0.13/kWh. While further analysis would be needed to more accurately determine waste characterization and prepare a specific equipment design, gasification could be a viable solution, particularly if additional biomass can be obtained.
- The levelized cost of energy for AD is about $0.24/kWh. This higher cost is reflective of the fact that AD produces only a small amount of renewable energy in comparison to gasification. Unless the amount of biomass is increased significantly, this technology will not be economical method to produce renewable energy.

As with solar energy, the ARRA may provide opportunities to receive funding for a bioenergy project.

Next Steps

Using the results of this analysis of potential methods for generating renewable energy at the Paso Robles Landfill, the following actions are suggested to continue the development of a solar PV project:

- Inspect the twenty-acre site on the north end of the landfill parcel. Hold discussions with the City of Paso Robles and Pacific Waste Systems to determine more precisely how much land would be available for solar development.
- Work with a supplier(s) to obtain a more precise array design and configuration for the site, and estimate the energy production and installed cost.
- Hold discussions with PG&E regarding interconnection to the grid (following the Small Generator Interconnection Program) and sale of the electricity to PG&E.
- Monitor the funding and loan guarantee programs under the ARRA, including those coming from the CEC's State Energy Program.

- Finally, if the actions above indicate a feasible project, write a brief business plan for presentation to the City.

Using the results of this analysis of potential methods for generating renewable energy at the Paso Robles Landfill, the following actions are suggested to continue the development of a biomass project:

- Obtain a better picture of the green waste composition at the landfill, and discuss the possibility of diverting the green waste now sent to Madera to a biomass project at the landfill.
- Contact wineries and co-ops, and discuss the possibility of diverting pomace to the landfill.
- With an estimate of future green waste volumes, examine the feasibility of anaerobic digestion versus gasification and select the best technology based upon both technical and cost considerations.
- For the selected technology, talk to at least three vendors and obtain the technical and cost data required to compare operational and cost issues. Select the best vendor and ask for a system quote.
- Finally, if the actions above indicate a feasible project, write a brief business plan for presentation to the City.

Limitations

The conceptual designs described here are based upon the available data regarding solar and biomass resources, and published design information from vendors. The economic analysis is based upon a rough form of LCOE. More detailed analyses are required before final decisions can be made regarding cost effectiveness of generating renewable energy at the Paso Robles Landfill.

APPENDIX D

EXISTING ZERO WASTE PROGRAMS

EXISTING ZERO WASTE PROGRAMS

The following table summarizes the existing zero waste programs that are currently available to the residents and businesses of the City. The programs discussed in greater detail later in the text.

SUMMARY OF CITY'S EXISTING ZERO WASTE PROGRAMS		
SERVICE	**ZERO WASTE PROGRAM**	**SERVICE PROVIDER**
Single Family Residential	Curbside Recycling	Paso Robles Waste Disposal
	Curbside Green Waste (Includes Christmas Trees)	
	Annual Clean-Up Week	
	Curbside Used Oil and Filter Recycling	
	Recycling Buy-Back Centers	
Multi-Family Residential	On-Site Recycling Collection	Paso Robles Waste Disposal
	Green Waste Collection	
	Recycling Buy-Back / Drop-Off Centers	Various Parties
Commercial	Single Stream Recycling	Paso Robles Waste Disposal
	Green Waste	
Construction and Demolition	Source-Separated Collection of Recyclable Materials	Paso Robles Roll-Off
	Certified Facility Recycling / Paso Robles Landfill Diversion Programs	Pacific Waste Services & Various Other Parties
Public Education Programs	City Website	City
	Paso Robles Disposal Website	Paso Robles Waste Disposal
	IWMA Website	IWMA
	Advertising in Phone Books, Television, and Newspaper	
	IWMA Hotline	
	IWMA Speakers Bureau	
	Presentations and Field Trips for School Children	
	School Food Waste Diversion	
	"Zero Waste in the Classroom" Program	
Ordinances and Other Programs Available Countywide	Mandatory Recycling Ordinance	IWMA
	Battery, Fluorescent Lamp and Fluorescent Tube Collection "Take-Back" Ordinance	
	Used Paint Collection at Retail Stores "Take-Back" Ordinance	
	Home-Generated Sharps Waste Collection at Pharmacies and Retailers "Take-Back" Ordinance	
	Other Household Hazardous Waste Collection at Permanent Collection Sites	
City Waste	Paso Robles Landfill Diversion Programs	Pacific Waste Services
Self-Haul Waste	Paso Robles Landfill Diversion Programs	

SINGLE-FAMILY RESIDENTIAL

The City has approximately 7,900 single-family detached homes that receive weekly solid waste, recycling, and green waste collection. This section describes the current solid waste and zero waste services offered to residents.

SOLID WASTE COLLECTION

Residents have three sizes of containers that they can choose for solid waste: 40-gallon, 60-gallon, and 90-gallon. If customers have more trash than can fit in their regular refuse cart, they can purchase tags to place on additional 32-gallon containers. Customers can pay an extra fee for "in-yard" service, also known as backyard service. In the case of disability, there is no extra charge for in-yard service. Residential customers may also request temporary three- or four-cubic yard bins when they need extra capacity.

The following table shows the price of each of the three solid waste container options along with the average price per gallon of service. This rate structure is what is referred to as a Regressive Variable Can Rate where the cost per unit volume (gallon) of service decreases as service volume increases.

CONTAINER SIZE (GALLON)	MONTHLY RATE	COST PER GALLON OF SERVICE
40	$26.42	$0.66
60	$34.67	$0.58
90	$38.13	$0.42

CURBSIDE RECYCLING COLLECTION

All customers are provided with a 60-gallon cart for weekly recycling collection. The following items are accepted for recycling: aluminum cans and foil, tin cans, aerosol cans, lids from jars, newspaper, cardboard, junk mail, books and phone books, egg cartons, frozen food packaging, paper bags and boxes, magazines, plastic bottles and containers (#1through #7), and glass bottles and jars.

Residential recyclables are delivered to the Paso Robles Recycling facility on Riverside Avenue in Paso Robles, which is owned by Waste Management. Waste Management then transfers the recyclables to their facility in Santa Maria for processing.

The following table summarizes the solid waste, recycling, and green waste tonnages collected from single-family homes in 2006 through 2008 for recycling, green waste, and solid waste and the associated single-family diversion rate. As shown, the diversion rate for the single-family residential waste stream has averaged approximately 50 percent over the last three years.

SINGLE-FAMILY RESIDENTIAL COLLECTION VOLUMES 2006-2008				
MATERIAL	**TONS**			
	2006	**2007**	**2008**	**Three-Year Average**
Diversion				
Curbside Commingled Recyclables	2,985	3,051	2,849	2,962
Curbside Greenwaste	3,697	3,639	3,658	3,665
Diversion Subtotal	**6,682**	**6,690**	**6,507**	**6,626**
Disposal				
Curbside Solid Waste	6,582	6,537	6,411	6,510
Disposal Subtotal	**6,582**	**6,537**	**6,411**	**6,510**
Total Generation	**13,264**	**13,227**	**12,917**	**13,136**
Diversion Rate	**50%**	**51%**	**50%**	**50%**

Source: Paso Robles Waste Disposal

CURBSIDE GREEN WASTE COLLECTION (INCLUDING CHRISTMAS TREES)

All customers are provided with a 90-gallon cart for weekly green waste collection. Acceptable materials include leaves, plant prunings, grass, weeds, tree trimmings, and Christmas trees. All residential green waste is delivered to the Buckeye Enterprises Chip and Grind facility that is owned by San Miguel Garbage. The facility is located outside of the City limits, in the unincorporated County. Green waste is chipped at the facility and shipped offsite.

ANNUAL CLEAN-UP WEEK

Paso Robles Waste Disposal conducts an annual clean-up week for single-family residential customers. There is no additional cost for this program. Residents can set out up to two cubic yards of materials or two large items for collection.

