4.1.4 Vehicles – Paved Road Dust

The U.S. EPA AP-42 emission factors from Chapter 13.2.1 – Paved Roads (January 2011) were used to calculate the fugitive dust emissions from paved roadways. The following predictive emissions equation was used to determine the fugitive dust emission factor for paved roads:

$$\mathrm{EF} = (\mathrm{k}(\mathrm{sL})^{0.91} \times (\mathrm{W})^{1.02})\ (1 - \text{control efficiency})$$

Where:
EF = particulate emission factor (having units matching the units of k),
k = particle size multiplier for particle size range and units of interest (see Table A 4-3),
sL = road surface silt loading (g/m^2) assumed to be 7.4 (as per US EPA AP-42 Section 13.2.1-3, silt loading for MSW landfills),
W = average weight (tons) of the vehicles traveling the road, and
control efficiency = reduction of fugitive dust emissions due to dust suppression activities.

Table A 4-3: Particle Size Assumptions for Paved Road Dust

Size Range	k (g/VKT)
$PM_{2.5}$	0.15
PM_{10}	0.62
SPM	3.23

The following is a sample calculation for SPM for the predictive emission factor for vehicles that will travel along the entrance road segment to/from Boundary Road. It was estimated that the fleet vehicles will have an average weight of 15.43 tons. The number of precipitation days was estimated to be 163 as per Environment Canada Climate Normals records. A control efficiency of 85% was selected to represent the dust suppression activities that will occur based on best management practices expected control efficiency.

$$\mathrm{EF} = (3.23\ \times (7.4)^{0.91} \times (15.43)^{1.02})(1 - 85\%)$$

$$\mathrm{EF} = 48.80\ \ \mathrm{g/VKT}$$

The following is a sample calculation for the SPM emission rate for vehicles travelling along the same paved road segment:

$$\mathrm{ER} = \frac{48.80\ \mathrm{g}}{\mathrm{VKT}} \times \frac{31.62\ \mathrm{VKT}}{\mathrm{hr}} \times \frac{1\ \mathrm{hr}}{3600\ \mathrm{s}}$$

$$\mathrm{ER} = 0.429\ \mathrm{g/s}$$

The emission rates of PM_{10} and $PM_{2.5}$ were calculated as presented above.

4.1.5 Material Transfer Fugitive Dust

The U.S. EPA AP-42 emission factors from Chapter 13.2.4 – Aggregate Handling and Storage Piles (November 2006) were used to calculate the fugitive dust emissions associated with material transfer activities that will occur at the landfill, the composting area, the organics processing facility, and the hydrocarbon (HC) impacted soil treatment area. The following predictive emissions equation was used in determining the emission factors for material handling:

$$\mathrm{EF} = \mathrm{k} \times 0.0016 \times \frac{\left(\frac{\mathrm{U}}{2.2}\right)^{1.3}}{\left(\frac{\mathrm{M}}{2}\right)^{1.4}}$$

Where:
EF = particulate emission factor (kg/Mg),
k = particle size multiplier for particle size range (see Table A 4-4),
U = mean wind speed (m/s), and
M = moisture content of material (percent) (%).

Table A 4-4: Particle Size Assumptions Material Transfer

Size Range	k
$PM_{2.5}$	0.053
PM_{10}	0.35
SPM	0.74

The following is a sample calculation for the SPM emission factor for material handling that will occur at the PHC impacted soil treatment area. A mean wind speed of 3.5 m/s obtained from the MOECC pre-processed meteorological data (1996-2000) used for the dispersion modelling assessment. A moisture content of 12% for municipal solid waste landfill cover soil was used, which was obtained from Table 13.2.4.1 of the U.S. EPA AP-42.

$$\mathrm{EF} = 0.74 \times 0.0016 \times \frac{\left(\frac{3.5\ \mathrm{m/s}}{2.2}\right)^{1.3}}{\left(\frac{12\%}{2}\right)^{1.4}}$$

$$\mathrm{EF} = 0.000176\ \mathrm{kg/Mg}$$

The following is a sample calculation for the SPM emission rate per drop for a handling rate of 106 tonnes/hr.

$$\mathrm{ER} = \frac{0.000176\ \mathrm{kg}}{\mathrm{tonnes}} \times \frac{106\ \mathrm{tonnes}}{\mathrm{hr}} \times \frac{1\ \mathrm{hr}}{3{,}600\ \mathrm{s}} \times \frac{1{,}000\ \mathrm{g}}{1\ \mathrm{kg}}$$

$$\mathrm{ER} = 0.00518\ \frac{\mathrm{g}}{\mathrm{s}}\ \text{per drop}$$

It was assumed that there will be two loaders in the PHC impacted soil treatment area that can be moving material simultaneously, at the same time that each biopile can be turned, thus a maximum of 2 drop points occurring at the same time during operations at the PHC impacted soil treatment area was assumed. The emission rate is as follows:

$$\mathrm{ER} = \mathrm{ER\ per\ drop}\ \times \#\ \mathrm{of\ drops}$$

$$\mathrm{ER} = 0.00518\frac{\mathrm{g}}{\mathrm{s}}\mathrm{per\ drop}\ \times 2$$

$$\mathrm{ER} = 0.0104\ \mathrm{g/s}$$

The emission rates of PM_{10} and $PM_{2.5}$ were calculated as presented above.

4.1.6 Dust Collectors

The Construction and Demolition (C&D) Recycling Facility and the Material Recovery Facility (MRF) will both have dust collectors to control particulate emissions from these facilities. An outlet loading emission factor of 10 mg/m^3 for SPM was used to calculate particulate emissions from these dust collectors. This emission factor is based on guidance provided in the MOECC *Procedure for Preparing an Emission Summary and Dispersion Modelling Report* (MOE, March 2009) for small dust collectors. An expected dust collector flow rate of 15,000 acfm was also assumed.

The following is a sample calculation for the emission rate of SPM from the dust collectors proposed at the MRF:

$$\mathrm{ER} = \mathrm{outlet\ loading}\ \frac{\mathrm{mg}}{\mathrm{m}^3} \times \mathrm{flow\ rate} \times \frac{\mathrm{ft}^3}{\mathrm{min}} \times \frac{1\ \mathrm{m}^3}{35.32\ \mathrm{ft}^3} \times \frac{1\ \mathrm{min}}{60\ \mathrm{s}} \times \frac{1\ \mathrm{g}}{1000\ \mathrm{mg}}$$

$$\mathrm{ER} = \frac{10\ \mathrm{mg}}{\mathrm{m}^3} \times \frac{15{,}000\ \mathrm{ft3}}{\mathrm{min}} \times \frac{1\ \mathrm{m}^3}{35.32\ \mathrm{ft}^3} \times \frac{1\ \mathrm{min}}{60\ \mathrm{s}} \times \frac{1\ \mathrm{g}}{1{,}000\ \mathrm{mg}}$$

$$\mathrm{ER} = 0.0708\ \mathrm{g/s}$$

Emission rates of PM_{10} and $PM_{2.5}$ were assumed to be 100% of the SPM emission rate.

4.1.7 Flare

The landfill gas (LFG) collection system will collect approximately 75% of the LFG produced by the landfill, (U.S. EPA, 2008). This collected gas is either combusted using an enclosed flare or sent to electrical generation plant, which converts the LFG (along with biogas from the organics processing area) to electricity. Based on design specifications, the flare has capacity for LFG and biogas with 56.2% methane and the flow rate of LFG and biogas to the flare will be 0.98 m^3/s, made up of 36% LFG and 64% biogas. LFG constituents and their estimated respective concentrations in the LFG were obtained from the U.S. EPA AP 42 Chapter 2.4 (Table 2.4-1). As worst-case estimates, the biogas was assumed to have the same constituents and concentration as the LFG.

The following is a sample calculation for the emission rate of the LFG constituents (in this case, vinyl chloride) from the flare:

$$\mathrm{ER} = \text{Landfill Gas flow rate}\ \frac{\mathrm{m}^3}{\mathrm{s}} \times \text{conc.} \frac{\mu\mathrm{g}}{\mathrm{m}^3} \times \frac{1\ \mathrm{g}}{1{,}000{,}000\ \mu\mathrm{g}} \times (1 - \text{ destruction efficiency } (\%))$$

Where:

ER	=	emission rate (g/s),
Land Fill Gas Flow rate	=	flow rate of landfill and organics gas to the flare (m^3/s),
conc.	=	concentration of the contaminant in the landfill gas ($\mu g/m^3$) obtained from US EPA AP 42 Chapter 2.4, and
destruction efficiency	=	amount of the contaminant that is destroyed during combustion (%) obtained from US EPA AP 42 Chapter 2.4.

$$\mathrm{ER} = 0.983\ \frac{\mathrm{m}^3}{\mathrm{s}} \times 3627.21 \frac{\mu g}{\mathrm{m}^3} \times \frac{1\ \mathrm{g}}{1{,}000{,}000\ \mu\mathrm{g}} \times (1 - 98\ \%)$$

$$\mathrm{ER} = 0.0000713\ \frac{\mathrm{g}}{\mathrm{s}}$$

The emission rate for reduced sulphur compounds was calculated based on expected LFG composition. The concentration of sulphur in the LFG was estimated by summing the concentration of compounds containing sulphur (based on US EPA AP 42 Chapter 2.4) multiplied by the number of moles of sulphur in each compound. The concentration of reduced compounds was determined to be 39.64 m^3 of sulphur per 1,000,000 m^3 of LFG.

$$\mathrm{ER} = \text{conc. of sulphur in the LFG}\ \frac{\mathrm{m3\ S}}{\mathrm{m3\ LFG}} \times \text{flow rate}\ \frac{\mathrm{m3LFG}}{\mathrm{sec}} \times \frac{1\ \mathrm{mol.K}}{8.3145\ \mathrm{m3\ S.PA}} \times \frac{101325\ \mathrm{Pa}}{298.15\ \mathrm{K}} \times \frac{32.1\ \mathrm{gS}}{\mathrm{mol}}$$

$$\mathrm{ER} = 39.64\ \frac{\mathrm{m^3S}}{1{,}000{,}000\ \mathrm{m^3\ LFG}} \times 0.983\ \frac{\mathrm{m3\ LFG}}{\mathrm{sec}} \times \frac{1\ \mathrm{mol.K}}{8.3145\ \mathrm{m3\ S.PA}} \times \frac{101325\ \mathrm{Pa}}{298.15\ \mathrm{K}} \times \frac{32.1\ g_s}{\mathrm{mol}}$$

$$\mathrm{ER} = 0.0511 \frac{g_s}{\mathrm{s}}$$

The sulphur dioxide emission rate from the flare was calculated as follows[1]:

$$\mathrm{ER} = \text{reduced sulphur compounds emission rate} \times {}^{MW_{SO2}}/_{MW_S}$$

$$\mathrm{ER} = 0.0511\ \frac{g_s}{s} \times \frac{64.0}{32.1}$$

$$\mathrm{ER} = 0.102 \frac{\mathrm{g}}{\mathrm{s}}$$

[1] S= sulphur

The following is a sample calculation for the emission rate of combustion by-products (in this case nitrogen oxides) from the flare:

$$\mathrm{ER} = \text{flow rate dscm} \times \text{percent of methane in LFG}(\%) \times \text{NOx emission factor} \times \text{conversion factors}$$

$$\mathrm{ER} = 0.983\ \frac{\mathrm{m^3}}{\mathrm{s}} \times 56.2\ \%\ \mathrm{CH4} \times 631\ \frac{\mathrm{kg}}{1{,}000{,}000\mathrm{dscm\ of\ CH4}} \times 1000\ \frac{\mathrm{g}}{\mathrm{kg}}$$

$$\mathrm{ER} = 0.348\ \frac{\mathrm{g}}{\mathrm{s}}$$

The emission rates for all LFG and biogas constituents were calculated as presented above.

4.1.8 Electrical Generation Plant

If built, the electrical generation plant would receive collected LFG and biogas from the organics processing facility. The combined gas would be used to fuel internal combustion engines that will be coupled to electrical generators. Electricity produced by the plant would be exported to the local electrical distribution system and/or used to power on-Site electrical demand. It is anticipated that 7 Jenbacher 1.06 MW engines (each with an electrical generator) would be required to combust this gas. LFG constituents and their estimated respective concentrations in the LFG were obtained from the U.S. EPA AP 42 Chapter 2.4 (Table 2.4-1).

The emission rates for the proposed electrical generation plant were calculated in the same manner as for the flare (refer to Section 4.1.7).

4.1.9 Landfill Cap

LFG not collected and distributed to the flare or the electrical generation plant may result in fugitive LFG emissions from the landfill cap. These fugitive emissions were estimated, including odour emissions. LFG constituents and their estimated respective concentrations in the LFG were obtained from the U.S. EPA AP 42 Chapter 2.4 (Table 2.4-1). Average LFG emissions per year were estimated using results from the LandGEM model (provided in Appendix C) based on a 75% capture efficiency.

The following is a sample calculation for the emission rate of vinyl chloride from the landfill cap:

$$\mathrm{ER} = \mathrm{conc.}\frac{\mathrm{\mu g}}{\mathrm{m^3}} \times \mathrm{LGF}\ \frac{\mathrm{m^3}}{\mathrm{yr}} \times \frac{1\ \mathrm{yr}}{365\ \mathrm{days}} \times \frac{1\ \mathrm{day}}{24\ \mathrm{hrs}} \times \frac{1\ \mathrm{hr}}{3{,}600\ \mathrm{s}} \times \frac{1\ \mathrm{g}}{1{,}000{,}000\ \mathrm{\mu g}} \times (1 - \text{collection efficiency } (\%))$$

Where:
ER = emission rate (m^3/s),
conc. = concentration of the contaminant in the landfill gas (g/m^3) obtained from US EPA AP 42 Chapter 2.4
LFG = average landfill gas emissions per yr (m^3/yr) (obtained from LandGEM), and
collection efficiency = collection efficiency of landfill gas.

$$\mathrm{ER} = 3627.21\ \frac{\mathrm{\mu g}}{\mathrm{m^3}} \times 13{,}199{,}538.3\frac{\mathrm{m^3}}{\mathrm{yr}} \times \frac{1\ \mathrm{yr}}{365\ \mathrm{days}} \times \frac{1\ \mathrm{day}}{24\ \mathrm{hrs}} \times \frac{1\ \mathrm{hr}}{3{,}600\ \mathrm{s}} \times \frac{1\ \mathrm{g}}{1{,}000{,}000\ \mathrm{\mu g}} \times (1 - 75\%)$$

$$\mathrm{ER} = 0.0003795\ \frac{\mathrm{g}}{\mathrm{s}}$$

Emissions of the remaining LFG constituents were calculated in the same manner presented above.

To calculate the odour emissions, the flow rate of the landfill cap is needed. The following is a sample calculation to determine the flow rate from the landfill cap:

$$\mathrm{FR} = \mathrm{LFG}\ \frac{\mathrm{m^3}}{\mathrm{yr}} \times \frac{1\ \mathrm{yr}}{365\ \mathrm{days}} \times \frac{1\ \mathrm{day}}{24\ \mathrm{hrs}} \times \frac{1\ \mathrm{hr}}{3{,}600\ \mathrm{s}} \times (1 - 75\%)$$

Where:
FR = flow Rate (m^3/s),
LFG = average landfill gas emissions per year (m^3/yr) (obtained from LandGEM), and
75% = collection efficiency of landfill gas.

$$\mathrm{FR} = 13{,}199{,}538.3\ \frac{\mathrm{m^3}}{\mathrm{yr}} \times \frac{1\ \mathrm{yr}}{365\ \mathrm{days}} \times \frac{1\ \mathrm{day}}{24\ \mathrm{hrs}} \times \frac{1\ \mathrm{hr}}{3{,}600\ \mathrm{s}} \times (1 - 75\%)$$

$$\mathrm{FR} = 0.105\ \frac{\mathrm{m^3}}{\mathrm{s}}$$

The following is a sample calculation for the emission rate of odour from the landfill cap. The odour concentration of the LFG was estimated to be 10,000 OU/m^3 based on the upper range from the MOECC's *Interim Guide to Estimate and Assessing Landfill Air Impacts* (MOE, 1992).

$$\mathrm{ER} = \mathrm{odour\ concentration}\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times \mathrm{flow\ rate}\frac{\mathrm{m^3}}{\mathrm{s}}$$

$$\mathrm{ER} = 10{,}000\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times 0.105\frac{\mathrm{m^3}}{\mathrm{s}}$$

$$\mathrm{ER} = 1{,}050\ \mathrm{OU/s}$$

4.1.10 Biofilters

Air from the PHC impacted soil treatment and the organics processing areas will be collected and treated through biofilters. There is proposed to be one biofilter for the PHC impacted soil treatment area and one biofilter for the organics processing area.

For the PHC impacted soil treatment area, the flow rate of the biofilter was estimated to be 15,000 m^3/hr based on Information provided by Taggart Miller.

For the organics processing facility, the maximum airflow for the biofilter was assumed to be 72,000m^3/hr based on the maximum design airflow provided by Taggart Miller.

Based on testing completed at similar facilities by BIOREM, maximum odour levels leaving the biofilters were estimated to be 500 OU/m^3.

The following is a sample calculation for the emission rate of odour from the PHC impacted soil treatment area:

$$\mathrm{ER} = \text{biofilter exit odour concentration}\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times \text{flow rate}\,\frac{\mathrm{m^3}}{\mathrm{hr}} \times \frac{1\ \mathrm{hr}}{3600\ \mathrm{s}}$$

$$\mathrm{ER} = 500\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times 15{,}000\,\frac{\mathrm{m^3}}{\mathrm{hr}} \times \frac{1\ \mathrm{hr}}{3600\ \mathrm{s}}$$

$$\mathrm{ER} = 2{,}083\ \mathrm{OU/s}$$

4.1.11 Leachate Pre-Treatment

Leachate odour emissions were estimated based on information obtained from BIOREM as well as the proposed flowrate of the scrubber system and odour emissions at other similar leachate pre-treatment operations. These were used as worst-case emissions from the proposed leachate treatment building. The design includes the use of a scrubber.

The following is a sample calculation for the emission rate of odour from the leachate facilities:

$$\mathrm{ER} = \text{odour concentration}\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times\ \text{flow rate}\,\frac{\mathrm{m^3}}{s}$$

$$\mathrm{ER} = 1{,}000\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times 6.94\,\frac{\mathrm{m^3}}{\mathrm{s}}$$

$$\mathrm{ER} = 6940\ \mathrm{OU/s}$$

4.1.12 Leachate Ponds

Emissions from the leachate ponds were estimated based on information obtained from the design team. Additionally a detection threshold (i.e. emission factor) of 100 OU for a final clarifier was obtained from a paper titled ‘Odor Threshold Emission Factors for Common WWTP Processes’ (St. Croix Sensory Inc., 2008). The volume throughput used is based on the maximum design capacity of the pond.

