SCS ENGINEERS

Report

Sustainable Materials Management – Yard Waste Study

Presented to:

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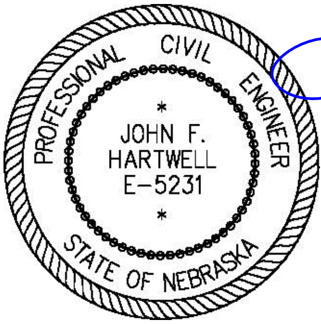
CERTIFICATION



I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Nebraska.

Date: 11/21/2016

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1.0 EXECUTIVE SUMMARY

The City of Omaha (City) currently contracts with Waste Management, Inc. (WMI) to provide solid waste collection services to City residences. The collection contract, initiated in 2004, currently runs through the year 2020 and includes 1) weekly municipal solid waste (MSW) pickup, 2) weekly recyclables pickup, and 3) separate weekly yard waste (sometimes abbreviate "YW") pickup from the first Monday of April through the week following Thanksgiving (co-collected and comingled remainder of year). The contract is the mechanism by which the City meets its' obligation under Nebraska Revised Statute Chapter 13 Section 13-2020 as a "metropolitan class city" to provide solid waste services.

WMI, since acquiring Deffenbaugh Industries (original City contractor), has encountered challenges to meet the requirements of the collection contract; specifically, with regard to meeting the requirements for yard waste collections during the separate collection periods. These challenges have been well documented by the media, Mayoral communications (website, Facebook, etc.), and other online and print sources, and have resulted in City permission to co-collect yard wastes and comingle them with MSW for disposal at Pheasant Point Landfill in 2015 and 2016.

To aid the City in future decision making and to help formulate a long term and sustainable materials management approach for yard wastes, the City retained SCS Engineers (SCS) to perform this Yard Waste Study (Study). SCS, as part of this Study, performed the following:

- Site visits to the City's Oma-Gro compost facility, WMI-operated Pheasant Point Landfill, Omaha Public Power District (OPPD)-owned and WMI-operated Elk City Station, and private compost operations.
- Observed WMI collection operations in various locations throughout the City which included a mix of collection conditions (i.e. curbside, alley way, on-street parking, heavy vegetative canopy, etc.).
- Identified alternatives for yard waste management for detailed analysis.
- Developed a pro forma model for the identified alternatives and performed scenario modeling.
- Performed landfill gas (LFG) recovery modeling and projections, and prepared greenhouse gas (GHG) emissions estimates for the identified alternatives.

The key economic and environmental findings of the Study are summarized below comparing the City's existing yard waste contract, which includes separate yard waste collection and composting (Scenario 1) and the current practice of co-collection and comingling with 100 percent of yard waste landfilled (Scenario 2). Additional modeled scenarios are detailed within Section 3 of the Study report.

- From an economic perspective, the more cost-effective scenario is Scenario 2 which allows 100% comingled collection of yard waste with MSW, thereby reducing the necessary collection routes through the collection area from 3 passes to 2 passes. In addition, the expense incurred for processing and producing compost (Oma-Gro) is eliminated. The economic impact associated with this scenario translates into a reduction in cost for the City's waste collections and handling budget of $8,350,000 or ~$60/hh-yr (~$5/hh-month). Depending on the scenario, the annual cost savings to City households range from a $4.6/hh-yr to $60/hh-yr, except for Scenario 3 (3rd Party composting using home-run collection methodology) where the cost of services increases by $ $2.80 to 3.40/hh-yr over the baseline scenario (Scenario 1).

- The separate collection costs for yard waste is a significant expense to the City and, while this practice allows for diverting yard waste from the landfill and beneficial use of this organic waste stream, the revenues achieved through the Oma-Gro operation do not cover the costs of collection, processing, and marketing of the finished compost. The true cost of producing compost by either a City-performed operation (Oma-Gro) or a City-contracted composting operation ranges, as a multiple of the current product fee schedule revenues, from ~7 to ~6.5, respectively. However, the most significant cost is the cost of collection and transport of diverted yard waste to the composting facility, and when combined with the cost of compost processing, the multiple of the current product fee schedule revenues dramatically rises to ~50.

- Scenario 5 provides an opportunity to eliminate the City's responsibility for collection, transport, and composting of yard waste by allowing interested citizenry to participate in a compost production program. In this scenario, the City would provide interested 3rd party composting contractors an at-risk opportunity to collect yard waste at designated drop-off locations. The diversion of yard waste would be strictly voluntary by the citizenry, and the cost of transporting the yard waste is borne by the participating citizenry exactly like other voluntary diversions efforts already in effect. SCS estimated that a likely maximum threshold for diversion under this scenario would be 15% but also believes that with a consistent education program the diversion could increase with time.

- WMI estimated that the Pheasant Point Landfill has 122 years of site life remaining and will reach capacity in the year 2137 this represents the baseline scenario (Scenario 1). SCS evaluated the 100% comingled yard waste scenario (Scenario 2) and determined that the landfill would reach capacity in 117.4 years (or during the year 2132). This represents a decrease in remaining operating life of 3.79%.

- GHG emissions were estimated for all the scenarios, and included emissions from collection, compost processing, and landfilling. GHG reductions from the use of compost are offset by increased emissions from the extra vehicle mileage incurred for the separate collection of yard waste, and about half of the increased landfill methane emissions from landfilling yard waste instead of diverting it to compost are offset by increased electricity production from higher landfill methane recovery rates at the landfill. Finally, when carbon storage of landfilled yard waste is considered, net emissions from diverting yard waste to composting are significantly higher than placing it in the landfill.

This report addresses the unique situation that the City of Omaha faces with respect to the operational and economic factors associated with its collection and composting systems. SCS understand the importance and value of composting as a viable solid waste management alternative. This report is not meant to say that landfilling is better than composting or that composting is better than landfilling. Furthermore, SCS understands that each community must balance economic and environmental factors in making a decision on how to best manage a given waste stream. This report attempts to provide an objective evaluation of the costs for separate or comingled collection of yard waste and estimates of GHG emissions for composting or landfilling yard waste.

2.0 BACKGROUND

2.1 INTRODUCTION

The City retained SCS to perform this Yard Waste Study (Study). The purposes of the Study was to evaluate financial and environmental aspects of the City's current yard waste collections and handling and, more specifically, to compare the costs and environmental aspects of the currently contracted separate yard waste collection and composting (Scenario 1) and the current City-allowed practice of co-collection and comingling with 100 percent of yard waste landfilled (Scenario 2). SCS was also asked to include alternative scenarios which were discussed during Council-approval of the SCS contract and/or identified in concert with the City's Public Works Department during execution of the Study. Details of the economic and environmental evaluation are presented in Sections 3 and 4 of this report.

2.2 OVERVIEW OF CITY'S CURRENT SYSTEM

The City is currently contracted with WMI to provide solid waste collection services to City residences. The collection contract, initiated in 2004, currently runs through the year 2020 and includes 1) weekly MSW pickup, 2) weekly recyclables pickup, and 3) separate weekly yard waste pickup from the first Monday of April through the week following Thanksgiving (co-collected and comingled remainder of year). The contract is the mechanism by which the City meets its' obligation under Nebraska Revised Statute Chapter 13 Section 13-2020 as a "metropolitan class city" to provide solid waste services.

MSW collected by the City is transported to and disposed at the Pheasant Point Landfill which is a WMI-owned and operated landfill located at 13505 N 216th Street near Bennington, Nebraska. Landfill gas generated by the Pheasant Point Landfill, and the adjacent, closed, Douglas County Landfill, is collected and routed to the Omaha Public Power District (OPPD)-owned and WMI-operated Elk City Station where the gas is used to produce electricity. The City, as part of its' annual solid waste budget, pays WMI to collect MSW from City residences and pays Pheasant Point Landfill (Douglas County who operates the scale house and billing operations) based on the tonnage delivered for disposal.

Recyclables collected by the City (residences and drop-off sites) are transported to Firstar Fiber Corporation (Firstar Fiber) located at 10330 I Street in Omaha, Nebraska. Firstar Fiber is a locally-owned and operated material recovery facility (MRF) which accepts the City's single stream (comingled) recyclables for sorting, processing, and subsequent marketing to end. The City, as part of its' annual solid waste budget, pays WMI to collect and deliver the recyclables to Firstar Fiber and Firstar Fiber incurs the costs of sorting, processing, and marketing the recyclable commodities and benefits from the sale of the commodities, if any.

Yard waste collected by the City, when collected separately (before the City approved of comingled collection with MSW), is transported to the Compost Facility which is a City-owned and operated facility located at 15705 Harlan Lewis Road in Bellevue, Nebraska. The facility, often referred to as Oma-Gro, is co-located with the City's Papillion Creek Wastewater Treatment Plant. The City, as part of its' annual solid waste budget, pays WMI to collect yard waste from City residences and to deliver the material to the Oma-Gro facility where the material is subsequently processed into compost which is marketed and sold by City-personnel.

Additional detail on the Pheasant Point Landfill, Elk City Station, and Compost Facility is provided below, since these operations would be impacted if the City elected to move away from separate yard waste collections.

2.2.1 Pheasant Point Landfill

The Pheasant Point Landfill began accepting MSW in 2003 and operates under Permit NE0204 issued by the Nebraska Department of Environmental Quality (NDEQ). The landfill, based on the most recent aerial survey (flown 4/13/2016), has an estimated remaining capacity (life of site) of just over 122 years based on information provided by WMI.

A comprehensive landfill gas collection and control system (GCCS) is installed at the Pheasant Point Landfill which is required by Clean Air Act regulations. The current GCCS is comprised of 41 vertical extraction wells, laterals and header lines which deliver collected landfill gas (LFG) to the Elk City Station for electrical generation. An additional 56 vertical extraction wells and appurtenant structures collect LFG from the closed Douglas County Landfill, which operated from 1989 to 2003, and the LFG is also delivered to the Elk City Station for electrical generation. Additional details for the GCCS and the LFG generation, capture and collection are included in Section 4 of this Study.

2.2.2 Elk City Station

The Elk City Station began operations in April 2002 and initially burned LFG from the Douglas County Landfill. Since that time, the plant expanded in 2006 and today the plant has a capacity of 6.2 megawatts and burns LFG from the closed Douglas County Landfill and the Pheasant Point Landfill. Elk City Station is a baseload generating plant, designed to run year round, and the average annual output of electricity produced from burning the LFG generated by organic waste materials is estimated to power 4,000 homes.

2.2.3 Compost Facility

Omaha Public Works owns and operates the Papillion Creek Wastewater Treatment Plant. As part of plant operations, bio solids are produced and managed by City personnel and, prior to 1996, limited biosolids composting and yard waste composting operations were performed at this location. In 1996, the current operation known as the Oma-Gro Compost Facility began operation. Separately collected yard waste is delivered to the site and the materials are composted using windrow methods.

3.0 ECONOMIC EVALUATION OF YARD WASTE HANDLING ALTERNATIVES

SCS performed an evaluation of the economic impact of numerous operational scenarios related to the collection, handling, and processing of yard waste generated by the residents of the City. The following is a summary of the methodology employed, and results and conclusions formed by that study.

3.1 ECONOMIC EVALUATION METHODOLOGY

SCS evaluated oral, visual and written information supplied by the City, Accounting and Public Works Departments, and Oma-Gro operational unit related to the historic generation and handling of MSW, yard waste and recyclables. Additionally, we similarly evaluated data supplied by the City's waste handling contractor, WMI, and 3rd party area composting contractors. This City-specific waste handling information, along with our professional engineering judgement, and readily available industry data were used to formulate a top down / bottom up evaluation of five compost handling and processing scenarios which the City desired.

3.2 DATA SOURCES

The City of Omaha, WMI, other 3rd party waste processors provided valuable City-specific data in the form of personnel interviews, site visits and, where appropriate, historic financial and operational data. Additional pertinent information was also obtained from a number of on-line or a number of industry references. The following is a partial listing of data sources employed to develop the economic projections presented herein:

- City of Omaha provided information:
  - Compost Operation (Oma-Gro) Financial Data - 2002 to 2015
  - Landfilled MSW Monthly Contracted Tonnages - 1995 – 2015
  - Diverted Recyclables Waste Monthly Contracted Tonnages – 1995 – 2015
  - Diverted Yard Waste Monthly Tonnages – 1995 – 2015
  - Total Waste Handled Monthly Tonnages – 1995 – 2015
  - City Paid Contracted Annual Waste Collection Rates and Other Unit Prices – 1996 – 2016
  - Oma-Gro Compost Sales Records – 2012-2015
  - Accounting Department, Public Works Department, and Oma-Gro operations staff interviews and site visits
- Waste Management, Inc. provided data:
  - Collection fleet, and tonnage handled data

- Key management staff interviews

- Site visits and observation of crew, equipment, waste load on various representative City routes

- Landfill gas system and energy plant system information

- Landfill aerial survey and gate receipt information

- Other data sources:
  - 3rd party compost processers
    - Site visit and key staff interviews

  - Various reference literature and treatises:
    - Pichtel, J, "Waste Management Practices - Municipal, Hazardous and Industrial", Taylor & Francis, New York, CRC Press, 2005, pp. 659.

    - Tchobanoglous, G., Theisen, H., Vigil, S.A., "Integrated Solid Waste Management – Engineering Principles and Management Issues", McGraw-Hill International Editions, - Civil Engineering Series, 1993, pp. 978.

    - USEPA Advancing Sustainable Materials Management, 2013 Fact Sheet - Assessing Trends in Material Generation, Recycling and Disposal in the United States, June 2015

    - Engineering Solutions & Design, Inc., "Final Report: State of Nebraska - Waste Characterization Study", State of Nebraska, Nebraska Department of Environmental Quality, 2009, pp. 2175.

  - On-line:
    - Google Earth, and Google Maps

    - Various web sites related to waste collection and compost processing equipment capacities, and costs

    - RS Means Costs Data

3.3 EVALUATION ASSUMPTIONS

City-specific waste handling cost and operational data gathered from the above noted sources was used to formulate a top down/bottom up evaluation of the current and potential future yard waste handling scenarios. The City provided historical financial and operations data related to compost handling, collection, processing and product sales records and revenue. The City also provided historical waste collection contract data. This data was used to establish historic waste composition profiles, and proportional compost revenue streams in the top down portion of the evaluation. Data obtained from WMI, in addition to the other data sources noted above, was used to assist in the development of the City-specific bottom up operational evaluation for the five identified and agreed upon yard waste handling scenarios.

3.3.1 City of Omaha Waste Stream Characteristics

The historical residential waste stream between 1995 and 2015 consisted of a landfilled MSW component amounting to a mean of 66.8% of the total collected waste stream (standard deviation (stdev) = 4.3%), while the diverted yard waste component mean amounted to 22.6% (stdev = 2.1%). The diverted recyclables component mean was 11.6% (stdev = 3.4%) of the total residential waste stream. These proportions were obtained from City records after removing the outlier collection years where yard waste collections were substantially reduced (2011 – Missouri River flood, 2014 to 2015 – contract performance exceptions).