USED OIL AND FILTER RECYCLING

Curbside

Paso Robles Waste Disposal collects used oil curbside from single-family homes, on the regular collection day. The hauler provides 15-quart oil collection containers and oil filter bags. The City receives Used Oil grant funding from the CIWMB each year, and these grant funds are pooled with other jurisdictions in the County, through the IWMA. The IWMA uses the grant funding to pay for all oil recycling containers and bags for recycling oil filters and also to pay for a portion of the cost of the Household Hazardous Waste collection centers. The IWMA also uses CIWMB Used Oil grant funding to pay Paso Robles Waste Disposal $6,000 per year to help fund the curbside oil collection.

Certified Collection Centers

There are five (5) certified used oil collection centers in the City that are listed below. In addition, the permanent Household Hazardous Waste facility at the City of Paso Robles Landfill also accepts used oil for recycling.

AirFlow Filter Service
1140 Ramada Dr.
Paso Robles, CA 93446
(805) 238-7076
CIWMB#: 40-C-06765

Kragen Auto Parts #1385
150 Niblick Rd.
Paso Robles, CA 93446
(805) 227-0425
CIWMB#: 40-C-04281

Jiffy Lube #2911
200 Oak Hill Rd.
Paso Robles, CA 93446
(805) 489-5779
CIWMB#: 40-C-06851

Paso Robles Landfill PHHWCF
9000 HWY 46 East & Union Rd.
Paso Robles, CA 93446
(805) 782-8530
CIWMB#: 40-C-06587

Kragen Auto Parts #0297
2044 Spring St.
Paso Robles, CA 93446

(805) 238-5516 CIWMB#: 40-C-02511

RECYCLING BUY-BACK CENTERS

There are six (6) recycling buy-back centers located in the City that are listed below. In addition, there are various locations in the City where residents can drop-off recyclables, including the Paso Robles Landfill.

Tomra Pacific, Inc.
189 Niblick Road

Tomra Pacific, Inc.
1465 Creston Road

Koker Metals
2704 Ramada Drive

Macoy Resource and Recycling
5815 Stockdale Road

A-1 Metals and Auto Salvage
5795 Stockdale Road

Paso Robles Recycling
(Waste Management Facility)
3350 Riverside Ave.

MULTI-FAMILY RESIDENTIAL

The City has approximately 3,400 multi-family units, which includes town homes, duplexes, and apartment buildings[1]. The solid waste, recycling, and green waste quantities for multi-family are not tracked separately by Paso Robles Waste Disposal; the tonnage is included in the totals for commercial waste.

SOLID WASTE COLLECTION

Solid waste service is available with the following bin sizes for multi-family housing: 1.5-, 2-, 3-, and 4-cubic yards.

ON-SITE RECYCLING COLLECTION

Commingled recycling service is provided to multi-family accounts with 3-cubic yard bins.

[1] Source: State of California, Department of Finance 2009 E-5 Report: 920 (Attached Single-Family, including Town Homes); 1,102 (2 - 4 units) and 1,388 (5 or more units).

GREEN WASTE COLLECTION

Green waste collection service is provided to multi-family accounts. Acceptable materials include leaves, plant prunings, grass, weeds with minimal amounts of soil, tree trimmings, and clean yard waste.

RECYCLING BUY-BACK CENTER

Multi-family residents have access to the same six buy-back facilities identified in the previous section - *Single-Family Residential Section*.

COMMERCIAL SECTOR

The commercial sector is served by Paso Robles Waste Disposal and Paso Robles Roll-Off, Inc. Both companies have the same owner.

SOLID WASTE COLLECTION

Commercial solid waste service is available through carts and bins. Carts are available in 40-, 60- and 90-gallon sizes and bins are available in sizes of 1.5-, 2-, 3-, and 4-cubic yards. Roll-Off service is offered through 10-, 20-, 30-, and 40-cubic yard roll off bins.

RECYCLING COLLECTION

Paso Robles Waste Disposal provides commercial customers with three-cubic yard cardboard-only bins, and office paper and commingled recycling programs. These services are offered for free as required by the franchise agreement. The office paper recycling program includes Paso Robles Waste Disposal, Inc. providing businesses with bags and racks for the paper collection and an employee is sent to the business weekly to empty the bags.

Commercial recyclables are taken to two different recycling facilities. Source-separated cardboard is taken to the Waste Management Recycling Facility on Riverside Drive in Paso Robles. Commingled commercial recyclables are delivered to the Processing Facility at the Cold Canyon Landfill. Approximately 66 percent of commercial accounts in the City subscribe to recycling service.

Roll-Off recycling service is also available to customers through bins of 10-, 20-, 30-, and 40-cubic yards.

GREEN WASTE COLLECTION

Paso Robles Waste Disposal also provides commercial customers with green waste collection in two-cubic yard bins. The material is delivered to the Buckeye Enterprises Chip and Grind Facility that is owned by San Miguel Garbage. Approximately 10 percent of commercial accounts in the City subscribe to green waste service.

The following table summarizes the amounts of solid waste, recycling, and green waste collected from commercial sources and multi-family residents in 2006 through 2008 and the resulting commercial sector diversion rate. The increase in the commercial sector diversion rate over this period is due in large part to the implementation of commingled recyclables collection, as shown in the next table.

COMMERCIAL/MULTI-FAMILY RESIDENTIAL COLLECTION VOLUMES, 2006 TO 2008				
Material	**Tons**			
	2006	**2007**	**2008**	**3-year Average**
Diversion				
Commercial Greenwaste	138	189	220	182
Commercial Cardboard	1,156	1,120	980	1,085
Commercial Commingled Recyclables	0	208	892	367
Diversion Subtotal	**1,294**	**1,517**	**2,092**	**1,634**
Disposal				
Commercial Solid Waste, Bin Service for Commercial and Multi-Family	13,376	13,145	12,231	12,917
Commercial Compactor – Paso Robles Roll-Off**	2,122	1,777	1,565	1,821
Commercial Open Top Boxes	1,082	609	438	710
Disposal Subtotal	**16,581**	**15,530**	**14,234**	**15,448**
Total Generation	**17,874**	**17,047**	**16,326**	**17,082**
Diversion Rate	**7%**	**9%**	**13%**	**10%**

Source: Paso Robles Waste Disposal

CITY WASTE

Pacific Waste Services tracks City Waste separately, and reports City waste volumes on a quarterly basis. City Waste includes waste delivered by both City department vehicles from City facilities, as well as sludge and grit from the City's Waste Water Treatment Plant (WWTP). Sludge is used at the landfill for on-site beneficial use. The following table summarizes the amounts of City Waste that entered the landfill in 2006 through 2008, the amount diverted and the resulting City Waste diversion rate.

CITY WASTE COLLECTION VOLUMES, 2006 TO 2008				
Material	**Tons**			
	2006	**2007**	**2008**	**3-year Average**
Diversion				
City Sludge	1,674	3,064	3,310	2,683
Diversion Subtotal	**1,674**	**3,064**	**3,310**	**2,683**
Disposal				
City Waste	2,770	2,096	2,521	2,462
City Grit	238	250	405	298
Disposal Subtotal	**3,008**	**2,347**	**2,926**	**2,760**
Total Generation	**4,682**	**5,411**	**6,236**	**5,443**
Diversion Rate	**36%**	**57%**	**53%**	**49%**

Source: Pacific Waste Services for the Paso Robles Landfill

UNCOMPACTED LANDFILL WASTE STREAM

The Uncompacted Landfill Waste Stream is comprised of self-haul loads and debris box loads, both of which included construction and demolition debris. Pacific Waste Services is currently recovering portions of this waste stream by directing clean source separated loads to on-site stockpiles. Recovery of material from mixed loads is limited to the picking that occurs at the working face.

Pacific Waste Services records only those loads where the customer advises the scale house personnel that the material is from a project with a County permit that requires verification of recycling as a "C&D Load." It is assumed that a substantial portion of the other Uncompacted Landfill Waste Stream also consists of construction and demolition debris.

