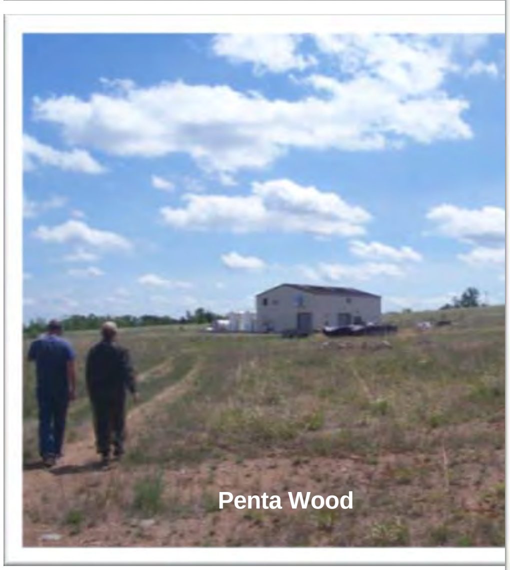
Wisconsin Initiative for Sustainable Remediation and Redevelopment
- WISRR -

January 2012

Site Specific Sustainability Analyses



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PURPOSE AND BACKGROUND

This document is intended for use by Department of Natural Resources (DNR), other state agency staff, and responsible parties (RPs), consultants or other interested parties. The primary purpose of this document is to provide information on sustainable cleanup practices at contaminated properties. This document is written to address both new sites and sites where existing systems are operating. It may be used along with published references and guidance documents, information from training courses and current professional journals. The material presented is based on available information and the knowledge and experience of the authors and the peer reviewers. The reader is referred to the DNR's Remediation and Redevelopment Program NR 700 rule series, along with supporting Brownfields redevelopment and technical guidance on soil and groundwater contamination site investigation, remediation and case closure.

DISCLAIMER

This document is intended solely as guidance, and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. This document does not establish or affect legal rights or obligations, and is not finally determinative of any of the issues addressed. This document does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this document will be made by applying the governing statutes and administrative rules to the relevant facts.

This document may be more complete when used in conjunction with other documents prepared by the Remediation and Redevelopment program staff. These documents are found at: http://dnr.wi.gov/org/aw/rr/archives/pub index.html Use the publications browser option on the left of screen to find by number. Guidance documents may also be obtained by sending a request to Public Information Requests, Bureau for Remediation and Redevelopment, Department of Natural Resources, P.O. Box 7921, Madison WI 53707.

This document will be updated as needed. Comments and concerns may be sent to "WISRR Site Specific Sustainability Analyses", Tom Coogan – RR/5, WDNR, P.O. Box 7921, Madison, WI 53707, or to Thomas.coogan@wisconsin.gov .

Wisconsin Initiative for Sustainable Remediation and Redevelopment

Site Specific Sustainability Analyses

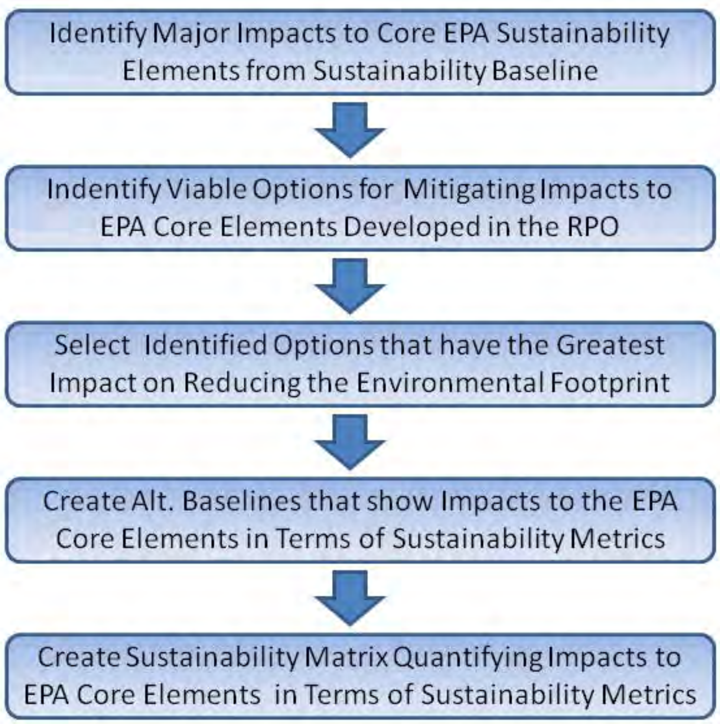
January 2012

Contents

INTRODUCTION

This document is a companion volume to the Wisconsin Initiative for Sustainable Remediation and Redevelopment (WISRR) Guidance Document. It contains four site specific sustainability analyses that apply green and sustainable remediation (GSR) concepts, methods, and processes presented in the guidance document (shown below) to derive more sustainable remediation alternatives for each site.

GSR PROCESS FLOW CHART



Sites selected by the Wisconsin Department of Natural Resources (WDNR) for this project were either State Lead Sites or sites where the State of Wisconsin had significant current or future financial obligations. Sites that were selected addressed a variety of technologies and contaminant types.

Each site specific sustainability analysis is included as a separate section within the document. The sections are as follows:

Section 2: **Delafield Landfill**

Section 3: **Refuse Hideaway Landfill**

Section 4: **Penta Wood Superfund Site**

Section 5: **N.W. Mauthe Chromium Site**

Delafield Landfill
Site Specific Sustainable Remediation System Evaluation

Prepared for:
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September 2009

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LIST OF ACRONYMS

ATVs	all terrain vehicles
BTU/kWh	British thermal unit per kilowatt hour
BTU/scf	British thermal unit per standard cubic foot
CO_2e	carbon dioxide equivalents
HDPE	high density polyethylene
Hp	horse power
kW	kilowatt
kWh	kilowatt hours
kWh m^2/day	kilowatt hour square meter per day
kWh/yr	kilowatt hour per year
LFG	landfill gas
LP	liquid propane
m	meter
m^2	square meters
m^3/yr	cubic meters per year
O&M	operation and maintenance
psig	pounds per square inch gauge
PV	photovoltaics
ROI	radius of influence
RPO	Remedial Process Optimization
scfm	standard cubic feet per minute
USEPA	United States Environmental Protection Agency
UST	underground storage tank
w.c.	water column
W/m^2	watt per square meter
WDNR	Wisconsin Department of Natural Resources
WWTP	wastewater treatment plant

1.0 INTRODUCTION

The purpose of this document is to provide a Site Specific Sustainable Remediation System Evaluation for the Delafield Landfill site located at South Service Road, Delafield, Wisconsin (Figure 1). To evaluate current site conditions, and the effect of any potential changes, a sustainability baseline was created that included current carbon footprint, energy usage, current operational costs and contaminant mass removal. A limited Remedial Process Optimization (RPO) was conducted for the site to identify major items that could be addressed to improve the sustainability and efficiency of the existing remedial system, and to reduce operation and maintenance (O&M) costs. An alternative energy evaluation was conducted to see if alternative energy could be used to offset current energy usage at the site. Potential sustainable activities were evaluated to enhance the reduction of contaminant levels and lower costs. Three sustainable activities were selected and a sustainability matrix was generated outlining costs and benefits of each activity in terms of various sustainability metrics, such as the increase or decrease in carbon footprint, energy usage, resource usage, waste generation and cost. The purpose of the sustainability matrix is to provide/quantify effects of the potential changes in terms of the sustainability metrics.

This document was generated using information supplied by the Wisconsin Department Natural of Resources (WDNR), including utility and operation and maintenance costs, monitoring reports and as builts where available, a site walk through and interviews with the WDNR site project manager. Due to the age of the site in some cases information was limited.

2.0 SITE DESCRIPTION

The Delafield Landfill (a/k/a Delafield San Transfer LF #719) is a former municipal landfill that operated from approximately 1970 into the early 1980s. The current landfill property is approximately 48 acres in size, and was previously part of a larger 138-acre parcel. Of the 48 acres, an estimated 42 acres was waste fill area. The landfill is relatively flat to gently sloping on the top with steep slopes to the south and southeast. The landfill is generally bordered by residential properties to the west and south and commercial/industrial properties to the east and north. The landfill is not secured by a fence and is subject to trespassing. A site location map is shown on Figure 1.

The landfill is located in what was an old gravel pit. The landfill is unlined and does not have a full clay cap at the surface of the landfill. It has been assumed that some landfill cap material may have been leftover materials from pit operations. The landfill cover is well vegetated with grass, and is generally open space with very few trees. The remedial system is shown on Figure 2. The landfill flare is shown on Figure 3.

The remedial system includes a landfill gas (LFG) and leachate collection system. The LFG flare station and a small equipment building are located in the southeast corner of the property. The leachate loading area is located along the south property boundary and includes a concrete pad with a drain piped back to three leachate underground storage tanks (USTs). The flare station is surrounded by chain link fence with a locked access gate. The locked equipment/ storage building is located adjacent to the flare station.

A review of Waukesha County tax records currently identifies the site owner as the Walter Nickel Trust; however, site remediation efforts are 100 percent state funded.

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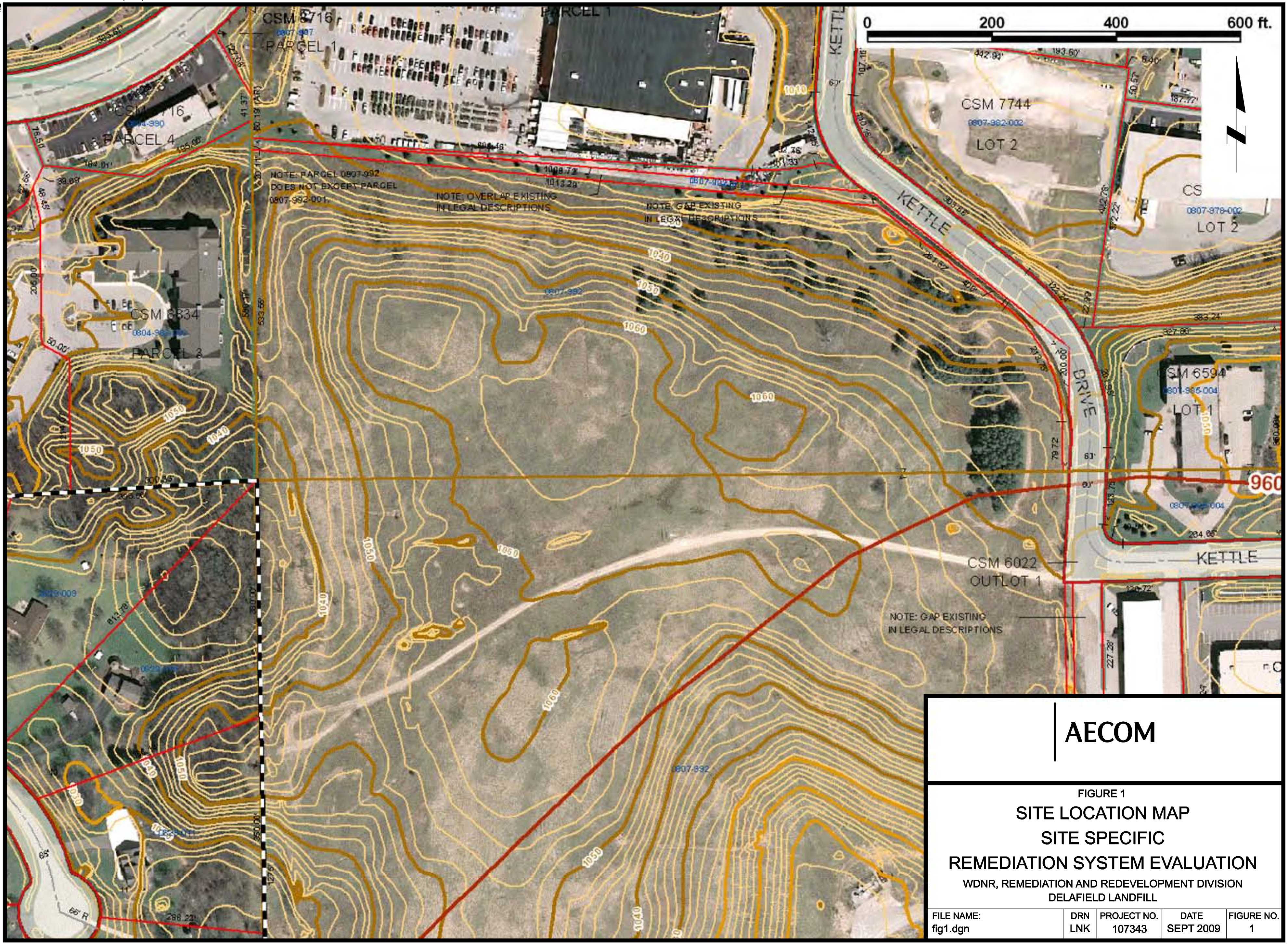

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FIGURE 1

SITE LOCATION MAP
SITE SPECIFIC
REMEDIATION SYSTEM EVALUATION

WDNR, REMEDIATION AND REDEVELOPMENT DIVISION
DELAFIELD LANDFILL

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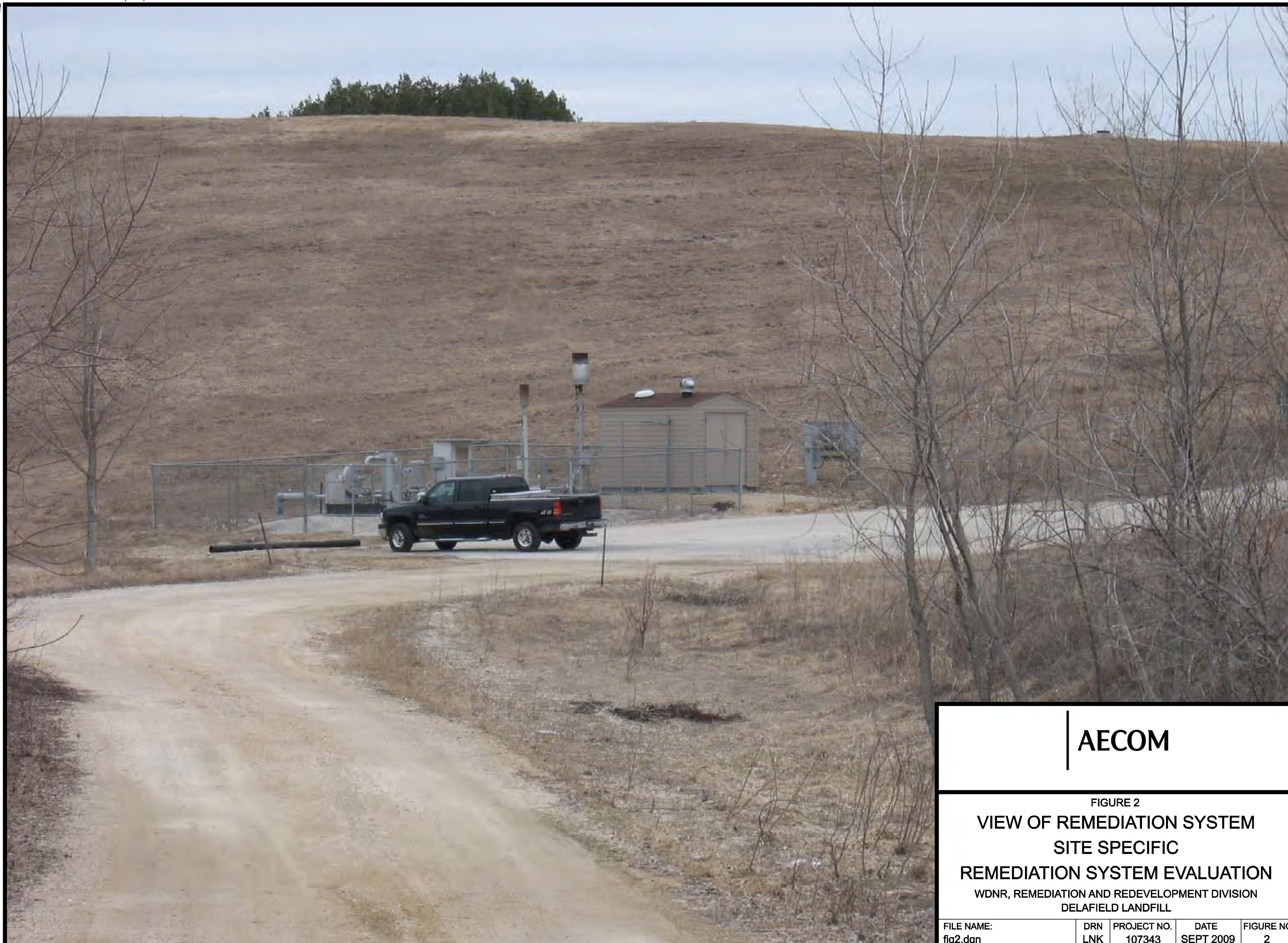

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FIGURE 2

VIEW OF REMEDIATION SYSTEM
SITE SPECIFIC
REMEDIATION SYSTEM EVALUATION

WDNR, REMEDIATION AND REDEVELOPMENT DIVISION
DELAFIELD LANDFILL

FILE NAME:	DRN	PROJECT NO.	DATE	FIGURE NO.
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FIGURE 3

VIEW OF LANDFILL GAS FLARE
SITE SPECIFIC
REMEDIATION SYSTEM EVALUATION

WDNR, REMEDIATION AND REDEVELOPMENT DIVISION
DELAFIELD LANDFILL

FILE NAME:	DRN	PROJECT NO.	DATE	FIGURE NO.
fig3.dgn	LNK	107343	SEPT 2009	3

3.0 CURRENT CONDITIONS

The current remedial approach at the Delafield Landfill site is long-term monitoring along with O&M of a LFG and leachate collection system.

Landfill monitoring consists of methane gas readings at 10 gas probes located along the perimeter of the landfill on a monthly basis. The WDNR also has a contract with Liesch Environmental to conduct private well sampling at residences surrounding the landfill on a semi-annual basis. There is currently no groundwater monitoring wells located at the site. All monitoring wells and/or piezometers previously installed at the site have been abandoned or destroyed.

The LFG collection system consists of 30 LFG extraction wells positioned in a loop near the perimeter of the landfill, with branches into the center of the landfill. The LFG extraction wells are completed in a vault at ground surface where conveyance piping connects to a control valve, orifice plate, and common header piping. The piping between the wellhead and header piping is flexible hose to allow some shifting/movement between the wells and header piping to occur. In some well vaults, the flexible hose section is reportedly too short, causing the flexible hose to shear/tear when movement occurs. This poor design and/or construction have resulted in pipe failure at several wells.

LFG is drawn from the extraction wells to the flare station via below grade 3- to 8-inch diameter high density polyethylene (HDPE) piping by vacuum created from a 5 horse power (Hp) New York blower. Where the HDPE pipe extends aboveground surface, the pipe diameter reduces to 4 inches. A knockout tank positioned before the blower removes any condensate, if present. A magnehelic pressure gauge, located on the 4 inch pipe before the knockout tank, indicates approximately 16 inches of water column (w.c.). The magnehelic pressure gauge on the knockout tank indicates approximately 7 inches w.c.

The drain on the knockout tank gravity flows to the leachate storage tank. The drain pipe is wrapped with electric heat tape for winter operation. During the winter of 2008/2009, the heat tape failed, and the drain line froze. Repairs and/or replacement of the heat tape are anticipated to be completed prior to the 2009/2010 winter.

An automated control valve, digital flow meter/temperature gauge, and flame arrestor are located between the blower and flare. A thermocouple control at the flare closes the automated control valve and shuts down the blower, in the event the flame at the flare goes out. A telemetry system is activated when an alarm condition exists in the system. Flow is approximately 260 standard cubic feet per minute (scfm). A magnehelic pressure gauge across the flame arrestor indicates approximately 2 inches w.c. Two 20-pound liquid propane (LP) tanks, connected in tandem, supply propane gas to the flare to ignite the flare when necessary. These tanks are changed out approximately once per year.

Influent methane gas levels measured at the flare station generally range from approximately 15 to 25 percent. Some historical methane gas measurements are: 3-20-08; 22.0 percent methane, 4-15-08; 24.2 percent methane, 4-30-08; 20.3 percent methane, 7-10-08; 18.5 percent methane, and 3-27-09; 17.9 percent methane. Methane levels are reportedly higher in winter months versus summer months. The elevated winter methane levels have been attributed to snow cover and/or frost providing an improved cap/seal resulting in more of the methane gas being drawn into the LFG extraction system. It is assumed that methane gas escapes the landfill cover during warmer months because of a poorly designed or non-existent landfill "cap".

The landfill cover generally appears to be well vegetated and in good condition. There are several areas of minor erosion and settlement resulting in ponding of surface water. As indicated above, the site is not secured by a perimeter fence, and is subject to trespassing. There are some signs of trespassing, including tracks in the grass, which appear to be from all terrain vehicles (ATVs).

Remedial equipment in the building generally consists of an Ingersoll-Rand air compressor with 120-gallon tank and two 5 Hp motors, Ingersoll-Rand air dryer system, and electrical panels associated with all of the remedial equipment in the building and flare station. The building appears to be a pre-fabricated 10-foot by 12-foot building set on a concrete pad. The building is insulated and the walls and ceiling are covered with drywall. A Dayton electric heater, suspended from the ceiling, provides heat in the winter. The building has three 2-bulb fluorescent light fixtures.

There is one passive and one turbine roof vent on the equipment building. There are also two large louvered vents on the walls of the building. The building reportedly gets very warm in the summer due to heat generated by the air compressor motors. During winter months, one of the louvered vents is covered with insulation board, while the rest of the vents remain operational.

The perimeter LFG header pipe includes three condensate drains. Each drain discharges by gravity to one of three sumps. A pneumatic pump in each sump discharges into a 1-inch diameter HDPE condensate force main, which rings the landfill. Based on drawings provided by the WDNR, the condensate force main appears to have been installed along the side of the perimeter LFG header pipe. The pumps are driven by the air compressor in the equipment building. The pneumatic pumps are reportedly problematic and require frequent maintenance to keep them operational. The condensate force main discharges into the leachate system near the leachate loading pad, located on the south side of the landfill.

The leachate collection system consists of a loading pad, three USTs (2,000, 6,000, and 10,000 gallons), and a leachate pumping station; all located on the south side of the landfill. All of these structures are connected by below grade piping.

Leachate is picked up approximately 20 times per month, removing an average of a total of approximately 100,000 gallons per month (1.2 million gallons annually). Leachate is pumped into 5,500-gallon tanker trucks and transported to the Waukesha Wastewater Treatment Plant (WWTP) for disposal. Leachate accumulation is highly variable and is likely a function of surface water infiltration through the cap.

A below grade sewer line, located in close proximity to the leachate collection system, is operated jointly by the Cities of Delafield and Hartland (a/k/a Del-Hart Wastewater Treatment Facility). The WDNR attempted to gain approval to discharge leachate to the Del-Hart facility. However, the approval was denied because chloride concentrations in the leachate are too high. The Del-Hart facility already processes wastewater with elevated chloride levels attributed to use of private water softener systems throughout their communities. The Del-Hart facility refused to accept the leachate over concerns that the leachate would add to the already elevated chloride levels. The WDNR has recently resampled the leachate and will be requesting the Del-Hart facility to reevaluate acceptance of the leachate to their facility.

4.0 BASELINE EVALUATION

A baseline analysis was conducted for the Delafield Landfill site. The baseline is a quantification of current site conditions using various sustainability metrics. This allows costs and benefits of potential changes to the system to be measured using the same set of sustainability metrics.

4.1 CARBON FOOTPRINT

The Delafield Landfill is typical old landfill site with primary contaminants of concern being methane gas and leachate. The site is currently in a long-term O&M mode. An analysis of site operations has identified applicable items associated with Scope 1 (direct discharge), Scope 2 (electricity) and Scope 3 (other indirect) at the site.

Scope 1 items identified at the site are propane usage for the flare station and methane in the LFG that is combusted by the flare station. Based on data collected from the site and a LFG system flow rate of 264 scfm, approximately 3,930,000 cubic meters per year (m^3/yr) of total LFG are discharged annually. With influent methane concentrations ranging from approximately 15 percent to 25 percent at the flare station, this equates to approximately 589,500 m^3/yr to 982,500 m^3/yr of methane discharged per year with the balance comprised of carbon dioxide, oxygen, and other organic compounds. Approximately 40 pounds of propane are used to supplement the flare station annually.

Scope 2 items consist of electricity consumed by the leachate collection system and flare station. This information is taken directly from utility bills provided by the WDNR.

Scope 3 items consist of fugitive methane emitted by the landfill, diesel fuel used in trucks used to haul leachate and unleaded gas used by O&M personnel at the site. For Scope 3, it was assumed 12 site visits per year were required for site sampling and O&M activities at 50 miles per visit (roundtrip) and leachate is hauled off-site 20 times per month at 30 miles per round trip.

To calculate fugitive methane emissions, the volume of methane being generated by the landfill, the United State Environmental Protection Agency's (USEPA's) Landfill Gas Emissions Model (LandGEM) was utilized. Because limited historical information is available for the landfill site, several assumptions needed to be made to utilize LandGEM. Assumptions that were made for the Delafield Landfill site and the LandGEM output are included in Appendix A.

The LandGem model predicts, that based on the assumptions outlined in Appendix A, the LFG generation from the landfill likely averages about 525 scfm. This indicates that the Delafield Landfill LFG extraction system is approximately 50 percent efficient. This means approximately 589,500 m^3/yr to 982,500 m^3/yr of fugitive methane is discharged per year.

The total annual carbon footprint generated by the Delafield Landfill site is estimated to be 33,771 tons carbon dioxide equivalents (CO_2e). The carbon footprint analysis is included in Appendix B.

4.2 ENERGY

Electric service at the site is provided by WE Energies, and is required to operate the remedial system components and provide indoor lighting in the equipment building. According to the WDNR project manager responsible for the site, there are two electric service accounts. One account was identified as serving the LFG system and the other account is for the leachate system.

For the 12-month time period from April 2008 to March 2009 the total costs for electricity for the LFG system and leachate system was $5,071 and $528, respectively. The total average monthly cost for electricity is approximately $466. Total electrical service requirements for the April 2008 to March 2009 operational year equals energy consumption of approximately 44,212 kilowatt hours (kWh) for the LFG system and approximately 3,824 kWh for the leachate system. Total costs average $0.115 per kWh at the LFG system and $0.138 per kWh at the leachate system.

The equipment building is heated with a small Dayton electric heater and has three 2-bulb fluorescent light fixtures. It is unclear which account these items fall under, and what portion of the total electric costs they contribute to.

4.3 OPERATIONAL COSTS

In additional to the electrical services discussed above, other operation costs associated with the LFG and leachate system operation and monitoring includes leachate transport and disposal, subcontractor costs, plowing, supply and equipment costs, telephone service, WDNR management costs, LP gas, etc.

The WDNR currently has a contract with the Waukesha WWTP for the disposal of leachate collected from the landfill. Total costs for the transport and disposal of leachate in 2008 was $51,200. The total cost for transport and disposal of the leachate for the first six months of 2009 (through June) is $24,000. Year around access is required to be maintained for the site, as leachate removal is conducted about 20 times per month. Plowing is required during winter months. Cost of plowing is dependant on snowfall and as a result costs are highly variable. Plowing costs at the site range, for the period 2006 through 2008, averaged approximately $7,500 annually. Telephone charges for the telemetry system ranged from $20 to $40 per month. As indicated above, the two LP tanks are exchanged approximately once per year at a cost of approximately $40 to $50 per year.

Total costs for private well sampling conducted by Leisch Environmental are $ 14,200 semi-annually. This includes costs for both consulting and laboratory analysis. WDNR management costs were not provided for this site, but WDNR personnel have the primary O&M responsibility at the site.

Total operational costs for the year 2008 were $86,780, not including WDNR personnel costs associated with O&M.

4.4 CONTAMINANT MASS REMOVAL

The contaminants of concern at the Delafield Landfill site consist of methane gas produced by the landfill waste and leachate exhibiting high chloride concentrations.

Based on a flow rate of 264 scfm, the LFG system discharges approximately 3,930,000 m^3/yr of total landfill gas. With influent methane concentrations ranging from approximately 15 to 25 percent at the flare station, approximately 589,500 m^3/yr to 982,500 m^3/yr of methane is discharged per year with the balance of LFG comprised of carbon dioxide, oxygen, and other organic compounds.

An average of 1.2 million gallons of high chloride leachate is disposed of annually at the Waukesha WWTP.

5.0 LIMITED REMEDIAL PROCESS OPTIMIZATION STUDY

RPO is a specific process that examines overall system effectiveness including incremental changes or system replacement to include considerations of new technologies, as well as alternative regulatory approaches. Optimization must be implemented within the confines of the existing decision document for the site.

The purpose of the limited RPO study is to identify possible changes to the site or remedial system that would significantly improve the system with regards to overall remedial sustainability. This includes decreasing the costs of operating the system and/or increasing the efficiency of contaminant mass removal. The limited RPO study is based on the current conditions previously noted in this document.

The following RPO recommendations were based on the assumption that the current technology will continue to be employed as the remedy at the site for 25 years. This is an arbitrary value selected for the purpose of comparing remedial options.

5.1 REPAIR LFG EXTRACTION WELLHEADS

Several of the LFG extraction wellheads are currently constructed with a short section of flexible hose located between the tee fitting at the top of the wellhead and the header pipe connections. As the landfill settles, the connection from the hose to the header pipe could potentially separate causing significant leaks in the LFG system. The short segment of flexible hose is necessary because of the direct-straight line connection between the tee and header pipe. Rotating the tee connection at wellhead to a different position for a longer segment of flexible hose would alleviate this issue. It is estimated that it would cost approximately $500 per wellhead to make the repair.

5.2 LFG SYSTEM BALANCING

Many older LFG collection systems, such as the one at Delafield, were designed for a condition that existed at the time that the system was installed. As the landfill ages, LFG generation rate declines. If the operation of the LFG collection system is not balanced to account for the declining methane production, the LFG collection system may pull too hard and draw air into the LFG system through the cover or through defects in the LFG system such as deteriorated well seals, broken pipe, cracked hose, or leaky pipe joints. This ultimately causes a decrease in the volume of landfill gas being removed from the landfill. It is recommended that the system be rebalanced to improve efficiency of the LFG collection system and raise the concentration of methane collected by the system. It is estimated that it would take approximately 20 visits to the site over a four to six week period to rebalance the system to current conditions. It is estimated that this would cost approximately $15,000 to $25,000 to complete the rebalancing. Some modifications to the site vacuum blower may be required to complete the rebalancing. It is estimated that this could potentially increase the efficiency of the LFG system from the current 50 percent removal efficiency to about 70 percent. This could also increase the LFG quality (methane content). An increase quantity and quality of LFG would be required to make the methane to energy alternatives viable at the site.

5.3 ADDITION OF LFG EXTRACTION WELLS

The LFG collection system at the Delafield Landfill is primarily designed to prevent methane from migrating outside of the boundaries of the landfill. Adding 10 additional LFG extraction wells to the interior of the landfill would significantly reduce the amount of fugitive methane that is emitted to the atmosphere. Each LFG extraction well that is added would cost approximately $8,000 to $10,000 dollars per installed extraction well or $80,000 to $100,000 total. It is estimated the additional LFG extraction wells could raise the efficiency of the current collection system from 50 percent to 75 percent and also increase the quality of the landfill gas. An increase in quantity and quality of LFG would be required to make the methane to energy alternatives viable at the site.

5.4 REGRADING OF SITE

Site grading is recommended to fill settlement areas and promote positive drainage off the landfill cover. Directing surface water flow off the landfill cover will reduce the amount of precipitation infiltrating into the landfill. This could potentially reduce the amount of moisture drawn into the LFG extraction wells reducing the condensate volume in the leachate collection system. It is estimated that filling in areas of the landfill that have settled would cost approximately $200,000 to $300,000.

5.5 EVALUATE CONDITION AND OPERATION OF PNEUMATIC PUMPS

Evaluate the condition of the pneumatic condensation and leachate pumps at the site. It is generally preferred that landfill pumps extract leachate and condensate at a slow steady rate versus rapid pumping that may cause silt and sediment to accumulate in the well/pump that caused by rapid evacuation of the well.

5.6 LEACHATE EVAPORATION

LFG can be used to evaporate leachate, reducing or eliminating the cost of off-site leachate disposal. Specially designed leachate evaporators can be purchased. However, enclosed LFG flares have also been successfully modified to accomplish leachate evaporation. Based on the volume and quality of LFG being collected from the site, an on-site leachate evaporation system may be able to handle about 1,500 gallons of leachate per day. This is about 45 percent of the leachate generated by the Delafield Landfill.

Due to the cost of installing a leachate evaporator or a specially modified enclosed flare (the current flare is a utility flare), it does not make sense to install leachate evaporation equipment for less than half of the volume of leachate generated by the site. It is estimated that a leachate evaporation system would cost approximately $1,000,000 to $1,200,000.

A modified enclosed flare could be installed to accomplish leachate reduction as well. A study would need to be conducted to determine how much leachate could be reduced using this method. The cost for the modified flare would range between $125,000 and $200,000.

6.0 ALTERNATIVE ENERGY ANALYSIS

An alternative energy analysis was conducted at the Delafield Landfill site. The analysis includes the evaluation of various methane to energy alternatives, solar power and wind power.

6.1 METHANE GAS TO ENERGY

The most significant concern for any use of the collected LFG (including flaring) is the apparent low methane content of the LFG (stated previously to be 15 to 25 percent methane by volume). To ensure complete combustion (thereby, ensuring that emissions to the air are minimized) federal regulations (40 CFR 60.18 (c)(3)(ii)) require that flare fuel gas must have a minimum heat value of 200 British thermal unit per standard cubic foot (BTU/scf) (about 20 percent methane by volume).

The low methane content of the LFG observed at the Delafield site is typical of many older landfills, because the LFG collection system is designed for a condition that no longer exists. As the landfill ages and the LFG generation rate declines, the operation of the LFG collection system must be modified (if possible) to accommodate the declining LFG generation rate. If this is not or cannot be accomplished, then the LFG collection system will pull in air through the landfill cover and waste mass or through defects in the LFG collection system (such as failed well seals, broken pipe, cracked hose, or leaky joints). Initially, this air intrusion simply dilutes the LFG. However, prolonged periods of air intrusion can inhibit the anaerobic decomposition of the waste in the landfill and slow or stop LFG generation. Air intrusion also presents the risk of subsurface oxidation in the landfill. LFG that has been diluted to a methane content of 15 percent generally also consists of about 13 percent carbon dioxide, 14 percent oxygen, and 58 percent nitrogen. In other words, it is about 72 percent air by volume. This indicates a significant air intrusion problem.

If the methane content of the LFG is sufficient (generally greater than 35 to 40 percent methane by volume), the LFG can be used for one or more beneficial purposes. Potential end uses of LFG include:

- Flaring to destroy hazardous air pollutants
- Generating electric power for internal (on landfill) use
- Generating electric power for export to the utility grid
- Direct use as a low to medium BTU fuel gas (for example as a boiler fuel to reduce the use of natural gas)
- Produce pipeline quality gas
- Compressed or liquefied gas vehicle fuel

In general, any of these uses require a minimum methane content of about 35 to 45 percent by volume. Therefore, unless the methane content of the LFG can be substantially improved (increased to at least 40 percent by volume), the only viable LFG utilization alternative for this site will be flaring. However, if the quality of the collected LFG can be improved sufficiently by reducing air intrusion, then beneficial use of the LFG can be considered. Each of the various LFG beneficial use scenarios is described briefly in the following paragraphs.

There are several different types of equipment used to generate electric power with LFG. These include: reciprocating engines, microturbines, Stirling engines, and turbines. The primary difference between these systems is the amount of LFG they consume and the amount of electric power they produce. For example:

- LFG fueled microturbines generally provide about 20 to 250 kilowatt (kW) of generating capacity, consume about 6,750-14,500 BTU/kWh, require a minimum fuel heat value about 350 BTU/scf, require LFG drying, and siloxane removal, and may require LFG compression (to about 85 pounds per square inch gauge (psig)) and sulfur removal. LFG, at 20 percent methane, has a heat value of about 200 BTU/scf. Heat recovery systems can significantly increase the thermal efficiency of microturbine based systems.

  The site has an average electric demand of approximately 5.5 kW. To account for peak demand, an output of 10 to 15 kW may be required. Therefore, one microturbine should be able to generate more than enough power to operate the on-site LFG and leachate collection systems. Any power generated that was not used on-site would be exported to the utility grid and would generate income for the state. However, unless it can be demonstrated that the methane content of the LFG can be increased to at least 35 percent by volume, generating electric power using microturbines will not be considered further.

- Stirling engines generally provide 30 to 50 kW of generating capacity, consume about 9,600 BTU/kWh, require a minimum fuel heat value about 350 BTU/scf, require only low pressure (less than 2 psig) compression, and do not require LFG drying, sulfur removal, and siloxane removal. Heat recovery systems can significantly increase the thermal efficiency of Stirling engine based systems.

  The site has an average electric demand of approximately 5.5 kW. To account for peak demand, an output of 10 to 15 kW may be required. Therefore, one Stirling engine should be able to generate more than enough power to operate the LFG and leachate collection systems. Any power generated that was not used on-site would be exported to the utility grid and would generate income for the state. However, unless it can be demonstrated that the methane content of the LFG can be increased to at least 35 percent by volume, generating electric power using Stirling engines will not be considered further.

- Reciprocating engines provide approximately 250 to 1,600 kW of generating capacity. The engines generally require a minimum fuel heat value about 400 BTU/scf, require only low pressure (less than 2 psig compression), and may not require LFG drying, sulfur removal, and siloxane removal. Heat recovery systems can significantly increase the thermal efficiency of reciprocating engine based systems.

  The site does not collect enough LFG to economically operate a reciprocating engine. In addition, unless it can be demonstrated that the methane content of the LFG can be increased to at least 40 percent by volume, generating electric power using a reciprocating engine will not be considered further.

- Turbines generally provide 700 to 21,000 kW of generating capacity, consume 8,700 to 14,100 BTU/kWh, require a minimum fuel heat value about 400 BTU/scf and high pressure (greater than 200 psig) compression, and may not require LFG drying, and siloxane removal. Heat recovery systems can significantly increase the thermal efficiency of turbine based systems.

  The site does not collect enough LFG to operate a turbine. In addition, unless it can be demonstrated that the methane content of the LFG can be increased to at least 40 percent by volume, generating electric power using turbines will not be considered further.

Most landfills generate more LFG than can be used on-site (except when a flare or leachate evaporation system is installed). Therefore, off-site sale of the LFG or the power generated using the LFG is often considered. When there is an end user of gas within about 6 to 12 miles of the site, it is often most economical to sell the LFG for fuel to reduce the end users consumption of natural gas or propane. This is due to the fact that there is generally less capital equipment and on going O&M expense associated with direct use than with other alternatives.

Although there are several commercial establishments located north and east of the site, their primary load would be seasonal heating. During the summer, they would likely not have need for the LFG, so the site would have to maintain and operate the existing LFG flare as a back-up system.

Manufacturing pipeline quality gas from LFG typically requires the raw LFG to have less than 0.2 percent oxygen and less than 3 percent nitrogen. This is very high quality LFG. The existing LFG system is estimated to be collecting gas that is approximately 14 percent oxygen and 58 percent nitrogen. Even if the performance of the site LFG collection system can be improved to minimize air intrusion, it is (in our experience) unlikely that the improved LFG could qualify as pipeline quality gas; therefore, this alternative will not be considered further.

Manufacturing compressed or liquefied vehicle fuels, or chemical feed stocks requires much the same equipment needed to produce pipeline quality gas. This equipment is expensive to purchase, and to operate and maintain. This alternative generally requires a large landfill producing high quality LFG to develop a cost-effective project. In addition, the vehicle fuels alternatives require a fleet that has been converted to operate on compressed gas or non-petroleum liquid fuels. This site is relatively isolated from a state-owned vehicle pool, and it may be difficult to convince others who are not involved with this project to convert their vehicles. Therefore, vehicle fuels will not be considered further for this project.

6.2 SOLAR ENERGY

Solar energy can be used through several methods including direct or indirect heating and lighting systems, photovoltaics (PV), or concentrating solar power. The NERL National Photovoltaic Resource Map indicates that in the vicinity of the site PV power averages about 4.4 kilowatt hour square meter per day (kWh m^2/day). The average electric power consumption on-site is about 48,000 kilowatt hour per year (kWh/yr), or about 132 kWh/day. To power the

Delafield system as currently configured, a PV system with an average efficiency of about 2.5 percent would require a collector area of about 1,200 m^2 to meet the site's average demand. To account for peak demand and to generate power to be stored for periods when the PV system cannot meet the average demand, you might need two to three times that much output (or about 260-400 kWh/day). Any power generated that was not used or stored on-site would be exported to the utility grid and would generate income for the state. The majority of the site faces south-southeast, and the topography of the site and the surrounding area is such that shadowing should not be a limiting factor.

The most significant concern for such a system would be vandalism on the unsecured site.

6.3 WIND ENERGY

Conduct a wind resource assessment to determine the potential for using wind energy. Wisconsin Focus on Energy Wind Resource Map indicates that, in the vicinity of the site, the wind power density at an altitude of 40 meters (m) is 100-200 watt per square meter (W/m^2). Then state that the average electric power consumption on-site is about 48,000 kWh/yr, or about 5.5 kW. A wind turbine with a constant output of about 6 kW could meet the site's average demand. To account for peak demand and to generate power to be stored for periods when the wind turbine cannot meet the average demand, you might need two to three times that much output (or about 15 to 20 kW). From the wind resource map, a wind turbine with a swept area of about 150 to 200 m^2 (or a blade diameter of about 14 to 16 m) would meet the average demand. Any power generated that was not used or stored on-site would be exported to the utility grid and would generate income for the state.

The most significant concern with a wind power system is the proximity of the nearby homes and the potential for shadow flicker and generator noise.

7.0 POTENTIAL SUSTAINABLE ACTIVITIES

Because the site is privately owned by the Walter Nickel Trust, some recommended sustainable activities may require permission by the Trust, despite the fact that site remediation efforts are 100 percent state funded.

Implementing the recommended RPOs will result in a more effective and efficient remedial system and achieve objectives quicker and at a lower cost (i.e., sustainable). In addition to the items mentioned in the RPO section of this document, some additional sustainable activities that may be considered are discussed below.

7.1 RECYCLING USED EQUIPMENT

The unused remedial equipment (flare, blower, and motor) on-site should be salvaged or recycled dependant upon condition. Although the market for used remedial equipment is small, the equipment could be sold and reused by another consultant at a different site. The equipment could also be reused by the WDNR at another state-funded site if equipment needs matched. If reuse is not possible, the equipment should be recycled or properly disposed of.

7.2 CREATION OF GREENSPACE/DOG PARK

The Delafield site is located in a mixed commercial and residential area. It is unlikely that the parcel can be redeveloped for this purpose in the near future. Evaluate the potential and community interest in using the site as green space/dog park.

7.3 USE SITE TO GENERATE ALTERNATIVE ENERGY SOLAR

As mentioned in the Alternative Energy evaluation, the Delafield site has potential for generating solar power to sell back to the utility. The majority of the site faces south-southeast, and the topography of the site and the surrounding area is such that shadowing should not be a limiting factor. A feasibility study would need to be conducted prior to implementing any alternative energy options at the site.

8.0 SUSTAINABILITY MATRIX

A sustainability matrix was created that compared sustainability metrics for the current operational baseline verses three potential modifications that could be made to the system. The selected options were rebalancing of the existing LFG system, addition of 10 LFG extraction wells and leachate reduction by use of a modified flare. Alternative energy (methane to energy) alternatives were not included in the matrix as these technologies are not viable given the current LFG quality. This could change if some of the RPO recommendations are implemented. The sustainability matrix for the Delafield site is presented in Table 1.

It should be noted that the best or most applicable sustainable alternative at the site may be a combination of the proposed options.

AECOM

Table 1
Sustainability Matrix Delafield Landfill Site

	Baseline[3]		Option 1 Landfill Gas Extraction System Rebalancing		Option 2 lation of 10 LFG Extraction Wells and Associated Header		Option 3 llation of Modified Flare for the Purpose of Leachate Redu	
Sustainability Metrics[1,2]	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**
Stewardship								
System Optimization (Qualitative)	Landfill gas system is removing 50 percent of landfill gas being generated.		Modified landfill gas system would remove 70 percent of landfill gas being generated.		Modified landfill gas system would remove 75 percent of landfill gas being generated.		Will not increase the effectiveness of the remedy.	
Restoration Timeframe (yrs)	NA	25	NA	25	NA	25	NA	25
Carbon Footprint/Air Emissions								
Tons CO_2e	33,776	844,400	22,952	573,800	20,246	506,580	33,771	844,275
Tons CO_2e from Combusted Methane	3,344	83,600	4,682	117,050	5,016	125,400	3,344	83,600
Tons CO_2e from Combusted Methane	30,404	760,100	18,242	456,050	15,202	380,050	30,404	760,100
Energy Usage								
Electricity (kWh)	48,036	1,200,900	48,036	1,200,900	48,036	1,200,900	48,036	1,200,900
Propane (Pounds)	40	1,000	40	1,000	40	1,000	40	1,000
Cost								
O&M Cost (dollars)	$86,870	$2,171,750	$86,870	$2,171,750	$86,870	$2,171,750	$72,870	$1,821,750
Cost of Modification (dollars)	NA	NA	NA	$15,000 to $25,000	NA	$80,000 to $100,000	NA	$125,000 to $200,000
Cost per Ton CO_2e Reduced (dollars)	NA	NA	$2.30	$0.09	$7.40	$0.30	$40,000	$1,600
Land & Ecosystems								
Community Benefits (qualitative)	NA	NA	Reduction in fugitive methane emitted		Reduction in fugitive methane emitted		Reduction in leachate discharged to WWTP	
Materials & Waste Generation								
Leachate Generation (gallons)	1,200,000	30,022,500	1,200,000	30,022,500	1,200,000	30,022,500	672,000	16,800,000

[1] Metrics may be either qualitative not applicable (NA) or quantitative based on available information and scope of project.

[2] Metrics may be added or deleted based on site specific conditions.

[3] Baseline: As the system is currently being operated.

* Assume upper limit costs are used for cost per ton CO_2e reduced.

APPENDIX A

LANDGEM ASSUMPTIONS AND ANALYSIS

WDNR Sustainability Project

Delafield Landfill Evaluation

September 20, 2009

By: Paul Wintheiser

Objective: Estimate current year landfill gas (LFG) generation rate.

Method: United states Environmental Protection Agency (US EPA) Landfill Gas Emissions Model (LandGEM).