The refuse collection rate for each waste category was calculate for the base year (2015) using the noted historic proportions, where the generation rate equaled the total annual tonnage handled (157,665 tons) times the mean component % divided by the contract number of households (139,889 hh). The total tonnage handled rate for 2015 was 1.127 tons/household – year or 6.48 lbs/hh-day. The collection rate for the contracted waste categories were 4.31 lbs/hh-day, 1.39 lbs/hh-day, and 0.77 lbs/hh-day for landfilled MSW, yard waste and recyclables, respectively.

The "Final Report: State of Nebraska – Waste Characterization Study", 2009 (NDEQ 2009) was used to characterize the waste constituent properties of MSW landfilled at the Pheasant Point Landfill. USEPA's "Municipal Solid Waste Generation, Recycling and Disposal in the United States: Facts and Figures", 2006, was used to develop an estimate of the constituent characteristics of the recycled waste stream. This information combined with data presented in Tchobanoglous et al., 1993 was used to develop representative 'loose', and 'as delivered via collection truck' specific weights for the bottom up evaluation. Loose or curbside specific weights were set at 170 pounds/cubic yard (pcy), 118 pcy and 76 pcy, for landfilled MSW, Yard waste and recyclables, respectively. The corresponding as delivered specific weights were set at 720 pcy, 500 pcy and 325 pcy, for landfilled MSW, yard waste, and recyclables, respectively.

3.3.2 Collection Route Characteristics

Using information from interviews with WMI, SCS estimated that 85% of the City households were served using normal curbside collection which employed a foreman/driver and a single helper. The remainder of the households (15%) required a more labor intensive three person service (one foreman/driver, and two helpers).

The City served residential household population center of mass was estimated to fall near the intersection of 72nd and Center Streets. Using a route methodology for a 'hypothetical' typical route centered on this population center of mass relative to the collection garage location and delivery point, seven collection routes were evaluated as listed below:

- Landfill delivery to the Pheasant Point Landfill from the population center
  - Route initiation from and termination at the north Omaha WMI garage

- Yard waste delivery to the Oma-Gro processing center from the population center

  - Route initiation from and termination at the north Omaha WMI garage

- Yard waste delivery to a rural Gretna, Nebraska based 3rd party composting contractor from the population center
  - Home run routing initiating and terminating at the rural Gretna location

  - Route initiation from and termination at a transfer station located in south central Omaha

- Yard waste delivery to a Pacific Junction, Iowa based 3rd party composting contractor from the population center
  - Home run routing initiating and terminating at the Pacific Junction location

  - Route initiation from and termination at a transfer station located in south central Omaha

- Recyclables delivery to Firstar Fiber's south central Omaha location from the population center
  - Route initiation from and termination at the north Omaha WMI garage

The collection fleet was assumed to consist of rear loading collection trucks with a vintage of ≥2010, with a 25 cubic yard (cy) capacity. The walking floor transfer trucks used in conjunction with the transfer station option were assumed to have a vintage of ≥ 2010, with a capacity of 100 cy.

Collection and transfer trucks were allowed to be filled with either 95% of the compacted volume capacity or weight limit unless the length of time required to achieve this condition created excessive crew overtime. Typically, crew overtime (1.5 x straight time pay) for the MSW and yard waste collection was limited to 0.5 hours. In the case of the recyclables, collection overtime was limited to 1.5 hours due to the relatively low weight and volume of recyclables collected at each household stop.

Staff raw labor was set at $17.50/hour (hr) for the collection truck foreman/driver and $13.50/hr for the collection crew helper(s). Maintenance staff raw labor rates were set at $30.00/hr and $18.00/hr for the supervisor and mechanic technician, respectively. The labor benefits multiplier was set at 1.40.

The economic evaluation was calibrated by comparing the size of the collection fleet and average route miles driven per day required for the current operating conditions (100% comingled yard waste).

Using the above noted variables, a fleet of 55, 25 cy rear loading collections trucks was required for the 100% comingled yard waste condition. WMI reports that the actual collection fleet required is 54, 25 cy trucks. Considering the 100% comingled scenario, the active collection fleet was projected to include an additional 18 rear loading trucks required for recyclables collection, bringing the active fleet total to 73 trucks. This evaluation also set the reserve fleet level at 20% of the active total fleet (87 trucks) which not only supplies vehicle spares for routine maintenance and dead-lined vehicles, but also is sufficient to cover the anticipated yard waste maximum collection peak rates that typically occur during the spring and late fall.

The average fleet mileage reported by WMI is 117 miles per route, which correlates well with the predicted route mileage of 114 miles. In addition, City staff reported that the contractor has incurred losses on services provided for the 100% comingled yard waste condition. The economic evaluation performed predicts that the loss on services is ~98% of the indicated monthly losses for the spring to fall season when the contractor is fully reimbursed at contract rates for yard waste collection. Similarly, the evaluation performed predicts that the loss on service is ~102% of the indicated monthly losses for the winter season when the contractor is not reimbursed at contract rates for yard waste collection.

Costing results presented below are based on the following selected key variables. Diesel fuel costs were set at $2.75/gal. Interest rates on capital improvements and rolling stock were set at 4.5% and 5.5% respectively. Capital improvement and rolling stock terms for payment or depreciation were set at 20 years and 15 years, respectively. Indirect operations support such as administration, management overhead, safety and training were set at 6%, 8.5% and 2.25% of direct operational labor, respectively. After tax profit was set at 10% of total operating expenses, and corporate taxes were assumed to be 25%.

The tipping fee paid for disposal at the Pheasant Point Landfill is $25.13/ton. No tipping fee is incurred by the City for Oma-Gro or Firstar Fiber.

3.3.3 Compost Operations Characteristics

The following discussion is based on a review of Oma-Gro production and sales records from 2012 through 2015, and information from personnel interviews and a site visit. The volumetric moisture content (MC_{vol}) of yard waste diverted to the compost processing center was set at 65% based on the assertion by staff that the grass component (YW_{grass}) had a MC_{vol} = 80%, and leaves (YW_{leaves}) =15%. The MC_{vol} for processed yard waste at the point of sale was set at 30%, since staff indicated that representative pile sampling indicated a MC_{vol} of 45%, but that at point of sale material was selected from the exterior of the finished product pile which was considerably drier based on tactile texture. Based on these values, the total dry weight of compost sold from 2012 through 2015 was 91% of the initially received dry tonnage. Oma-Gro staff indicates that they estimate that 10% of the yard waste received for processing is eventually rejected as unsuitable for processing. It should be noted that this material is diverted to the City's Papillion Creek Wastewater Treatment Plant (WWTP) where is it used to stabilize WWTP derived sludge.

From 2012 through 2015, 82,450 bags of Oma-Gro were produced and sold. Of these, 522 cy were sold as individual bags (14,086 bags), and 2,532 cy. were sold in pallet sized bag lots (68,364 bags). The total volume of Oma-Gro distributed or sold was 55,727 cy. On a volume basis the sales are characterized as:

- Bulk Sale in cy lots = 94.80%
- Pallet sized bag lots = 4.31%
- Individual bag lots = 0.89%

Considering the bulk cubic yard lot sale, 51.58% of the total volume of Oma-Gro produced was sold at 'self-loaded' pricing. The remainder (43.23%) was sold at 'loaded' pricing. The fee schedule used during the reviewed period was $1.50/individual bag, $0.80/palletized bag, $8.00/self-loaded cy and $11.00/loaded cy. The aggregated (2002 through 2010) revenue per ton of Oma-Gro sold was determined to be $4.65/ton using the above noted fee schedule rates.

3.4 ECONOMIC EVALUATION SCENARIOS

The Yard Waste Study included evaluation of two current operational scenarios: the current contract which includes separate yard waste collection and composting (Scenario 1) and the current practice of co-collection and comingling with 100 percent of yard waste landfilled (Scenario 2). An additional three alternative operational scenarios were identified and evaluated as part of this Study for a total of five operational scenarios. The following five scenario descriptions contain values which bear defining.

The total annual cost of collection includes all expenses related to the procurement, operation, and maintenance of the collection rolling stock and infrastructure for the 3rd party collections contractor (currently WMI). The total annual cost of composting includes the tipping fees for yard waste and landfilled MSW (T), compost processing (C) and rejected yard waste transport (R) to the Pheasant Point Landfill (T C & R Expenses). Total annual net cost for collections and processing is the cost of composting plus T C & R Expenses minus the revenue derived from Oma-Gro operations where the Oma-Gro operation is part of the scenario. Otherwise the value displayed is effectively the total annual cost of collections and processing.

The total annual (net or otherwise) cost of collections and processing is also presented in terms of cost per household where the value is simply divided by the number of contracted households (139,889 households in 2015).

The cost of compost processing (diverted yard waste) is the total cost of labor, benefits and all other expenses based on historic data supplied by the City for the Oma-Gro operation, or for projected compost processing by a 3rd party compost contractor. This excludes costs for rejected yard waste tipping fees and transport to the Pheasant Point Landfill. The values provided for 3rd party compost contractor are the average for operations considered at a rural Gretna, NE location and an operation near Pacific Junction, IA. SCS assumed that one of these operations would employ an aerated static pile aerobic composting process, and the other would employ the windrowing process currently used at the Oma-Gro facility.

T C & R cost (yard waste only) is the total cost for producing and processing yard waste only which includes tipping fees, compost processing and rejected yard waste transport to the Pheasant Point landfill. This value is presented as dollars per year ($/yr) and dollars per household per year ($/hh-yr).

The difference (Δ) between the total annual cost of T C & R expense and collection for all waste streams handled in the considered scenario compared to the 0% comingled yard waste Scenario (Scenario 1). This value is presented as $/yr and $/hh-yr.

Annual mileage is projected based on the total miles driven by the collection rolling stock each year. An expression of this value is also presented as the difference (Δ) between the considered scenario and the 0% Comingled yard waste Scenario (Scenario 1).

Finally, the T C & R compost cost and total compost (T C& R) and collection costs are provided as an expression of the historic revenue generated in compost sales. These are provided as a multiple of the yard waste revenue stream, and as a price per individual bag lot, and individual 'self-loaded' bulk cubic yard lot. In order to provide the bag and bulk rates, the assumption had to be made that the sale volume proportion for individual bags (0.89%), pallet size bag lot (4.31%), self-load bulk (51.58%) and loaded bulk (43.23%) hold regardless of the volume of yard waste produced. This is because the cost data provided and tracked was not broken out by product.

3.4.1 Scenario 1 (Baseline) – 0% Comingled and 100% Oma-Gro Compost Processing

Scenario 1 evaluates the full diversion of yard waste to the Oma-Gro composting operation with no yard waste being collected comingled with MSW and delivered directly to the Pheasant Point Landfill (excluding 10% of yard waste delivered to the Oma-Gro facility which upon inspection was rejected and delivered to the landfill for disposal).

The projected costs of composting and collections for this scenario are:

Table 1. Scenario 1 (Baseline) - 0% Comingled Yard Waste – Compost Processing and Collection Costs

Variable Description	Costs	
Compost Processing Cost (YW Only)	$790,000/yr	$5.67/hh-yr
T C &R Cost (YW Only)	$1,150,000/yr	
T C &R Cost (MSW and YW)	$4,260,000/yr	
Collection Cost (MSW, YW & Rec)	$26,190,000/yr	
Total T C & R and Collections Cost (MSW, YW & Rec)	**$30,280,000/yr**	**$216/hh-yr**

The following table provides a comparison of compost processing and collection costs relative to the current revenue stream.

Table 2. Scenario 1 (Baseline) - 0% Comingled Yard Waste – Compost Costs Compared to Historic Revenue Stream

Variable Description	T C & R Cost	T C & R and Collection Cost
Multiplier (Cost / Fee Schedule Based Revenue)	6.90	51.4
Bag (Individual Lots)	$10.40 /bag	$77.10 /bag
Bulk (Self-Loaded CY Lots)	$51.00 /cy	$410 /cy

This scenario requires an active collection fleet of 102 trucks (46 MSW, 38 yard waste and 18 recyclables) with a reserve fleet of 21 trucks for a total fleet of 123 collection trucks. The collection rolling fleet annual mileage is 2,410,000 miles for this scenario. This is the base comparison for the remaining scenarios.

3.4.2 Scenario 2 – 100% Comingled and 0% Oma-Gro Compost Processing

Scenario 2 evaluates the comingled collection and delivery of all yard waste to the Pheasant Point Landfill with no yard waste diversion and production of compost either by the City or by 3rd party contractors.
The projected costs of composting and collections for this scenario are:

Table 3. Scenario 2 - 100% Comingled Yard Waste – Compost Processing and Collection Costs

Variable Description	Costs	
Compost Processing Cost (YW Only)	$0/yr	$0.00/hh-yr
T C &R Cost (YW Only)	$0/yr	
T C &R Cost (MSW and YW)	$4,120,000/yr	
Collection Cost (MSW, YW & Rec)	$17,810,000/yr	
Total T C & R and Collections Cost (MSW, YW & Rec)	**$21,930,000/yr**	**$157/hh-yr**
Δ T C & R and Collection Cost from Scenario 1 (0% Comingled yard waste)	($8,350,000)/yr	($59.70)/hh-yr

This scenario requires an active collection fleet of 73 trucks (55 MSW, 0 yard waste and 18 recyclables) with a reserve fleet of 14 trucks for a total fleet of 87 collection trucks. The collection rolling fleet annual mileage is 1,930,000 miles for this scenario. This is 480,000 miles less than the base comparison presented in Scenario 1 – 0% Comingled yard waste (2,410,000 miles).

3.4.3 Scenario 3 - 0% Comingled and 100% Contracted 3rd Party – Home Run Yard Waste Collection

Scenario 3 evaluates the full diversion of yard waste to a City-contracted 3rd party composting operation with no yard waste being collected comingled with MSW for delivery directly to the Pheasant Point Landfill (except the 10% of yard waste delivered to the Oma-Gro facility which upon inspection was rejected for processing). This option presumes that the collection fleet travels from it collection route to the composting facility located in either rural Gretna, NE or Pacific Junction, IA (aka. Home Run travel).

The projected costs of compost and collections for this scenario are:

Table 4. Scenario 3 - 0% Comingled Yard Waste – with City-Contracted 3rd Party Composting Contractor using Home Run Collection - Compost Processing and Collection Costs

Variable Description	Costs	
Compost Processing Cost (YW Only) [1]	$640,000 to $790,000/yr	$4.58 to $5.67/hh-yr
T C &R Cost (YW Only) [1&2]	$930,000 to $1,180,000/yr	

T C &R Cost (MSW and YW) [1&2]	$4,040,000 to $4,290,000/yr	
Collection Cost (MSW, YW & Rec) [1&2]	$26,710,000 to $26,390,000/yr	
Total T C & R and Collections Cost (MSW, YW & Rec) [1&2]	**$30,760,000 to $30,680,000/yr**	**$219 to $218/hh-yr**
Δ T C & R and Collection Cost from Scenario 1 (0% Comingled YW) [1&2]	$470,000 to $400,000/yr	$3.40 to $2.80/hh-yr
Note[1] Range between aerated static pile vs Oma-Gro composting methodology Note[2] Range between potential rural Gretna and Pacific Junction 3rd party composting contractors		

The following table provides a comparison of compost processing and collection costs relative to the current revenue stream.