CONSTRUCTION AND DEMOLITION (C&D) DEBRIS

Paso Robles Roll-Off has the exclusive rights to offer Roll-Off service in the City. The agreement has a 10-year term and is set to expire on August 31, 2013. The agreement contains a provision that the company "shall make reasonable efforts to attain the waste diversion goals of the IWMA and the City in disposing of solid waste." The agreement also directs the hauler to deliver all solid waste collected to the City of Paso Robles Landfill. The Paso Robles Landfill charges the standard tipping fee of $38.55 per ton for all loads of construction and demolition debris that it receives.

SOURCE SEPARATED COLLECTION OF RECYCLABLE MATERIALS

Paso Robles Roll-Off provides reduced rates for loads of source separated construction and demolition debris.

C&D ORDINANCE

The City has drafted, but not passed, an ordinance for C&D debris recycling. The ordinance would require applicants of "covered" construction and demolition projects (which are further defined in the ordinance) to submit a Waste Management Plan to the City. Certain applicants would also be required to submit a performance security to the City, which would be returned to the applicant at the conclusion of the project (subject to documentation showing that the applicant recycled 75 percent of the waste from the project).

The IWMA lists construction and demolition debris recycling facilities on its website, including facility name, location, phone number, and types of materials accepted for recycling. The IWMA also publishes a one-page brochure summary of the facilities that accept construction and demolition debris for recycling.

CERTIFIED RECYCLING FACILITIES

Solid waste and recycling facilities in the County can become "certified" C&D debris recycling facilities by consistently recycling 50 percent of the C&D waste that they receive. The City's landfill is a certified C&D facility. Certified facilities send reports to IWMA each

quarter to maintain compliance. The facilities are required to report the total amount of construction and demolition waste received and recycled, and the resulting diversion rate.

The following table summarizes the amounts collected from C&D debris sources and in 2006 through 2008 for recycling and solid waste, and the resulting C&D sector diversion rate. The diversion rate has fallen despite the reduction in disposal tons. With the economic conditions resulting in less construction work, the generation of material is declining and also reducing the amount of material diverted.

SELF-HAUL WASTE STREAM

PWS tracks self-haul waste separately, and reports self-haul volumes on a quarterly basis. Portions of the Self-Haul waste stream are manually recovered from the working face along with portions of the Construction and Demolition Debris loads.

The following table provides a summary of the Uncompacted Landfill Waste for 2006 through 2008 and the associated diversion.

UNCOMPACTED LANDFILL WASTE STREAM VOLUMES, 2006 TO 2008				
Material	**Tons**			
	2006	**2007**	**2008**	**3-year Average**
Incoming Tonnage				
Self-Haul Waste	4,631	3,009	1,679	3,106
Minimum Loads	1,506	1,364	949	1,273
Uncompacted Loads	6,803	4,736	3,139	4,893
C&D Loads	300	183	120	201
Total Incoming	**13,240**	**9,292**	**5,887**	**9,473**
Total Diversion	**222**	**1,821**	**2,723**	**1,589**
Total Disposal	**13,018**	**7,470**	**3,164**	**7,884**
Total Generation	**13,240**	**9,292**	**5,887**	**9,473**
Diversion Rate	**2%**	**20%**	**46%**	**17%**

Source: Pacific Waste Services for the Paso Robles Landfill

PUBLIC EDUCATION PROGRAMS

MULTI-FAMILY RECYCLING OUTREACH AND PUBLIC EDUCATION

The IWMA works in cooperation with Paso Robles Waste Disposal to provide outreach to multi-family buildings to encourage them to subscribe to free recycling services. A grant

from the Department of Conservation has provided funding for purchasing new recycling bins. As part of the outreach program:

- Brochures are provided to each multi-family unit;
- In-unit (small) recycling containers are provided to each unit; and
- Stickers are placed on the recycling containers. The stickers explain which materials are suitable for recycling.

CITY, PASO ROBLES WASTE DISPOSAL AND IWMA WEBSITES; ADVERTISING IN PHONE BOOKS, TELEVISION AND NEWSPAPERS; IWMA HOTLINE, AND IWMA SPEAKERS BUREAU

Recycling and waste collection information is available on the City's website, the website of Paso Robles Waste Disposal, and the IWMA web site. Paso Robles Waste Disposal provides a packet of solid waste and recycling information to new accounts. The IWMA has placed a 16-page insert in the AT&T phone book under "recycling" and runs television and newspaper ads to promote recycling. The IWMA also staffs a recycling telephone hotline, and maintains a speaker's bureau program, where recycling speakers are made available to civic and service groups, upon request.

PRESENTATIONS AND FIELD TRIPS FOR SCHOOL CHILDREN

The IWMA produces a recycling education program for school-age children and class presentations are made throughout the County each year. Field trips are available for groups of school children each year. In 2008, the IWMA provided 588 classroom presentations and 144 field trips Countywide, for the City of Paso Robles; there were 131 classroom presentations and 16 field trips that were conducted during the school year. Most students are elementary school children, but some are from middle school, high school, or college age. The field trips are taken to the Cold Canyon Landfill to view the composting site, processing facility, landfill, and Resource Recovery Park at Cold Canyon.

There is an educational center within the processing facility. A brochure is sent to every teacher in the County in the Fall, and interested teachers contact the IWMA to schedule the field trips. The field trip lessons are science-based and grade-specific. In addition, educational materials are available for classroom use.

SCHOOL FOOD WASTE DIVERSION

This program provides assistance in the setup and maintenance of vermicomposting (composting with worms) and in-vessel composting systems designed to accept food waste at schools. Large worm bins (4 feet wide by 16 feet long and 2 feet deep) are located at the Virginia Peterson Elementary and the Bauer-Speck Elementary Schools in Paso Robles, and the bins handle each school's lunch waste. In addition, 39 classrooms in Paso Robles have small worm bins. The small bins are 2 feet wide by 3 feet long and 1 foot deep. They are used as trial bins that teachers can use from three weeks to three months to decide if they are interested in moving up to a large worm bin. The IWMA also provides the students with a 45-minute presentation and demonstrates how to use the small worm bins.

ZERO WASTE IN THE CLASSROOM

The IWMA will soon be implementing a program in which teachers and students review and measure classroom-based waste and implement programs to reduce the waste in their own classrooms.

ORDINANCES AND OTHER PROGRAMS AVAILABLE COUNTYWIDE

The IWMA has passed a number of ordinances in supporting effective solid waste management in the County, including a Mandatory Recycling Ordinance. In addition, the County has been a national leader in passing "take back" legislation that requires retailers of targeted items in the IWMA region to establish within their retail outlet a system for the acceptance and collection of the following materials:

- Sharps;
- Household batteries and fluorescent tubes; and
- Latex Paint.

MANDATORY RECYCLING ORDINANCE

The IWMA passed an ordinance in January of 2009 that requires mandatory recycling from single-family and multi-family residents, commercial establishments, and at special events.

The ordinance has requirements for tenants, building owners and managers, and franchise haulers. Main elements of the ordinance are described below.

- The ordinance only applies to those service areas in which garbage and recycling collection is available through a franchise agreement as defined in the ordinance.
- Requires all single-family residents to separate recyclable materials from garbage going to the landfill for disposal;
- Requires for multi-family residential facilities that the responsible person provide on-site recycling service to the occupants and requires recyclables to be sorted from garbage;
- For commercial facilities, the responsible person provides on-site recycling services to occupants and requires that recyclables be sorted form garbage;
- Special events shall have recycling containers available at least equal to the number of garbage containers; and
- Self-haul loads shall comply with the ordinance by recycling those items that can be recycled at the landfill.

In all cases, garbage should contain no more than 20 percent of recyclable materials or the customer may be fined. For violations of multi-family, commercial, special events or self-haul, the fine is $1,000 per day. For single-family violations, the fine is to be determined by the City.