Assumptions:

1) Waste fill area covers approximately 42 acres (based on review of historical aerial photographs presented on Waukesha County interactive mapping web site).
2) Waste filling began prior to date of 1970 aerial photo presented on Waukesha County interactive mapping web site.
3) Waste filling ended after date of 1980 aerial photo presented on Waukesha County interactive mapping web site.
4) Site fill life was approximately 11 years.
5) Final cover high point elevation is approximately 1,063 ft MSL (based on review of current surface elevations presented on Waukesha County interactive mapping web site). .
6) Final cover perimeter elevation averages approximately 1027 ft MSL (based on review of historical aerial photographs, and current surface elevations presented on Waukesha County interactive mapping web site).
7) Waste bottom elevation is probably approximately 990 ft MSL (based on review of historical aerial photographs, groundwater elevation, and current surface elevations presented on Waukesha County interactive mapping web site).
8) Waste fill depth is probably approximately 49 feet (based on items 5, 6, and 7, above; and on review of LFG system drawings provided by the Wisconsin Department of Natural Resources (WDNR). The WDNR drawings indicate an average installed LFG well depth of approximately 36 ft).
9) Waste fill volume is approximately 3,320,240 cubic yards (cy).
10) Waste fill density is approximately 1,200 pounds per cubic yard (lb/cy).
11) Waste filling rate was an average of approximately 181,100 tons per year.
12) Run LandGEM for a range representing Clean Air Act, “inventory conventional”, and wet conditions.
13) There are 30 LFG wells on site (based on review of AECOM notes of meeting with WDNR site personnel).

14) Because the majority of the existing LFG wells are located at the perimeter of the waste fill, the existing LFG system was probably intended primarily to control LFG migration rather than to minimize surface emissions.

15) The current average LFG collection rate is approximately 264 standard cubic feet per minute (scfm), based on review of AECOM notes of meeting with WDNR site personnel.

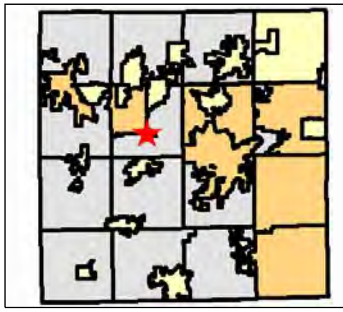
Results:

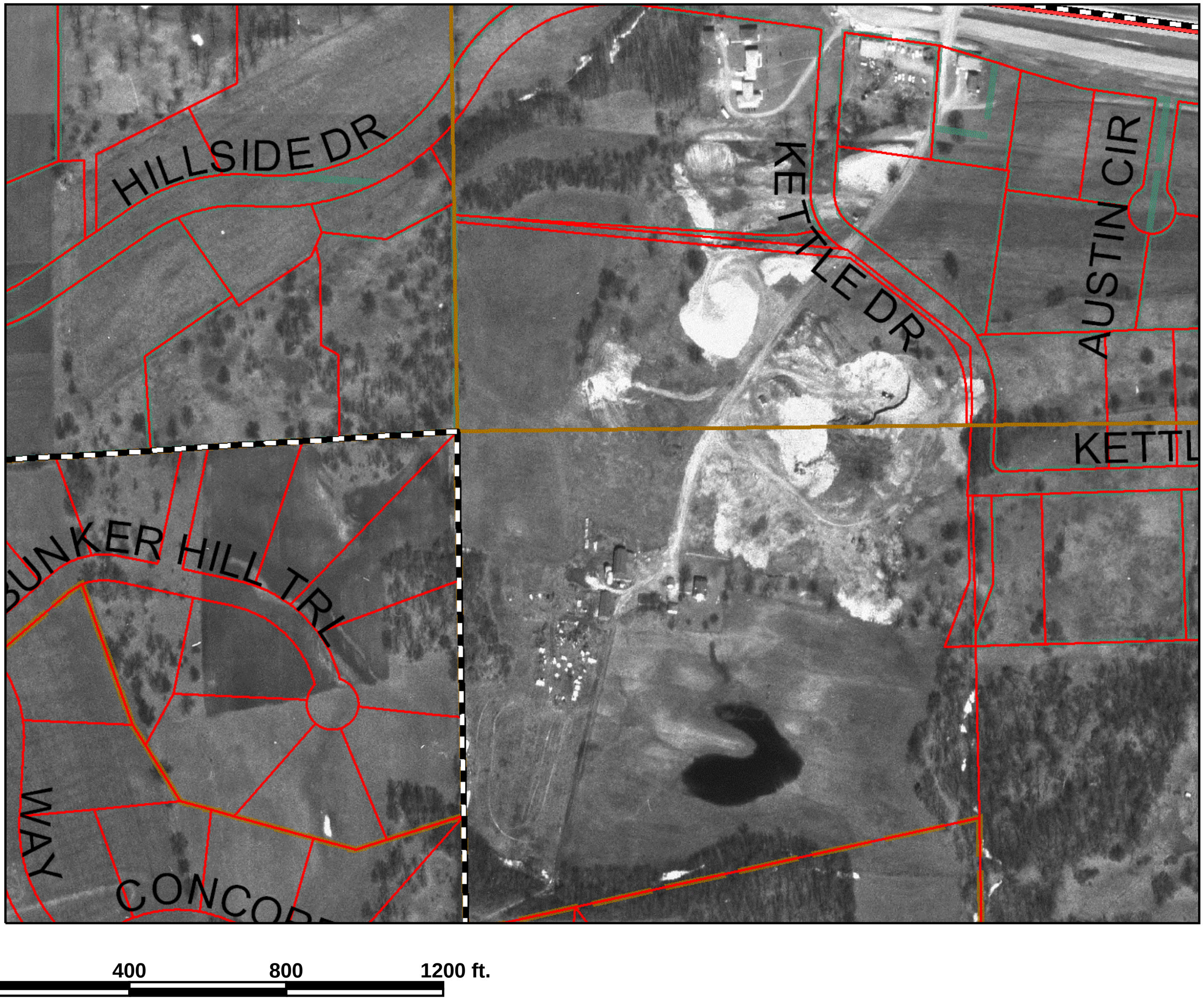
1) Thirty LFG wells over 38 acres (approximately 3 acres are currently under a Home Depot parking lot) is an average of 1 well per 1.27 acres. This results in an average radius of influence (ROI) of approximately 133 feet (without overlapping ROI), or about 166 ft with 20% ROI overlap. This range compares favorably with current WDNR LFG well spacing requirements.

2) Year 2009 LFG generation rate ranges from approximately 403 standard cubic feet per minute (scfm) to approximately 984 scfm, and likely averages approximately 525 scfm.

3) Based on a current average LFG generation rate of approximately 525 scfm, the current average LFG collection efficiency is about 50%. Based on information presented in Section 2.4.4.2 of AP-42, LFG collection efficiency ranges from 60 – 85%, and averages 75%. Therefore, for an old landfill with a LFG collection system intended primarily to control LFG migration, a LFG collection efficiency of about 50% is reasonable.

Delafield 1963





Legend

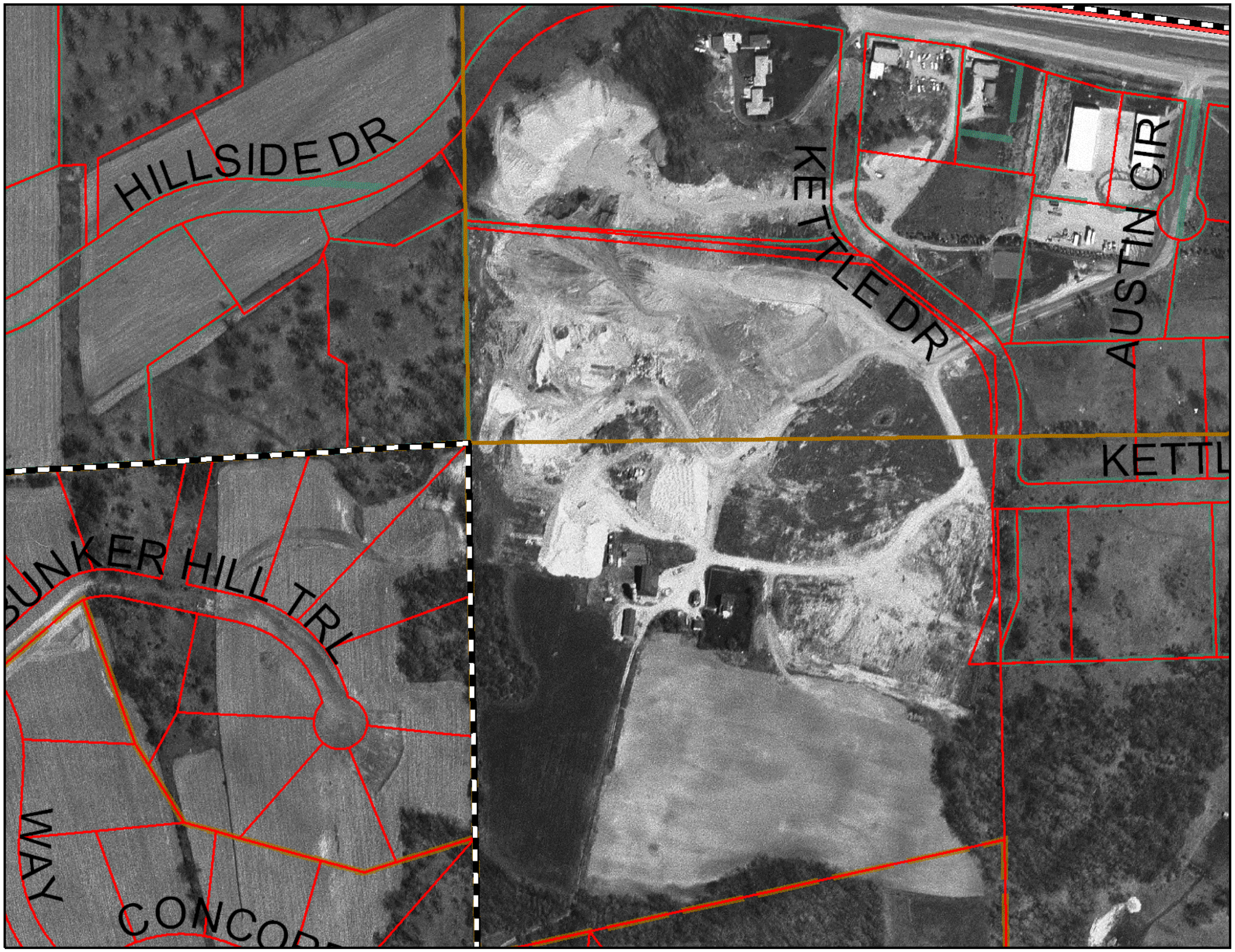
Street Centerlines (Basemap)
Road Classification
County
Interstate
Interstate Ramp
State
State Ramp
US
US Ramp
Civil Division Boundaries
Surrounding Counties
PLSS Section Lines
PLSS Quarter Section Lines
Parcels
Shared Interest Parcels
Assessor Plat
Condo Plat
CSM
Subdivision Plat
Lakes and Rivers
Streams and Creeks
Waukesha County 1963
Value
High : 255
Low : 52

Notes: 1:5000

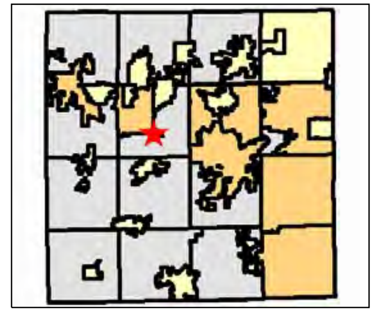
Map Generated: Aug 21, 2009

WAUKESHA COUNTY
Internet Mapping Site

Delafield 1970



0 425 850 1275 ft.



Legend

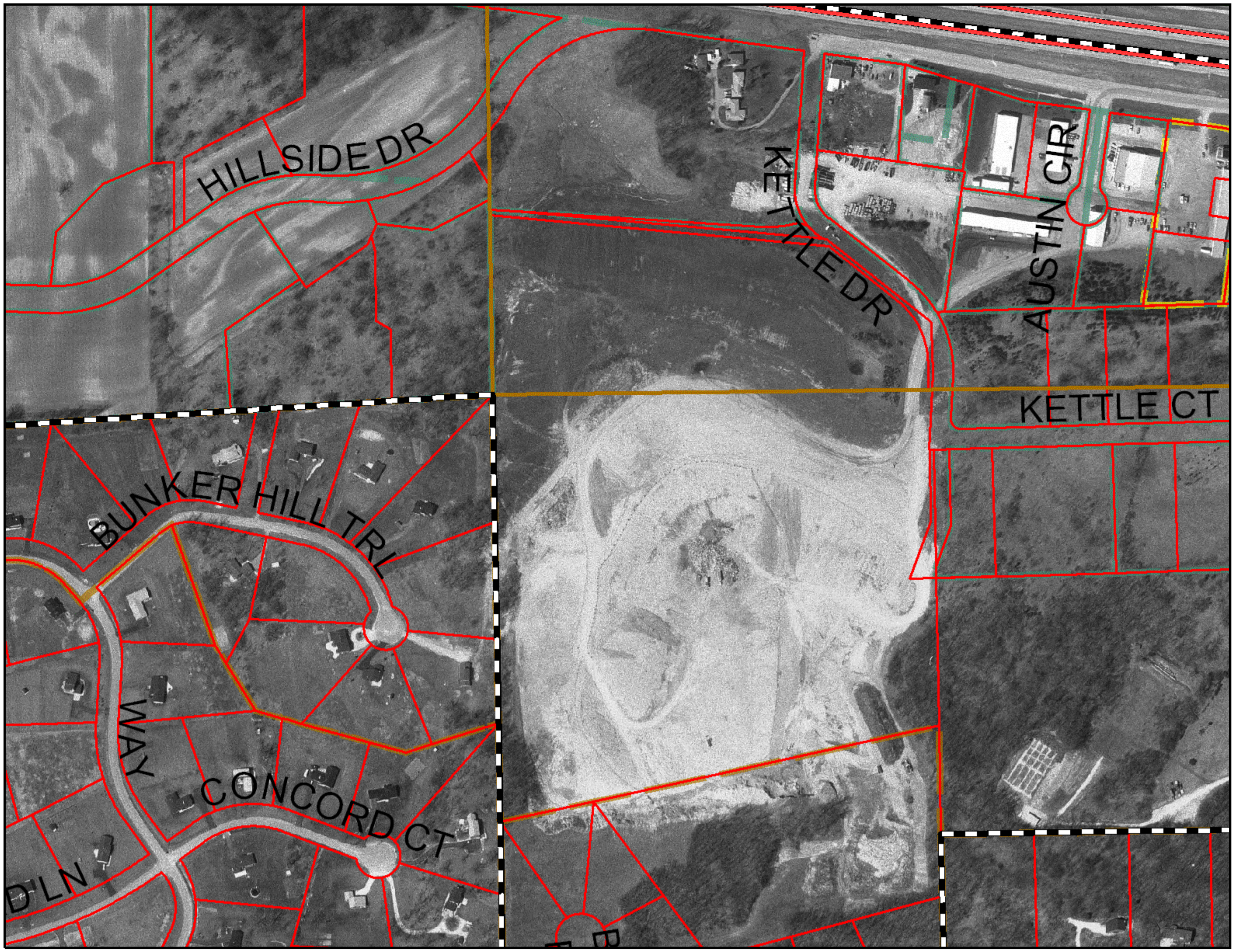
Street Centerlines (Basemap)
Road Classification
County
Interstate
Interstate Ramp
State
State Ramp
US
US Ramp
Civil Division Boundaries
Surrounding Counties
PLSS Section Lines
PLSS Quarter Section Lines
Parcels
Shared Interest Parcels
Assessor Plat
Condo Plat
CSM
Subdivision Plat
Lakes and Rivers
Streams and Creeks
Waukesha County 1970
Value
High : 255
Low : 38

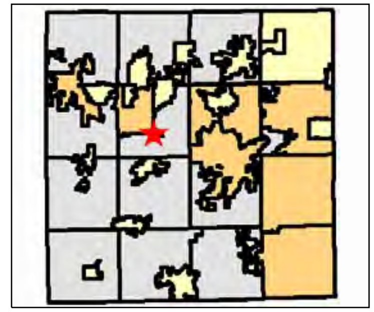
Notes: 1:5000

Map Generated: Aug 21, 2009

WAUKESHA COUNTY
Internet Mapping Site

Delafield 1980





Legend

Street Centerlines (Basemap)
Road Classification
County
Interstate
Interstate Ramp
State
State Ramp
US
US Ramp
Civil Division Boundaries
Surrounding Counties
PLSS Section Lines
PLSS Quarter Section Lines
Parcels
Shared Interest Parcels
Assessor Plat
Condo Plat
CSM
Subdivision Plat
Lakes and Rivers
Streams and Creeks
Waukesha County 1980
Value
High : 255
Low : 37

0 500 1000 1500 ft.

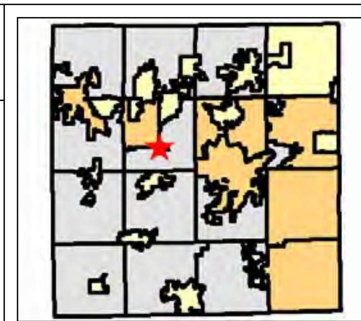
Notes: 1:6000

Map Generated: Aug 21, 2009

WAUKESHA COUNTY
Internet Mapping Site

Delafield 1990

0 500 1000 1500 ft.



Legend

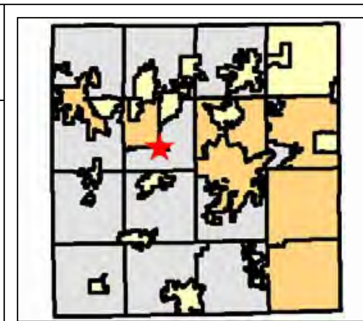
Street Centerlines (Basemap)
Road Classification
County
Interstate
Interstate Ramp
State
State Ramp
US
US Ramp
Civil Division Boundaries
Surrounding Counties
PLSS Section Lines
PLSS Quarter Section Lines
Parcels
Shared Interest Parcels
Assessor Plat
Condo Plat
CSM
Subdivision Plat
Lakes and Rivers
Streams and Creeks
Waukesha County 1990
Value
High : 255
Low : 0

Notes: 1:6000

Map Generated: Aug 21, 2009

WAUKESHA COUNTY
Internet Mapping Site

Delafield 1995



Legend

Street Centerlines (Basemap)
Road Classification
- County
- Interstate
- Interstate Ramp
- State
- State Ramp
- US
- US Ramp
- Civil Division Boundaries
- Surrounding Counties
- PLSS Section Lines
- PLSS Quarter Section Lines
- Parcels
- Shared Interest Parcels
- Assessor Plat
- Condo Plat
- CSM
- Subdivision Plat
- Lakes and Rivers
- Streams and Creeks

Waukesha County 1995
Value
High : 255
Low : 10

0 500 1000 1500 ft.

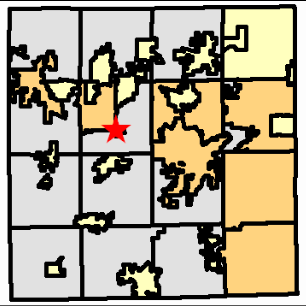
Notes: 1:6000

Map Generated: Aug 21, 2009

WAUKESHA COUNTY
Internet Mapping Site

Delafield North Topo 2005 Annotated

0 200 400 600 ft.



Legend

Points of Interest

Type

- Airport
- Cemetery
- Fire Station
- Government Building
- Hospital
- Library
- Post Office
- Park or Recreation
- School
- Unincorporated Place
- County Parks
- Police Station
- Sheriff Substation
- Civil Division Boundaries
- Surrounding Counties
- PLSS Section Lines
- PLSS Quarter Section Lines

Cartographic Elements

Type

- Easement Line (Major)
- Dimension arrow
- Extended Tie Line
- Identification Arrow
- Meander Line
- Note Leader
- Parcel Line (Water)
- Tangency Tic
- Tie Hook
- Tie Line
- ROW Centerline
- RR ROW Centerline
- ROW Radius
- Sub Block 100
- Sub Block 200
- Parcels
- Shared Interest Parcels

Road Rights of Way

ROW Type

- Dedicated
- Proposed
- Reserved
- Vacated
- Assessor Plat
- Condo Plat
- CSM
- Subdivision Plat

Railroad Rights of Way

RR ROW Status

- Active

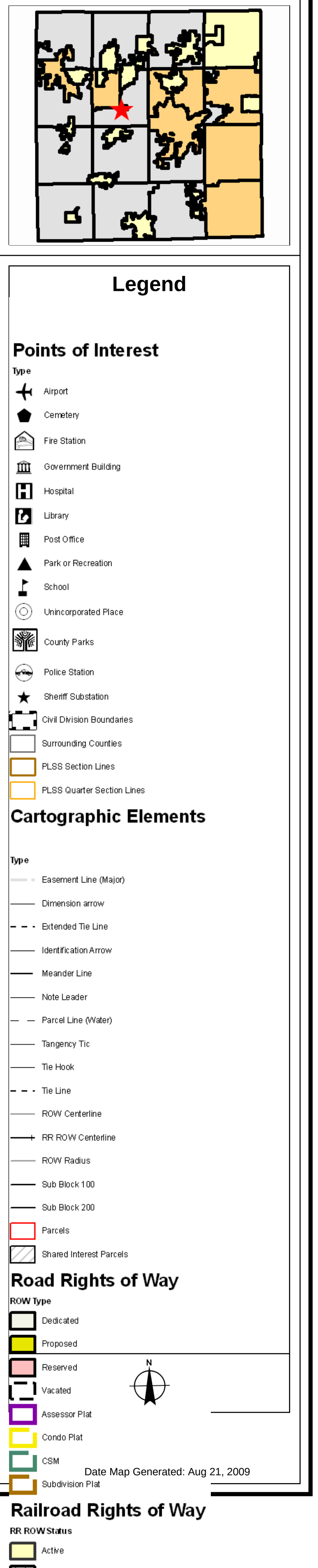
Notes: 1:2400

Date Map Generated: Aug 21, 2009

Delafield Topo and Water Table 2

WAUKESHA COUNTY Internet Mapping Site

0 200 400 600 ft.



Notes: 1:2400

Date Map Generated: Aug 21, 2009

RESULTS **Landfill Name or Identifier:** Delafield

Closure Year (with 80-year limit) = 1981
Methane = 20 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.
User-specified Unit: *av ft^3/min*

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1970	164,636	181,100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	164,636	181,100	164,636	181,100	7.175E+03	6.842E+06	4.597E+02	9.129E+02	1.368E+06	9.194E+01	1.002E+04	5.474E+06	3.678E+02	9.810E+01	2.737E+04	1.839E+00
1972	164,636	181,100	329,273	362,200	1.400E+04	1.335E+07	8.970E+02	1.781E+03	2.670E+06	1.794E+02	1.955E+04	1.068E+07	7.176E+02	1.914E+02	5.340E+04	3.588E+00
1973	164,636	181,100	493,909	543,300	2.049E+04	1.954E+07	1.313E+03	2.607E+03	3.908E+06	2.626E+02	2.862E+04	1.563E+07	1.050E+03	2.802E+02	7.817E+04	5.252E+00
1974	164,636	181,100	658,545	724,400	2.667E+04	2.543E+07	1.709E+03	3.393E+03	5.086E+06	3.417E+02	3.724E+04	2.034E+07	1.367E+03	3.646E+02	1.017E+05	6.835E+00
1975	164,636	181,100	823,182	905,500	3.254E+04	3.103E+07	2.085E+03	4.141E+03	6.206E+06	4.170E+02	4.544E+04	2.483E+07	1.668E+03	4.449E+02	1.241E+05	8.340E+00
1976	164,636	181,100	987,818	1,086,600	3.813E+04	3.636E+07	2.443E+03	4.852E+03	7.272E+06	4.886E+02	5.325E+04	2.909E+07	1.954E+03	5.213E+02	1.454E+05	9.772E+00
1977	164,636	181,100	1,152,455	1,267,700	4.345E+04	4.143E+07	2.784E+03	5.528E+03	8.286E+06	5.567E+02	6.067E+04	3.314E+07	2.227E+03	5.940E+02	1.657E+05	1.113E+01
1978	164,636	181,100	1,317,091	1,448,800	4.850E+04	4.625E+07	3.108E+03	6.171E+03	9.250E+06	6.215E+02	6.773E+04	3.700E+07	2.486E+03	6.631E+02	1.850E+05	1.243E+01
1979	164,636	181,100	1,481,727	1,629,900	5.331E+04	5.084E+07	3.416E+03	6.783E+03	1.017E+07	6.832E+02	7.445E+04	4.067E+07	2.733E+03	7.289E+02	2.034E+05	1.366E+01
1980	164,636	181,100	1,646,364	1,811,000	5.789E+04	5.520E+07	3.709E+03	7.365E+03	1.104E+07	7.418E+02	8.084E+04	4.416E+07	2.967E+03	7.915E+02	2.208E+05	1.484E+01
1981	0	0	1,811,000	1,992,100	6.224E+04	5.935E+07	3.988E+03	7.919E+03	1.187E+07	7.975E+02	8.691E+04	4.748E+07	3.190E+03	8.510E+02	2.374E+05	1.595E+01
1982	0	0	1,811,000	1,992,100	5.920E+04	5.646E+07	3.793E+03	7.533E+03	1.129E+07	7.586E+02	8.267E+04	4.516E+07	3.035E+03	8.095E+02	2.258E+05	1.517E+01
1983	0	0	1,811,000	1,992,100	5.632E+04	5.370E+07	3.608E+03	7.165E+03	1.074E+07	7.216E+02	7.864E+04	4.296E+07	2.887E+03	7.700E+02	2.148E+05	1.443E+01
1984	0	0	1,811,000	1,992,100	5.357E+04	5.108E+07	3.432E+03	6.816E+03	1.022E+07	6.865E+02	7.481E+04	4.087E+07	2.746E+03	7.324E+02	2.043E+05	1.373E+01
1985	0	0	1,811,000	1,992,100	5.096E+04	4.859E+07	3.265E+03	6.484E+03	9.718E+06	6.530E+02	7.116E+04	3.887E+07	2.612E+03	6.967E+02	1.944E+05	1.306E+01
1986	0	0	1,811,000	1,992,100	4.847E+04	4.622E+07	3.106E+03	6.167E+03	9.244E+06	6.211E+02	6.769E+04	3.698E+07	2.485E+03	6.627E+02	1.849E+05	1.242E+01
1987	0	0	1,811,000	1,992,100	4.611E+04	4.397E+07	2.954E+03	5.867E+03	8.794E+06	5.908E+02	6.439E+04	3.517E+07	2.363E+03	6.304E+02	1.759E+05	1.182E+01
1988	0	0	1,811,000	1,992,100	4.386E+04	4.182E+07	2.810E+03	5.580E+03	8.365E+06	5.620E+02	6.125E+04	3.346E+07	2.248E+03	5.997E+02	1.673E+05	1.124E+01
1989	0	0	1,811,000	1,992,100	4.172E+04	3.978E+07	2.673E+03	5.308E+03	7.957E+06	5.346E+02	5.826E+04	3.183E+07	2.138E+03	5.704E+02	1.591E+05	1.069E+01
1990	0	0	1,811,000	1,992,100	3.969E+04	3.784E+07	2.543E+03	5.049E+03	7.569E+06	5.085E+02	5.542E+04	3.027E+07	2.034E+03	5.426E+02	1.514E+05	1.017E+01
1991	0	0	1,811,000	1,992,100	3.775E+04	3.600E+07	2.419E+03	4.803E+03	7.200E+06	4.837E+02	5.271E+04	2.880E+07	1.935E+03	5.161E+02	1.440E+05	9.675E+00
1992	0	0	1,811,000	1,992,100	3.591E+04	3.424E+07	2.301E+03	4.569E+03	6.848E+06	4.601E+02	5.014E+04	2.739E+07	1.841E+03	4.910E+02	1.370E+05	9.203E+00
1993	0	0	1,811,000	1,992,100	3.416E+04	3.257E+07	2.189E+03	4.346E+03	6.514E+06	4.377E+02	4.770E+04	2.606E+07	1.751E+03	4.670E+02	1.303E+05	8.754E+00
1994	0	0	1,811,000	1,992,100	3.249E+04	3.098E+07	2.082E+03	4.134E+03	6.197E+06	4.164E+02	4.537E+04	2.479E+07	1.665E+03	4.442E+02	1.239E+05	8.327E+00
1995	0	0	1,811,000	1,992,100	3.091E+04	2.947E+07	1.980E+03	3.932E+03	5.894E+06	3.960E+02	4.316E+04	2.358E+07	1.584E+03	4.226E+02	1.179E+05	7.921E+00
1996	0	0	1,811,000	1,992,100	2.940E+04	2.804E+07	1.884E+03	3.741E+03	5.607E+06	3.767E+02	4.105E+04	2.243E+07	1.507E+03	4.020E+02	1.121E+05	7.535E+00
1997	0	0	1,811,000	1,992,100	2.797E+04	2.667E+07	1.792E+03	3.558E+03	5.334E+06	3.584E+02	3.905E+04	2.133E+07	1.433E+03	3.824E+02	1.067E+05	7.167E+00
1998	0	0	1,811,000	1,992,100	2.660E+04	2.537E+07	1.704E+03	3.385E+03	5.073E+06	3.409E+02	3.715E+04	2.029E+07	1.364E+03	3.637E+02	1.015E+05	6.818E+00
1999	0	0	1,811,000	1,992,100	2.530E+04	2.413E+07	1.621E+03	3.220E+03	4.826E+06	3.243E+02	3.534E+04	1.930E+07	1.297E+03	3.460E+02	9.652E+04	6.485E+00
2000	0	0	1,811,000	1,992,100	2.407E+04	2.295E+07	1.542E+03	3.063E+03	4.591E+06	3.084E+02	3.361E+04	1.836E+07	1.234E+03	3.291E+02	9.181E+04	6.169E+00
2001	0	0	1,811,000	1,992,100	2.290E+04	2.183E+07	1.467E+03	2.913E+03	4.367E+06	2.934E+02	3.197E+04	1.747E+07	1.174E+03	3.130E+02	8.733E+04	5.868E+00
2002	0	0	1,811,000	1,992,100	2.178E+04	2.077E+07	1.395E+03	2.771E+03	4.154E+06	2.791E+02	3.041E+04	1.662E+07	1.116E+03	2.978E+02	8.308E+04	5.582E+00
2003	0	0	1,811,000	1,992,100	2.072E+04	1.976E+07	1.327E+03	2.636E+03	3.951E+06	2.655E+02	2.893E+04	1.580E+07	1.062E+03	2.833E+02	7.902E+04	5.310E+00
2004	0	0	1,811,000	1,992,100	1.971E+04	1.879E+07	1.263E+03	2.507E+03	3.758E+06	2.525E+02	2.752E+04	1.503E+07	1.010E+03	2.694E+02	7.517E+04	5.051E+00
2005	0	0	1,811,000	1,992,100	1.875E+04	1.788E+07	1.201E+03	2.385E+03	3.575E+06	2.402E+02	2.618E+04	1.430E+07	9.609E+02	2.563E+02	7.150E+04	4.804E+00
2006	0	0	1,811,000	1,992,100	1.783E+04	1.700E+07	1.143E+03	2.269E+03	3.401E+06	2.285E+02	2.490E+04	1.360E+07	9.140E+02	2.438E+02	6.802E+04	4.570E+00
2007	0	0	1,811,000	1,992,100	1.696E+04	1.617E+07	1.087E+03	2.158E+03	3.235E+06	2.174E+02	2.369E+04	1.294E+07	8.694E+02	2.319E+02	6.470E+04	4.347E+00
2008	0	0	1,811,000	1,992,100	1.613E+04	1.539E+07	1.034E+03	2.053E+03	3.077E+06	2.068E+02	2.253E+04	1.231E+07	8.270E+02	2.206E+02	6.154E+04	4.135E+00
2009	0	0	1,811,000	1,992,100	1.535E+04	1.464E+07	9.834E+02	1.953E+03	2.927E+06	1.967E+02	2.143E+04	1.171E+07	7.867E+02	2.098E+02	5.854E+04	3.933E+00
2010	0	0	1,811,000	1,992,100	1.460E+04	1.392E+07	9.354E+02	1.858E+03	2.784E+06	1.871E+02	2.039E+04	1.114E+07	7.483E+02	1.996E+02	5.569E+04	3.742E+00
2011	0	0	1,811,000	1,992,100	1.389E+04	1.324E+07	8.898E+02	1.767E+03	2.649E+06	1.780E+02	1.939E+04	1.059E+07	7.118E+02	1.899E+02	5.297E+04	3.559E+00
2012	0	0	1,811,000	1,992,100	1.321E+04	1.260E+07	8.464E+02	1.681E+03	2.519E+06	1.693E+02	1.845E+04	1.008E+07	6.771E+02	1.806E+02	5.039E+04	3.386E+00
2013	0	0	1,811,000	1,992,100	1.257E+04	1.198E+07	8.051E+02	1.599E+03	2.397E+06	1.610E+02	1.755E+04	9.586E+06	6.441E+02	1.718E+02	4.793E+04	3.220E+00
2014	0	0	1,811,000	1,992,100	1.195E+04	1.140E+07	7.658E+02	1.521E+03	2.280E+06	1.532E+02	1.669E+04	9.119E+06	6.127E+02	1.634E+02	4.559E+04	3.063E+00
2015	0	0	1,811,000	1,992,100	1.137E+04	1.084E+07	7.285E+02	1.447E+03	2.168E+06	1.457E+02	1.588E+04	8.674E+06	5.828E+02	1.555E+02	4.337E+04	2.914E+00
2016	0	0	1,811,000	1,992,100	1.082E+04	1.031E+07	6.930E+02	1.376E+03	2.063E+06	1.386E+02	1.510E+04	8.251E+06	5.544E+02	1.479E+02	4.125E+04	2.772E+00
2017	0	0	1,811,000	1,992,100	1.029E+04	9.811E+06	6.592E+02	1.309E+03	1.962E+06	1.318E+02	1.437E+04	7.848E+06	5.273E+02	1.407E+02	3.924E+04	2.637E+00
2018	0	0	1,811,000	1,992,100	9.786E+03	9.332E+06	6.270E+02	1.245E+03	1.866E+06	1.254E+02	1.367E+04	7.466E+06	5.016E+02	1.338E+02	3.733E+04	2.508E+00
2019	0	0	1,811,000	1,992,100	9.309E+03	8.877E+06	5.964E+02	1.184E+03	1.775E+06	1.193E+02	1.300E+04	7.102E+06	4.772E+02	1.273E+02	3.551E+04	2.386E+00
2020	0	0	1,811,000	1,992,100	8.855E+03	8.444E+06	5.674E+02	1.127E+03	1.689E+06	1.135E+02	1.237E+04	6.755E+06	4.539E+02	1.211E+02	3.378E+04	2.269E+00
2021	0	0	1,811,000	1,992,100	8.423E+03	8.032E+06	5.397E+02	1.072E+03	1.606E+06	1.079E+02	1.176E+04	6.426E+06	4.317E+02	1.152E+02	3.213E+04	2.159E+00
2022	0	0	1,811,000	1,992,100	8.012E+03	7.640E+06	5.134E+02	1.019E+03	1.528E+06	1.027E+02	1.119E+04	6.112E+06	4.107E+02	1.095E+02	3.056E+04	2.053E+00
2023	0	0	1,811,000	1,992,100	7.622E+03	7.268E+06	4.883E+02	9.697E+02	1.454E+06	9.766E+01	1.064E+04	5.814E+06	3.907E+02	1.042E+02	2.907E+04	1.953E+00
2024	0	0	1,811,000	1,992,100	7.250E+03	6.913E+06	4.645E+02	9.224E+02	1.383E+06	9.290E+01	1.012E+04	5.531E+06	3.716E+02	9.912E+01	2.765E+04	1.858E+00
2025	0	0	1,811,000	1,992,100	6.896E+03	6.576E+06	4.419E+02	8.775E+02	1.315E+06	8.837E+01	9.630E+03	5.261E+06	3.535E+02	9.429E+01	2.630E+04	1.767E+00
2026	0	0	1,811,000	1,992,100	6.560E+03	6.255E+06	4.203E+02	8.347E+02	1.251E+06	8.406E+01	9.160E+03	5.004E+06	3.362E+02	8.969E+01	2.502E+04	1.681E+00
2027	0	0	1,811,000	1,992,100	6.240E+03	5.950E+06	3.998E+02	7.940E+02	1.190E+06	7.996E+01	8.714E+03	4.760E+06	3.198E+02	8.532E+01	2.380E+04	1.599E+00
2028	0	0	1,811,000	1,992,100	5.936E+03	5.660E+06	3.803E+02	7.552E+02	1.132E+06	7.606E+01	8.289E+03	4.528E+06	3.042E+02	8.115E+01	2.264E+04	1.521E+00
2029	0	0	1,811,000	1,992,100	5.646E+03	5.384E+06	3.618E+02	7.184E+02	1.077E+06	7.235E+01	7.885E+03	4.307E+06	2.894E+02	7.720E+01	2.154E+04	1.447E+00
2030	0	0	1,811,000	1,992,100	5.371E+03	5.122E+06	3.441E+02	6.834E+02	1.024E+06	6.882E+01	7.500E+03	4.097E+06	2.753E+02	7.343E+01	2.049E+04	1.376E+00
2031	0	0	1,811,000	1,992,100	5.109E+03	4.872E+06	3.273E+02	6.500E+02	9.744E+05	6.547E+01	7.134E+03	3.897E+06	2.619E+02	6.985E+01	1.949E+04	1.309E+00
2032	0	0	1,811,000	1,992,100	4.860E+03	4.634E+06	3.114E+02	6.183E+02	9.268E+05	6.227E+01	6.786E+03	3.707E+06	2.491E+02	6.644E+01	1.854E+04	1.245E+00
2033	0	0	1,811,000	1,992,100	4.623E+03	4.408E+06	2.962E+02	5.882E+02	8.816E+05	5.924E+01	6.455E+03	3.527E+06	2.369E+02	6.320E+01	1.763E+04	1.185E+00
2034	0	0	1,811,000	1,992,100	4.397E+03	4.193E+06	2.817E+02	5.595E+02	8.386E+05	5.635E+01	6.140E+03	3.355E+06	2.254E+02	6.012E+01	1.677E+04	1.127E+00
2035	0	0	1,811,000	1,992,100	4.183E+03	3.989E+06	2.680E+02	5.322E+02	7.977E+05	5.360E+01	5.841E+03	3.191E+06	2.144E+02	5.719E+01	1.595E+04	1.072E+00
2036	0	0	1,811,000	1,992,100	3.979E+03	3.794E+06	2.549E+02	5.062E+02	7.588E+05	5.099E+01	5.556E+03	3.035E+06	2.039E+02	5.440E+01	1.518E+04	1.020E+00
2037	0	0	1,811,000	1,992,100	3.785E+03	3.609E+06	2.425E+02	4.816E+02	7.218E+05	4.850E+01	5.285E+03	2.887E+06	1.940E+02	5.175E+01	1.444E+04	9.700E-01
2038	0	0	1,811,000	1,992,100	3.600E+03	3.433E+06	2.307E+02	4.581E+02	6.866E+05	4.613E+01	5.027E+03	2.746E+06	1.845E+02	4.922E+01	1.373E+04	9.227E-01
2039	0	0	1,811,000	1,992,100	3.425E+03	3.266E+06	2.194E+02	4.357E+02	6.531E+05	4.388E+01	4.782E+03	2.613E+06	1.755E+02	4.682E+01	1.306E+04	8.777E-01
2040	0	0	1,811,000	1,992,100	3.258E+03	3.106E+06	2.087E+02	4.145E+02	6.213E+05	4.174E+01	4.549E+03	2.485E+06	1.670E+02	4.454E+01	1.243E+04	8.349E-01
2041	0	0	1,811,000	1,992,100	3.099E+03	2.955E+06	1.985E+02	3.943E+02	5.910E+05	3.971E+01	4.327E+03	2.364E+06	1.588E+02	4.237E+01	1.182E+04	7.941E-01
2042	0	0	1,811,000	1,992,100	2.948E+03	2.811E+06	1.889E+02	3.750E+02	5.622E+05	3.777E+01	4.116E+03	2.249E+06	1.511E+02	4.030E+01	1.124E+04	7.554E-01
2043	0	0	1,811,000	1,992,100	2.804E+03	2.674E+06	1.796E+02	3.567E+02	5.347E+05	3.593E+01	3.915E+03	2.139E+06	1.437E+02	3.833E+01	1.069E+04	7.186E-01
2044	0	0	1,811,000	1,992,100	2.667E+03	2.543E+06	1.709E+02	3.393E+02	5.087E+05	3.418E+01	3.724E+03	2.035E+06	1.367E+02	3.647E+01	1.017E+04	6.835E-01
2045	0	0	1,811,000	1,992,100	2.537E+03	2.419E+06	1.625E+02	3.228E+02	4.838E+05	3.251E+01	3.543E+03	1.935E+06	1.300E+02	3.469E+01	9.677E+03	6.502E-01

RESULTS **Landfill Name or Identifier:** Delafield

Closure Year (with 80-year limit) = 1981

Methane = 20 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.