Table 5. Scenario 3 - 0% Comingled Yard Waste – City-Contracted 3rd Party Composter - Compost Costs Compared to Historic Revenue Stream

Variable Description	T C & R Cost[1&2]	T C & R and Collection Cost[1&2]
Multiplier (Cost / Fee Schedule Based Revenue)	5.60 to 7.10	53.3 to 52.90
Bag (Individual Lots)	$8.50 to $10.70 /bag	$79.90 to $77.10 /bag
Bulk (Self-Loaded CY Lots)	$45.10 to $56.90 /cy.	$430 to $420 /cy
Note[1] Range between aerated static pile vs Oma-Gro composting methodology Note[2] Range between potential rural Gretna and Pacific Junction 3rd party composting contractors		

This scenario requires an active collection fleet of 104 trucks (46 MSW, 40 yard waste and 18 recyclables) with a reserve fleet of 22 trucks for a total fleet of 126 collection trucks for a rural Gretna based composting operation. A Pacific Junction based operation requires an active collection fleet of 103 trucks (46 MSW, 39 yard waste and 18 recyclables) with a reserve fleet of 21 trucks for a total fleet of 124 collection trucks. The collection rolling fleet annual mileage is 2,570,000 miles to 2,550,000 miles for this scenario for the rural Gretna and Pacific Junction 3rd party City-contracted compost contractors. This ranges from 160,000 miles to 140,000 miles more than the base comparison presented in Scenario 1 – 0% Comingled yard waste (2,410,000 miles).

3.4.4 Scenario 4 - 0% Comingled and 100% Contracted 3rd Party – Transfer Station Yard Waste Collection

Scenario 4 evaluates the full diversion of yard waste to a City-contracted 3rd party composting operation with no yard waste being collected comingled with MSW and delivered directly to the Pheasant Point Landfill (except the 10% of yard waste delivered to the Oma-Gro facility which upon inspection was rejected for processing). This option presumes that the collection fleet travels from its collection route to a transfer station that is owned and operated by the 3rd party contractor. The location of the transfer station is presumed to be in the vicinity of Firstar Fiber. A small fleet (~3 trucks) of 100 CY walking floor transfer trailers would operate out of the transfer station and convey all yard waste to the composting facility located in either rural Gretna, NE or Pacific Junction, IA (aka Transfer Station travel). The transfer station is further presumed to have the maintenance garage and parking facilities for both the collection and transfer fleets.

The projected costs of composting and collections for this scenario are:

Table 6. Scenario 4 - 0% Comingled Yard Waste – with City-Contracted 3rd Party Composting Contractor using Transfer Station - Compost Processing and Collection Costs

Variable Description	Costs	
Compost Processing Cost (YW Only) [1]	$640,000 to $790,000/yr	$4.58 to $5.67/hh-yr
T C &R Cost (YW Only) [1&2]	$930,000 to $1,180,000/yr	
T C &R Cost (MSW and YW) [1&2]	$4,040,000 to $4,290,000/yr	
Collection Cost (MSW, YW & Rec) [1&2]	$24,630,000 to $24,690,000/yr	
Total T C & R and Collections Cost (MSW, YW & Rec) [1&2]	**$29,250,00 to $29,640,000/yr**	**$208 to $211/hh-yr**
Δ T C & R and Collection Cost from Scenario 1 (0% Comingled YW) [1&2]	($1,030,000) to ($640,000)/yr	($7.40) to ($4.60)/hh-yr
Note[1] Range between aerated static pile vs Oma-Gro composting methodology Note[2] Range between potential rural Gretna and Pacific Junction 3rd party composting contractors		

The following table provides a comparison of compost processing and collection costs relative to the current revenue stream.

Table 7. Scenario 4 - 0% Comingled Yard Waste – City-Contracted 3rd Party Composter - Compost Costs Compared to Historic Revenue Stream

Variable Description	T C & R Cost[1&2]	T C & R and Collection Cost[1&2]
Multiplier (Cost / Fee Schedule Based Revenue)	5.60 to 7.10	37.10 to 38.80
Bag (Individual Lots)	$8.50 to $10.70 /bag	$55.70 to $58.30 /bag
Bulk (Self-Loaded CY Lots)	$45.10 to $56.90 /cy.	$300 to $310 /cy
Note[1] Range between aerated static pile vs Oma-Gro composting methodology Note[2] Range between potential rural Gretna and Pacific Junction 3rd party composting contractors		

Both a rural Gretna operation and a Pacific Junction based operation require an active collection fleet of 99 trucks (46 MSW, 35 yard waste and 18 recyclables with 2 walking floor transfer trailer trucks) with a reserve fleet of 21 trucks (including 1 transfer trailer truck) for a total fleet of 120 collection trucks. The collection rolling fleet annual mileage is 2,060,000 miles to 2,065,000 miles for this scenario for the rural Gretna and Pacific Junction 3rd party City-contracted compost contractors. This ranges from 350,000 miles to 345,000 miles less than the base comparison presented in Scenario 1 – 0% Comingled yard waste (2,410,000 miles).

3.4.5 Scenario 5 – 85% Comingled and 15% Voluntary Drop Off with 3rd Party Compost Processing

Scenario 5 evaluates the 15% diversion of yard waste to an at-risk a 3rd party composting contractor and 85% yard waste being collected comingled with MSW and delivered directly to the Pheasant Point Landfill. In this scenario, the 15% yard waste diversion is a voluntary diversion where city residents self-transport yard waste to designated citizen drop-off locations. The City would arrange for one or more 3rd party composting contractors to collect yard waste from these drop-off locations, transport and process compost entirely at their own risk with no remuneration by the city.

The projected costs of composting and collections for this scenario are:

Table 8. Scenario 5 - 85% Comingled Yard Waste – with Voluntary Citizen Drop-Off and at-Risk Compost Processing by Various 3rd Party Contractors - Compost Processing and Collection Costs

Variable Description	Costs	
Compost Processing Cost (YW Only)	$0/yr	$0.00/hh-yr
T C &R Cost (YW Only)	$0/yr	
T C &R Cost (MSW and YW)	$3,970,000/yr	
Collection Cost (MSW, YW & Rec)	$17,880,000/yr	
Total T C & R and Collections Cost (MSW, YW & Rec)	**$21,850,000/yr**	**$156/hh-yr**
Δ T C & R and Collection Cost from Scenario 1 (0% Comingled YW)[1]	($8,430,000)/yr	($60.30)/hh-yr
Note[1] – This option has greater savings associated with it compared to the 100% comingled Scenario 2, because this scenario does not require the City collection contractor to handle 15% of the diverted yard waste and the City doesn't pay tipping fees for the diverted yard waste..		

This scenario requires an active collection fleet of 73 trucks (55 MSW, 0 yard waste and 18 recyclables) with a reserve fleet of 14 trucks for a total fleet of 87 collection trucks. The collection rolling fleet annual mileage is 1,930,000 miles for this scenario. This is 480,000 miles less than the base comparison presented in Scenario #1 – 0% Comingled yard waste (2,410,000 miles).

3.5 LANDFILL SITE LIFE EVALUATION

Based on analysis performed by WMI, the Pheasant Point Landfill has an anticipated site life of 122 years with closure anticipated in the year 2137. This estimate assumes an average annual gate take of 550,000 tons of waste. The available airspace is as of the most recent aerial survey in April 2016 was 80,862,511 cy. WMI estimates that the weight of waste required to occupy this space amounts to 67,115,884 tons. The WMI methodology does not account for waste settlement or change in annual gate take tonnage due to either changes in diversion rates or changes in population of the service area.

Using the above noted assumptions, SCS evaluated the 100% comingled yard waste scenario (Scenario 2) and determined that the landfill would reach capacity in 117.4 years (or during the year 2132). This represents a decrease in remaining operating life of 3.79%.

3.6 ECONOMIC EVALUATION CONCLUSIONS

From an economic perspective, the most cost-effective scenario considered is Scenario 2 which allows 100% comingled collection of yard waste with MSW, thereby reducing the necessary collection routes through the collection area from 3 passes to 2 passes. In addition, the expense incurred for processing and producing compost (Oma-Gro) is eliminated. The economic impact associated with this scenario translates into a reduction in cost for the City's waste collections and handling budget of $8,350,000 or ~$60/hh-yr (~$5/hh-month). Depending on the scenario, the annual cost savings to City households range from a $4.6/hh-yr to $60/hh-yr, except for Scenario 3 (3rd Party composting using home-run collection methodology) where the cost of services increases by $2.80 to 3.40/hh/yr over the baseline scenario (Scenario 1).

The true cost of producing compost by either a City-performed operation (Oma-Gro) or a City-contracted composting operation ranges as a multiple of the current product fee schedule revenues from ~7 to ~6.5, respectively. The most significant cost, however, is the cost of collection and transport of diverted yard waste to the composting facility, and when combined with the cost of compost processing, the multiple of the current product fee schedule revenues dramatically rises to a range of ~50. The multiple ranges from ~50+ to ~40 for 3rd party contracted compost contractors depending on whether home run collection or transfer station methodology are used.

Scenario 5 provides an opportunity to eliminate the City's responsibility for collection, transport, and composting of yard waste by allowing interested citizenry to participate in a compost production program. In this scenario, the City would provide interested 3rd party composting contractors an at-risk opportunity to collect yard waste at designated drop-off locations. The diversion of yard waste would be strictly voluntary by the citizenry, and the cost of transporting the yard waste is borne by the participating citizenry exactly like other voluntary diversions efforts already in effect. SCS estimated that a likely maximum threshold for diversion under this scenario would be 15% but also believes that with a consistent education program the diversion could increase with time.

4.0 ENVIRONMENTAL EVALUATION OF YARD WASTE HANDLING ALTERNATIVES

SCS performed an evaluation of the environmental impact of two operational scenarios (Scenario 1 and Scenario 2) related to the collection, handling, and processing of yard waste generated by the residents of the City. This section summarizes the methods, sources of data, and results of LFG recovery projections and greenhouse gas (GHG) emissions estimates for the Pheasant Point Landfill in Omaha, Nebraska. Two alternative LFG recovery projections were developed as part of the Yard Waste Study and assume the following future waste disposal scenarios:

- Scenario 1 – "Baseline" or yard waste Diversion Scenario in which separate collection of 100 percent of generated yard waste for composting will occur and achieve 90 percent diversion of generated and collected yard waste starting in 2017, with the remaining 10 percent returning to the Pheasant Point Landfill.
- Scenario 2 - "Commingled Collection" Scenario which assumes that 100 percent of yard waste which is currently generated (approximately 35,600 tons per year) will be collected together with other MSW and other wastes, and disposed in the landfill starting in 2017.

Fugitive emissions of uncollected landfill methane are the largest potential source of GHG emissions in the waste sector. Methane emissions from the landfill are equal to the amount of methane generated minus the amount collected and destroyed in the combustion devices, and the amount oxidized in the cover soils. At landfills with high collection efficiencies, methane emissions are significantly reduced. If collected methane is used for electricity generation, as occurs at this facility, emissions reduction can offset a large percentage of landfill methane emissions.

LFG recovery, not generation, from landfills, is measured and recorded, which creates significant uncertainty regarding the total volume of potential landfill methane emissions. LFG generation models are used with wet or dry climate default assumptions for demonstrating compliance with Clean Air Act regulations, but produce unreliable estimates for most locations and conditions. For this reason, SCS developed an empirically-based LFG recovery modeling method, which is discussed below.

Because of the importance of landfill methane generation and collection in determining GHG emissions, this study initially focuses on developing LFG recovery projections, which are used to estimate landfill methane emissions. Other GHG emissions sources in the waste sector considered in this study include emissions from waste and yard waste collection and from compost facility operations. Offsetting GHG emissions reduction considered include landfill methane utilization, compost use, and carbon storage.

The LFG recovery projections were developed using the empirically-based SCS LFG recovery modeling method. GHG emissions calculation were developed using the LFG model results and emissions factors derived from U.S. EPA's Waste Reduction Model (WARM) and LFG-to-energy (LFGE) benefits calculator tool developed by the Landfill Methane Outreach Program

(LMOP), and Carbon-dioxide (CO_2) emissions conversion factors developed by the EPA. The model results (Table 13 through 14, and Figure 1) and GHG emissions estimates (Tables 15 and 16, and Figure 2) are shown in pages below.

4.1 SCS LFG RECOVERY MODELING METHOD

The LFG model used by SCS applies the same first-order decay equation as the U.S. Environmental Protection Agency's Landfill Gas Emissions Model (LandGEM). Unlike LandGEM which estimates LFG generation for regulatory purposes, the LFG model developed by SCS estimates LFG recovery for non-regulatory applications. The LFG recovery model used by SCS applies values for the potential methane generation capacity (L_o) and methane generation rate (k) that are either (1) calibrated to LFG flow and methane data collected from the landfill being modeled, or (2) assigned default values developed by SCS based on a database of over 1,100 years of LFG flow and methane data from 230 landfills with operational LFG collection systems.

The LFG modeling method used by SCS projects the recovery potential, which is the maximum amount of LFG a fully comprehensive, efficiently operated LFG collection and control system (GCCS) can recover. Expected recovery given the limitations of the actual or proposed collection system is calculated by multiplying the recovery potential by the estimated fraction of LFG that is effectively collected, a measure we call collection system coverage. Like collection efficiency, collection system coverage is a measure of the efficiency of the collection system design and performance. Unlike collection efficiency, collection system coverage is a percentage of the LFG recovery potential, not a percentage of LFG generation.

The L_0 and k values developed by SCS for modeling LFG recovery at U.S. landfills should not be used for any regulatory purpose as they are not consistent with U.S. EPA regulation and guidance for LFG modeling for Clean Air Act programs.

4.2 DATA SOURCES

Douglas County Environmental Services (Douglas County) and Waste Management, Inc. (WMI) provided data used for this study, along with information available on-line or contained in SCS's files from prior work. Douglas County is the landfill scale house operator and WMI owns and operates the Pheasant Point Landfill. SCS used the following data to develop the LFG recovery projections and GHG emissions estimates:

- Historical waste disposal rates for Douglas County Landfill in 1989 – 2003 and for Pheasant Point Landfill in 2003 – 2014 were provided in "Combined Douglas and Pheasant Waste Receipts for Gas Curve 2016". The table showed that waste receipt tonnages were reduced by 30 percent for inputs into LandGEM model runs.

- Waste disposal rates for 2015, including total waste disposed and total amount of inert waste, construction and demolition (C&D) waste, and special waste disposed.