BATTERY, FLUORESCENT LAMP, AND FLUORESCENT TUBE RECYCLING ORDINANCE

There are 300 retail outlets throughout the County that collect batteries and fluorescent lamps in response to a Countywide ordinance that requires retail take-back of these items by the retailers that sell them. In Paso Robles, there are 15 collection locations for compact fluorescent lamps and tubes and forty collection sites for batteries. The ordinance requires the following from retailers:

- Retailers must establish a convenient location within the store for lamp and/or battery collection;

- Retailers must provide an appropriate receptacle within the store for lamp and/or battery collection;
- Retailers must provide appropriate signage to inform customers of the program; and
- Retailers are prohibited from charging consumers for the lamp and/or battery take-back program.

The IWMA has provided containers for recycling of fluorescent lamps, tubes, and batteries. These containers were purchased by using funds from a Household Hazardous Waste Grant from the CIWMB. The battery and bulb recycling containers are located in the reception area of the Paso Robles Waste Disposal offices, as a convenient drop-off location for all residents.

USED PAINT COLLECTION AT RETAIL STORES ORDINANCE

Beginning July of 2009, there is a new ordinance that covers all paint retailers in all of the jurisdictions of the County. The ordinance requires that every retailer who sells regulated paint must accept, collect, and dispose of latex paint. The ordinance requires the following from retailers:

- Retailers must establish a convenient location within the store for paint collection;
- Retailers must provide appropriate signage to inform customers of the program; and
- Retailers are prohibited from charging consumers for the paint take-back program.

HOME-GENERATED SHARPS WASTE COLLECTION AT PHARMACIES AND RETAILERS ORDINANCE

There is an ordinance that covers all sharps retailers in all of the jurisdictions of the County. There are currently seven (7) retailers in Paso Robles that are collecting sharps from consumers. The ordinance requires that every retailer who sells sharps must accept, collect, and dispose of sharps. The ordinance requires the following from retailers:

- Retailers must establish a convenient location within the store for sharps collection;
- Retailers must provide an appropriate receptacle within the store for sharps collection;
- Retailers must provide appropriate signage to inform customers of the program; and
- Retailers are prohibited from charging consumers for the sharps take-back program.

OTHER HOUSEHOLD HAZARDOUS WASTE

There are six (6) collection centers in the County for Household Hazardous Waste (HHW). The closest center for Paso Robles residents is located at the Paso Robles Landfill. It is open from 11:00 am to 3:00 pm on Saturdays. The center is also open for businesses that are

considered small volume generators. The scheduled day for acceptance from these generators is typically the same day that the HHW center has a pick-up scheduled for its material.

APPENDIX E

DATA SOURCES

DATA SOURCES

The BAS Team reviewed the following data, reports, agreements, etc., and consulted with various sources for information to prepare this Section One report.

- Met with City staff to review existing policies and programs;
- Reviewed the City's two franchise agreements with Paso Robles Waste Disposal and Paso Robles Roll-Off, and the amendments to the agreements;
- Reviewed the City's 2000 Used Oil Grant application;
- Reviewed the City's draft Construction and Demolition Debris Ordinance;
- Retrieved population and housing data from the California Department of Finance website;
- Interviewed County of San Luis Obispo Integrated Waste Management Authority (IWMA) staff and consultants (Bill Worrell, Mike DeMilo) and reviewed the Authority's website and published ordinances;
- Reviewed IWMA's Construction and Demolition Debris Recycling Guide and Power Point presentation on C&D recycling;
- Reviewed IWMA's ordinances on mandatory recycling and retailer take-back of sharps, batteries, fluorescent lamps, and paint;
- Reviewed IWMA board meeting minutes related to annual public education and vermicomposting program in schools;
- Interviewed representatives of Paso Robles Waste Disposal and reviewed their website;
- Reviewed the California Integrated Waste Management Board's (CIWMB) waste composition data;
- Reviewed the IWMA AB 939 Annual Reports for 2006 and 2007;
- Reviewed the CIWMB's database of facilities;
- Reviewed disposal records from the Paso Robles Landfill;
- Reviewed IWMA quarterly fee invoices to the City for 2006 through 2008;
- Reviewed hauler tonnage data on disposal, recycling, and green waste collection;
- Met with and/or conducted telephone interviews with facilities;
- Reviewed pending legislation, AB 479;
- Reviewed the capacity limits and acceptable materials for various facilities in the County; and
- Reviewed the 2007-08 Grand Jury report on "Waste Management in San Luis Obispo County."

APPENDIX F

OPERATIONS AT PASO ROBLES LANDFILL

OPERATIONS AT PASO ROBLES LANDFILL

OVERVIEW

Paso Robles Landfill is located nine (9) miles east of the City of Paso Robles (City) adjacent to and north of Highway 46. The landfill is owned by the City and the Public Works has one sight and managers the landfill. The City has contracted with Pacific Waste Services, Inc. (PWS) to perform the day-to-day duties of operating the facility. PWS' contract with the City expires in 2020. The landfill is operated from 8:00 a.m. to 3:00 p.m., Monday through Saturday and 8:00 a.m. to 2:00 p.m. on Sundays. The site is open to the general public and franchised or permitted waste haulers. The landfill occupies 80 acres and has a permitted footprint of 65 acres, and a maximum permitted capacity of 6,495,000 cubic yards (cy).

SITE PLAN

The landfill currently consists of four (4) disposal unit modules, along with infrastructure and ancillary features, including a scale and combination scalehouse and office building, a permitted household hazardous waste drop-off facility operated by the San Luis Obispo Integrated Waste Management Authority (IWMA), a landfill gas collection and flare system, water supply and leachate storage tanks, and stormwater sediment basins. Four (4) additional disposal unit modules are yet to be constructed but are within the permitted landfill footprint.

WASTE ORIGIN

Data on the jurisdiction of origin for waste disposed at the City's landfill, as well as waste origin data for the Chicago Grade and Cold Canyon Landfills in San Luis Obispo County reveals that with the exception of limited waste from Unincorporated Monterey County (approximately 200 tons per year or 0.5 percent of the total waste received), all of the waste entering the Paso Robles Landfill is from the San Luis Obispo County IWMA jurisdictions.

The landfill is a Class III waste management unit; under this designation the waste types accepted for disposal are: non-hazardous agricultural, construction and demolition debris,

industrial wastes, metals, mixed municipal wastes, dried sewage sludge from the City's waste water treatment plant, used tires, wood waste, and treated wood waste are also accepted. Discharge of liquid wastes is prohibited. The following table provides the waste types and relative percentages by weight of materials received at the landfill based on the site operators' analysis of gate records from the past several years.

Waste Stream (1)	Percent of Total
Residential Curbside Collection Wastes	22.6%
Commercial Waste	41.8%
Roll-Off Debris Box Waste	16.6%
Self-Hauled Wastes	15.6%
City of Paso Robles Waste and Debris	2.8%
Sewage Treatment Plant Grit Screenings	0.4%
Mattresses and Sofas.	0.2%
Total	**100.0%**

(1) Treated and dried sewage sludge from the City's wastewater treatment plant is also accepted at the landfill. This material is stockpiled and used as a soil amendment to promote vegetative growth on intermediate landfill slopes.

Other waste materials received at the site are separated for recycling and are not disposed of in the landfill. These materials include concrete, asphalt, appliances, clean wood waste, green waste and used tires (see Waste Recovery section below).

WASTE DISPOSAL RATES

Annual and daily average municipal solid waste (MSW) disposal rates for the Paso Robles Landfill are provided below and exclude source-separated recyclable materials delivered to the landfill.

	Year	Disposal Rate	
		Tons/Year	Tons/Day [1]
Actual	2003	49,530	162
	2004	49,650	162
	2005	46,300	151
	2006	51,050	167
Projections	2007	53,100	174
	2008	55,200	180
	2009	57,400	188
	2010	59,700	195
	2011	62,100	203
	Site Life Estimate	75,000	245

[1] Six (6) day per week average

It is estimated that the site has an excess of soils needed for landfill operations and closure and will not require any imported soil for daily, intermediate, or final cover soil needs.