User-specified Unit: *av ft^3/min*

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2046	0	0	1,811,000	1,992,100	2.413E+03	2.301E+06	1.546E+02	3.071E+02	4.603E+05	3.092E+01	3.370E+03	1.841E+06	1.237E+02	3.300E+01	9.205E+03	6.185E-01
2047	0	0	1,811,000	1,992,100	2.296E+03	2.189E+06	1.471E+02	2.921E+02	4.378E+05	2.942E+01	3.206E+03	1.751E+06	1.177E+02	3.139E+01	8.756E+03	5.883E-01
2048	0	0	1,811,000	1,992,100	2.184E+03	2.082E+06	1.399E+02	2.778E+02	4.165E+05	2.798E+01	3.049E+03	1.666E+06	1.119E+02	2.986E+01	8.329E+03	5.596E-01
2049	0	0	1,811,000	1,992,100	2.077E+03	1.981E+06	1.331E+02	2.643E+02	3.961E+05	2.662E+01	2.901E+03	1.585E+06	1.065E+02	2.840E+01	7.923E+03	5.323E-01
2050	0	0	1,811,000	1,992,100	1.976E+03	1.884E+06	1.266E+02	2.514E+02	3.768E+05	2.532E+01	2.759E+03	1.507E+06	1.013E+02	2.701E+01	7.536E+03	5.064E-01
2051	0	0	1,811,000	1,992,100	1.879E+03	1.792E+06	1.204E+02	2.391E+02	3.584E+05	2.408E+01	2.625E+03	1.434E+06	9.634E+01	2.570E+01	7.169E+03	4.817E-01
2052	0	0	1,811,000	1,992,100	1.788E+03	1.705E+06	1.145E+02	2.275E+02	3.410E+05	2.291E+01	2.497E+03	1.364E+06	9.164E+01	2.444E+01	6.819E+03	4.582E-01
2053	0	0	1,811,000	1,992,100	1.701E+03	1.622E+06	1.090E+02	2.164E+02	3.243E+05	2.179E+01	2.375E+03	1.297E+06	8.717E+01	2.325E+01	6.487E+03	4.358E-01
2054	0	0	1,811,000	1,992,100	1.618E+03	1.543E+06	1.036E+02	2.058E+02	3.085E+05	2.073E+01	2.259E+03	1.234E+06	8.292E+01	2.212E+01	6.170E+03	4.146E-01
2055	0	0	1,811,000	1,992,100	1.539E+03	1.467E+06	9.859E+01	1.958E+02	2.935E+05	1.972E+01	2.149E+03	1.174E+06	7.887E+01	2.104E+01	5.869E+03	3.944E-01
2056	0	0	1,811,000	1,992,100	1.464E+03	1.396E+06	9.378E+01	1.862E+02	2.792E+05	1.876E+01	2.044E+03	1.117E+06	7.503E+01	2.001E+01	5.583E+03	3.751E-01
2057	0	0	1,811,000	1,992,100	1.392E+03	1.328E+06	8.921E+01	1.772E+02	2.655E+05	1.784E+01	1.944E+03	1.062E+06	7.137E+01	1.904E+01	5.311E+03	3.568E-01
2058	0	0	1,811,000	1,992,100	1.324E+03	1.263E+06	8.486E+01	1.685E+02	2.526E+05	1.697E+01	1.849E+03	1.010E+06	6.789E+01	1.811E+01	5.052E+03	3.394E-01
2059	0	0	1,811,000	1,992,100	1.260E+03	1.201E+06	8.072E+01	1.603E+02	2.403E+05	1.614E+01	1.759E+03	9.611E+05	6.458E+01	1.722E+01	4.805E+03	3.229E-01
2060	0	0	1,811,000	1,992,100	1.198E+03	1.143E+06	7.678E+01	1.525E+02	2.286E+05	1.536E+01	1.673E+03	9.142E+05	6.143E+01	1.638E+01	4.571E+03	3.071E-01
2061	0	0	1,811,000	1,992,100	1.140E+03	1.087E+06	7.304E+01	1.450E+02	2.174E+05	1.461E+01	1.592E+03	8.696E+05	5.843E+01	1.559E+01	4.348E+03	2.922E-01
2062	0	0	1,811,000	1,992,100	1.084E+03	1.034E+06	6.948E+01	1.380E+02	2.068E+05	1.390E+01	1.514E+03	8.272E+05	5.558E+01	1.483E+01	4.136E+03	2.779E-01
2063	0	0	1,811,000	1,992,100	1.031E+03	9.836E+05	6.609E+01	1.312E+02	1.967E+05	1.322E+01	1.440E+03	7.869E+05	5.287E+01	1.410E+01	3.934E+03	2.643E-01
2064	0	0	1,811,000	1,992,100	9.812E+02	9.356E+05	6.286E+01	1.248E+02	1.871E+05	1.257E+01	1.370E+03	7.485E+05	5.029E+01	1.341E+01	3.742E+03	2.515E-01
2065	0	0	1,811,000	1,992,100	9.333E+02	8.900E+05	5.980E+01	1.188E+02	1.780E+05	1.196E+01	1.303E+03	7.120E+05	4.784E+01	1.276E+01	3.560E+03	2.392E-01
2066	0	0	1,811,000	1,992,100	8.878E+02	8.466E+05	5.688E+01	1.130E+02	1.693E+05	1.138E+01	1.240E+03	6.773E+05	4.551E+01	1.214E+01	3.386E+03	2.275E-01
2067	0	0	1,811,000	1,992,100	8.445E+02	8.053E+05	5.411E+01	1.075E+02	1.611E+05	1.082E+01	1.179E+03	6.442E+05	4.329E+01	1.155E+01	3.221E+03	2.164E-01
2068	0	0	1,811,000	1,992,100	8.033E+02	7.660E+05	5.147E+01	1.022E+02	1.532E+05	1.029E+01	1.122E+03	6.128E+05	4.118E+01	1.098E+01	3.064E+03	2.059E-01
2069	0	0	1,811,000	1,992,100	7.641E+02	7.287E+05	4.896E+01	9.723E+01	1.457E+05	9.792E+00	1.067E+03	5.829E+05	3.917E+01	1.045E+01	2.915E+03	1.958E-01
2070	0	0	1,811,000	1,992,100	7.269E+02	6.931E+05	4.657E+01	9.248E+01	1.386E+05	9.314E+00	1.015E+03	5.545E+05	3.726E+01	9.938E+00	2.772E+03	1.863E-01
2071	0	0	1,811,000	1,992,100	6.914E+02	6.593E+05	4.430E+01	8.797E+01	1.319E+05	8.860E+00	9.655E+02	5.275E+05	3.544E+01	9.453E+00	2.637E+03	1.772E-01
2072	0	0	1,811,000	1,992,100	6.577E+02	6.272E+05	4.214E+01	8.368E+01	1.254E+05	8.428E+00	9.184E+02	5.017E+05	3.371E+01	8.992E+00	2.509E+03	1.686E-01
2073	0	0	1,811,000	1,992,100	6.256E+02	5.966E+05	4.008E+01	7.960E+01	1.193E+05	8.017E+00	8.736E+02	4.773E+05	3.207E+01	8.554E+00	2.386E+03	1.603E-01
2074	0	0	1,811,000	1,992,100	5.951E+02	5.675E+05	3.813E+01	7.572E+01	1.135E+05	7.626E+00	8.310E+02	4.540E+05	3.050E+01	8.136E+00	2.270E+03	1.525E-01
2075	0	0	1,811,000	1,992,100	5.661E+02	5.398E+05	3.627E+01	7.203E+01	1.080E+05	7.254E+00	7.905E+02	4.318E+05	2.902E+01	7.740E+00	2.159E+03	1.451E-01
2076	0	0	1,811,000	1,992,100	5.385E+02	5.135E+05	3.450E+01	6.851E+01	1.027E+05	6.900E+00	7.519E+02	4.108E+05	2.760E+01	7.362E+00	2.054E+03	1.380E-01
2077	0	0	1,811,000	1,992,100	5.122E+02	4.884E+05	3.282E+01	6.517E+01	9.769E+04	6.564E+00	7.153E+02	3.907E+05	2.625E+01	7.003E+00	1.954E+03	1.313E-01
2078	0	0	1,811,000	1,992,100	4.872E+02	4.646E+05	3.122E+01	6.199E+01	9.292E+04	6.243E+00	6.804E+02	3.717E+05	2.497E+01	6.662E+00	1.858E+03	1.249E-01
2079	0	0	1,811,000	1,992,100	4.635E+02	4.420E+05	2.969E+01	5.897E+01	8.839E+04	5.939E+00	6.472E+02	3.536E+05	2.376E+01	6.337E+00	1.768E+03	1.188E-01
2080	0	0	1,811,000	1,992,100	4.409E+02	4.204E+05	2.825E+01	5.609E+01	8.408E+04	5.649E+00	6.156E+02	3.363E+05	2.260E+01	6.028E+00	1.682E+03	1.130E-01
2081	0	0	1,811,000	1,992,100	4.194E+02	3.999E+05	2.687E+01	5.336E+01	7.998E+04	5.374E+00	5.856E+02	3.199E+05	2.150E+01	5.734E+00	1.600E+03	1.075E-01
2082	0	0	1,811,000	1,992,100	3.989E+02	3.804E+05	2.556E+01	5.076E+01	7.608E+04	5.112E+00	5.570E+02	3.043E+05	2.045E+01	5.454E+00	1.522E+03	1.022E-01
2083	0	0	1,811,000	1,992,100	3.795E+02	3.618E+05	2.431E+01	4.828E+01	7.237E+04	4.862E+00	5.299E+02	2.895E+05	1.945E+01	5.188E+00	1.447E+03	9.725E-02
2084	0	0	1,811,000	1,992,100	3.610E+02	3.442E+05	2.313E+01	4.593E+01	6.884E+04	4.625E+00	5.040E+02	2.754E+05	1.850E+01	4.935E+00	1.377E+03	9.251E-02
2085	0	0	1,811,000	1,992,100	3.433E+02	3.274E+05	2.200E+01	4.369E+01	6.548E+04	4.400E+00	4.795E+02	2.619E+05	1.760E+01	4.694E+00	1.310E+03	8.799E-02
2086	0	0	1,811,000	1,992,100	3.266E+02	3.114E+05	2.093E+01	4.156E+01	6.229E+04	4.185E+00	4.561E+02	2.492E+05	1.674E+01	4.465E+00	1.246E+03	8.370E-02
2087	0	0	1,811,000	1,992,100	3.107E+02	2.963E+05	1.991E+01	3.953E+01	5.925E+04	3.981E+00	4.338E+02	2.370E+05	1.592E+01	4.248E+00	1.185E+03	7.962E-02
2088	0	0	1,811,000	1,992,100	2.955E+02	2.818E+05	1.893E+01	3.760E+01	5.636E+04	3.787E+00	4.127E+02	2.254E+05	1.515E+01	4.040E+00	1.127E+03	7.574E-02
2089	0	0	1,811,000	1,992,100	2.811E+02	2.681E+05	1.801E+01	3.577E+01	5.361E+04	3.602E+00	3.925E+02	2.144E+05	1.441E+01	3.843E+00	1.072E+03	7.204E-02
2090	0	0	1,811,000	1,992,100	2.674E+02	2.550E+05	1.713E+01	3.402E+01	5.100E+04	3.427E+00	3.734E+02	2.040E+05	1.371E+01	3.656E+00	1.020E+03	6.853E-02
2091	0	0	1,811,000	1,992,100	2.544E+02	2.426E+05	1.630E+01	3.236E+01	4.851E+04	3.259E+00	3.552E+02	1.940E+05	1.304E+01	3.478E+00	9.702E+02	6.519E-02
2092	0	0	1,811,000	1,992,100	2.420E+02	2.307E+05	1.550E+01	3.079E+01	4.614E+04	3.100E+00	3.379E+02	1.846E+05	1.240E+01	3.308E+00	9.229E+02	6.201E-02
2093	0	0	1,811,000	1,992,100	2.302E+02	2.195E+05	1.475E+01	2.928E+01	4.389E+04	2.949E+00	3.214E+02	1.756E+05	1.180E+01	3.147E+00	8.779E+02	5.898E-02
2094	0	0	1,811,000	1,992,100	2.189E+02	2.088E+05	1.403E+01	2.786E+01	4.175E+04	2.805E+00	3.057E+02	1.670E+05	1.122E+01	2.993E+00	8.351E+02	5.611E-02
2095	0	0	1,811,000	1,992,100	2.083E+02	1.986E+05	1.334E+01	2.650E+01	3.972E+04	2.669E+00	2.908E+02	1.589E+05	1.067E+01	2.847E+00	7.943E+02	5.337E-02
2096	0	0	1,811,000	1,992,100	1.981E+02	1.889E+05	1.269E+01	2.520E+01	3.778E+04	2.538E+00	2.766E+02	1.511E+05	1.015E+01	2.708E+00	7.556E+02	5.077E-02
2097	0	0	1,811,000	1,992,100	1.884E+02	1.797E+05	1.207E+01	2.398E+01	3.594E+04	2.415E+00	2.631E+02	1.437E+05	9.658E+00	2.576E+00	7.187E+02	4.829E-02
2098	0	0	1,811,000	1,992,100	1.792E+02	1.709E+05	1.148E+01	2.281E+01	3.418E+04	2.297E+00	2.503E+02	1.367E+05	9.187E+00	2.451E+00	6.837E+02	4.594E-02
2099	0	0	1,811,000	1,992,100	1.705E+02	1.626E+05	1.092E+01	2.169E+01	3.252E+04	2.185E+00	2.381E+02	1.301E+05	8.739E+00	2.331E+00	6.503E+02	4.370E-02
2100	0	0	1,811,000	1,992,100	1.622E+02	1.547E+05	1.039E+01	2.064E+01	3.093E+04	2.078E+00	2.265E+02	1.237E+05	8.313E+00	2.217E+00	6.186E+02	4.157E-02
2101	0	0	1,811,000	1,992,100	1.543E+02	1.471E+05	9.885E+00	1.963E+01	2.942E+04	1.977E+00	2.154E+02	1.177E+05	7.908E+00	2.109E+00	5.885E+02	3.954E-02
2102	0	0	1,811,000	1,992,100	1.468E+02	1.399E+05	9.403E+00	1.867E+01	2.799E+04	1.881E+00	2.049E+02	1.120E+05	7.522E+00	2.006E+00	5.598E+02	3.761E-02
2103	0	0	1,811,000	1,992,100	1.396E+02	1.331E+05	8.944E+00	1.776E+01	2.662E+04	1.789E+00	1.949E+02	1.065E+05	7.155E+00	1.909E+00	5.325E+02	3.578E-02
2104	0	0	1,811,000	1,992,100	1.328E+02	1.266E+05	8.508E+00	1.690E+01	2.532E+04	1.702E+00	1.854E+02	1.013E+05	6.806E+00	1.815E+00	5.065E+02	3.403E-02
2105	0	0	1,811,000	1,992,100	1.263E+02	1.204E+05	8.093E+00	1.607E+01	2.409E+04	1.619E+00	1.764E+02	9.636E+04	6.474E+00	1.727E+00	4.818E+02	3.237E-02
2106	0	0	1,811,000	1,992,100	1.202E+02	1.146E+05	7.698E+00	1.529E+01	2.291E+04	1.540E+00	1.678E+02	9.166E+04	6.159E+00	1.643E+00	4.583E+02	3.079E-02
2107	0	0	1,811,000	1,992,100	1.143E+02	1.090E+05	7.323E+00	1.454E+01	2.180E+04	1.465E+00	1.596E+02	8.719E+04	5.858E+00	1.563E+00	4.359E+02	2.929E-02
2108	0	0	1,811,000	1,992,100	1.087E+02	1.037E+05	6.966E+00	1.383E+01	2.073E+04	1.393E+00	1.518E+02	8.294E+04	5.572E+00	1.486E+00	4.147E+02	2.786E-02
2109	0	0	1,811,000	1,992,100	1.034E+02	9.861E+04	6.626E+00	1.316E+01	1.972E+04	1.325E+00	1.444E+02	7.889E+04	5.301E+00	1.414E+00	3.945E+02	2.650E-02
2110	0	0	1,811,000	1,992,100	9.837E+01	9.380E+04	6.303E+00	1.252E+01	1.876E+04	1.261E+00	1.374E+02	7.504E+04	5.042E+00	1.345E+00	3.752E+02	2.521E-02

RESULTS

Landfill Name or Identifier: Delafield

Closure Year (with 80-year limit) = 1981
Methane = 20 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.
User-specified Unit: *av ft^3/min*

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1970	164,636	181,100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	164,636	181,100	164,636	181,100	3.392E+03	3.234E+06	2.173E+02	4.315E+02	6.468E+05	4.346E+01	4.736E+03	2.587E+06	1.738E+02	4.637E+01	1.294E+04	8.692E-01
1972	164,636	181,100	329,273	362,200	6.650E+03	6.342E+06	4.261E+02	8.462E+02	1.268E+06	8.522E+01	9.287E+03	5.073E+06	3.409E+02	9.092E+01	2.537E+04	1.704E+00
1973	164,636	181,100	493,909	543,300	9.781E+03	9.327E+06	6.267E+02	1.245E+03	1.865E+06	1.253E+02	1.366E+04	7.462E+06	5.014E+02	1.337E+02	3.731E+04	2.507E+00
1974	164,636	181,100	658,545	724,400	1.279E+04	1.220E+07	8.194E+02	1.627E+03	2.439E+06	1.639E+02	1.786E+04	9.756E+06	6.555E+02	1.749E+02	4.878E+04	3.278E+00
1975	164,636	181,100	823,182	905,500	1.568E+04	1.495E+07	1.005E+03	1.995E+03	2.990E+06	2.009E+02	2.190E+04	1.196E+07	8.037E+02	2.144E+02	5.981E+04	4.018E+00
1976	164,636	181,100	987,818	1,086,600	1.846E+04	1.760E+07	1.183E+03	2.348E+03	3.520E+06	2.365E+02	2.577E+04	1.408E+07	9.460E+02	2.523E+02	7.040E+04	4.730E+00
1977	164,636	181,100	1,152,455	1,267,700	2.112E+04	2.014E+07	1.353E+03	2.688E+03	4.029E+06	2.707E+02	2.950E+04	1.611E+07	1.083E+03	2.888E+02	8.057E+04	5.414E+00
1978	164,636	181,100	1,317,091	1,448,800	2.369E+04	2.259E+07	1.518E+03	3.014E+03	4.518E+06	3.035E+02	3.308E+04	1.807E+07	1.214E+03	3.239E+02	9.035E+04	6.071E+00
1979	164,636	181,100	1,481,727	1,629,900	2.615E+04	2.494E+07	1.675E+03	3.327E+03	4.987E+06	3.351E+02	3.652E+04	1.995E+07	1.340E+03	3.575E+02	9.975E+04	6.702E+00
1980	164,636	181,100	1,646,364	1,811,000	2.852E+04	2.719E+07	1.827E+03	3.628E+03	5.439E+06	3.654E+02	3.982E+04	2.175E+07	1.462E+03	3.899E+02	1.088E+05	7.308E+00
1981	0	0	1,811,000	1,992,100	3.079E+04	2.936E+07	1.973E+03	3.918E+03	5.872E+06	3.946E+02	4.300E+04	2.349E+07	1.578E+03	4.210E+02	1.174E+05	7.891E+00
1982	0	0	1,811,000	1,992,100	2.958E+04	2.821E+07	1.895E+03	3.764E+03	5.642E+06	3.791E+02	4.131E+04	2.257E+07	1.516E+03	4.045E+02	1.128E+05	7.582E+00
1983	0	0	1,811,000	1,992,100	2.842E+04	2.710E+07	1.821E+03	3.616E+03	5.421E+06	3.642E+02	3.969E+04	2.168E+07	1.457E+03	3.886E+02	1.084E+05	7.284E+00
1984	0	0	1,811,000	1,992,100	2.731E+04	2.604E+07	1.750E+03	3.475E+03	5.208E+06	3.499E+02	3.813E+04	2.083E+07	1.400E+03	3.734E+02	1.042E+05	6.999E+00
1985	0	0	1,811,000	1,992,100	2.624E+04	2.502E+07	1.681E+03	3.338E+03	5.004E+06	3.362E+02	3.664E+04	2.002E+07	1.345E+03	3.587E+02	1.001E+05	6.724E+00
1986	0	0	1,811,000	1,992,100	2.521E+04	2.404E+07	1.615E+03	3.207E+03	4.808E+06	3.230E+02	3.520E+04	1.923E+07	1.292E+03	3.447E+02	9.615E+04	6.461E+00
1987	0	0	1,811,000	1,992,100	2.422E+04	2.310E+07	1.552E+03	3.082E+03	4.619E+06	3.104E+02	3.382E+04	1.848E+07	1.241E+03	3.311E+02	9.238E+04	6.207E+00
1988	0	0	1,811,000	1,992,100	2.327E+04	2.219E+07	1.491E+03	2.961E+03	4.438E+06	2.982E+02	3.250E+04	1.775E+07	1.193E+03	3.182E+02	8.876E+04	5.964E+00
1989	0	0	1,811,000	1,992,100	2.236E+04	2.132E+07	1.433E+03	2.845E+03	4.264E+06	2.865E+02	3.122E+04	1.706E+07	1.146E+03	3.057E+02	8.528E+04	5.730E+00
1990	0	0	1,811,000	1,992,100	2.148E+04	2.048E+07	1.376E+03	2.733E+03	4.097E+06	2.753E+02	3.000E+04	1.639E+07	1.101E+03	2.937E+02	8.194E+04	5.505E+00
1991	0	0	1,811,000	1,992,100	2.064E+04	1.968E+07	1.322E+03	2.626E+03	3.936E+06	2.645E+02	2.882E+04	1.574E+07	1.058E+03	2.822E+02	7.872E+04	5.290E+00
1992	0	0	1,811,000	1,992,100	1.983E+04	1.891E+07	1.271E+03	2.523E+03	3.782E+06	2.541E+02	2.769E+04	1.513E+07	1.016E+03	2.711E+02	7.564E+04	5.082E+00
1993	0	0	1,811,000	1,992,100	1.905E+04	1.817E+07	1.221E+03	2.424E+03	3.634E+06	2.441E+02	2.661E+04	1.453E+07	9.766E+02	2.605E+02	7.267E+04	4.883E+00
1994	0	0	1,811,000	1,992,100	1.831E+04	1.746E+07	1.173E+03	2.329E+03	3.491E+06	2.346E+02	2.556E+04	1.396E+07	9.383E+02	2.503E+02	6.982E+04	4.691E+00
1995	0	0	1,811,000	1,992,100	1.759E+04	1.677E+07	1.127E+03	2.238E+03	3.354E+06	2.254E+02	2.456E+04	1.342E+07	9.015E+02	2.405E+02	6.708E+04	4.507E+00
1996	0	0	1,811,000	1,992,100	1.690E+04	1.611E+07	1.083E+03	2.150E+03	3.223E+06	2.165E+02	2.360E+04	1.289E+07	8.661E+02	2.310E+02	6.445E+04	4.331E+00
1997	0	0	1,811,000	1,992,100	1.624E+04	1.548E+07	1.040E+03	2.066E+03	3.096E+06	2.080E+02	2.267E+04	1.239E+07	8.322E+02	2.220E+02	6.193E+04	4.161E+00
1998	0	0	1,811,000	1,992,100	1.560E+04	1.487E+07	9.994E+02	1.985E+03	2.975E+06	1.999E+02	2.178E+04	1.190E+07	7.995E+02	2.133E+02	5.950E+04	3.998E+00
1999	0	0	1,811,000	1,992,100	1.499E+04	1.429E+07	9.602E+02	1.907E+03	2.858E+06	1.920E+02	2.093E+04	1.143E+07	7.682E+02	2.049E+02	5.717E+04	3.841E+00
2000	0	0	1,811,000	1,992,100	1.440E+04	1.373E+07	9.226E+02	1.832E+03	2.746E+06	1.845E+02	2.011E+04	1.098E+07	7.381E+02	1.969E+02	5.492E+04	3.690E+00
2001	0	0	1,811,000	1,992,100	1.383E+04	1.319E+07	8.864E+02	1.760E+03	2.639E+06	1.773E+02	1.932E+04	1.055E+07	7.091E+02	1.892E+02	5.277E+04	3.546E+00
2002	0	0	1,811,000	1,992,100	1.329E+04	1.268E+07	8.517E+02	1.691E+03	2.535E+06	1.703E+02	1.856E+04	1.014E+07	6.813E+02	1.817E+02	5.070E+04	3.407E+00
2003	0	0	1,811,000	1,992,100	1.277E+04	1.218E+07	8.183E+02	1.625E+03	2.436E+06	1.637E+02	1.783E+04	9.743E+06	6.546E+02	1.746E+02	4.871E+04	3.273E+00
2004	0	0	1,811,000	1,992,100	1.227E+04	1.170E+07	7.862E+02	1.561E+03	2.340E+06	1.572E+02	1.713E+04	9.361E+06	6.289E+02	1.678E+02	4.680E+04	3.145E+00
2005	0	0	1,811,000	1,992,100	1.179E+04	1.124E+07	7.554E+02	1.500E+03	2.248E+06	1.511E+02	1.646E+04	8.994E+06	6.043E+02	1.612E+02	4.497E+04	3.021E+00
2006	0	0	1,811,000	1,992,100	1.133E+04	1.080E+07	7.257E+02	1.441E+03	2.160E+06	1.451E+02	1.582E+04	8.641E+06	5.806E+02	1.549E+02	4.321E+04	2.903E+00
2007	0	0	1,811,000	1,992,100	1.088E+04	1.038E+07	6.973E+02	1.385E+03	2.076E+06	1.395E+02	1.520E+04	8.302E+06	5.578E+02	1.488E+02	4.151E+04	2.789E+00
2008	0	0	1,811,000	1,992,100	1.046E+04	9.971E+06	6.699E+02	1.330E+03	1.994E+06	1.340E+02	1.460E+04	7.977E+06	5.360E+02	1.430E+02	3.988E+04	2.680E+00
2009	0	0	1,811,000	1,992,100	1.005E+04	9.580E+06	6.437E+02	1.278E+03	1.916E+06	1.287E+02	1.403E+04	7.664E+06	5.149E+02	1.374E+02	3.832E+04	2.575E+00
2010	0	0	1,811,000	1,992,100	9.652E+03	9.204E+06	6.184E+02	1.228E+03	1.841E+06	1.237E+02	1.348E+04	7.363E+06	4.947E+02	1.320E+02	3.682E+04	2.474E+00
2011	0	0	1,811,000	1,992,100	9.274E+03	8.843E+06	5.942E+02	1.180E+03	1.769E+06	1.188E+02	1.295E+04	7.075E+06	4.753E+02	1.268E+02	3.537E+04	2.377E+00
2012	0	0	1,811,000	1,992,100	8.910E+03	8.497E+06	5.709E+02	1.134E+03	1.699E+06	1.142E+02	1.244E+04	6.797E+06	4.567E+02	1.218E+02	3.399E+04	2.284E+00
2013	0	0	1,811,000	1,992,100	8.561E+03	8.163E+06	5.485E+02	1.089E+03	1.633E+06	1.097E+02	1.195E+04	6.531E+06	4.388E+02	1.170E+02	3.265E+04	2.194E+00
2014	0	0	1,811,000	1,992,100	8.225E+03	7.843E+06	5.270E+02	1.047E+03	1.569E+06	1.054E+02	1.149E+04	6.275E+06	4.216E+02	1.125E+02	3.137E+04	2.108E+00
2015	0	0	1,811,000	1,992,100	7.903E+03	7.536E+06	5.063E+02	1.005E+03	1.507E+06	1.013E+02	1.104E+04	6.029E+06	4.051E+02	1.080E+02	3.014E+04	2.025E+00
2016	0	0	1,811,000	1,992,100	7.593E+03	7.240E+06	4.865E+02	9.661E+02	1.448E+06	9.730E+01	1.060E+04	5.792E+06	3.892E+02	1.038E+02	2.896E+04	1.946E+00
2017	0	0	1,811,000	1,992,100	7.295E+03	6.956E+06	4.674E+02	9.282E+02	1.391E+06	9.348E+01	1.019E+04	5.565E+06	3.739E+02	9.974E+01	2.783E+04	1.870E+00
2018	0	0	1,811,000	1,992,100	7.009E+03	6.684E+06	4.491E+02	8.918E+02	1.337E+06	8.981E+01	9.788E+03	5.347E+06	3.593E+02	9.583E+01	2.673E+04	1.796E+00
2019	0	0	1,811,000	1,992,100	6.734E+03	6.422E+06	4.315E+02	8.568E+02	1.284E+06	8.629E+01	9.404E+03	5.137E+06	3.452E+02	9.207E+01	2.569E+04	1.726E+00
2020	0	0	1,811,000	1,992,100	6.470E+03	6.170E+06	4.145E+02	8.232E+02	1.234E+06	8.291E+01	9.035E+03	4.936E+06	3.316E+02	8.846E+01	2.468E+04	1.658E+00
2021	0	0	1,811,000	1,992,100	6.216E+03	5.928E+06	3.983E+02	7.910E+02	1.186E+06	7.966E+01	8.681E+03	4.742E+06	3.186E+02	8.499E+01	2.371E+04	1.593E+00
2022	0	0	1,811,000	1,992,100	5.973E+03	5.695E+06	3.827E+02	7.599E+02	1.139E+06	7.654E+01	8.340E+03	4.556E+06	3.061E+02	8.166E+01	2.278E+04	1.531E+00
2023	0	0	1,811,000	1,992,100	5.738E+03	5.472E+06	3.677E+02	7.301E+02	1.094E+06	7.353E+01	8.013E+03	4.378E+06	2.941E+02	7.846E+01	2.189E+04	1.471E+00
2024	0	0	1,811,000	1,992,100	5.513E+03	5.258E+06	3.533E+02	7.015E+02	1.052E+06	7.065E+01	7.699E+03	4.206E+06	2.826E+02	7.538E+01	2.103E+04	1.413E+00
2025	0	0	1,811,000	1,992,100	5.297E+03	5.051E+06	3.394E+02	6.740E+02	1.010E+06	6.788E+01	7.397E+03	4.041E+06	2.715E+02	7.243E+01	2.021E+04	1.358E+00
2026	0	0	1,811,000	1,992,100	5.090E+03	4.853E+06	3.261E+02	6.476E+02	9.707E+05	6.522E+01	7.107E+03	3.883E+06	2.609E+02	6.959E+01	1.941E+04	1.304E+00
2027	0	0	1,811,000	1,992,100	4.890E+03	4.663E+06	3.133E+02	6.222E+02	9.326E+05	6.266E+01	6.829E+03	3.730E+06	2.506E+02	6.686E+01	1.865E+04	1.253E+00
2028	0	0	1,811,000	1,992,100	4.698E+03	4.480E+06	3.010E+02	5.978E+02	8.960E+05	6.020E+01	6.561E+03	3.584E+06	2.408E+02	6.424E+01	1.792E+04	1.204E+00
2029	0	0	1,811,000	1,992,100	4.514E+03	4.305E+06	2.892E+02	5.744E+02	8.609E+05	5.784E+01	6.304E+03	3.444E+06	2.314E+02	6.172E+01	1.722E+04	1.157E+00
2030	0	0	1,811,000	1,992,100	4.337E+03	4.136E+06	2.779E+02	5.518E+02	8.271E+05	5.558E+01	6.056E+03	3.309E+06	2.223E+02	5.930E+01	1.654E+04	1.112E+00
2031	0	0	1,811,000	1,992,100	4.167E+03	3.974E+06	2.670E+02	5.302E+02	7.947E+05	5.340E+01	5.819E+03	3.179E+06	2.136E+02	5.697E+01	1.589E+04	1.068E+00
2032	0	0	1,811,000	1,992,100	4.004E+03	3.818E+06	2.565E+02	5.094E+02	7.636E+05	5.130E+01	5.591E+03	3.054E+06	2.052E+02	5.474E+01	1.527E+04	1.026E+00
2033	0	0	1,811,000	1,992,100	3.847E+03	3.668E+06	2.465E+02	4.894E+02	7.336E+05	4.929E+01	5.372E+03	2.934E+06	1.972E+02	5.259E+01	1.467E+04	9.858E-01
2034	0	0	1,811,000	1,992,100	3.696E+03	3.524E+06	2.368E+02	4.702E+02	7.048E+05	4.736E+01	5.161E+03	2.819E+06	1.894E+02	5.053E+01	1.410E+04	9.472E-01
2035	0	0	1,811,000	1,992,100	3.551E+03	3.386E+06	2.275E+02	4.518E+02	6.772E+05	4.550E+01	4.959E+03	2.709E+06	1.820E+02	4.855E+01	1.354E+04	9.100E-01
2036	0	0	1,811,000	1,992,100	3.412E+03	3.253E+06	2.186E+02	4.341E+02	6.507E+05	4.372E+01	4.764E+03	2.603E+06	1.749E+02	4.665E+01	1.301E+04	8.744E-01
2037	0	0	1,811,000	1,992,100	3.278E+03	3.126E+06	2.100E+02	4.171E+02	6.251E+05	4.200E+01	4.577E+03	2.501E+06	1.680E+02	4.482E+01	1.250E+04	8.401E-01
2038	0	0	1,811,000	1,992,100	3.149E+03	3.003E+06	2.018E+02	4.007E+02	6.006E+05	4.036E+01	4.398E+03	2.403E+06	1.614E+02	4.306E+01	1.201E+04	8.071E-01
2039	0	0	1,811,000	1,992,100	3.026E+03	2.885E+06	1.939E+02	3.850E+02	5.771E+05	3.877E+01	4.225E+03	2.308E+06	1.551E+02	4.137E+01	1.154E+04	7.755E-01
2040	0	0	1,811,000	1,992,100	2.907E+03	2.772E+06	1.863E+02	3.699E+02	5.545E+05	3.725E+01	4.060E+03	2.218E+06	1.490E+02	3.975E+01	1.109E+04	7.451E-01
2041	0	0	1,811,000	1,992,100	2.793E+03	2.664E+06	1.790E+02	3.554E+02	5.327E+05	3.579E+01	3.901E+03	2.131E+06	1.432E+02	3.819E+01	1.065E+04	7.159E-01
2042	0	0	1,811,000	1,992,100	2.684E+03	2.559E+06	1.719E+02	3.415E+02	5.118E+05	3.439E+01	3.748E+03	2.047E+06	1.376E+02	3.669E+01	1.024E+04	6.878E-01
2043	0	0	1,811,000	1,992,100	2.578E+03	2.459E+06	1.652E+02	3.281E+02	4.918E+05	3.304E+01	3.601E+03	1.967E+06	1.322E+02	3.525E+01	9.835E+03	6.608E-01
2044	0	0	1,811,000	1,992,100	2.477E+03	2.362E+06	1.587E+02	3.152E+02	4.725E+05	3.175E+01	3.459E+03	1.890E+06	1.270E+02	3.387E+01	9.449E+03	6.349E-01
2045	0	0	1,811,000	1,992,100	2.380E+03	2.270E+06	1.525E+02	3.029E+02	4.539E+05	3.050E+01	3.324E+03	1.816E+06	1.220E+02	3.254E+01	9.079E+03	6.100E-01

RESULTS **Landfill Name or Identifier:** Delafield

Closure Year (with 80-year limit) = 1981
Methane = 20 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.
User-specified Unit: *av ft^3/min*

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2046	0	0	1,811,000	1,992,100	2.287E+03	2.181E+06	1.465E+02	2.910E+02	4.361E+05	2.930E+01	3.193E+03	1.745E+06	1.172E+02	3.127E+01	8.723E+03	5.861E-01
2047	0	0	1,811,000	1,992,100	2.197E+03	2.095E+06	1.408E+02	2.796E+02	4.190E+05	2.816E+01	3.068E+03	1.676E+06	1.126E+02	3.004E+01	8.381E+03	5.631E-01
2048	0	0	1,811,000	1,992,100	2.111E+03	2.013E+06	1.353E+02	2.686E+02	4.026E+05	2.705E+01	2.948E+03	1.610E+06	1.082E+02	2.886E+01	8.052E+03	5.410E-01
2049	0	0	1,811,000	1,992,100	2.028E+03	1.934E+06	1.300E+02	2.581E+02	3.868E+05	2.599E+01	2.832E+03	1.547E+06	1.040E+02	2.773E+01	7.737E+03	5.198E-01
2050	0	0	1,811,000	1,992,100	1.949E+03	1.858E+06	1.249E+02	2.480E+02	3.717E+05	2.497E+01	2.721E+03	1.487E+06	9.989E+01	2.664E+01	7.433E+03	4.994E-01
2051	0	0	1,811,000	1,992,100	1.872E+03	1.785E+06	1.200E+02	2.382E+02	3.571E+05	2.399E+01	2.615E+03	1.428E+06	9.597E+01	2.560E+01	7.142E+03	4.799E-01
2052	0	0	1,811,000	1,992,100	1.799E+03	1.715E+06	1.153E+02	2.289E+02	3.431E+05	2.305E+01	2.512E+03	1.372E+06	9.221E+01	2.460E+01	6.862E+03	4.610E-01
2053	0	0	1,811,000	1,992,100	1.728E+03	1.648E+06	1.107E+02	2.199E+02	3.296E+05	2.215E+01	2.414E+03	1.319E+06	8.859E+01	2.363E+01	6.593E+03	4.430E-01
2054	0	0	1,811,000	1,992,100	1.661E+03	1.584E+06	1.064E+02	2.113E+02	3.167E+05	2.128E+01	2.319E+03	1.267E+06	8.512E+01	2.270E+01	6.334E+03	4.256E-01
2055	0	0	1,811,000	1,992,100	1.596E+03	1.521E+06	1.022E+02	2.030E+02	3.043E+05	2.045E+01	2.228E+03	1.217E+06	8.178E+01	2.181E+01	6.086E+03	4.089E-01
2056	0	0	1,811,000	1,992,100	1.533E+03	1.462E+06	9.822E+01	1.950E+02	2.924E+05	1.964E+01	2.141E+03	1.169E+06	7.857E+01	2.096E+01	5.847E+03	3.929E-01
2057	0	0	1,811,000	1,992,100	1.473E+03	1.404E+06	9.437E+01	1.874E+02	2.809E+05	1.887E+01	2.057E+03	1.124E+06	7.549E+01	2.014E+01	5.618E+03	3.775E-01
2058	0	0	1,811,000	1,992,100	1.415E+03	1.349E+06	9.067E+01	1.801E+02	2.699E+05	1.813E+01	1.976E+03	1.080E+06	7.253E+01	1.935E+01	5.398E+03	3.627E-01
2059	0	0	1,811,000	1,992,100	1.360E+03	1.296E+06	8.711E+01	1.730E+02	2.593E+05	1.742E+01	1.899E+03	1.037E+06	6.969E+01	1.859E+01	5.186E+03	3.484E-01
2060	0	0	1,811,000	1,992,100	1.306E+03	1.246E+06	8.370E+01	1.662E+02	2.491E+05	1.674E+01	1.824E+03	9.965E+05	6.696E+01	1.786E+01	4.983E+03	3.348E-01
2061	0	0	1,811,000	1,992,100	1.255E+03	1.197E+06	8.041E+01	1.597E+02	2.394E+05	1.608E+01	1.753E+03	9.575E+05	6.433E+01	1.716E+01	4.787E+03	3.217E-01
2062	0	0	1,811,000	1,992,100	1.206E+03	1.150E+06	7.726E+01	1.534E+02	2.300E+05	1.545E+01	1.684E+03	9.199E+05	6.181E+01	1.649E+01	4.600E+03	3.090E-01
2063	0	0	1,811,000	1,992,100	1.159E+03	1.105E+06	7.423E+01	1.474E+02	2.210E+05	1.485E+01	1.618E+03	8.838E+05	5.939E+01	1.584E+01	4.419E+03	2.969E-01
2064	0	0	1,811,000	1,992,100	1.113E+03	1.061E+06	7.132E+01	1.416E+02	2.123E+05	1.426E+01	1.554E+03	8.492E+05	5.706E+01	1.522E+01	4.246E+03	2.853E-01
2065	0	0	1,811,000	1,992,100	1.070E+03	1.020E+06	6.852E+01	1.361E+02	2.040E+05	1.370E+01	1.493E+03	8.159E+05	5.482E+01	1.462E+01	4.079E+03	2.741E-01
2066	0	0	1,811,000	1,992,100	1.028E+03	9.799E+05	6.584E+01	1.307E+02	1.960E+05	1.317E+01	1.435E+03	7.839E+05	5.267E+01	1.405E+01	3.919E+03	2.633E-01
2067	0	0	1,811,000	1,992,100	9.873E+02	9.414E+05	6.326E+01	1.256E+02	1.883E+05	1.265E+01	1.379E+03	7.532E+05	5.060E+01	1.350E+01	3.766E+03	2.530E-01
2068	0	0	1,811,000	1,992,100	9.486E+02	9.045E+05	6.078E+01	1.207E+02	1.809E+05	1.216E+01	1.325E+03	7.236E+05	4.862E+01	1.297E+01	3.618E+03	2.431E-01
2069	0	0	1,811,000	1,992,100	9.114E+02	8.691E+05	5.839E+01	1.160E+02	1.738E+05	1.168E+01	1.273E+03	6.953E+05	4.671E+01	1.246E+01	3.476E+03	2.336E-01
2070	0	0	1,811,000	1,992,100	8.756E+02	8.350E+05	5.610E+01	1.114E+02	1.670E+05	1.122E+01	1.223E+03	6.680E+05	4.488E+01	1.197E+01	3.340E+03	2.244E-01
2071	0	0	1,811,000	1,992,100	8.413E+02	8.022E+05	5.390E+01	1.070E+02	1.604E+05	1.078E+01	1.175E+03	6.418E+05	4.312E+01	1.150E+01	3.209E+03	2.156E-01
2072	0	0	1,811,000	1,992,100	8.083E+02	7.708E+05	5.179E+01	1.028E+02	1.542E+05	1.036E+01	1.129E+03	6.166E+05	4.143E+01	1.105E+01	3.083E+03	2.072E-01
2073	0	0	1,811,000	1,992,100	7.766E+02	7.406E+05	4.976E+01	9.881E+01	1.481E+05	9.952E+00	1.084E+03	5.925E+05	3.981E+01	1.062E+01	2.962E+03	1.990E-01
2074	0	0	1,811,000	1,992,100	7.462E+02	7.115E+05	4.781E+01	9.494E+01	1.423E+05	9.562E+00	1.042E+03	5.692E+05	3.825E+01	1.020E+01	2.846E+03	1.912E-01
2075	0	0	1,811,000	1,992,100	7.169E+02	6.836E+05	4.593E+01	9.122E+01	1.367E+05	9.187E+00	1.001E+03	5.469E+05	3.675E+01	9.802E+00	2.735E+03	1.837E-01
2076	0	0	1,811,000	1,992,100	6.888E+02	6.568E+05	4.413E+01	8.764E+01	1.314E+05	8.826E+00	9.619E+02	5.255E+05	3.531E+01	9.417E+00	2.627E+03	1.765E-01
2077	0	0	1,811,000	1,992,100	6.618E+02	6.311E+05	4.240E+01	8.420E+01	1.262E+05	8.480E+00	9.241E+02	5.049E+05	3.392E+01	9.048E+00	2.524E+03	1.696E-01
2078	0	0	1,811,000	1,992,100	6.358E+02	6.063E+05	4.074E+01	8.090E+01	1.213E+05	8.148E+00	8.879E+02	4.851E+05	3.259E+01	8.693E+00	2.425E+03	1.630E-01
2079	0	0	1,811,000	1,992,100	6.109E+02	5.826E+05	3.914E+01	7.773E+01	1.165E+05	7.828E+00	8.531E+02	4.660E+05	3.131E+01	8.353E+00	2.330E+03	1.566E-01
2080	0	0	1,811,000	1,992,100	5.870E+02	5.597E+05	3.761E+01	7.468E+01	1.119E+05	7.521E+00	8.196E+02	4.478E+05	3.009E+01	8.025E+00	2.239E+03	1.504E-01
2081	0	0	1,811,000	1,992,100	5.639E+02	5.378E+05	3.613E+01	7.175E+01	1.076E+05	7.226E+00	7.875E+02	4.302E+05	2.891E+01	7.710E+00	2.151E+03	1.445E-01
2082	0	0	1,811,000	1,992,100	5.418E+02	5.167E+05	3.472E+01	6.894E+01	1.033E+05	6.943E+00	7.566E+02	4.133E+05	2.777E+01	7.408E+00	2.067E+03	1.389E-01
2083	0	0	1,811,000	1,992,100	5.206E+02	4.964E+05	3.335E+01	6.624E+01	9.928E+04	6.671E+00	7.270E+02	3.971E+05	2.668E+01	7.118E+00	1.986E+03	1.334E-01
2084	0	0	1,811,000	1,992,100	5.002E+02	4.770E+05	3.205E+01	6.364E+01	9.539E+04	6.409E+00	6.985E+02	3.816E+05	2.564E+01	6.839E+00	1.908E+03	1.282E-01
2085	0	0	1,811,000	1,992,100	4.806E+02	4.583E+05	3.079E+01	6.114E+01	9.165E+04	6.158E+00	6.711E+02	3.666E+05	2.463E+01	6.570E+00	1.833E+03	1.232E-01
2086	0	0	1,811,000	1,992,100	4.617E+02	4.403E+05	2.958E+01	5.875E+01	8.806E+04	5.917E+00	6.448E+02	3.522E+05	2.367E+01	6.313E+00	1.761E+03	1.183E-01
2087	0	0	1,811,000	1,992,100	4.436E+02	4.230E+05	2.842E+01	5.644E+01	8.460E+04	5.685E+00	6.195E+02	3.384E+05	2.274E+01	6.065E+00	1.692E+03	1.137E-01
2088	0	0	1,811,000	1,992,100	4.262E+02	4.064E+05	2.731E+01	5.423E+01	8.129E+04	5.462E+00	5.952E+02	3.251E+05	2.185E+01	5.827E+00	1.626E+03	1.092E-01
2089	0	0	1,811,000	1,992,100	4.095E+02	3.905E+05	2.624E+01	5.210E+01	7.810E+04	5.247E+00	5.718E+02	3.124E+05	2.099E+01	5.599E+00	1.562E+03	1.049E-01
2090	0	0	1,811,000	1,992,100	3.934E+02	3.752E+05	2.521E+01	5.006E+01	7.504E+04	5.042E+00	5.494E+02	3.001E+05	2.017E+01	5.379E+00	1.501E+03	1.008E-01
2091	0	0	1,811,000	1,992,100	3.780E+02	3.605E+05	2.422E+01	4.810E+01	7.209E+04	4.844E+00	5.279E+02	2.884E+05	1.938E+01	5.168E+00	1.442E+03	9.688E-02
2092	0	0	1,811,000	1,992,100	3.632E+02	3.463E+05	2.327E+01	4.621E+01	6.927E+04	4.654E+00	5.072E+02	2.771E+05	1.862E+01	4.966E+00	1.385E+03	9.308E-02
2093	0	0	1,811,000	1,992,100	3.490E+02	3.328E+05	2.236E+01	4.440E+01	6.655E+04	4.472E+00	4.873E+02	2.662E+05	1.789E+01	4.771E+00	1.331E+03	8.943E-02
2094	0	0	1,811,000	1,992,100	3.353E+02	3.197E+05	2.148E+01	4.266E+01	6.394E+04	4.296E+00	4.682E+02	2.558E+05	1.719E+01	4.584E+00	1.279E+03	8.593E-02
2095	0	0	1,811,000	1,992,100	3.221E+02	3.072E+05	2.064E+01	4.099E+01	6.144E+04	4.128E+00	4.498E+02	2.457E+05	1.651E+01	4.404E+00	1.229E+03	8.256E-02
2096	0	0	1,811,000	1,992,100	3.095E+02	2.951E+05	1.983E+01	3.938E+01	5.903E+04	3.966E+00	4.322E+02	2.361E+05	1.586E+01	4.232E+00	1.181E+03	7.932E-02
2097	0	0	1,811,000	1,992,100	2.974E+02	2.836E+05	1.905E+01	3.784E+01	5.671E+04	3.810E+00	4.152E+02	2.268E+05	1.524E+01	4.066E+00	1.134E+03	7.621E-02
2098	0	0	1,811,000	1,992,100	2.857E+02	2.724E+05	1.831E+01	3.635E+01	5.449E+04	3.661E+00	3.990E+02	2.180E+05	1.464E+01	3.906E+00	1.090E+03	7.322E-02
2099	0	0	1,811,000	1,992,100	2.745E+02	2.618E+05	1.759E+01	3.493E+01	5.235E+04	3.517E+00	3.833E+02	2.094E+05	1.407E+01	3.753E+00	1.047E+03	7.035E-02
2100	0	0	1,811,000	1,992,100	2.637E+02	2.515E+05	1.690E+01	3.356E+01	5.030E+04	3.380E+00	3.683E+02	2.012E+05	1.352E+01	3.606E+00	1.006E+03	6.759E-02
2101	0	0	1,811,000	1,992,100	2.534E+02	2.416E+05	1.624E+01	3.224E+01	4.833E+04	3.247E+00	3.538E+02	1.933E+05	1.299E+01	3.465E+00	9.665E+02	6.494E-02
2102	0	0	1,811,000	1,992,100	2.435E+02	2.322E+05	1.560E+01	3.098E+01	4.643E+04	3.120E+00	3.400E+02	1.857E+05	1.248E+01	3.329E+00	9.286E+02	6.239E-02
2103	0	0	1,811,000	1,992,100	2.339E+02	2.231E+05	1.499E+01	2.976E+01	4.461E+04	2.997E+00	3.266E+02	1.784E+05	1.199E+01	3.198E+00	8.922E+02	5.995E-02
2104	0	0	1,811,000	1,992,100	2.247E+02	2.143E+05	1.440E+01	2.860E+01	4.286E+04	2.880E+00	3.138E+02	1.714E+05	1.152E+01	3.073E+00	8.572E+02	5.760E-02
2105	0	0	1,811,000	1,992,100	2.159E+02	2.059E+05	1.383E+01	2.747E+01	4.118E+04	2.767E+00	3.015E+02	1.647E+05	1.107E+01	2.952E+00	8.236E+02	5.534E-02
2106	0	0	1,811,000	1,992,100	2.075E+02	1.978E+05	1.329E+01	2.640E+01	3.957E+04	2.658E+00	2.897E+02	1.583E+05	1.063E+01	2.836E+00	7.913E+02	5.317E-02
2107	0	0	1,811,000	1,992,100	1.993E+02	1.901E+05	1.277E+01	2.536E+01	3.802E+04	2.554E+00	2.783E+02	1.521E+05	1.022E+01	2.725E+00	7.603E+02	5.108E-02
2108	0	0	1,811,000	1,992,100	1.915E+02	1.826E+05	1.227E+01	2.437E+01	3.652E+04	2.454E+00	2.674E+02	1.461E+05	9.816E+00	2.618E+00	7.305E+02	4.908E-02
2109	0	0	1,811,000	1,992,100	1.840E+02	1.755E+05	1.179E+01	2.341E+01	3.509E+04	2.358E+00	2.569E+02	1.404E+05	9.431E+00	2.516E+00	7.018E+02	4.716E-02
2110	0	0	1,811,000	1,992,100	1.768E+02	1.686E+05	1.133E+01	2.249E+01	3.372E+04	2.265E+00	2.469E+02	1.349E+05	9.062E+00	2.417E+00	6.743E+02	4.531E-02

RESULTS

Landfill Name or Identifier: Delafield

Closure Year (with 80-year limit) = 1981
Methane = 20 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.
User-specified Unit: *av ft^3/min*