The following is a sample calculation for the emission rate of odour from the leachate holding pond:

$$\mathrm{ER} = \text{odour detection limit}\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times\ \text{volumetric throughput}\,\frac{\mathrm{m^3}}{s}$$

$$\mathrm{ER} = 100\ \frac{\mathrm{OU}}{\mathrm{m^3}} \times 0.0093\,\frac{\mathrm{m^3}}{\mathrm{s}}$$

$$\mathrm{ER} = 0.93\ \mathrm{OU/s}$$

4.1.13 Composting/Curing Pad

Leaf and yard, wood waste, and digested product will be composted or cured on-Site. Emission factors used to calculate the odour emissions associated with the proposed composting/curing pad activities were obtained from a study completed for GORE (Barth & Bitter GmbH, 2006). The annual throughput of compost/curing pad activities is anticipated to be 50,000 tonnes/yr, 60% of which will be digested product, and 40% of which will be yard waste. Approximately 32,300 tonnes of the final product may be produced annually.

The following is a sample calculation for the emission rate of the composting/curing pad pile:

$$\mathrm{ER} = \text{emission factor}\ \frac{\mathrm{OU}}{\mathrm{m}^2 - s} \times \text{area}\ (\mathrm{m}^2)$$

$$\mathrm{ER} = 0.56\ \frac{\mathrm{OU}}{\mathrm{m}^2 - s} \times 447(\mathrm{m}^2)$$

$$\mathrm{ER} = 250\ \mathrm{OU/s}$$

The average emission rate for all composting/curing pad activities was calculated.

4.1.14 Stationary Fuel Combustion

The proposed CRRRC buildings may be heated using fuel oil. Anticipated fuel oil usage rates for stationary fuel combustion were provided by Taggart Miller. U.S. EPA AP-42 emission factors from Chapter 1.3 – Fuel Oil Combustion (US EPA1999) were used to calculate emissions from combustion.

The following is a sample calculation for the MRF building for the emission rate of NOx:

$$\mathrm{ER} = \text{diesel usage} \frac{10^3\ \mathrm{gal}}{\mathrm{yr}} \times \text{emission factor NOx} \frac{\mathrm{lb}}{10^3\ \mathrm{gal}} \times \frac{1\ \mathrm{yr}}{365\ \mathrm{days}} \times \frac{1\ \mathrm{day}}{24\ \mathrm{hrs}} \times \frac{1\ \mathrm{hr}}{3600\ \mathrm{s}}$$

$$\mathrm{ER} = 21 \frac{10^3\ \mathrm{gal}}{\mathrm{yr}} \times 20 \frac{\mathrm{lb}}{10^3\ \mathrm{gal}} \times \frac{1\ \mathrm{yr}}{365\ \mathrm{days}} \times \frac{1\ \mathrm{day}}{24\ \mathrm{hrs}} \times \frac{1\ \mathrm{hr}}{3600\ \mathrm{s}} \times \frac{453.6\ \mathrm{g}}{1\ \mathrm{lb}}$$

$$\mathrm{ER} = 0.006 \frac{\mathrm{tonnes}}{\mathrm{yr}}$$

4.2 Greenhouse Gas – Emission Calculations

4.2.1 Biogas and Landfill Gas Combustion

Emissions for carbon dioxide, methane and nitrous oxide from biogas and LFG combustion have been estimated using the Ontario MOECC Publication entitled *Guideline for Greenhouse Gas Emissions Reporting* (as set out under *O. Reg.* 452/09 under the *EPA*) (February 2012, PIBs 8024e). It is assumed that the LFG will be made up of 56.2% methane and the flow rate of LFG and biogas to the flare will be 3,537 m^3/hr. The combustion of biogas and landfill gas will occur 24 hours a day, 365 days of the year.

The following is a sample calculation for the annual flare consumption of the LFG constituents (in this case, methane):

$$\text{Annual flare methane consumption} = \text{LFG flow rate } \frac{m^3}{hr} \times \text{percent of methane in LFG (\%)} \times \frac{24\text{ hr}}{1\text{ day}} \times \frac{365\text{ days}}{1\text{ year}}$$

$$\text{Annual flare methane consumption} = 3{,}537\ \frac{m^3}{hr} \times 56\% \times \frac{24\text{ hr}}{1\text{ day}} \times \frac{365\text{ days}}{1\text{ year}}$$

$$\text{Annual flare methane consumption} = 17{,}413{,}075\,\frac{m^3}{\text{yr}}$$

The High Heat Value of LFG and biogas is assumed to be 0.0359 GJ/m^3, obtained from Table 20-1 of the "*Guideline for Greenhouse Gas Emissions Reporting".* The following is a sample calculation for the GHG emissions (in this case, methane) from the flare:

$$CH_4\text{emissions} = \text{annual flare methane consumption} \left(\frac{m^3}{yr}\right) \times \text{HighHeat Value} \times \frac{1\text{g}}{\text{GJ}} \times \frac{1\text{tonne}}{1{,}000{,}000\text{ g}}$$

$$CH_4\text{emissions} = 17{,}413{,}075\,\frac{m^3}{yr} \times 0.0359\ \frac{\text{GJ}}{m^3} \times \frac{1\text{g}}{\text{GJ}} \times \frac{1\text{tonne}}{1{,}000{,}000\text{ g}}$$

$$CH_4\text{emissions} = 0.63\,\frac{\text{tonnes}}{\text{yr}}$$

All of the collected LFG will be conveyed to either the flare or the engines, therefore the GHG emissions for the engines were calculated as presented above. Emissions of the remaining LFG constituents considered to be GHGs were calculated in the same manner presented above for the flare.

4.2.2 Landfill Cap

LFG emissions are based on average annual LFG emissions from LandGEM results. Methane molecular weight was assumed as 0.656 kg/m^3 at 25°C and 101.3 kPa; carbon dioxide molecular weight was assumed as 1.808 kg/m^3 at 25°C and 101.3 kPa.

The following is a sample calculation for the methane emissions through the cap:

$$CH_4\text{emissions through cap} \left(\frac{m^3}{yr}\right) =$$
$$\text{methane LFG emissions} \left(\frac{m^3}{yr}\right) \times \big(1 - \text{collection efficiency (\%)}\big) \times \text{molecular weight}\frac{\text{kg}}{\text{m}^3} \times \frac{1\text{ tonnes}}{1000\text{kg}}$$

$$CH_4\text{emissions through cap} = 6{,}600{,}000\ \frac{m^3}{yr} \times (1 - 75\%) \times 0.656\,\frac{\text{kg}}{\text{m}^3} \times \frac{1\text{ tonnes}}{1000\text{kg}}$$

$$CH_4\text{emissions through cap} = 1{,}080\,\frac{\text{tonnes}}{\text{yr}}$$

Emissions of the remaining LFG constituents considered to be GHGs were calculated in the same manner as presented above.

4.2.3 Composting/Curing Pad

The composting/curing pad activities were assessed for GHG emissions using emission factors for nitrous oxide and methane documented in the 2006 International Panel on Climate Change (IPCC) report - Chapter 4 (*Biological Treatment of Solid Waste*), and an emission factor for carbon dioxide from the report titled *Greenhouse Gas Emissions Estimation Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal, Wastewater Treatment, Ethanol Fermentation* (RTI, December 2010).

The following is a sample calculation for the emission rate of methane from the total mass of compost processed, so as to be more conservative:

$$\mathrm{ER} = \text{emission factor } \frac{\mathrm{kg}\ CO_2}{kg\ wet\ waste} \times \text{total mass of compost processed} \frac{\mathrm{kg}}{\mathrm{yr}} \times \frac{1\ \mathrm{tonnes}}{1000\ \mathrm{kg}}$$

$$\mathrm{ER} = 0.004\ \frac{\mathrm{kg}\ CH_4}{kg\ wet\ waste} \times 50{,}000{,}000 \frac{\mathrm{kg}}{\mathrm{yr}} \times \frac{1\ \mathrm{tonnes}}{1000\ \mathrm{kg}}$$

$$\mathrm{ER} = 200\ \mathrm{tonnes/yr}$$

Emissions of the remaining composting/curing pad activities constituents considered to be GHGs were calculated in the same manner presented above.

4.2.4 Stationary Fuel Combustion

The Proposed CRRRC buildings may be heated using fuel oil. Maximum fuel oil usage rates for stationary fuel combustion were provided by Taggart Miller. Emissions for carbon dioxide, methane and nitrous oxide from the stationary combustion have been estimated using the Ontario MOECC Publication entitled *Guideline for Greenhouse Gas Emissions Reporting* (as set out under O. Reg. 452/09 under the *EPA*) (February 2012, PIBs 8024e). Equation 20-1 of ON.20 General Stationary Combustion was used.

The following is a sample calculation for the emission rate of CH_4 from proposed stationary combustion:

$$\mathrm{ER} = \text{diesel usage} \frac{\mathrm{L}}{\mathrm{yr}} \times \text{emission factor } CH_4 \frac{\mathrm{g}}{L} \times \frac{1\ \mathrm{tonne}}{1{,}000{,}000\ \mathrm{g}}$$

$$\mathrm{ER} = 611{,}049\ \frac{\mathrm{L}}{\mathrm{yr}} \times 0.133\ \frac{\mathrm{g}}{L} \times \frac{1\ \mathrm{tonne}}{1{,}000{,}000\ \mathrm{g}}$$

$$\mathrm{ER} = 0.08 \frac{\mathrm{tonnes}}{\mathrm{yr}}$$

4.2.5 Mobile Equipment

Exhaust emissions from mobile equipment were calculated using emission factors from Canada's National Inventory (1990-2009) (Environment Canada, 2013). It was assumed that all mobile equipment is fueled by diesel.

The annual fuel consumption for each type of vehicle was calculated based on the vehicle horsepower. The following is a sample calculation for the fuel consumption of a backhoe:

$$F\text{uel Consumption} = \text{BSFC}\,\frac{\text{lb}}{\text{hp}-\text{hr}} \times \text{hp} \times \frac{\text{LF}}{\text{fuel density}} \times \frac{\text{hrs}}{\text{yr}} \times \#\text{ of equipment}$$

$$\text{Fuel Consumption} = 0.367\,\frac{\text{lb}}{\text{hp}-\text{hr}} \times 117\text{ hp} \times \frac{0.21}{0.845\text{kg/L}} \times 0.45359\,\frac{\text{kg}}{\text{lb}} \times 500\,\frac{\text{hr}}{\text{yr}} \times 1\text{ backhoe}$$

$$\text{Fuel Consumption} = 2{,}420\text{ L/yr}$$

Where:
BSFC = Brake specific fuel consumption conversion (lb/hp-hr), and
LF = loading factor

Crank case load factors for non-road Engine Modelling (Compression Ignition) – U.S. EPA 009d (July, 2010) were used to calculate the greenhouse gas exhaust emissions. The following was completed to calculate the annual emissions of carbon dioxide from the same backhoe:

$$\text{ER} = \text{EF}\,\frac{\text{g}}{\text{L}} \times \text{Vehicle Fuel Consumption}\,\frac{\text{L}}{\text{yr}} \times \frac{1\text{ tonne}}{1{,}000{,}000\text{ g}}$$

Where:
ER = emission rate (tonnes/yr), and
EF = emission factor (g/L)

$$\text{ER} = 2{,}663\,\frac{\text{g}}{\text{L}} \times 2{,}420\,\frac{\text{L}}{\text{yr}} \times \frac{1\text{ tonne}}{1{,}000{,}000\text{ g}}$$

$$\text{ER} = 6.44\,\frac{\text{tonnes}}{\text{year}}$$

4.2.6 Exhaust Emissions (Fleet and Leachate Trucks)

The emission rate of carbon dioxide from the exhaust of the on-Site fleet vehicles was calculated as described in Section 4.1.2 of this report. The emission rate of carbon dioxide from the exhaust of the on-Site leachate trucks was also calculated following the methodology described in Section 4.1.2 and using Tier 1 emission factors from MOBILE 6. The following calculation was completed to obtain the annual emissions of carbon dioxide from the exhaust of fleet trucks on the paved roads:

$$\text{Annual ER} = \text{Emissions rate (fleet \& leachate trucks)}\frac{\text{g}}{\text{s}} \times \frac{3600\text{ s}}{\text{hr}} \times \frac{12\text{ hr}}{\text{day}} \times \frac{365\text{ days}}{\text{year}} \times \frac{1\text{ tonnes}}{1{,}000{,}000\text{ g}}$$

$$\text{Annual ER} = 14.37\frac{\text{g}}{\text{s}} \times \frac{3600\text{ s}}{\text{hr}} \times \frac{12\text{ hr}}{\text{day}} \times \frac{365\text{ days}}{\text{year}} \times \frac{1\text{ tonnes}}{1{,}000{,}000\text{ g}}$$

$$\text{Annual ER} = 227\text{ tonnes/yr}$$

Where:
Annual ER = emission rate (tonnes/yr)

5.0 EMISSION RATES

This section outlines the emission rates to be used in the Air Quality & Odour Assessment, in g/s, which were calculated for each activity as described in Section 4.0.

5.1 Air Quality & Odour Assessment

Table A 5-1 summarizes the emission rates for each activity at the CRRRC.

Table A 5-2 illustrates the percentage that each source contributes to the overall emissions from the CRRRC for the Air Quality & Odour Assessment.

Table A 5-1: Summary of Emission Rates during Operation of the CRRRC

Facility	Activity	Contaminant (g/s)								
		SPM	PM_{10}	$PM_{2.5}$	NO_x/ NO_2 (1)	SO_2	CO	H_2S	C_2H_3Cl	Odour (OU/s)
Flare and/or Electrical Generation Plant	Enclosed LFG and biogas flare and/or engines	0.1309	0.1309	0.1309	0.4404	0.1018	4.6546	0.0031	0.0002	—
Construction and Demolition Processing Facility	Dust collector	0.0708	0.0708	0.0708	—	—	—	—	—	—
Materials Recovery Facility	Dust collector	0.0708	0.0708	0.0708	—	—	—	—	—	—
Organics Processing Facility	Biofilter	—	—	—	—	—	—	—	—	10,000
	Organics processing operations (material handling)	0.0043	0.0021	0.0003	—	—	—	—	—	—
	Organics processing operations (tailpipe emissions)	0.0278	0.0278	0.0278	0.4472	0.00001	0.4777	—	—	—
Composting	Composting, curing, and post processing (material handling)	0.0046	0.0022	0.0003	—	—	—	—	—	309
	Composting, curing, and post processing (tailpipe emissions)	0.0559	0.0584	0.0584	1.1572	0.00002	0.9882	—	—	—
PHC Contaminated Soil Treatment	Biofilter	—	—	—	—	—	—	—	—	2,083
	PHC contaminated soil treatment operations (material handling)	0.0104	0.0049	0.0007	—	—	—	—	—	—
	PHC contaminated soil treatment operations (tailpipe emissions)	0.0025	0.0025	0.0025	0.0433	0.000001	0.0429	—	—	—
Landfill	Landfill cap	—	—	—	—	—	—	0.0047	0.0004	1,046
	Landfill operations (material handling)	0.0161	0.0076	0.0012	—	—	—	—	—	1,347
	Landfill operations (tailpipe emissions)	0.0618	0.0618	0.0618	1.0799	0.00002	1.0717	—	—	—
Leachate Pre-treatment Facility	Leachate pre-treatment	—	—	—	—	—	—	—	—	6,944
	Leachate equalization pond	—	—	—	—	—	—	—	—	0.9250
	Leachate effluent ponds	—	—	—	—	—	—	—	—	0.9250

Facility	Activity	Contaminant (g/s)								
		SPM	PM_{10}	$PM_{2.5}$	NO_x/ NO_2 [(1)]	SO_2	CO	H_2S	C_2H_3Cl	Odour (OU/s)
Paved Roads	Fugitive road dust	0.6332	0.1215	0.0294	—	—	—	—	—	—
	Vehicle exhaust	0.0013	0.0013	0.0011	0.0315	0.0001	0.0073	—	—	—
Unpaved Roads	Fugitive road dust	0.2880	0.0778	0.0078	—	—	—	—	—	—
	Vehicle exhaust	0.0001	0.0001	0.0001	0.0025	0.0000	0.0006	—	—	—
Emergency Generator[(2)]	Diesel emergency power generator	0.0004	0.0004	0.0004	0.1446	0.0708	0.0152	—	—	—
Support Activities	Operational support activities, such as maintenance activities (including welding, compressor, diesel fire pump, lights)	These activities are considered to be negligible in comparison to the other activities occurring on site.								
	Stationary Fuel Combustion	—[(3)]	—[(3)]	—[(3)]	0.0387	—[(3)]	—[(3)]	—	—	—

Notes:

[(1)] NOx emissions were assumed to be all NO_2

[(2)] The emergency power generator was evaluated separately as it used to provide electricity during a power outage when other equipment is not in operation.

[(3)] Compound from this activity is considered to be negligible in comparison to the other activities occurring on Site.