- Yard waste tonnages diverted to compost from 1995 – 2015, as reported in "City of Omaha MSW tonnage history". Reported tonnages of yard waste diverted were increased by 50 percent to account for 60 percent moisture content expected for collected yard waste, as compared to 40 percent moisture content for composted yard waste.

- Estimated total amount of yard waste generated and collected in 2015 (35,618 tons), including separate yard waste collection and yard waste collected with MSW.

- A "Pheasant Point Landfill Life of Site Calculation" which shows 80.86 million cubic yards (yd^3) remaining airspace as of 4/13/16, an estimated in-place waste density of 0.83 yd^3 per ton, a 67.1 million ton remaining site capacity, and a projected remaining lifespan of 122 years.

- "State of Nebraska Waste Characterization Study" prepared for State of Nebraska, Department of Environmental Quality" by Engineering Solutions and Design, Inc., March 9, 2009. This study included a table (A.19) summarizing the composition of wastes disposed in Pheasant Point Landfill in 2006.

- A schematic drawing dated 2006 showing the GCCS installed in the Douglas County Landfill ("Gas System Location Plan" by Thiele Geotech, Inc.).

- A drawing dated September 2015 showing the southeastern portion of the Pheasant Point Landfill and the GCCS installed in that area as of that date ("Pheasant Point Landfill GCCS Expansion – 2015 GCCS As-Built Layout" by Blackstone Environmental).

- Historical total annual LFG collected and combusted in 1997 – 2014. Measured average methane concentrations in recovered LFG in 2011 – 2014.

- "Elk City Power Station Gas Recovery Logs" for 2015 (excluding February data) and 2016 (January – September data). Data included LFG flows and gas quality values measured at Plant 1, Plant 2, and the flare station between 6 and 23 days per month. Power loads in kilowatts (kW) for each engine and engine downtimes also were noted.

- Sandhu. G.S., Frey, H.C., Bartelt-Hunt, S.L., Jones, E. (2016). Real-World Activity, Fuel Use, and Emissions of Diesel Side-Loader Refuse Trucks, Atmospheric Environment, 129: 98-104.

- Sandhu. G.S., Frey, H.C., Bartelt-Hunt, S.L., Jones, E. (2015). In-use Activity, Fuel Use, and Emissions of Heavy Duty Diesel Roll-Off Refuse Trucks. Journal of the Air and Waste Management Association, 65(3): 306-323.

- Monthly wellfield monitoring data for 2015 and 2016 (through September) showing methane and oxygen percentages measured in each well in both landfills.

In addition, SCS had in its files emission factors developed by the U.S. EPA for calculating GHG emissions.

4.3 WASTE DISPOSAL RATES

The Douglas County Landfill began operations in 1989 and closed in 2003 after receiving about 8.6 million tons of waste. The Pheasant Point Landfill began operations in 2003, has about 6.8 million tons of waste in place as of late 2016, and had a 67.1 million ton remaining site capacity as of April 2016. Historical annual total waste disposal estimates include the 30 percent inert/C&D/special waste discount added back into the totals.

Data on the types of waste disposed in 2006 (from a waste characterization study) indicated that yard waste amounted to about 3 percent of total waste disposed, and C&D waste including wood amounted to about 1 percent. This incidental amount of C&D apparently included amounts commingled with MSW only, and excluded separate loads of C&D waste, inerts, and special waste, which WMI reported amounted to 109,451 tons in 2015, or about 22 percent of total waste received in 2015 (501,725 tons). Based on this information, annual total waste disposed historically was estimated to consist of 79 percent MSW (including yard waste), 20 percent inert and special waste, and 1 percent C&D waste containing wood. The inert and special waste was assumed to generate no LFG. The C&D waste containing wood was assumed to generate LFG at a reduced rate compared to MSW.

A separate tracking of yard waste tonnages generated, diverted, and disposed was necessary for LFG modeling purposes and to develop forecasts of future yard waste disposal under alternative (separate vs. commingled yard waste collection) scenarios. Historical data on tonnages of yard waste collected and diverted to composting in 1995-2015, and estimates of yard waste generated and disposed in 2015, were used to estimate historical yard waste generation and disposal. During the period that the separate yard waste collection program was in full operation (1995-2010), historic diversion of yard waste ranged between about 28,000 and 37,500 tons per year, with estimated diversion rates of 70-90 percent of generated and collected yard waste. Yard waste diversion declined after 2010, and reached low points of about 7,400 tons in 2011 and about 5,660 tons in 2015.

Table 9 below shows estimated annual waste disposal by source category, including the yard waste portion of MSW, for 2013 – 2015 (actual) and 2016 (projected).

Table 9. Estimated Waste Disposal Rates by Source Category: 2013-2016 (in Tons)

Year	MSW		C&D	Total in Model	Inert & Special Waste (excluded)	Total - All Wastes Received
	Total	Yard Waste Portion				
2013	325,019	9,047	3,283	328,302	82,075	410,377
2014	307,406	14,224	3,105	310,511	77,628	388,139
2015	387,906	29,956	3,918	391,824	109,451	501,275
2016	389,612	35,770	3,935	393,547	109,933	503,480

Not including the yard waste portion of MSW, waste disposal rates for all source categories are assumed to increase at a rate of 0.44 percent annually after 2015 until the site capacity is reached.

4.3.1 Future Waste Disposal Rates with Yard Waste Diversion at 90 Percent ("Baseline" Scenario)

For this study, the "Baseline" disposal scenario assumes that separate yard waste collection will re-start in January 2017 and achieve a 100 percent collection rate and a 90 percent diversion rate for generated yard waste, with 10 percent of generated and separately collected yard waste returning to the landfill. A 90 percent diversion rate for converting yard waste to compost is the estimated maximum rate achieved historically and the assumed maximum sustainable rate.

Due to a projected 32,340 ton increase in yard waste diversion over current rates starting in 2017, MSW and total waste disposal under the Baseline Scenario is projected to decrease by about 30,000 tons in 2017 (assuming slight increases in non-yard waste disposal). After 2017, all waste categories and total waste disposal is assumed to increase at an annual rate of 0.44 percent.

Annual waste disposal estimates by waste category for 1989 – 2040 under the Baseline Scenario are shown in Table 10, including MSW, inert waste (including special waste), and C&D waste. Also shown in Table 10 are the estimated annual tons of yard waste tons generated, diverted, and disposed, the estimated yard waste diversion rate, and the calculated fraction of yard waste disposed as a percentage of MSW disposed.

4.3.2 Future Waste Disposal Rates with Commingled Yard Waste Collection ("Commingled" Scenario)

To evaluate the effects of commingled collection and disposal yard waste, an alternative future waste disposal scenario was evaluated in which 100 percent of the yard waste being generated and collected will be landfilled starting in January 2017. This additional organic material would contribute to higher LFG generation and recovery rates and potentially greater electricity generation from the LFGE facility due to the greater amounts of available fuel. Assuming 0.44 percent future growth in yard waste generation, an estimated 35,930 tons/year of yard waste would be landfilled under the Commingled Scenario in 2017, with amounts increasing to 38,000 tons by 2030 and 40,000 tons by 2042.

Annual waste disposal estimates by waste category for 1989 – 2040 under the Commingled Scenario are shown in Table 11, including MSW, inert waste (including special waste), and C&D waste. Also shown in Table 11 are the estimated annual tons of yard waste generated, diverted, and disposed, the estimated yard waste diversion rate, and the calculated fraction of yard waste disposed as a percentage of MSW disposed.

Table 10. Annual Waste Disposal Estimates
Separate Yard Waste and MSW Collection Scenario (Baseline)
Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Inert Waste Disposal (tons/yr)	Annual C&D Waste Disposal (tons/yr)	Annual MSW Disposal (tons/yr)	Yard Waste Generated (tons/yr)	Yard Waste Diverted (tons/yr)	Yard Waste Disposed (tons/yr)	Yard Waste Diversion Rate (%)	Yard Waste Disposal % of MSW Disposed
1989	30,530	1,221	120,900	9,559	0	9,559	0%	8%
1990	106,714	4,269	422,589	33,413	0	33,413	0%	8%
1991	97,165	3,887	384,773	30,423	0	30,423	0%	8%
1992	105,862	4,234	419,212	33,146	0	33,146	0%	8%
1993	112,030	4,481	443,640	35,077	0	35,077	0%	8%
1994	122,644	4,906	485,671	38,401	0	38,401	0%	8%
1995	119,122	4,765	471,723	39,729	29,797	9,932	75%	2%
1996	130,315	5,213	516,049	46,236	35,139	11,097	76%	2%
1997	134,246	5,370	531,614	39,494	30,411	9,084	77%	2%
1998	139,032	5,561	550,565	45,188	35,247	9,941	78%	2%
1999	131,284	5,251	519,885	40,204	31,761	8,443	79%	2%
2000	118,019	4,721	467,356	40,232	32,186	8,046	80%	2%
2001	138,475	5,539	548,363	43,358	34,686	8,672	80%	2%
2002	126,790	5,072	502,088	40,576	32,461	8,115	80%	2%
2003	114,441	4,578	453,185	39,474	35,077	8,769	89%	2%
2004	115,742	4,630	458,338	46,814	37,451	9,363	80%	2%
2005	119,390	4,776	472,786	44,238	35,390	8,848	80%	2%
2006	117,359	4,694	464,743	49,359	35,928	13,431	73%	3%
2007	120,777	4,831	478,279	42,719	34,176	8,544	80%	2%
2008	110,617	4,425	438,042	39,772	27,840	11,932	70%	3%
2009	91,097	3,644	360,743	34,189	30,770	3,419	90%	1%

**Table 10. Annual Waste Disposal Estimates
Separate Yard Waste and MSW Collection Scenario (Baseline)
Douglas County and Pheasant Point Landfills Combined, Omaha, NE**

Year	Annual Inert Waste Disposal (tons/yr)	Annual C&D Waste Disposal (tons/yr)	Annual MSW Disposal (tons/yr)	Yard Waste Generated (tons/yr)	Yard Waste Diverted (tons/yr)	Yard Waste Disposed (tons/yr)	Yard Waste Diversion Rate (%)	Yard Waste Disposal % of MSW Disposed
2010	83,977	3,359	332,548	34,020	30,618	3,402	90%	1%
2011	85,398	3,416	338,178	32,317	7,433	24,884	23%	7%
2012	78,138	3,126	309,426	29,542	17,725	11,817	60%	4%
2013	82,075	3,283	325,019	30,155	21,109	9,047	70%	3%
2014	77,628	3,105	307,406	28,448	14,224	14,224	50%	5%
2015	109,451	3,918	387,906	35,618	5,662	29,956	16%	8%
2016	109,933	3,935	389,612	35,770	0	35,770	0%	9%
2017	110,417	3,952	358,990	35,930	32,337	3,593	90%	1%
2018	110,903	3,969	360,430	36,090	32,481	3,609	90%	1%
2019	111,391	3,986	361,870	36,250	32,625	3,625	90%	1%
2020	111,881	4,004	363,320	36,410	32,769	3,641	90%	1%
2021	112,373	4,022	364,770	36,570	32,913	3,657	90%	1%
2021	112,373	4,022	364,770	36,570	32,913	3,657	90%	1%
2022	112,867	4,040	366,230	36,730	33,057	3,673	90%	1%
2023	113,364	4,058	367,700	36,890	33,201	3,689	90%	1%
2024	113,863	4,076	369,170	37,050	33,345	3,705	90%	1%
2025	114,364	4,094	370,650	37,210	33,489	3,721	90%	1%
2026	114,867	4,112	372,140	37,370	33,633	3,737	90%	1%
2027	115,372	4,130	373,630	37,530	33,777	3,753	90%	1%
2028	115,880	4,148	375,120	37,700	33,930	3,770	90%	1%
2029	116,390	4,166	376,620	37,870	34,083	3,787	90%	1%

Table 10. Annual Waste Disposal Estimates
Separate Yard Waste and MSW Collection Scenario (Baseline)
Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Inert Waste Disposal (tons/yr)	Annual C&D Waste Disposal (tons/yr)	Annual MSW Disposal (tons/yr)	Yard Waste Generated (tons/yr)	Yard Waste Diverted (tons/yr)	Yard Waste Disposed (tons/yr)	Yard Waste Diversion Rate (%)	Yard Waste Disposal % of MSW Disposed
2030	116,902	4,184	378,120	38,040	34,236	3,804	90%	1%
2031	117,416	4,202	379,630	38,210	34,389	3,821	90%	1%
2032	117,933	4,220	381,150	38,380	34,542	3,838	90%	1%
2033	118,452	4,239	382,670	38,550	34,695	3,855	90%	1%
2034	118,973	4,258	384,200	38,720	34,848	3,872	90%	1%
2035	119,496	4,277	385,740	38,890	35,001	3,889	90%	1%
2036	120,022	4,296	387,280	39,060	35,154	3,906	90%	1%
2037	120,550	4,315	388,830	39,230	35,307	3,923	90%	1%
2038	121,080	4,334	390,390	39,400	35,460	3,940	90%	1%
2039	121,613	4,353	391,950	39,570	35,613	3,957	90%	1%
2040	122,148	4,372	393,520	39,740	35,766	3,974	90%	1%

Table 11. Annual Waste Disposal Estimates
Comingled and MSW Collection Scenario
Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Inert Waste Disposal (tons/yr)	Annual C&D Waste Disposal (tons/yr)	Annual MSW Disposal (tons/yr)	Yard Waste Generated (tons/yr)	Yard Waste Diverted (tons/yr)	Yard Waste Disposed (tons/yr)	Yard Waste Diversion Rate (%)	Yard Waste Disposal % of MSW Disposed
1989	30,530	1,221	120,900	9,559	0	9,559	0%	8%
1990	106,714	4,269	422,589	33,413	0	33,413	0%	8%
1991	97,165	3,887	384,773	30,423	0	30,423	0%	8%
1992	105,862	4,234	419,212	33,146	0	33,146	0%	8%
1993	112,030	4,481	443,640	35,077	0	35,077	0%	8%
1994	122,644	4,906	485,671	38,401	0	38,401	0%	8%
1995	119,122	4,765	471,723	39,729	29,797	9,932	75%	2%
1996	130,315	5,213	516,049	46,236	35,139	11,097	76%	2%
1997	134,246	5,370	531,614	39,494	30,411	9,084	77%	2%
1998	139,032	5,561	550,565	45,188	35,247	9,941	78%	2%
1999	131,284	5,251	519,885	40,204	31,761	8,443	79%	2%
2000	118,019	4,721	467,356	40,232	32,186	8,046	80%	2%
2001	138,475	5,539	548,363	43,358	34,686	8,672	80%	2%
2002	126,790	5,072	502,088	40,576	32,461	8,115	80%	2%
2003	114,441	4,578	453,185	43,846	35,077	8,769	80%	2%
2004	115,742	4,630	458,338	46,814	37,451	9,363	80%	2%
2005	119,390	4,776	472,786	44,238	35,390	8,848	80%	2%
2006	117,359	4,694	464,743	49,359	35,928	13,431	73%	3%
2007	120,777	4,831	478,279	42,719	34,176	8,544	80%	2%
2008	110,617	4,425	438,042	39,772	27,840	11,932	70%	3%
2009	91,097	3,644	360,743	34,189	30,770	3,419	90%	1%