SITE LIFE ESTIMATES

The design capacity of the facility is 6.5 million cubic yards of waste, with an estimated 3.3 million cubic yards of remaining capacity as of April 2007. This estimate was based on the calculated remaining airspace and a landfill industry airspace utilization factor figure of 1,250 pounds per cubic yard for in-place density. The estimated closure date of the facility is 2051 based on 75,000 tons per year of waste disposal.

COMPACTION TECHNIQUES

Current site waste filling procedures rely on the horizontal lift method of construction. With this method the active fill area is determined by dividing the total lift thickness into the average monthly waste volume. The working face dimensions are then determined by dividing that area by the desired length to arrive at the required width for the working face. These dimensions are then measured out on the cell base and staked using scrap PVC piping or long wood poles obtained from the working face. Grading ribbons are then tied to the poles at the appropriate elevations to maintain finished cell grades.

Once the cell dimensions have been staked the previous soil cover materials are carefully stripped away using a dozer to expose the upper most levels of the in-place waste. This practice is necessary to save valuable landfill airspace and to ensure any tightly packed soil surfaces are broken up to promote vertical liquid drainage and reduce lateral leachate flow.

Waste materials are then spread with the crawler-dozer and the refuse compactor in thin horizontal lifts across the entire working face. Typically, wastes will be unloaded and placed from above the active working area using a dozer to position the waste in thin horizontal lifts. With this fill method it is desirable to keep fill lift to a maximum of 18 inches. The refuse compactor then makes 3 to 5 passes over the waste lift to compact material to maximum density. Typically, the 75- to 150-foot wide working face is sloped at an angle of 3 to 5 percent, with the outer edges of the fill sloped 3:1. The total height of the waste cell usually ranges from 8-12 feet, but varies depending on the specific fill sequence and shape of each optimal cell.

CURRENT ALTERNATIVE DAILY COVER USE

The site has been approved to use tarps as ADC since the late 1990's. Since that time, daily cover tarps have been proven as an industry standard for protection of the waste fill from litter production and against harborage of vectors and birds. Daily use of ADC tarps (including at the end of the day each Saturday) has been approved by the CIWMB. A description of the approved long-term ADC tarping procedures is as follows:

- Tarps are used only when site conditions allow;
- Soil cover is used during periods of excessively high winds;
- Tarps are placed across the working face each day;
- Tarps are placed and shingle overlapped to promote drainage off the working face;
- Typical overlaps will be 2 feet when during periods when rain is forecast and 1 foot all other times;[1]
- Tarps lap a minimum of two feet on to adjacent soil cover;

- Tarps are held in-place using waste tires or other manageable inert objects.

The general procedures for alternative daily cover are as follows: 1) waste spreading, grading and compaction is completed at the end of the day; 2) outer edges (slopes of the horizontal lift) are covered with soil cover; 3) tarps are positioned as described above using landfill equipment assisted by landfill labor; 4) tarps are anchored by placing tires or other heavy objects around the perimeter; and 5) additional soil cover is placed on the active face as necessary to cover all waste.

Tarps are used mainly on the horizontal of the working face. Soil cover is applied to the outer (3:1) edges of the active fill area. Typically soil cover will be applied to the outer slopes on a daily basis; however, this schedule may vary while the actual working-face location and configuration, in which case the slopes may be covered by tarps.

Tarp removal is completed in the morning in the reverse order described above for removal. The tarps are folded over to half sixed then dragged off the waste fill using the landfill equipment. When not needed or not being used, tarps are stored on the ground near the working area, out of the way of traffic.

Typically a minimum of 12 inches of interim cover soil will be placed on the top of the finished cell once it has been constructed to the desired elevation and graded appropriately for drainage. At this point the soil cover will be trackpacked and smooth graded forming a firm surface for use as future unloading area.

WASTE RECOVERY

Recycling efforts at the landfill include recovery of:

- Inert materials such as asphalt, concrete, and roof tile which are used for roads and wet weather pads;
- Metals (appliances, refrigerators, scarp metal) and tires.

Typically, these materials are unloaded in designated areas by the customers and haulers, although PWS also actively recovers mixed materials from the active landfill face. Grinding

of wood waste materials is subcontracted to a company with portable grinding equipment. Processed wood waste is ground, loaded into trucks, and hauled off-site to biomass fuel facilities in the California Central Valley. Excess material is used on-site as soil erosion mitigation material on site interim covered side slopes. There are also containers for source-separated recyclables at the landfill scalehouse. Under a separate permit, the IWMA operates a Household Hazardous Waste (HHW) and E-waste drop-off center at the landfill.

HOUSEHOLD HAZARDOUS WASTE DROP-OFF CENTER

One of the on-site facilities at the PRL is a household hazardous waste (HHW) drop-off center owned and operated by the San Luis Obispo County Integrated Waste Management Association (IWMA).

At Paso Robles Landfill, an aggressive load check program has been established to preclude the disposal of hazardous and prohibited wastes. Signs indicating the types of wastes not accepted at the landfill are located at the gatehouse. Self-haul landfill customers are routinely questioned about the contents of their load. Inspections of the waste at the landfill gate also occur. If hazardous or prohibited waste constituents are detected at the landfill gate, the customers are advised of proper disposal of the materials and are directed to bring the materials to the HHW facility when that facility is open (Saturdays 11 a.m. to 3 p.m.).

At the disposal area, the spotter and the heavy equipment operator are trained in the detection of and response to prohibited and hazardous waste constituents. If feasible, the non-disposable waste is returned to the landfill customer. If the customer is not determined, the hazardous/prohibited waste is properly handled by a landfill employee and removed from the disposal area. The waste then is stored until lawful disposal occurs at the HHW Facility. At a minimum, an average of three (3) vehicle load checks are performed weekly Monday through Friday each week. Typically, the load checks include two (2) commercial vehicle loads and one (1) self-haul load that are randomly selected and inspected for hazardous and unacceptable waste materials. Load checks are performed consistent with the procedures and safety precautions detailed in the Hazardous Waste Exclusion and Load Checking Program for the Paso Robles Landfill.

Operational Procedures

The IWMA's Household Waste Collection Program (HHWCP) facilities are open to San Luis Obispo County Residents. CESQG Businesses may participate in the HHWCP by reservation only.

The San Luis Obispo County Household Hazardous Waste Collection Facilities are establishes to accept household hazardous waste such as cleaners, polishes, automotive products (including batteries), paints and thinners, solvents, adhesives, aerosol products, pool chemicals, pesticides, pharmaceuticals, waste oil filters, electronic waste, and hobby supplies (i.e. photographic chemicals, art supplies, etc.).

Publicity and information provided to the public bringing HHW to the collection facilities indicate that materials:

- will be limited to 15-gallon or 125 pounds of materials from any vehicle bringing in household wastes;
- should be in structurally sound and sealed containers;
- should be in labeled containers, and
- that the contents in containers should be known by the participant transporting the waste to the collection facility.

Publicity for collection facilities will indicate that explosives, radioactive, and site remediation wastes will not be accepted. If anyone brings these materials to a collection facility, the set-forth protocol should be followed.