— Compound not emitted from that source

SPM = Suspended particulate matter
PM_{10} = Particles nominally smaller than 10 µm in diameter
$PM_{2.5}$ = Particles nominally smaller than 2.5 µm in diameter
SO_2 = Sulphur dioxide
CO = Carbon monoxide
H_2S = Hydrogen sulphide
C_2H_3Cl = Vinyl chloride

Table A 5-2: Summary of Percentage Contributions of Emissions during Operation of the CRRRC

Facility	Activity	Contaminant								
		SPM	PM_{10}	$PM_{2.5}$	NO_x/ NO_2 [(1)]	SO_2	CO	H_2S	C_2H_3Cl	Odour
Flare	Enclosed LFG flare	9.49%	20.43%	28.22%	13.59%	99.86%	64.26%	39.57%	39.57%	—
Electrical Generation Plant[1]	LFG and biogas to energy engines									
Construction and Demolition Processing Facility	Dust collector	5.13%	11.05%	15.26%	—	—	—	—	—	—
Materials Recovery Facility	Dust collector	5.13%	11.05%	15.26%	—	—	—	—	—	—
Organics Processing Facility	Biofilter	—	—	—	—	—	—	—	—	46.02%
	Organics processing operations (material handling)	0.31%	0.32%	0.07%	—	—	—	—	—	—
	Organics processing operations (tailpipe emissions)	2.01%	4.33%	5.98%	13.80%	0.009%	6.60%	—	—	—
Composting	Composting, curing, and post processing (material handling)	0.33%	0.34%	0.07%	—	—	—	—	—	1.42%
	Composting, curing, and post processing (tailpipe emissions)	4.06%	9.12%	12.59%	35.71%	0.02%	13.64%	—	—	—
PHC Impacted Soil Treatment	Biofilter	—	—	—	—	—	—	—	—	9.59%
	PHC impacted soil treatment operations (material handling)	0.75%	0.76%	0.16%	—	—	—	—	—	—
	PHC impacted soil treatment operations (tailpipe emissions)	0.18%	0.39%	0.53%	1.33%	0.0008%	0.59%	—	—	—
Landfill	Landfill cap	—	—	—	—	—	—	60.43%	60.43%	4.82%
	Landfill operations (material handling)	1.17%	1.19%	0.25%	—	—	—	—	—	6.20%
	Landfill operations (tailpipe emissions)	4.49%	9.65%	13.33%	33.32%	0.02%	14.80%	—	—	—
Leachate Pre-treatment Facility	Leachate Pre-treatment Facility	—	—	—	—	—	—	—	—	31.96%
	Leachate holding ponds	—	—	—	—	—	—	—	—	0.004%

Facility	Activity	Contaminant								
		SPM	PM_{10}	$PM_{2.5}$	NO_x/ NO_2 (1)	SO_2	CO	H_2S	C_2H_3Cl	Odour
	Leachate equalization ponds	—	—	—	—	—	—	—	—	0.004%
Paved Roads	Fugitive road dust	45.92%	18.97%	6.34%	—	—	—	—	—	—
	Vehicle exhaust	0.10%	0.21%	0.24%	0.97%	0.09%	0.10%	—	—	—
Unpaved Roads	Fugitive road dust	20.89%	12.14%	1.68%	—	—	—	—	—	—
	Vehicle exhaust	0.01%	0.02%	0.02%	0.08%	0.007%	0.01%	—	—	—
Emergency Generator(2)	Diesel emergency power generator	—	—	—	—	—	—	—	—	—
Support Activities	Operational support activities, such as maintenance activities (including welding, compressor, diesel fire pump, lights)	These activities are considered to be negligible in comparison to the other activities occurring on site.								
	Stationary Fuel Combustion	— (3)	— (3)	1.19%	— (3)	— (3)	— (3)	—	—	—

Notes:

(1) Emission rates for NO2 were not calculated, a conservative conversion value of 100% of NOx was applied.
(2) The emergency power generator was evaluated separately as it used to provide electricity during a power outage when other equipment is not in operation.
(3) Compound from this activity is considered to be negligible in comparison to the other activities occurring on Site.
— Compound not emitted from that source
SPM = Suspended particulate matter
PM10 = Particles nominally smaller than 10 µm in diameter
PM2.5 = Particles nominally smaller than 2.5 µm in diameter
SO_2 = Sulphur dioxide
CO = Carbon monoxide
H_2S = Hydrogen sulphide
C_2H_3Cl = Vinyl chloride

5.2 Greenhouse Gas Assessment

Table A 5-3 summarizes the emission rates in tonnes per year for each activity at the proposed facility.

Table A 5-4 illustrates the percentage each source contributes to the overall emissions from the proposed facility for the GHG Assessment.

Table A 5-3: Summary of GHG Emission Rates during Operation of the CRRRC

Facility	Contaminant (tonnes)		
	CO_2	CH_4	N_2O
Flare and/or Electrical Generation Plant	34,002	0.62	0.06
Construction and Demolition Facility	*GHG already accounted for in the stationary fuel combustion*		
Material Recovery Facility	*GHG already accounted for in the stationary fuel combustion*		
Organics Processing Facility	*GHG already accounted for in the stationary fuel combustion*		
Composting/Curing Pad Activities	18,480	200	15.0
PHC Soil Treatment	*GHG already accounted for in the stationary fuel combustion*		
Leachate Pre-treatment Facility	*GHG already accounted for in the stationary fuel combustion*		
Landfill	2,983	1,082	—
Stationary Fuel Combustion(1)	1,627	0.08	0.24
Mobile Equipment	12,414	0.70	5.13
Tailpipe (Hauling Trucks)	227	—	—

Notes:
(1) Stationary fuel combustion includes heating of the CRRRC buildings.
(2) Tailpipe emissions include the leachate trucks.
CO_2 = Carbon dioxide
CH_4 = Methane
N_2O = Nitrous oxide

Table A 5-4: Summary of Percentage Contributions of GHG Emissions during Operation of the CRRRC

Facility	Contaminant		
	CO_2	CH_4	N_2O
Flare	48.81%	0.05%	0.30%
Electrical Generation Plant(1)			
Construction and Demolition Facility	*GHG already accounted for in the stationary fuel combustion*		
Material Recovery Facility	*GHG already accounted for in the stationary fuel combustion*		
Organics Processing Facility	*GHG already accounted for in the stationary fuel combustion*		
Composting/Curing Pad Activities	26.53%	15.58%	73.40%
PHC Soil Treatment	*GHG already accounted for in the stationary fuel combustion*		
Leachate Pre-Treatment Facility	*GHG already accounted for in the stationary fuel combustion*		
Landfill	4.28%	84.31%	—
Stationary Fuel Combustion(2)	2.34%	<0.01%	1.20%
Mobile Equipment	17.82%	<0.01%	25.09%
Tailpipe (Hauling Trucks) (3)	0.32%	—	—

Notes:

(1) Only one of either the engines or flare is running at any given time, so the total emission rates do not include the flare emission rates.
(2) Stationary fuel combustion includes heating of the CRRRC buildings.
(3) Tailpipe emissions include the leachate trucks.
CO_2 = Carbon dioxide
CH_4 = Methane
N_2O = Nitrous oxide

5.3 Ontario Compliance Assessment

Ontario Regulation 419/05: Air Pollution – Local Air Quality (as set out under O. Reg. 419/05 under the *EPA*) considers the emissions from selected stationary sources only. Although as per O. Reg. 524/98-S.13 the emissions from on-Site vehicles and fugitive emissions from on-Site roadways and storage piles are exempt from Ontario Reg. 419 compliance assessment, they have conservatively been included in the O.Reg. 419/05 compliance assessment for the CRRRC.

For the compliance assessment, odour based compounds (whole odour and H_2S) were assessed via modelling with AERMOD against the MOECC guideline limits, with an allowed frequency of occurrence in excess of the 10-minute standard of no more than 0.5 % at any of the nearby residences (referred to as discrete receptors), as per the MOECC Technical Bulletin titled Methodology for Modelling Assessments of Contaminants with 10-minute Average Standards and Guidelines (MOE, 2008).

5.4 Averaging Periods

A proposed operation schedule was developed by the design team and Taggart Miller. This schedule (presented in Table A 5-5) was used when estimating emissions.

Table A 5-5: Preliminary Operation Schedule

Facility	Activity	Daily Operating Hours (hours/day)	Annual Operating Period (days/year)
MRF and C&D Processing Facilities	Dust collectors	12	312
Organics Processing Facility	Compost processing operations biofilter	24	365
	Material handling at organics processing facility	12	312
PHC impacted soil treatment facility	PHC impacted soil treatment facility biofilter	24	365
	Material handling at PHC impacted soil treatment facility	12	312
Composting	Composting/Curing pad operations	12	312
	Material handling at composting/curing pad	12	312
Flare and Energy Processing Facility	LFG and biogas combustion	24	365
Leachate Pre-Treatment	Ventilation from leachate pre-treatment operations	24	365
	Leachate holding ponds	24	365
Landfill	Landfill gas fugitive losses through the cover soils	24	365
	Material handling at the landfill	12	312
	Fugitive dust from paved and unpaved roads	Variable – based on individual activities/area	Variable - based on individual activities/area
	Exhaust from on-Site vehicles	Variable – based on individual activities/area	Variable - based on individual activities/area

6.0 CONSERVATISM IN EMISSION RATE CALCULATIONS

Table 6-1 outlines the areas where conservatism was assumed in the emission rate calculations, which results in an assessment that is not likely to under-predict the emissions associated with the Project.

Table 6-1: Areas of Conservatism in the Emission Rate Calculations

Project Activity	Conservatism
All CRRRC facilities/activities	Superimposing the emissions from all the CRRRC components, which results in the maximum possible emissions from the proposed CRRRC
Fugitive Dust from Unpaved Roads	See discussion below in Section 6.1

6.1 Fugitive Dust from Paved and Unpaved Roads

Roadway segments in the proposed CRRRC were assessed based on the type of roadway and anticipated traffic. Emission estimation equations from Chapters 13.2.1 and 13.2.2 of the AP-42 Emission Factor (U.S. EPA, 2011 & U.S. EPA, 2006, respectively) were used for fugitive road dust from paved and unpaved roads, respectively. These emission estimates are conservative and will overestimate emissions from facility roadways for the following reasons:

- The U.S. EPA AP-42 equations were developed from measured emissions from public roadways and as a result will tend to over-estimate low speed vehicle traffic from construction Sites.
- All roadways at the proposed CRRRC were modelled assuming simultaneous and continuous use; however, it is unlikely that this situation will occur in reality.
- As the best management practices are revised through continuous improvements, the emissions from the on-Site roadways are likely to decrease.

The AERMOD dispersion model was used to predict the changes to air quality. The parameters that were required for modelling include the locations of the roadway segments, base elevations, effective heights of the emissions, and the initial plume size in the lateral and vertical directions.

It is recognized that this modelling approach will result in higher predicted concentrations close to the roadways than actual values for the following reasons:

- There has been extensive research on the estimation of the “transportable fraction” of fugitive dust from roadways. Studies completed by the Desert Research Institute in Nevada and in the San Joaquin Valley, CA (Watson et al. 1996) showed a large (i.e., greater than 90%) decrease in dust concentration within 100 m of an unpaved road (Watson et al. 1996; Watson et al. 2000). A value of 75% reduction has been suggested beyond 50 m for unpaved roadway emissions. This value would increase at greater distances. This adjustment was not be made to the dispersion modelling concentration results.
- When the roads are wet or snow-covered, the emissions will be reduced or eliminated. AERMOD has the capacity to have a variable emission rate that could account for actual meteorological emissions; variable emission rates were used in this assessment to more accurately represent winter conditions.

Despite the limitations of the emission rate estimates and dispersion modelling, these are the best estimates available. The above noted biases in the emission estimates are cumulative.

In addition, the best management practices will further reduce emissions; specifically, watering will be used on facility roads on dry days to decrease emissions from roads.

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ATTACHMENT 1

Activity	Assumption			
	Parameter	Value	Unit	Notes
Flare (S1)	Flow rate to flare	0.98	am³/s	Based on 1000 cfm of biogas (received from Taggart Miller) and 1,770 cfm of landfill gas (obtained from LandGEM model). Converted to m3/s and assumed actual.
Engines (S2)	Flow rate to engines	0.98	am³/s	Flow rate for each of the 7 engines. Based on the engine specs. Assumed actual.
C&D and MRF (S3 and S4)	Flow rate of dust collectors	15,000	acfm	Provided by Taggart Miller. Stack assumed to be in the centre of the building. Assumed actual.
	Outlet loading	10	mg/m³	Manufacturer guarantee and MOECC recommendation for small dust collectors.
Organics and HC Soil Biofilters (S5 and S8)	Odour concentration	500	OU/m³	Estimated by BIOREM as a maximum concentration output for a similar facility.
	Stack volumetric flow rate for organics processing facility	72,000	Am³/hr	Estimated. Assumed to be actual.
	Stack volumetric flow rate for HC soil facility	15,000	Am³/hr	Estimated. Assumed to be actual.
Leachate building stack (S11)	Odour concentration	1,000	OU/m3	Estimated and assumes the exhaust is equipped with a scrubber.
	Stack volumetric flow rate	25,000	Am3/hr	Estimated. Assumed to be actual.
Organics Processing (S6)	Number of drop points for organics process	4	drop pts	Based on information provided by Taggart Miller (equipment list and maximum number of drop points).
	Number of drop points for transfer of organic waste for off-site treatment	2	drop pts	Based on information provided by Taggart Miller (equipment list and maximum number of drop points).
	Food waste handling rate	50,000	tonnes/yr	Provided by Taggart Miller.
	Non-food organic waste handling rate	16,000	tonnes/yr	Provided by Taggart Miller.
	Bulking agent handling rate	7,000	tonnes/yr	Provided by Taggart Miller.
PHC Impacted Soil Material Handling (S9)	Number of drop points	2	drop pts	Assumed that there are 2 loaders in the HC soil area that can be moving material simultaneously, at the same time that each biopile can be turned.
	Handling rate	106	tonnes/hr	Based on information provided by Taggart Miller.

Activity	Assumption			
	Parameter	**Value**	**Unit**	**Notes**
Compost Material Handling (S7)	Number of drop points	7	drop pts	Based on information provided by Taggart Miller. Based on 7 pieces of equipment.
	Leaf and yard waste material handling	20000	tonnes/yr	Provided by Taggart Miller.
	Digestate compost material handling	30000	tonnes/yr	Provided by Taggart Miller.
Landfill Operations (S10)	Landfill area	839,408	m^2	From the site plans designed by Golder.
	LFG Emissions	13,199,538	m^3/yr	Annual average of LFG emissions calculated using the LandGEM model.
	Collection efficiency	75%	%	Typical range of operation. Based on recommendation from MOECC.
	Odour concentration	10,000	OU/m^3	Based on the 'upper range' estimate of odour concentration from the MOECC's Interim Guide to Estimate and Assess Landfill Air Impacts.
Composting (S7)	Annual throughput	50,000	tonnes/yr	Provided by Taggart Miller.
	Proportion that is organic waste	60%	%	Provided by Taggart Miller.
	Proportion that is yard waste	40%	%	Provided by Taggart Miller.
	Amount of finished product	32,300	tonnes/yr	Calculated based on information provided by Taggart Miller (annual throughput of compost produced, and breakdown percentages).
	Pile height	4	m	Estimated pile size.
	Pile base size	8	m	Estimated pile size.
Paved Roads (S12)	Silt loading	7.4	g/m^2	US EPA AP-42 Section 13.2.1-3, mean silt loading for MSW landfills.
	Control Efficiency	85%	%	Estimated based best management practices expected control efficiency.
Unpaved Roads (S13)	Silt content	6.40	%	US EPA AP-42 Section 13.2.2 for MSW landfills.
	Dust Suppressant Control Efficiency	85%	%	Estimated based on use of dust suppressants.
Emergency Power Generator (S14)	Power output	274	hp	From equipment specifications.
	Emission factor	1.9	g/hp-hr	From equipment specifications.
Stationary Fuel Combustion (S14-S20)	Fuel oil usage	134,412	gal/yr	Provided by Taggart Miller.

Notes: — denotes not applicable

APPENDIX B

Dispersion Modelling

December 2014

Technical Support Document #3

APPENDIX B – DISPERSION MODELLING

TAGGART
GROUP OF COMPANIES

THE MILLER GROUP

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1.0 INTRODUCTION

This Appendix is part of the Air Quality and Odour Assessment Technical Supporting Document (TSD) #3 for the proposed Capital Region Resource Recovery Centre (CRRRC) at the Boundary Road Site to be located in the Ottawa, Ontario.

1.1 Purpose

This Appendix documents the methods, inputs and assumptions that were used to complete the dispersion modelling to predict ground-level concentrations of indicator contaminants resulting from the proposed CRRRC. The modelling approach described within this Appendix follows generally accepted practices for conducting EAs and, where appropriate, follows guidance in the Ontario Ministry of the Environment and Climate Change (MOECC) document "*Guideline A-11: Air Dispersion Modelling Guideline for Ontario, Version 2.0"*, dated March 2009 (ADMGO) PIBS 5165e02.

2.0 AIR DISPERSION MODEL

The likely environmental effects for the air quality indicators were evaluated with the aid of the AERMOD dispersion model (Version 13350). The selection of this model was based on the following capabilities:

- Evaluates the various source configurations and compounds associated with the CRRRC;
- Has a technical basis that is scientifically sound, and is in keeping with the current understanding of dispersion in the atmosphere;
- Applies formulations that are clearly delineated and are subjected to rigorous independent scrutiny;
- Makes predictions that are consistent with observations; and
- Is recognized by provincial regulators as one suitable for use (MOE, 2009).

AERMOD was developed by the United States Environmental Protection Agency (U.S. EPA), and consists of the model and two pre-processors; the AERMET meteorological pre-processor and the AERMAP terrain pre-processor (Figure B1). The following approved dispersion model and pre-processors were used in the assessment:

- AERMOD dispersion model (v. 13350);
- AERMAP surface pre-processor (v. 11103); and
- Building Profile Input Program (BPIP) building downwash pre-processor (v.42104).

AERMET was not used in this assessment, as a pre-processed MOECC meteorological 5-year dataset was used.

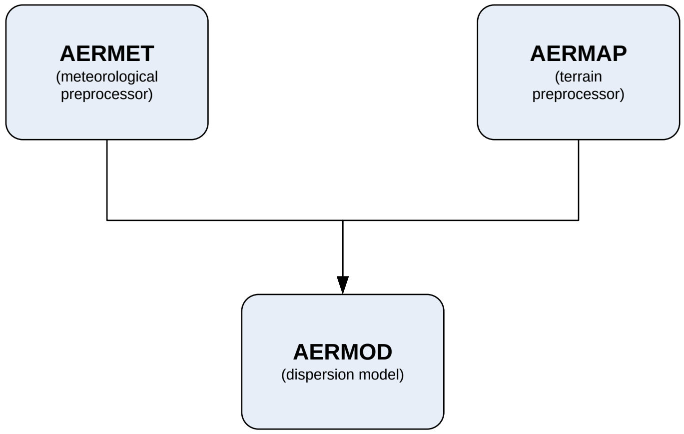


Figure B1: AERMOD Model System

To predict ambient air concentrations with the aid of AERMOD, a series of inputs are required that parameterize the sources of emissions as well as their transport. These inputs can be grouped into categories:

- Dispersion meteorological data;
- Terrain and receptors; and
- Emissions and source configurations.

Each of these input categories are discussed separately in the following sections.

3.0 DISPERSION METEOROLOGY

The selection of appropriate meteorological data for use in dispersion modelling is an important step in any modelling study. The selection of meteorological data needs to consider the requirements of the models selected, the availability of meteorological data and the relevance of the available data to the project in question. The meteorological input files used by the AERMOD dispersion model are generated using the AERMET pre-processor, which is designed to be run in three stages:

1) Extracts the data and assesses data quality;
2) Merges the available data for 24-hour periods and writes these data to an intermediate file; and
3) Reads the merged data file and develops the necessary boundary layer parameters for dispersion calculations by AERMOD.