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1970	164,636	181,100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	164,636	181,100	164,636	181,100	5.622E+03	5.361E+06	3.602E+02	7.154E+02	1.072E+06	7.205E+01	7.851E+03	4.289E+06	2.882E+02	7.687E+01	2.145E+04	1.441E+00
1972	164,636	181,100	329,273	362,200	1.086E+04	1.036E+07	6.961E+02	1.382E+03	2.072E+06	1.392E+02	1.517E+04	8.288E+06	5.569E+02	1.485E+02	4.144E+04	2.784E+00
1973	164,636	181,100	493,909	543,300	1.575E+04	1.502E+07	1.009E+03	2.004E+03	3.004E+06	2.019E+02	2.200E+04	1.202E+07	8.074E+02	2.154E+02	6.008E+04	4.037E+00
1974	164,636	181,100	658,545	724,400	2.031E+04	1.937E+07	1.301E+03	2.584E+03	3.873E+06	2.603E+02	2.836E+04	1.549E+07	1.041E+03	2.777E+02	7.747E+04	5.205E+00
1975	164,636	181,100	823,182	905,500	2.456E+04	2.342E+07	1.574E+03	3.125E+03	4.684E+06	3.147E+02	3.429E+04	1.874E+07	1.259E+03	3.358E+02	9.368E+04	6.294E+00
1976	164,636	181,100	987,818	1,086,600	2.852E+04	2.720E+07	1.827E+03	3.629E+03	5.439E+06	3.655E+02	3.983E+04	2.176E+07	1.462E+03	3.899E+02	1.088E+05	7.309E+00
1977	164,636	181,100	1,152,455	1,267,700	3.222E+04	3.072E+07	2.064E+03	4.099E+03	6.144E+06	4.128E+02	4.499E+04	2.458E+07	1.651E+03	4.405E+02	1.229E+05	8.256E+00
1978	164,636	181,100	1,317,091	1,448,800	3.566E+04	3.400E+07	2.285E+03	4.537E+03	6.801E+06	4.569E+02	4.980E+04	2.720E+07	1.828E+03	4.875E+02	1.360E+05	9.139E+00
1979	164,636	181,100	1,481,727	1,629,900	3.887E+04	3.707E+07	2.490E+03	4.946E+03	7.413E+06	4.981E+02	5.428E+04	2.965E+07	1.992E+03	5.315E+02	1.483E+05	9.962E+00
1980	164,636	181,100	1,646,364	1,811,000	4.187E+04	3.992E+07	2.682E+03	5.327E+03	7.984E+06	5.365E+02	5.846E+04	3.194E+07	2.146E+03	5.724E+02	1.597E+05	1.073E+01
1981	0	0	1,811,000	1,992,100	4.466E+04	4.258E+07	2.861E+03	5.682E+03	8.517E+06	5.722E+02	6.236E+04	3.407E+07	2.289E+03	6.106E+02	1.703E+05	1.144E+01
1982	0	0	1,811,000	1,992,100	4.164E+04	3.971E+07	2.668E+03	5.298E+03	7.941E+06	5.336E+02	5.814E+04	3.176E+07	2.134E+03	5.693E+02	1.588E+05	1.067E+01
1983	0	0	1,811,000	1,992,100	3.882E+04	3.702E+07	2.487E+03	4.940E+03	7.404E+06	4.975E+02	5.421E+04	2.962E+07	1.990E+03	5.308E+02	1.481E+05	9.950E+00
1984	0	0	1,811,000	1,992,100	3.620E+04	3.452E+07	2.319E+03	4.606E+03	6.904E+06	4.639E+02	5.055E+04	2.761E+07	1.855E+03	4.949E+02	1.381E+05	9.277E+00
1985	0	0	1,811,000	1,992,100	3.375E+04	3.218E+07	2.162E+03	4.294E+03	6.437E+06	4.325E+02	4.713E+04	2.575E+07	1.730E+03	4.615E+02	1.287E+05	8.650E+00
1986	0	0	1,811,000	1,992,100	3.147E+04	3.001E+07	2.016E+03	4.004E+03	6.002E+06	4.033E+02	4.394E+04	2.401E+07	1.613E+03	4.303E+02	1.200E+05	8.065E+00
1987	0	0	1,811,000	1,992,100	2.934E+04	2.798E+07	1.880E+03	3.733E+03	5.596E+06	3.760E+02	4.097E+04	2.238E+07	1.504E+03	4.012E+02	1.119E+05	7.520E+00
1988	0	0	1,811,000	1,992,100	2.736E+04	2.609E+07	1.753E+03	3.481E+03	5.218E+06	3.506E+02	3.820E+04	2.087E+07	1.402E+03	3.741E+02	1.044E+05	7.011E+00
1989	0	0	1,811,000	1,992,100	2.551E+04	2.432E+07	1.634E+03	3.246E+03	4.865E+06	3.269E+02	3.562E+04	1.946E+07	1.307E+03	3.488E+02	9.730E+04	6.537E+00
1990	0	0	1,811,000	1,992,100	2.378E+04	2.268E+07	1.524E+03	3.026E+03	4.536E+06	3.048E+02	3.321E+04	1.814E+07	1.219E+03	3.252E+02	9.072E+04	6.095E+00
1991	0	0	1,811,000	1,992,100	2.218E+04	2.115E+07	1.421E+03	2.822E+03	4.229E+06	2.842E+02	3.097E+04	1.692E+07	1.137E+03	3.032E+02	8.459E+04	5.683E+00
1992	0	0	1,811,000	1,992,100	2.068E+04	1.972E+07	1.325E+03	2.631E+03	3.943E+06	2.650E+02	2.887E+04	1.577E+07	1.060E+03	2.827E+02	7.887E+04	5.299E+00
1993	0	0	1,811,000	1,992,100	1.928E+04	1.838E+07	1.235E+03	2.453E+03	3.677E+06	2.470E+02	2.692E+04	1.471E+07	9.882E+02	2.636E+02	7.354E+04	4.941E+00
1994	0	0	1,811,000	1,992,100	1.798E+04	1.714E+07	1.152E+03	2.287E+03	3.428E+06	2.303E+02	2.510E+04	1.371E+07	9.214E+02	2.458E+02	6.856E+04	4.607E+00
1995	0	0	1,811,000	1,992,100	1.676E+04	1.598E+07	1.074E+03	2.133E+03	3.196E+06	2.148E+02	2.340E+04	1.279E+07	8.591E+02	2.292E+02	6.393E+04	4.295E+00
1996	0	0	1,811,000	1,992,100	1.563E+04	1.490E+07	1.001E+03	1.988E+03	2.980E+06	2.003E+02	2.182E+04	1.192E+07	8.010E+02	2.137E+02	5.961E+04	4.005E+00
1997	0	0	1,811,000	1,992,100	1.457E+04	1.389E+07	9.336E+02	1.854E+03	2.779E+06	1.867E+02	2.035E+04	1.112E+07	7.469E+02	1.992E+02	5.558E+04	3.734E+00
1998	0	0	1,811,000	1,992,100	1.359E+04	1.296E+07	8.704E+02	1.729E+03	2.591E+06	1.741E+02	1.897E+04	1.036E+07	6.964E+02	1.857E+02	5.182E+04	3.482E+00
1999	0	0	1,811,000	1,992,100	1.267E+04	1.208E+07	8.116E+02	1.612E+03	2.416E+06	1.623E+02	1.769E+04	9.663E+06	6.493E+02	1.732E+02	4.832E+04	3.246E+00
2000	0	0	1,811,000	1,992,100	1.181E+04	1.126E+07	7.567E+02	1.503E+03	2.253E+06	1.513E+02	1.649E+04	9.010E+06	6.054E+02	1.615E+02	4.505E+04	3.027E+00
2001	0	0	1,811,000	1,992,100	1.101E+04	1.050E+07	7.056E+02	1.401E+03	2.100E+06	1.411E+02	1.538E+04	8.401E+06	5.645E+02	1.506E+02	4.200E+04	2.822E+00
2002	0	0	1,811,000	1,992,100	1.027E+04	9.791E+06	6.579E+02	1.306E+03	1.958E+06	1.316E+02	1.434E+04	7.833E+06	5.263E+02	1.404E+02	3.916E+04	2.631E+00
2003	0	0	1,811,000	1,992,100	9.574E+03	9.129E+06	6.134E+02	1.218E+03	1.826E+06	1.227E+02	1.337E+04	7.303E+06	4.907E+02	1.309E+02	3.652E+04	2.454E+00
2004	0	0	1,811,000	1,992,100	8.926E+03	8.512E+06	5.719E+02	1.136E+03	1.702E+06	1.144E+02	1.247E+04	6.810E+06	4.575E+02	1.220E+02	3.405E+04	2.288E+00
2005	0	0	1,811,000	1,992,100	8.323E+03	7.937E+06	5.333E+02	1.059E+03	1.587E+06	1.067E+02	1.162E+04	6.349E+06	4.266E+02	1.138E+02	3.175E+04	2.133E+00
2006	0	0	1,811,000	1,992,100	7.760E+03	7.400E+06	4.972E+02	9.874E+02	1.480E+06	9.944E+01	1.084E+04	5.920E+06	3.978E+02	1.061E+02	2.960E+04	1.989E+00
2007	0	0	1,811,000	1,992,100	7.236E+03	6.900E+06	4.636E+02	9.206E+02	1.380E+06	9.272E+01	1.010E+04	5.520E+06	3.709E+02	9.893E+01	2.760E+04	1.854E+00
2008	0	0	1,811,000	1,992,100	6.746E+03	6.433E+06	4.323E+02	8.584E+02	1.287E+06	8.645E+01	9.421E+03	5.147E+06	3.458E+02	9.224E+01	2.573E+04	1.729E+00
2009	0	0	1,811,000	1,992,100	6.290E+03	5.998E+06	4.030E+02	8.004E+02	1.200E+06	8.061E+01	8.784E+03	4.799E+06	3.224E+02	8.600E+01	2.399E+04	1.612E+00
2010	0	0	1,811,000	1,992,100	5.865E+03	5.593E+06	3.758E+02	7.463E+02	1.119E+06	7.516E+01	8.190E+03	4.474E+06	3.006E+02	8.019E+01	2.237E+04	1.503E+00
2011	0	0	1,811,000	1,992,100	5.469E+03	5.215E+06	3.504E+02	6.958E+02	1.043E+06	7.008E+01	7.636E+03	4.172E+06	2.803E+02	7.477E+01	2.086E+04	1.402E+00
2012	0	0	1,811,000	1,992,100	5.099E+03	4.862E+06	3.267E+02	6.488E+02	9.724E+05	6.534E+01	7.120E+03	3.890E+06	2.614E+02	6.971E+01	1.945E+04	1.307E+00
2013	0	0	1,811,000	1,992,100	4.754E+03	4.533E+06	3.046E+02	6.049E+02	9.067E+05	6.092E+01	6.639E+03	3.627E+06	2.437E+02	6.500E+01	1.813E+04	1.218E+00
2014	0	0	1,811,000	1,992,100	4.433E+03	4.227E+06	2.840E+02	5.640E+02	8.454E+05	5.680E+01	6.190E+03	3.382E+06	2.272E+02	6.061E+01	1.691E+04	1.136E+00
2015	0	0	1,811,000	1,992,100	4.133E+03	3.941E+06	2.648E+02	5.259E+02	7.882E+05	5.296E+01	5.771E+03	3.153E+06	2.118E+02	5.651E+01	1.576E+04	1.059E+00
2016	0	0	1,811,000	1,992,100	3.854E+03	3.675E+06	2.469E+02	4.903E+02	7.350E+05	4.938E+01	5.381E+03	2.940E+06	1.975E+02	5.269E+01	1.470E+04	9.876E-01
2017	0	0	1,811,000	1,992,100	3.593E+03	3.426E+06	2.302E+02	4.572E+02	6.853E+05	4.604E+01	5.017E+03	2.741E+06	1.842E+02	4.913E+01	1.371E+04	9.209E-01
2018	0	0	1,811,000	1,992,100	3.350E+03	3.195E+06	2.147E+02	4.263E+02	6.389E+05	4.293E+01	4.678E+03	2.556E+06	1.717E+02	4.580E+01	1.278E+04	8.586E-01
2019	0	0	1,811,000	1,992,100	3.124E+03	2.979E+06	2.001E+02	3.974E+02	5.957E+05	4.003E+01	4.362E+03	2.383E+06	1.601E+02	4.271E+01	1.191E+04	8.006E-01
2020	0	0	1,811,000	1,992,100	2.913E+03	2.777E+06	1.866E+02	3.706E+02	5.555E+05	3.732E+01	4.067E+03	2.222E+06	1.493E+02	3.982E+01	1.111E+04	7.464E-01
2021	0	0	1,811,000	1,992,100	2.716E+03	2.590E+06	1.740E+02	3.455E+02	5.179E+05	3.480E+01	3.792E+03	2.072E+06	1.392E+02	3.713E+01	1.036E+04	6.960E-01
2022	0	0	1,811,000	1,992,100	2.532E+03	2.414E+06	1.622E+02	3.222E+02	4.829E+05	3.245E+01	3.536E+03	1.932E+06	1.298E+02	3.462E+01	9.658E+03	6.489E-01
2023	0	0	1,811,000	1,992,100	2.361E+03	2.251E+06	1.513E+02	3.004E+02	4.503E+05	3.025E+01	3.297E+03	1.801E+06	1.210E+02	3.228E+01	9.005E+03	6.050E-01
2024	0	0	1,811,000	1,992,100	2.201E+03	2.099E+06	1.410E+02	2.801E+02	4.198E+05	2.821E+01	3.074E+03	1.679E+06	1.128E+02	3.010E+01	8.396E+03	5.641E-01
2025	0	0	1,811,000	1,992,100	2.052E+03	1.957E+06	1.315E+02	2.611E+02	3.914E+05	2.630E+01	2.866E+03	1.566E+06	1.052E+02	2.806E+01	7.829E+03	5.260E-01
2026	0	0	1,811,000	1,992,100	1.914E+03	1.825E+06	1.226E+02	2.435E+02	3.650E+05	2.452E+01	2.672E+03	1.460E+06	9.809E+01	2.616E+01	7.299E+03	4.904E-01
2027	0	0	1,811,000	1,992,100	1.784E+03	1.701E+06	1.143E+02	2.270E+02	3.403E+05	2.286E+01	2.492E+03	1.361E+06	9.146E+01	2.440E+01	6.806E+03	4.573E-01
2028	0	0	1,811,000	1,992,100	1.664E+03	1.586E+06	1.066E+02	2.117E+02	3.173E+05	2.132E+01	2.323E+03	1.269E+06	8.527E+01	2.275E+01	6.346E+03	4.264E-01
2029	0	0	1,811,000	1,992,100	1.551E+03	1.479E+06	9.939E+01	1.974E+02	2.958E+05	1.988E+01	2.166E+03	1.183E+06	7.951E+01	2.121E+01	5.917E+03	3.975E-01
2030	0	0	1,811,000	1,992,100	1.446E+03	1.379E+06	9.267E+01	1.840E+02	2.758E+05	1.853E+01	2.020E+03	1.103E+06	7.413E+01	1.977E+01	5.517E+03	3.707E-01
2031	0	0	1,811,000	1,992,100	1.349E+03	1.286E+06	8.640E+01	1.716E+02	2.572E+05	1.728E+01	1.883E+03	1.029E+06	6.912E+01	1.844E+01	5.144E+03	3.456E-01
2032	0	0	1,811,000	1,992,100	1.257E+03	1.199E+06	8.056E+01	1.600E+02	2.398E+05	1.611E+01	1.756E+03	9.592E+05	6.445E+01	1.719E+01	4.796E+03	3.222E-01
2033	0	0	1,811,000	1,992,100	1.172E+03	1.118E+06	7.511E+01	1.492E+02	2.236E+05	1.502E+01	1.637E+03	8.944E+05	6.009E+01	1.603E+01	4.472E+03	3.005E-01
2034	0	0	1,811,000	1,992,100	1.093E+03	1.042E+06	7.004E+01	1.391E+02	2.085E+05	1.401E+01	1.526E+03	8.339E+05	5.603E+01	1.495E+01	4.169E+03	2.801E-01
2035	0	0	1,811,000	1,992,100	1.019E+03	9.719E+05	6.530E+01	1.297E+02	1.944E+05	1.306E+01	1.423E+03	7.775E+05	5.224E+01	1.393E+01	3.888E+03	2.612E-01
2036	0	0	1,811,000	1,992,100	9.503E+02	9.062E+05	6.089E+01	1.209E+02	1.812E+05	1.218E+01	1.327E+03	7.249E+05	4.871E+01	1.299E+01	3.625E+03	2.435E-01
2037	0	0	1,811,000	1,992,100	8.860E+02	8.449E+05	5.677E+01	1.127E+02	1.690E+05	1.135E+01	1.237E+03	6.759E+05	4.542E+01	1.211E+01	3.380E+03	2.271E-01
2038	0	0	1,811,000	1,992,100	8.261E+02	7.878E+05	5.293E+01	1.051E+02	1.576E+05	1.059E+01	1.154E+03	6.302E+05	4.235E+01	1.130E+01	3.151E+03	2.117E-01
2039	0	0	1,811,000	1,992,100	7.703E+02	7.345E+05	4.935E+01	9.801E+01	1.469E+05	9.871E+00	1.076E+03	5.876E+05	3.948E+01	1.053E+01	2.938E+03	1.974E-01
2040	0	0	1,811,000	1,992,100	7.182E+02	6.849E+05	4.602E+01	9.138E+01	1.370E+05	9.203E+00	1.003E+03	5.479E+05	3.681E+01	9.820E+00	2.740E+03	1.841E-01
2041	0	0	1,811,000	1,992,100	6.697E+02	6.386E+05	4.291E+01	8.521E+01	1.277E+05	8.581E+00	9.351E+02	5.109E+05	3.432E+01	9.156E+00	2.554E+03	1.716E-01
2042	0	0	1,811,000	1,992,100	6.244E+02	5.954E+05	4.001E+01	7.944E+01	1.191E+05	8.001E+00	8.719E+02	4.763E+05	3.200E+01	8.537E+00	2.382E+03	1.600E-01
2043	0	0	1,811,000	1,992,100	5.822E+02	5.552E+05	3.730E+01	7.407E+01	1.110E+05	7.460E+00	8.130E+02	4.441E+05	2.984E+01	7.960E+00	2.221E+03	1.492E-01
2044	0	0	1,811,000	1,992,100	5.428E+02	5.176E+05	3.478E+01	6.907E+01	1.035E+05	6.956E+00	7.580E+02	4.141E+05	2.782E+01	7.422E+00	2.070E+03	1.391E-01
2045	0	0	1,811,000	1,992,100	5.061E+02	4.826E+05	3.243E+01	6.440E+01	9.653E+04	6.486E+00	7.068E+02	3.861E+05	2.594E+01	6.920E+00	1.931E+03	1.297E-01

RESULTS **Landfill Name or Identifier:** Delafield

Closure Year (with 80-year limit) = 1981
Methane = 20 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.
User-specified Unit: *av ft^3/min*

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2046	0	0	1,811,000	1,992,100	4.719E+02	4.500E+05	3.024E+01	6.004E+01	9.000E+04	6.047E+00	6.590E+02	3.600E+05	2.419E+01	6.452E+00	1.800E+03	1.209E-01
2047	0	0	1,811,000	1,992,100	4.400E+02	4.196E+05	2.819E+01	5.598E+01	8.391E+04	5.638E+00	6.144E+02	3.357E+05	2.255E+01	6.016E+00	1.678E+03	1.128E-01
2048	0	0	1,811,000	1,992,100	4.103E+02	3.912E+05	2.629E+01	5.220E+01	7.824E+04	5.257E+00	5.729E+02	3.130E+05	2.103E+01	5.609E+00	1.565E+03	1.051E-01
2049	0	0	1,811,000	1,992,100	3.825E+02	3.648E+05	2.451E+01	4.867E+01	7.295E+04	4.902E+00	5.342E+02	2.918E+05	1.961E+01	5.230E+00	1.459E+03	9.803E-02
2050	0	0	1,811,000	1,992,100	3.567E+02	3.401E+05	2.285E+01	4.538E+01	6.802E+04	4.570E+00	4.980E+02	2.721E+05	1.828E+01	4.876E+00	1.360E+03	9.141E-02
2051	0	0	1,811,000	1,992,100	3.325E+02	3.171E+05	2.131E+01	4.231E+01	6.342E+04	4.261E+00	4.644E+02	2.537E+05	1.705E+01	4.547E+00	1.268E+03	8.523E-02
2052	0	0	1,811,000	1,992,100	3.101E+02	2.957E+05	1.987E+01	3.945E+01	5.913E+04	3.973E+00	4.330E+02	2.365E+05	1.589E+01	4.239E+00	1.183E+03	7.946E-02
2053	0	0	1,811,000	1,992,100	2.891E+02	2.757E+05	1.852E+01	3.678E+01	5.514E+04	3.705E+00	4.037E+02	2.205E+05	1.482E+01	3.953E+00	1.103E+03	7.409E-02
2054	0	0	1,811,000	1,992,100	2.696E+02	2.570E+05	1.727E+01	3.430E+01	5.141E+04	3.454E+00	3.764E+02	2.056E+05	1.382E+01	3.685E+00	1.028E+03	6.908E-02
2055	0	0	1,811,000	1,992,100	2.513E+02	2.397E+05	1.610E+01	3.198E+01	4.793E+04	3.221E+00	3.510E+02	1.917E+05	1.288E+01	3.436E+00	9.587E+02	6.441E-02
2056	0	0	1,811,000	1,992,100	2.343E+02	2.235E+05	1.501E+01	2.982E+01	4.469E+04	3.003E+00	3.272E+02	1.788E+05	1.201E+01	3.204E+00	8.938E+02	6.006E-02
2057	0	0	1,811,000	1,992,100	2.185E+02	2.084E+05	1.400E+01	2.780E+01	4.167E+04	2.800E+00	3.051E+02	1.667E+05	1.120E+01	2.987E+00	8.334E+02	5.600E-02
2058	0	0	1,811,000	1,992,100	2.037E+02	1.943E+05	1.305E+01	2.592E+01	3.885E+04	2.611E+00	2.845E+02	1.554E+05	1.044E+01	2.785E+00	7.771E+02	5.221E-02
2059	0	0	1,811,000	1,992,100	1.900E+02	1.811E+05	1.217E+01	2.417E+01	3.623E+04	2.434E+00	2.653E+02	1.449E+05	9.736E+00	2.597E+00	7.245E+02	4.868E-02
2060	0	0	1,811,000	1,992,100	1.771E+02	1.689E+05	1.135E+01	2.253E+01	3.378E+04	2.270E+00	2.473E+02	1.351E+05	9.078E+00	2.422E+00	6.756E+02	4.539E-02
2061	0	0	1,811,000	1,992,100	1.651E+02	1.575E+05	1.058E+01	2.101E+01	3.149E+04	2.116E+00	2.306E+02	1.260E+05	8.464E+00	2.258E+00	6.299E+02	4.232E-02
2062	0	0	1,811,000	1,992,100	1.540E+02	1.468E+05	9.865E+00	1.959E+01	2.937E+04	1.973E+00	2.150E+02	1.175E+05	7.892E+00	2.105E+00	5.873E+02	3.946E-02
2063	0	0	1,811,000	1,992,100	1.436E+02	1.369E+05	9.198E+00	1.827E+01	2.738E+04	1.840E+00	2.005E+02	1.095E+05	7.359E+00	1.963E+00	5.476E+02	3.679E-02
2064	0	0	1,811,000	1,992,100	1.339E+02	1.276E+05	8.576E+00	1.703E+01	2.553E+04	1.715E+00	1.869E+02	1.021E+05	6.861E+00	1.830E+00	5.106E+02	3.431E-02
2065	0	0	1,811,000	1,992,100	1.248E+02	1.190E+05	7.997E+00	1.588E+01	2.380E+04	1.599E+00	1.743E+02	9.521E+04	6.397E+00	1.706E+00	4.761E+02	3.199E-02
2066	0	0	1,811,000	1,992,100	1.164E+02	1.110E+05	7.456E+00	1.481E+01	2.219E+04	1.491E+00	1.625E+02	8.877E+04	5.965E+00	1.591E+00	4.439E+02	2.982E-02
2067	0	0	1,811,000	1,992,100	1.085E+02	1.035E+05	6.952E+00	1.381E+01	2.069E+04	1.390E+00	1.515E+02	8.277E+04	5.561E+00	1.483E+00	4.139E+02	2.781E-02
2068	0	0	1,811,000	1,992,100	1.012E+02	9.647E+04	6.482E+00	1.287E+01	1.929E+04	1.296E+00	1.413E+02	7.718E+04	5.185E+00	1.383E+00	3.859E+02	2.593E-02
2069	0	0	1,811,000	1,992,100	9.433E+01	8.995E+04	6.044E+00	1.200E+01	1.799E+04	1.209E+00	1.317E+02	7.196E+04	4.835E+00	1.290E+00	3.598E+02	2.417E-02
2070	0	0	1,811,000	1,992,100	8.795E+01	8.387E+04	5.635E+00	1.119E+01	1.677E+04	1.127E+00	1.228E+02	6.709E+04	4.508E+00	1.202E+00	3.355E+02	2.254E-02
2071	0	0	1,811,000	1,992,100	8.200E+01	7.820E+04	5.254E+00	1.043E+01	1.564E+04	1.051E+00	1.145E+02	6.256E+04	4.203E+00	1.121E+00	3.128E+02	2.102E-02
2072	0	0	1,811,000	1,992,100	7.646E+01	7.291E+04	4.899E+00	9.729E+00	1.458E+04	9.798E-01	1.068E+02	5.833E+04	3.919E+00	1.045E+00	2.916E+02	1.960E-02
2073	0	0	1,811,000	1,992,100	7.129E+01	6.798E+04	4.568E+00	9.071E+00	1.360E+04	9.135E-01	9.955E+01	5.439E+04	3.654E+00	9.747E-01	2.719E+02	1.827E-02
2074	0	0	1,811,000	1,992,100	6.647E+01	6.339E+04	4.259E+00	8.458E+00	1.268E+04	8.518E-01	9.282E+01	5.071E+04	3.407E+00	9.088E-01	2.535E+02	1.704E-02
2075	0	0	1,811,000	1,992,100	6.198E+01	5.910E+04	3.971E+00	7.886E+00	1.182E+04	7.942E-01	8.655E+01	4.728E+04	3.177E+00	8.474E-01	2.364E+02	1.588E-02
2076	0	0	1,811,000	1,992,100	5.779E+01	5.511E+04	3.703E+00	7.353E+00	1.102E+04	7.405E-01	8.070E+01	4.408E+04	2.962E+00	7.901E-01	2.204E+02	1.481E-02
2077	0	0	1,811,000	1,992,100	5.388E+01	5.138E+04	3.452E+00	6.856E+00	1.028E+04	6.904E-01	7.524E+01	4.110E+04	2.762E+00	7.367E-01	2.055E+02	1.381E-02
2078	0	0	1,811,000	1,992,100	5.024E+01	4.791E+04	3.219E+00	6.392E+00	9.581E+03	6.438E-01	7.015E+01	3.832E+04	2.575E+00	6.869E-01	1.916E+02	1.288E-02
2079	0	0	1,811,000	1,992,100	4.684E+01	4.467E+04	3.001E+00	5.960E+00	8.933E+03	6.002E-01	6.541E+01	3.573E+04	2.401E+00	6.404E-01	1.787E+02	1.200E-02
2080	0	0	1,811,000	1,992,100	4.367E+01	4.165E+04	2.798E+00	5.557E+00	8.330E+03	5.597E-01	6.099E+01	3.332E+04	2.239E+00	5.971E-01	1.666E+02	1.119E-02
2081	0	0	1,811,000	1,992,100	4.072E+01	3.883E+04	2.609E+00	5.181E+00	7.766E+03	5.218E-01	5.687E+01	3.107E+04	2.087E+00	5.568E-01	1.553E+02	1.044E-02
2082	0	0	1,811,000	1,992,100	3.797E+01	3.621E+04	2.433E+00	4.831E+00	7.241E+03	4.865E-01	5.302E+01	2.897E+04	1.946E+00	5.191E-01	1.448E+02	9.731E-03
2083	0	0	1,811,000	1,992,100	3.540E+01	3.376E+04	2.268E+00	4.504E+00	6.752E+03	4.537E-01	4.944E+01	2.701E+04	1.815E+00	4.840E-01	1.350E+02	9.073E-03
2084	0	0	1,811,000	1,992,100	3.301E+01	3.148E+04	2.115E+00	4.200E+00	6.295E+03	4.230E-01	4.609E+01	2.518E+04	1.692E+00	4.513E-01	1.259E+02	8.460E-03
2085	0	0	1,811,000	1,992,100	3.078E+01	2.935E+04	1.972E+00	3.916E+00	5.870E+03	3.944E-01	4.298E+01	2.348E+04	1.578E+00	4.208E-01	1.174E+02	7.888E-03
2086	0	0	1,811,000	1,992,100	2.870E+01	2.736E+04	1.839E+00	3.651E+00	5.473E+03	3.677E-01	4.007E+01	2.189E+04	1.471E+00	3.923E-01	1.095E+02	7.354E-03
2087	0	0	1,811,000	1,992,100	2.676E+01	2.551E+04	1.714E+00	3.404E+00	5.103E+03	3.429E-01	3.736E+01	2.041E+04	1.371E+00	3.658E-01	1.021E+02	6.857E-03
2088	0	0	1,811,000	1,992,100	2.495E+01	2.379E+04	1.598E+00	3.174E+00	4.758E+03	3.197E-01	3.484E+01	1.903E+04	1.279E+00	3.411E-01	9.516E+01	6.394E-03
2089	0	0	1,811,000	1,992,100	2.326E+01	2.218E+04	1.490E+00	2.960E+00	4.436E+03	2.981E-01	3.248E+01	1.774E+04	1.192E+00	3.180E-01	8.872E+01	5.961E-03
2090	0	0	1,811,000	1,992,100	2.169E+01	2.068E+04	1.390E+00	2.760E+00	4.136E+03	2.779E-01	3.029E+01	1.655E+04	1.112E+00	2.965E-01	8.273E+01	5.558E-03
2091	0	0	1,811,000	1,992,100	2.022E+01	1.928E+04	1.296E+00	2.573E+00	3.857E+03	2.591E-01	2.824E+01	1.543E+04	1.037E+00	2.765E-01	7.713E+01	5.183E-03
2092	0	0	1,811,000	1,992,100	1.885E+01	1.798E+04	1.208E+00	2.399E+00	3.596E+03	2.416E-01	2.633E+01	1.438E+04	9.664E-01	2.578E-01	7.192E+01	4.832E-03
2093	0	0	1,811,000	1,992,100	1.758E+01	1.676E+04	1.126E+00	2.237E+00	3.353E+03	2.253E-01	2.455E+01	1.341E+04	9.011E-01	2.404E-01	6.706E+01	4.506E-03
2094	0	0	1,811,000	1,992,100	1.639E+01	1.563E+04	1.050E+00	2.086E+00	3.126E+03	2.100E-01	2.289E+01	1.250E+04	8.402E-01	2.241E-01	6.252E+01	4.201E-03
2095	0	0	1,811,000	1,992,100	1.528E+01	1.457E+04	9.792E-01	1.945E+00	2.915E+03	1.958E-01	2.134E+01	1.166E+04	7.834E-01	2.090E-01	5.830E+01	3.917E-03
2096	0	0	1,811,000	1,992,100	1.425E+01	1.359E+04	9.130E-01	1.813E+00	2.718E+03	1.826E-01	1.990E+01	1.087E+04	7.304E-01	1.948E-01	5.435E+01	3.652E-03
2097	0	0	1,811,000	1,992,100	1.329E+01	1.267E+04	8.513E-01	1.691E+00	2.534E+03	1.703E-01	1.855E+01	1.014E+04	6.810E-01	1.817E-01	5.068E+01	3.405E-03
2098	0	0	1,811,000	1,992,100	1.239E+01	1.181E+04	7.937E-01	1.576E+00	2.363E+03	1.587E-01	1.730E+01	9.451E+03	6.350E-01	1.694E-01	4.725E+01	3.175E-03
2099	0	0	1,811,000	1,992,100	1.155E+01	1.101E+04	7.401E-01	1.470E+00	2.203E+03	1.480E-01	1.613E+01	8.812E+03	5.921E-01	1.579E-01	4.406E+01	2.960E-03
2100	0	0	1,811,000	1,992,100	1.077E+01	1.027E+04	6.901E-01	1.370E+00	2.054E+03	1.380E-01	1.504E+01	8.216E+03	5.520E-01	1.473E-01	4.108E+01	2.760E-03
2101	0	0	1,811,000	1,992,100	1.004E+01	9.576E+03	6.434E-01	1.278E+00	1.915E+03	1.287E-01	1.402E+01	7.661E+03	5.147E-01	1.373E-01	3.830E+01	2.574E-03
2102	0	0	1,811,000	1,992,100	9.363E+00	8.928E+03	5.999E-01	1.191E+00	1.786E+03	1.200E-01	1.307E+01	7.143E+03	4.799E-01	1.280E-01	3.571E+01	2.400E-03
2103	0	0	1,811,000	1,992,100	8.730E+00	8.325E+03	5.593E-01	1.111E+00	1.665E+03	1.119E-01	1.219E+01	6.660E+03	4.475E-01	1.194E-01	3.330E+01	2.237E-03
2104	0	0	1,811,000	1,992,100	8.140E+00	7.762E+03	5.215E-01	1.036E+00	1.552E+03	1.043E-01	1.137E+01	6.210E+03	4.172E-01	1.113E-01	3.105E+01	2.086E-03
2105	0	0	1,811,000	1,992,100	7.590E+00	7.237E+03	4.863E-01	9.657E-01	1.447E+03	9.725E-02	1.060E+01	5.790E+03	3.890E-01	1.038E-01	2.895E+01	1.945E-03
2106	0	0	1,811,000	1,992,100	7.076E+00	6.748E+03	4.534E-01	9.004E-01	1.350E+03	9.068E-02	9.882E+00	5.398E+03	3.627E-01	9.675E-02	2.699E+01	1.814E-03
2107	0	0	1,811,000	1,992,100	6.598E+00	6.292E+03	4.227E-01	8.395E-01	1.258E+03	8.455E-02	9.214E+00	5.033E+03	3.382E-01	9.021E-02	2.517E+01	1.691E-03
2108	0	0	1,811,000	1,992,100	6.152E+00	5.866E+03	3.942E-01	7.828E-01	1.173E+03	7.883E-02	8.591E+00	4.693E+03	3.153E-01	8.411E-02	2.347E+01	1.577E-03
2109	0	0	1,811,000	1,992,100	5.736E+00	5.470E+03	3.675E-01	7.298E-01	1.094E+03	7.350E-02	8.010E+00	4.376E+03	2.940E-01	7.843E-02	2.188E+01	1.470E-03
2110	0	0	1,811,000	1,992,100	5.348E+00	5.100E+03	3.427E-01	6.805E-01	1.020E+03	6.853E-02	7.468E+00	4.080E+03	2.741E-01	7.312E-02	2.040E+01	1.371E-03

APPENDIX B

CARBON FOOTPRINT ANALYSIS

Carbon Footprint Calculations -Baseline

Delafield Sanitary Transfer Landfill #719
South Service Road
Delafield, WI 53018-2132

Scope 1

			Emission Factors			Mass						CO_2e Greenhouse Gas Potentials 1	25	296	Total		
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO_2/gal	lb CH_4/gal	lb N_2O/gal	lb CO_2	kg CO_2	lb CH_4	kg CH_4	lb N_2O	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Propane for Flare	2008	40.0	12.5	0.0002	0.0009	32,743.48	14,852.44	0.52	0.24	2.36	1.07	14,852.44	5.94	316.54	15,174.92	33,460.69	16.73
Methane Gas- Destroyed	2008	--	--	--	--	--	--	--	1,103,104.50	--	--	--	3,033,537	--	3,033,537.38	6,688,949.91	3,344.47
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	296	Total		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Leachate Collection System	2008	3,824	0.003824	1.66	19.24	27.59	0.01	0.07	0.11	0.01	1.84	31.23	72.92	33.07	0.02
Flare Blower	2008	44,212	0.044212	1.66	19.24	27.59	0.07	0.85	1.22	0.07	21.27	361.06	843.04	382.40	0.19
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	296	Total		
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	600	33.33	8.81	0.0036	0.0004	293.67	0.12	0.01	293.67	3.04	3.91	300.61	662.84	0.33
Diesel - Leachate Hauling	2008	7,200	900	10.15	0.000041	0.000038	9,135.00	0.04	0.03	9135.00	0.92	10.23	9,146.15	20,167.26	10.08
Methane Gas- Fugitive	2008	--	--	--	--	--	--	1,103,104.50	--	--	27,577,613	--	27,577,612.50	60,808,635.56	30,404.32
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
30,636,687.51	67,552,291.74	33,776.15

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
Diesel fuel used for leachate transport. Leachate disposed of in Waukesha, Wisconsin.
12 site visits/year for site sampling and O&M; 50 miles/visit (roundtrip).
20 site visits/month for leachate disposal; 12 months/year; 30 miles/visit (roundtrip).
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009.
2. Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..
3. Greenhouse Gas Potential for CH4 taken from IPCC (2006). Greenhouse Gas Potential for N2O taken from IPCC Third Assessment Report (2001).
4. For every pound of methane combusted there are 2.75 pounds of carbon produced.
5. Utility usage reported by We Energies.
6. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.
7. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

AECOM

Carbon Footprint Calculations - Option 1 Rebalancing Landfill Gas Extraction System

Delafield Sanitary Transfer Landfill #719
South Service Road
Delafield, WI 53018-2132

Scope 1

Gaseous Fuels Burned On-Site	Year	Usage (lbs/yr)	Emission Factors: lbs CO_2/gal	Emission Factors: lb CH_4/gal	Emission Factors: lb N_2O/gal	Mass: lb CO_2	Mass: kg CO_2	Mass: lb CH_4	Mass: kg CH_4	Mass: lb N_2O	Mass: kg N_2O	CO_2e Greenhouse Gas Potentials: 1 kg CO_2e/kg CO_2	CO_2e Greenhouse Gas Potentials: 25 kg CO_2e/kg CH_4	CO_2e Greenhouse Gas Potentials: 296 kg CO_2e/kg N_2O	Total: kg CO_2e	Total: lb CO_2e	Total: ton CO_2e
Propane for Flare	2008	40.0	12.5	0.0002	0.0009	32,743.48	14,852.44	0.52	0.24	2.36	1.07	14,852.44	5.94	316.54	15,174.92	33,460.69	16.73
Methane Gas- Destroyed	2008	--	--	--	--	--	--	--	1,544,346.30	--	--	--	4,246,952	--	4,246,952.33	9,364,529.88	4,682.26
			See Note 1	See Note 1	See Note 1				See Note 2				See Note 3, 4	See Note 3			

Scope 2

Purchased Electricity	Year	Usage (kWh)	Usage (GWh)	Emission Factors: lb CO_2/GWh	Emission Factors: lb CH_4/GWh	Emission Factors: lb N_2O/GWh	Mass: lb CO_2	Mass: lb CH_4	Mass: lb N_2O	CO_2e Greenhouse Gas Potentials: 1 lb CO_2e/lb CO_2	CO_2e Greenhouse Gas Potentials: 25 lb CO_2e/lb CH_4	CO_2e Greenhouse Gas Potentials: 296 lb CO_2e/lb N_2O	Total: kg CO_2e	Total: lb CO_2e	Total: ton CO_2e
Leachate Collection System	2008	3,824	0.003824	1.66	19.24	27.59	0.01	0.07	0.11	0.01	1.84	31.23	72.92	33.07	0.02
Flare Blower	2008	44,212	0.044212	1.66	19.24	27.59	0.07	0.85	1.22	0.07	21.27	361.06	843.04	382.40	0.19
		See Note 5		See Note 6	See Note 6	See Note 6					See Note 3	See Note 3			

Scope 3

Sampling/O&M Vehicle Usage	Year	Usage (miles/yr)	Usage (gal/yr)	Emission Factors: kg CO_2/gallon	Emission Factors: kg CH_4/gallon	Emission Factors: kg N_2O/gallon	Mass: kg CO_2	Mass: kg CH_4	Mass: kg N_2O	CO_2e Greenhouse Gas Potentials: 1 kg CO_2e/kg CO_2	CO_2e Greenhouse Gas Potentials: 25 kg CO2e/kg CH_4	CO_2e Greenhouse Gas Potentials: 296 kg CO2e/kg N_2O	Total: kg CO_2e	Total: lb CO_2e	Total: ton CO_2e
Unleaded Gasoline	2008	600	33.33	8.81	0.0036	0.0004	293.67	0.12	0.01	293.67	3.04	3.91	300.61	662.84	0.33
Diesel - Leachate Hauling	2008	7,200	900	10.15	0.000041	0.000038	9,135.00	0.04	0.03	9135.00	0.92	10.23	9,146.15	20,167.26	10.08
Methane Gas- Fugitive	2008	--	--	--	--	--	--	661,862.70	--	--	16,546,568	--	16,546,567.50	36,485,181.34	18,242.59
				See Note 7	See Note 7	See Note 7		See Note 2			See Note 3	See Note 3			

Totals: kg CO_2e	Totals: lb CO_2e	Totals: ton CO_2e
20,819,057.46	45,904,417.48	22,952.21

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
Diesel fuel used for leachate transport. Leachate disposed of in Waukesha, Wisconsin.
12 site visits/year for site sampling and O&M; 50 miles/visit (roundtrip).
20 site visits/month for leachate disposal; 12 months/year; 30 miles/visit (roundtrip).
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.
Option 1 - assumes that LFG extraction system becomes 20 percent more efficient but LFG quality remains the same.

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. *Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009.*
2. *Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..*
3. *Greenhouse Gas Potential for CH4 taken from IPCC (2006). Greenhouse Gas Potential for N2O taken from IPCC Third Assessment Report (2001).*
4. *For every pound of methane combusted there are 2.75 pounds of carbon produced.*
5. *Utility usage reported by We Energies.*
6. *EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.*
7. *EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.*

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Carbon Footprint Calculations - Option 2 - Addition of 10 LFG Extraction \Wells

Delafield Sanitary Transfer Landfill #719
South Service Road
Delafield, WI 53018-2132

Scope 1

			Emission Factors			Mass						CO_2e Greenhouse Gas Potentials			Total		
												1	25	296			
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO_2/gal	lb CH_4/gal	lb N_2O/gal	lb CO_2	kg CO_2	lb CH_4	kg CH_4	lb N_2O	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Propane for Flare	2008	40.0	12.5	0.0002	0.0009	32,743.48	14,852.44	0.52	0.24	2.36	1.07	14,852.44	5.94	316.54	15,174.92	33,460.69	16.73
Methane Gas- Destroyed	2008	--	--	--	--	--	--	--	1,654,656.75	--	--	--	4,550,306	--	4,550,306.06	10,033,424.87	5,016.71
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	296			
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Leachate Collection System	2008	3,824	0.003824	1.66	19.24	27.59	0.01	0.07	0.11	0.01	1.84	31.23	72.92	33.07	0.02
Flare Blower	2008	44,212	0.044212	1.66	19.24	27.59	0.07	0.85	1.22	0.07	21.27	361.06	843.04	382.40	0.19
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	296			
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	600	33.33	8.81	0.0036	0.0004	293.67	0.12	0.01	293.67	3.04	3.91	300.61	662.84	0.33
Diesel - Leachate Hauling	2008	7,200	900	10.15	0.000041	0.000038	9,135.00	0.04	0.03	9135.00	0.92	10.23	9,146.15	20,167.26	10.08
Methane Gas- Fugitive	2008	--	--	--	--	--	--	551,552.25	--	--	13,788,806	--	13,788,806.25	30,404,317.78	15,202.16
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
18,364,649.94	40,492,448.92	20,246.22

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M actvities.*
Diesel fuel used for leachate transport. Leachate disposed of in Waukesha, Wisconsin.
12 site visits/year for site sampling and O&M; 50 miles/visit (roundtrip).
10 site visits/month for leachate disposal; 12 months/year; 30 miles/visit (roundtrip).
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.
Option 2 - assumes that LFG extraction system becomes 25 percent more efficient but LFG quality remains the same.

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. *Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009.*
2. *Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..*
3. *Greenhouse Gas Potential for CH4 taken from IPCC (2006). Greenhouse Gas Potential for N2O taken from IPCC Third Assessment Report (2001).*
4. *For every pound of methane combusted there are 2.75 pounds of carbon produced.*
5. *Utility usage reported by We Energies.*
6. *EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.*
7. *EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.*

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Carbon Footprint Calculations - Option 3 - Installing Modified Flare for Leachate Reduction Purposes

Delafield Sanitary Transfer Landfill #719
South Service Road
Delafield, WI 53018-2132

Scope 1

			Emission Factors			Mass						CO_2e Greenhouse Gas Potentials			Total		
												1	25	296			
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO_2/gal	lb CH_4/gal	lb N_2O/gal	lb CO_2	kg CO_2	lb CH_4	kg CH_4	lb N_2O	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Propane for Flare	2008	40.0	12.5	0.0002	0.0009	32,743.48	14,852.44	0.52	0.24	2.36	1.07	14,852.44	5.94	316.54	15,174.92	33,460.69	16.73
Methane Gas- Destroyed	2008	--	--	--	--	--	--	--	1,103,104.50	--	--	--	3,033,537	--	3,033,537.38	6,688,949.91	3,344.47
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	296			
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Leachate Collection System	2008	3,824	0.003824	1.66	19.24	27.59	0.01	0.07	0.11	0.01	1.84	31.23	72.92	33.07	0.02
Flare Blower	2008	44,212	0.044212	1.66	19.24	27.59	0.07	0.85	1.22	0.07	21.27	361.06	843.04	382.40	0.19
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	296			
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	600	33.33	8.81	0.0036	0.0004	293.67	0.12	0.01	293.67	3.04	3.91	300.61	662.84	0.33
Diesel - Leachate Hauling	2008	3,888	486	10.15	0.000041	0.000038	4,932.90	0.02	0.02	4932.90	0.50	5.52	4,938.92	10,890.32	5.45
Methane Gas- Fugitive	2008	--	--	--	--	--	--	1,103,104.50	--	--	27,577,613	--	27,577,612.50	60,808,635.56	30,404.32
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
30,632,480.28	67,543,014.81	33,771.51

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
Diesel fuel used for leachate transport. Leachate disposed of in Waukesha, Wisconsin.
12 site visits/year for site sampling and O&M; 50 miles/visit (roundtrip).
10 site visits/month for leachate disposal; 12 months/year; 30 miles/visit (roundtrip).
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.
Option 1 - assumes a 46 percent decrease in the leachate that needs to be hauled annually based on current conditions at the site.

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009.
2. Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..
3. Greenhouse Gas Potential for CH4 taken from IPCC (2006). Greenhouse Gas Potential for N2O taken from IPCC Third Assessment Report (2001).
4. For every pound of methane combusted there are 2.75 pounds of carbon produced.
5. Utility usage reported by We Energies.
6. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.
7. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

Refuse Hideaway Landfill Site Specific Sustainable Remediation System Evaluation

Prepared for:
Wisconsin Department of Natural Resources
Remediation and Redevelopment Program
101 South Webster Street
Madison, WI 53703

Prepared by:
AECOM
Project No. 60134224(107343)

May 2011

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Appendix

LIST OF ABBREVIATIONS

BTU/kWh	British thermal unit per kilowatt hour
BTU/scf	British thermal unit per standard cubic foot
CO_2e	carbon dioxide equivalents
DOE	Department of Energy
HDPE	high density polyethylene
hp	horse power
kg	kilograms
kW	kilowatt
kWh	kilowatt hours
kWh/yr	kilowatt hour per year
LBG	Leggette, Brashears & Graham, Inc.
LFG	landfill gas
LP	liquid propane
m	meter
m^2	square meters
m^3	cubic meters
m^3/yr	cubic meters per year
MMSD	Madison Municipal Sewage District
O&M	operation and maintenance
psig	pounds per square inch gauge
PV	photovoltaic
PVC	polyvinyl chloride
RHD	Refuse Hideaway Landfill
RPO	Remedial Process Optimization
scfm	standard cubic feet per minute
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOCs	volatile organic compounds
W/m^2	watt per square meter
WDNR	Wisconsin Department of Natural Resources

1.0 INTRODUCTION

The purpose of this document is to provide a Site Specific Sustainable Remediation System Evaluation for the Refuse Hideaway Landfill (RHL) site located at 7562 U.S. Highway 14 in Middleton, Wisconsin (Figure 1). To evaluate current site conditions and the effects of any potential changes, a sustainability baseline was created that quantifies the current system's sustainability and provides the starting point from which the effect of any changes to the system/remedy can be measured. The sustainability baseline includes current carbon footprint, energy usage, current operational costs, and contaminant mass removal. Once the baseline was completed, a limited Remedial Process Optimization (RPO) study was conducted to identify major items that could be addressed to improve the sustainability and efficiency of the existing remedial system, and to reduce operation and maintenance (O&M) costs. An alternative energy evaluation was also conducted to determine if alternative energy could be used to offset current energy usage at the site.