Table 11. Annual Waste Disposal Estimates
Comingled and MSW Collection Scenario
Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Inert Waste Disposal (tons/yr)	Annual C&D Waste Disposal (tons/yr)	Annual MSW Disposal (tons/yr)	Yard Waste Generated (tons/yr)	Yard Waste Diverted (tons/yr)	Yard Waste Disposed (tons/yr)	Yard Waste Diversion Rate (%)	Yard Waste Disposal % of MSW Disposed
2010	83,977	3,359	332,548	34,020	30,618	3,402	90%	1%
2011	85,398	3,416	338,178	32,317	7,433	24,884	23%	7%
2012	78,138	3,126	309,426	29,542	17,725	11,817	60%	4%
2013	82,075	3,283	325,019	30,155	21,109	9,047	70%	3%
2014	77,628	3,105	307,406	28,448	14,224	14,224	50%	5%
2015	109,451	3,918	387,906	35,618	5,662	29,956	16%	8%
2016	109,933	3,935	389,612	35,770	0	35,770	0%	9%
2017	110,417	3,952	391,330	35,930	0	35,930	0%	9%
2018	110,903	3,969	393,048	36,090	0	36,090	0%	9%
2019	111,391	3,986	394,773	36,250	0	36,250	0%	9%
2020	111,881	4,004	396,505	36,410	0	36,410	0%	9%
2021	112,373	4,022	398,245	36,570	0	36,570	0%	9%
2022	112,867	4,040	399,993	36,730	0	36,730	0%	9%
2023	113,364	4,058	401,748	36,890	0	36,890	0%	9%
2024	113,863	4,076	403,511	37,050	0	37,050	0%	9%
2025	114,364	4,094	405,282	37,210	0	37,210	0%	9%
2026	114,867	4,112	407,061	37,370	0	37,370	0%	9%
2027	115,372	4,130	408,848	37,530	0	37,530	0%	9%
2028	115,880	4,148	410,642	37,700	0	37,700	0%	9%
2029	116,390	4,166	412,444	37,870	0	37,870	0%	9%
2030	116,902	4,184	414,264	38,040	0	38,040	0%	9%

Table 11. Annual Waste Disposal Estimates
Comingled and MSW Collection Scenario
Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Inert Waste Disposal (tons/yr)	Annual C&D Waste Disposal (tons/yr)	Annual MSW Disposal (tons/yr)	Yard Waste Generated (tons/yr)	Yard Waste Diverted (tons/yr)	Yard Waste Disposed (tons/yr)	Yard Waste Diversion Rate (%)	Yard Waste Disposal % of MSW Disposed
2031	117,416	4,202	416,092	38,210	0	38,210	0%	9%
2032	117,933	4,220	417,927	38,380	0	38,380	0%	9%
2033	118,452	4,239	419,769	38,550	0	38,550	0%	9%
2034	118,973	4,258	421,619	38,720	0	38,720	0%	9%
2035	119,496	4,277	423,477	38,890	0	38,890	0%	9%
2036	120,022	4,296	425,342	39,060	0	39,060	0%	9%
2037	120,550	4,315	427,215	39,230	0	39,230	0%	9%
2038	121,080	4,334	429,096	39,400	0	39,400	0%	9%
2039	121,613	4,353	430,984	39,570	0	39,570	0%	9%
2040	122,148	4,372	432,880	39,740	0	39,740	0%	9%

4.4 EXISTING LFG COLLECTION SYSTEM

Wellfield monitoring data indicates that the LFG collection system operating in 2016 consists of 56 vertical extraction wells and 11 leachate collection risers installed in the Douglas County Landfill and 41 vertical extraction wells installed in the Pheasant Point Landfill. Available site drawings showing the current GCCS layout are limited to a 2005 schematic of the Douglas County Landfill collection system and a 2015 drawing of the southeastern portion of the Pheasant Point Landfill showing 31 of the 41 wells. The drawings suggest that both landfills have a comprehensive GCCS installed. Wellfield monitoring data indicated that all 97 wells installed are operating effectively, with only a few wells experiencing limited periods of low methane or high oxygen levels in 2015 and 2016. Based on this information and measured actual LFG recovery rates, collection system coverage at both the Douglas County and Pheasant Point Landfills is estimated to be approximately 85 percent in 2016. Estimated collection system coverage for prior years with flow data (1997-2015) was back-calculated based on actual reported LFG recovery as a percentage of modeled LFG recovery potential.

Collection system coverage was assumed to remain at 85 percent in both landfills in all future years. Maintaining 85 percent collection system coverage in future years will require annual collection system expansions into recently disposed waste in the Pheasant Point Landfill, as well as ongoing repairs to the existing collection system and replacement of non-operational wells in both landfills.

Although the above listed system coverage estimates are suitable for evaluating the effects of different options for the management of yard waste, additional information, including the timing and amounts of waste disposal in future disposal cells in Pheasant Point Landfill, and plans for future collection system expansions in Pheasant Point or other system improvements in both landfills, which were not evaluated for this study, could yield more precise estimates of collection system coverage.

4.4.1 Historical LFG Recovery Rates

SCS uses actual LFG recovery rates to calibrate the LFG recovery model by adjusting model input parameters to correlate projected with actual LFG recovery given the estimated collection system coverage. Average total LFG flow and methane content for 2015 and 2016 is summarized below in Table 2 along with the calculated LFG flows at 50 percent methane. The annual average recovery rates shown below reflect total combined LFG and methane flows from both LFG-to-energy plants and the flare station. Measured values were averaged for each month of record (covering 6 to 25 days per month for 11 months in 2015 and 9 months in 2016) and the monthly average unadjusted LFG flows and LFG flows adjusted to 50 percent methane were averaged to yield annual recovery rates.

Table 12. Landfill LFG Recovery Data

Year	Average LFG Recovery (scfm)	Average Methane Content (%)	Average LFG Recovery (scfm at 50% methane)
2015	2,586	52.2%	2,700
2016 (through September)	2,920	52.4%	3,063

As shown in the above table, LFG recovery increased by 363 scfm or 13 percent between 2015 and 2016. This increase exceeds the expected rate of increase in the combined total LFG recovery potential for both sites, which implies improved collection system coverage and efficiency in 2016.

4.5 LFG MODEL ASSUMPTIONS

4.5.1 Scenario 1 (Baseline) – 0% Comingled and 100% Oma-Gro Compost Processing

SCS prepared the baseline LFG recovery model using the following input parameters:

- **Refuse Filling History and Projections:** Reported and estimated disposal of MSW, yard waste, C&D, and inert waste (including special waste) were used as model inputs for the Douglas County and Pheasant Point Landfill. Historical and projected waste disposal for 2013-2016 is shown in Table 9. Waste disposal rates for each waste category in 1989-2040 under the Baseline Scenario, including the yard waste portion of MSW disposed, are shown in Table 10. Yard waste tonnages were subtracted from MSW tonnages and modeled separately.

- **Methane Decay Rate Constant (k):** A k value of 0.051 yr^{-1} was selected for MSW disposed at the landfill through 2016 based on calibration of the model to actual 2016 LFG recovery at the estimated collection system coverage rate (85%). This k value for MSW matches the precipitation based default value for a site in this region that receives 28 inches of precipitation per year.[1] The MSW k value also reflects the moisture contribution to the landfill of disposed waste, which included an average of over 60 percent of generated yard waste since 2010. For MSW disposed starting in 2017, the k value was reduced by approximately 5 percent to 0.048 yr^{-1} to account for the estimated effect on waste decay rates of the loss of moisture from diverting 90 percent of generated yard waste. Waste in place in the Pheasant Point Landfill prior to 2017 also would be affected to a lesser extent by the future loss of moisture inputs to the landfill. MSW k values for this waste were assumed to decline by 0.25 percent per year starting in 2017 using SCS's unique variable k module. MSW k values under the Baseline Scenario were assumed to decrease to 0.050 yr^{-1} by 2024, and to stop declining after reaching 0.048 yr^{-1} 2041.

[1] See www.worldclimate.com data for Waterloo and Omaha Nebraska.

yard waste was assigned a k value of 0.075 yr^{-1}, which is the average of values assigned to garden waste in wet and dry temperate climates in the Intergovernmental Panel on Climate Change (IPCC) Model.[2]

A k value of 0.030 yr^{-1} was selected for C&D wastes based on the k value assigned for C&D waste at a landfill in this climate when calculating methane emissions for the Federal GHG Reporting Program (under the "modified bulk waste" model option). Inert wastes including special wastes were assumed to generate no LFG and were assigned a k value of zero.

- **Ultimate Methane Recovery Potential (L_0):** An L_0 value of 3,030 ft^3/ton was used for MSW based on calibration of the model to agree with actual reported LFG flows. This L_0 value matches the SCS default value for MSW. Yard waste was assigned an L_0 value of 2,980 ft^3/ton, which is calculated from the value for degradable organic carbon (DOC) of 0.20 for yard waste in the IPCC Model and IPCC's methodology for converting DOC to an L_0 value. An L_0 value of 1,190 ft^3/ton was used for C&D wastes based on the DOC (0.08) and resulting L_0 value assigned for C&D waste at a landfill when calculating methane emissions for the Federal GHG Reporting Program (under the "modified bulk waste" model option). Inert wastes were assumed to generate no LFG and were assigned an L_0 value of zero.

- **System Coverage:** Estimates of collection system coverage were developed as described above and are shown in Table 13, which shows the LFG recovery model results.

4.5.2 Scenario 2 – 100% Comingled and 0% Oma-Gro Compost Processing

SCS prepared the Commingled Scenario LFG recovery model using the following input parameters:

- **Refuse Filling History and Projections:** Historical and projected waste disposal for all years prior to 2017 match the Baseline Scenario tonnages shown in Table 9. Starting in 2017, the landfill will receive yard waste which will be additional to the amounts of wastes disposed under the Baseline Scenario. Approximately 35,930 tons of yard waste will be disposed in 2017 under the commingled scenario. Yard waste disposal is assumed to increase at the same rate as all other waste categories (0.44% per year) while the landfill remains in operation. Waste disposal rates for each waste category in 1989-2040 under the Commingled Scenario, including the yard waste portion of MSW disposed, are shown in Table 11.

- **Methane Decay Rate Constant (k):** Model k values for MSW (0.051), yard waste (0.075), and for C&D waste (0.030) match values assigned in the Baseline Scenario.

[2] See Table 3-3 in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change (IPCC), Volume 5 (Waste), Chapter 3 (Solid Waste Disposal). Default k values for garden waste are 0.05 for dry temperate climates and 0.10 for wet temperate climates.

Unlike in the Baseline Scenario where moisture levels are expected to decline in the landfill due to the diversion of 90 percent of future yard waste, the MSW k value in the Commingled Scenario is not adjusted downward in future years.

- **Ultimate Methane Recovery Potential (L_0):** Model L_0 values for MSW (3,030 ft^3/ton), yard waste (2,980 ft^3/ton), and C&D wastes (1,190 ft^3/ton) match values used in the Baseline Scenario.

- **System Coverage:** Estimates of collection system coverage match values used in the Baseline Scenario and are shown in Table 14.

4.6 LFG RECOVERY PROJECTIONS

The LFG recovery projections for the Douglas County and Pheasant Point Landfills combined are presented in Tables 13 and 14 and Figure 1. All LFG flow values are adjusted to 50 percent methane content. Table 10 (Baseline Scenario) and 11 (Commingled Scenario) include the following information:

- Annual historical waste disposal rates.
- Annual waste in place values.
- Projected LFG recovery potential, which is the maximum amount of LFG that is recoverable with a fully comprehensive collection system.
- Estimated collection system coverage.
- Projected annual average LFG recovery from the existing/planned system, which is equal to the recovery potential multiplied by the estimated system coverage.
- Projected collection efficiency, which is equal to projected LFG recovery divided by projected LFG generation.

Figure 1 provides the following information in a graph format:

- Projected LFG recovery potential under the Baseline Scenario (solid red line).
- Projected LFG recovery potential under the Commingled Scenario (dashed red line after 2017).
- Projected LFG recovery from the existing/planned system under the Baseline Scenario (solid black line).
- Projected LFG recovery from the existing/planned system under the Alternative Scenario (dashed black line after 2017).
- Average actual LFG recovery rates for 1997 through 2016.

Table 13. LFG Recover Projection – Baseline (Separate Yard Waste and MSW Collection) Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Total Waste Disposal (tons/yr)	Total Waste In Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Existing/Planned System (scfm)	LFG Recovery from Existing/Planned System (mmcf/day)	LFG Recovery from Existing/Planned System (mmBtu/yr)	Maximum LFGE Plant Capacity* (MW)
1989	152,652	152,652	0	0.00	0	0%	0	0.00	0	0
1990	533,572	686,224	72	0.10	19,192	0%	0	0.00	0	0
1991	485,824	1,172,048	321	0.46	85,273	0%	0	0.00	0	0
1992	529,308	1,701,356	534	0.77	141,907	0%	0	0.00	0	0
1993	560,152	2,261,508	756	1.09	201,059	0%	0	0.00	0	0
1994	613,221	2,874,729	981	1.41	261,012	0%	0	0.00	0	0
1995	595,610	3,470,339	1,220	1.76	324,520	0%	0	0.00	0	0
1996	651,577	4,121,916	1,431	2.06	380,709	0%	0	0.00	0	0
1997	671,230	4,793,146	1,658	2.39	440,995	15%	257	0.37	68,291	0
1998	695,158	5,488,304	1,882	2.71	500,544	21%	386	0.56	102,624	0
1999	656,420	6,144,724	2,106	3.03	560,111	33%	695	1.00	184,840	0
2000	590,096	6,734,820	2,301	3.31	611,916	48%	1,101	1.59	292,843	0
2001	692,377	7,427,197	2,456	3.54	653,069	45%	1,098	1.58	291,906	0
2002	633,950	8,061,147	2,650	3.82	704,669	43%	1,134	1.63	301,633	0
2003	572,203	8,633,350	2,807	4.04	746,575	47%	1,318	1.90	350,615	0
2004	578,710	9,212,060	2,929	4.22	778,947	45%	1,317	1.90	350,369	0
2005	596,952	9,809,012	3,048	4.39	810,549	47%	1,424	2.05	378,742	0
2006	586,797	10,395,809	3,169	4.56	842,769	56%	1,774	2.55	471,849	0
2007	603,887	10,999,696	3,281	4.72	872,464	66%	2,157	3.11	573,611	0
2008	553,083	11,552,779	3,393	4.89	902,422	63%	2,141	3.08	569,507	0
2009	455,484	12,008,263	3,478	5.01	924,947	62%	2,160	3.11	574,415	0
2010	419,884	12,428,147	3,512	5.06	933,917	68%	2,383	3.43	633,710	0