The AERMET pre-processor produces two meteorological data files. The first file contains boundary layer scaling parameters (e.g., surface friction velocity, mixing height, and Monin-Obukhov length) as well as wind speeds, wind directions and temperature at a reference-height (i.e., 10m). The second file contains one or more levels (a profile) of winds, temperature, and the standard deviation of the fluctuating components of the wind. These files are used as inputs to AERMOD.

3.1 Meteorological Data Sources

The MOECC, as well as other agencies, recommends that five years of hourly data be used in the model (MOE, 2009) to cover a wide range of potential meteorological conditions. To facilitate modelling assessments, the MOECC has developed a series of pre-processed meteorological datasets for regions throughout Ontario. The dataset for Eastern Ontario, which is comprised of hourly surface meteorological data from Ottawa Airport (Station ID 610600) and upper air data from Maniwaki (Station ID 7034480) for the period 1996-2000 were used in the assessment.

The wind rose for the MOECC meteorological dataset showing the direction as "blowing from" is provided below (Figure B2).

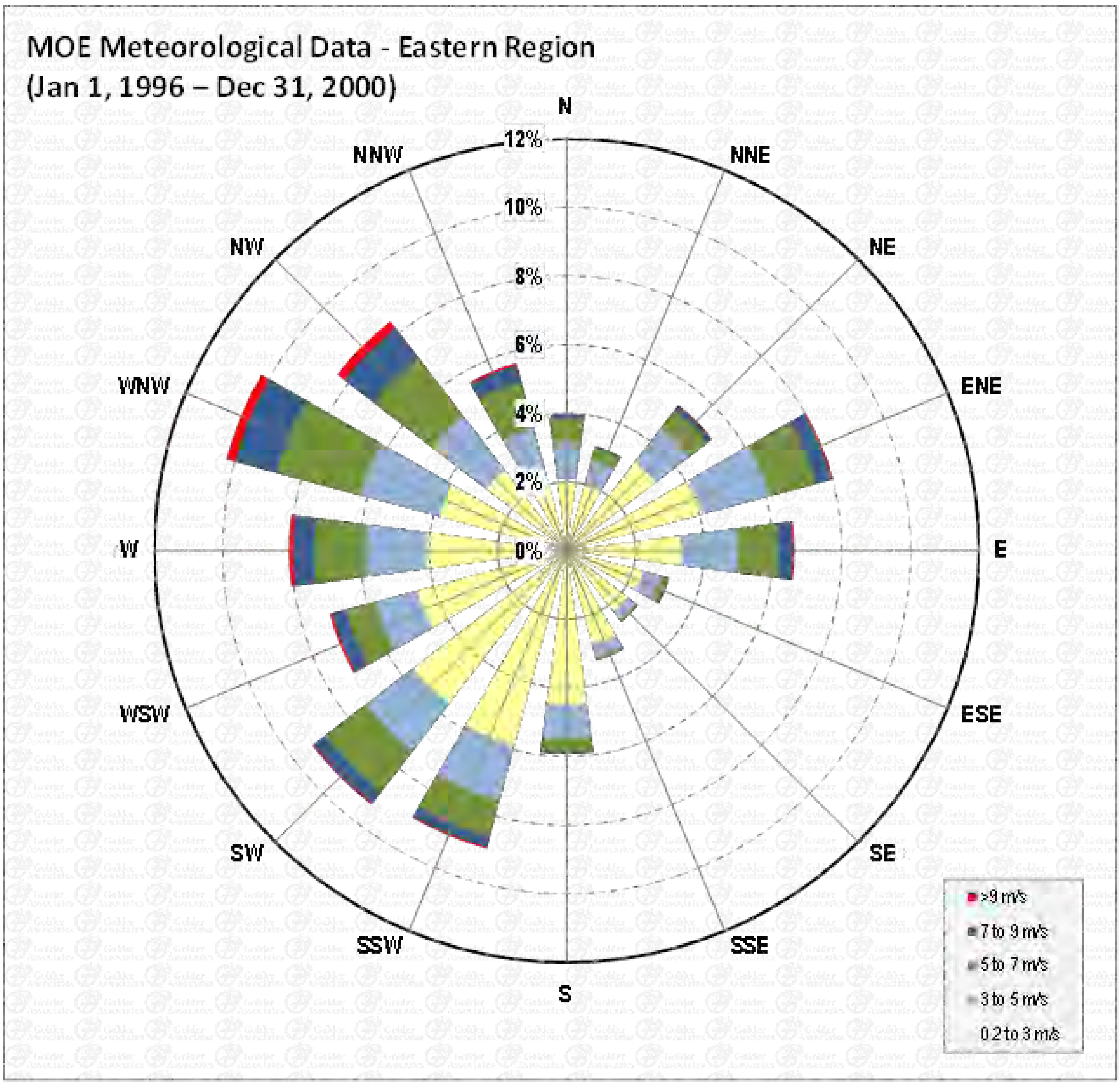


Figure B2: Eastern Region Wind Rose

3.2 Land Use Data

The MOECC provides regional meteorological datasets, generated in AERMET, using different wind independent surface conditions, called "URBAN", "FOREST" and "CROPS". The "CROPS" dataset was selected based on the average surface conditions surrounding the Project in all directions. The surface conditions used to generate meteorological datasets are the Albedo, the Bowen ratio and the surface roughness length. The relevant parameters for the CROPS dataset are provided below (Table B 3-1).

Table B 3-1: Land Use Characteristics by Season

Season	Albedo	Bowen Ratio	Roughness Length (m)
Winter	0.6	1.5	0.095
Spring	0.16	0.35	0.15
Summer	0.19	0.65	0.265
Fall	0.19	0.85	0.13

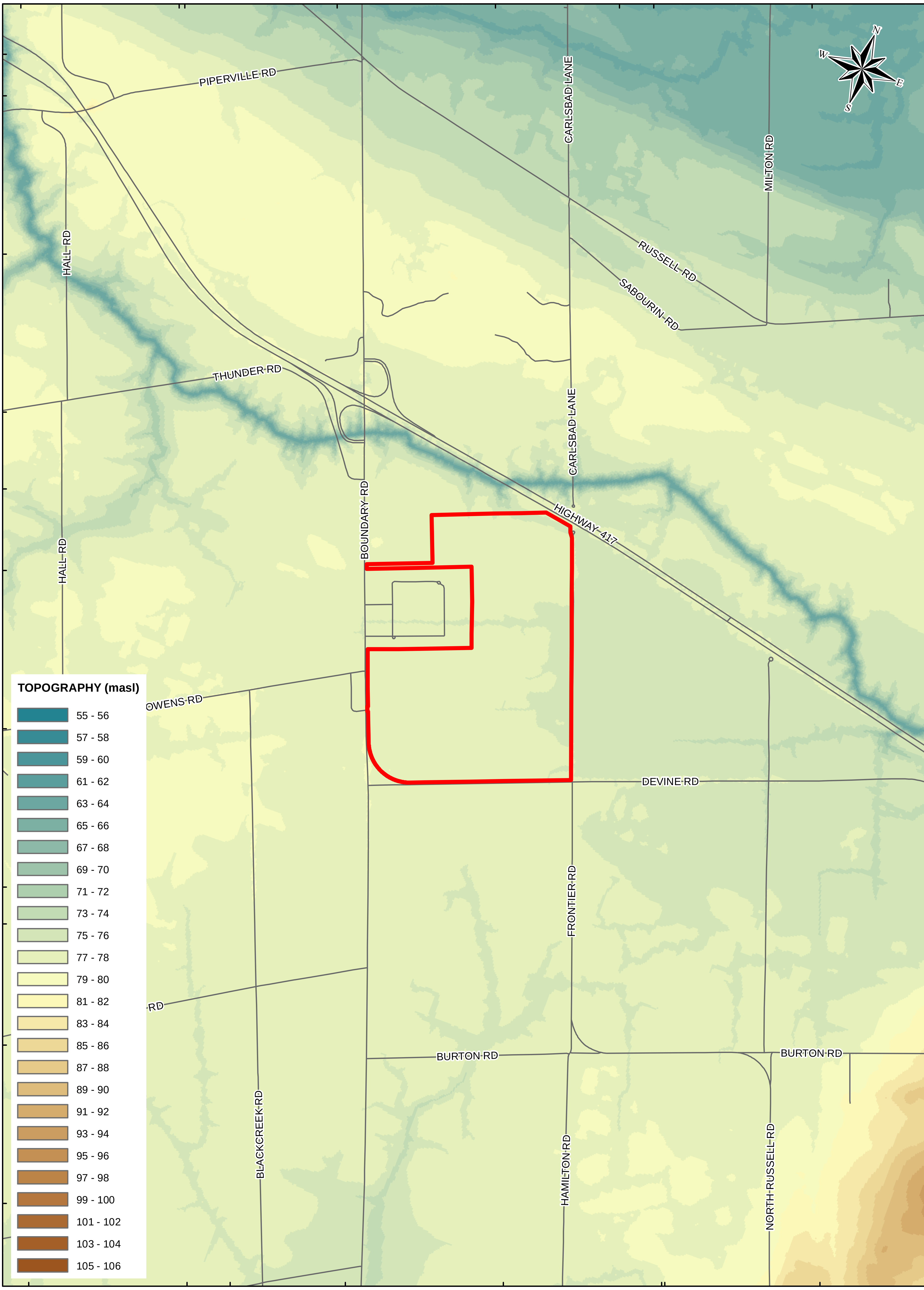
4.0 TERRAIN AND RECEPTORS

Terrain elevations have the potential to influence air quality and odour concentrations at individual receptors, therefore surrounding terrain data is required when using regulatory dispersion models in both simple and complex terrain situations (U.S. EPA, 2004). Digital terrain data is used in the AERMAP pre-processor to determine the base elevations of receptors, sources and buildings. AERMAP then searches the terrain height and location that has the greatest influence on dispersion for each receptor (U.S. EPA, 2004). This is referred to as the hill height scale. The base elevation and hill height scale produced by AERMAP are directly inserted into the AERMOD input file.

4.1 Digital Terrain Data

Digital terrain data was obtained from the MOECC (7.5 minute format) (MOE, 2011) and is presented in Figure B4. DEM files used in the modelling for the CRRRC are as follows:

- 1424_1.DEM
- 1424_2.DEM
- 1425_1.DEM
- 1425_2.DEM
- 1426_1.DEM
- 1426_2.DEM



LEGEND

PROPERTY BOUNDARY

500 250 0 500 1,000

SCALE 1:25,000 METRES

NOTE

THIS FIGURE IS TO BE READ IN CONJUCTION WITH THE ACCOMPANYING REPORT.

REFERENCE

LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2012.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18

PROJECT

ENVIRONMENTAL ASSESSMENT OF THE CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE

DIGITAL TERRAIN DATA

Golder Associates
Ottawa, Ontario

PROJECT No. 12-1125-0045			SCALE AS SHOWN	REV. 0.0
DESIGN	AVW	DEC. 2013	FIGURE B3	
GIS	BR	DEC. 2013		
CHECK	PLE	AUG. 2014		
REVIEW	PAS	AUG. 2014		

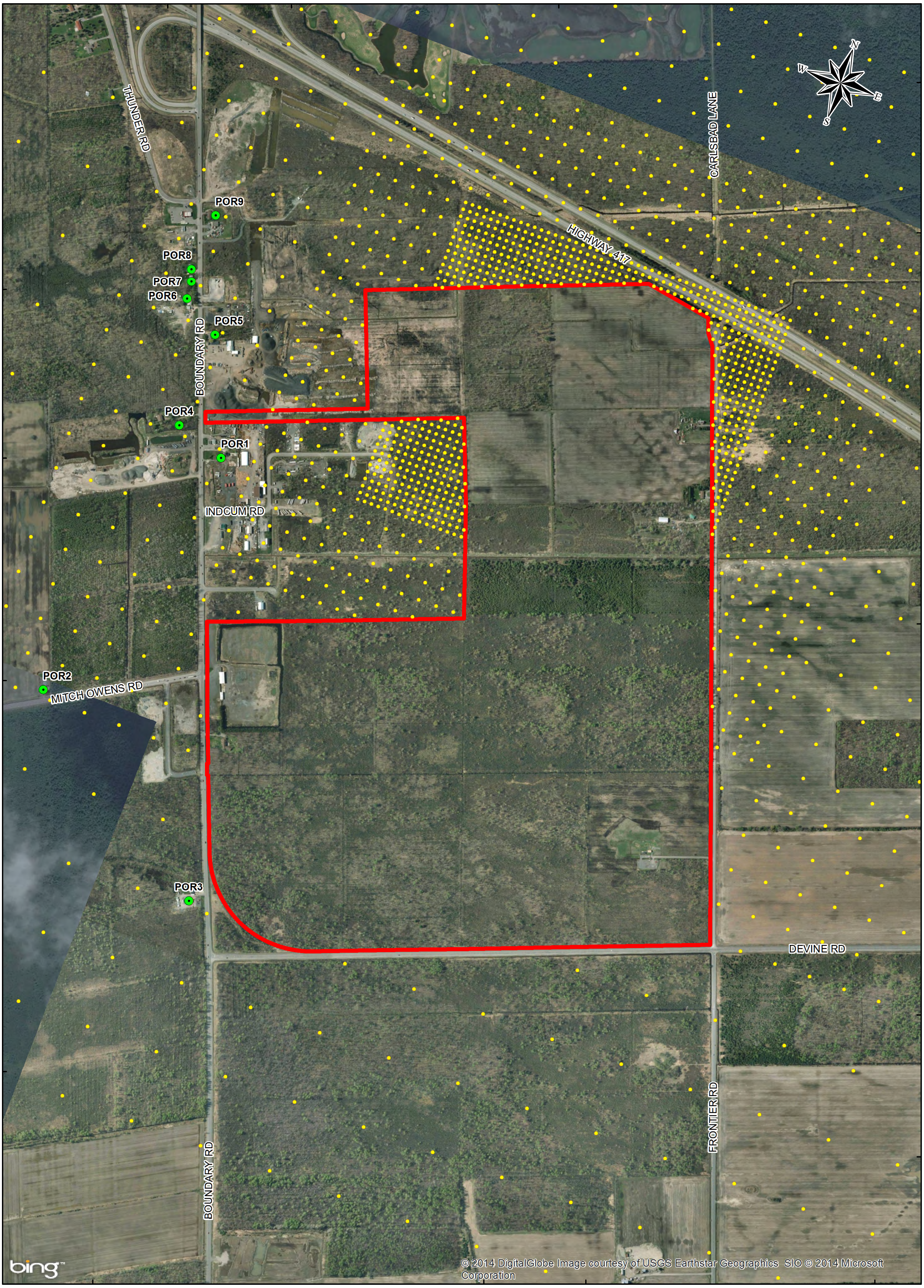
Path: N:\Active\Spatial_IM\Miller_Paving_Ltd\CRRRC\GIS\MXDs\12-1125-0045\Working\Phase2000\Task110-Atmosphere\Air Quality & Odour Assessment\1211250045-2000-0110-B03_DigitalTerrainData.mxd

4.2 Model Receptors

A nested grid of receptors, based on the Guideline, was developed for the assessment. Receptors were generally centered on the sources and were placed as follows:

- 20 m spacing within 200 m of all sources of emissions;
- 50 m spacing within 300 m of all sources of emissions;
- 100 m spacing within 800 m of all sources of emissions;
- 200 m spacing within 1,800 m of all sources of emissions; and
- 500 m spacing within 5,000 m of all sources of emissions.

An additional set of receptors representing the location of nearby residences (i.e. discrete receptors) was also used in the assessment, as shown in Figure B4.



LEGEND

- DISPERSION MODELLING RECEPTORS
- DISCRETE RECEPTORS
- PROPERTY BOUNDARY (INCLUDING RECEPTORS LOCATED ALONG THE PROPERTY BOUNDARY AT A SPACING OF 10 m)

200 100 0 200

SCALE 1:10,000 METRES

NOTE

THIS FIGURE IS TO BE READ IN CONJUCTION WITH THE ACCOMPANYING REPORT.

REFERENCE

BACKGROUND IMAGERY - BING MAPS AERIAL (C) 2010 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2012.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18

PROJECT

ENVIRONMENTAL ASSESSMENT OF THE CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE

DISPERSION MODELLING RECEPTORS

Golder Associates
Ottawa, Ontario

PROJECT No. 12-1125-0045			SCALE AS SHOWN	REV. 0.0
DESIGN	AVW	DEC. 2013	FIGURE B4	
GIS	BR	DEC. 2013		
CHECK	PLE	AUG. 2014		
REVIEW	PAS	AUG. 2014		

Path: \\golder.gds\gal\Ottawa\Active\Spatial_IM\Miller_Paving_Ltd\CRRRC\GIS\MXDs\12-1125-0045\Working\Phase2000\Task110-Atmosphere\Air Quality & Odour Assessment\1211250045-2000-0110-B04_DispersionModellingReceptors.mxd

5.0 EMISSIONS AND SOURCE CONFIGURATIONS

Air and odour emission rates were estimated for the Project works and activities for which a measurable change from existing conditions is anticipated and may occur. These emission rates were then used as inputs for the dispersion modelling that provided estimates of maximum ground-level concentrations resulting from the Project emissions.

Emission rates were calculated for proposed activities at the CRRRC. Proposed CRRRC component footprints and corresponding waste acceptance rates were considered. Sources of emissions during operations included surface activities and on-Site vehicle movements.

Appendix A – Emission Estimates to the Air Quality and Odour Assessment TSD#3 provides a detailed description of the methods, inputs and assumption used to estimate emission rates.

During the development of the emission rates, consideration was also given to those elements incorporated into the Project design, as well as the operational practices that could aid in eliminating or reducing emissions. These practices and design elements are considered to be an integral component of the CRRRC Project and were included as part of the assessment.

The dispersion modelling included the combined effects of the Site vehicles, diversion facilities and landfill operations, and fugitive dust emissions.

6.0 MODEL SOURCE CONFIGURATIONS

The model source types (US EPA, 1995) used in this assessment include: point, area, and volume sources. The point sources and area sources are presented in Figure B5.