Potential sustainable activities/alternatives were identified during the RPO and alternative energy evaluations that increase the sustainability of the remediation system by increasing the efficiency of the existing system, decreasing operation costs or decreasing the overall environmental footprint of the remediation. These activities/alternatives were vetted for potential application at the site. Three best sustainable alternatives were selected and a sustainability matrix was generated, outlining each activity's costs and benefits in terms of various sustainability metrics, such as the increase or decrease in carbon footprint, energy usage, resource usage, waste generation, and cost. The sustainability matrix will provide and quantify effects of the potential changes in relation to the sustainability metrics.

This document used information supplied by the Wisconsin Department Natural of Resources (WDNR), including utility and operation and maintenance costs, monitoring reports and as-builts, where available; a site walkthrough, and interviews with the WDNR site project manager. Due to the site's age, information was sometimes limited.

2.0 Site Description

The RHL site is a former municipal landfill that operated for 14 years, from approximately 1974 to 1988. The landfill accepted a variety of municipal, commercial, and industrial wastes, including barrels of glue and paint, barrels of ink and ink washes, spray paint booth by-products and paint stripper sludge, and spill residues containing volatile organic compounds (VOCs). The current landfill property is approximately 40 acres in size. Of the 40 acres, an estimated 23 acres was waste fill area containing an estimated 1.2 million cubic yard landfill. The topography of the landfill parcel varies extensively. Bluffs are present along the north and west sides and along a portion of the east side of the landfill. Ground elevation at the site drops as much as approximately 200 feet toward the south and east sides of the parcel. Surface drainage generally flows to the south and east. The landfill is generally bordered by agricultural land with a wetland area located southeast of the site. A site location map is shown on Figure 1.

The landfill was constructed with no liner, leaving the existing sandy soils and sandstone bedrock beneath the site exposed to contaminants leaching from the landfill. A 2-foot clay cap with a 2- to 3-foot soil cover was completed over the landfill in 1990. The landfill cover is well vegetated with grass and is generally open space. The remedial system is shown on Figure 2. The landfill flare is shown on Figure 3.

The remedial system includes a landfill gas (LFG) and leachate collection system. The LFG flare station and small equipment buildings are located along the property's east central area. The leachate loading area is located along the access road and includes a concrete pad with a drain piped back to a leachate underground storage tank (UST). The flare station is surrounded by chain link fence with a locked access gate. The locked equipment/storage buildings are located adjacent to the flare station.

A review of the United States Environmental Protection Agency (USEPA) National Priorities List Site Narrative for Refuse Hideaway Landfill identifies the site owner as "John W. Debeck (deceased) – No Owner." Site remediation efforts are 100 percent state funded.

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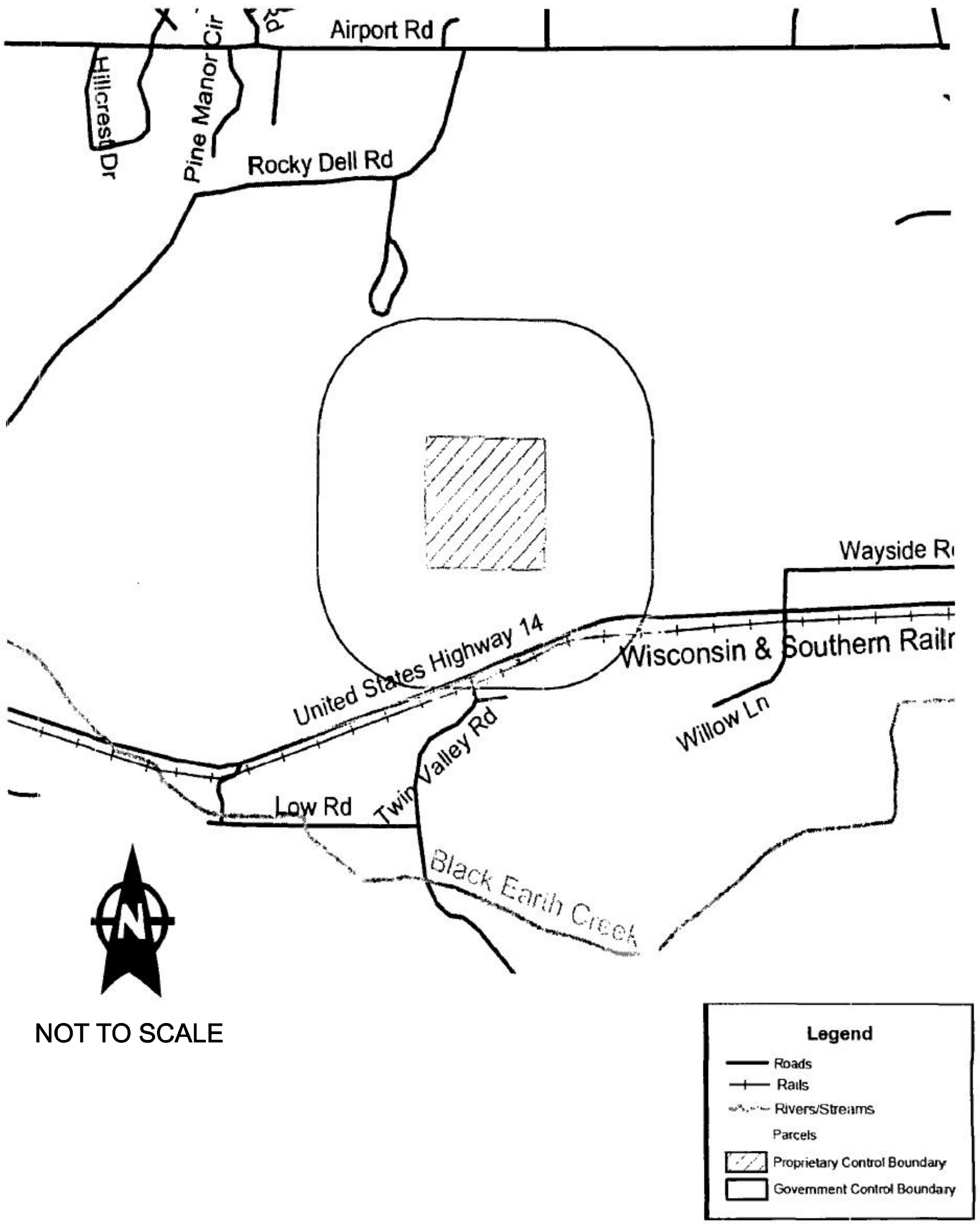

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FIGURE 1

SITE LOCATION MAP
SITE SPECIFIC
REMEDIATION SYSTEM EVALUATION

WDNR, REMEDIATION AND REDEVELOPMENT DIVISION
REFUSE HIDEAWAY LANDFILL

FILE NAME:	DRN	PROJECT NO.	DATE	FIGURE NO.
Figure 1.dgn	ALB	107343	MAY 2011	1

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FIGURE 2

VIEW OF REMEDIATION SYSTEM
SITE SPECIFIC
REMEDIATION SYSTEM EVALUATION

WDNR, REMEDIATION AND REDEVELOPMENT DIVISION
REFUSE HIDEAWAY LANDFILL

FILE NAME:	DRN	PROJECT NO.	DATE	FIGURE NO.
Figure 2.dgn	ALB	107343	MAY 2011	2

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FIGURE 3

VIEW OF LANDFILL FLARE
SITE SPECIFIC
REMEDIATION SYSTEM EVALUATION

WDNR, REMEDIATION AND REDEVELOPMENT DIVISION
REFUSE HIDEAWAY LANDFILL

FILE NAME:	DRN	PROJECT NO.	DATE	FIGURE NO.
Figure 3.dgn	ALB	107343	MAY 2011	3

3.0 CURRENT CONDITIONS

The current remedial approach at the RHL site consists of landfill gas and leachate capture with an LFG extraction and leachate collection system, and long-term groundwater monitoring for natural attenuation of contaminants in groundwater. Off-site remedial actions include providing point of entry treatment systems for two private wells.

Current site information, presented below, is a summary of data provided by the WDNR project manager during the site walkthrough and responses to questions. The USEPA “Five Year Review Report[1], dated September 2007, was also used as a source of information for this report.

The landfill gas monitoring system consists of 22 gas probes (labeled GP-1 through GP-24, with probes GP-14 and GP-15 not noted on the site maps) located along the perimeter of the landfill. The Five Year report notes that:

- Monthly monitoring for landfill gas in soil is conducted at 13 gas monitoring wells and ambient air monitoring locations around and outside of the landfill.
- Gas monitoring occurs at 11 locations on-site.
- Methane is generally not detected in the gas probes surrounding the landfill, with the exception of seasonal low-concentration detections in one or several probes located at the southwest corner of the landfill.

The Five Year report summarizes that landfill gas is migrating a short distance in one area and only seasonally from the landfill.

The LFG collection system consists of 13 vertical LFG extraction wells connected to a three-branched common header pipe system. The LFG extraction wells extend to the base of the landfill, approximately 36 to 81 feet below ground surface.

The three-branched header pipe system covers the northern, central, and southern areas of the landfill. LFG is drawn from the extraction wells to the flare station via below grade high density polyethylene (HDPE) piping by vacuum created from a 10 horse power (hp) New York blower. Where the HDPE pipe extends above the ground surface, it transitions to polyvinyl chloride (PVC) piping. Four drip legs, associated with the header piping system, remove condensate from the LFG and gravity drains it to the leachate collection system.

A Linklater Corporation fully enclosed ground flare burns the LFG. An automated control valve and flame arrestor are located between the blower and flare. A thermocouple control at the flare controls the LFG blower in the event the flame at the flare goes out. A telemetry system is activated when an alarm condition exists in the system. Flow is approximately 650 standard cubic feet per minute (scfm).

[1] Five Year Review Report, Refuse hideaway Landfill Superfund Site, Middleton Wisconsin. Wisconsin Department of Natural Resources. Dated September 18, 2007.

A single 150-gallon (estimated size) liquid propane (LP) tank supplies propane gas to the flare to ignite the flare, when necessary. The WDNR project manager reported that this tank has only been filled twice in the last 11 years. The Five Year Report notes that influent methane gas levels measured from July 2003 through June 2006 at the flare station ranged from approximately 23 to 38 percent, with a collection efficiency of 80 to 88 percent.

The most recent data was collected and documented by Leggette Brashears & Graham, Inc. (LBG) in their Operation and Maintenance Annual Report – July 2009 Through June 2010[2], and indicates the average methane gas level at the ground flare was 31.5 percent during the period of November 2009 through January 2010. Review of the historical seasonal fluctuations and data ranges reported by LBG suggests this is an accurate representation of methane gas levels at the ground flare for the year 2010.

Leachate is collected from nine of the 13 gas extraction wells. These nine wells are dual purpose gas extraction and leachate recovery wells. Pneumatic leachate pumps remove the leachate from the wells and convey it through HDPE piping to a 25,000-gallon, double walled UST. The UST is located adjacent to a concrete loading pad.

Leachate is picked up in 5,000-gallon loads several times a month. The UST is reported to be emptied by vacuum truck before it becomes half-full, which means it is pumped out an average of one to two times per week. The Five Year report indicates that between 75,000 and 232,000 gallons of leachate are removed per year, depending on seasonal weather conditions and precipitation. Leachate is transported to the Madison Metropolitan Sewerage District (MMSD) treatment plant, located approximately 15 miles to the southeast of the site. According to LBG, 469,239 gallons of leachate were removed from the site in 2010.

The Five Year report notes that the leachate collection system is successful in capturing leachate and its contaminants, making them unavailable for migration from the landfill.

There are two remedial equipment sheds onsite. One houses the LFG extraction blower and the other houses the leachate extraction equipment.

The LFG extraction blower shed is approximately 10 x 10 feet in size and wood construction without insulation. There are three louver vents and one turbine roof vent on the building. It houses a 10 hp New York LFG extraction blower with associated piping.

The leachate extraction equipment is housed in an approximately 10 x 10-foot prefabricated insulated metal frame shed. There are two louver vents and one turbine roof vent on the building. It houses a Curtis Toledo two-stage, 15 hp, air compressor with a 120-gallon tank to supply air to the pneumatic leachate pumps and a Hankenson dessicant air dryer to condition the air going to the pumps.

The Five Year review notes that the site's average annual costs are approximately $100,000, but fluctuate depending on the degree of operation and maintenance that occurs during a year.

[2] Operation and Maintenance Annual Report – July 2009 Through June 2010, Refuse Hideaway Landfill, 7562 U.S. Highway 14, Middleton, Wisconsin 53562. Leggette, Brashears & Graham, Inc. September 2010.

4.0 BASELINE EVALUATION

A baseline analysis was conducted for the Refuse Hideaway Landfill site. The baseline is a quantification of current site conditions using various sustainability metrics. This allows costs and benefits of potential changes to the system to be measured, using the same set of sustainability metrics.

4.1 CARBON FOOTPRINT

The primary contaminants of concern at RHL are methane gas, leachate, and VOCs. The site is currently in a long-term O&M mode. An analysis of site operations has identified applicable items associated with Scope 1 (direct discharge), Scope 2 (electricity), and Scope 3 (other indirect) at the site.

Scope 1 items identified at the site are propane usage for the flare station and methane in the LFG combusted by the flare station. Based on data from the USEPA's Landfill Gas Emissions Model (LandGEM), the landfill produced approximately 2,716,000 cubic meters (m^3) of LFG in 2010. According to LBG, influent methane concentrations averaged approximately 31.5 percent at the flare station from November 2009 to January 2010. This equates to approximately 856,000 cubic meters per year (m^3/yr) of methane discharged, with the balance comprised of carbon dioxide, oxygen, and other organic compounds. Based on the Five Year Review, 80 to 88 percent of methane is captured by the LFG system. The flare was only running 53 percent of the time that the blower was running, resulting in slightly more than half of the methane captured by the LFG system being destroyed. Approximately 23 pounds of propane are used to supplement the flare station annually.

Scope 2 items consist of electricity consumed by the leachate collection system and flare station. This information was provided by the WDNR.

Scope 3 items consist of fugitive methane escaping from the landfill; methane released while the blower is running, but the flare is not; diesel fuel consumed by trucks used to haul leachate; and unleaded gas used by O&M personnel at the site. Based on data from the Five Year Review, 80 to 88 percent of the methane produced is captured by the landfill gas system. For Scope 3, it was assumed that 20 percent of the LFG escaped due to imperfections in the landfill cap. During 2010, LBG reported the flare was running only 53 percent of the time the blower was running. This resulted in LFG escaping through the landfill gas system without being destroyed 47 percent of the time the blower was running. It was also assumed that, during 2010, 119 site visits were required for site sampling and O&M activities at 16 miles per visit (roundtrip), four site visits were required for WDNR inspections at 22 miles per visit (roundtrip), and leachate was hauled off-site 94 times (when tank is approximately 5,000 gallons full) at 30 miles per round trip.

To calculate fugitive methane emissions, the volume of methane being generated by the landfill, the LandGEM was used. Because limited historical information is available for the landfill site, several assumptions were made to use LandGEM. The assumptions for the RHL site and the LandGEM output are included in Appendix A.

The total annual carbon footprint generated by the RHL site is estimated to be 10,549 tons carbon dioxide equivalents (CO_2e). The carbon footprint analysis is included in Appendix B.

4.2 ENERGY

Electric service at the site is provided by Madison Gas and Electric Company, and is required to operate the remedial system components and provide lighting, heating, cooling, and ventilation to the buildings.

According to the WDNR, 43,039 kilowatt hours (kWh) of electricity were used at the site during 2010 for a total cost of $5,742 or approximately $480 per month. This corresponds to approximately $0.133 per kWh.

4.3 OPERATIONAL COSTS

In additional to the electrical services discussed above, other operation costs associated with the LFG and leachate system operation and monitoring include leachate transport and disposal, subcontractor costs, plowing, supply and equipment costs, telephone service, WDNR management costs, and LP gas. The Five Year review noted the annual average total costs for the site was approximately $100,000.

The WDNR currently has a contract with the MMSD to dispose leachate collected from the landfill at a cost of $7.31 per 1,000 gallons. Leachate is transported by Madison-Odana. The total costs for the 94 trips to dispose 469,000 gallons of leachate during the 12-month period between July 2009 and June 2010 was $3,428. Year round access is required to maintain the site, as leachate is removed two to six times per month. Plowing is required during winter months, with costs highly variable, depending on snowfall amounts. Telephone charges from TDS Utilities are $27 per month. The liquid propane tank has been filled twice in the past 11 years at a minimal cost.

Site sampling and O&M activities are performed by LBG. Private sampling activities are performed by BT2, Inc. Sampling costs were not provided for this report.

4.4 CONTAMINANT MASS REMOVAL

The contaminants of concern at RHL are methane gas produced by the landfill waste and leachate. Based on data from the LandGEM model, the landfill produced approximately 2,716,000 m^3 of LFG during 2010. Influent methane concentrations averaged approximately 31.5 percent at Sample Port A of the flare station from November 2009 to January 2010. Based on these values, approximately 856,000 m^3/yr of methane gas are discharged, with the balance comprised of carbon dioxide, oxygen, and other organic compounds.

During 2010, 469,000 gallons of leachate were removed from the site and transported to the MMSD treatment plant approximately 15 miles southeast of the site.

5.0 LIMITED REMEDIAL PROCESS OPTIMIZATION STUDY

RPO is a specific process that examines overall system effectiveness, including incremental changes or system replacement to include considerations of new technologies and alternative regulatory approaches. Optimization must be implemented within the confines of the existing decision document for the site.

The purpose of the limited RPO study is to identify possible changes to the site or remedial system that would significantly improve the system with regards to overall remedial sustainability. This includes decreasing the costs of operating the system and/or increasing the efficiency of contaminant mass removal. The limited RPO study is based on the current conditions previously noted in this document.

The following RPO recommendations were based on the assumption that the current technology will continue to be employed as the remedy at the site for 25 years. This is an arbitrary value selected for the purpose of comparing remedial options.

5.1 LFG SYSTEM BALANCING

Many older LFG collection systems, such as the one at Refuse Hideaway, were designed for a condition that existed at the time that the system was installed. The LFG generation rate declines as the landfill ages. If operating the LFG collection system is not balanced to account for the declining methane production, the LFG collection system may pull too hard and draw air into the LFG system through the cover or through defects in the LFG system, such as deteriorated well seals, broken pipe, cracked hose, or leaky pipe joints. This ultimately causes a decrease in the volume of landfill gas being removed from the landfill. It is recommended that the system be rebalanced to improve efficiency of the LFG collection system and raise the concentration of methane collected by the system. It is estimated that it would take approximately 20 visits to the site over a 4- to 6-week period to rebalance the system to current conditions. It is estimated that this would cost approximately $15,000 to $25,000 to complete the rebalancing. Some modifications to the site vacuum blower may be required to complete the rebalancing. This could also increase the LFG quality (methane content). Balancing the system may also help prevent some of the frequent flare issues/outages at the site. An increase in LFG quantity and quality would be required to make the methane to energy alternatives viable at the site.

5.2 LFG SYSTEM PERFORMANCE

LBG's Annual Report indicated that the blower was working 67 percent of the time and the flare was working 33 percent of the time. While the blower was working without being combusted by the flare, an estimated 230,000 kilograms (kg) of methane gas was directly released to the atmosphere. This is equivalent to 6.33 tons of CO_2 emitted to the atmosphere and approximately 60 percent of the total emissions for the site. It is recommended that the LFG system be repaired to maximize system performance. It is estimated that repairing the system would cost $10,000 to $15,000.

5.3 EVALUATE FLARE

The flare currently operating at RHL was designed for the conditions that existed at the site when the flare was installed. The LFG generation rate declines as the landfill ages. At this time, it would be relevant to evaluate other alternatives to the flare, including whether a candlestick flare or other technologies that use the methane gas for energy generation may be more appropriate remedial options, based on current site conditions.

Another option is to evaluate the current flare to determine if running it on a schedule would provide a more acceptable level of performance and more efficient combustion. This could be achieved by using a timer with the flare station. The estimated cost to purchase and install a timer is approximately $1,000 to $5,000.

5.4 EVALUATE CONDITION AND OPERATION OF PNEUMATIC PUMPS

The Five Year Review indicated that seven leachate pumps and one new pneumatic leachate pump were installed in 2005 and 2006. The seven leachate pumps were cleaned due to significant scale that accumulated during more than 10 years of use. When the pumps were reinstalled, they were still not functional. The pumps were then replaced. In addition, a pneumatic pump at Extraction Well GW-10 was installed to accommodate the greater than expected leachate build-up.

The O&M Annual Report, prepared by LBG, indicated that numerous repairs and troubleshooting activities were performed during the 2009-2010 operating year. Eight groundwater pumps required maintenance during the year and, according to the report, the pump at Extraction Well GW-13 was still malfunctioning. The manufacturer was contacted for additional support. The pump at Extraction Well GW-7 is lodged in the well and removal is not possible.

It is unclear whether additional pump repair or replacement would further optimize the LFG extraction system.

5.5 LEACHATE EVAPORATION OR WATERING

LFG can be used to evaporate leachate, reducing or eliminating the cost of off-site leachate disposal. Specially designed leachate evaporators can be purchased; however, enclosed LFG flares have also been successfully modified to accomplish leachate evaporation. Based on the volume and quality of LFG being collected from the site, an on-site leachate evaporation system may be able to handle approximately 1,500 gallons of leachate per day. The O&M Annual Report indicated that 469,239 gallons of leachate were collected for the year. This equals an average of 1,285 gallons of leachate per day or approximately 86 percent capacity of the leachate evaporation system.

Due to the cost of installing a leachate evaporator or a specially modified enclosed flare, it is not economical to install leachate evaporation equipment. It is estimated that a leachate evaporation system would cost approximately $1,000,000 to $1,200,000.

A modified enclosed flare could be installed to accomplish leachate reduction also. A study is needed to determine how much leachate could be reduced using this method. The estimated cost for the modified flare is between $125,000 and $200,000.

An alternative to evaporation is using the leachate to water the vegetation on the landfill during the May through October period, providing analytical results indicated that the leachate contains no contaminants of concern. Setting up a watering system would cost approximately $5,000.00 to $10,000.

6.0 ALTERNATIVE ENERGY ANALYSIS

An alternative energy analysis was conducted at the RHL site. The analysis includes evaluating various methane-to-energy alternatives, solar power, and wind power.

6.1 METHANE GAS TO ENERGY

The most significant concern for any use of the collected LFG, including flaring, is the methane content of the LFG, previously stated to average 31.5 percent methane by volume. To ensure complete combustion, and ensuring that emissions to the air are minimized, federal regulations (40 CFR 60.18 (c)(3)(ii)) require that flare fuel gas must have a minimum heat value of 200 British thermal unit per standard cubic foot (BTU/scf) or approximately 20 percent methane by volume.

Methane concentrations at the site exceed the threshold needed to convert methane to energy; however, concentrations in the LFG are likely elevated due to the intermittent operation of the LFG extraction system. Typically, as a landfill ages, the operation of the LFG collection system must be modified, if possible, to accommodate the declining LFG generation rate. If this is not accomplished, the LFG collection system will pull in air through the landfill cover or from the edges of the landfill and waste mass or through defects in the LFG collection system, such as failed well seals, broken pipe, cracked hose, or leaky joints. Initially, this air intrusion simply dilutes the LFG. However, prolonged periods of air intrusion can inhibit the anaerobic decomposition of the waste in the landfill, and slow or stop LFG generation. Air intrusion also presents the risk of subsurface oxidation in the landfill.

If the methane content of the LFG is sufficient (generally greater than 35 to 40 percent methane by volume), the LFG can be used for one or more beneficial purposes. Potential end uses of LFG include:

- Flaring to destroy hazardous air pollutants
- Generating electric power for internal (on landfill) use
- Generating electric power for export to the utility grid
- Direct use as a low to medium BTU fuel gas (e.g., as a boiler fuel to reduce the use of natural gas)
- Produce pipeline quality gas
- Compressed or liquefied gas vehicle fuel

Generally, any of these uses require a minimum methane content of approximately 35 to 45 percent by volume. Unless the methane content of the LFG can be improved (increased to at least 40 percent by volume), the only viable LFG utilization alternative for this site will be flaring. If the quality of the collected LFG can be improved sufficiently by reducing air intrusion, then beneficial use of the LFG can be considered. Each of the various LFG beneficial use scenarios is described briefly in the following paragraphs.

There are several different types of equipment used to generate electric power with LFG. These include reciprocating engines, microturbines, Stirling engines, and turbines. The primary difference between these systems is the amount of LFG they consume and the amount of electric power they produce. For example:

- LFG fueled microturbines generally provide approximately 20 to 250 kilowatt (kW) of generating capacity, consume approximately 6,750 to14,500 British thermal units per kilowatt hour (BTU/kWh), require a minimum fuel heat value of approximately 350 BTU/scf, require LFG drying and siloxane removal, and may require LFG compression to about 85 pounds per square inch gauge (psig) and sulfur removal. LFG, at 20 percent methane, has a heat value of approximately 200 BTU/scf. Heat recovery systems can significantly increase the thermal efficiency of microturbine based systems.

  The site has an average electric demand of approximately 4.9 kW. To account for peak demand, an output of 10 to 15 kW may be required. Therefore, one microturbine should be able to generate sufficient power to operate the on-site LFG and leachate collection systems. Any power generated that was not used on-site would be exported to the utility grid and would generate income for the state. However, unless it can be demonstrated that the methane content of the LFG can be increased to at least 35 percent by volume, generating electric power using microturbines will not be considered further.

- Stirling engines generally provide 30 to 50 kW of generating capacity, consume about 9,600 BTU/kWh, require a minimum fuel heat value of approximately 350 BTU/scf, require only low pressure (less than 2 psig) compression, and do not require LFG drying, sulfur removal, and siloxane removal. Heat recovery systems can significantly increase the thermal efficiency of Stirling engine based systems.

  The site has an average electric demand of approximately 4.9 kW. To account for peak demand, an output of 10 to 15 kW may be required. Therefore, one Stirling engine should be able to generate sufficient power to operate the LFG and leachate collection systems. Any power generated that was not used on-site would be exported to the utility grid and would generate income for the state. However, unless it can be demonstrated that the methane content of the LFG can be increased to at least 35 percent by volume, generating electric power using Stirling engines will not be considered further.

- Reciprocating engines provide approximately 250 to 1,600 kW of generating capacity. The engines generally require a minimum fuel heat value about 400 BTU/scf, require only low pressure (less than 2 psig compression), and may not require LFG drying, sulfur removal, and siloxane removal. Heat recovery systems can significantly increase the thermal efficiency of reciprocating engine based systems.

  The site does not collect enough LFG to economically operate a reciprocating engine. Unless it can be demonstrated that the methane content of the LFG can be increased to at least 40 percent by volume, generating electric power using a reciprocating engine will not be considered further.

- Turbines generally provide 700 to 21,000 kW of generating capacity, consume 8,700 to 14,100 BTU/kWh, require a minimum fuel heat value of approximately 400 BTU/scf and high pressure (greater than 200 psig) compression, and may not require LFG drying, and siloxane removal. Heat recovery systems can significantly increase the thermal efficiency of turbine based systems.

The site does not collect enough LFG to operate a turbine. Unless it can be demonstrated that the methane content of the LFG can be increased to at least 40 percent by volume, generating electric power using turbines will not be considered further.

Most landfills generate more LFG than can be used on-site, except when a flare or leachate evaporation system is installed. Therefore, off-site sale of the LFG or the power generated using the LFG is often considered. When there is an end user of gas within approximately 6 to 12 miles of the site, it is often most economical to sell the LFG for fuel to reduce the end users' consumption of natural gas or propane. This is due to the fact that there is generally less capital equipment and ongoing O&M expense associated with direct use than with other alternatives.

Although there are several commercial establishments located north and east of the site, their primary load would be seasonal heating. During the summer, they would likely not have need for the LFG, so the site would have to maintain and operate the existing LFG flare as a back-up system.

Manufacturing pipeline quality gas from LFG typically requires the raw LFG to have less than 0.2 percent oxygen and less than 3 percent nitrogen. This is very high quality LFG. The existing LFG system is estimated to be collecting gas that is approximately 2 to11 percent oxygen and 50 to 80 percent nitrogen. Even if the performance of the site LFG collection system can be improved to minimize air intrusion, it is unlikely that the improved LFG could qualify as pipeline quality gas; therefore, this alternative will not be considered further.

Manufacturing compressed or liquefied vehicle fuels, or chemical feed stocks, requires the same equipment needed to produce pipeline quality gas. This equipment is expensive to purchase, and to operate and maintain. This alternative generally requires a large landfill producing high quality LFG to develop a cost-effective project. In addition, the vehicle fuel alternatives require a fleet that has been converted to operate on compressed gas or non-petroleum liquid fuels. This site is relatively isolated from a state-owned vehicle pool, and it may be difficult to convince others, who are not involved with this project, to convert their vehicles. Therefore, vehicle fuels will not be considered further for this project.

6.2 SOLAR ENERGY

A 10 kW photovoltaic (PV) solar array was installed to the east of the blower station in the fall of 2009. The site was chosen for a pilot project because it is a south facing site with high public visibility. The PV array consists of 44 PV solar panels. Electricity produced is directly connected to the grid with no battery backup. The project is a partnership between the WDNR and the United States Department of Energy (DOE) to research the use of renewable energy to power the cleanup of contaminated sites. The total project cost was approximately $100,000, paid for by a combination of a grant from Wisconsin Focus on Energy, federal research funding, and the Wisconsin Environmental Fund. It is estimated that the electricity produced will save the State 25 percent of the approximately $6,000 in electricity costs the site uses every year to power the decontamination process.

Security on the unsecured site is a major concern, but has not been an issue at the time of this report.

6.3 WIND ENERGY

The Wisconsin Focus on Energy Wind Resource Map indicates that, in the vicinity of the site, the wind power density at an altitude of 40 meters (m) is 100 to 200 watts per square meter (W/m^2). The average electric power consumption on-site is approximately 43,039 kilowatt hours per year (kWh/yr) or approximately 4.9 kW. A wind turbine with a constant output of approximately 6 kW could meet the site's average demand. To account for peak demand and to generate power to be stored for periods when the wind turbine cannot meet the average demand, two to three times that much output, or approximately 15 to 20 kW, would be required. From the wind resource map, a wind turbine with a swept area of approximately 150 to 200 square meter (m^2), or a blade diameter of about 14 to 16 m, would meet the average demand. Any power generated that was not used or stored on-site would be exported to the utility grid and would generate income for the State.

The site is in a valley surrounded by bluffs and trees. This would greatly diminish the actual wind density at the site. Therefore, wind energy as an alternative will not be considered further.

7.0 POTENTIAL SUSTAINABLE ACTIVITIES

Implementing the recommended RPOs will result in a more effective and efficient remedial system and achieve quicker results at a lower cost (i.e., sustainable). In addition to the items mentioned in the RPO section of this document, some additional sustainable activities that may be considered are discussed below.

7.1 IMPROVEMENTS TO FLARE SYSTEM

As mentioned in the limited RPO study, 60 percent of the greenhouse gas emissions at the site are a result of inefficiencies in the flare system. The flare system should be improved so the flare is running whenever the blower operates. This could be done by scheduling the flare system using a timer so the flare/blower systems are only running for a portion of the day or redesigning the flare to run using with a lower methane flow.

7.2 INCREASE SOLAR ENERGY GENERATION

As discussed earlier, the WDNR has partnered with the DOE to conduct a pilot PV solar study. The current PV array does not produce enough electricity to support all of the site's electricity needs. Feasibility studies of the pilot project have already been conducted. Expanding the pilot project would require minimal additional assessment.

7.3 LEACHATE EVAPORATION OR WATERING

The leachate at RHL contains trace amounts of metals and VOCs. After reviewing the leachate sampling results from 2010, it has been determined that the leachate is of high enough quality to be used onsite instead of hauled to the MMSD. This would save diesel fuel burning and reduce greenhouse gas emissions. Possible activities include using the leachate to water the landfill cap or releasing the leachate for evaporation.

8.0 SUSTAINABILITY MATRIX

A sustainability matrix was created that compared sustainability metrics for the current operational baseline to three potential modifications that could be made to the system. The selected options were improving the methane flare, increasing solar energy generation, and evaporating the leachate or using the leachate for watering. Alternative energy (methane to energy) alternatives were not included in the matrix because these technologies are not viable, given the current LFG quality. This could change if some of the RPO recommendations are implemented. The sustainability matrix for the Refuse Hideaway site is presented in Table 1.

The best or most applicable sustainable alternative at the site may be a combination of the proposed options.

AECOM

Table 1
Sustainability Matrix - Refuse Hideaway Landfill

	Baseline[3]		Option 1 Flare System Improvements		Option 2 Increase Solar Energy Generation		Option 3 Leachate Evaporation or Watering	
Sustainability Metrics[1,2]	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**
Stewardship								
System Optimization (Qualitative)	Landfill gas system is removing 50 percent of landfill gas being generated.		Improved flare system would remove 100% of landfill gas in LFG extraction system (80% of total.)		Increased solar energy would provide 100% of landfill electricity needs.		Leachate will be evaporated or used for watering instead of being hauled to MMSD.	
Restoration Timeframe (yrs)	NA	25	NA	25	NA	25	NA	25
Emissions								
Tons CO_2e	10,549	263,730	4,884	122,105	10,549	263,725	10,545	263,631
Tons CO_2e from Combusted Methane	788	19,692	1,488	37,196	788	19,692	788	19,692
Tons CO_2e from LFG System Fugitive Methane	6,365	159,129	0	0	6,365	159,129	6,365	159,129
Energy Usage								
Electricity (kWh)	43,039	1,075,975	43,039	1,075,975	0	0	43,039	1,075,975
Propane (Pounds)	23	575	23	575	23	575	23	575
Cost								
O&M Cost (dollars)	$100,000	$2,500,000	$100,000	$2,500,000	$100,000	$2,500,000	$96,572	$2,414,300
Cost of Modification (dollars)	NA	NA	$1,000-5,000	$1,000-5,000	$200,000-300,000	$200,000-300,000	NA	NA
Cost per Ton CO_2e Reduced (dollars)[4]	NA	NA	$0.88	$0.04	$1,582,906.14	$63,316.25	NA	NA
Land & Ecosystems								
Community Benefits (qualitative)	NA		Reduction in fugitive methane emitted		Reduction in Scope 2 emissions - Purchased electricity		Reduction in leachate discharged to MMSD	
Materials & Waste Generation								
Leachate Generation (gallons)	469,239	11,730,975	469,239	11,730,975	469,239	11,730,975	469,239	11,730,975

[1] Metrics may be either qualitative not applicable (NA) or quantitative based on available information and scope of project.

[2] Metrics may be added or deleted based on site specific conditions.

[3] Baseline: As the system is currently being operated.

[4] Costs per Ton CO2e are based on higher Cost of Modification number listed.

* Assume upper limit costs are used for cost per ton CO_2e reduced.

MMSD: Madison Municipal Sewage District

APPENDIX A

LANDGEM ASSUMPTIONS AND ANALYSIS

Summary Report

Landfill Name or Identifier:

Date: Monday, February 28, 2011

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} k L_o \left(\frac{M_i}{10} \right) e^{-k t_{ij}}$$

Where,

Q_{CH_4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate *($year^{-1}$)*
L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year *(decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1974**	
Landfill Closure Year (with 80-year limit)	**1989**	
Actual Closure Year (without limit)	***1989***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**706,678**	*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**817**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1974	39,995	43,994	0	0
1975	40,904	44,994	39,995	43,994
1976	41,111	45,222	80,898	88,988
1977	41,772	45,949	122,009	134,210
1978	42,347	46,582	163,781	180,159
1979	40,999	45,099	206,128	226,741
1980	42,353	46,588	247,127	271,840
1981	42,646	46,911	289,480	318,428
1982	43,321	47,653	332,126	365,339
1983	43,715	48,087	375,447	412,992
1984	43,985	48,383	419,163	461,079
1985	44,402	48,842	463,147	509,462
1986	44,673	49,140	507,549	558,304
1987	44,844	49,328	552,222	607,444
1988	45,370	49,907	597,065	656,772
1989	0	0	642,435	706,679
1990	0	0	642,435	706,679
1991	0	0	642,435	706,679
1992	0	0	642,435	706,679
1993	0	0	642,435	706,679
1994	0	0	642,435	706,679
1995	0	0	642,435	706,679
1996	0	0	642,435	706,679
1997	0	0	642,435	706,679
1998	0	0	642,435	706,679
1999	0	0	642,435	706,679
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2001	0	0	642,435	706,679
2002	0	0	642,435	706,679
2003	0	0	642,435	706,679
2004	0	0	642,435	706,679
2005	0	0	642,435	706,679
2006	0	0	642,435	706,679
2007	0	0	642,435	706,679
2008	0	0	642,435	706,679
2009	0	0	642,435	706,679
2010	0	0	642,435	706,679
2011	0	0	642,435	706,679
2012	0	0	642,435	706,679
2013	0	0	642,435	706,679

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2014	0	0	642,435	706,679
2015	0	0	642,435	706,679
2016	0	0	642,435	706,679
2017	0	0	642,435	706,679
2018	0	0	642,435	706,679
2019	0	0	642,435	706,679
2020	0	0	642,435	706,679
2021	0	0	642,435	706,679
2022	0	0	642,435	706,679
2023	0	0	642,435	706,679
2024	0	0	642,435	706,679
2025	0	0	642,435	706,679
2026	0	0	642,435	706,679
2027	0	0	642,435	706,679
2028	0	0	642,435	706,679
2029	0	0	642,435	706,679
2030	0	0	642,435	706,679
2031	0	0	642,435	706,679
2032	0	0	642,435	706,679
2033	0	0	642,435	706,679
2034	0	0	642,435	706,679
2035	0	0	642,435	706,679
2036	0	0	642,435	706,679
2037	0	0	642,435	706,679
2038	0	0	642,435	706,679
2039	0	0	642,435	706,679
2040	0	0	642,435	706,679
2041	0	0	642,435	706,679
2042	0	0	642,435	706,679
2043	0	0	642,435	706,679
2044	0	0	642,435	706,679
2045	0	0	642,435	706,679
2046	0	0	642,435	706,679
2047	0	0	642,435	706,679
2048	0	0	642,435	706,679
2049	0	0	642,435	706,679
2050	0	0	642,435	706,679
2051	0	0	642,435	706,679
2052	0	0	642,435	706,679
2053	0	0	642,435	706,679

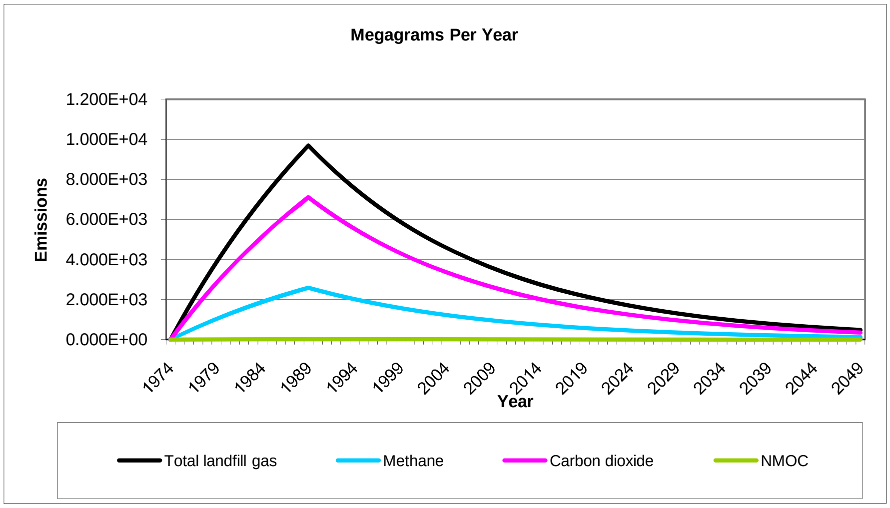
Pollutant Parameters

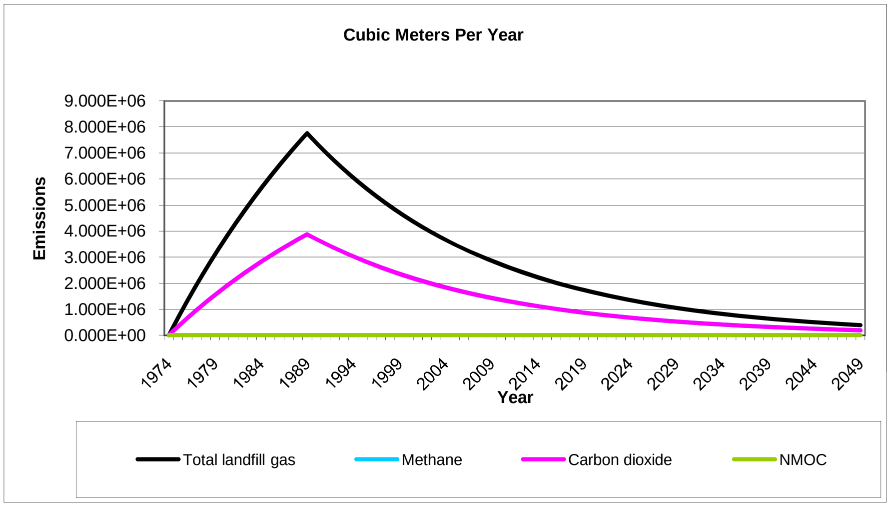
	Compound	Gas / Pollutant Default Parameters: Concentration (*ppmv*)	Molecular Weight	User-specified Pollutant Parameters: Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