Table 13. LFG Recover Projection – Baseline (Separate Yard Waste and MSW Collection)
Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Total Waste Disposal	Total Waste In Place	LFG Recovery Potential			LFG System Coverage	LFG Recovery from Existing/Planned System			Maximum LFGE Plant Capacity*
	(tons/yr)	(tons)	(scfm)	(mmcf/day)	(mmBtu/yr)	(%)	(scfm)	(mmcf/day)	(mmBtu/yr)	(MW)
2011	426,992	12,855,139	3,527	5.08	938,145	73%	2,588	3.73	688,211	0
2012	390,690	13,245,829	3,551	5.11	944,478	64%	2,288	3.30	608,604	0
2013	410,377	13,656,206	3,554	5.12	945,143	68%	2,404	3.46	639,464	0
2014	388,139	14,044,345	3,564	5.13	947,980	70%	2,510	3.61	667,562	0
2015	501,275	14,545,620	3,566	5.13	948,321	76%	2,700	3.89	717,953	7.6
2016	503,480	15,049,100	3,617	5.21	962,024	85%	3,063	4.41	814,489	8.6
2017	473,359	15,522,459	3,668	5.28	975,598	85%	3,106	4.47	826,011	8.7
2018	475,440	15,997,899	3,674	5.29	977,165	85%	3,111	4.48	827,362	8.7
2019	477,530	16,475,429	3,682	5.30	979,191	85%	3,117	4.49	829,099	8.8
2020	479,630	16,955,059	3,691	5.32	981,633	85%	3,125	4.50	831,188	8.8
2021	481,740	17,436,799	3,702	5.33	984,452	85%	3,134	4.51	833,595	8.8
2022	483,860	17,920,659	3,713	5.35	987,611	85%	3,144	4.53	836,290	8.8
2023	485,990	18,406,649	3,727	5.37	991,080	85%	3,156	4.54	839,245	8.9
2024	488,130	18,894,779	3,741	5.39	994,828	85%	3,168	4.56	842,436	8.9
2025	490,280	19,385,059	3,756	5.41	998,827	85%	3,180	4.58	845,839	8.9
2026	492,440	19,877,499	3,772	5.43	1,003,052	85%	3,194	4.60	849,434	9.0
2027	494,610	20,372,109	3,788	5.45	1,007,481	85%	3,208	4.62	853,200	9.0
2028	496,790	20,868,899	3,806	5.48	1,012,092	85%	3,223	4.64	857,119	9.1
2029	498,980	21,367,879	3,823	5.51	1,016,866	85%	3,238	4.66	861,175	9.1
2030	501,180	21,869,059	3,842	5.53	1,021,784	85%	3,254	4.69	865,354	9.1
2031	503,390	22,372,449	3,861	5.56	1,026,830	85%	3,270	4.71	869,640	9.2
2032	505,600	22,878,049	3,880	5.59	1,031,990	85%	3,286	4.73	874,022	9.2

Table 13. LFG Recover Projection – Baseline (Separate Yard Waste and MSW Collection) Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Total Waste Disposal (tons/yr)	Total Waste In Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Existing/Planned System (scfm)	LFG Recovery from Existing/Planned System (mmcf/day)	LFG Recovery from Existing/Planned System (mmBtu/yr)	Maximum LFGE Plant Capacity* (MW)
2033	507,820	23,385,869	3,900	5.62	1,037,251	85%	3,303	4.76	878,489	9.3
2034	510,050	23,895,919	3,920	5.65	1,042,601	85%	3,320	4.78	883,031	9.3
2035	512,290	24,408,209	3,941	5.67	1,048,029	85%	3,338	4.81	887,638	9.4
2036	514,540	24,922,749	3,961	5.70	1,053,525	85%	3,355	4.83	892,303	9.4
2037	516,800	25,439,549	3,982	5.73	1,059,080	85%	3,373	4.86	897,017	9.5
2038	519,070	25,958,619	4,003	5.76	1,064,687	85%	3,391	4.88	901,775	9.5
2039	521,350	26,479,969	4,025	5.80	1,070,337	85%	3,409	4.91	906,569	9.6
2040	523,640	27,003,609	4,046	5.83	1,076,024	85%	3,427	4.93	911,394	9.6

Table 14. LFG Recovery Projection – 100% Commingled Yard Waste and MSW Collection Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Total Waste Disposal (tons/yr)	Total Waste In Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Existing/Planned System (scfm)	LFG Recovery from Existing/Planned System (mmcf/day)	LFG Recovery from Existing/Planned System (mmBtu/yr)	Maximum LFGE Plant Capacity* (MW)
1989	152,652	152,652	0	0.00	0	0%	0	0.00	0	0
1990	533,572	686,224	72	0.10	19,192	0%	0	0.00	0	0
1991	485,824	1,172,048	321	0.46	85,273	0%	0	0.00	0	0
1992	529,308	1,701,356	534	0.77	141,907	0%	0	0.00	0	0
1993	560,152	2,261,508	756	1.09	201,059	0%	0	0.00	0	0
1994	613,221	2,874,729	981	1.41	261,012	0%	0	0.00	0	0
1995	595,610	3,470,339	1,220	1.76	324,520	0%	0	0.00	0	0
1996	651,577	4,121,916	1,431	2.06	380,709	0%	0	0.00	0	0
1997	671,230	4,793,146	1,658	2.39	440,995	15%	257	0.37	68,291	0
1998	695,158	5,488,304	1,882	2.71	500,544	21%	386	0.56	102,624	0
1999	656,420	6,144,724	2,106	3.03	560,111	33%	695	1.00	184,840	0
2000	590,096	6,734,820	2,301	3.31	611,916	48%	1,101	1.59	292,843	0
2001	692,377	7,427,197	2,456	3.54	653,069	45%	1,098	1.58	291,906	0
2002	633,950	8,061,147	2,650	3.82	704,669	43%	1,134	1.63	301,633	0
2003	572,203	8,633,350	2,807	4.04	746,575	47%	1,318	1.90	350,615	0
2004	578,710	9,212,060	2,929	4.22	778,947	45%	1,317	1.90	350,369	0
2005	596,952	9,809,012	3,048	4.39	810,549	47%	1,424	2.05	378,742	0
2006	586,797	10,395,809	3,169	4.56	842,769	56%	1,774	2.55	471,849	0
2007	603,887	10,999,696	3,281	4.72	872,464	66%	2,157	3.11	573,611	0
2008	553,083	11,552,779	3,393	4.89	902,422	63%	2,141	3.08	569,507	0
2009	455,484	12,008,263	3,478	5.01	924,947	62%	2,160	3.11	574,415	0
2010	419,884	12,428,147	3,512	5.06	933,917	68%	2,383	3.43	633,710	0

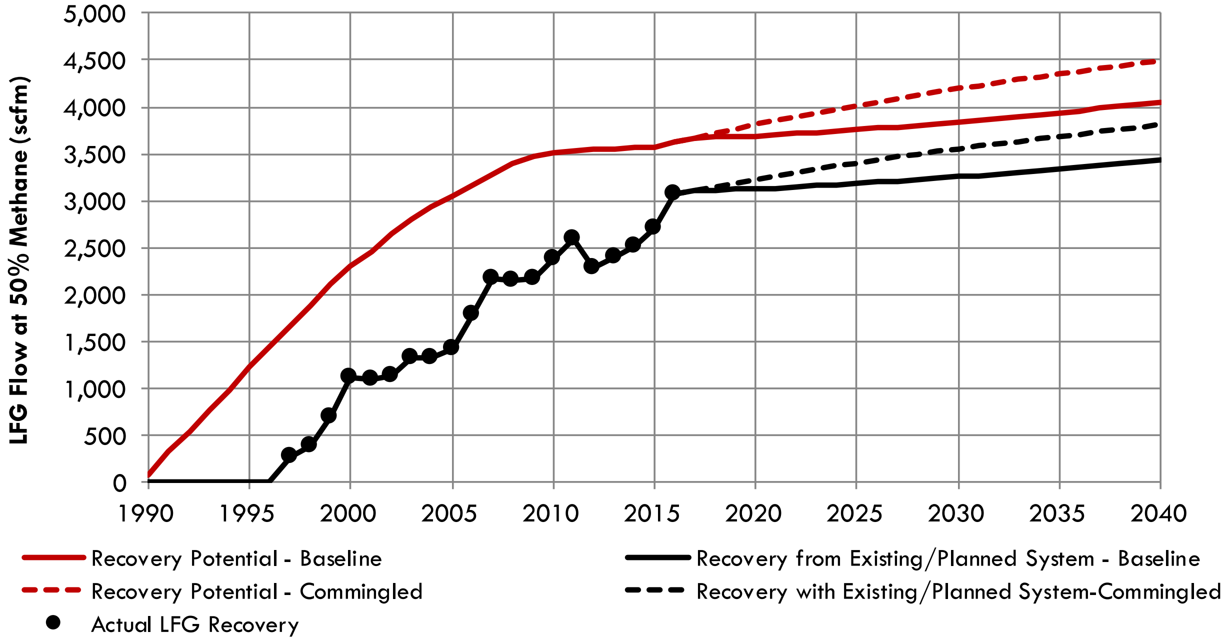
**Table 14. LFG Recovery Projection – 100% Commingled Yard Waste and MSW Collection
Douglas County and Pheasant Point Landfills Combined, Omaha, NE**

Year	Annual Total Waste Disposal (tons/yr)	Total Waste In Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Existing/Planned System (scfm)	LFG Recovery from Existing/Planned System (mmcf/day)	LFG Recovery from Existing/Planned System (mmBtu/yr)	Maximum LFGE Plant Capacity* (MW)
2011	426,992	12,855,139	3,527	5.08	938,145	73%	2,588	3.73	688,211	0
2012	390,690	13,245,829	3,551	5.11	944,478	64%	2,288	3.30	608,604	0
2013	410,377	13,656,206	3,554	5.12	945,143	68%	2,404	3.46	639,464	0
2014	388,139	14,044,345	3,564	5.13	947,980	70%	2,510	3.61	667,562	0
2015	501,275	14,545,620	3,566	5.13	948,321	76%	2,700	3.89	717,953	7.6
2016	503,480	15,049,100	3,617	5.21	962,024	85%	3,063	4.41	814,489	8.6
2017	505,699	15,554,799	3,668	5.28	975,598	85%	3,106	4.47	826,011	8.7
2018	507,920	16,062,719	3,717	5.35	988,654	85%	3,148	4.53	837,095	8.8
2019	510,150	16,572,869	3,765	5.42	1,001,228	85%	3,188	4.59	847,767	9.0
2020	512,390	17,085,259	3,810	5.49	1,013,351	85%	3,226	4.65	858,057	9.1
2021	514,640	17,599,899	3,854	5.55	1,025,053	85%	3,264	4.70	867,989	9.2
2022	516,900	18,116,799	3,897	5.61	1,036,362	85%	3,300	4.75	877,588	9.3
2023	519,170	18,635,969	3,938	5.67	1,047,305	85%	3,335	4.80	886,875	9.4
2024	521,450	19,157,419	3,978	5.73	1,057,907	85%	3,369	4.85	895,872	9.5
2025	523,740	19,681,159	4,016	5.78	1,068,190	85%	3,401	4.90	904,599	9.6
2026	526,040	20,207,199	4,054	5.84	1,078,176	85%	3,433	4.94	913,073	9.7
2027	528,350	20,735,549	4,091	5.89	1,087,885	85%	3,464	4.99	921,312	9.7
2028	530,670	21,266,219	4,126	5.94	1,097,336	85%	3,494	5.03	929,331	9.8
2029	533,000	21,799,219	4,161	5.99	1,106,547	85%	3,524	5.07	937,147	9.9
2030	535,350	22,334,569	4,194	6.04	1,115,535	85%	3,552	5.12	944,773	10.0
2031	537,710	22,872,279	4,227	6.09	1,124,317	85%	3,580	5.16	952,224	10.1
2032	540,080	23,412,359	4,260	6.13	1,132,906	85%	3,608	5.20	959,511	10.1

Table 14. LFG Recovery Projection – 100% Commingled Yard Waste and MSW Collection Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Year	Annual Total Waste Disposal	Total Waste In Place	LFG Recovery Potential			LFG System Coverage	LFG Recovery from Existing/Planned System			Maximum LFGE Plant Capacity*
	(tons/yr)	(tons)	(scfm)	(mmcf/day)	(mmBtu/yr)	(%)	(scfm)	(mmcf/day)	(mmBtu/yr)	(MW)
2033	542,460	23,954,819	4,291	6.18	1,141,317	85%	3,635	5.23	966,646	10.2
2034	544,850	24,499,669	4,322	6.22	1,149,561	85%	3,661	5.27	973,640	10.3
2035	547,250	25,046,919	4,353	6.27	1,157,651	85%	3,687	5.31	980,502	10.4
2036	549,660	25,596,579	4,383	6.31	1,165,597	85%	3,712	5.35	987,242	10.4
2037	552,080	26,148,659	4,412	6.35	1,173,409	85%	3,737	5.38	993,868	10.5
2038	554,510	26,703,169	4,441	6.40	1,181,098	85%	3,762	5.42	1,000,390	10.6
2039	556,950	27,260,119	4,469	6.44	1,188,672	85%	3,786	5.45	1,006,813	10.6
2040	559,400	27,819,519	4,498	6.48	1,196,139	85%	3,809	5.49	1,013,147	10.7

**Figure 1. LFG Recovery Projection
Douglas County and Pheasant Point Landfills Combined, Omaha, NE**



4.6.1 Model Results – Scenario 1 (Baseline) – 0% Comingled and 100% Oma-Gro Compost Processing

As shown in Table 12, the estimated LFG recovery potential is projected to have modest increases after 2017 despite ongoing increases in total waste disposal, due to the diversion of 90 percent of generated yard waste. The LFG recovery potential is projected to be 3,668 scfm in 2017, 3,691 scfm in 2020, 3,842 scfm in 2030, and 4,046 scfm in 2040. Projected LFG recovery assuming 85 percent collection system coverage is 3,106 scfm in 2017, 3,125 scfm in 2020, 3,254 in 2030, and 3,427 in 2040. The largest size LFGE facility that could be supported at 100 percent capacity by these rates of LFG recovery is projected to slowly increase over time from 8.6 megawatts (MW) in 2016 to 9.6 MW in 2040.

4.6.2 Model Results – Scenario 2 – 100% Comingled and 0% Oma-Gro Compost Processing

LFG recovery projections under the Commingled Scenario, which assumes 100 percent disposal of future yard waste generated, is shown in Table 13. Yard waste disposal is projected to allow the LFG recovery potential to increase to 3,810 scfm in 2020, 4,194 scfm in 2030, and 4,498 scfm in 2040. Projected LFG recovery assuming 85 percent collection system coverage is 3,226 scfm in 2020 (a 101 scfm or 3.2% increase over Baseline Scenario recovery), 3,552 scfm in 2030 (a 298 scfm or 9.2% increase over Baseline Scenario recovery), and 3,809 in 2040 (a 382 scfm or 11.2% increase over Baseline Scenario recovery). The largest LFGE facility that could be supported at 100 percent capacity by this rate of LFG recovery is estimated to increase above Baseline Scenario levels to 9 MW by 2019, 10 MW by 2030, and 10.7 MW by 2040.