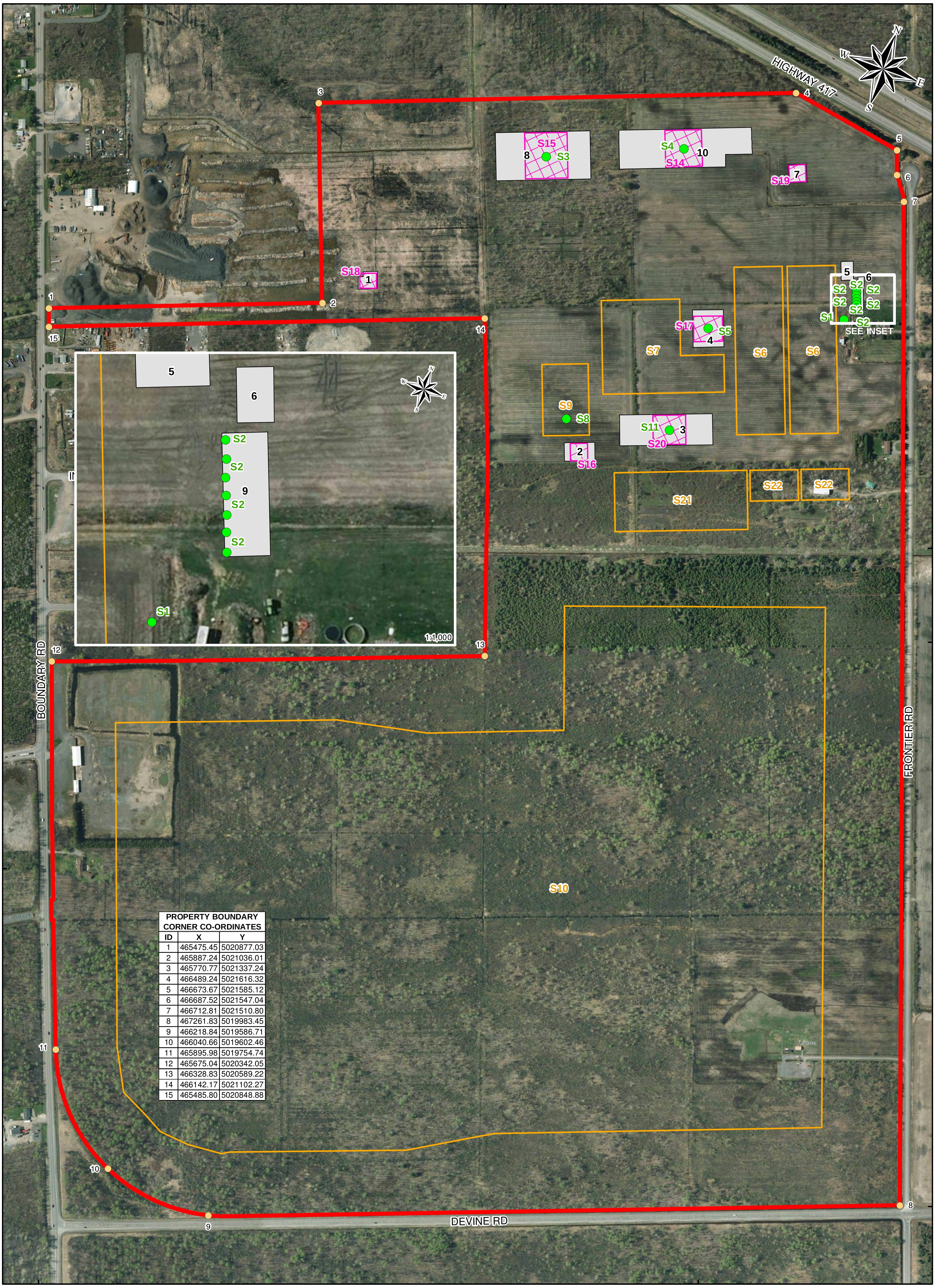
6.1 Point Sources

Point sources are typically stacks or vents. For the Project, the following were modelled as point sources:

- Landfill gas and biogas flare and engines;
- Dust collectors for the construction and demolition (C&D) recycling facility and the material recovery facility (MRF); and
- Biofilters for the organics processing facility and the hydrocarbon impacted soil treatment facility.

The location of the stacks and stack parameters were provided by Taggart Miller. For the stack locations of the dust collectors, they were assumed to be located in the centre of the C&D and MRF buildings. Where no stack parameters were available, the values were estimated based on other representative facilities and professional judgement.

The point source model input parameters used in the model are presented in Table B 6-1.



PROPERTY BOUNDARY CORNER CO-ORDINATES		
ID	X	Y
1	465475.45	5020877.03
2	465887.24	5021036.01
3	465770.77	5021337.24
4	466489.24	5021616.32
5	466673.67	5021585.12
6	466687.52	5021547.04
7	466712.81	5021510.80
8	467261.83	5019983.45
9	466218.84	5019586.71
10	466040.66	5019602.46
11	465895.98	5019754.74
12	465675.04	5020342.05
13	466328.83	5020589.22
14	466142.17	5021102.27
15	465485.80	5020848.88

LEGEND

- POINT SOURCES
- PROPERTY BOUNDARY CORNER CO-ORDINATES
- VOLUME SOURCE
- PROPERTY BOUNDARY
- AREA SOURCES
- BUILDINGS

BUILDING HEIGHTS
BUILDING 1 - 7.50 m
BUILDING 2 - 9.00 m
BUILDING 3 - 15.50 m
BUILDING 4 - 15.50 m
BUILDING 5 - 10.75 m
BUILDING 6 - 6.50 m
BUILDING 7 - 8.00 m
BUILDING 8 - 13.75 m
BUILDING 9 - 6.00 m
BUILDING 10 - 13.50 m

Point Sources		
Source ID	X Coordinate	Y Coordinate
S1	466687.1	5021298.5
S2	Various	Various
S3	466145.7	5021382.2
S4	466349.7	5021470
S5	466485.8	5021210.5
S8	466355.3	5020948.9
S11	466483.6	5021034.7

Area Sources
Source ID
S6
S7
S9
S10
S21
S22

Volume Sources
Source ID
S14
S15
S16
S17
S18
S19
S20

200 100 0 200
SCALE 1:6,000 METRES

NOTE

THIS FIGURE IS TO BE READ IN CONJUCTION WITH THE ACCOMPANYING REPORT.

REFERENCE

BACKGROUND IMAGERY - BING MAPS AERIAL (C) 2010 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
AERIAL PHOTOGRAPHS PURCHASED FROM THE CITY OF OTTAWA.
LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2012.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18

PROJECT

ENVIRONMENTAL ASSESSMENT OF THE CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE

DISPERSION MODELLING PLAN

Golder Associates
Ottawa, Ontario

PROJECT No. 12-1125-0045			SCALE AS SHOWN	REV. 0.0
DESIGN	AVW	DEC. 2013	FIGURE B5	
GIS	BR	DEC. 2013		
CHECK	PLE	AUG. 2014		
REVIEW	PAS	AUG. 2014		

Path: N:\Active\Spatial_IM\Miller_Paving_Ltd\CRRRC\GIS\MXDs\12-1125-0045\Working\Phase2000\Task110-Atmosphere\Air Quality & Odour Assessment\1211250045-2000-0110-B05_DispersionModellingPlan.mxd

Table B 6-1: Point Source Summary

Source Description (and ID #)	Stack Height Above Grade [m]	Stack Gas Exit Velocity (m/s)	Stack Inner Diameter (m)	Stack Exit Gas Temp. (°C)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operation (g/s)
Flare (S1)	12.2	16.6	3.0	1528	466687.10	5021298.50	NO_X	0.348
							SO_2	0.102
							CO	0.407
							SPM	0.131
							PM_{10}	0.131
							$PM_{2.5}$	0.131
							C_2H_3Cl	0.0000713
							H_2S	0.000131
Engine 1 to Engine 7 (S2)	12.5	17.8	0.3	509	466688.80 466690.80 466692.30 466694.10 466696.10 466697.60 466699.50	5021351.40 5021346.60 5021341.90 5021337.40 5021332.50 5021328.10 5021323.00	NO_X	0.442
							SO_2	0.102
							CO	4.672
							SPM	0.128
							PM_{10}	0.128
							$PM_{2.5}$	0.128
							C_2H_3Cl	0.00025
							H_2S	0.0031
C&D Dust Collector (S3)	15.75	9.0	1.0	20	466349.70	5021470.00	SPM	0.0708
							PM_{10}	0.0708
							$PM_{2.5}$	0.0708

Source Description (and ID #)	Stack Height Above Grade [m]	Stack Gas Exit Velocity (m/s)	Stack Inner Diameter (m)	Stack Exit Gas Temp. (°C)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operation (g/s)
MRF Dust Collector (S4)	15.5	9.0	1.0	20	466688.80	5021351.40	SPM	0.0708
							PM_{10}	0.0708
							$PM_{2.5}$	0.0708
Organics Processing Biofilter (S5)	18.0	17.7	1.2	25	466485.80	5021210.50	Odour	10,000
Hydrocarbon Soil Biofilter (S8)	4.0	8.3	0.8	25	466355.30	5020948.90	Odour	2,083
Leachate Pre-treatment Stack (S11)	18.0	8.8	1.0	25	466483.60	5021034.70	Odour	6,944

6.2 Area Sources

Area sources are used to model low level or ground releases. In general, area sources result in much higher ground level concentrations than those of volume or point sources. To remain conservative, the non-roads vehicle activities (tailpipe exhaust and material transfers) in the composting area, organics processing area, PHC impacted soil area and the landfill were modelled as an area source. The emissions from the working face of the landfill and the landfill cap were included in the landfill area source. The area sources parameters used in the model are presented in Table B 6-2. The area source release height above grade for the areas were provided by Taggart Miller. The landfill area source release height above grade was estimated to be 10% of the fetch of the landfill area to represent worst-case modelling heights for the area sources.

Table B 6-2: Area Source Summary

Source Description (and ID #)	Release Height Above Grade (m)	Area (m^2)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operations (g/s-m^2)
Composting Area (S7)	4	22,739	466669.10 466493.20 466646.10 466741.30	5021094.40 5021317.40 5021374.00 5021122.10	Odour	1.36E-02
Organics Processing Facility, Composting Facility, and the PHC Soil Treatment Area (S6, S7 & S9)	4	99,595	466376.5 466328.6 466340.6 466302.4 466209.7 466441.6 466473.7 466535.8 466493.2 466647.3 466741.5 466588.9 466566.5 466354.0 466365.3	5020973.9 5020955.9 5020926.0 5020911.0 5021160.1 5021249.9 5021169.8 5021196.0 5021317.2 5021374.8 5021122.7 5021062.9 5021117.5 5021039.7 5021009.8	SPM	1.06E-06
					PM_{10}	9.82E-07
					$PM_{2.5}$	9.04E-07
					NOx	1.65E-05
					SO2	2.79E-10
					CO	1.51E-05

Source Description (and ID #)	Release Height Above Grade (m)	Area (m^2)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operations ($g/s\text{-}m^2$)
Landfill (including landfill working face and cap) (S10)	1.9	839,407	465806.10 465988.00 466023.00 466065.00 466100.00 466148.90 466204.90 466216.60 466482.40 466608.30 467100.40 466818.20 466421.80 466489.40 466284.20 466139.60	5020284.20 5019792.20 5019726.90 5019705.90 5019687.20 5019682.50 5019687.20 5019694.20 5019794.50 5019869.10 5020058.00 5020850.90 5020708.60 5020519.70 5020440.40 5020410.10	NO_X	1.29E-06
					SO_2	2.45E-11
					CO	1.28E-06
					SPM	9.34E-08
					PM_{10}	8.30E-08
					$PM_{2.5}$	7.51E-08
					C_2H_3Cl	4.52E-10
					H_2S	5.56E-09
					Odour	2.85E-03
Leachate equalization pond (S21)	0.6	19,688	466456.2 466432.2 466622.8 466656.6	5020853.8 5020940.2 5021016.3 5020930.4	Odour	1.40E-01
Leachate effluent ponds (S22)	0.6	6,629	466674.6 466655.4 466765.4 466785.8	5020980.5 5021030.2 5021075.4 5021023.3	Odour	4.70E-05

6.3 Volume Sources

Volume sources are used to model releases from a variety of industrial sources that cannot be classified as a stack or vent. The MOECC has suggested that roads should be modelled as a series of individual volume sources creating a line that follows the road (MOE, 2009). The roads in the assessment were modelled using this volume source approach. The roads were divided into contiguous volume sources with a release height of 3.5 m which is assumed to be the height of the haul truck (National Stone, Sand and Gravel Association, 2004). The roads were assumed to be 7.5 m wide (for 2 lanes). Each lane was modelled separately to reduce the size of the exclusion zone (U.S. EPA, 2011). The emission rate for the entire road segment was divided amongst the total volume sources for the entire segment including both lanes. There were eleven paved road segments and 1 unpaved road segment considered in the assessment. The volume sources along the entrance way were removed since the model does not calculate concentration in a volume source exclusion zone. (U.S. EPA, 2011).

Additionally, the stationary fuel combustion sources for the Proposed CRRRC buildings were also modelled as volume sources. The volume sources were used to more accurately portray the variability of the stationary combustion stacks of different heights and configuration. Individual volume sources were created for each building to represent the combustion from those buildings.

The volume sources used in the assessment for the stationary combustion are summarized in Table B 6-3 and the building locations that correspond to these volume sources are depicted in Figure B5, while the volume sources for the roads are summarized in Table B 6-4 and depicted in Figure B6.

Table B 6-3: Facility Volume Source Summary

Source Description (and ID #)	Release Height Above Grade (m)	Initial Lateral Dimension of Volume (m)[1]	Initial Vertical Dimension of Volume (m)[2]	Indicator Compound	Emission Rate During Operations (g/s)
MRF (S14)	13.5	50.2	6.3	NO_X	6.05E-03
C&D (S15)	13.8	60.5	6.4	NO_X	6.05E-03
PHC Impacted Soil Treatment Facility (S16)	9.0	23.5	4.2	NO_X	3.46E-03
Organics Processing Facility (S17)	15.5	40.8	7.2	NO_X	5.18E-03
Administrative Building (S18)	7.5	20.7	3.5	NO_X	3.74E-04
Maintenance Building (S19)	8.0	23.8	3.7	NO_X	2.30E-03
Leachate Pre-treatment Facility (S20)	15.5	38.3	7.2	NO_X	1.53E-02

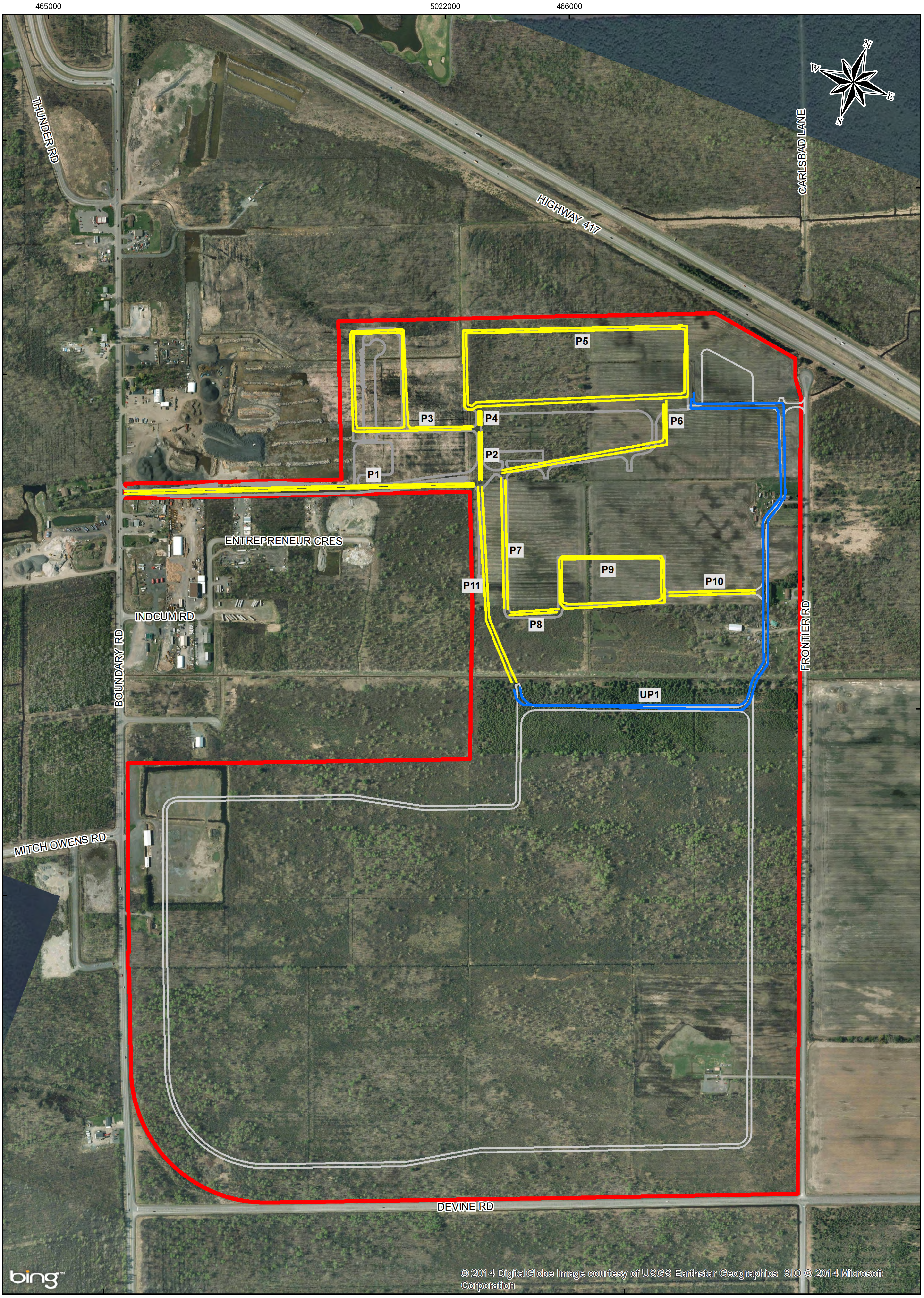
Table B 6-4: Road Volume Source Summary

Source Description (and ID #)	Release Height Above Grade (m)	Initial Lateral Dimension of Volume (m)[1]	Initial Vertical Dimension of Volume (m)[2]	Indicator Compound	Emission Rate During Operations (g/s)	# of AERMOD Sources Comprising Segment	Emission Rate per Model Source (g/s)
Paved Roads (S12) - P1	3.50	3.1	1.63	NO_X	2.13E-02	146	1.46E-04
				SO_2	5.95E-05		4.07E-07
				CO	4.92E-03		3.37E-05
				SPM	4.29E-01		2.94E-03
				PM_{10}	8.23E-02		5.70E-04
				$PM_{2.5}$	1.99E-02		1.41E-04
Paved Roads (S12) - P2	3.50	3.1	1.63	NO_X	1.17E-03	22	5.31E-05
				SO_2	3.26E-06		1.48E-07
				CO	2.70E-04		1.23E-05
				SPM	2.35E-02		1.07E-03
				PM_{10}	4.51E-03		2.07E-04
				$PM_{2.5}$	1.09E-03		5.15E-05
Paved Roads (S12) - P3	3.50	3.1	1.63	NO_X	2.01E-03	152	1.32E-05
				SO_2	5.60E-06		3.69E-08
				CO	4.63E-04		3.05E-06
				SPM	4.04E-02		2.66E-04
				PM_{10}	7.75E-03		5.16E-05
				$PM_{2.5}$	1.88E-03		1.28E-05
Paved Roads (S12) - P4	3.50	3.1	1.63	NO_X	3.11E-03	8	3.88E-04
				SO_2	8.67E-06		1.08E-06
				CO	7.17E-04		8.96E-05
				SPM	6.25E-02		7.83E-03
				PM_{10}	1.20E-02		1.52E-03
				$PM_{2.5}$	2.90E-03		3.76E-04
Paved Roads (S12) - P5	3.50	3.1	1.63	NO_X	2.26E-03	244	9.27E-06
				SO_2	6.31E-06		2.59E-08
				CO	5.22E-04		2.14E-06
				SPM	4.55E-02		1.87E-04
				PM_{10}	8.73E-03		3.62E-05
				$PM_{2.5}$	2.11E-03		8.98E-06