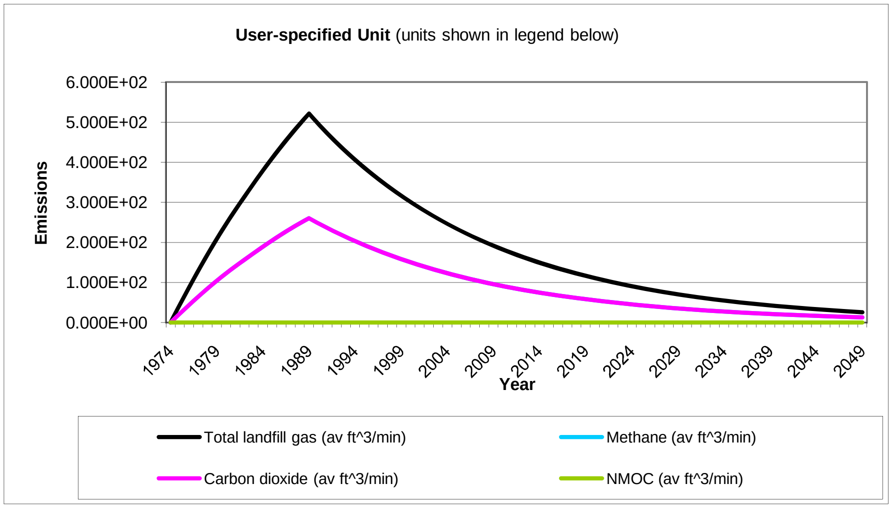
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
Emissions
1.200E+04
1.000E+04
8.000E+03
6.000E+03
4.000E+03
2.000E+03
0.000E+00
1974 1979 1984 1989 1994 1999 2004 2009 2014 2019 2024 2029 2034 2039 2044 2049
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
9.000E+06
8.000E+06
7.000E+06
6.000E+06
5.000E+06
4.000E+06
3.000E+06
2.000E+06
1.000E+06
0.000E+00
1974 1979 1984 1989 1994 1999 2004 2009 2014 2019 2024 2029 2034 2039 2044 2049
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+02
0.000E+00
1974 1979 1984 1989 1994 1999 2004 2009 2014 2019 2024 2029 2034 2039 2044 2049
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1974	0	0	0	0	0	0
1975	8.303E+02	6.648E+05	4.467E+01	2.218E+02	3.324E+05	2.234E+01
1976	1.639E+03	1.312E+06	8.818E+01	4.378E+02	6.562E+05	4.409E+01
1977	2.412E+03	1.932E+06	1.298E+02	6.444E+02	9.659E+05	6.490E+01
1978	3.162E+03	2.532E+06	1.701E+02	8.446E+02	1.266E+06	8.506E+01
1979	3.887E+03	3.112E+06	2.091E+02	1.038E+03	1.556E+06	1.046E+02
1980	4.548E+03	3.642E+06	2.447E+02	1.215E+03	1.821E+06	1.224E+02
1981	5.206E+03	4.169E+06	2.801E+02	1.391E+03	2.084E+06	1.400E+02
1982	5.837E+03	4.674E+06	3.141E+02	1.559E+03	2.337E+06	1.570E+02
1983	6.452E+03	5.166E+06	3.471E+02	1.723E+03	2.583E+06	1.736E+02
1984	7.045E+03	5.641E+06	3.790E+02	1.882E+03	2.821E+06	1.895E+02
1985	7.614E+03	6.097E+06	4.097E+02	2.034E+03	3.049E+06	2.048E+02
1986	8.165E+03	6.538E+06	4.393E+02	2.181E+03	3.269E+06	2.196E+02
1987	8.694E+03	6.962E+06	4.678E+02	2.322E+03	3.481E+06	2.339E+02
1988	9.201E+03	7.368E+06	4.950E+02	2.458E+03	3.684E+06	2.475E+02
1989	9.694E+03	7.763E+06	5.216E+02	2.589E+03	3.881E+06	2.608E+02
1990	9.221E+03	7.384E+06	4.961E+02	2.463E+03	3.692E+06	2.481E+02
1991	8.772E+03	7.024E+06	4.719E+02	2.343E+03	3.512E+06	2.360E+02
1992	8.344E+03	6.681E+06	4.489E+02	2.229E+03	3.341E+06	2.245E+02
1993	7.937E+03	6.355E+06	4.270E+02	2.120E+03	3.178E+06	2.135E+02
1994	7.550E+03	6.045E+06	4.062E+02	2.017E+03	3.023E+06	2.031E+02
1995	7.182E+03	5.751E+06	3.864E+02	1.918E+03	2.875E+06	1.932E+02
1996	6.831E+03	5.470E+06	3.675E+02	1.825E+03	2.735E+06	1.838E+02
1997	6.498E+03	5.203E+06	3.496E+02	1.736E+03	2.602E+06	1.748E+02
1998	6.181E+03	4.950E+06	3.326E+02	1.651E+03	2.475E+06	1.663E+02
1999	5.880E+03	4.708E+06	3.163E+02	1.571E+03	2.354E+06	1.582E+02
2000	5.593E+03	4.479E+06	3.009E+02	1.494E+03	2.239E+06	1.505E+02
2001	5.320E+03	4.260E+06	2.862E+02	1.421E+03	2.130E+06	1.431E+02
2002	5.061E+03	4.052E+06	2.723E+02	1.352E+03	2.026E+06	1.361E+02
2003	4.814E+03	3.855E+06	2.590E+02	1.286E+03	1.927E+06	1.295E+02
2004	4.579E+03	3.667E+06	2.464E+02	1.223E+03	1.833E+06	1.232E+02
2005	4.356E+03	3.488E+06	2.344E+02	1.163E+03	1.744E+06	1.172E+02
2006	4.143E+03	3.318E+06	2.229E+02	1.107E+03	1.659E+06	1.115E+02
2007	3.941E+03	3.156E+06	2.121E+02	1.053E+03	1.578E+06	1.060E+02
2008	3.749E+03	3.002E+06	2.017E+02	1.001E+03	1.501E+06	1.009E+02
2009	3.566E+03	2.856E+06	1.919E+02	9.526E+02	1.428E+06	9.594E+01
2010	3.392E+03	2.716E+06	1.825E+02	9.061E+02	1.358E+06	9.126E+01
2011	3.227E+03	2.584E+06	1.736E+02	8.619E+02	1.292E+06	8.681E+01
2012	3.069E+03	2.458E+06	1.651E+02	8.199E+02	1.229E+06	8.257E+01
2013	2.920E+03	2.338E+06	1.571E+02	7.799E+02	1.169E+06	7.855E+01
2014	2.777E+03	2.224E+06	1.494E+02	7.419E+02	1.112E+06	7.472E+01
2015	2.642E+03	2.116E+06	1.421E+02	7.057E+02	1.058E+06	7.107E+01
2016	2.513E+03	2.012E+06	1.352E+02	6.713E+02	1.006E+06	6.761E+01
2017	2.391E+03	1.914E+06	1.286E+02	6.385E+02	9.571E+05	6.431E+01
2018	2.274E+03	1.821E+06	1.223E+02	6.074E+02	9.104E+05	6.117E+01
2019	2.163E+03	1.732E+06	1.164E+02	5.778E+02	8.660E+05	5.819E+01
2020	2.058E+03	1.648E+06	1.107E+02	5.496E+02	8.238E+05	5.535E+01
2021	1.957E+03	1.567E+06	1.053E+02	5.228E+02	7.836E+05	5.265E+01
2022	1.862E+03	1.491E+06	1.002E+02	4.973E+02	7.454E+05	5.008E+01
2023	1.771E+03	1.418E+06	9.528E+01	4.730E+02	7.090E+05	4.764E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2024	1.685E+03	1.349E+06	9.063E+01	4.500E+02	6.745E+05	4.532E+01
2025	1.602E+03	1.283E+06	8.621E+01	4.280E+02	6.416E+05	4.311E+01
2026	1.524E+03	1.221E+06	8.201E+01	4.071E+02	6.103E+05	4.100E+01
2027	1.450E+03	1.161E+06	7.801E+01	3.873E+02	5.805E+05	3.900E+01
2028	1.379E+03	1.104E+06	7.420E+01	3.684E+02	5.522E+05	3.710E+01
2029	1.312E+03	1.051E+06	7.059E+01	3.504E+02	5.253E+05	3.529E+01
2030	1.248E+03	9.993E+05	6.714E+01	3.333E+02	4.997E+05	3.357E+01
2031	1.187E+03	9.506E+05	6.387E+01	3.171E+02	4.753E+05	3.193E+01
2032	1.129E+03	9.042E+05	6.075E+01	3.016E+02	4.521E+05	3.038E+01
2033	1.074E+03	8.601E+05	5.779E+01	2.869E+02	4.301E+05	2.890E+01
2034	1.022E+03	8.182E+05	5.497E+01	2.729E+02	4.091E+05	2.749E+01
2035	9.719E+02	7.783E+05	5.229E+01	2.596E+02	3.891E+05	2.615E+01
2036	9.245E+02	7.403E+05	4.974E+01	2.469E+02	3.702E+05	2.487E+01
2037	8.794E+02	7.042E+05	4.732E+01	2.349E+02	3.521E+05	2.366E+01
2038	8.365E+02	6.699E+05	4.501E+01	2.234E+02	3.349E+05	2.250E+01
2039	7.957E+02	6.372E+05	4.281E+01	2.125E+02	3.186E+05	2.141E+01
2040	7.569E+02	6.061E+05	4.072E+01	2.022E+02	3.031E+05	2.036E+01
2041	7.200E+02	5.766E+05	3.874E+01	1.923E+02	2.883E+05	1.937E+01
2042	6.849E+02	5.484E+05	3.685E+01	1.829E+02	2.742E+05	1.842E+01
2043	6.515E+02	5.217E+05	3.505E+01	1.740E+02	2.608E+05	1.753E+01
2044	6.197E+02	4.962E+05	3.334E+01	1.655E+02	2.481E+05	1.667E+01
2045	5.895E+02	4.720E+05	3.172E+01	1.575E+02	2.360E+05	1.586E+01
2046	5.607E+02	4.490E+05	3.017E+01	1.498E+02	2.245E+05	1.508E+01
2047	5.334E+02	4.271E+05	2.870E+01	1.425E+02	2.136E+05	1.435E+01
2048	5.074E+02	4.063E+05	2.730E+01	1.355E+02	2.031E+05	1.365E+01
2049	4.826E+02	3.865E+05	2.597E+01	1.289E+02	1.932E+05	1.298E+01
2050	4.591E+02	3.676E+05	2.470E+01	1.226E+02	1.838E+05	1.235E+01
2051	4.367E+02	3.497E+05	2.350E+01	1.166E+02	1.748E+05	1.175E+01
2052	4.154E+02	3.326E+05	2.235E+01	1.110E+02	1.663E+05	1.118E+01
2053	3.951E+02	3.164E+05	2.126E+01	1.055E+02	1.582E+05	1.063E+01
2054	3.759E+02	3.010E+05	2.022E+01	1.004E+02	1.505E+05	1.011E+01
2055	3.575E+02	2.863E+05	1.924E+01	9.550E+01	1.432E+05	9.618E+00
2056	3.401E+02	2.723E+05	1.830E+01	9.085E+01	1.362E+05	9.149E+00
2057	3.235E+02	2.591E+05	1.741E+01	8.642E+01	1.295E+05	8.703E+00
2058	3.077E+02	2.464E+05	1.656E+01	8.220E+01	1.232E+05	8.279E+00
2059	2.927E+02	2.344E+05	1.575E+01	7.819E+01	1.172E+05	7.875E+00
2060	2.785E+02	2.230E+05	1.498E+01	7.438E+01	1.115E+05	7.491E+00
2061	2.649E+02	2.121E+05	1.425E+01	7.075E+01	1.061E+05	7.126E+00
2062	2.520E+02	2.018E+05	1.356E+01	6.730E+01	1.009E+05	6.778E+00
2063	2.397E+02	1.919E+05	1.289E+01	6.402E+01	9.596E+04	6.447E+00
2064	2.280E+02	1.826E+05	1.227E+01	6.090E+01	9.128E+04	6.133E+00
2065	2.169E+02	1.737E+05	1.167E+01	5.793E+01	8.683E+04	5.834E+00
2066	2.063E+02	1.652E+05	1.110E+01	5.510E+01	8.259E+04	5.549E+00
2067	1.962E+02	1.571E+05	1.056E+01	5.241E+01	7.856E+04	5.279E+00
2068	1.867E+02	1.495E+05	1.004E+01	4.986E+01	7.473E+04	5.021E+00
2069	1.776E+02	1.422E+05	9.553E+00	4.743E+01	7.109E+04	4.776E+00
2070	1.689E+02	1.352E+05	9.087E+00	4.511E+01	6.762E+04	4.543E+00
2071	1.607E+02	1.286E+05	8.644E+00	4.291E+01	6.432E+04	4.322E+00
2072	1.528E+02	1.224E+05	8.222E+00	4.082E+01	6.119E+04	4.111E+00
2073	1.454E+02	1.164E+05	7.821E+00	3.883E+01	5.820E+04	3.911E+00
2074	1.383E+02	1.107E+05	7.440E+00	3.694E+01	5.536E+04	3.720E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2075	1.315E+02	1.053E+05	7.077E+00	3.513E+01	5.266E+04	3.538E+00
2076	1.251E+02	1.002E+05	6.732E+00	3.342E+01	5.009E+04	3.366E+00
2077	1.190E+02	9.530E+04	6.403E+00	3.179E+01	4.765E+04	3.202E+00
2078	1.132E+02	9.066E+04	6.091E+00	3.024E+01	4.533E+04	3.046E+00
2079	1.077E+02	8.623E+04	5.794E+00	2.877E+01	4.312E+04	2.897E+00
2080	1.024E+02	8.203E+04	5.511E+00	2.736E+01	4.101E+04	2.756E+00
2081	9.744E+01	7.803E+04	5.243E+00	2.603E+01	3.901E+04	2.621E+00
2082	9.269E+01	7.422E+04	4.987E+00	2.476E+01	3.711E+04	2.493E+00
2083	8.817E+01	7.060E+04	4.744E+00	2.355E+01	3.530E+04	2.372E+00
2084	8.387E+01	6.716E+04	4.512E+00	2.240E+01	3.358E+04	2.256E+00
2085	7.978E+01	6.388E+04	4.292E+00	2.131E+01	3.194E+04	2.146E+00
2086	7.589E+01	6.077E+04	4.083E+00	2.027E+01	3.038E+04	2.041E+00
2087	7.219E+01	5.780E+04	3.884E+00	1.928E+01	2.890E+04	1.942E+00
2088	6.867E+01	5.499E+04	3.694E+00	1.834E+01	2.749E+04	1.847E+00
2089	6.532E+01	5.230E+04	3.514E+00	1.745E+01	2.615E+04	1.757E+00
2090	6.213E+01	4.975E+04	3.343E+00	1.660E+01	2.488E+04	1.671E+00
2091	5.910E+01	4.733E+04	3.180E+00	1.579E+01	2.366E+04	1.590E+00
2092	5.622E+01	4.502E+04	3.025E+00	1.502E+01	2.251E+04	1.512E+00
2093	5.348E+01	4.282E+04	2.877E+00	1.428E+01	2.141E+04	1.439E+00
2094	5.087E+01	4.073E+04	2.737E+00	1.359E+01	2.037E+04	1.368E+00
2095	4.839E+01	3.875E+04	2.603E+00	1.293E+01	1.937E+04	1.302E+00
2096	4.603E+01	3.686E+04	2.476E+00	1.229E+01	1.843E+04	1.238E+00
2097	4.378E+01	3.506E+04	2.356E+00	1.170E+01	1.753E+04	1.178E+00
2098	4.165E+01	3.335E+04	2.241E+00	1.112E+01	1.668E+04	1.120E+00
2099	3.962E+01	3.172E+04	2.132E+00	1.058E+01	1.586E+04	1.066E+00
2100	3.769E+01	3.018E+04	2.028E+00	1.007E+01	1.509E+04	1.014E+00
2101	3.585E+01	2.870E+04	1.929E+00	9.575E+00	1.435E+04	9.643E-01
2102	3.410E+01	2.730E+04	1.835E+00	9.108E+00	1.365E+04	9.173E-01
2103	3.244E+01	2.597E+04	1.745E+00	8.664E+00	1.299E+04	8.726E-01
2104	3.085E+01	2.471E+04	1.660E+00	8.241E+00	1.235E+04	8.300E-01
2105	2.935E+01	2.350E+04	1.579E+00	7.839E+00	1.175E+04	7.895E-01
2106	2.792E+01	2.236E+04	1.502E+00	7.457E+00	1.118E+04	7.510E-01
2107	2.656E+01	2.127E+04	1.429E+00	7.093E+00	1.063E+04	7.144E-01
2108	2.526E+01	2.023E+04	1.359E+00	6.748E+00	1.011E+04	6.796E-01
2109	2.403E+01	1.924E+04	1.293E+00	6.418E+00	9.621E+03	6.464E-01
2110	2.286E+01	1.830E+04	1.230E+00	6.105E+00	9.151E+03	6.149E-01
2111	2.174E+01	1.741E+04	1.170E+00	5.808E+00	8.705E+03	5.849E-01
2112	2.068E+01	1.656E+04	1.113E+00	5.524E+00	8.281E+03	5.564E-01
2113	1.967E+01	1.575E+04	1.058E+00	5.255E+00	7.877E+03	5.292E-01
2114	1.871E+01	1.499E+04	1.007E+00	4.999E+00	7.493E+03	5.034E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1974	0	0	0	0	0	0
1975	6.085E+02	3.324E+05	2.234E+01	1.947E+00	5.432E+02	3.650E-02
1976	1.201E+03	6.562E+05	4.409E+01	3.843E+00	1.072E+03	7.204E-02
1977	1.768E+03	9.659E+05	6.490E+01	5.657E+00	1.578E+03	1.060E-01
1978	2.317E+03	1.266E+06	8.506E+01	7.415E+00	2.069E+03	1.390E-01
1979	2.849E+03	1.556E+06	1.046E+02	9.115E+00	2.543E+03	1.709E-01
1980	3.334E+03	1.821E+06	1.224E+02	1.067E+01	2.976E+03	1.999E-01
1981	3.815E+03	2.084E+06	1.400E+02	1.221E+01	3.406E+03	2.288E-01
1982	4.278E+03	2.337E+06	1.570E+02	1.369E+01	3.819E+03	2.566E-01
1983	4.729E+03	2.583E+06	1.736E+02	1.513E+01	4.221E+03	2.836E-01
1984	5.163E+03	2.821E+06	1.895E+02	1.652E+01	4.609E+03	3.097E-01
1985	5.580E+03	3.049E+06	2.048E+02	1.786E+01	4.981E+03	3.347E-01
1986	5.984E+03	3.269E+06	2.196E+02	1.915E+01	5.342E+03	3.589E-01
1987	6.372E+03	3.481E+06	2.339E+02	2.039E+01	5.688E+03	3.822E-01
1988	6.743E+03	3.684E+06	2.475E+02	2.158E+01	6.019E+03	4.044E-01
1989	7.105E+03	3.881E+06	2.608E+02	2.273E+01	6.342E+03	4.261E-01
1990	6.758E+03	3.692E+06	2.481E+02	2.162E+01	6.033E+03	4.053E-01
1991	6.429E+03	3.512E+06	2.360E+02	2.057E+01	5.738E+03	3.856E-01
1992	6.115E+03	3.341E+06	2.245E+02	1.957E+01	5.459E+03	3.668E-01
1993	5.817E+03	3.178E+06	2.135E+02	1.861E+01	5.192E+03	3.489E-01
1994	5.533E+03	3.023E+06	2.031E+02	1.770E+01	4.939E+03	3.319E-01
1995	5.263E+03	2.875E+06	1.932E+02	1.684E+01	4.698E+03	3.157E-01
1996	5.007E+03	2.735E+06	1.838E+02	1.602E+01	4.469E+03	3.003E-01
1997	4.762E+03	2.602E+06	1.748E+02	1.524E+01	4.251E+03	2.856E-01
1998	4.530E+03	2.475E+06	1.663E+02	1.449E+01	4.044E+03	2.717E-01
1999	4.309E+03	2.354E+06	1.582E+02	1.379E+01	3.847E+03	2.585E-01
2000	4.099E+03	2.239E+06	1.505E+02	1.312E+01	3.659E+03	2.458E-01
2001	3.899E+03	2.130E+06	1.431E+02	1.248E+01	3.481E+03	2.339E-01
2002	3.709E+03	2.026E+06	1.361E+02	1.187E+01	3.311E+03	2.225E-01
2003	3.528E+03	1.927E+06	1.295E+02	1.129E+01	3.149E+03	2.116E-01
2004	3.356E+03	1.833E+06	1.232E+02	1.074E+01	2.996E+03	2.013E-01
2005	3.192E+03	1.744E+06	1.172E+02	1.021E+01	2.850E+03	1.915E-01
2006	3.037E+03	1.659E+06	1.115E+02	9.716E+00	2.711E+03	1.821E-01
2007	2.889E+03	1.578E+06	1.060E+02	9.242E+00	2.578E+03	1.732E-01
2008	2.748E+03	1.501E+06	1.009E+02	8.792E+00	2.453E+03	1.648E-01
2009	2.614E+03	1.428E+06	9.594E+01	8.363E+00	2.333E+03	1.568E-01
2010	2.486E+03	1.358E+06	9.126E+01	7.955E+00	2.219E+03	1.491E-01
2011	2.365E+03	1.292E+06	8.681E+01	7.567E+00	2.111E+03	1.418E-01
2012	2.250E+03	1.229E+06	8.257E+01	7.198E+00	2.008E+03	1.349E-01
2013	2.140E+03	1.169E+06	7.855E+01	6.847E+00	1.910E+03	1.283E-01
2014	2.036E+03	1.112E+06	7.472E+01	6.513E+00	1.817E+03	1.221E-01
2015	1.936E+03	1.058E+06	7.107E+01	6.195E+00	1.728E+03	1.161E-01
2016	1.842E+03	1.006E+06	6.761E+01	5.893E+00	1.644E+03	1.105E-01
2017	1.752E+03	9.571E+05	6.431E+01	5.606E+00	1.564E+03	1.051E-01
2018	1.667E+03	9.104E+05	6.117E+01	5.332E+00	1.488E+03	9.995E-02
2019	1.585E+03	8.660E+05	5.819E+01	5.072E+00	1.415E+03	9.508E-02
2020	1.508E+03	8.238E+05	5.535E+01	4.825E+00	1.346E+03	9.044E-02
2021	1.434E+03	7.836E+05	5.265E+01	4.590E+00	1.280E+03	8.603E-02
2022	1.364E+03	7.454E+05	5.008E+01	4.366E+00	1.218E+03	8.184E-02
2023	1.298E+03	7.090E+05	4.764E+01	4.153E+00	1.159E+03	7.784E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2024	1.235E+03	6.745E+05	4.532E+01	3.950E+00	1.102E+03	7.405E-02
2025	1.174E+03	6.416E+05	4.311E+01	3.758E+00	1.048E+03	7.044E-02
2026	1.117E+03	6.103E+05	4.100E+01	3.574E+00	9.972E+02	6.700E-02
2027	1.063E+03	5.805E+05	3.900E+01	3.400E+00	9.486E+02	6.373E-02
2028	1.011E+03	5.522E+05	3.710E+01	3.234E+00	9.023E+02	6.063E-02
2029	9.615E+02	5.253E+05	3.529E+01	3.077E+00	8.583E+02	5.767E-02
2030	9.146E+02	4.997E+05	3.357E+01	2.926E+00	8.164E+02	5.486E-02
2031	8.700E+02	4.753E+05	3.193E+01	2.784E+00	7.766E+02	5.218E-02
2032	8.276E+02	4.521E+05	3.038E+01	2.648E+00	7.387E+02	4.964E-02
2033	7.872E+02	4.301E+05	2.890E+01	2.519E+00	7.027E+02	4.722E-02
2034	7.488E+02	4.091E+05	2.749E+01	2.396E+00	6.684E+02	4.491E-02
2035	7.123E+02	3.891E+05	2.615E+01	2.279E+00	6.358E+02	4.272E-02
2036	6.776E+02	3.702E+05	2.487E+01	2.168E+00	6.048E+02	4.064E-02
2037	6.445E+02	3.521E+05	2.366E+01	2.062E+00	5.753E+02	3.866E-02
2038	6.131E+02	3.349E+05	2.250E+01	1.962E+00	5.473E+02	3.677E-02
2039	5.832E+02	3.186E+05	2.141E+01	1.866E+00	5.206E+02	3.498E-02
2040	5.547E+02	3.031E+05	2.036E+01	1.775E+00	4.952E+02	3.327E-02
2041	5.277E+02	2.883E+05	1.937E+01	1.688E+00	4.710E+02	3.165E-02
2042	5.020E+02	2.742E+05	1.842E+01	1.606E+00	4.481E+02	3.011E-02
2043	4.775E+02	2.608E+05	1.753E+01	1.528E+00	4.262E+02	2.864E-02
2044	4.542E+02	2.481E+05	1.667E+01	1.453E+00	4.054E+02	2.724E-02
2045	4.320E+02	2.360E+05	1.586E+01	1.382E+00	3.857E+02	2.591E-02
2046	4.110E+02	2.245E+05	1.508E+01	1.315E+00	3.668E+02	2.465E-02
2047	3.909E+02	2.136E+05	1.435E+01	1.251E+00	3.490E+02	2.345E-02
2048	3.719E+02	2.031E+05	1.365E+01	1.190E+00	3.319E+02	2.230E-02
2049	3.537E+02	1.932E+05	1.298E+01	1.132E+00	3.157E+02	2.122E-02
2050	3.365E+02	1.838E+05	1.235E+01	1.077E+00	3.003E+02	2.018E-02
2051	3.201E+02	1.748E+05	1.175E+01	1.024E+00	2.857E+02	1.920E-02
2052	3.044E+02	1.663E+05	1.118E+01	9.741E-01	2.718E+02	1.826E-02
2053	2.896E+02	1.582E+05	1.063E+01	9.266E-01	2.585E+02	1.737E-02
2054	2.755E+02	1.505E+05	1.011E+01	8.814E-01	2.459E+02	1.652E-02
2055	2.620E+02	1.432E+05	9.618E+00	8.385E-01	2.339E+02	1.572E-02
2056	2.493E+02	1.362E+05	9.149E+00	7.976E-01	2.225E+02	1.495E-02
2057	2.371E+02	1.295E+05	8.703E+00	7.587E-01	2.117E+02	1.422E-02
2058	2.255E+02	1.232E+05	8.279E+00	7.217E-01	2.013E+02	1.353E-02
2059	2.145E+02	1.172E+05	7.875E+00	6.865E-01	1.915E+02	1.287E-02
2060	2.041E+02	1.115E+05	7.491E+00	6.530E-01	1.822E+02	1.224E-02
2061	1.941E+02	1.061E+05	7.126E+00	6.211E-01	1.733E+02	1.164E-02
2062	1.847E+02	1.009E+05	6.778E+00	5.908E-01	1.648E+02	1.108E-02
2063	1.757E+02	9.596E+04	6.447E+00	5.620E-01	1.568E+02	1.054E-02
2064	1.671E+02	9.128E+04	6.133E+00	5.346E-01	1.491E+02	1.002E-02
2065	1.589E+02	8.683E+04	5.834E+00	5.085E-01	1.419E+02	9.533E-03
2066	1.512E+02	8.259E+04	5.549E+00	4.837E-01	1.350E+02	9.068E-03
2067	1.438E+02	7.856E+04	5.279E+00	4.602E-01	1.284E+02	8.625E-03
2068	1.368E+02	7.473E+04	5.021E+00	4.377E-01	1.221E+02	8.205E-03
2069	1.301E+02	7.109E+04	4.776E+00	4.164E-01	1.162E+02	7.805E-03
2070	1.238E+02	6.762E+04	4.543E+00	3.961E-01	1.105E+02	7.424E-03
2071	1.177E+02	6.432E+04	4.322E+00	3.767E-01	1.051E+02	7.062E-03
2072	1.120E+02	6.119E+04	4.111E+00	3.584E-01	9.998E+01	6.717E-03
2073	1.065E+02	5.820E+04	3.911E+00	3.409E-01	9.510E+01	6.390E-03
2074	1.013E+02	5.536E+04	3.720E+00	3.243E-01	9.046E+01	6.078E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2075	9.640E+01	5.266E+04	3.538E+00	3.084E-01	8.605E+01	5.782E-03
2076	9.170E+01	5.009E+04	3.366E+00	2.934E-01	8.185E+01	5.500E-03
2077	8.723E+01	4.765E+04	3.202E+00	2.791E-01	7.786E+01	5.232E-03
2078	8.297E+01	4.533E+04	3.046E+00	2.655E-01	7.407E+01	4.976E-03
2079	7.893E+01	4.312E+04	2.897E+00	2.525E-01	7.045E+01	4.734E-03
2080	7.508E+01	4.101E+04	2.756E+00	2.402E-01	6.702E+01	4.503E-03
2081	7.141E+01	3.901E+04	2.621E+00	2.285E-01	6.375E+01	4.283E-03
2082	6.793E+01	3.711E+04	2.493E+00	2.174E-01	6.064E+01	4.074E-03
2083	6.462E+01	3.530E+04	2.372E+00	2.068E-01	5.768E+01	3.876E-03
2084	6.147E+01	3.358E+04	2.256E+00	1.967E-01	5.487E+01	3.687E-03
2085	5.847E+01	3.194E+04	2.146E+00	1.871E-01	5.219E+01	3.507E-03
2086	5.562E+01	3.038E+04	2.041E+00	1.780E-01	4.965E+01	3.336E-03
2087	5.291E+01	2.890E+04	1.942E+00	1.693E-01	4.723E+01	3.173E-03
2088	5.033E+01	2.749E+04	1.847E+00	1.610E-01	4.492E+01	3.018E-03
2089	4.787E+01	2.615E+04	1.757E+00	1.532E-01	4.273E+01	2.871E-03
2090	4.554E+01	2.488E+04	1.671E+00	1.457E-01	4.065E+01	2.731E-03
2091	4.332E+01	2.366E+04	1.590E+00	1.386E-01	3.867E+01	2.598E-03
2092	4.120E+01	2.251E+04	1.512E+00	1.318E-01	3.678E+01	2.471E-03
2093	3.919E+01	2.141E+04	1.439E+00	1.254E-01	3.499E+01	2.351E-03
2094	3.728E+01	2.037E+04	1.368E+00	1.193E-01	3.328E+01	2.236E-03
2095	3.546E+01	1.937E+04	1.302E+00	1.135E-01	3.166E+01	2.127E-03
2096	3.373E+01	1.843E+04	1.238E+00	1.079E-01	3.011E+01	2.023E-03
2097	3.209E+01	1.753E+04	1.178E+00	1.027E-01	2.864E+01	1.925E-03
2098	3.052E+01	1.668E+04	1.120E+00	9.767E-02	2.725E+01	1.831E-03
2099	2.904E+01	1.586E+04	1.066E+00	9.290E-02	2.592E+01	1.741E-03
2100	2.762E+01	1.509E+04	1.014E+00	8.837E-02	2.465E+01	1.657E-03
2101	2.627E+01	1.435E+04	9.643E-01	8.406E-02	2.345E+01	1.576E-03
2102	2.499E+01	1.365E+04	9.173E-01	7.996E-02	2.231E+01	1.499E-03
2103	2.377E+01	1.299E+04	8.726E-01	7.606E-02	2.122E+01	1.426E-03
2104	2.261E+01	1.235E+04	8.300E-01	7.235E-02	2.019E+01	1.356E-03
2105	2.151E+01	1.175E+04	7.895E-01	6.882E-02	1.920E+01	1.290E-03
2106	2.046E+01	1.118E+04	7.510E-01	6.547E-02	1.826E+01	1.227E-03
2107	1.946E+01	1.063E+04	7.144E-01	6.227E-02	1.737E+01	1.167E-03
2108	1.851E+01	1.011E+04	6.796E-01	5.924E-02	1.653E+01	1.110E-03
2109	1.761E+01	9.621E+03	6.464E-01	5.635E-02	1.572E+01	1.056E-03
2110	1.675E+01	9.151E+03	6.149E-01	5.360E-02	1.495E+01	1.005E-03
2111	1.593E+01	8.705E+03	5.849E-01	5.099E-02	1.422E+01	9.557E-04
2112	1.516E+01	8.281E+03	5.564E-01	4.850E-02	1.353E+01	9.091E-04
2113	1.442E+01	7.877E+03	5.292E-01	4.613E-02	1.287E+01	8.648E-04
2114	1.372E+01	7.493E+03	5.034E-01	4.388E-02	1.224E+01	8.226E-04

APPENDIX B

CARBON FOOTPRINT ANALYSIS

AECOM

Carbon Footprint Calculations — Baseline

Refuse Hideaway Landfill
7562 US Highway 14
Middleton, WI 53562

Scope 1

			Emission Factors			Mass						CO2e Greenhouse Gas Potentials			Total		
												1	25	298			
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO_2/gal	lb CH_4/gal	lb N_2O/gal	lb CO_2	kg CO_2	lb CH_4	kg CH_4	lb N_2O	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Propane for Flare	2010	23.0	12.5	0.0002	0.0009	18,827.50	8,540.15	0.30	0.14	1.36	0.61	8,540.15	3.42	183.24	8,726.81	19,242.61	9.62
Methane Gas- Destroyed	2010	--	--	--	--	--	--	--	259,802.34	--	--	--	714,456	--	714,456.42	1,575,376.41	787.69
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

			Emission Factors			Mass			CO2e Greenhouse Gas Potentials			Total		
									1	25	298			
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Remedial System	2010	43,039	0.043039	1.97	26.79	27.3	0.08	1.15	1.17	0.08	28.83	350.14	835.65	379.05	0.19
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

				Emission Factors			Mass			CO2e Greenhouse Gas Potentials			Total		
										1	25	298			
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2010	1,992	110.67	8.81	0.0036	0.0004	974.97	0.40	0.04	974.97	10.08	13.06	998.11	2,200.84	1.10
Diesel - Leachate Hauling	2010	2,820	353	10.15	0.000041	0.000038	3,577.88	0.01	0.01	3577.88	0.36	4.03	3,582.27	7,898.90	3.95
Methane Gas - Fugitive from LFG System	2010	--	--	--	--	--	--	230,935.41	--	--	5,773,385	--	5,773,385.22	12,730,314.42	6,365.16
Methane Gas- Fugitive Escape	2010	--	--	--	--	--	--	122,684.44	--	--	3,067,111	--	3,067,110.90	6,762,979.53	3,381.49
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
9,569,095.38	21,098,391.76	10,549.20

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M actvities.*
Diesel fuel used for leachate transport. Leachate disposed of in Madison, Wisconsin.
119 site visits in 2010 for site sampling and O&M; 30 miles/visit (roundtrip)
4 site visits per year for WDNR inspections; 22 miles/visit (roundtrip)
94 site visits for leachate disposal (tank emptied at ~5,000 gallons); 30 miles/visit (roundtrip)
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009
2. Derived from 2010 cubic meters per year methane value presented in the Results table, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..
3. Greenhouse Gas Potential for CH4 and N2O taken from IPCC Fourth Assessment Report (2007).
4. For every pound of methane combusted there are 2.75 pounds of carbon produced.
5. Utility usage reported by Madison Gas and Electric.
6. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Madison Gas & Electric Co. Emission Profile, 2005.
7. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

AECOM

Carbon Footprint Calculations

Option 1 - Improvements to Flare System

Refuse Hideaway Landfill
7562 US Highway 14
Middleton, WI 53562

Scope 1

												CO_2e					
												Greenhouse Gas Potentials					
			Emission Factors			Mass						1	25	298	Total		
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO_2/gal	lb CH_4/gal	lb N_2O/gal	lb CO_2	kg CO_2	lb CH_4	kg CH_4	lb N_2O	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Propane for Flare	2010	23.0	12.5	0.0002	0.0009	18,827.50	8,540.15	0.30	0.14	1.36	0.61	8,540.15	3.42	183.24	8,726.81	19,242.61	9.62
Methane Gas- Destroyed	2010	--	--	--	--	--	--	--	490,737.74	--	--	--	1,349,529	--	1,349,528.80	2,975,711.00	1,487.86
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

									CO_2e					
									Greenhouse Gas Potentials					
			Emission Factors			Mass			1	25	298	Total		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Remedial System	2010	43,039	0.043039	1.97	26.79	27.3	0.08	1.15	1.17	0.08	28.83	350.14	835.65	379.05	0.19
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

									CO_2e					
									Greenhouse Gas Potentials					
			Emission Factors			Mass			1	25	298	Total		
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2010	1,992	110.67	8.81	0.0036	0.0004	974.97	0.40	0.04	974.97	10.08	13.06	998.11	2,200.84	1.10
Diesel - Leachate Hauling	2010	2,820	353	10.15	0.000041	0.000038	3,577.88	0.01	0.01	3577.88	0.36	4.03	3,582.27	7,898.90	3.95
Methane Gas - Fugitive from LFG System	2010	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Methane Gas- Fugitive Escape	2010	--	--	--	--	--	--	122,684.44	--	--	3,067,111	--	3,067,110.90	6,762,979.53	3,381.49
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
4,430,782.53	9,768,411.93	4,884.21

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M actvities.*
Diesel fuel used for leachate transport. Leachate disposed of in Madison, Wisconsin.
119 site visits in 2010 for site sampling and O&M; 30 miles/visit (roundtrip)
4 site visits per year for WDNR inspections; 22 miles/visit (roundtrip)
94 site visits for leachate disposal (tank emptied at ~5,000 gallons); 30 miles/visit (roundtrip)
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.
Option 1 assumes that flare is burning 100% of time that blower is running resulting in no fugitive emissions from LFG System

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m ^{3} *(gas)*
Density of propane= 1.83 kg/m ^{3} *(gas)*

Source Notes:
1. *Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009.*
2. *Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..*
3. *Greenhouse Gas Potential for CH4 and N2O taken from IPCC Fourth Assessment Report (2007).*
4. *For every pound of methane combusted there are 2.75 pounds of carbon produced.*
5. *Utility usage reported by Madison Gas and Electric.*
6. *EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Madison Gas & Electric Co. Emission Profile, 2005.*
7. *EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2:* CH_4 *and* N_2O *Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.*

AECOM

Carbon Footprint Calculations

Option 2 - Increase Solar Energy Generation

Refuse Hideaway Landfill
7562 US Highway 14
Middleton, WI 53562

Scope 1

												CO$_2$e					
												Greenhouse Gas Potentials					
			Emission Factors			Mass						1	25	298	Total		
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO$_2$/gal	lb CH$_4$/gal	lb N$_2$O/gal	lb CO$_2$	kg CO$_2$	lb CH$_4$	kg CH$_4$	lb N$_2$O	kg N$_2$O	kg CO$_2$e/kg CO$_2$	kg CO$_2$e/kg CH$_4$	kg CO$_2$e/kg N$_2$O	kg CO$_2$e	lb CO$_2$e	ton CO$_2$e
Propane for Flare	2010	23.0	12.5	0.0002	0.0009	18,827.50	8,540.15	0.30	0.14	1.36	0.61	8,540.15	3.42	183.24	8,726.81	19,242.61	9.62
Methane Gas- Destroyed	2010	--	--	--	--	--	--	--	259,802.34	--	--	--	714,456	--	714,456.42	1,575,376.41	787.69
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

									CO$_2$e					
									Greenhouse Gas Potentials					
			Emission Factors			Mass			1	25	298	Total		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO$_2$/GWh	lb CH$_4$/GWh	lb N$_2$O/GWh	lb CO$_2$	lb CH$_4$	lb N$_2$O	lb CO$_2$e/lb CO$_2$	lb CO$_2$e/lb CH$_4$	lb CO$_2$e/lb N$_2$O	kg CO$_2$e	lb CO$_2$e	ton CO$_2$e
Remedial System	2010	--	--	1.97	26.79	27.3	--	--	--	--	--	--	--	--	--
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

									CO$_2$e					
									Greenhouse Gas Potentials					
			Emission Factors			Mass			1	25	298	Total		
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO$_2$/gallon	kg CH$_4$/gallon	kg N$_2$O/gallon	kg CO$_2$	kg CH$_4$	kg N$_2$O	kg CO$_2$e/kg CO$_2$	kg CO2e/kg CH$_4$	kg CO2e/kg N$_2$O	kg CO$_2$e	lb CO$_2$e	ton CO$_2$e
Unleaded Gasoline	2010	1,992	110.67	8.81	0.0036	0.0004	974.97	0.40	0.04	974.97	10.08	13.06	998.11	2,200.84	1.10
Diesel - Leachate Hauling	2010	2,820	353	10.15	0.000041	0.000038	3,577.88	0.01	0.01	3577.88	0.36	4.03	3,582.27	7,898.90	3.95
Methane Gas - Fugitive from LFG System	2010	--	--	--	--	--	--	230,935.41	--	--	5,773,385	--	5,773,385.22	12,730,314.42	6,365.16
Methane Gas- Fugitive Escape	2010	--	--	--	--	--	--	122,684.44	--	--	3,067,111	--	3,067,110.90	6,762,979.53	3,381.49
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO$_2$e	lb CO$_2$e	ton CO$_2$e
9,568,259.73	21,098,012.71	10,549.01

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M actvities.*
Diesel fuel used for leachate transport. Leachate disposed of in Madison, Wisconsin.
119 site visits in 2010 for site sampling and O&M; 30 miles/visit (roundtrip)
4 site visits per year for WDNR inspections; 22 miles/visit (roundtrip)
94 site visits for leachate disposal (tank emptied at ~5,000 gallons); 30 miles/visit (roundtrip)
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.
**Option 2 assumes that all electricity for remedial system will be powered with solar power*

Conversions/Factors: *1,000 kWh = 1.0E+6 GWh*
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009
2. Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..
3. Greenhouse Gas Potential for CH4 and N2O taken from IPCC Fourth Assessment Report (2007).
4. For every pound of methane combusted there are 2.75 pounds of carbon produced.
5. Utility usage reported by Madison Gas and Electric.
6. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Madison Gas & Electric Co. Emission Profile, 2005.
7. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH$_4$ and N$_2$O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

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Carbon Footprint Calculations

Option 3 - Leachate Evaporation or Watering

Refuse Hideaway Landfill
7562 US Highway 14
Middleton, WI 53562

Scope 1

			Emission Factors			Mass						CO_2e Greenhouse Gas Potentials			Total		
												1	25	298			
Gaseous Fuels Burned On-Site	**Year**	**Usage (lbs/yr)**	lbs CO_2/gal	lb CH_4/gal	lb N_2O/gal	lb CO_2	kg CO_2	lb CH_4	kg CH_4	lb N_2O	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Propane for Flare	2010	23.0	12.5	0.0002	0.0009	18,827.50	8,540.15	0.30	0.14	1.36	0.61	8,540.15	3.42	183.24	8,726.81	19,242.61	9.62
Methane Gas- Destroyed	2010	--	--	--	--	--	--	--	259,802.34	--	--	--	714,456	--	714,456.42	1,575,376.41	787.69
			See Note 1	*See Note 1*	*See Note 1*				*See Note 2*				*See Note 3, 4*	*See Note 3*			

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	298			
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Remedial System	2010	43,039	0.043039	1.97	26.79	27.3	0.08	1.15	1.17	0.08	28.83	350.14	835.65	379.05	0.19
		See Note 5		*See Note 6*	*See Note 6*	*See Note 6*					*See Note 3*	*See Note 3*			

Scope 3

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	298			
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2010	1,992	110.67	8.81	0.0036	0.0004	974.97	0.40	0.04	974.97	10.08	13.06	998.11	2,200.84	1.10
Diesel - Leachate Hauling	2010	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Methane Gas - Fugitive from LFG System	2010	--	--	--	--	--	--	230,935.41	--	--	5,773,385	--	5,773,385.22	12,730,314.42	6,365.16
Methane Gas- Fugitive Escape	2010	--	--	--	--	--	--	122,684.44	--	--	3,067,111	--	3,067,110.90	6,762,979.53	3,381.49
				See Note 7	*See Note 7*	*See Note 7*		See Note 2			*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
9,565,513.11	21,090,492.86	10,545.25

Assumptions:
Unleaded gasoline used for consultant transport to conduct O&M actvities.
Diesel fuel used for leachate transport. Leachate disposed of in Madison, Wisconsin.
119 site visits in 2010 for site sampling and O&M; 30 miles/visit (roundtrip)
4 site visits per year for WDNR inspections; 22 miles/visit (roundtrip)
94 site visits for leachate disposal (tank emptied at ~5,000 gallons); 30 miles/visit (roundtrip)
18 miles/gallon for field vehicle and 8 miles/gallon for Heavy Duty Hauling Vehicle.
Option 3 assumes that no leachate hauling is required

Conversions/Factors:
1,000 kWh = 1.0E+6 GWh
Density of methane = 0.717 kg/m^3 (gas)
Density of propane= 1.83 kg/m^3 (gas)

Source Notes:
1. *Leonardo Academy, Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener Program, April 21, 2009*
2. *Derived from 2008 cubic meters per year methane value presented in Table Results - 1, landgem-v302.xls prepared by Paul Wintheiser, P.E., AECOM Environment..*
3. *Greenhouse Gas Potential for CH4 and N2O taken from IPCC Fourth Assessment Report (2007).*
4. *For every pound of methane combusted there are 2.75 pounds of carbon produced.*
5. *Utility usage reported by Madison Gas and Electric.*
6. *EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Madison Gas & Electric Co. Emission Profile, 2005.*
7. *EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.*

Penta Wood
Site Specific Sustainable Remediation System Evaluation

Prepared for:
Wisconsin Department of Natural Resources
Remediation and Redevelopment Program
101 South Webster Street
Madison, WI 53703

Prepared by:
AECOM
Project No. 60134224(107343)

January 2010

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LIST OF ACRONYMS

ACA	ammonia copper arsenate
ACZA	ammonia, copper II oxide, zinc and arsenate
AST	aboveground storage tank
bgs	below ground surface
CAMU	corrective action management unit
CO_2e	Carbon dioxide equivalents
DAF	dissolved air flotation
FS	feasibility study
g/cm^3	grams per cubic centimeter
GAC	granular activated carbon
gpm	gallons per minute
HDPE	high density polyethylene
Hp	horse power
kW	kilowatt
kWh	kilowatt hours
LEL	lower exposure limit
LNAPL	light non-aqueous phase liquid
m^2	square meters
NPL	National Priorities List
O&G	oil and grease
O&M	operation and maintenance
P&T	pump and treatment
PCP	pentachlorophenol
ppb	parts per billion
psi	pounds per square inch
PV	photovoltaics
PVC	polyvinylchloride
PWP	Penta Wood Products
RA	remedial action
RDVF	rotary drum vacuum filter
RI	remedial investigation
ROD	Record of Decision
ROI	radius of influence
RPO	remedial process optimization
SACM	Superfund Accelerated Cleanup Model
scfm	standard cubic feet per minute
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VFD	variable frequency drive
WDNR	Wisconsin Department of Natural Resources
WDOJ	Wisconsin Department of Justice
WisDOT	Wisconsin Department of Transportation
WPDES	Wisconsin Pollutant Discharge Elimination System

1.0 INTRODUCTION

The purpose of this document is to provide a Site Specific Sustainable Remediation System Evaluation for the Penta Wood site located west of Siren, Wisconsin. To evaluate current site conditions, and effects of potential changes, a sustainability baseline was created that included a current carbon footprint, energy usage, operational costs and contaminant mass removal. A limited remedial process optimization (RPO) was conducted for the site to identify major items that could be addressed to improve the sustainability and efficiency of the existing remedial system, and to reduce operation and maintenance (O&M) costs. An alternative energy evaluation was conducted to see if alternative energy could be used to offset current energy usage at the site. Potential sustainable activities were evaluated to enhance reduction of contaminant levels and lower costs. Three sustainable activities were selected and a sustainability matrix was generated outlining costs and benefits of each activity in terms of various sustainability metrics, such as the increase or decrease in carbon footprint, energy usage, resource usage, waste generation and cost. The purpose of the sustainability matrix is to provide/quantify effects of potential changes in terms of the sustainability metrics.

This document was generated using information provided by the Wisconsin Department Natural Resources (WDNR) and the current system operator, CH_2M Hill. Information included utility and O&M costs, monitoring reports and as-built drawings, where available. A site walk and interviews with the WDNR site project manager were conducted on June 2, 2009.

2.0 SITE DESCRIPTION

The Penta Wood Products (PWP) site is a former wood treating facility located on Daniels 70 (former State Route 70), approximately 2 miles west of the Village of Siren in the Town of Daniels, Burnett County, Wisconsin. A site plan, illustrating site features, is included in Figure 2-1. PWP operated for 39 years, beginning in 1953 and ceasing operations in 1992 due to the financial inability of the facility to comply with Wisconsin Department of Justice (WDOJ) requirements. PWP operations actively used approximately 80 acres of a 120 acre parcel. Approximately 40 undeveloped acres, consisting mainly of forest land, was sold after the facility closed in May 1992. The PWP property is located in a rural agricultural and residential area and is bordered by forested areas to the east, west, and north. Daniels 70 forms the southern border of the property, with the exception of 8 acres located south of Daniels 70.

Former site buildings consisted of a main treatment building, oil/water separator building, and various other buildings including sawmills, garages, and storage sheds. The PWP site also included an unlined drainage ditch (gully) where wastewater was discharged, a wastewater lagoon, and wood chip pile. A wetland area is located off-site approximately 400 feet north of the lagoon.

When PWP began operation in 1953, raw timber was cut into posts and telephone poles and treated by dipping into open tanks of pentachlorophenol (PCP) solution or by introducing the PCP into the wood under vacuum. In 1956, a pressure-treatment vessel was installed which used a 5 percent to 7 percent PCP solution in a No. 2 fuel oil carrier. In 1975, a second pressure-treatment process was added which used chemonite, a water-born salt treatment consisting of ammonia, copper II oxide, zinc, and arsenate (ACZA).

During operation, PWP historically disposed of wastes on-site. PCP/oil and metals contaminated wastewater from the oil/water separator tank was directed to the gully and discharged into the lagoon located on the northeast corner of the property. PCP/oil and metals contaminated wastewater was also discharged into a wood chip pile, located in the northwest corner of the property. WDNR inspections conducted during the 1970s noted several large spills, stained soil, and poor operating practices at the facility. During a large fire that destroyed the treatment building circa 1979, PWP released approximately 10,000 gallons of the PCP/oil mixture to the oil/water separator. The oil/water separator overflowed and discharged to the gully and lagoon. In 1988, the WDNR closed the on-site potable supply well due to high PCP concentrations detected in water samples. In 1989, the Wisconsin Department of Transportation (WisDOT) detected high levels of PCP in surface soil samples collected in the south Daniels 70 right of way. WDNR inspections, conducted in June 1989, revealed ongoing discharges of PCP contaminated wastes to on-site soils. In addition, erosion around the lagoon area resulted in PCP contamination of surface water and sediments of the wetland area. Assessments of the site revealed on-site soil and groundwater were contaminated with PCP, arsenic, copper, and zinc from the on-site wood treating operations.

The WDOJ filed a preliminary injunction against PWP in 1991 for raw material storage, waste handling practices, and Wisconsin Pollutant Discharge Elimination System (WPDES) violations leading the facility to voluntarily close in May 1992. In April 1993, the United States Environmental Protection Agency (USEPA) initiated site assessment activities. Due to high permeability surficial soils, precipitation on-site flowed rapidly downward through the soil carrying contaminants to the groundwater aquifer. Spills and poor waste handling practices over time resulted in soil contamination from ground surface to a depth of over 100 feet to the groundwater table. The PCP/oil mixture spread as light non-aqueous phase liquid (LNAPL) on the groundwater table over an estimated 4-acre area.