4.7 GHG EMISSIONS ESTIMATES

GHG emissions estimates from MSW disposal and separate yard waste collection and composting under the Baseline Scenario – 0% Comingled and 100% Oma-Gro Compost Processing and from waste MSW disposal without separate yard waste collection for composting under the Comingled Scenario - 100% Comingled and 0% Oma-Gro Compost Processing were developed for this study. GHG emissions from additional waste collection truck mileage for separate collection of yard waste under the Baseline Scenario were added to the analysis. Since the purpose of this evaluation was to estimate the net difference in GHG estimates under the two future disposal scenarios, GHG emissions calculations did not need to include sources assumed to have the same emissions under either scenario, including landfill operations and collecting waste for disposal (only additional truck mileage for separate yard waste collection for composting was accounted for). Accordingly, the analysis was limited to the following emissions sources and sinks:

- For the Baseline Scenario, GHG emissions were the sum of the following:
  - Annual landfill methane emissions, which are equal to the uncollected methane (generation minus recovered) multiplied by 1 minus the oxidation rate, plus the amount of collected methane which is not destroyed in the engines or flare (methane recovery times (1 minus the destruction efficiency)).
  - Annual CO_2 emissions reduction resulting from the use of electricity generated by the LFG-to-energy facility, which is equal to the annual power produced by the facility multiplied by an estimated CO_2 emissions reduction rate for offsetting electricity production from fossil fuels.
  - Annual CO_2 emissions resulting from additional truck mileage incurred for the separate collection of yard waste diverted in the Baseline Scenario.
  - Annual CO_2 emissions resulting from the production of compost (including fugitive emissions and compost pile turning) in the Baseline Scenario.
  - Annual CO_2 emissions reduction resulting from using compost produced from the yard waste diverted in the Baseline Scenario.
- For the Comingled Scenario, GHG emissions were the sum of the following:
  - Annual landfill methane emissions, which are calculated as described above for the Baseline Scenario.
  - Annual CO_2 emissions reduction resulting from the use of electricity generated by the LFG-to-energy facility, which is calculated as described above for the Baseline Scenario.

- Annual CO_2 emissions reduction resulting from carbon storage ("sequestration") in the landfill the additional yard waste disposed under the Commingled Scenario.

Emissions reduction achieved by carbon storage of additional yard waste disposed in the Commingled Scenario is relatively large and exceeds additional emissions reduction from producing more electricity at the LFG-to-energy plants under the Commingled Scenario. For this reason, GHG emissions estimates are shown both with and without including carbon storage of additional yard waste disposed in the Commingled Scenario in the calculations.

The calculation and comparison of net GHG emissions from the Baseline and Commingled Scenarios are provided without including additional carbon storage of yard waste in Table 15 and with including additional carbon storage of yard waste in Table 16. The exhibits show annual GHG emissions from the above sources, and the following assumptions used in the calculations (with sources listed):

- LFG generation is estimated by dividing the modeled LFG recovery potential by 95 percent. This relationship of LFG generation to recovery potential assumes that 95 percent is the maximum achievable collection efficiency, which is based on the maximum value assigned to a landfill with a final cover and active collection system under the Federal GHG Reporting Program. Based on the estimated collection system coverage value of 85 percent for 2016, which was assumed to be maintained in future years, collection efficiency was estimated to be approximately 80 percent starting in 2016.

- Methane oxidation rate is assumed to be 10 percent, which is the default value under the Federal GHG Reporting Program without site-specific soil depth and methane flux data (which can allow for up to a 35% oxidation rate).

- Methane destruction efficiency is assumed to be 99 percent which is the default value under the Federal GHG Reporting Program.

- LFGE facility annual electricity output is estimated based on the following:

  - For 2015 and 2016, average actual total plant electrical load (in kW) was calculated from the power station gas recovery logs. The average annual value was converted to megawatts per year and reduced by an assumed 8 percent parasitic load (power used for operating the plants) to yield electrical output.

  - For future years, a 75 percent facility utilization factor (capacity factor) was multiplied by the projected (fuel-based) maximum facility generating capacity for that year (calculated in Tables 13 and 14 using a heat rate of 10,800 Btus per kilowatt-hour (Btu/kWh)) to estimate the total plant electrical load. The capacity factor was based on the average of values estimated for 2015 (81%) and 2016 (69%), which were calculated by dividing the average total plant electrical load by the estimated maximum generating capacity based on fuel availability (from Tables 13 and 14). The estimated electrical plant load was reduced by 8 percent to account for the parasitic load and estimate total annual electrical output.

- CO_2 emissions reduced per kWh of electricity produced are estimated to be 1.12 pounds, which is the value provided in LMOP's LFG utilization benefits "calculator tool".

- CO_2 emissions from additional collection vehicle mileage incurred in the Baseline Scenario for the separate collection of yard waste for composting are estimated to be 0.034 metric tonnes (Mg) per ton (U.S.) of yard waste collected, based on the following:

  - Estimated additional mileage in 2015 (484,362 miles) which would have occurred with separate collection of yard waste (2,410,275 miles), assuming 100 percent of generated yard waste in 2015 (35,168 tons) is collected separately, vs. with commingled collection of yard waste and other waste (1,925,913 miles).

  - A fossil fuel emissions factor for heavy diesel fueled trucks of 0.0025 Mg CO_2 per mile travelled, which is based on fuel consumption data discussed elsewhere in this study.

- CO_2 emissions from processing compost (pile turning) are estimated to be 0.12 Mg per ton (U.S.) of yard waste, based on an emissions factor of 2.2 therms per ton of yard waste per the U.S. EPA's Waste Reduction Model (WARM) documentation (Exhibit 2-6 in Organics Material Chapter – Yard Trimmings), and converting to CO_2 using the EPA CO_2 converter.

- Fugitive CO_2 and N_2O emissions of 0.07 Mg CO_2-equivalent (CO_2e) per ton of yard waste from the compost pile, based on EPA's WARM documentation (Exhibit 2-5 in Organics Material Chapter – Yard Trimmings).

- The fraction of yard waste delivered for composting that ultimately is used is estimated to be 50 percent (includes deductions for volume reduction during composting and for unused compost).

- CO_2 emissions reduction from the use of compost (due to benefits to soil) is estimated to be 0.24 Mg per ton of compost used, based on WARM documentation (Exhibit 2-7 in Organics Material Chapter – Yard Trimmings). Because only 50 percent of composted yard waste is assumed used, there is a net emissions reduction of only 0.12 Mg CO_2 per ton of yard waste composted.

- CO_2 emissions reduction from carbon storage resulting from landfilling of additional yard waste disposed in the Commingled Scenario (90% of generated yard waste) is estimated to be 0.54 Mg CO_2 per ton of yard waste landfilled, based on WARM documentation (Exhibit 2-10 in Organics Material Chapter – Yard Trimmings).

- Methane density is 0.0007168 Mg per cubic meter (per IPCC Model).

- Methane has a CO_2e emissions multiplier of 25, based on the most recent value recognized by the U.S. EPA.

As shown in Tables 15 and 16, landfill methane emissions are higher under the Commingled Scenario than under the Baseline Scenario by an amount which increases over time from 1 percent in 2018 to 11 percent in 2040. However, about 54 percent of this difference in emissions is offset by the increase in electricity generation and use under the Commingled Scenario. In addition, higher emissions in the Baseline Scenario from separately collecting and processing compost slightly exceed emissions reduction from the use of composted yard waste. As a result, GHG emissions without considering carbon storage of additional yard waste are slightly lower in 2017 and 2018 and only modestly higher after 2018 in the Commingled Scenario as compared to the Baseline Scenario (Table 15). The net increase in GHG emissions without considering carbon storage is projected to be 442 Mg CO_2e in 2020 and to increase over time to 2,459 Mg CO_2e in 2040.

Emissions reduction from carbon storage of yard waste in the landfill under the Commingled Scenario (Table 16) is relatively large, and is projected to increase slowly over time from 17,540 Mg CO_2e in 2018 to 19,314 Mg CO_2e in 2040. As a result, GHG emissions are reduced under the Commingled Scenario by 17,563 Mg CO_2e per year in 2018, 16,778 Mg CO_2e per year in 2025, and 16,854 Mg CO_2e per year in 2040.

Table 15. Comparison of Net GHG Emissions from LFG and Composting VS. Increased LFG without Composting (Carbon Storage in Landfills not Included) Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Assumptions:

Maximum collection efficiency at 100% collection system coverage		95%	Minimum of 5% of generated methane is emitted or oxidized
Methane oxidation rate (% of uncollected methane)		10%	EPA Methane Reporting Rule default without soil depth and methane flux/area data
Methane destruction efficiency of LFG combustion devices		99%	Default destruction efficiency used in Federal GHG Reporting Rule
Lbs CO2 emissions reduction/kWh electricity produced		1.12	per LMOP LFGE benefits calculator tool (2016 version)
Capacity factor (LFG utilization %) at LFG-to-energy facility		75%	Based on the 2015-16 average total plant load (in kW) as a % of available LFG (at 10,800 Btu/kWh)
LFG-to-energy facility parasitic load (energy used for plant operation)		8%	Based on value used in LMOP LFGE benefits calculator tool
Fossil fuel (diesel) emissions for yard waste collection & transport to compost plant (Mg CO2/mile traveled)		0.0025	Based on 2.5 kg CO2 per mile traveled calculated using 2015 vehicle mileage and fuel consumption data.
2015 MSW + yard waste collection truck miles - 0% commingling:	2,410,275 miles		
2015 MSW + yard collection truck miles - 100% commingled:	1,925,913 miles	0.034	(Mg CO2/ton yard waste) - Additional vehicle emissions for separate yard waste collection
Fossil fuel emissions from compost pile turning (Mg CO2/ton yard waste)		0.012	CO2e emissions for 0.22 million Btu (2.2 therms)/ton yd waste (WARM Exhibit 2-6) + EPA converter
Fugitive CH4 and N2O emissions (Mg CO2/ton yard waste)		0.07	per WARM model v. 14 documentation - Organic Materials Chapters - Yard Trimmings (Exhibit 2-5)
Fraction of yard waste converted to compost and applied to soil		50%	Assumed to include mass reduction from converting from 60% to 40% moisture after collection
Emissions reduction from compost use (Mg CO2/ton compost)		0.24	per WARM model v. 14 documentation - Organic Materials Chapters - Yard Trimmings (Exhibit 2-7)
Methane density (Mg/m3)		0.0007168	
CO2 equivalent (CO2e) factor for methane		25	

	Scenario 1: GHG Emissions with Composting Yard Waste (Baseline)							Scenario 2: GHG Emissions with Landfilling Yard Waste							
	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	Net CO2 Emissions from Yard Waste Collection & Composting (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Composting (Mg)	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	Net CO2 Emissions from Yard Waste Collection & Composting (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Composting (Mg)	Net CO2e Emissions: Scenario 2 - Scenario 1 (Mg)
2015	20,021	72%	2,674	66,842	25,080	50	41,811	20,021	72%	2,674	66,842	25,080	50	41,811	0
2016	20,311	80%	1,952	48,798	24,396	0	24,402	20,311	80%	1,952	48,798	24,396	0	24,402	0
2017	20,597	80%	1,979	49,480	26,810	287	22,957	20,597	80%	1,979	49,480	26,810	0	22,670	(287)
2018	20,630	80%	1,982	49,554	26,854	289	22,989	20,873	80%	2,005	50,136	27,170	0	22,966	(23)
2019	20,673	80%	1,986	49,652	26,910	290	23,032	21,138	80%	2,031	50,768	27,516	0	23,251	220
2020	20,724	80%	1,991	49,771	26,978	291	23,084	21,394	80%	2,055	51,377	27,850	0	23,526	442
2021	20,784	80%	1,996	49,910	27,056	292	23,146	21,641	80%	2,079	51,965	28,173	0	23,792	646
2022	20,851	80%	2,003	50,066	27,144	294	23,216	21,880	80%	2,101	52,533	28,484	0	24,049	833
2023	20,924	80%	2,009	50,237	27,240	295	23,293	22,111	80%	2,123	53,083	28,786	0	24,298	1,005
2024	21,003	80%	2,017	50,424	27,343	296	23,377	22,335	80%	2,145	53,616	29,078	0	24,539	1,162
2025	21,087	80%	2,025	50,622	27,454	298	23,466	22,552	80%	2,165	54,133	29,361	0	24,773	1,306
2026	21,177	80%	2,033	50,833	27,570	299	23,562	22,763	80%	2,185	54,636	29,636	0	25,000	1,438

	Scenario 1: GHG Emissions with Composting Yard Waste (Baseline)							Scenario 2: GHG Emissions with Landfilling Yard Waste							
	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	Net CO2 Emissions from Yard Waste Collection & Composting (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Composting (Mg)	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	Net CO2 Emissions from Yard Waste Collection & Composting (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Composting (Mg)	Net CO2e Emissions: Scenario 2 - Scenario 1 (Mg)
2027	21,270	80%	2,042	51,054	27,693	300	23,662	22,968	80%	2,205	55,124	29,903	0	25,221	1,559
2028	21,368	80%	2,051	51,285	27,820	301	23,766	23,167	80%	2,224	55,599	30,164	0	25,436	1,669
2029	21,468	80%	2,061	51,523	27,952	303	23,875	23,362	80%	2,243	56,063	30,417	0	25,646	1,771
2030	21,572	80%	2,071	51,770	28,087	304	23,987	23,551	80%	2,261	56,515	30,665	0	25,850	1,863
2031	21,679	80%	2,081	52,023	28,226	306	24,102	23,737	80%	2,278	56,957	30,907	0	26,051	1,948
2032	21,788	80%	2,091	52,282	28,368	307	24,220	23,918	80%	2,296	57,390	31,143	0	26,246	2,026
2033	21,899	80%	2,102	52,546	28,513	308	24,340	24,096	80%	2,313	57,813	31,375	0	26,438	2,098
2034	22,012	80%	2,113	52,814	28,661	310	24,463	24,270	80%	2,329	58,228	31,602	0	26,626	2,163
2035	22,126	80%	2,123	53,087	28,810	311	24,587	24,441	80%	2,345	58,636	31,825	0	26,811	2,224
2036	22,242	80%	2,135	53,363	28,962	312	24,714	24,608	80%	2,361	59,036	32,043	0	26,993	2,279
2037	22,360	80%	2,146	53,642	29,115	314	24,841	24,773	80%	2,377	59,429	32,258	0	27,171	2,330
2038	22,478	80%	2,157	53,925	29,269	315	24,970	24,936	80%	2,393	59,817	32,470	0	27,347	2,377
2039	22,597	80%	2,168	54,209	29,425	316	25,100	25,096	80%	2,408	60,199	32,679	0	27,520	2,420
2040	22,717	80%	2,180	54,495	29,581	318	25,231	25,253	80%	2,423	60,575	32,884	0	27,691	2,459
2041	22,838	80%	2,191	54,783	29,739	319	25,363	25,409	80%	2,438	60,947	33,087	0	27,860	2,496
2042	22,965	80%	2,203	55,087	29,905	321	25,502	25,562	80%	2,453	61,313	33,287	0	28,026	2,524
2043	23,094	80%	2,216	55,393	30,072	322	25,643	25,714	80%	2,467	61,676	33,485	0	28,191	2,548
2044	23,222	80%	2,228	55,699	30,239	323	25,783	25,865	80%	2,481	62,035	33,681	0	28,354	2,571
2045	23,349	80%	2,240	56,002	30,405	325	25,922	26,013	80%	2,496	62,391	33,875	0	28,516	2,593
2046	23,475	80%	2,252	56,305	30,570	326	26,061	26,161	80%	2,510	62,743	34,067	0	28,676	2,615
2047	23,601	80%	2,264	56,606	30,734	328	26,199	26,307	80%	2,524	63,092	34,258	0	28,835	2,635
2048	23,727	80%	2,276	56,906	30,898	329	26,337	26,452	80%	2,538	63,439	34,447	0	28,992	2,655
2049	23,852	80%	2,288	57,204	31,061	331	26,474	26,596	80%	2,551	63,783	34,634	0	29,149	2,675
2050	23,976	80%	2,300	57,501	31,223	332	26,611	26,739	80%	2,565	64,125	34,821	0	29,304	2,694