Source Description (and ID #)	Release Height Above Grade (m)	Initial Lateral Dimension of Volume (m)[1]	Initial Vertical Dimension of Volume (m)[2]	Indicator Compound	Emission Rate During Operations (g/s)	# of AERMOD Sources Comprising Segment	Emission Rate per Model Source (g/s)
Paved Roads (S12) - P6	3.50	3.1	1.63	NO_X	5.99E-04	88	6.80E-06
				SO_2	1.67E-06		1.90E-08
				CO	1.38E-04		1.57E-06
				SPM	1.20E-02		1.37E-04
				PM_{10}	2.31E-03		2.66E-05
				$PM_{2.5}$	5.59E-04		6.59E-06
Paved Roads (S12) - P7	3.50	3.1	1.63	NO_X	1.14E-04	54	2.11E-06
				SO_2	3.18E-07		5.89E-09
				CO	2.63E-05		4.87E-07
				SPM	2.29E-03		4.26E-05
				PM_{10}	4.40E-04		8.24E-06
				$PM_{2.5}$	1.07E-04		2.05E-06
Paved Roads (S12) - P8	3.50	3.1	1.63	NO_X	5.62E-06	22	2.55E-07
				SO_2	1.57E-08		7.13E-10
				CO	1.30E-06		5.89E-08
				SPM	1.13E-04		5.15E-06
				PM_{10}	2.17E-05		9.96E-07
				$PM_{2.5}$	5.25E-06		2.47E-07
Paved Roads (S12) - P9	3.50	3.1	1.63	NO_X	3.54E-05	120	2.95E-07
				SO_2	9.88E-08		8.23E-10
				CO	8.16E-06		6.80E-08
				SPM	7.12E-04		5.94E-06
				PM_{10}	1.37E-04		1.15E-06
				$PM_{2.5}$	3.31E-05		2.86E-07
Paved Roads (S12) - P10	3.50	3.1	1.63	NO_X	1.12E-05	38	2.96E-07
				SO_2	3.14E-08		8.25E-10
				CO	2.59E-06		6.82E-08
				SPM	2.26E-04		5.96E-06
				PM_{10}	4.34E-05		1.15E-06
				$PM_{2.5}$	1.05E-05		2.86E-07

Source Description (and ID #)	Release Height Above Grade (m)	Initial Lateral Dimension of Volume (m)[1]	Initial Vertical Dimension of Volume (m)[2]	Indicator Compound	Emission Rate During Operations (g/s)	# of AERMOD Sources Comprising Segment	Emission Rate per Model Source (g/s)
Paved Roads (S12) - P11	3.50	3.1	1.63	NO_X	8.61E-04	86	1.00E-05
				SO_2	2.40E-06		2.79E-08
				CO	1.99E-04		2.31E-06
				SPM	1.73E-02		2.02E-04
				PM_{10}	3.32E-03		3.91E-05
				$PM_{2.5}$	8.04E-04		9.70E-06
Unpaved Roads (S13) - UP1	3.50	3.1	1.63	NO_X	0.0036	274	1.30E-05
				SO_2	0.00029		1.06E-06
				CO	0.00061		2.22E-06
				SPM	0.288		1.05E-03
				PM_{10}	0.078		2.84E-04
				$PM_{2.5}$	0.078		2.87E-05

Notes:
[1] Initial lateral dimension = (Haul Route Width + 9.75 m)/4.3
[2] Initial vertical dimension = (2 x height of haul truck in m)/4.3



LEGEND

- PROPERTY BOUNDARY
- UNPAVED ROADS
- PAVED ROADS
- MODELLED PAVED ROADS
- MODELLED UNPAVED ROADS

NOTE

THIS FIGURE IS TO BE READ IN CONJUCTION WITH THE ACCOMPANYING REPORT.

REFERENCE

BACKGROUND IMAGERY - BING MAPS AERIAL (C) 2010 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2012.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18

150 75 0 150
SCALE 1:7,500 METRES

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE
ROAD SEGMENTS PLAN

Golder Associates
Ottawa, Ontario

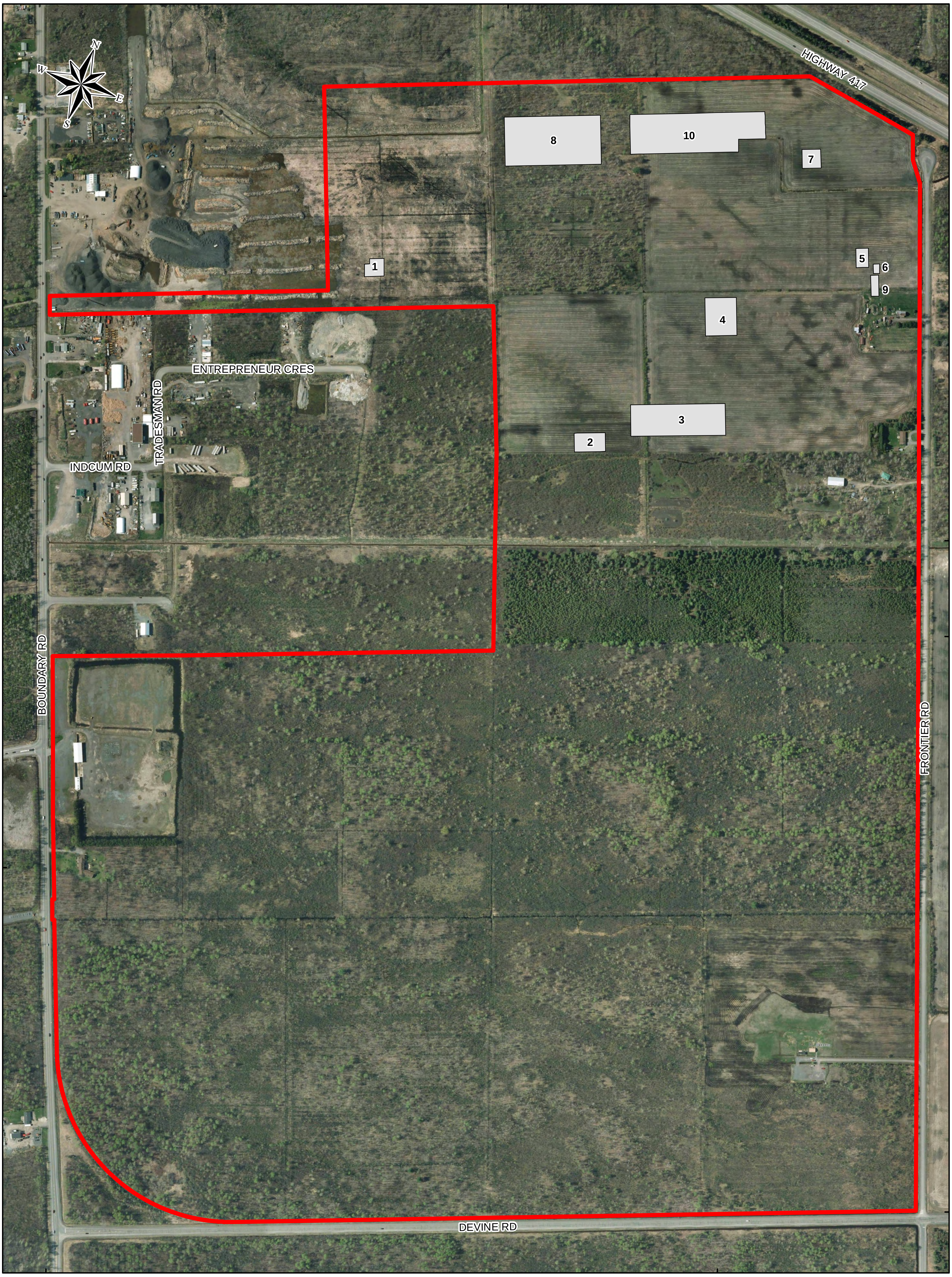
PROJECT No. 12-1125-0045			SCALE AS SHOWN	REV. 0.0
DESIGN	AVW	DEC. 2013	FIGURE B6	
GIS	PJM	DEC. 2013		
CHECK	PLE	AUG. 2014		
REVIEW	PAS	AUG. 2014		

Path: N:\Active\Spatial_IM\Miller_Paving_Ltd\CRRRC\GIS\MXDs\12-1125-0045\Working\Phase2000\Task110-Atmosphere\Air Quality & Odour Assessment\1211250045-2000-0110-B06_RoadSegmentSources.mxd

6.4 Building Downwash

For point sources, AERMOD relies on the PRIME (Plume Rise Model Enhancement) downwash algorithm. The PRIME algorithm is designed to incorporate the two fundamental features associated with building downwash: enhanced plume dispersion coefficients due to the turbulent wake, and reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.

Building downwash occurs when the aerodynamic turbulence induced by a nearby building causes a contaminant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level concentrations. For the air dispersion modelling, the building must be represented as rectangular prisms with flat tops. To calculate the building downwash it is necessary to enter a representative height of the building which is not necessarily the highest point on the building. Figure B7 presents buildings that were used in the Building Profile Input Program (BPIP) and their respective heights.



LEGEND

BUILDINGS

PROPERTY BOUNDARY

BUILDING NUMBER	NAME FOR REFERENCE	MODELLED HEIGHT (m)
1	ADMINISTRATION	7.50
2	HC SOIL BUILDING	9.00
3	LEACHATE	15.50
4	ORGANICS PRE-PROCESSING	15.50
5	SECONDARY DIGESTER	10.75
6	ANCILLARY BUILDING	6.50
7	MAINTENANCE BUILDING	8.00
8	CONSTRUCTION AND DEMOLITION	13.75
9	7 ENGINES	6.00
10	MATERIALS RECOVERY FACILITY	13.50

200 100 0 200

SCALE 1:6,000 METRES

NOTE

THIS FIGURE IS TO BE READ IN CONJUCTION WITH THE ACCOMPANYING REPORT.

REFERENCE

BACKGROUND IMAGERY - BING MAPS AERIAL (C) 2010 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
AERIAL PHOTOGRAPHS PURCHASED FROM THE CITY OF OTTAWA.
LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2012.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18

PROJECT

ENVIRONMENTAL ASSESSMENT OF THE CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE

BUILDING PROFILE INPUT PROGRAM (BPIP) PLAN

Golder Associates
Ottawa, Ontario

PROJECT No. 12-1125-0045			SCALE AS SHOWN	REV. 0.0
DESIGN	AVW	DEC. 2013	FIGURE B7	
GIS	BR/PM	DEC. 2013		
CHECK	PLE	AUG. 2014		
REVIEW	PAS	AUG. 2014		

Path: N:\Active\Spatial_IM\Miller_Paving_Ltd\CRRRC\GIS\MXDs\12-1125-0045\Working\Phase2000\Task110-Atmosphere\Air Quality & Odour Assessment\1211250045-2000-0110-B07_BuildingProfileInput.mxd

7.0 MODEL OPTIONS AND RESULTS POST-PROCESSING

7.1 Options Used in the AERMOD Model

The options used in the AERMOD model are summarized in the Table B 7-1.

Table B 7-1: Options Used in the AERMOD Model

Modelling Parameter	Description	Used in the Assessment?
DFAULT	Specifies that regulatory default options will be used.	No
CONC	Specifies that concentration values will be calculated.	Yes
OLM	Specifies that the non-default Ozone Limiting Method for NO_2 conversion will be used.	No
DDPLETE	Specifies that dry deposition will be calculated.	No
WDPLETE	Specifies that wet deposition will be calculated.	No
FLAT	Specifies that the non-default option of assuming flat terrain will be used.	No, the model will use elevated terrain as detailed in the AERMAP output.
NOSTD	Specifies that the non-default option of no stack-tip downwash will be used.	No
AVERTIME	Time averaging periods calculated.	1-hr, 24-hr
URBANOPT	Allows the model to incorporate the effects of increased surface heating from an urban area on pollutant dispersion under stable atmospheric conditions.	No
URBANROUGHNESS	Specifies the urban roughness length (m).	No, site specific urban roughness values were incorporated into the AERMET processing.
FLAGPOLE	Specifies that receptor heights above local ground level are allowed on the receptors.	No

7.2 Time Average Conversions

The smallest time scale that AERMOD predicts is a 1-hour average value. There are instances when criteria are based on different averaging times, and in these cases the following conversion factor, recommended by the MOECC for conversion from a 1-hour averaging period to the applicable averaging period less than 1-hour could be used (MOE, 2009). An example is given below for converting from a 1-hour averaging period to a 10-minute averaging period:

$$F = \left(\frac{t_1}{t_0}\right)^n$$

$$= \left(\frac{60}{10}\right)^{0.28}$$

$$= 1.65$$

Where:

F = the factor to convert from the averaging period t_1 output from the model (MOECC assumes AERMOD predicts true 60 minute averages) to the desired averaging period t_0 (assumed to be 10-minutes in the example above), and

n = the exponent variable; in this case the MOECC value of n = 0.28 is used for conversion.

For averaging periods greater than 1-hour, the AERMOD output was used directly.

Modelling of odour based compounds (whole odour and H_2S) was completed in accordance to the MOECC Technical Bulletin titled *Methodology for Modelling Assessments of Contaminants with 10-minute Average Standards and Guidelines* (MOE, 2008).

REFERENCES

National Stone, Sand & Gravel Association, 2004. *Modeling Fugitive Dust Sources*.

MOE (Ontario Ministry of the Environment). 2009. *Air Dispersion Modelling Guideline for Ontario, Version 2.0*. PIBS: 5165e02, Toronto, Ontario

MOE (Ontario Ministry of the Environment) . 2008. *Methodology for Modelling Assessments of Contaminants with 10-Minute Average Standards and Guidelines under O.Reg. 419/05*. Technical Bulletin.

MOE (Ontario Ministry of the Environment). 2011. *Air Pollution - Local Air Quality - Ontario Digital Elevation Model Data*. Retrieved October 29, 2013, from Ontario Ministry of the Environment: http://www.ene.gov.on.ca/environment/en/industry/standards/industrial_air_emissions/air_pollution/STDPROD_084098.html

United States Environmental Protection Agency (U.S. EPA). 2004. *Users Guide for the AERMOD Terrain Preprocessor (AERMAP).* EPA-454/B-03-003. Office of Air Quality Planning and Standards. Emissions, Monitoring, and Analysis Division. Research Triangle Park, North Carolina.

United States Environmental Protection Agency (U.S. EPA). 1995. *Compilation of Air Pollutant Emission Factors.* Volume 1: Stationary Point and Area Sources. AP-42 Fifth Edition (and updates). Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

United States Environmental Protection Agency (U.S. EPA). 2011. *Haul Road Workgroup Final Report.* Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

APPENDIX C

LandGEM Modelling Results

TECHNICAL MEMORANDUM

DATE November 2013 **PROJECT No.** 12-1125-0045/2000/0110

ESTIMATE OF LANDFILL GAS GENERATION
CAPITAL REGION RESOURCE RECOVERY CENTRE (CRRRC)

Introduction

Estimates of landfill gas (LFG) generation were prepared for the landfill associated with the proposed Taggart Miller Capital Region Resource Recovery Centre (CRRRC) as described in this technical memorandum. The estimated LFG generation rates from the landfill footprint will be used in the estimation of air emissions from the CRRRC. The estimated LFG generation rates herein are not intended for use in sizing/specifying LFG equipment or associated collection system.

This memorandum concerns only LFG generated from landfilled materials. Biogas generated from other on-site facilities, such as the Organics Processing Facility, is not considered in this memorandum.

Methodology

At the request of Mr. Rudolf Wan (Ministry of the Environment (MOE) - Toronto) during a conference call on October 9, 2013, LFG generation rates from landfilled materials at the proposed CRRRC were estimated using the LandGEM model (1991) developed by the United States Environmental Protection Agency (US EPA). The LandGEM model is based on a first-order decay model of landfill gas generation. It should be noted that the LandGEM model was developed to estimate LFG generation rates for landfills accepting municipal solid waste (MSW) (US EPA, 2005). The projected waste materials anticipated to be landfilled at the CRRRC consist primarily of industrial, commercial and institutional (IC&I) and construction and demolition (C&D) materials, and may differ from a typical municipal solid waste (MSW) composition. As a result, it is expected that LFG generation rate results generated by the LandGEM model may not be representative of the actual LFG generation rates for the CRRRC landfill.

The key input parameters for the model are the projected annual tonnages of waste disposed of in the landfill footprint, the landfill gas production potential (L_o) and the landfill gas generation rate factor (k). L_o is a measure of the ultimate methane yield in cubic metres of methane per tonne of waste (m^3/tonne), and k is the methane generation rate constant in year^{-1}. Both L_o and k are highly influenced by moisture content, as well as waste composition, temperature, pH, particle size and availability of nutrients.

The LandGEM model was used to estimate LFG generation rates for the CRRRC based on the maximum projected waste tonnages to be landfilled at the CRRRC provided by Taggart Miller, assuming an operational lifespan of 30 years. Tonnages of soils were removed from the projected waste tonnages as it was assumed that rates of LFG produced by soil would be negligible. Tonnages of C&D, IC&I, leaf and yard, clean source-separated organics and mixed organics waste were included.

The following default values for L_o and k for Ontario used in the LFG generation estimates as described in the MOE *Interim Guide to Estimate and Assess Landfill Air Impacts* (MOE, 1992):

$$L_o = 125\ m^3/tonne$$

$$k = 0.04\ year^{-1}$$

For the model, LFG generated at the landfill site was assumed to be comprised of 50% methane (CH_4) by volume.