CURRENT STAFFING AND EQUIPMENT NEEDS

Landfill staffing and equipment needs for the landfill, as reported in the *Joint Technical Document* (JTD) are as follows:

Number	Staff Position
1	Site Manager
2	Equipment Operators
1	Part-Time Seasonal Equipment Operator
1	Scale Attendant
1	Mechanic
1	Spotter/Laborers/Material Reclamation Specialist
7	**Total**

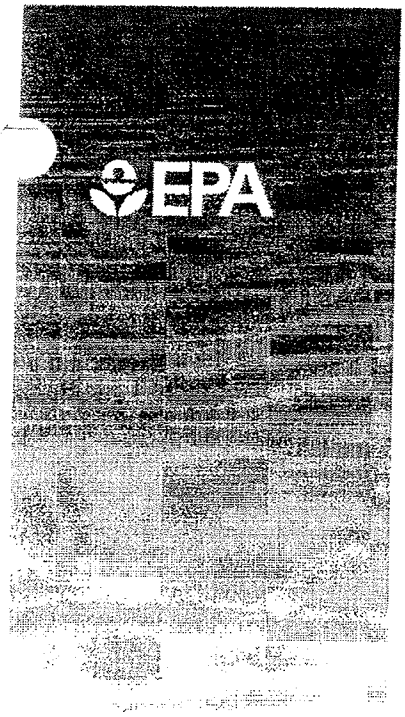
Number	Equipment Type
1	Komatsu D65X crawler
1	Caterpillar (CAT) 826 compactor
1	CAT 953 track loader with 3 in 1 bucket
1	Cat 623B scraper
1	Ford 8000N, 4,000-gallon water truck
1	For F700 utility truck
2	Roll-off chassis utility truck
1	Kenworth 10-wheel dump truck
9	**Total**

Notes: During our June 10, 2009, site visit Jim Wyse for PWS reported that:

- It does not have a dedicated mechanic. Routine maintenance is handled by the equipment operators.
- Weekend staffing consists of 1 operator, 1 laborer and 1 scalehouse attendant.

APPENDIX G

LANDFILL RECLAMATION



United States
Environmental Protection
Agency

Solid Waste
and Emergency Response
(5306W)

EPA530-F-97-001
July 1997

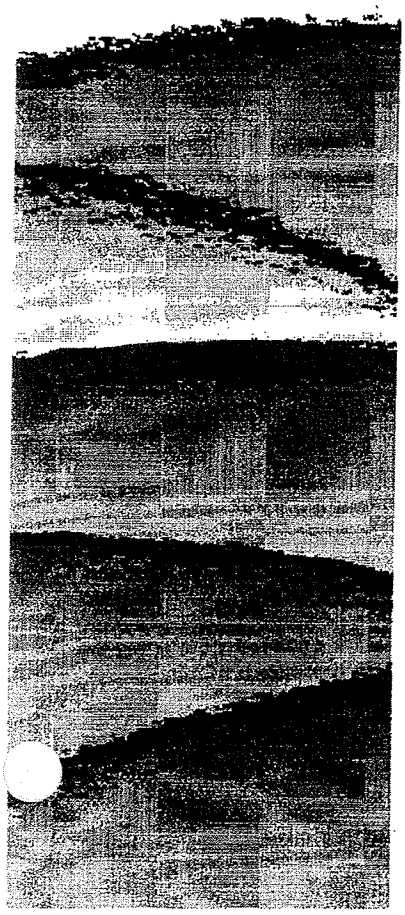
Landfill Reclamation

This fact sheet describes new and innovative technologies and products that meet the performance standards of the Criteria for Municipal Solid Waste Landfills (40 CFR Part 258).

Landfill reclamation is a relatively new approach used to expand municipal solid waste (MSW) landfill capacity and avoid the high cost of acquiring additional land. Reclamation costs are often offset by the sale or use of recovered materials, such as recyclables, soil, and waste, which can be burned as fuel. Other important benefits may include avoided liability through site remediation, reductions in closure costs, and reclamation of land for other uses.

Despite its many benefits, some potential drawbacks exist to landfill reclamation. This technology may release methane and other gases, for example, that result from decomposing wastes. It may also unearth hazardous materials, which can be costly to manage. In addition, the excavation work involved in reclamation may cause adjacent landfill areas to sink or collapse. Finally, the dense, abrasive nature of reclaimed waste may shorten the life of excavation equipment. To identify potential problems, landfill operators considering reclamation activities should conduct a site characterization study.

Landfill reclamation projects have been successfully implemented at MSW facilities across the country since the 1980s. This fact sheet provides information on this technology and presents case studies of successful reclamation projects.



The Reclamation Process

Landfill reclamation is conducted in a number of ways, with the specific approach based on project goals and objectives and site-specific characteristics. The equipment used for reclamation projects is adapted primarily from technologies already in use in the mining industry, as well as in construction and other solid waste management operations. In general, landfill reclamation follows these steps:

Excavation

An excavator removes the contents of the landfill cell. A front-end loader then organizes the excavated materials into manageable stockpiles and separates out bulky material, such as appliances and lengths of steel cable.

Soil Separation (Screening)

A trommel (i.e., a revolving cylindrical sieve) or vibrating screens separate soil (including the cover material) from solid waste in the excavated material. The size and type of screen used depends on the end use of the recovered material. For example, if the reclaimed soil typically is used as landfill cover, a 2.5-inch screen is used for separation. If, however, the reclaimed soil is sold as construction fill, or for another end use requiring fill material with a high fraction of soil content, a smaller mesh screen is used to remove small pieces of metal, plastic, glass, and paper.

Trommel screens are more effective than vibrating screens for basic landfill reclamation. Vibrating screens, however, are smaller, easier to set up, and more mobile.

Printed on paper that contains at least 20 percent postconsumer fiber.

Processing for Reclamation of Recyclable Material or Disposal

Depending on local conditions, either the soil or the waste may be reclaimed. The separated soil can be used as fill material or as daily cover in a sanitary landfill. The excavated waste can be processed at a materials recovery facility to remove valuable components (e.g., steel and aluminum) or burned in a municipal waste combustor (MWC) to produce energy.

Steps in Project Planning

Before initiating a landfill reclamation project, facility operators should carefully assess all aspects of such an effort.

The following is a recommended approach:

1. Conduct a site characterization study.
2. Assess potential economic benefits.
3. Investigate regulatory requirements.
4. Establish a preliminary worker health and safety plan.
5. Assess project costs.

Benefits and Drawbacks

Facility operators considering the establishment of a landfill reclamation program must weigh several benefits and drawbacks associated with this waste management approach.

Potential Benefits

Extending landfill capacity at the current site
Landfill reclamation extends the life of the current facility by removing recoverable materials and reducing waste volume through combustion and compaction.

Generating revenues from the sale of recyclable materials
Recovered materials, such as ferrous metals, aluminum, plastic, and glass, can be sold if markets exist for these materials.

Lowering operating costs or generating revenues from the sale of reclaimed soil
Reclaimed soil can be used on site as daily cover material on other landfill cells, thus avoiding the cost of importing cover soil. Also, a market might exist for reclaimed soil used in other applications, such as construction fill.

Producing energy at MWCs
Combustible reclaimed waste can be mixed with fresh waste and burned to produce energy at MWCs.

Reducing landfill closure costs and reclaiming land for other uses
By reducing the size of the landfill "footprint" through cell reclamation, the facility operator may be able to either lower the cost of closing the landfill or make land available for other uses.

Retrofitting liners and removing hazardous materials
Liners and leachate collection systems can be installed at older landfills. These systems can be inspected and repaired if they are already installed. Also, hazardous waste can be removed and managed in a more secure fashion.

Potential Drawbacks

Managing hazardous materials
Hazardous wastes that may be uncovered during reclamation operations, especially at older landfills, are subject to special handling and disposal requirements. Management costs for hazardous waste can be relatively high, but may reduce future liability.

Controlling releases of landfill gases and odors
Cell excavation raises a number of potential problems related to the release of gases. Methane and other gases, generated by decomposing wastes, can cause explosions and fires. Hydrogen sulfide gas, a highly flammable and odorous gas, can be fatal when inhaled at sufficient concentrations.

Controlling subsidence or collapse
Excavation of one landfill area can undermine the integrity of adjacent cells, which can sink or collapse into the excavated area.

Increasing wear on excavation and MWC equipment
Reclamation activities shorten the useful life of equipment, such as excavators and loaders, because of the high density of waste being handled. Also, the high particulate content and abrasive nature of reclaimed waste can increase wear on MWC equipment (e.g., grates and air pollution control systems).

This planning sequence assumes that project planners will make an interim assessment of the project's feasibility after each planning step. After completion of all five steps, planners should conclude the feasibility assessment by weighing costs against benefits. A thorough final assessment should include a review of project goals and objectives and consideration of alternative approaches for achieving those ends.