Between April 1994 and June 1996, USEPA conducted short-term removal actions including removal of approximately 29 aboveground storage tanks (ASTs) and 6 underground storage tanks (USTs) which were filled with PCP and ACZA contaminated sludge, 393 drums of PCP contaminated oil and sludge, 21,500 gallons of PCP contaminated liquids, 18,800 gallons of PCP and ammonia copper arsenate (ACA) contaminated liquids, 51 drums of contaminated sludge, 773 tons of contaminated surface soils, and 9 drums of asbestos containing wastes. Approximately 4,800 tons of arsenic contaminated soil was excavated and treated with cement and used to construct a 4-acre bio-pad for potential treatment of PCP contaminated soils. The site was listed on the National Priorities List (NPL) in June 1996.

A remedial investigation (RI) and feasibility study (FS) was completed in May 1998. The Record of Decision (ROD) was signed in September 1998 identifying remedial alternatives for both soil and groundwater contamination. The remedial design was completed in November 1999 and remedial action (RA) was completed in September 2000. The RA included demolition of buildings, consolidation of PCP and arsenic contaminated soils in a 7-acre corrective action management unit (CAMU), installation of a groundwater pump and treatment (P&T) system, installation of biovent wells, capping the CAMU, security fencing, and natural attenuation monitoring.

A total of 10 soil borings were advanced for construction of the remedial system. Seven borings were constructed as dual-purpose bioventing/free product recovery and groundwater extraction wells. Two borings were constructed as biovent only wells. The borings were 16 inches in diameter to facilitate a 6-inch diameter groundwater extraction well and a 4-inch diameter bioventing/free product recovery well, installed in the same borehole. The system was designed to create drawdown in the groundwater extraction wells, thus, providing hydraulic containment and maximizing LNAPL thickness for recovery by the biovent/free product recovery wells. Impacted groundwater would be treated on-site and discharged to the infiltration basin. Free product would be removed for off-site disposal. Bioventing on-site was not anticipated to start until after LNAPL was no longer being effectively removed. Initially, the P&T system's main components consisted of an oil/water separator, bag filters, organoclay, and granular activated carbon (GAC). P&T system operation began in September 2000 and was shut down in September 2001 resulting from emulsified oil in the groundwater repeatedly fouling the GAC. Additional pretreatment was required before the existing system would operate properly. During 2001 and 2002 treatability studies and a pilot test were conducted to determine site-specific design parameters for pretreatment. Design work and construction were completed in 2003 and the pretreatment system became operational in February 2004. The pretreatment system included an oil/water separator, chemical addition for coagulation and flocculation, dissolved air flotation (DAF), dewatering with a rotary drum vacuum filter, and associated storage tanks.

The property is currently owned by Penta Wood Products. The responsibility for remedial operation will be transferred from the USEPA to the WDNR in 2014.

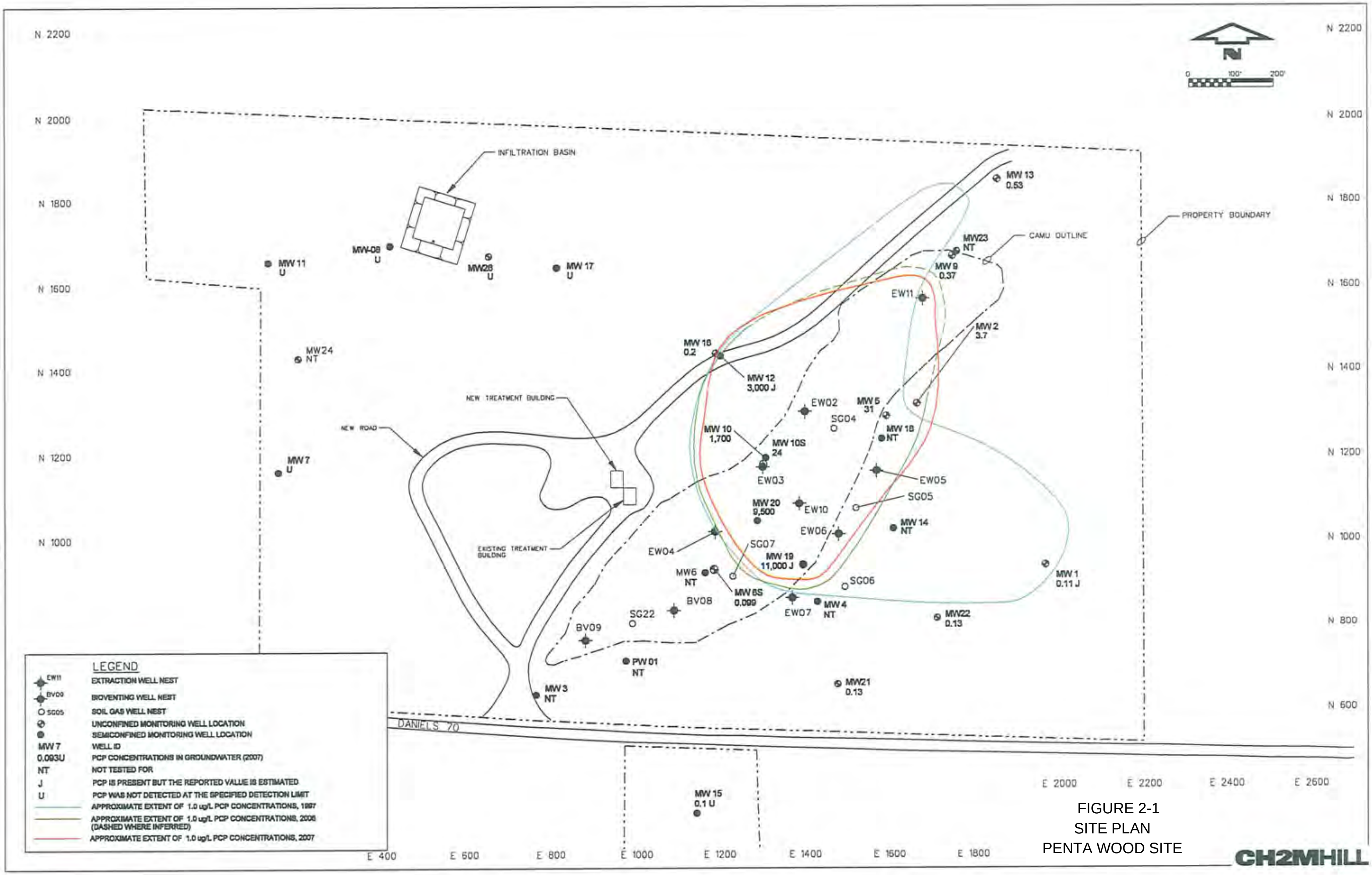

FIGURE 2-1
SITE PLAN
PENTA WOOD SITE

CH2MHILL

3.0 CURRENT CONDITIONS

The current remedial approach at the PWP site is O&M of three remedial subsystems (groundwater P&T, LNAPL removal, and bioventing) in coordination with long-term groundwater monitoring to evaluate natural attenuation. Each of the three subsystems can operate independent of the other two. Only the groundwater P&T and LNAPL recovery systems were operated initially due to potential adverse effects of the biovent system, while significant thickness of free product is present. The USEPA and WDNR have determined that the impacted groundwater, LNAPL, and other waste generated at the site are F032-listed hazardous wastes. The remedial approach was designed to reach treatment goals in 30 years.

The P&T system is contained in two attached metal frame buildings. The original system was housed in a 30- by 42-foot building. The pretreatment components added in 2003 are located in a 52- by 67-foot building. Both buildings were designed and built with curbs for secondary containment and storage tanks to contain spills. The primary components of the current P&T system consists of an oil-water separator, free product storage tank, chemical conditioning with ferric sulfate and polymer addition, DAF, rotary drum vacuum filter (RDVF), bag filters, a 2,500-pound GAC vessel, two 10,000-pound GAC vessels, sodium hydroxide addition for pH adjustment, associated tanks and piping, and discharge to an on-site infiltration gallery. The system was designed for a groundwater extraction rate of 120 gallons per minute (gpm) and currently operates at approximately 90 gpm.

Eight groundwater extraction wells were designed to depress the water table and capture the area of PCP contaminated groundwater with concentrations exceeding 1,000 parts per billion (ppb). LNAPL pumps are installed in six biovent wells and one product recovery well. Groundwater is extracted at a rate of approximately 10 to 12 gpm per well. Each groundwater extraction well is fitted with a 2 horsepower (Hp) electrical submersible pump (Grundfos Model 16S20-18). Each pump is equipped with a variable frequency drive (VFD) and is housed in a control cabinet located in the treatment building. The VFD controls pump speed and flow rates. LNAPL is extracted with top-loading pneumatic pumps (QED Hammerhead) from the dual-purpose wells. Groundwater conveyance piping is a 2-by 3-inch diameter dual-wall high-density polyethylene (HDPE) pipe and free product conveyance piping is 1- by 2-inch diameter dual-wall HDPE pipe. Groundwater wells were constructed with 20-foot screens located about 20 feet below the groundwater table. Biovent wells are constructed of Schedule 80 polyvinyl chloride (PVC) and were designed with 60-foot screened intervals extending from 40 feet above the groundwater table to 20 feet below the groundwater table. Groundwater exists at approximately 100 below ground surface (bgs).

The DAF unit was installed to improve the performance of the GAC. The DAF unit provides removal of total suspended solids (TSS) and free and emulsified oil and grease (O&G) from the groundwater and oil/water separator waste streams. The RDVF is used to dewater “float” from the DAF unit on a diatomaceous earth precoat with a surface area of 56.5 square feet. The RDVF was sized to operate 4 to 8 hours per day, three times per week and has a 4- to 6-gpm vacuum pump seal water demand. After “float” from the DAF unit is fed to the RDVF basin, the “float” adheres to the surface of the precoat under vacuum. Solids remaining on the precoat are scraped off with a blade and fall into a dumpster where it is stored until transported off-site for disposal.

The 2,500-pound GAC prefilter vessel removes residual particulates from treatment water so that the 10,000-pound GAC vessels function more efficiently. The 2,500-pound GAC prefilter vessel is backwashed on an as-needed basis to flush the GAC vessel of particulate buildup. GAC prefilter effluent is then treated by two 10,000-pound GAC vessels before discharge to the infiltration gallery.

Compressed air is required for operation of several treatment system components in addition to operation of LNAPL pneumatic recovery pumps. The current total estimated air demand is 36 standard cubic feet per minute (scfm) at 105 pounds per square inch (psi). Two compressors currently exist on-site. The original 7.5 Hp compressor, capable of supplying 24 scfm at 110 psi, was undersized after the addition of pretreatment equipment. A 20 Hp compressor, capable of supplying 70 scfm at 110 psi, was added to operate the additional equipment. The two compressors are connected to a common manifold. The original compressor is currently not in use, but can be used if additional air demand is necessary in the future.

The bioventing system was designed as “follow-up” to the LNAPL recovery effort. The objective of the bioventing system is to enhance aerobic degradation of PCP contaminated soil by injecting air into the unsaturated zone above the groundwater table. The bioventing system consists of nine injection wells, a 75-Hp centrifugal blower, connecting piping, and associated controls. Design airflow rates ranged for 200 to 500 scfm (per well) at a pressure of approximately 50 inches of water. Biovent well locations were based on a 125-foot design radius of influence (ROI). The blower is capable of providing up to a total of 5,000 scfm at 55 inches of water and currently set up to provide a total of 4,000 scfm. The system can accommodate additional wells, if expansion is required. Biovent system piping consists of a 12-inch diameter HDPE intake pipe, a 16-inch diameter HDPE manifold, which supplies 6-inch and 8-inch diameter HDPE header pipes. The 6-inch and 8-inch diameter HDPE header pipes reduce to 4-inch diameter flexible pipe at each of the biovent wells.

The bioventing system was started in September 2007 after LNAPL was no longer being consistently removed. An evaluation indicated that LNAPL recovery could not be substantially improved and only a small percentage of remaining LNAPL would likely be recovered. The area requiring bioventing extends from the surface in the central area of the CAMU to a depth approximately 10 feet below the groundwater table. The volume of contaminated soil to be biovented has been estimated to be approximately 400,000 cubic yards.

During biovent system startup, several objectives needed to be met including evaluating the presence of methane or other explosive gases and risks, evaluating temperature changes in the subsurface and risks, and determining effects on LNAPL thickness or spreading of the plume. Startup monitoring demonstrated that there was not an explosive hazard and methane levels generally were not a concern. Methane present in the shallow subsurface appeared to be escaping through ground surface and not migrating laterally. However, it was determined that the biovent system should be shut down during winter months when the ground surface is frozen (impervious layer), introducing the risk of lateral migration. During bioventing, subsurface temperatures did not change enough to cause concern. Monitoring also demonstrated that LNAPL thickness did not change during biovent operation and the LNAPL plume did not spread.

The bioventing system was shut down in November 2007 for winter and restarted in May 2008. The bioventing system was again shut down in November 2008 and restarted in May 2009.

Flow rates at the biovent wells have generally ranged from 100 to 450 scfm (per well) during operation with higher flow rates set in the deeper wells. During operation, soil gas monitoring was conducted on four nests of shallow, intermediate, and deep monitoring wells, four perimeter monitoring wells, and one additional shallow monitoring well. Readings were collected for oxygen, carbon dioxide, temperature, lower explosive limit (LEL), and methane. During operation, oxygen, carbon dioxide, temperature, LEL, and methane readings have ranged from 0 to 22.9 percent, 0 to 28.5 percent, 24 to 84 degrees Fahrenheit, 0 to 100 percent, and 0 to 17.9 percent, respectively. Soil gas measurements were also collected to evaluate the ROI of the system. Pressure readings have ranged from 0.1 to 2.4 inches of water.

AECOM reviewed the 2008 Annual Report, dated November 2009, and prepared by CH_2M Hill for this site-specific evaluation. During 2008, the P&T system extracted over 18.1million gallons of groundwater with pumping rates generally ranging from 15 to 76 gpm with an average of 56 gpm, while the system was operating. The effective extraction rate, including time when wells were not operating, was 36 gpm. PCP influent concentrations during 2008 ranged from 2,200 to 4,400 ppb with an average concentration of 3,255 ppb. The estimated PCP mass removed during 2008 was approximately 492 pounds, bringing the total PCP mass removed, from the dissolved phase, since 2000 to 7,028 pounds. This is estimated to be a 90 percent total reduction, based on the estimated mass prior to system startup.

For 2008, the volume of liquid waste captured by the oil/water separator was used to estimate the volume of LNAPL removed and resulting mass of PCP removed. Based on the roughly 5,854 gallons of liquid waste removed it, was estimated that one-half, or 2,815 gallons, of LNAPL were removed. Assuming a LNAPL density of 0.84 grams per cubic centimeter (g/cm^3), and a PCP concentration of 5 percent, it was estimated that 986 pounds of PCP present in LNAPL was removed during 2008. An estimated 5,824 pounds of PCP have been removed by LNAPL recovery since 2004.

GAC change-out occurred every 16 to 20 weeks during the first half of 2008. Changes to operating procedures and pH adjustment have significantly increased the lifespan of the GAC since 2007. Approximately 50,000 pounds of GAC are consumed per year at the site which equates to three to four carbon change-outs per year.

During 2008 approximately 211,400 pounds of filter cake, 70,007 pounds of carbon, 28,036 pounds of LNAPL, and 3,176 pounds of miscellaneous debris was generated at the PWP site.

Groundwater monitoring at the site is conducted on a semiannual basis. The spring sampling event consists of sampling at five monitoring wells, five residential wells, and one on-site potable well. The fall sampling event consists of sampling at 14 monitoring wells, five residential wells, and one on-site potable well. Water level and LNAPL measurements are conducted to determine groundwater flow direction(s) in the unconfined and confined aquifers and determine remaining LNAPL thickness. Monitoring data continues to show that the P&T system is maintaining hydraulic control (capture) and the plume boundary is gradually decreasing. LNAPL thickness appears to be increasing in the central area of the CAMU where the depression induced from pumping is greatest.

There are five residences within 1,000 feet of the PWP site which have potable wells. Annual sampling of the private wells has demonstrated that the contaminate plume has remained on-site.

4.0 BASELINE EVALUATION

A baseline analysis was conducted for the PWP site. The baseline is a quantification of the current site conditions using various sustainability metrics. This allows costs and benefits of potential changes to the remedial system to be measured using the same set of sustainability metrics.

4.1 CARBON FOOTPRINT

The PWP operated as a wood treating facility from 1953 until 1992, when it closed. The PWP site was placed in the Superfund Accelerated Cleanup Model (SACM) pilot program in 1993. The site is currently in a long-term O&M mode with groundwater P&T, free product recovery and biovent systems being active at the site. An analysis of site operations has identified applicable items associated with Scope 1 (direct discharge), Scope 2 (electricity) and Scope 3 (other indirect) at the site.

Scope 1 items identified at the site are propane usage for the heating the treatment buildings during winter months. Approximately 18,000 to 24,000 pounds of propane are used to heat the facility during winter months. This information is taken directly from utility bills provided by the remedial system operator.

Scope 2 items consist of electricity consumed by the treatment equipment, tank heaters and lighting. This information is taken directly from utility bills provided by the remedial system operator.

Scope 3 items consist of diesel fuel used by trucks to haul hazardous waste and activated granulated carbon to and from the site, unleaded gas used by O&M personnel at the site. For Scope 3, it was assumed two site visits per year were required for site sampling with mobilization from Milwaukee. It is also assumed that a full time operator is at the site approximately 50 hours per week and the operator makes an average of six trips per week with the round trip mileage to the site being 20 miles. Disposal of hazardous waste, which includes spent cake, filter cake and free product, is also included in Scope 3 items. Hazardous wastes are shipped by North Shore Environmental to Pollution Control Industries in Chicago, Illinois which in turn sends the waste to Ross Incineration Services in Grafton Ohio. Based on information provided by the operator, approximately 13 transport loads of hazardous material are sent to Ross Incineration for disposal. The round trip distance from the PWP site to Ross Incineration is approximately 1,500 miles. Hazardous materials incineration is included in the carbon footprint as actual combustion of the materials and do not include the energy (natural gas/electricity) used as an ignition source or as fuel for the incinerator.

Fugative methane emissions generated by anaerobic digestion of organic contaminants at the site, in the vicinity of the CAMU, have a significant impact on the environmental footprint of the remedial action at the site. The volume of fugitive methane emitted could not be quantified, and thus are not included in the carbon footprint analysis for the site. It is anticipated that this fugitive methane will be emitted from the site for a prolonged period of time due to the presence of oil soaked wood chips within the CAMU. Bioventing efforts are underway to try to mitigate methane generation by injecting air into the vadose zone.

The total annual carbon footprint generated by the PWP site is estimated to be 482.98 tons carbon dioxide equivalents (CO_2e). The carbon footprint analysis is included in Appendix A.

4.2 ENERGY

Electric service at the site is provided by Northwestern Wisconsin Electric and is required to operate the remedial equipment, provide indoor lighting and supplemental heating in the treatment building and heat the outdoor chemical storage tanks. Propane for the site is primarily used to heat the buildings.

For the 12-month time period from January to December 2008 the total costs for electricity was $51,227. The total average monthly cost for electricity is approximately $4,269. Total electrical service requirements for the January to December 2009 operational year equals energy consumption of approximately 465,126 kilowatt hours (kWh). Average monthly energy consumption is approximately 38,761 kWh and total costs average $0.110 per kWh for 2008.

For the 4-month time period from January to April 2009 the total costs for electricity was $17,690. The total average monthly cost for electricity is approximately $4,423. Total electrical service requirements for the January to April 2009 time period equals energy consumption of approximately 173,960 kWh. Average monthly energy consumption is approximately 43,490 kWh and total costs average $0.101 per kWh for 2009.

For the 12-month time period from January to December 2008 the total costs for propane was $48,804 for 21,270 gallons. The total average monthly cost for propane is approximately $4,067 for average monthly usage of 1,418 gallons of propane. The propane tank was filled 15 times during 2008. Average propane costs for 2008 are $2.29 per gallon.

For the 4-month time period from January to April 2009 the total costs for propane was $38,116.98 for 16,410 gallons. The total average monthly cost for propane is approximately $9,529.25 for average monthly usage of 1,368 gallons of propane. The propane tank was filled 12 times so far during 2009. Average propane costs so far for 2009 are $2.32 per gallon.

4.3 OPERATIONAL COSTS

Total operational costs, including electricity and propane, associated with the treatment system operation and monitoring includes consultant costs, bag filters, chemical additives, GAC replacement and disposal, telephone service, filter cake disposal, LNAPL disposal, analytical costs, maintenance and equipment costs, etc. Costs provided by the operator show that $1,221,000 was expended to operate the PWP system in 2008 and $1,158,000 was expended to operate the PWP system in 2009.

A detailed breakdown of operational costs was not provided for operational years 2008 and 2009. The detailed breakdown for operating year 2006 (reported in the Draft Penta Wood Products Remedial Action Optimization Report, February 2006) indicated that the largest cost component was discharge and disposal costs, which were projected to be approximately $538,000 in 2006. Other projected costs were project management and reporting $156,736, O&M Labor $120,100, groundwater sampling labor $37,800, consumables (GAC, chemicals) $156,301, laboratory costs $34,700 and other(parts, maintenance etc.) $83,975. Given that total operation and maintenance costs in 2006 and 2009 are similar the detailed cost breakdown should be similar as well.

4.4 CONTAMINANT MASS REMOVAL

The remedial system at the PWP site has removed approximately 7,028 pounds of dissolved phase PCP from groundwater and an additional 5,824 pounds of PCP entrained in the LNAPL through December 2008. Approximately 29,500 gallons of free product (Fuel Oil No. 2) had been collected and disposed of through the end of December 2008.

5.0 LIMITED REMEDIAL PROCESS OPTIMIZATION STUDY

The limited RPO is a specific process that examines overall remedial system effectiveness, including incremental changes and/or system replacement to include considerations of new technologies, as well as alternative regulatory approaches. Optimization must be implemented within the confines of the existing site decision document.

The purpose of the limited RPO study is to identify possible changes to the site or remedial system that would significantly improve the system with regards to overall remedial sustainability. This includes decreasing the costs of operating the system and/or increasing the efficiency of LNAPL or PCP impacted water removal. The limited RPO study is based on the analysis of documents and information provided by the site operator and WDNR, as well as information obtained during the site walk conducted June 2, 2009. These documents may not include the most current site information and many recent optimization studies that are currently underway or are considered draft.

The following RPO recommendations were based on the assumption that the current technology will continue to be employed as the site remedy for an additional 30 years. This value was selected for the purpose of comparing remedial options based on an estimate of cleanup time presented in the ROD.

5.1 REROUTE GROUNDWATER EXTRACTION INFLUENT AROUND DAF TANK

Evaluate rerouting the groundwater influent header to bypass the coagulant reaction tank, the flocculant reaction tank and DAF unit and flow directly into the DAF pump tank. The purpose of the DAF process, as stated in the O&M Manual, is to remove TSS and emulsified O&G from the influent stream prior to processing the water through a series of granular activated carbon units, after which the effluent pH is adjusted and the water is discharged to the reinfiltration basin. The on-site operator has done on-site jar testing and determined that emulsified oil is present in “micels” in the total influent collected from the groundwater extraction system, and thus, the influent needs to be run through the DAF system. Analysis of individual extraction wells could be conducted to determine if emulsified oil is present in water extracted from all extraction wells or just wells closer to the original source area. Sampling influent from individual groundwater extraction wells would also allow for the adjustment of the remedial system so pumping rates could be increased from wells that have the highest contaminant concentrations.

Rerouting the influent from groundwater extraction wells without emulsified oil around the DAF unit would significantly decrease the through-put on the DAF unit. This should result in a corresponding reduction in the $FeSO_4$ coagulant, the cationic polymer and drying agent. The change would also result in a significant reduction in the “filter cake” hazardous waste generated by the process. GAC lifespan should not be affected as the dissolved phase PCP concentration should remain constant.

5.2 BIOVENTING SYSTEM MODIFICATION

The current bioventing system consists of nine biovent (injection) wells, a 75-Hp centrifugal blower, connecting piping, and associated controls. Seven of the injection wells are located within the lateral extent of the CAMU. Two of the injection wells are located just outside the

CAMU boundary. Well locations are shown on Figure 2-1. The blower is currently operating at a total flow rate of 4,000 scfm, or about 450 scfm per well.

An analysis of collected data indicates there are only a few locations were the vadose zone is depleted of oxygen to the point where it would impact aerobic microbial activity. These points, specifically SG22 and SG07S, correlate with the location of the on-site CAMU. Oxygen concentrations at other monitoring points indicate some reduction in oxygen concentrations, but concentrations are sufficient to support aerobic degradation of contaminants. With the exception of biovent wells in the vicinity of SG22 and SG07S, consider modifying system operation to pulse the biovent system on an as needed basis based on results of vapor point monitoring. A smaller blower should be considered for points that require constant air injection.

Evaluate the potential for adding additional vent wells CAMU to prevent the vadose zone from being depleted of oxygen.

5.3 EVALUATE INSTALLATION OF PRECOALESCING TANK PRIOR TO OIL WATER SEPARATOR

Evaluate placement of a precoalescing tank prior to the oil/water separator that would receive total fluids from the free product removal system. The tank would provide additional residence time to allow the emulsified O&G to coalesce. It also would provide a steadier stream of influent into the oil water separator. Currently, water is pulsed into the oil/water separator as the pneumatic pumps fill and discharge to the separator. The pulsing tends to increase the emulsification of O&G in the influent.

5.4 CREATE WIND BREAK AROUND EXTERIOR TANKS

Currently $FeSO_4$ and NaOH storage tanks are kept outside of the treatment facility and exposed extremely cold and windy conditions during winter months. These tanks must be kept at minimum temperatures of 72 and 52 degrees Fahrenheit, which require a great deal of electricity to maintain these temperatures during winter months. Examine the feasibility of creating a windbreak around the tanks to shelter the tanks from the elements.

5.5 METHANE GENERATION UNDER CAMU

Based on the amount of organic material left in place within the CAMU, it is apparent that the generation of methane will be an issue even after the remediation system has been shut down. Any methane generated would eventually be emitted to the atmosphere. Methane has a high global warming potential and thus any methane emitted would have a significant effect on the sustainability/environmental footprint of the remediation.

Evaluate methods for creating a passive venting system in this area that could supply oxygen to the vadose zone in sufficient quantities to keep the vadose zone from going anaerobic. This potentially could be accomplished by installing small windmills such as those used to aerate ponds which could be modified to inject air into the vadose zone.

6.0 ALTERNATIVE ENERGY ANALYSIS

An alternative energy analysis was conducted at the PWP site. The analysis includes the evaluation of solar power, wind power and geothermal heating.

6.1 SOLAR ENERGY

Solar energy can be used through several methods including direct or indirect heating and lighting systems, photovoltaics (PV), or concentrating solar power. The NERL National Photovoltaic Resource Map indicates that in the vicinity of the site PV power averages about 3.0 kWh m^2/day. The average electric power consumption on-site is about 465,000 kWh/yr for 2008, or about 1,274 kWh/day. To meet the electrical demand of the PWP site as currently configured, a PV system with an average efficiency of about 2.5 percent would require a collector area of about 17,000 m^2 to meet the site's average demand. To account for peak demand and to generate power to be stored for periods when the PV system cannot meet the average demand, you might need two to three times that much output (or about 930 - 1,395,000 kWh/day). Any power generated that was not used or stored on-site would be exported to the utility grid and would generate income for the state. The majority of the site is clear of trees or any obstructions that obstruct or shadow the photovoltaic cells. Due to the size of the photovoltaic array needed to provide electricity for the site, putting up a solar array would be cost prohibitive.

6.2 WIND ENERGY

Conduct a wind resource assessment to determine the potential for using wind energy. The Wisconsin Focus on Energy Wind Resource Map indicates that, in the vicinity of the site, the wind power density at an altitude of 40 meters is 200-300 W/m^2. The average electric power consumption on-site is about 465,000 kWh/yr, or about 53 kW. A wind turbine or turbines, with a constant output of about 53 kW, could meet the site's average demand. To account for peak demand and to generate power to be stored for periods when the wind turbine cannot meet the average demand, you might need two to three times that much output (or about 106 to 159 kW). Installation of a 100 kW wind turbine, which would produce approximately 140,000 kWh of electricity per year at the site, would cost approximately $300,000, and have a payback period of 28 years without any incentives included. Any power generated that was not used or stored on-site would be exported to the utility grid and would generate income for the state.

The most significant concern with a wind power system is the proximity of nearby homes and the potential height restrictions due to proximity to the nearby local airport.

6.3 GEOTHERMAL HEATING

Currently the PWP site uses approximately 22,000 pounds of propane to provide heat to the building during winter months as well as using electric space heaters in select locations. The remediation system as currently configured pumps at a rate of approximately 60 gpm which would be a sufficient throughput to use geothermal heating to offset heating costs during winter months. A detailed analysis of the building and heating system would need to be conducted to determine if it was feasible and cost effective to install a heat exchange unit that would use the thermal energy in the extracted groundwater to heat the building.

7.0 POTENTIAL SUSTAINABLE ACTIVITIES

Currently, Penta Wood Products Inc. is listed in the tax records as the owner of record at the site. Penta Wood Products Inc. is no longer a viable entity. Some recommended sustainable activities may require permission by the property owner. It is unclear whether the EPA, WDNR or Burnett County would require permission prior to implementing these activities.

Implementing the recommended RPOs will result in a more effective and efficient remedial system and achieve objectives quicker and at a lower cost (i.e., sustainable). In addition to the items mentioned in the RPO section of this document, some additional sustainable activities that may be considered are discussed below.

7.1 RECYCLING USED EQUIPMENT

As the remediation equipment at the site is taken offline, the equipment should be salvaged or recycled dependent upon condition. Although the market for used remedial equipment is small, the equipment could be sold and reused by another consultant at a different site. If reuse is not possible, the equipment should be recycled and/or properly disposed of.

7.2 REPURPOSING FACILITY

The PWP site is located in a rural area. Once remediation has been completed, the site building and site could be reused for commercial or industrial purposes. It is unlikely that the parcel can be redeveloped for residential use or parkland due to the presence of the CAMU at the site.

7.3 USE SITE TO GENERATE ALTERNATIVE ENERGY

As mentioned in the Alternative Energy evaluation, the PWP site has potential for generating wind power to sell back to the utility. Project managers from Northwestern Wisconsin Electric, which provide electric service to the site, indicated that the PWP site is one of only two sites within their service area that would be suitable for the production of wind power. North West Wisconsin Electric also indicated that the infrastructure required to put power back into the grid was located close to the PWP site and connection to the grid would require relatively little work. There is an airport nearby and an evaluation would need to be conducted to determine the maximum height of the windmills. A feasibility study would need to be conducted prior to implementing any alternative energy options at the site.

8.0 SUSTAINABILITY MATRIX

A sustainability matrix was created that compared sustainability metrics for the current operational baseline verses three potential modifications that could be made to the system. The selected options are rerouting the groundwater extraction well influent, installation of passive venting system and the installation of wind turbines to offset electricity usage at the site as well as to provide energy to the grid after site closure. The sustainability matrix for the PWP site is presented in Table 8-1.

It should be noted that the best or most applicable sustainable alternative at the site may be a combination of the proposed options. In addition to the alternatives presented in the matrix, other RPO recommendations should be considered for implementation after being fully evaluated.

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Table 8-1 Sustainability Matrix Penta Wood Products Site								
	Baseline[3]		Option 1 Rerouting 20 percent of Influent Around DAF		Option 2 Installing Passive Soil Venting in CAMU Area		Option 3 Installation of 100 kW Wind Turbine	
Sustainability Metrics[1,2]	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**
System Optimization (Qualitative)	All groundwater influent is being routed through the DAF system and the biovent system operates continuously for approximately 7 months per year.		Would decrease filter cake production by 20 percent. Would not increase the effectiveness of the extraction system.		Passive venting would eliminate the need to operate the biovent blower which consumes approximately 200,000 kW of energy per year.		Will not increase the effectiveness of the remedy but would offset electric usage at the site by 140,000 kW per year.	
Restoration Timeframe (yrs)	NA	25	NA	25	NA	25	NA	25
Carbon Footprint/Air Emissions								
Tons CO_2e	482.98	12,074.50	475.6	11,890.30	482.06	12,051.50	482.29	12,057.30
Energy Usage								
Electricity (kWh)	456,126	11,403,150	456,126	11,403,150	256,126	6,403,150	306,126	7,653,150
Propane (Pounds)	21,270.20	531,755	21270.2	531,755	21,270.20	531,755	21,270.20	531,755
Cost								
O&M Cost (dollars)	$1,221,000	$30,525,000	$1,183,000	$29,575,500	$1,201,000	$30,025,000	$72,870	$1,821,750
Cost of Modification (dollars)	NA	NA	NA	$10,000	NA	$30,000 to $50,000	NA	$300,000
Cost per Ton CO_2e Reduced (dollars)	NA	NA	$1,351.00	$54.00	$54,347.00	$2,173.90	$508,474	$20,338
Land & Ecosystems								
Community Benefits (qualitative)	NA	NA	Reduction in hazardous waste produced.		Reduction in fugitive methane emitted. Would operate beyond lifespan of the extraction system as methane generation will be an ongoing problem at this site.		Generation of renewable power will offset energy usage at the site. Power can still be generated and fed back to the grid after site is closed.	
Materials & Waste Generation								
Reduced Filter Cake Generation (pounds)	NA	NA	42,280	1,057,000	NA	NA	NA	NA

[1] Metrics may be either qualitative not applicable (NA) or quantitative based on available information and scope of project.

[2] Metrics may be added or deleted based on site specific conditions.

[3] Baseline: As the system is currently being operated.

* Assume upper limit costs are used for cost per ton CO_2e reduced.

APPENDIX A

CARBON FOOTPRINT ANALYSIS

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Carbon Footprint Calculations Baseline Calculation

Penta Wood Products
8682 State Road 70
Siren, WI 54872

Scope 1

											CO_2e					
											Greenhouse Gas Potentials					
					Emission Factors			Mass			1	25	310	Total		
Gaseous Fuels Burned On-Site	**Year**	**Usage (gallons/yr)**	**Heat Content (mmBtu/barrel)**	**Usage (TJ/yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO2e	lb CO2e	ton CO2e
Propane	2008	21,270.2	3.849	2.057	79,600	10	0.6	163,704.43	20.57	1.23	163,704.43	514.15	382.53	164,601.10	362,877.20	181.44
		See Note 1	*See Note 4*		*See Note 2*	*See Note 2*	*See Note 2*									

Scope 2

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			Mass			1	25	310	Total		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	456,126	0.456126	1.74	27.46	27.55	0.79	12.53	12.57	0.79	313.13	3895.54	1,909.41	4,209.47	2.10
		See Note 1		*See Note 3*	*See Note 3*	*See Note 3*									

Scope 3

										CO_2e					
										Greenhouse Gas Potentials					
										1	25	310			
Sampling/O&M/ Vehicle Usage/Waste Disposal	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	**kg CO_2/gallon**	**kg CH_4/gallon**	**kg N_2O/gallon**	**kg CO_2**	**kg CH_4**	**kg N_2O**	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline- Sampling	2008	1,200	66.67	8.81	0.0036	0.0004	587.33	0.24	0.03	587.33	6.07	8.18	601.59	1,326.50	0.66
Unleaded Gasoline- O&M	2008	6,240	346.67	8.81	0.0036	0.0004	3,054.13	1.26	0.14	3054.13	31.57	42.56	3,128.26	6,897.82	3.45
Diesel - Fuel Hauling	2008	3,600	450	10.15	0.000041	0.000038	4,567.50	0.02	0.02	4567.50	0.46	5.36	4,573.32	10,084.16	5.04
Diesel-Filter Cake	2008	10,500	1313	10.15	0.000041	0.000038	13,321.88	0.05	0.05	13321.88	1.34	15.62	13,338.84	29,412.14	14.71
Diesel-Carbon Disposal	2008	6,000	750	10.15	0.000041	0.000038	7,612.50	0.03	0.03	7612.50	0.77	8.93	7,622.19	16,806.94	8.40
Fuel Oil No 2 Incineration	2008		3760	22.383			84,160.08			84160.08			84,160.08	185,572.98	92.79
			Generation(pounds/yr)	**kg CO_2/pound**											
Filter Cake Incineration	2008		211400	0.113			23,888.20			23888.20			23,888.20	52,673.48	26.34
Pentachlorophenol Incineration in Oil	2009		492	10.9			5,362.80			5362.80			5,362.80	11,824.97	5.91
Pentachlorophenol Incineration on Oil	2009		986	10.9			10,747.40			10747.40			10,747.40	23,698.02	11.85
Carbon Disposal Incineration	2009		69515	1.7			118,175.50			118175.50			118,175.50	260,576.98	130.29
											See Note 3	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
438,108.69	965,960.66	482.98

Note

Conversions: *1 barrel = 42 gallons*
1 MMBTU = 0.00105506 TJ
1,000 kWh = 1.0E+6 GWh
1 gallon No. 2 Fuel oil = 7.2 lbs

Source Notes: *1. Utility usage reported by NSP.*
(Intergovern
3. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Xcel Energy Inc. Pollutant Output Emission Rates, 2005.
4. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Appendix B, Table B-3: Factors for Calculating CO_2 Emissions for LPG Use.

Notes and Assumptions: *1. A twenty mile round trip to the site for the operator 6 times per week 52 weeks a year.*
2. A sampling crew will be mobilized from Milwaukee twice per year to conduct monitoring well sampling.
3. All hazardous waste (Oil, filter cake and expended GAC) is hauled to Grafton Ohio for incineration at 1500 miles per round trip.
4. Based on a stoichiometrical relationship 1 pound of GAC produces 1.7 kg of CO_2 when combusted assuming complete combustion.
5. The combustion of 1 metric tonne of Diatomaceous Earth emits 250 kg (0.113 kg/pound) of CO_2, including the energy used to combust the material.
6. Based on a stoichiometrical relationship 1 pound of Pentachlorophenol produces 24 pounds or 10.9 kg of CO_2 when combusted assuming complete combustion.
7. Weight of dissolved phase pentachlorophenol was subtracted from GAC disposal weight.
8. Weight of pentachlorophenol dissolved in oil was subtracted from weight of the No. 2 Fuel oil that was disposed.
9. Fuel Oil No. 2 emits 22.83 kg of CO2 per gallon when fully combusted per US Energy Information Administration.

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Carbon Footprint Calculations — Option 1, Rerouting 20 Percent of Groundwater Around DAF Unit

Penta Wood Products
8682 State Road 70
Siren, WI 54872

Scope 1

					Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	310	Total		
Gaseous Fuels Burned On-Site	**Year**	**Usage (gallons/yr)**	**Heat Content (mmBtu/barrel)**	**Usage (TJ/yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO2e	lb CO2e	ton CO2e
Propane	2008	21,270.2	3.849	2.057	79,600	10	0.6	163,704.43	20.57	1.23	163,704.43	514.15	382.53	164,601.10	362,877.20	181.44
		See Note 1	*See Note 4*		*See Note 2*	*See Note 2*	*See Note 2*									

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	310	Total		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	456,165	0.456165	1.74	27.46	27.55	0.79	12.53	12.57	0.79	313.16	3,895.88	1,909.58	4,209.83	2.10
		See Note 1		*See Note 3*	*See Note 3*	*See Note 3*									

Scope 3

										CO_2e Greenhouse Gas Potentials 1	25	310			
Sampling/O&M/ Vehicle Usage/Waste Disposal	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	**kg CO_2/gallon**	**kg CH_4/gallon**	**kg N_2O/gallon**	**kg CO_2**	**kg CH_4**	**kg N_2O**	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline- Sampling	2008	1,200	66.67	8.81	0.0036	0.0004	587.33	0.24	0.03	587.33	6.07	8.18	601.59	1,326.50	0.66
Unleaded Gasoline- O&M	2008	6,240	346.67	8.81	0.0036	0.0004	3,054.13	1.26	0.14	3,054.13	31.57	42.56	3,128.26	6,897.82	3.45
Diesel - Fuel Hauling	2008	3,600	450.00	10.15	0.000041	0.000038	4,567.50	0.02	0.02	4,567.50	0.46	5.36	4,573.32	10,084.16	5.04
Diesel-Filter Cake	2008	9,000	1,125.00	10.15	0.000041	0.000038	11,418.75	0.05	0.04	11,418.75	1.15	13.39	11,433.29	25,210.40	12.61
Diesel-Carbon Disposal	2008	6,000	750.00	10.15	0.000041	0.000038	7,612.50	0.03	0.03	7,612.50	0.77	8.93	7,622.19	16,806.94	8.40
Fuel Oil No 2 Incineration	2008		3,760.00	22.383			84,160.08			84,160.08			84,160.08	185,572.98	92.79
			Generation(pounds/yr)	**kg CO_2/pound**											
Filter Cake Incineration	2008		169,120.00	0.113			19,110.56			19,110.56			19,110.56	42,138.78	21.07
Pentachlorophenol Incineration in Oil	2009		492.00	10.9			5,362.80			5,362.80			5,362.80	11,824.97	5.91
Pentachlorophenol Incineration on Oil	2009		986.00	10.9			10,747.40			10,747.40			10,747.40	23,698.02	11.85
Carbon Disposal Incineration	2009		69,515.00	1.7			118,175.50			118,175.50			118,175.50	260,576.98	130.29
											See Note 3	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
431,425.67	951,224.59	475.61

Note

Conversions: *1 barrel = 42 gallons*
1 MMBTU = 0.00105506 TJ
1,000 kWh = 1.0E+6 GWh
1 gallon No. 2 Fuel oil = 7.2 lbs

Source Notes: *1. Utility usage reported by NSP.*
(Intergovern
3. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Xcel Energy Inc. Pollutant Output Emission Rates, 2005.
4. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Appendix B, Table B-3: Factors for Calculating CO_2 Emissions for LPG Use.

Notes and Assumptions: *1. A twenty mile round trip to the site for the operator 6 times per week 52 weeks a year.*
2. A sampling crew will be mobilized from Milwaukee twice per year to conduct monitoring well sampling.
3. All hazardous waste (Oil, filter cake and expended GAC) is hauled to Grafton Ohio for incineration at 1500 miles per round trip.
4. Based on a stoichiometrical relationship 1 pound of GAC produces 1.7 kg of CO_2 when combusted assuming complete combustion.
5. The combustion of 1 metric tonne of Diatomaceous Earth emits 250 kg (0.113 kg/pound) of CO_2, including the energy used to combust the material.
6. Based on a stoichiometrical relationship 1 pound of Pentachlorophenol produces 24 pounds or 10.9 kg of CO_2 when combusted assuming complete combustion.
7. Weight of dissolved phase pentachlorophenol was subtracted from GAC disposal weight.
8. Weight of pentachlorophenol dissolved in oil was subtracted from weight of the No. 2 Fuel oil that was disposed.
9. Fuel Oil No. 2 emits 22.83 kg of CO2 per gallon when fully combusted per US Energy Information Administration.

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Carbon Footprint Calculations   Option 2, Installing Passive Venting in CAMU Area

Penta Wood Products
8682 State Road 70
Siren, WI 54872

Scope 1

					Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
											1	25	310			
Gaseous Fuels Burned On-Site	**Year**	**Usage (gallons/yr)**	**Heat Content (mmBtu/barrel)**	**Usage (TJ/yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO2e	lb CO2e	ton CO2e
Propane	2008	21,270.2	3.849	2.057	79,600	10	0.6	163,704.43	20.57	1.23	163,704.43	514.15	382.53	164,601.10	362,877.20	181.44
		See Note 1	*See Note 4*		*See Note 2*	*See Note 2*	*See Note 2*									

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	310			
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	256,126	0.256126	1.74	27.46	27.55	0.45	7.03	7.06	0.45	175.83	2187.44	1,072.18	2,363.72	1.18
		See Note 1		*See Note 3*	*See Note 3*	*See Note 3*									

Scope 3

										CO_2e Greenhouse Gas Potentials					
										1	25	310			
Sampling/O&M/ Vehicle Usage/Waste Disposal	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	**kg CO_2/gallon**	**kg CH_4/gallon**	**kg N_2O/gallon**	**kg CO_2**	**kg CH_4**	**kg N_2O**	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline- Sampling	2008	1,200	66.67	8.81	0.0036	0.0004	587.33	0.24	0.03	587.33	6.07	8.18	601.59	1,326.50	0.66
Unleaded Gasoline- O&M	2008	6,240	346.67	8.81	0.0036	0.0004	3,054.13	1.26	0.14	3054.13	31.57	42.56	3,128.26	6,897.82	3.45
Diesel - Fuel Hauling	2008	3,600	450	10.15	0.000041	0.000038	4,567.50	0.02	0.02	4567.50	0.46	5.36	4,573.32	10,084.16	5.04
Diesel-Filter Cake	2008	10,500	1313	10.15	0.000041	0.000038	13,321.88	0.05	0.05	13321.88	1.34	15.62	13,338.84	29,412.14	14.71
Diesel-Carbon Disposal	2008	6,000	750	10.15	0.000041	0.000038	7,612.50	0.03	0.03	7612.50	0.77	8.93	7,622.19	16,806.94	8.40
Fuel Oil No 2 Incineration	2008		3760	22.383			84,160.08			84160.08			84,160.08	185,572.98	92.79
			Generation(pounds/yr)	**kg CO_2/pound**											
Filter Cake Incineration	2008		211400	0.113			23,888.20			23888.20			23,888.20	52,673.48	26.34
Pentachlorophenol Incineration in Oil	2009		492	10.9			5,362.80			5362.80			5,362.80	11,824.97	5.91
Pentachlorophenol Incineration on Oil	2009		986	10.9			10,747.40			10747.40			10,747.40	23,698.02	11.85
Carbon Disposal Incineration	2009		69515	1.7			118,175.50			118175.50			118,175.50	260,576.98	130.29
		--	--	--	--	--	--		--	--	0	--	0.00	0.00	0.00
											See Note 3	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
437,271.46	964,114.91	482.06

Note

Conversions: *1 barrel = 42 gallons*
1 MMBTU = 0.00105506 TJ
1,000 kWh = 1.0E+6 GWh
1 gallon No. 2 Fuel oil = 7.2 lbs

Source Notes: *1. Utility usage reported by NSP.*
(Intergovern
3. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Xcel Energy Inc. Pollutant Output Emission Rates, 2005.
4. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Appendix B, Table B-3: Factors for Calculating CO_2 Emissions for LPG Use.