LFG Generation Estimates

The resulting theoretical LFG generation rate estimates obtained from the LandGEM model are presented in Attachment A and illustrated in Figure 1. Table 1 presents a summary of LFG and methane generation rates.

Table 1: Estimated LFG and Methane Generation Rates using the Projected Maximum Waste Tonnage Landfilled

Year	Total LFG		Total Methane*	
	m^3/hour	scfm	m^3/hour	scfm
5	1,115	655	555	330
10	2,240	1,320	1,120	660
15	3,165	1,865	1,585	930
20	3,925	2,310	1,960	1,155
25	4,545	2,675	2,270	1,335
30 (Peak)	5,050	2,975	2,525	1,485
35	4,135	2,435	2,070	1,215
40	3,385	1,995	1,695	995
45	2,770	1,630	1,385	815
50	2,270	1,335	1,135	670

* Assumes LFG is comprised of 50% methane.
m^3 = cubic metres
scfm = standard cubic feet per minute

It should be noted that this memorandum provides an estimate of landfill gas generation, which is not the same as the landfill gas collection rate since any future LFG collection system would not be able to collect all of the LFG generated.

Limitations

It should be noted that landfill gas modelling without the benefit of actual measurement of LFG emissions, is a very inexact science. Model results can vary, perhaps substantially, from actual LFG generation rates. Caution should always be exercised when using LFG generation rates derived from first order decay modelling.

Closure

We trust this technical memorandum satisfies your current needs. If you have any questions regarding this memorandum, please contact the undersigned.

GOLDER ASSOCIATES LTD.

A.M. Harwood, M.Eng., P.Eng.
Environmental Engineer

Rachel Wyles, M.Eng., P.Eng. (BC)
Air Quality Specialist

ALC/AMH/RW/sg

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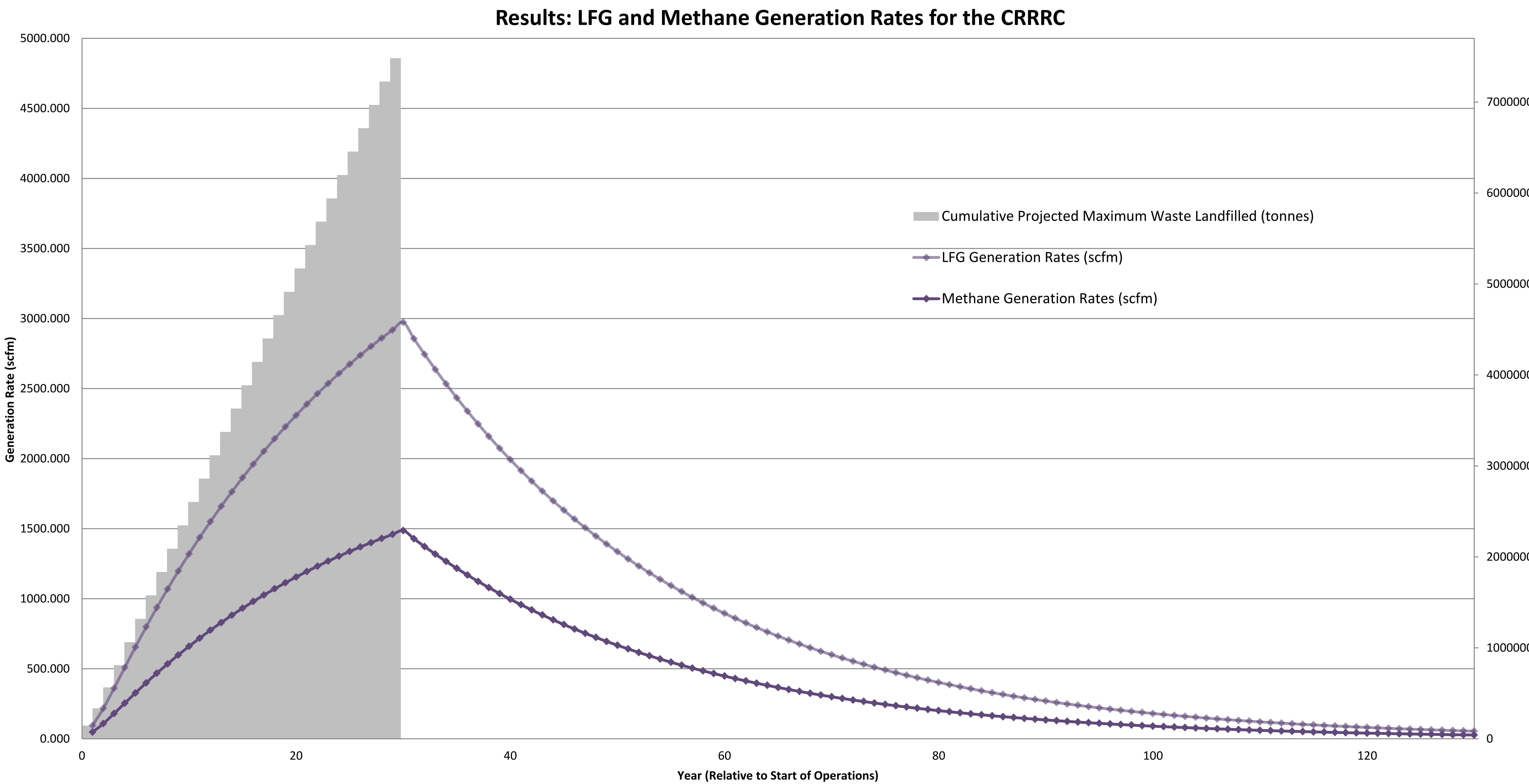
Attachments: Figure 1
Attachment A

References

MOE, Air Resources Branch. *Interim Guide to Estimate and Assess Landfill Air Impacts.* October 1992.

United State Environmental Protection Agency. Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide. May 2005.



Golder Associates	Date: November 2013 Drawn: ALC Project: 12-1125-0045 Review: AMH	**LFG and Methane Generation Rates for the CRRRC**	FIGURE 1

ATTACHMENT A

Summary Report

Landfill Name or Identifier: Maximum Tonnage- MOE Inputs

Date: Friday, November 08, 2013

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

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

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

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

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

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

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1**	
Landfill Closure Year (with 80-year limit)	**30**	
Actual Closure Year (without limit)	***30***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.040**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**125**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

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

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1	144,900	159,390	0	0
2	190,500	209,550	144,900	159,390
3	229,680	252,648	335,400	368,940
4	246,000	270,600	565,080	621,588
5	251,786	276,964	811,080	892,188
6	256,800	282,480	1,062,866	1,169,152
7	256,800	282,480	1,319,666	1,451,632
8	256,800	282,480	1,576,466	1,734,112
9	256,800	282,480	1,833,266	2,016,592
10	256,800	282,480	2,090,066	2,299,072
11	256,800	282,480	2,346,866	2,581,552
12	256,800	282,480	2,603,666	2,864,032
13	256,800	282,480	2,860,466	3,146,512
14	256,800	282,480	3,117,266	3,428,992
15	256,800	282,480	3,374,066	3,711,472
16	256,800	282,480	3,630,866	3,993,952
17	256,800	282,480	3,887,666	4,276,432
18	256,800	282,480	4,144,466	4,558,912
19	256,800	282,480	4,401,266	4,841,392
20	256,800	282,480	4,658,066	5,123,872
21	256,800	282,480	4,914,866	5,406,352
22	256,800	282,480	5,171,666	5,688,832
23	256,800	282,480	5,428,466	5,971,312
24	256,800	282,480	5,685,266	6,253,792
25	256,800	282,480	5,942,066	6,536,272
26	256,800	282,480	6,198,866	6,818,752
27	256,800	282,480	6,455,666	7,101,232
28	256,800	282,480	6,712,466	7,383,712
29	256,800	282,480	6,969,266	7,666,192
30	256,800	282,480	7,226,066	7,948,672
31	0	0	7,482,866	8,231,152
32	0	0	7,482,866	8,231,152
33	0	0	7,482,866	8,231,152
34	0	0	7,482,866	8,231,152
35	0	0	7,482,866	8,231,152
36	0	0	7,482,866	8,231,152
37	0	0	7,482,866	8,231,152
38	0	0	7,482,866	8,231,152
39	0	0	7,482,866	8,231,152
40	0	0	7,482,866	8,231,152

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
41	0	0	7,482,866	8,231,152
42	0	0	7,482,866	8,231,152
43	0	0	7,482,866	8,231,152
44	0	0	7,482,866	8,231,152
45	0	0	7,482,866	8,231,152
46	0	0	7,482,866	8,231,152
47	0	0	7,482,866	8,231,152
48	0	0	7,482,866	8,231,152
49	0	0	7,482,866	8,231,152
50	0	0	7,482,866	8,231,152
51	0	0	7,482,866	8,231,152
52	0	0	7,482,866	8,231,152
53	0	0	7,482,866	8,231,152
54	0	0	7,482,866	8,231,152
55	0	0	7,482,866	8,231,152
56	0	0	7,482,866	8,231,152
57	0	0	7,482,866	8,231,152
58	0	0	7,482,866	8,231,152
59	0	0	7,482,866	8,231,152
60	0	0	7,482,866	8,231,152
61	0	0	7,482,866	8,231,152
62	0	0	7,482,866	8,231,152
63	0	0	7,482,866	8,231,152
64	0	0	7,482,866	8,231,152
65	0	0	7,482,866	8,231,152
66	0	0	7,482,866	8,231,152
67	0	0	7,482,866	8,231,152
68	0	0	7,482,866	8,231,152
69	0	0	7,482,866	8,231,152
70	0	0	7,482,866	8,231,152
71	0	0	7,482,866	8,231,152
72	0	0	7,482,866	8,231,152
73	0	0	7,482,866	8,231,152
74	0	0	7,482,866	8,231,152
75	0	0	7,482,866	8,231,152
76	0	0	7,482,866	8,231,152
77	0	0	7,482,866	8,231,152
78	0	0	7,482,866	8,231,152
79	0	0	7,482,866	8,231,152
80	0	0	7,482,866	8,231,152

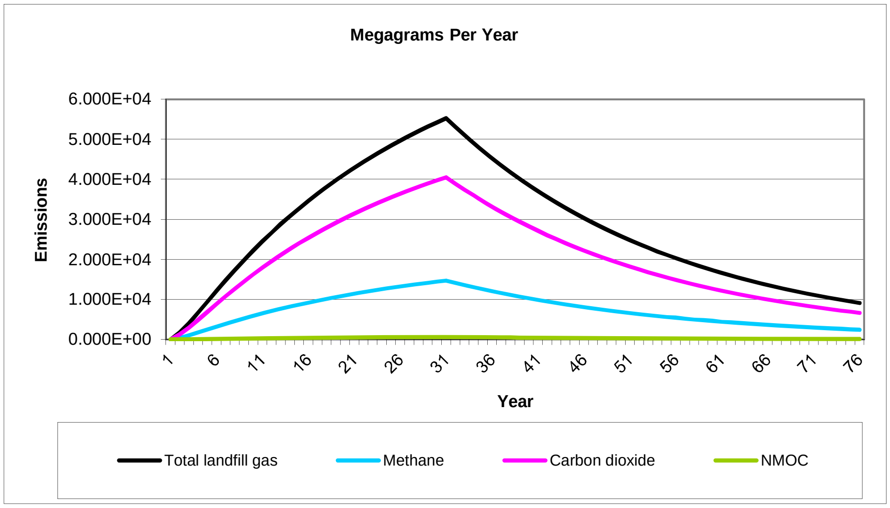
Pollutant Parameters

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

Pollutant Parameters (Continued)