Conduct a Site Characterization Study

The first step in a landfill reclamation project calls for a thorough site assessment to establish the portion of the landfill that will undergo reclamation and estimate a material processing rate.

The site characterization should assess facility aspects, such as geological features, stability of the surrounding area, and proximity of ground water, and should determine the fractions of usable soil, recyclable material, combustible waste, and hazardous waste at the site.

Assess Potential Economic Benefits

Information collected in the site characterization provides project planners with a basis for assessing the potential economic benefits of a reclamation project. If the planners identify likely financial benefits for the undertaking, then the assessment will provide support for further investing in project planning. Although economics are likely to serve as the principal incentive for a reclamation project, other considerations may also come into play, such as a communitywide commitment to recycling and environmental management.

Most potential economic benefits associated with landfill reclamation are indirect; however, a project can generate revenues if markets exist for recovered materials. Although the economic benefits from reclamation projects are facility-specific, they may include any or all of the following:

- Increased disposal capacity.
- Avoided or reduced costs of:
  - —Landfill closure.
  - —Postclosure care and monitoring.
  - —Purchase of additional capacity or sophisticated systems.
  - —Liability for remediation of surrounding areas.
- Revenues from:
  - —Recyclable and reusable materials (e.g., ferrous metals, aluminum, plastic, and glass).
  - —Combustible waste sold as fuel.
  - —Reclaimed soil used as cover material, sold as construction fill, or sold for other uses.
- Land value of sites reclaimed for other uses.

Thus, this step in project planning calls for investigating the following areas:

- Current landfill capacity and projected demand.
- Projected costs for landfill closure or expansion of the site.
- Current and projected costs of future liabilities.
- Projected markets for recycled and recovered materials.
- Projected value of land reclaimed for other uses.

Investigate Regulatory Requirements

Landfill reclamation operations are not restricted under current federal regulations. Before undertaking a reclamation project, however, state and local authorities should be consulted regarding any special requirements. Although some states have enacted general provisions concerning the beneficial use of recovered materials, as of 1996, only New York State had established specific landfill reclamation rules. In most states, officials offer assistance in project development, and they review work plans on a case-by-case basis. A few states, such as New York and New Jersey, encourage landfill reclamation by making grant money available.

Establish a Preliminary Worker Health and Safety Plan

After project planners establish a general framework for the landfill reclamation effort, they must account for the health and safety risks the project will pose for facility workers. Once potential risks are identified from the site characterization study and historical information about facility operations, methods to mitigate or eliminate them should be developed. This information then becomes part of a comprehensive health and safety program. Before the reclamation operation begins, all workers who will be involved in the project need to be well versed in the safety plan and receive training in emergency response procedures.

Drawing up a safety and health plan can be particularly challenging given the difficulty of accurately characterizing the nature of material buried in a landfill. Project workers are likely to encounter some hazardous materials; therefore, the health and safety program should account for a variety of materials handling and response scenarios.

Although the health and safety program should be based on site-specific conditions and waste types, as well as project goals and objectives, a typical health and safety program might call for the following:

- Hazard communication (i.e., a "Right to Know" component) to inform personnel of potential risks.
- Respiratory protection measures, including hazardous material identification and assessment; engineering controls; written standard operating procedures; training in equipment use, respirator selection, and fit testing; proper storage of materials; and periodic reevaluation of safeguards.
- Confined workspace safety procedures, including air quality testing for explosive concentrations, oxygen deficiency, and hydrogen sulfide levels, before any worker enters a confined space (e.g., an excavation vault or a ditch deeper than 3 feet).
- Dust and noise control.
- Medical surveillance stipulations that are mandatory in certain circumstances and optional in others.
- Safety training that includes accident prevention and response procedures regarding hazardous materials.
- Recordkeeping.

The program should also cover the protective equipment workers will be required to wear, especially if hazardous wastes may be unearthed. The three categories of safety equipment used in landfill reclamation projects are:

- Standard safety equipment (e.g., hard hats, steel-toed shoes, safety glasses and/or face shields, protective gloves, and hearing protection).
- Specialized safety equipment (e.g., chemically protective overalls, respiratory protection, and self-contained breathing apparatus).
- Monitoring equipment (e.g., a combustible gas meter, a hydrogen sulfide chemical reagent diffusion tube indicator, and an oxygen analyzer).

Assess Project Costs

Planners can use information collected from the preceding steps to analyze the estimated capital and operational costs of a landfill reclamation operation. Along with the expenses incurred in project planning, project costs may also include the following:

- Capital costs:
  - — Site preparation.
  - — Rental or purchase of reclamation equipment.
  - — Rental or purchase of personnel safety equipment.
  - — Construction or expansion of materials handling facilities.
  - — Rental or purchase of hauling equipment.
- Operational costs:
  - — Labor (e.g., equipment operation and materials handling).
  - — Equipment fuel and maintenance.
  - — Landfilling nonreclaimed waste or noncombustible fly and bottom ash if waste material is sent off site for final disposal.
  - — Administrative and regulatory compliance expenses (e.g., recordkeeping).
  - — Worker training in safety procedures.
  - — Hauling costs.

Part of the cost analysis involves determining whether the various aspects of the reclamation effort will result in reasonable costs relative to the anticipated economic benefits. If the combustible portion of the reclaimed waste will be sent to an offsite MWC, for example, planners should assess whether transportation costs will be offset by the energy recovery benefits. Planners also need to consider whether capital costs can be minimized by renting or borrowing heavy equipment, such as excavating and trommel machinery, from other departments of municipal or county governments. Long-term reclamation projects may benefit from equipment purchases.

Case Studies

Table 1. Landfill Reclamation Project Summaries

Project	Operation Start	Mined Area	Use of Recovered Material	Main Objectives
Naples Landfill (Collier County, Florida)	April 1986 (ongoing).	10 acres	Cover material.	Decrease liability. Recover soil.
Edinburg Landfill (Edinburg, New York)	Dec. 1990 and June 1991 (both completed).	1 acre		Alternative to landfill closure.
	Aug. - Sept. 1992 (completed).	1.6 acre	Construction fill.	Reduce landfill footprint.
Frey Farm Landfill (Lancaster County, Pennsylvania)	Jan. 1991 - July 1996 (completed).	300,000 to 400,000 cubic yards	Waste-to-energy fuel. Cover material.	Recover fuel. Reuse of landfill capacity.

Source Based on: Dickinson, 1995.

Naples Landfill Collier County, Florida

In 1986, the Collier County Solid Waste Management Department at the Naples Landfill conducted one of the earliest landfill reclamation projects in the country. At that time, the Naples facility, a 33-acre unlined landfill, contained MSW buried for up to 15 years.

In an evaluation performed by the University of Florida on 38 of the state's unlined landfills, investigators discovered that the Naples Landfill (along with 27 others) posed a threat to ground water. Moreover, the high cost of complying with the state's capping regulations for unlined landfills concerned many county officials. Florida's capping regulations required the installation of a relatively impermeable cover or cap and postclosure monitoring.

Naples officials developed a reclamation plan with the following objectives: decreasing site closure costs, reducing the risk of groundwater contamination, recovering and burning combustible waste in a proposed waste-to-energy facility, recovering soil for use as landfill cover material, and recovering recyclable materials. Collier County never built the waste-to-energy plant. The project did prove successful, however, in recovering landfill cover material. The project proved less successful at recycling recovered materials (e.g., ferrous metals, plastics, and aluminum). These materials required substantial processing to upgrade their quality for sale, something the county chose not to pursue.

In 1991, the U.S. Environmental Protection Agency selected the Naples Landfill reclamation project as a demonstration project for the Municipal Solid Waste Innovative Technology Evaluation (MITE) program. The MITE program assessed the excavation and mechanical processing techniques used in the project for reclaiming cover material to be used in ongoing landfill operations. It also assessed the capacity and performance of equipment, the environmental aspects of the project, the characteristics of recovered materials, the market acceptability of recovered materials, and the probable costs and economics of the overall project. The MITE assessment found the processing techniques used in the Naples project effective and efficient for recovering soil but not for recovering recyclables of marketable quality.