Notes and Assumptions: *1. A twenty mile round trip to the site for the operator 6 times per week 52 weeks a year.*
2. A sampling crew will be mobilized from Milwaukee twice per year to conduct monitoring well sampling.
3. All hazardous waste (Oil, filter cake and expended GAC) is hauled to Grafton Ohio for incineration at 1500 miles per round trip.
4. Based on a stoichiometrical relationship 1 pound of GAC produces 1.7 kg of CO_2 when combusted assuming complete combustion.
5. The combustion of 1 metric tonne of Diatomaceous Earth emits 250 kg (0.113 kg/pound) of CO_2, including the energy used to combust the material.
6. Based on a stoichiometrical relationship 1 pound of Pentachlorophenol produces 24 pounds or 10.9 kg of CO_2 when combusted assuming complete combustion.
7. Weight of dissolved phase pentachlorophenol was subtracted from GAC disposal weight.
8. Weight of pentachlorophenol dissolved in oil was subtracted from weight of the No. 2 Fuel oil that was disposed.
9. Fuel Oil No. 2 emits 22.83 kg of CO2 per gallon when fully combusted per US Energy Information Administration.

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Carbon Footprint Calculations   Option 3, Installation of Wind Power to Offset Energy Usage

Penta Wood Products
8682 State Road 70
Siren, WI 54872

Scope 1

					Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
											1	25	310			
Gaseous Fuels Burned On-Site	**Year**	**Usage (gallons/yr)**	**Heat Content (mmBtu/barrel)**	**Usage (TJ/yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO2e	lb CO2e	ton CO2e
Propane	2008	21,270.2	3.849	2.057	79,600	10	0.6	163,704.43	20.57	1.23	163,704.43	514.15	382.53	164,601.10	362,877.20	181.44
		See Note 1	*See Note 4*		*See Note 2*	*See Note 2*	*See Note 2*									

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials			Total		
										1	25	310			
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	306,126	0.306126	1.74	27.46	27.55	0.53	8.41	8.43	0.53	210.16	2614.47	1,281.49	2,825.16	1.41
		See Note 1		*See Note 3*	*See Note 3*	*See Note 3*									

Scope 3

										CO_2e Greenhouse Gas Potentials					
										1	25	310			
Sampling/O&M/ Vehicle Usage/Waste Disposal	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	**kg CO_2/gallon**	**kg CH_4/gallon**	**kg N_2O/gallon**	**kg CO_2**	**kg CH_4**	**kg N_2O**	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline- Sampling	2008	1,200	66.67	8.81	0.0036	0.0004	587.33	0.24	0.03	587.33	6.07	8.18	601.59	1,326.50	0.66
Unleaded Gasoline- O&M	2008	6,240	346.67	8.81	0.0036	0.0004	3,054.13	1.26	0.14	3054.13	31.57	42.56	3,128.26	6,897.82	3.45
Diesel - Fuel Hauling	2008	3,600	450	10.15	0.000041	0.000038	4,567.50	0.02	0.02	4567.50	0.46	5.36	4,573.32	10,084.16	5.04
Diesel-Filter Cake	2008	10,500	1313	10.15	0.000041	0.000038	13,321.88	0.05	0.05	13321.88	1.34	15.62	13,338.84	29,412.14	14.71
Diesel-Carbon Disposal	2008	6,000	750	10.15	0.000041	0.000038	7,612.50	0.03	0.03	7612.50	0.77	8.93	7,622.19	16,806.94	8.40
Fuel Oil No 2 Incineration	2008		3760	22.383			84,160.08			84160.08			84,160.08	185,572.98	92.79
			Generation(pounds/yr)	**kg CO_2/pound**											
Filter Cake Incineration	2008		211400	0.113			23,888.20			23888.20			23,888.20	52,673.48	26.34
Pentachlorophenol Incineration in Oil	2009		492	10.9			5,362.80			5362.80			5,362.80	11,824.97	5.91
Pentachlorophenol Incineration on Oil	2009		986	10.9			10,747.40			10747.40			10,747.40	23,698.02	11.85
Carbon Disposal Incineration	2009		69515	1.7			118,175.50			118175.50			118,175.50	260,576.98	130.29
		--	--	--	--	--	--		--	--	0	--	0.00	0.00	0.00
											See Note 3	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
437,480.77	964,576.35	482.29

Note

Conversions: *1 barrel = 42 gallons*
1 MMBTU = 0.00105506 TJ
1,000 kWh = 1.0E+6 GWh
1 gallon No. 2 Fuel oil = 7.2 lbs

Source Notes: *1. Utility usage reported by NSP.*
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4. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Appendix B, Table B-3: Factors for Calculating CO_2 Emissions for LPG Use.

Notes and Assumptions: *1. A twenty mile round trip to the site for the operator 6 times per week 52 weeks a year.*
2. A sampling crew will be mobilized from Milwaukee twice per year to conduct monitoring well sampling.
3. All hazardous waste (Oil, filter cake and expended GAC) is hauled to Grafton Ohio for incineration at 1500 miles per round trip.
4. Based on a stoichiometrical relationship 1 pound of GAC produces 1.7 kg of CO_2 when combusted assuming complete combustion.
5. The combustion of 1 metric tonne of Diatomaceous Earth emits 250 kg (0.113 kg/pound) of CO_2, including the energy used to combust the material.
6. Based on a stoichiometrical relationship 1 pound of Pentachlorophenol produces 24 pounds or 10.9 kg of CO_2 when combusted assuming complete combustion.
7. Weight of dissolved phase pentachlorophenol was subtracted from GAC disposal weight.
8. Weight of pentachlorophenol dissolved in oil was subtracted from weight of the No. 2 Fuel oil that was disposed.
9. Fuel Oil No. 2 emits 22.83 kg of CO2 per gallon when fully combusted per US Energy Information Administration.

N.W. Mauthe
Site Specific Sustainable Remediation System Evaluation

Prepared for:
Wisconsin Department of Natural Resources
Remediation and Redevelopment Program
101 South Webster Street
Madison, WI 53703

Prepared by:
AECOM
Project No. 60134224(107343)

September 2009

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LIST OF ACRONYMS

µg/L	micrograms per liter
ACL	alterative concentration limit
CO_2e	Carbon Dioxide Equivalents
EPA	Environmental Protection Agency
ES	Enforcement Standard
FS	Feasibility Study
gpm	gallons per minute
KW	kilowatt
kWh	kilowatt hours
LED	light emitting diode
mg/kg	milligrams per kilograms
mg/L	milligram per liter
mpg	miles per gallon
NPL	National Priorities List
PAL	Preventative Action Limit
PLC	programmable logic controller
PV	photovoltaics
RI	Remedial Investigation
ROD	Record of Decision
RPO	Remedial Process Optimization
VOCs	volatile organic compounds
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources

1.0 INTRODUCTION

The purpose of this document is to provide a Site Specific Sustainable Remediation System Evaluation for the N.W. Mauthe site. To evaluate current conditions on the site, and the effect of any potential changes, a sustainability baseline was created that included current carbon footprint, energy usage, current operational costs and contaminant mass removal. A limited Remedial Process Optimization (RPO) was conducted for the site to identify major items that could be addressed to improve the sustainability and efficiency of the existing remedial system, and to reduce operation and maintenance costs. An alternative energy evaluation was conducted to see if alternative energy could be used to offset current energy usage at the site. Potential sustainable activities were evaluated to enhance the reduction of contaminant levels and lower costs. Three sustainable activities were selected and a sustainability matrix was generated outlining the costs and benefits of each activity in terms of various sustainability metrics, such as the increase or decrease in carbon footprint, energy usage, resource usage, waste generation and cost. The purpose of the sustainability matrix is to provide/quantify effects of the potential changes in terms of the sustainability metrics.

This document was generated using information supplied by Wisconsin Department Natural Resources (WDNR), including utility and operation and maintenance costs, monitoring reports and as builts where available, a site walk through and interviews with the WDNR site project manager. Due to the age of the site in some cases information was limited.

2.0 SITE DESCRIPTION

The N.W. Mauthe site is a former electroplating facility located at 725 South Outagamie Street, Appleton, Wisconsin. Chromium plating operations were conducted at the site from 1960 until 1976 after which zinc, cadmium, copper, and possibly silver plating operations were continued until 1987. The property is 0.56 acres and topographically flat with a downward slope for a railroad corridor. Also, the site is bordered to the south/southeast by an active railroad corridor, to the north, east and south by residences, to the southeast and southwest by commercial businesses and to the west and northwest by an industrial plant, Miller Electric. A site location map is shown on Figure 1, and a site detail map is shown on Figure 2.

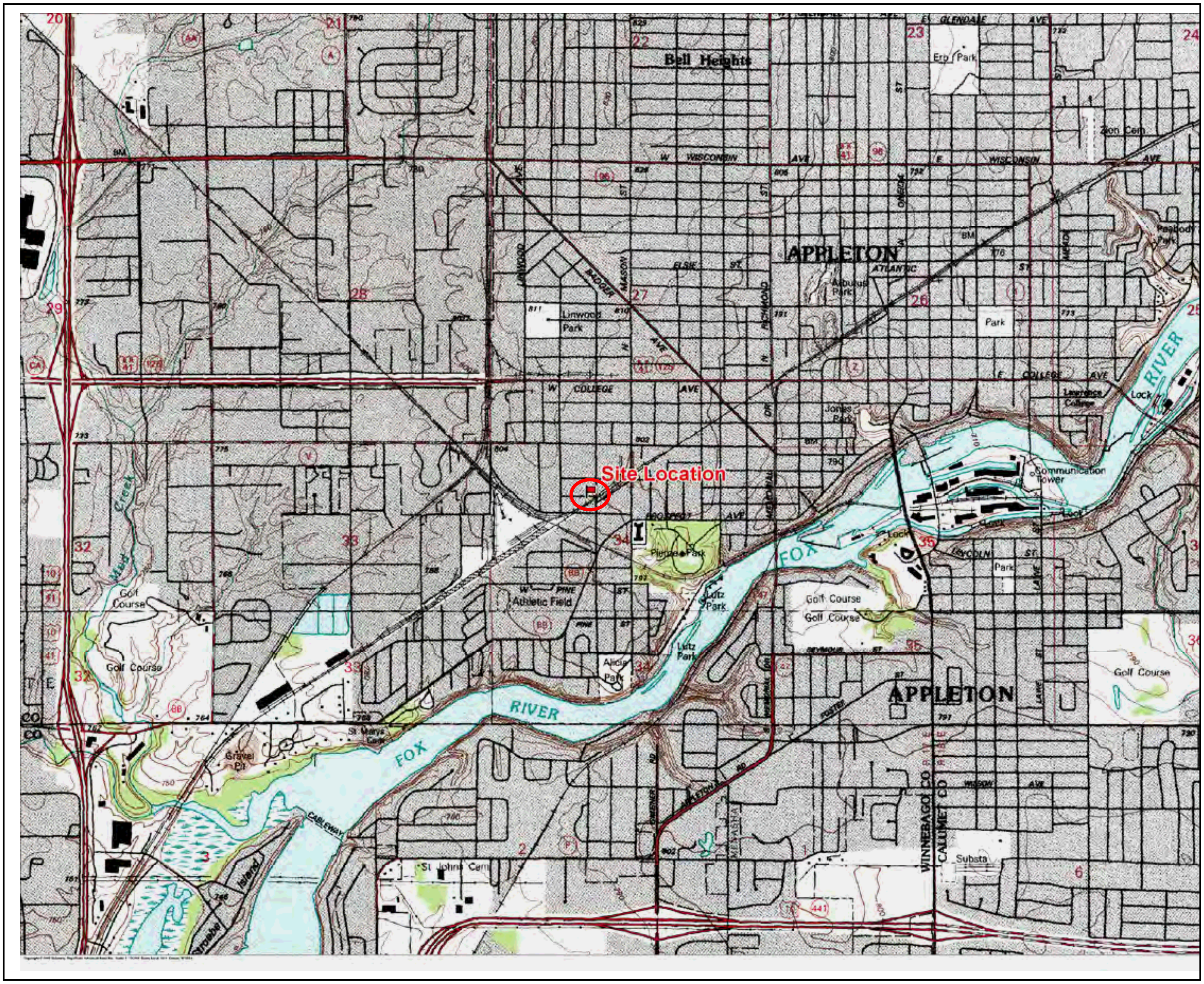
The WDNR initiated a site assessment in 1982 following a report of yellowish-green water being pumped from a residential foundation drain sump south of the site. Plating solutions that leaked from tanks and vats in the plating buildings had reportedly been discharged to ground surface via sump pumps. Immediate action included installation of a shallow drain system to collect contaminated groundwater and surface water. A temporary asphalt cover was installed in 1984 to limit infiltration of surface water, while a cleanup plan was developed. The site assessment subsequently lead to a series of investigations that culminated in the National Priorities List (NPL) listing of the site in 1989, at which time it became Wisconsin's No. 1 priority site.

The Environmental Protection Agency (EPA) conducted a removal action in 1991, aimed at removing chromium impacted soils adjacent to the former chrome plating building and securing the site with a chain-link fence. Building interiors were decontaminated and miscellaneous debris and wastes were containerized and stored in the building or were properly disposed of off site. Remedial Investigation (RI) and Feasibility Study (FS) reports were approved by the WDNR and EPA in 1993. A Record of Decision (ROD) was issued by the EPA in 1994.

Implementation of the ROD included demolition of site buildings and disposal of containerized wastes in 1994. Soil with total chromium concentrations of 500 milligrams per kilograms (mg/kg) or greater were excavated and removed from site in 1995. The treatment building and system components were constructed and installed between 1995 and 1996. The site was capped with 2 feet of clay and a vegetative cover established in 1996. Treatment system operation began in January 1997. The groundwater cleanup standard set forth in the ROD for chromium is 5 micrograms per liter (µg/L), which was the 1992 Wisconsin Administrative Code (WAC) NR 140 Preventative Action Limit (PAL).

The remedial system includes collection of groundwater from three groundwater extraction trenches, totaling 1,080 linear feet in length. Four house foundation drain systems are also hooked up to the extraction trenches. Groundwater collected in the extraction trenches gravity flows to two manholes and is subsequently pumped to the treatment building. Between 1997 and April 2006 the treatment system was a batch process. Extracted groundwater was transferred from a storage tank to a reaction tank for each batch and treated utilizing ferrous sulfate and caustic additions. After chemical addition, mixing, aeration, and settling, the treated groundwater was discharged to the City of Appleton sanitary sewer system. In April 2006, the treatment system was taken off-line, but remains in-place. Since April 2006, groundwater recovered from the extraction trenches has been discharged directly to sanitary sewer under a permit with the City. Total chromium concentrations in the influent flows have been at levels below discharge standards since the system began operation in 1997.

The site owner is identified as Carol Mauthe; however, site remediation efforts are 100 percent state funded.



Source: 2000 DeLorme Topo Tools

N

Figure 1 Site Location Map	
N.W. Mauthe 725 South Outagamie Street Appleton, Wisconsin 54914-5072	
OMNNI ASSOCIATES	Project Number: N1866A05
	Date: May 14, 2008
One Systems Drive, Appleton, Wisconsin 54914-1654 Phone: (920) 735-6900 Fax: (920) 830-6100	

FIGURE 2
SITE DETAIL MAP

N.W. MAUTHE
725 SOUTH OUTAGAMIE STREET
APPLETON, WISCONSIN

OMNI ASSOCIATES
ONE SYSTEMS DRIVE
APPLETON, WI 54914
PHONE (920) 735-6900
FAX (920) 830-6100

PROJECT MANAGER:	BDW	PROJECT NO:	N1866A05
PROJECT ENGINEER:	BDW	FILE NO:	SITEDET.MXD
DRAWN BY:	JCW	SCALE:	1 " equals 48 '
REVIEWED BY:	BDW	DATE:	5/14/2008

3.0 CURRENT CONDITIONS

The current remedial approach at the N.W. Mauthe site is to contain the contaminate plume on the property with no source area treatment of the groundwater plume. As a result, the WDNR has projected the site will not achieve remedial cleanup goals for approximately 500 years. As indicated above, the remedial equipment at the site is sitting idle and groundwater pumped from the extraction trenches is being discharged directly to the City of Appleton sanitary sewer under an industrial discharge permit, which is valid until May 2012.

The extraction system appears to be extracting a baseline flow of approximately 20,000 to 50,000 gallons per month (0.46 to 1.2 gallons per minute (gpm)) out of the 1,080 linear feet of groundwater extraction trench and four residential house drain systems. Elevated monthly flows up to 150,000 gallons have been recorded. Elevated flows are most likely the result of infiltration from drainage ditches adjacent to the site during the spring snow melt or periods of excessive rainfall. The groundwater table is located approximately 7 to 10 feet below ground surface beneath the site.

Groundwater infiltrating into the collection trenches gravity flows to two manholes and is conveyed to the treatment building by an electric submersible pump located in each manhole. The manholes are approximately 33-feet deep. Water levels within the manholes are controlled by float switches. The pumps each have a pumping capacity of 43 gpm. Hydrogen sulfide was reportedly corroding the concrete, piping, and wiring in Manhole No. 2. This has lead to several complaints about odors emanating from this manhole. Maintenance on Manhole Nos. 1 and 2 was completed November 2008, including repairs to conduit and wiring. The rigid piping at Manhole No. 2 was replaced with a flexible hose to simplify pump access. The pump at Manhole No. 2 is scheduled to be replaced in the near future.

An unfiltered sample of the discharge water is currently being collected weekly and analyzed by a laboratory for hexavalent chromium. Influent samples are also collected from Manhole Nos. 1 and 2 on a weekly basis and field screened for hexavalent chromium and pH. A filtered sample of the discharge water is collected monthly and submitted to the laboratory for analysis of total dissolved chromium. Compliance sampling of the remedial system effluent is conducted by the City of Appleton twice per year, and by an environmental consultant once per year.

Groundwater samples collected from monitoring wells at the site indicate that concentrations of chromium and several other volatile organic compounds (VOCs) have been detected above the WDNR NR 140 PALs and Enforcement Standards (ESs) at several monitoring wells across the site. The highest total chromium concentrations currently detected at the monitoring wells are approximately 76,000 ug/L (April 2009). Based in this chromium concentration, a reduction of 99.99 and 99.93 percent would be needed to meet the PAL and ES, respectively. Although standards are exceeded at most monitoring wells, contaminant trends appear to be stable or decreasing and the groundwater contaminant plume appears to be controlled by the extraction trenches.

Remedial equipment located in the treatment building generally consists of a 9,000-gallon storage tank with a top mounted mixer, 6,100-gallon reaction tank, diaphragm pump for water transfer between tanks, reaction tank mixer and air diffuser, water level indicators, pH monitors, air compressor, sludge transfer pump, sludge tank, and tanker truck feed pump. A programmable logic controller (PLC) system, with telemetry, controls the process equipment. The treatment system at the site is generally considered antiquated and the WDNR has previously indicated that it would likely not be used going forward, if groundwater treatment was required.

The treatment building consists of three main areas including the treatment system area housing the remedial equipment, control room, and truck bay. The truck bay was built for anticipated sludge removal but has never been used. The control room was built assuming a full-time operator would remain on site during treatment system operation. In May 2008, a cooperative agreement was established between WDNR and The City of Appleton Parks Department. The City is currently using the truck bay for equipment storage and the control room is being utilized by City workers. In exchange, site maintenance, lawn mowing, and snow removal is conducted by the City.

4.0 BASELINE EVALUATION

A sustainability baseline analysis was conducted for the N.W. Mauthe site. The sustainability baseline is a quantification of current site conditions using various sustainability metrics. This allows costs and benefits of potential changes/modifications to the remedial system to be measured using the same set of sustainability metrics.

4.1 CARBON FOOTPRINT

The N.W. Mauthe site is a relatively simple site that is currently in a long-term operation and maintenance mode. An analysis of site operations has identified applicable items associated with Scope 1 (direct discharge), Scope 2 (electricity) and Scope 3 (other indirect) at the site. The only Scope 1 item identified at the site is electrical usage. The only Scope 2 item is natural gas, used for heating the building. Scope 3 items were limited to consultant travel to/from the site for operation and maintenance and sampling activities. Scope 1 and 2 items were taken directly from utility bills provided by WDNR. For Scope 3, it was estimated that a contractor visited once per week and groundwater sampling was conducted four times per year. It was assumed that the consultant had to drive 50 miles to get to and from the site in a vehicle that gets 18 miles per gallon (mpg). Based on all information provided, it is estimated that the N.W. Mauthe site has a yearly operational carbon footprint baseline of 14.60 tons of Carbon Dioxide Equivalents (CO_2e). The carbon footprint analysis is included in Appendix A.

4.2 ENERGY

Electric service at the site is required to operate the remedial equipment and provide indoor and outdoor lighting. The treatment equipment area, control room, and truck bay are heated with natural gas furnaces. Electrical and natural gas services are provided by WE Energies. In 2008, utility costs for electricity and gas were $1,659 and $1,996, respectively. The average monthly cost for electricity and gas is approximately $138 and $166, respectively. Total electrical and gas service requirements for the 2008 operational year equals energy consumption of about 13,488 kilowatt hours (kWh) and approximately 1,714 therms, respectively. Total costs average $0.12 per kWh and $1.16 per therm. Average monthly costs for the first eight months of 2009 operation were slightly elevated from 2008. The average monthly cost for electricity and natural gas was $153 and $190, respectively. Gas and electric rates remained relatively constant.

4.3 OPERATIONAL COSTS

In additional to natural gas and electrical services discussed above, other operation costs associated with the treatment system operation and monitoring include telephone service, municipal utility charges, consulting costs, supply and equipment costs, subcontractor costs, and WDNR management.

Historical telephone charges average approximately $35 and $45 per month for AT&T and Ameritech services, respectively, or $420 to $540 per year. Municipal utility charges historically averaged about $295 per month. City of Appleton sewer/water and stormwater charges were $25 per month and $40 per month, respectively. Total costs, including telephone service and municipal water and sewer charges, average approximately $400 per month or $4,800 per year. Utility services are billed directly to the WDNR.

Operation and maintenance costs vary significantly from year to year depending on the amount of unscheduled maintenance that needs to be conducted at the facility or on the remedial system. These costs tend to increase as the remedial system and building in which it is housed ages. The operation and maintenance costs incurred for the period from May 2008 through April 2009 are summarized below.

The total costs reported for the May 2008 to September 2008 (5 months) time period on WDNR Form 4400-194 was $18,782. This included consultant services, roof snow guard and gutter repairs, man-door replacement, and lock replacement. Utility services are not included in the above dollar amount. Based on utility bills, electric and gas services during the May to September 2008 time period totaled $507 and $107, respectively. The approximate WDNR management cost of $689 was incurred during the May to September 2008 time period. As such, total costs for the May to September 2008 period are $20,485.

The total cost reported for the October 2008 to April 2009 (7 months) time period on WDNR Form 4400-194 was $32,507. This included consultant services, heater maintenance, fire extinguisher service, a cross-connection control performance test, damper repairs and maintenance, manhole repairs, pump maintenance, piping retrofit, and electrical and conduit repairs. Based on utility bills, electric and gas services during the October 2008 to April 2009 time period totaled $1,244 and $1,951, respectively. The approximate WDNR management cost of $700 was also incurred during the October 2008 to April 2009 time period. As such, total costs for the October 2008 to April 2009 period are $36,802.

The total cost for operating and maintaining the N.W. Mauthe remediation system for the May 2008 to April 2009 (12 months) time period is approximately $57,286, not including telephone and utility services, which are estimated to be approximately $4,800 per year.

Currently, groundwater is not being treated before discharge to the City of Appleton sanitary sewer. The City industrial discharge permit is valid through May 2012. If the City does not renew, the permit costs of operating a treatment system would likely double or triple the current operating budget, not including capital costs of designing and installing a new treatment system.

4.4 CONTAMINANT MASS REMOVAL

The estimated mass of chromium removed at the site was extrapolated from the total flow from extraction trenches and chromium concentrations in effluent samples collected from the discharge to the City of Appleton sanitary sewer. During the period from May 2008 to September 2008, approximately 324,350 gallons of groundwater was extracted from the collection trenches and discharged to the sanitary sewer. During this period, total chromium concentrations in the effluent ranged from 0.679 to 1.29 milligrams per liter (mg/L). Based on this flow and discharge sampling results, approximately 2.8 pounds of chromium was removed from the subsurface during this period. Similarly, during the period from October 2008 to April 2009 approximately 375,342 gallons of groundwater were extracted from the collection trenches and discharged to the sanitary sewer. During this period, total chromium concentrations in the effluent ranged from 0.73 to 2.9 mg/L. Based on this flow and discharge sampling results, approximately 5.6 pounds of chromium was removed from the subsurface during this period.

A total of 8.4 pounds of chromium were removed during the operational period from May 2008 to April 2009. Operational costs for the same period were approximately $62,086. This equates to costs of approximately $7,309 per pound of chromium extracted from the site. It should be noted that there may be limited removal of the chromium in the sanitary wastewater system so the overall net effect of the cleanup is to transfer contaminants from groundwater to surface water.

5.0 LIMITED REMEDIAL PROCESS OPTIMIZATION STUDY

RPO is a specific process that examines overall system effectiveness including incremental changes or system replacement to include considerations of new technologies, as well as alternative regulatory approaches. Optimization must be implemented within the confines of the existing decision document for the site.

The purpose of the limited RPO study is to identify possible changes to the site or remedial system that would significantly improve the system with regards to overall remedial sustainability. This includes decreasing the costs of operating the system and/or increasing the efficiency of chromium mass removal. The limited RPO study is based on the current conditions previously noted in this document.

The following RPO recommendations were based on the assumption that the current technology will continue to be employed as the site remedy for the foreseeable future. Potential alternative remedies are discussed in the Potential Sustainable Activities section (Chapter 7) of this document.

5.1 DEVELOP EXIT STRATEGY

The current regulatory “driver” for groundwater contamination at the site is the 5 µg/L 1992 WAC NR 140 PAL for chromium. Given site and operational conditions, the 5 µg/L standard is not possible to achieve in a reasonable time period. The ROD outlines a procedure in which an alternate concentration limit (ACL) can be established under the substantive requirements of WAC’s NR 140.28, which can be no higher than the ES of 100 µg/L or a technical impractical waiver under Section 12d of CERCLA may be used to set a goal higher than the ES.

Based on groundwater monitoring well data, it is not clear whether the south leg of Trench No. 2 is removing any contaminants. Placement of sentinel wells immediately upgradient of this trench section would determine if any chromium contamination above WDNR standards is flowing into this portion of trench. A similar approach could be used with Trench No. 1. If chromium concentrations do not exceed the WDNR ES for chromium, the trenches should not be operated. The trenches would be reactivated if the WDNR ES for chromium is exceeded in the sentinel wells. This approach would decrease operational costs going forward and potentially reduce the length of the trench that may need to maintained or replaced in the future.

5.2 EXAMINE ALTERNATIVES TO PUMP AND TREAT

The current remediation system installed at the N.W. Mauthe site is unlikely to clean up groundwater contamination in a reasonable time period. The current time period to achieve cleanup goals is estimated to be 500 years. During this timeframe, and most likely within the next 10 years, the extraction trenches will need to be maintained, which may include rehabilitation or reinstallation if the existing remedy is to remain in-place. The cost of replacing the existing trenches could exceed $1,000,000 and create a significant carbon footprint during the construction phase of trench replacement. In all likelihood, trenches and the associated remedial system would need to be replaced multiple times if the technology at the site remains the same.

It would be beneficial to examine alternative treatment technologies such as phytoremediation of chromium in the source area, and chemical injection in the source area to reduce chromium concentrations. Another possibility is placing a slurry wall around the site to fully encapsulate the contaminants as there is a 2-foot clay cap already present at the site.

5.3 EVALUATE SURFACE WATER INFILTRATION INTO TRENCH NOS. 1 AND 2

Based on the data provided, groundwater extraction Trench Nos. 1 and 2 appear to be highly sensitive to infiltration of surface water during wet periods, which is then pumped into the City of Appleton sanitary sewer system. Based on an analysis of the data, there appears to be a baseline flow of approximately 20,000 gallons of groundwater combined from both trenches and four residential house drains. Based on 2009 data, this increases to approximately 133,000 gallons per month during spring run off period. Lining the drainage ditches immediately adjacent to Trench Nos. 1 and 2 could limit the processing of clean surface water through the sanitary sewer system. The rapid infiltration through these ditches could also be the primary "driver" for off site plume migration. An engineering study would be required to determine the exact costs of lining the ditch, but an order of magnitude cost would be approximately $100,000 for 5,000-square yards. Costs do not include allowances for working in railway right of way. It is estimated that by limiting infiltration at the site, water discharged to the sanitary sewer could be reduced by 50 to 60 percent.

5.4 MOVE SANITARY DISCHARGE POINT FROM EXISTING BUILDING TO SMALL REMEDIATION ENCLOSURE

Currently, no treatment is being required prior to discharge of groundwater effluent from Trench Nos. 1 and 2 at the site provided chromium concentrations below permitted concentrations. The site has operated under this permit since 2006 without approaching the permitted concentration of 7 mg/L total chromium. It is unlikely that these concentrations, based on current operational status, will ever exceed the permitted values. Also, in the event that groundwater treatment is ever required again, it is likely that an ion exchange system will be used, as the existing treatment system is antiquated and would be very expensive to operate. An order of magnitude estimate for moving the connection to a small out building would be approximately $20,000 to $30,000.

Removal of the sanitary connection from the building would save approximately $3,000 per year in utility costs. In addition, the existing building could be rented out for $1,000 to $2,000 per month to offset the operation and maintenance costs. It is estimated that the payback time for this option would range from 2 to 3 years, assuming the building is rented and the tenant assumes utility and grounds keeping costs.

5.5 EVALUATE TRENCH PERFORMANCE

Based on data provided, there is approximately 1,080 linear feet of extraction trench with a base flow rate, from the entire length of the trench, of approximately 0.46 gpm. Specifications and data regarding installation and operation of the extraction trenches was limited, as a result, a mass flux calculation could not be completed. However, based on the baseline flow rates, it is questionable whether the groundwater trenches are effectively containing the contaminant plume. The fact that the extraction trenches appear to be having little impact on groundwater flow direction, water table elevations and gradients may be evidence of this. The extraction trenches have been active for a period of 12 to 13 years. In general, extraction trenches, depending on chemical conditions within the aquifer and biological growth within the trench, have an operational lifespan of about 10 to 25 years before requiring major rehabilitation or replacement.

6.0 ALTERNATIVE ENERGY ANALYSIS

A preliminary analysis of the potential use of alternative energy at the N.W. Mauthe site indicated that small scale solar energy appear to be the only feasible form of alternative energy that could be used at the site. Solar energy can be used through several methods including direct or indirect heating and lighting systems, photovoltaics (PV), or concentrating solar power. It is estimated that 11 kilowatt (KW) of photopholtaic solar power to offset the total amount of electricity used at the site. The estimated costs would be $87,000 with a payback period of approximately 30 years. If incentives were applied, the payback period would decrease significantly. It would be more feasible to offset electrical usage if the RPO recommendation of removing the sanitary connection from the building to a newly constructed small out building was implemented. The building could be constructed such that the only electricity required would be for light emitting diode (LED) lighting and to operate the two groundwater extraction pumps and small electric heater to keep the sanitary connections from freezing in the winter. This would eliminate the need for natural gas at the site. Supplying the current remediation system with 100 percent renewable energy would decrease the annual carbon footprint by 0.06 tons CO_2e per year. There would need to be a two meter system installed in which the power produced would be sold back to the utility at higher rate than it was purchased.

7.0 POTENTIAL SUSTAINABLE ACTIVITIES

The purpose of the groundwater treatment system was to reduce contaminant levels to meet state and/or federal groundwater quality standards. Based on system performance and contaminant levels detected in the groundwater monitoring wells, it does not appear that groundwater quality standards can be met in a reasonable time period. The following activities were evaluated to enhance the reduction of contaminant levels and lower costs.

7.1 PHYTOREMEDIATION

The feasibility of using phytoremediation to actively address soil and groundwater contamination on site needs to be examined. Phytoremediation may be utilized in conjunction with other remedial actions for hydraulic control and to degrade, extract, contain, or immobilize contaminants in both soil and groundwater. Several varieties of trees (hybrid poplars, willows, and cottonwoods) have shown the ability to effectively withdraw groundwater and control migration of a contaminant plume (phytopumping). For sites with metals contamination, the uptake of contaminants by the roots of plants and the translocation of contaminants within the plants (phytoextraction) is most often used. As such, the use of a phytoremediation tree plot for hydraulic control is likely more appropriate for the subject site. Placement of trees for the purpose of phytoremediation would also sequester carbon creating a carbon sink. There would only be a small carbon footprint generated as a result of employing this technology.

7.2 CHEMICAL INJECTION

The possibility of source area treatment using chemical injection technologies should also be examined. Metals, such as chromium, can be treated in-situ by injecting chemicals that will immobilize the metals by increasing the pH such as magnesium hydroxide and dipotassium phosphate (forming metal oxides and hydroxides that precipitate out and become permanently immobilized). This type of approach uses less energy and achieves objectives quicker and at a lower cost (i.e., sustainable). Chemical injection is an in-situ technology that is carbon neutral once employed.

7.3 REPURPOSING EXISTING TREATMENT FACILITY

Relocating a treatment system to a smaller building would allow the current building to be reused or rented in its entirety for another purpose. The cooperative agreement between the WDNR and the City Parks Department expires in May 2010, and the City currently only uses a portion of the building. If the treatment system area was cleared of unused remedial equipment and the entire building was available the building would likely be more attractive to another tenant, if the City decides not to renew their agreement. The N.W. Mauthe site is located in an area that has both industrial and residential development. The treatment building at the N.W. Mauthe site would readily lend itself for reuse as a light industrial or commercial facility.

The unused remedial equipment on site could be salvaged or recycled dependant upon condition. Although the market for used remedial equipment is limited, the equipment could be sold and reused by another consultant or contractor at a different site. The equipment could also be reused by the WDNR at another state funded site, if equipment needs matched. If reuse is not possible, the equipment should be recycled or properly disposed of. As previously stated, this would decrease the carbon footprint at the site by approximately 12 tons CO_2e per year.

8.0 SUSTAINABILITY MATRIX

A sustainability matrix was created that compared sustainability metrics for the current operational baseline verses three potential modifications that could be made to the system. The options that were selected were lining of the ditch adjacent to the property to prevent surface water infiltration, moving the sanitary connection from the existing treatment building to a newly constructed remediation system enclosure and installing solar photovoltaics to replace all electric power at the site. It must be noted that the best or most applicable sustainable alternative at the site may be a combination of the proposed options. The analysis does not include potential extraction trench rehabilitation/replacement which was not included in the generation of sustainability metrics. Alternative technologies were not included as pilot studies would be required to determine what would be required to complete the remediation. The sustainability matrix is included in Table 1.

AECOM

Table 1
Sustainability Matrix N.W. Mauthe Site

	Baseline[3]		Option 1 Prevent Surface Water Infiltration		Option 2 Move Sanitary Sewer Connection and Repurpose Treatment Buidling		Option 3 Photovoltaic Installation	
Sustainability Metrics[1,2]	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**	**Annual**	**Life Cycle**
Stewardship								
System Optimization (Qualitative)	System may not be performing as designed.		Improve effectiveness of remedy as infiltration may be driving contaminant migration.		Will not increase the effectiveness of the remedy		Will not increase the effectiveness of the remedy.	
Restoration Timeframe (yrs)	NA	500	NA	500	NA	500	NA	500
Carbon Footprint/Air Emissions								
Tons CO2e	14.6	7,300	14.57	7,285	1.72	860	14.54	7,270
Energy Usage								
Electricity (kWh)	13,488	6,744,000	7000	3,500,000	13,488	6,744,000	0	0
Natural Gas (Therms)	1,714	857,000	1,714	857,000	0	0	1,714	857,000
Cost								
O&M Cost (dollars)	$62,086	$31,043,300	$58,486	$29,243,000	$60,086	$30,043,000	$60,467	$30,213,500
Cost of Modification (dollars)	NA	NA	NA	$100,000	NA	$20,000 to $30,000	NA	$87,000
Cost per Pound Contaminant Removed	$7,309	NA	$6,962	NA	$7,034	NA	$7,198	NA
Land & Ecosystems								
Community Benefits (qualitative)	NA	NA	Fifty to sixty percent less water is being discharged to sanitary sewer.		Building can be repurposed for beneficial purpose and potentially generate revenue		Use of Green Power. Lower Carbon Footprint.	
Materials & Waste Generation								
Sanitary Sewer Discharge (gallons)	820,000	410,000,000	240,000	120,000,000	820,000	410,000,000	820,000	410,000,000

[1] Metrics may be either qualitative (+/-), not applicable (NA) or quantitative based on available information and scope of project.
[2] Metrics may be added or deleted based on site specific conditions.
[3] Base Line : As the system is currently being operated.

APPENDIX A

CARBON FOOTPRINT ANALYSIS

Carbon Footprint Calculations - Baseline Conditions

Mauthe
725 South Outagamie Street
Appleton, WI 54914-5072

Scope 1

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			**Mass**			1	25	296	**Total**		
Gaseous Fuels Burned On-Site	**Year**	**Usage (therms/yr)**	**Usage (TJ//yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Natural Gas	2008	1,714	0.18	64,200	10	0.6	11,606.94	1.81	0.11	11,606.94	45.20	32.11	11,684.24	25,763.76	12.88
		See Note 1		*See Note 2*	*See Note 2*	*See Note 2*					*See Note 3*	*See Note 3*			

Scope 2

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			**Mass**			1	25	296	**Total**		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	13,488	0.013488	1.66	19.24	27.59	0.02	0.26	0.37	0.02	6.49	110.15	52.92	116.66	0.06
		See Note 1		*See Note 4*	*See Note 4*	*See Note 4*					*See Note 3*	*See Note 3*			

Scope 3

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			**Mass**			1	25	296	**Total**		
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	3,000	166.67	8.81	0.0036	0.0004	1,468.33	0.61	0.07	1468.33	15.18	19.54	1,503.05	3,314.22	1.66
				See Note 5	*See Note 5*	*See Note 5*					*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
13,240.21	29,194.64	14.60

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
60 site visits/year
50 miles/visit (roundtrip)
18 miles/gallon (for field vehicle)

Conversions: *1 therm = 105,506,000 joules*
1 Joules = 1.0E -12 Terajoules
1,000 kWh = 1.0E+6 GWh

Source Notes: *1. Utility usage reported by We Energies.*

2. IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006, Volume 2: Energy Tables 1.4 and 2.4, Emission Factors, Commercial/Instiutional - Stationary Combustion.

3. Greenhouse Gas Potential for CH_4 taken from IPCC (2006). Greenhouse Gas Potential for N_2O taken from IPCC Third Assessment Report (2001).

4. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.

5. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

Carbon Footprint Calculations — Option 1 - Prevent Surface Water Infiltration

Mauthe
725 South Outagamie Street
Appleton, WI 54914-5072

Scope 1

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	296	Total		
Gaseous Fuels Burned On-Site	**Year**	**Usage (therms/yr)**	**Usage (TJ/yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Natural Gas	2008	1,714	0.18	64,200	10	0.6	11,606.94	1.81	0.11	11,606.94	45.20	32.11	11,684.24	25,763.76	12.88
		See Note 1		*See Note 2*	*See Note 2*	*See Note 2*					*See Note 3*	*See Note 3*			

Scope 2

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	296	Total		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	7,000	0.007	1.66	19.24	27.59	0.01	0.13	0.19	0.01	3.37	57.17	27.46	60.55	0.03
		See Note 1		*See Note 4*	*See Note 4*	*See Note 4*					*See Note 3*	*See Note 3*			

Scope 3

				Emission Factors			Mass			CO_2e Greenhouse Gas Potentials 1	25	296	Total		
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	3,000	166.67	8.81	0.0036	0.0004	1,468.33	0.61	0.07	1468.33	15.18	19.54	1,503.05	3,314.22	1.66
				See Note 5	*See Note 5*	*See Note 5*					*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
13,214.76	29,138.53	14.57

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
60 site visits/year
50 miles/visit (roundtrip)
18 miles/gallon (for field vehicle)
**** Electric usage reflects reduced pumping from the groundwater extraction trenches. Pumping from the groundwater extraction trenches is the major consumer of electricity at the site.***
An electric usage calculator was used to approximate the decrease in electric usage casued by reduced pumping.

Conversions: *1 therm = 105,506,000 joules*
1 Joules = 1.0E -12 Terajoules
1,000 kWh = 1.0E+6 GWh

Source Notes: *1. Utility usage reported by We Energies.*

2. IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006, Volume 2: Energy Tables 1.4 and 2.4, Emission Factors, Commercial/Instiutional - Stationary Combustion.

3. Greenhouse Gas Potential for CH_4 taken from IPCC (2006). Greenhouse Gas Potential for N_2O taken from IPCC Third Assessment Report (2001).

4. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.

5. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

AECOM

Carbon Footprint Calculations - Option 2 - Move Sanitary Sewer Connectiuon and Repurpose Treatment Building

Mauthe
725 South Outagamie Street
Appleton, WI 54914-5072

Scope 1

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			**Mass**			1	25	296	**Total**		
Gaseous Fuels Burned On-Site	**Year**	**Usage (therms/yr)**	**Usage (TJ/yr)**	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO_2e/kg CH_4	kg CO_2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Natural Gas	2008	0	0.00	64,200	10	0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		See Note 1		*See Note 2*	*See Note 2*	*See Note 2*					*See Note 3*	*See Note 3*			

Scope 2

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			**Mass**			1	25	296	**Total**		
Purchased Electricity	**Year**	**Usage (kWh)**	**Usage (GWh)**	lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	lb CO_2	lb CH_4	lb N_2O	lb CO_2e/lb CO_2	lb CO_2e/lb CH_4	lb CO_2e/lb N_2O	kg CO_2e	lb CO_2e	ton CO_2e
	2008	13,488	0.013488	1.66	19.24	27.59	0.02	0.26	0.37	0.02	6.49	110.15	52.92	116.66	0.06
		See Note 1		*See Note 4*	*See Note 4*	*See Note 4*					*See Note 3*	*See Note 3*			

Scope 3

										CO_2e					
										Greenhouse Gas Potentials					
				Emission Factors			**Mass**			1	25	296	**Total**		
Sampling/O&M Vehicle Usage	**Year**	**Usage (miles/yr)**	**Usage (gal/yr)**	kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	kg CO_2	kg CH_4	kg N_2O	kg CO_2e/kg CO_2	kg CO2e/kg CH_4	kg CO2e/kg N_2O	kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	3,000	166.67	8.81	0.0036	0.0004	1,468.33	0.61	0.07	1468.33	15.18	19.54	1,503.05	3,314.22	1.66
				See Note 5	*See Note 5*	*See Note 5*					*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
1,555.97	3,430.89	1.72

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
60 site visits/year
50 miles/visit (roundtrip)
18 miles/gallon (for field vehicle)
**** No natural gas would be consumed if the sanitary sewer connection were moved to a small remediation enclosure. Natural gas is used for heating the existing treatment building***
**** Revenue generated by rental/repurposing of the existing treatment building are not included in the analysis.***

Conversions: *1 therm = 105,506,000 joules*
1 Joules = 1.0E -12 Terajoules
1,000 kWh = 1.0E+6 GWh

Source Notes: *1. Utility usage reported by We Energies.*

2. IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006, Volume 2: Energy Tables 1.4 and 2.4, Emission Factors, Commercial/Instiutional - Stationary Combustion.

3. Greenhouse Gas Potential for CH_4 taken from IPCC (2006). Greenhouse Gas Potential for N_2O taken from IPCC Third Assessment Report (2001).

4. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.

5. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.

Carbon Footprint Calculations - Option 3 - Installation of Photovoltaics at Site

Mauthe
725 South Outagamie Street
Appleton, WI 54914-5072

Scope 1

Gaseous Fuels Burned On-Site	Year	Usage (therms/yr)	Usage (TJ/yr)	Emission Factors kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ	Mass kg CO_2	kg CH_4	kg N_2O	CO_2e Greenhouse Gas Potentials 1 kg CO_2e/kg CO_2	25 kg CO_2e/kg CH_4	296 kg CO_2e/kg N_2O	Total kg CO_2e	lb CO_2e	ton CO_2e
Natural Gas	2008	1,714	0.18	64,200	10	0.6	11,606.94	1.81	0.11	11,606.94	45.20	32.11	11,684.24	25,763.76	12.88
		See Note 1		*See Note 2*	*See Note 2*	*See Note 2*					*See Note 3*	*See Note 3*			

Scope 2

Purchased Electricity	Year	Usage (kWh)	Usage (GWh)	Emission Factors lb CO_2/GWh	lb CH_4/GWh	lb N_2O/GWh	Mass lb CO_2	lb CH_4	lb N_2O	CO_2e Greenhouse Gas Potentials 1 lb CO_2e/lb CO_2	25 lb CO_2e/lb CH_4	296 lb CO_2e/lb N_2O	Total kg CO_2e	lb CO_2e	ton CO_2e
	2008	0	0	1.66	19.24	27.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		See Note 1		*See Note 4*	*See Note 4*	*See Note 4*					*See Note 3*	*See Note 3*			

Scope 3

Sampling/O&M Vehicle Usage	Year	Usage (miles/yr)	Usage (gal/yr)	Emission Factors kg CO_2/gallon	kg CH_4/gallon	kg N_2O/gallon	Mass kg CO_2	kg CH_4	kg N_2O	CO_2e Greenhouse Gas Potentials 1 kg CO_2e/kg CO_2	25 kg CO2e/kg CH_4	296 kg CO2e/kg N_2O	Total kg CO_2e	lb CO_2e	ton CO_2e
Unleaded Gasoline	2008	3,000	166.67	8.81	0.0036	0.0004	1,468.33	0.61	0.07	1468.33	15.18	19.54	1,503.05	3,314.22	1.66
				See Note 5	*See Note 5*	*See Note 5*					*See Note 3*	*See Note 3*			

Totals		
kg CO_2e	lb CO_2e	ton CO_2e
13,187.29	29,077.98	14.54

Assumptions: *Unleaded gasoline used for consultant transport to conduct O&M activities.*
60 site visits/year
50 miles/visit (roundtrip)
18 miles/gallon (for field vehicle)
**** Assumes 100 percent of the electricity will be generated by photovoltaic power.***

Conversions: *1 therm = 105,506,000 joules*
1 Joules = 1.0E -12 Terajoules
1,000 kWh = 1.0E+6 GWh

Source Notes: *1. Utility usage reported by We Energies.*

2. IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006, Volume 2: Energy Tables 1.4 and 2.4, Emission Factors, Commercial/Instiutional - Stationary Combustion.

3. Greenhouse Gas Potential for CH_4 taken from IPCC (2006). Greenhouse Gas Potential for N_2O taken from IPCC Third Assessment Report (2001).

4. EPA (Environmental Protection Agency) eGRIDweb Parent Company Owner-based Level Emissions Profile- Wisconsin Energy Corp. Pollutant Output Emission Rates, 2005.

5. EPA (Environmental Protection Agency) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Direct Emissions from Mobil Combustion Sources, Section 3, Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles, Gasoline Light-Duty Trucks, and Section 4, Table 5: Factors for Gasoline and On-Road Diesel Fuel, May 2008.