Table 16. Comparison of Net GHG Emissions from LFG and Composting VS. Increased LFG without Composting (Carbon Storage of Net Landfilled Yard Waste Included) Douglas County and Pheasant Point Landfills Combined, Omaha, NE

Assumptions:

Maximum collection efficiency at 100% collection system coverage			95%	Minimum of 5% of generated methane is emitted or oxidized
Methane oxidation rate (% of uncollected methane)			10%	EPA Methane Reporting Rule default without soil depth and methane flux/area data
Methane destruction efficiency of LFG combustion devices			99%	Default destruction efficiency used in Federal GHG Reporting Rule
Lbs CO2 emissions reduction/kWh electricity produced			1.12	per LMOP LFGE benefits calculator tool (2016 version)
Capacity factor (LFG utilization %) at LFG-to-energy facility			75%	Based on the 2015-16 average total plant load (in kW) as a % of available LFG (at 10,800 Btu/kWh)
LFG-to-energy facility parasitic load (energy used for plant operation)			8%	Based on value used in LMOP LFGE benefits calculator tool
Fossil fuel (diesel) emissions for yard waste collection & transport to compost plant (Mg CO2/mile traveled)			0.0025	Based on 2.5 kg CO2 per mile traveled calculated using 2015 vehicle mileage and fuel consumption data.
2015 MSW + yard waste collection truck miles - 0% commingling:	2,410,275	miles		
2015 MSW + yard collection truck miles - 100% commingled:	1,925,913	miles	0.034	(Mg CO2/ton yard waste) - Additional vehicle emissions for separate yard waste collection
Fossil fuel emissions from compost pile turning (Mg CO2/ton yard waste)			0.012	CO2e emissions for 0.22 million Btu (2.2 therms)/ton yd waste (WARM Exhibit 2-6) + EPA converter
Fugitive CH4 and N2O emissions (Mg CO2/ton yard waste)			0.07	per WARM model v. 14 documentation - Organic Materials Chapters - Yard Trimmings (Exhibit 2-5)
Fraction of yard waste converted to compost and applied to soil			50%	Assumed to include mass reduction from converting from 60% to 40% moisture after collection
Emissions reduction from compost use (Mg CO2/ton compost)			0.24	per WARM model v. 14 documentation - Organic Materials Chapters - Yard Trimmings (Exhibit 2-7)
Emission reduction from landfilling yard waste due to carbon storage (Mg CO2/ton yard waste)			0.54	per WARM model v. 14 documentation - Organic Materials Chapters - Yard Trimmings
Methane density (Mg/m3)			0.0007168	
CO2 equivalent (CO2e) factor for methane			25	

	Scenario 1: GHG Emissions with Composting Yard Waste (Baseline)							Scenario 2: GHG Emissions with Landfilling Yard Waste							
	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	Net CO2 Emissions from Yard Waste Collection & Composting (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Composting (Mg)	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	CO2 Emissions Reduction from Carbon storage in landfill of additional yard waste (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Carbon Storage (Mg)	Net CO2e Emissions: Scenario 2 - Scenario 1 (Mg)
2015	20,021	72%	2,674	66,842	25,080	50	41,811	20,021	72%	2,674	66,842	25,080	-50	41,811	0
2016	20,311	80%	1,952	48,798	24,396	0	24,402	20,311	80%	1,952	48,798	24,396	0	24,402	0
2017	20,597	80%	1,979	49,480	26,810	287	22,957	20,597	80%	1,979	49,480	26,810	17,462	5,208	(17,749)
2018	20,630	80%	1,982	49,554	26,854	289	22,989	20,873	80%	2,005	50,136	27,170	17,540	5,426	(17,563)
2019	20,673	80%	1,986	49,652	26,910	290	23,032	21,138	80%	2,031	50,768	27,516	17,618	5,634	(17,398)
2020	20,724	80%	1,991	49,771	26,978	291	23,084	21,394	80%	2,055	51,377	27,850	17,695	5,831	(17,253)
2021	20,784	80%	1,996	49,910	27,056	292	23,146	21,641	80%	2,079	51,965	28,173	17,773	6,019	(17,127)
2022	20,851	80%	2,003	50,066	27,144	294	23,216	21,880	80%	2,101	52,533	28,484	17,851	6,198	(17,017)
2023	20,924	80%	2,009	50,237	27,240	295	23,293	22,111	80%	2,123	53,083	28,786	17,929	6,369	(16,924)
2024	21,003	80%	2,017	50,424	27,343	296	23,377	22,335	80%	2,145	53,616	29,078	18,006	6,532	(16,844)

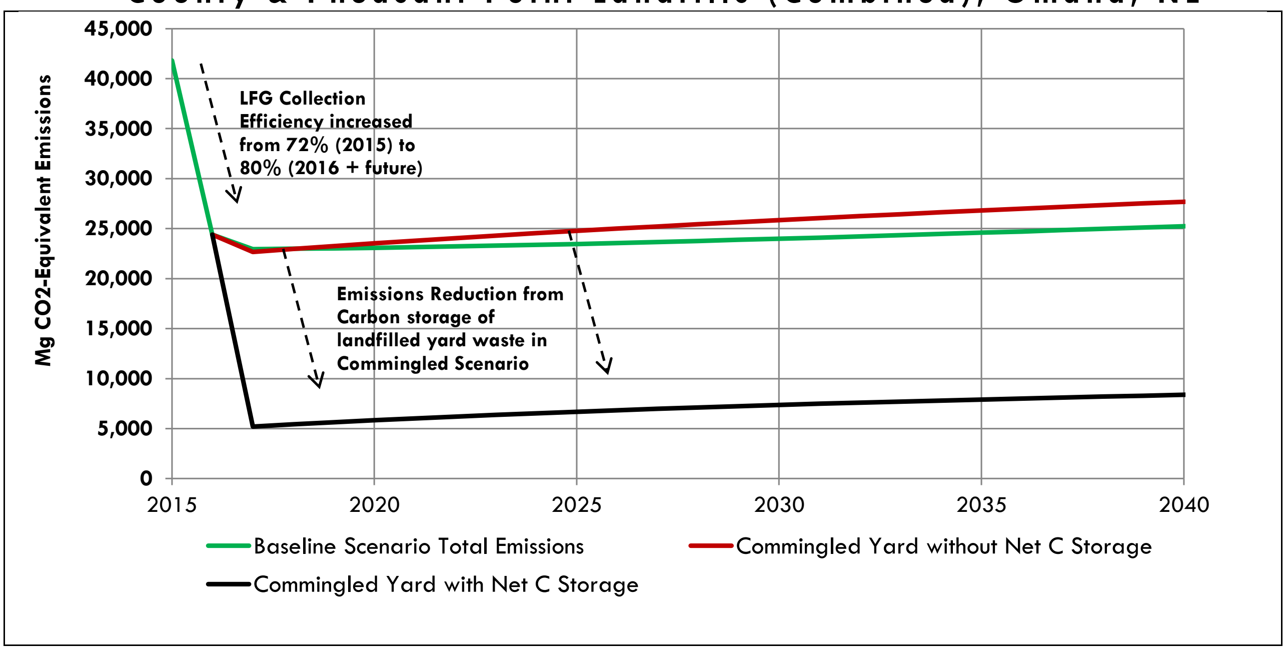
	Scenario 1: GHG Emissions with Composting Yard Waste (Baseline)							Scenario 2: GHG Emissions with Landfilling Yard Waste							
	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	Net CO2 Emissions from Yard Waste Collection & Composting (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Composting (Mg)	Landfill Methane Generation (Mg)	Estimated Landfill Gas Collection Efficiency %	Landfill Methane Emissions (Mg)	CO2 Equivalent Landfill Methane Emissions (Mg)	CO2 Emissions Reduction from LFG-to-Energy (LFGE) (Mg)	CO2 Emissions Reduction from Carbon storage in landfill of additional yard waste (Mg)	Net CO_2 Equivalent Landfill Methane Emissions + LFGE and Carbon Storage (Mg)	Net CO2e Emissions: Scenario 2 - Scenario 1 (Mg)
2025	21,087	80%	2,025	50,622	27,454	298	23,466	22,552	80%	2,165	54,133	29,361	18,084	6,688	(16,778)
2026	21,177	80%	2,033	50,833	27,570	299	23,562	22,763	80%	2,185	54,636	29,636	18,162	6,838	(16,724)
2027	21,270	80%	2,042	51,054	27,693	300	23,662	22,968	80%	2,205	55,124	29,903	18,240	6,981	(16,681)
2028	21,368	80%	2,051	51,285	27,820	301	23,766	23,167	80%	2,224	55,599	30,164	18,322	7,114	(16,653)
2029	21,468	80%	2,061	51,523	27,952	303	23,875	23,362	80%	2,243	56,063	30,417	18,405	7,241	(16,634)
2030	21,572	80%	2,071	51,770	28,087	304	23,987	23,551	80%	2,261	56,515	30,665	18,487	7,363	(16,624)
2031	21,679	80%	2,081	52,023	28,226	306	24,102	23,737	80%	2,278	56,957	30,907	18,570	7,480	(16,622)
2032	21,788	80%	2,091	52,282	28,368	307	24,220	23,918	80%	2,296	57,390	31,143	18,653	7,594	(16,626)
2033	21,899	80%	2,102	52,546	28,513	308	24,340	24,096	80%	2,313	57,813	31,375	18,735	7,703	(16,637)
2034	22,012	80%	2,113	52,814	28,661	310	24,463	24,270	80%	2,329	58,228	31,602	18,818	7,808	(16,654)
2035	22,126	80%	2,123	53,087	28,810	311	24,587	24,441	80%	2,345	58,636	31,825	18,901	7,911	(16,677)
2036	22,242	80%	2,135	53,363	28,962	312	24,714	24,608	80%	2,361	59,036	32,043	18,983	8,009	(16,704)
2037	22,360	80%	2,146	53,642	29,115	314	24,841	24,773	80%	2,377	59,429	32,258	19,066	8,105	(16,736)
2038	22,478	80%	2,157	53,925	29,269	315	24,970	24,936	80%	2,393	59,817	32,470	19,148	8,198	(16,772)
2039	22,597	80%	2,168	54,209	29,425	316	25,100	25,096	80%	2,408	60,199	32,679	19,231	8,289	(16,811)
2040	22,717	80%	2,180	54,495	29,581	318	25,231	25,253	80%	2,423	60,575	32,884	19,314	8,377	(16,854)
2041	22,838	80%	2,191	54,783	29,739	319	25,363	25,409	80%	2,438	60,947	33,087	19,396	8,463	(16,900)
2042	22,965	80%	2,203	55,087	29,905	321	25,502	25,562	80%	2,453	61,313	33,287	19,484	8,542	(16,960)
2043	23,094	80%	2,216	55,393	30,072	322	25,643	25,714	80%	2,467	61,676	33,485	19,571	8,620	(17,023)
2044	23,222	80%	2,228	55,699	30,239	323	25,783	25,865	80%	2,481	62,035	33,681	19,659	8,695	(17,088)
2045	23,349	80%	2,240	56,002	30,405	325	25,922	26,013	80%	2,496	62,391	33,875	19,746	8,769	(17,153)
2046	23,475	80%	2,252	56,305	30,570	326	26,061	26,161	80%	2,510	62,743	34,067	19,834	8,842	(17,219)
2047	23,601	80%	2,264	56,606	30,734	328	26,199	26,307	80%	2,524	63,092	34,258	19,921	8,913	(17,286)
2048	23,727	80%	2,276	56,906	30,898	329	26,337	26,452	80%	2,538	63,439	34,447	20,009	8,984	(17,354)
2049	23,852	80%	2,288	57,204	31,061	331	26,474	26,596	80%	2,551	63,783	34,634	20,096	9,053	(17,422)
2050	23,976	80%	2,300	57,501	31,223	332	26,611	26,739	80%	2,565	64,125	34,821	20,184	9,121	(17,490)

4.8 ENVIRONMENTAL EVALUATION CONCLUSIONS

In conclusion, if carbon storage of landfilled yard waste is not considered, GHG emissions will increase slightly by converting from separate collection of yard waste for composting to commingled yard waste collection and disposal with other wastes. If carbon storage of landfilled yard waste is considered in the calculations, GHG emissions will decrease by converting from separate collection of yard waste for composting to commingled yard waste collection and disposal with other wastes.

The results of this study are summarized graphically in Figure 2. As the figure shows, net GHG emissions declined significantly in 2016 due to the increase in estimated collection efficiency from 72 percent to 80 percent. Future GHG emissions are projected to be relatively constant under the Baseline Scenario, assuming 80 percent LFG collection efficiency is maintained. Additional decreases in GHG emissions may be achieved after 2017 under the Commingled Collection Scenario if emissions reduction from carbon storage of landfilled yard waste is included in the calculations.

Figure 2. Annual Emissions (Mg CO2e): Yard Waste Diversion (Baseline vs. Commingled Collection and Disposal – Douglas County & Pheasant Point Landfills (Combined), Omaha, NE



5.0 DISCLAIMER

This report has been prepared in accordance with the care and skill generally exercised by reputable engineering and LFG professionals, under similar circumstances, in this or similar localities. The pro forma cost models and LFG recovery projections are based on our engineering judgment as of the date of this report. No warranty, express or implied, is made as to the professional opinions presented herein.

Specific to the LFG recovery projections, changes in the landfill property use and conditions (for example: variations in rainfall, water levels, landfill operations, final cover systems, or other factors) may affect future gas recovery at the landfill. SCS does not guarantee the quantity or the quality of the available landfill gas.

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