During the MITE demonstration project, Collier County effectively and efficiently recovered a soil fraction deemed environmentally safe under Florida's MSW compost regulations. The 50,000 tons of reclaimed soil were suitable for use as a landfill cover material and as a soil medium for supporting plant growth.

The mention of publications, products, or organizations in this fact sheet does not constitute or imply endorsement or approval for use by the U.S. Environmental Protection Agency.

Air quality monitoring indicated that landfill gas was not an issue at the reclamation site, apparently due to the high degree of waste decomposition that had already occurred. As a result of this finding, typical personnel protective gear worn during the project consisted of standard construction apparel.

Ongoing reclamation activities at the Naples facility focus exclusively on recovering soil for use as landfill cover material. All excavated materials other than the reclaimed soil and small amounts of recyclables are redisposed of in lined landfill cells. Reclamation activities are only performed on an as-needed basis. A 3-inch trommel screen is used to reclaim the soil cover material. The weight ratio of reclaimed soil to overs (i.e., materials caught by the screen), after white goods and tires are separated, is 60 to 40. This indicates that the Collier County landfill reclamation project is efficient given that 60 percent of the reclaimed material is reused as landfill cover material.

Based on 1995 prices, landfill cover material costs Collier County $3.25 per ton. According to Collier County's director of solid waste, the reclamation of cover material on an as-needed basis costs the county $2.25 per ton, a savings of $1 per ton.

According to county officials, the reclamation project yielded the following benefits: lower operating costs through reuse of cover materials, extended landfill life, reduced potential for ground-water contamination from unlined cells, and possible avoidance of future remediation costs.

Edinburg Landfill Edinburg, New York

The New York State Energy Research and Development Authority (NYSERDA) and the New York State Department of Environmental Conservation sponsored projects to assess the feasibility and cost-effectiveness of undertaking landfill reclamation efforts to avoid closures and reduce the footprint of state landfills. NYSERDA established these projects in anticipation of the closure of numerous landfills in New York State, and based, in part, on the success of the Naples Landfill reclamation project.

NYSERDA's first demonstration project was conducted at a 5-acre MSW landfill in Edinburg, New York, which received waste from 1969 to 1991. NYSERDA chose the Edinburg Landfill because of its small size and lack of buried industrial waste. After NYSERDA chose to sponsor the reclamation of 1 acre of the 5-acre landfill, Edinburg town officials expanded the project to reclaim 1.6 additional acres.

NYSERDA divided the Edinburg demonstration project into three phases. The first phase, started in December 1990, included the excavation of 5,000 cubic yards of waste from a 12-year-old section of the landfill at an average depth of 20 feet. The second phase, initiated in June 1991, included the excavation of 10,000 cubic yards of waste from a 20-year-old section of the landfill at an average depth of 8 feet. The first two phases of the demonstration project cost an estimated $5 per cubic yard for excavation and processing. This cost included the inspection and supervision of a fully contracted operation and was based on an average excavation rate of 1,000 to 1,200 cubic yards per day.

The third phase of the Edinburg project occurred from August to September 1992. NYSERDA provided the majority of the project funding, with the remaining funding (primarily for phase three) provided by the town of Edinburg. This third and final phase reclaimed an additional 1.6 acres (31,000 cubic yards) in 28 days. Because the town supplied required equipment and labor, the contracted cost for this phase decreased from $5 per cubic yard excavated to $3 per cubic yard. Subsequently, the town looked into reclaiming the remaining 2.4 acres of the landfill and completely eliminating the footprint. The proposed fourth stage proved unviable, so the remaining portion of the landfill will be capped.

The Edinburg Landfill is located in a soil-rich area that provides ample amounts of landfill cover material. For this reason, officials tested and approved the reclaimed soil (75 percent of the reclaimed material) for off-site use as construction fill in nonsurface applications. A test burn performed on the reclaimed waste found the British thermal unit (Btu) value to be lower than desired because of the high degree of waste decomposition and stones remaining in the screened material.

The recovered nonsoil materials, representing 25 percent of the reclaimed waste, were hand-sorted for potential recyclables. Although 50 percent of the nonsoil material was considered recyclable, cleaning the materials to market standards was not feasible. Some tires, white goods, and ferrous metals, however, were separated and recycled. The remaining materials were sent to a nearby landfill.

NYSERDA officials developed a worker health and safety plan for the Edinburg project that established work zones, personnel protection requirements, and other operating procedures. The inspectors, as well as all personnel working at the site, were required to wear respirators, goggles, helmets, and protective suits. Excavation equipment was used to separate suspicious drums and other potentially hazardous material for evaluation by the safety inspector using appropriate monitoring equipment. In the event that hazardous materials were encountered, the health and safety plan provided for a project contingency plan, a segregated disposal area, and special waste handling procedures. No significant quantities of hazardous materials, however, were unearthed.

The Edinburg Landfill Reclamation Project was successful both in securing offsite uses for the reclaimed soil and in reducing the landfill footprint to decrease closure costs. The economic benefits would be enhanced further if the avoided costs for postclosure maintenance and monitoring, as well as potential remediation and the value of recovered landfill space, are also considered.

Frey Farm Landfill Lancaster County, Pennsylvania

In 1990, the Lancaster County Solid Waste Management Authority constructed an MWC to use in reducing the volume of waste deposited in the Frey Farm Landfill, a lined site (double layers of 60-mil high density polyethylene sheeting on a 6-inch clay sub-base) containing MSW deposited for up to 5 years. After building the MWC, the quantity of waste received at the facility declined, leaving a significant portion of the MWC capacity unused. In an effort to increase the energy production and efficiency of the MWC, officials initiated a landfill reclamation project to augment the facility's supply of fresh waste with reclaimed waste.

The reclaimed waste had a high Btu value (about 3,080 Btu per pound). To achieve a more efficient, higher heating value of 5,060 Btu per pound of waste, four parts of fresh waste, which included tires and woodchips, were mixed with one part reclaimed waste.

Between 1991 and 1993, approximately 287,000 cubic yards of MSW were excavated from the landfill. These reclamation activities processed 2,645 tons of screened refuse per week for the MWC. As a result, Lancaster County converted 56 percent of the reclaimed waste into fuel. The county also recovered 41 percent of the reclaimed material as soil during trommeling operations. The remaining 3 percent proved noncombustible and was reburied in the landfill. By the end of the project in 1996, landfill operators had reclaimed 300,000 to 400,000 cubic yards of material.

Before the reclamation work began, officials prepared a safety plan for work at the site and assigned a full-time compliance officer to oversee the operations. During reclamation, workers took precautions to avoid damaging the site's synthetic liner, since it would be reused following the reclamation operations. An initial layer of protective material surrounded the synthetic liner system, aiding worker precautions by acting as a buffer between the liner and the excavation tools. Continuous air monitoring for methane, both in the cabs of vehicles and in the reclamation area, enhanced the operation's safety operations.

Benefits of the project at Frey Farm Landfill include: reclaimed landfill space, supplemented energy production, and recovered soil and ferrous metals. Drawbacks include: increased generation of ash caused by the high soil content found in reclaimed waste, increased odor and air emissions, increased traffic on roads between the MWC and the landfill, and increased wear on both the landfill operation and MWC equipment (i.e., due to the abrasive properties of the reclaimed waste).

Costs for the resource recovery portion of the project were relatively low for the following reasons:

- The distance for transporting both the reclaimed waste and the ash was only 18 miles each way.
- The management authority avoided commercial hauling prices by using its own trucks and employees to transport the reclaimed waste and the ash.
- The landfill and MWC were operated by the same management authority, thus no tipping fees were required. (Generally, a higher tipping fee can be charged at an MWC for reclaimed waste because of its abrasiveness and higher density, which increases the wear and tear on equipment.)

By 1996, MWC facility operators no longer needed supplemental feed materials from Frey Farm Landfill to run at full capacity. Thus, landfill officials concluded the reclamation project in July of that year.

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