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

Graphs


Megagrams Per Year
Emissions
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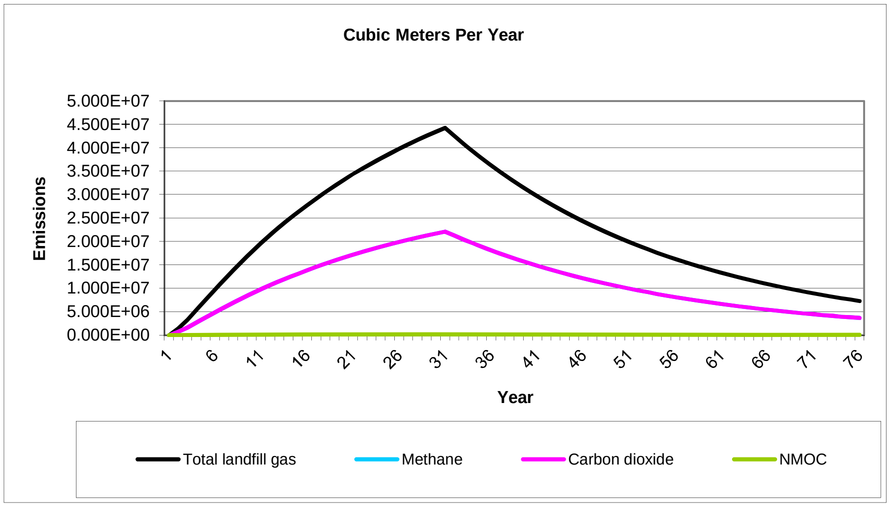
5.000E+04
4.000E+04
3.000E+04
2.000E+04
1.000E+04
0.000E+00
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
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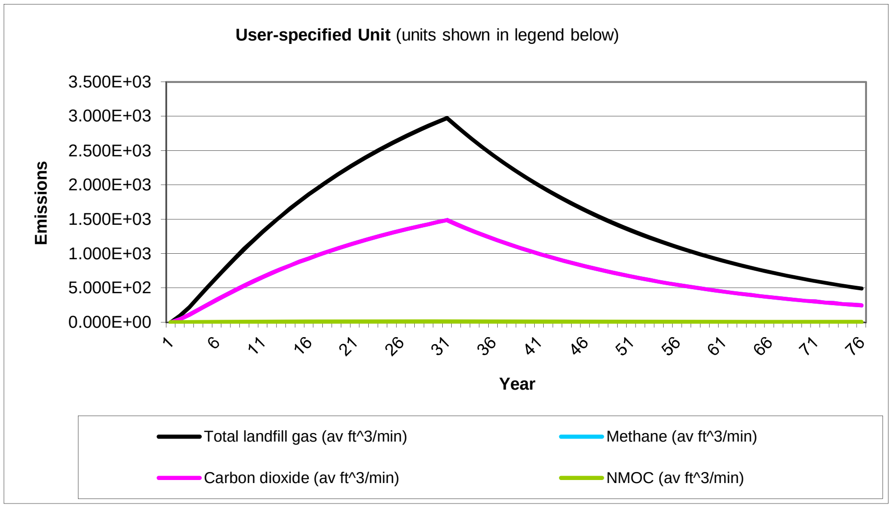
4.500E+07
4.000E+07
3.500E+07
3.000E+07
2.500E+07
2.000E+07
1.500E+07
1.000E+07
5.000E+06
0.000E+00
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1	0	0	0	0	0	0
2	1.777E+03	1.423E+06	9.563E+01	4.748E+02	7.116E+05	4.781E+01
3	4.044E+03	3.239E+06	2.176E+02	1.080E+03	1.619E+06	1.088E+02
4	6.703E+03	5.368E+06	3.606E+02	1.790E+03	2.684E+06	1.803E+02
5	9.458E+03	7.573E+06	5.089E+02	2.526E+03	3.787E+06	2.544E+02
6	1.218E+04	9.750E+06	6.551E+02	3.252E+03	4.875E+06	3.275E+02
7	1.485E+04	1.189E+07	7.989E+02	3.966E+03	5.945E+06	3.994E+02
8	1.742E+04	1.395E+07	9.370E+02	4.652E+03	6.973E+06	4.685E+02
9	1.988E+04	1.592E+07	1.070E+03	5.311E+03	7.961E+06	5.349E+02
10	2.225E+04	1.782E+07	1.197E+03	5.944E+03	8.910E+06	5.986E+02
11	2.453E+04	1.964E+07	1.320E+03	6.552E+03	9.822E+06	6.599E+02
12	2.672E+04	2.140E+07	1.438E+03	7.137E+03	1.070E+07	7.188E+02
13	2.882E+04	2.308E+07	1.551E+03	7.698E+03	1.154E+07	7.753E+02
14	3.084E+04	2.470E+07	1.659E+03	8.238E+03	1.235E+07	8.297E+02
15	3.278E+04	2.625E+07	1.764E+03	8.756E+03	1.313E+07	8.819E+02
16	3.465E+04	2.774E+07	1.864E+03	9.254E+03	1.387E+07	9.320E+02
17	3.644E+04	2.918E+07	1.960E+03	9.733E+03	1.459E+07	9.802E+02
18	3.816E+04	3.056E+07	2.053E+03	1.019E+04	1.528E+07	1.027E+03
19	3.981E+04	3.188E+07	2.142E+03	1.063E+04	1.594E+07	1.071E+03
20	4.140E+04	3.315E+07	2.228E+03	1.106E+04	1.658E+07	1.114E+03
21	4.293E+04	3.437E+07	2.310E+03	1.147E+04	1.719E+07	1.155E+03
22	4.439E+04	3.555E+07	2.389E+03	1.186E+04	1.777E+07	1.194E+03
23	4.580E+04	3.668E+07	2.464E+03	1.223E+04	1.834E+07	1.232E+03
24	4.716E+04	3.776E+07	2.537E+03	1.260E+04	1.888E+07	1.269E+03
25	4.846E+04	3.880E+07	2.607E+03	1.294E+04	1.940E+07	1.304E+03
26	4.971E+04	3.980E+07	2.674E+03	1.328E+04	1.990E+07	1.337E+03
27	5.091E+04	4.077E+07	2.739E+03	1.360E+04	2.038E+07	1.370E+03
28	5.206E+04	4.169E+07	2.801E+03	1.391E+04	2.085E+07	1.401E+03
29	5.317E+04	4.258E+07	2.861E+03	1.420E+04	2.129E+07	1.430E+03
30	5.424E+04	4.343E+07	2.918E+03	1.449E+04	2.172E+07	1.459E+03
31	5.526E+04	4.425E+07	2.973E+03	1.476E+04	2.213E+07	1.487E+03
32	5.309E+04	4.251E+07	2.857E+03	1.418E+04	2.126E+07	1.428E+03
33	5.101E+04	4.085E+07	2.745E+03	1.363E+04	2.042E+07	1.372E+03
34	4.901E+04	3.925E+07	2.637E+03	1.309E+04	1.962E+07	1.318E+03
35	4.709E+04	3.771E+07	2.534E+03	1.258E+04	1.885E+07	1.267E+03
36	4.524E+04	3.623E+07	2.434E+03	1.209E+04	1.811E+07	1.217E+03
37	4.347E+04	3.481E+07	2.339E+03	1.161E+04	1.740E+07	1.169E+03
38	4.176E+04	3.344E+07	2.247E+03	1.116E+04	1.672E+07	1.124E+03
39	4.013E+04	3.213E+07	2.159E+03	1.072E+04	1.607E+07	1.079E+03
40	3.855E+04	3.087E+07	2.074E+03	1.030E+04	1.544E+07	1.037E+03
41	3.704E+04	2.966E+07	1.993E+03	9.894E+03	1.483E+07	9.965E+02
42	3.559E+04	2.850E+07	1.915E+03	9.506E+03	1.425E+07	9.574E+02
43	3.419E+04	2.738E+07	1.840E+03	9.134E+03	1.369E+07	9.199E+02
44	3.285E+04	2.631E+07	1.768E+03	8.776E+03	1.315E+07	8.838E+02
45	3.157E+04	2.528E+07	1.698E+03	8.431E+03	1.264E+07	8.491E+02
46	3.033E+04	2.428E+07	1.632E+03	8.101E+03	1.214E+07	8.159E+02
47	2.914E+04	2.333E+07	1.568E+03	7.783E+03	1.167E+07	7.839E+02
48	2.800E+04	2.242E+07	1.506E+03	7.478E+03	1.121E+07	7.531E+02
49	2.690E+04	2.154E+07	1.447E+03	7.185E+03	1.077E+07	7.236E+02
50	2.584E+04	2.069E+07	1.390E+03	6.903E+03	1.035E+07	6.952E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
51	2.483E+04	1.988E+07	1.336E+03	6.632E+03	9.941E+06	6.680E+02
52	2.386E+04	1.910E+07	1.284E+03	6.372E+03	9.552E+06	6.418E+02
53	2.292E+04	1.835E+07	1.233E+03	6.122E+03	9.177E+06	6.166E+02
54	2.202E+04	1.763E+07	1.185E+03	5.882E+03	8.817E+06	5.924E+02
55	2.116E+04	1.694E+07	1.138E+03	5.652E+03	8.472E+06	5.692E+02
56	2.033E+04	1.628E+07	1.094E+03	5.430E+03	8.139E+06	5.469E+02
57	1.953E+04	1.564E+07	1.051E+03	5.217E+03	7.820E+06	5.254E+02
58	1.877E+04	1.503E+07	1.010E+03	5.013E+03	7.514E+06	5.048E+02
59	1.803E+04	1.444E+07	9.701E+02	4.816E+03	7.219E+06	4.850E+02
60	1.732E+04	1.387E+07	9.320E+02	4.627E+03	6.936E+06	4.660E+02
61	1.664E+04	1.333E+07	8.955E+02	4.446E+03	6.664E+06	4.477E+02
62	1.599E+04	1.281E+07	8.604E+02	4.272E+03	6.403E+06	4.302E+02
63	1.536E+04	1.230E+07	8.266E+02	4.104E+03	6.152E+06	4.133E+02
64	1.476E+04	1.182E+07	7.942E+02	3.943E+03	5.910E+06	3.971E+02
65	1.418E+04	1.136E+07	7.631E+02	3.788E+03	5.679E+06	3.815E+02
66	1.363E+04	1.091E+07	7.332E+02	3.640E+03	5.456E+06	3.666E+02
67	1.309E+04	1.048E+07	7.044E+02	3.497E+03	5.242E+06	3.522E+02
68	1.258E+04	1.007E+07	6.768E+02	3.360E+03	5.036E+06	3.384E+02
69	1.209E+04	9.678E+06	6.503E+02	3.228E+03	4.839E+06	3.251E+02
70	1.161E+04	9.299E+06	6.248E+02	3.102E+03	4.649E+06	3.124E+02
71	1.116E+04	8.934E+06	6.003E+02	2.980E+03	4.467E+06	3.001E+02
72	1.072E+04	8.584E+06	5.767E+02	2.863E+03	4.292E+06	2.884E+02
73	1.030E+04	8.247E+06	5.541E+02	2.751E+03	4.124E+06	2.771E+02
74	9.895E+03	7.924E+06	5.324E+02	2.643E+03	3.962E+06	2.662E+02
75	9.507E+03	7.613E+06	5.115E+02	2.539E+03	3.806E+06	2.558E+02
76	9.134E+03	7.314E+06	4.915E+02	2.440E+03	3.657E+06	2.457E+02
77	8.776E+03	7.028E+06	4.722E+02	2.344E+03	3.514E+06	2.361E+02
78	8.432E+03	6.752E+06	4.537E+02	2.252E+03	3.376E+06	2.268E+02
79	8.102E+03	6.487E+06	4.359E+02	2.164E+03	3.244E+06	2.179E+02
80	7.784E+03	6.233E+06	4.188E+02	2.079E+03	3.116E+06	2.094E+02
81	7.479E+03	5.989E+06	4.024E+02	1.998E+03	2.994E+06	2.012E+02
82	7.185E+03	5.754E+06	3.866E+02	1.919E+03	2.877E+06	1.933E+02
83	6.904E+03	5.528E+06	3.714E+02	1.844E+03	2.764E+06	1.857E+02
84	6.633E+03	5.311E+06	3.569E+02	1.772E+03	2.656E+06	1.784E+02
85	6.373E+03	5.103E+06	3.429E+02	1.702E+03	2.552E+06	1.714E+02
86	6.123E+03	4.903E+06	3.294E+02	1.636E+03	2.452E+06	1.647E+02
87	5.883E+03	4.711E+06	3.165E+02	1.571E+03	2.355E+06	1.583E+02
88	5.652E+03	4.526E+06	3.041E+02	1.510E+03	2.263E+06	1.521E+02
89	5.431E+03	4.349E+06	2.922E+02	1.451E+03	2.174E+06	1.461E+02
90	5.218E+03	4.178E+06	2.807E+02	1.394E+03	2.089E+06	1.404E+02
91	5.013E+03	4.014E+06	2.697E+02	1.339E+03	2.007E+06	1.349E+02
92	4.817E+03	3.857E+06	2.591E+02	1.287E+03	1.928E+06	1.296E+02
93	4.628E+03	3.706E+06	2.490E+02	1.236E+03	1.853E+06	1.245E+02
94	4.446E+03	3.560E+06	2.392E+02	1.188E+03	1.780E+06	1.196E+02
95	4.272E+03	3.421E+06	2.298E+02	1.141E+03	1.710E+06	1.149E+02
96	4.104E+03	3.287E+06	2.208E+02	1.096E+03	1.643E+06	1.104E+02
97	3.943E+03	3.158E+06	2.122E+02	1.053E+03	1.579E+06	1.061E+02
98	3.789E+03	3.034E+06	2.038E+02	1.012E+03	1.517E+06	1.019E+02
99	3.640E+03	2.915E+06	1.959E+02	9.724E+02	1.457E+06	9.793E+01
100	3.498E+03	2.801E+06	1.882E+02	9.342E+02	1.400E+06	9.409E+01
101	3.360E+03	2.691E+06	1.808E+02	8.976E+02	1.345E+06	9.040E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
102	3.229E+03	2.585E+06	1.737E+02	8.624E+02	1.293E+06	8.685E+01
103	3.102E+03	2.484E+06	1.669E+02	8.286E+02	1.242E+06	8.345E+01
104	2.980E+03	2.387E+06	1.604E+02	7.961E+02	1.193E+06	8.018E+01
105	2.864E+03	2.293E+06	1.541E+02	7.649E+02	1.146E+06	7.703E+01
106	2.751E+03	2.203E+06	1.480E+02	7.349E+02	1.102E+06	7.401E+01
107	2.643E+03	2.117E+06	1.422E+02	7.061E+02	1.058E+06	7.111E+01
108	2.540E+03	2.034E+06	1.366E+02	6.784E+02	1.017E+06	6.832E+01
109	2.440E+03	1.954E+06	1.313E+02	6.518E+02	9.770E+05	6.564E+01
110	2.344E+03	1.877E+06	1.261E+02	6.262E+02	9.387E+05	6.307E+01
111	2.253E+03	1.804E+06	1.212E+02	6.017E+02	9.019E+05	6.060E+01
112	2.164E+03	1.733E+06	1.164E+02	5.781E+02	8.665E+05	5.822E+01
113	2.079E+03	1.665E+06	1.119E+02	5.554E+02	8.325E+05	5.594E+01
114	1.998E+03	1.600E+06	1.075E+02	5.336E+02	7.999E+05	5.374E+01
115	1.919E+03	1.537E+06	1.033E+02	5.127E+02	7.685E+05	5.164E+01
116	1.844E+03	1.477E+06	9.922E+01	4.926E+02	7.384E+05	4.961E+01
117	1.772E+03	1.419E+06	9.533E+01	4.733E+02	7.094E+05	4.767E+01
118	1.702E+03	1.363E+06	9.160E+01	4.547E+02	6.816E+05	4.580E+01
119	1.636E+03	1.310E+06	8.800E+01	4.369E+02	6.549E+05	4.400E+01
120	1.572E+03	1.258E+06	8.455E+01	4.198E+02	6.292E+05	4.228E+01
121	1.510E+03	1.209E+06	8.124E+01	4.033E+02	6.045E+05	4.062E+01
122	1.451E+03	1.162E+06	7.805E+01	3.875E+02	5.808E+05	3.903E+01
123	1.394E+03	1.116E+06	7.499E+01	3.723E+02	5.581E+05	3.750E+01
124	1.339E+03	1.072E+06	7.205E+01	3.577E+02	5.362E+05	3.603E+01
125	1.287E+03	1.030E+06	6.923E+01	3.437E+02	5.152E+05	3.461E+01
126	1.236E+03	9.899E+05	6.651E+01	3.302E+02	4.950E+05	3.326E+01
127	1.188E+03	9.511E+05	6.390E+01	3.173E+02	4.755E+05	3.195E+01
128	1.141E+03	9.138E+05	6.140E+01	3.048E+02	4.569E+05	3.070E+01
129	1.096E+03	8.780E+05	5.899E+01	2.929E+02	4.390E+05	2.950E+01
130	1.053E+03	8.435E+05	5.668E+01	2.814E+02	4.218E+05	2.834E+01
131	1.012E+03	8.105E+05	5.446E+01	2.704E+02	4.052E+05	2.723E+01
132	9.724E+02	7.787E+05	5.232E+01	2.598E+02	3.893E+05	2.616E+01
133	9.343E+02	7.482E+05	5.027E+01	2.496E+02	3.741E+05	2.513E+01
134	8.977E+02	7.188E+05	4.830E+01	2.398E+02	3.594E+05	2.415E+01
135	8.625E+02	6.906E+05	4.640E+01	2.304E+02	3.453E+05	2.320E+01
136	8.287E+02	6.636E+05	4.458E+01	2.213E+02	3.318E+05	2.229E+01
137	7.962E+02	6.375E+05	4.284E+01	2.127E+02	3.188E+05	2.142E+01
138	7.650E+02	6.125E+05	4.116E+01	2.043E+02	3.063E+05	2.058E+01
139	7.350E+02	5.885E+05	3.954E+01	1.963E+02	2.943E+05	1.977E+01
140	7.061E+02	5.654E+05	3.799E+01	1.886E+02	2.827E+05	1.900E+01
141	6.785E+02	5.433E+05	3.650E+01	1.812E+02	2.716E+05	1.825E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1	0	0	0	0	0	0
2	1.303E+03	7.116E+05	4.781E+01	2.041E+01	5.693E+03	3.825E-01
3	2.964E+03	1.619E+06	1.088E+02	4.643E+01	1.295E+04	8.704E-01
4	4.913E+03	2.684E+06	1.803E+02	7.696E+01	2.147E+04	1.443E+00
5	6.932E+03	3.787E+06	2.544E+02	1.086E+02	3.029E+04	2.035E+00
6	8.923E+03	4.875E+06	3.275E+02	1.398E+02	3.900E+04	2.620E+00
7	1.088E+04	5.945E+06	3.994E+02	1.705E+02	4.756E+04	3.195E+00
8	1.276E+04	6.973E+06	4.685E+02	2.000E+02	5.578E+04	3.748E+00
9	1.457E+04	7.961E+06	5.349E+02	2.283E+02	6.369E+04	4.279E+00
10	1.631E+04	8.910E+06	5.986E+02	2.555E+02	7.128E+04	4.789E+00
11	1.798E+04	9.822E+06	6.599E+02	2.816E+02	7.857E+04	5.279E+00
12	1.958E+04	1.070E+07	7.188E+02	3.068E+02	8.558E+04	5.750E+00
13	2.112E+04	1.154E+07	7.753E+02	3.309E+02	9.231E+04	6.203E+00
14	2.260E+04	1.235E+07	8.297E+02	3.541E+02	9.878E+04	6.637E+00
15	2.403E+04	1.313E+07	8.819E+02	3.764E+02	1.050E+05	7.055E+00
16	2.539E+04	1.387E+07	9.320E+02	3.978E+02	1.110E+05	7.456E+00
17	2.670E+04	1.459E+07	9.802E+02	4.183E+02	1.167E+05	7.842E+00
18	2.797E+04	1.528E+07	1.027E+03	4.381E+02	1.222E+05	8.212E+00
19	2.918E+04	1.594E+07	1.071E+03	4.571E+02	1.275E+05	8.568E+00
20	3.034E+04	1.658E+07	1.114E+03	4.753E+02	1.326E+05	8.910E+00
21	3.146E+04	1.719E+07	1.155E+03	4.929E+02	1.375E+05	9.239E+00
22	3.254E+04	1.777E+07	1.194E+03	5.097E+02	1.422E+05	9.554E+00
23	3.357E+04	1.834E+07	1.232E+03	5.259E+02	1.467E+05	9.858E+00
24	3.456E+04	1.888E+07	1.269E+03	5.414E+02	1.510E+05	1.015E+01
25	3.552E+04	1.940E+07	1.304E+03	5.564E+02	1.552E+05	1.043E+01
26	3.643E+04	1.990E+07	1.337E+03	5.707E+02	1.592E+05	1.070E+01
27	3.731E+04	2.038E+07	1.370E+03	5.845E+02	1.631E+05	1.096E+01
28	3.816E+04	2.085E+07	1.401E+03	5.977E+02	1.668E+05	1.120E+01
29	3.897E+04	2.129E+07	1.430E+03	6.105E+02	1.703E+05	1.144E+01
30	3.975E+04	2.172E+07	1.459E+03	6.227E+02	1.737E+05	1.167E+01
31	4.050E+04	2.213E+07	1.487E+03	6.345E+02	1.770E+05	1.189E+01
32	3.891E+04	2.126E+07	1.428E+03	6.096E+02	1.701E+05	1.143E+01
33	3.739E+04	2.042E+07	1.372E+03	5.857E+02	1.634E+05	1.098E+01
34	3.592E+04	1.962E+07	1.318E+03	5.627E+02	1.570E+05	1.055E+01
35	3.451E+04	1.885E+07	1.267E+03	5.406E+02	1.508E+05	1.013E+01
36	3.316E+04	1.811E+07	1.217E+03	5.194E+02	1.449E+05	9.737E+00
37	3.186E+04	1.740E+07	1.169E+03	4.991E+02	1.392E+05	9.355E+00
38	3.061E+04	1.672E+07	1.124E+03	4.795E+02	1.338E+05	8.988E+00
39	2.941E+04	1.607E+07	1.079E+03	4.607E+02	1.285E+05	8.636E+00
40	2.826E+04	1.544E+07	1.037E+03	4.426E+02	1.235E+05	8.297E+00
41	2.715E+04	1.483E+07	9.965E+02	4.253E+02	1.186E+05	7.972E+00
42	2.608E+04	1.425E+07	9.574E+02	4.086E+02	1.140E+05	7.659E+00
43	2.506E+04	1.369E+07	9.199E+02	3.926E+02	1.095E+05	7.359E+00
44	2.408E+04	1.315E+07	8.838E+02	3.772E+02	1.052E+05	7.070E+00
45	2.313E+04	1.264E+07	8.491E+02	3.624E+02	1.011E+05	6.793E+00
46	2.223E+04	1.214E+07	8.159E+02	3.482E+02	9.714E+04	6.527E+00
47	2.136E+04	1.167E+07	7.839E+02	3.345E+02	9.333E+04	6.271E+00
48	2.052E+04	1.121E+07	7.531E+02	3.214E+02	8.967E+04	6.025E+00
49	1.971E+04	1.077E+07	7.236E+02	3.088E+02	8.616E+04	5.789E+00
50	1.894E+04	1.035E+07	6.952E+02	2.967E+02	8.278E+04	5.562E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
51	1.820E+04	9.941E+06	6.680E+02	2.851E+02	7.953E+04	5.344E+00
52	1.748E+04	9.552E+06	6.418E+02	2.739E+02	7.641E+04	5.134E+00
53	1.680E+04	9.177E+06	6.166E+02	2.632E+02	7.342E+04	4.933E+00
54	1.614E+04	8.817E+06	5.924E+02	2.528E+02	7.054E+04	4.739E+00
55	1.551E+04	8.472E+06	5.692E+02	2.429E+02	6.777E+04	4.554E+00
56	1.490E+04	8.139E+06	5.469E+02	2.334E+02	6.511E+04	4.375E+00
57	1.431E+04	7.820E+06	5.254E+02	2.242E+02	6.256E+04	4.203E+00
58	1.375E+04	7.514E+06	5.048E+02	2.155E+02	6.011E+04	4.039E+00
59	1.321E+04	7.219E+06	4.850E+02	2.070E+02	5.775E+04	3.880E+00
60	1.270E+04	6.936E+06	4.660E+02	1.989E+02	5.549E+04	3.728E+00
61	1.220E+04	6.664E+06	4.477E+02	1.911E+02	5.331E+04	3.582E+00
62	1.172E+04	6.403E+06	4.302E+02	1.836E+02	5.122E+04	3.442E+00
63	1.126E+04	6.152E+06	4.133E+02	1.764E+02	4.921E+04	3.307E+00
64	1.082E+04	5.910E+06	3.971E+02	1.695E+02	4.728E+04	3.177E+00
65	1.039E+04	5.679E+06	3.815E+02	1.628E+02	4.543E+04	3.052E+00
66	9.987E+03	5.456E+06	3.666E+02	1.565E+02	4.365E+04	2.933E+00
67	9.596E+03	5.242E+06	3.522E+02	1.503E+02	4.194E+04	2.818E+00
68	9.219E+03	5.036E+06	3.384E+02	1.444E+02	4.029E+04	2.707E+00
69	8.858E+03	4.839E+06	3.251E+02	1.388E+02	3.871E+04	2.601E+00
70	8.510E+03	4.649E+06	3.124E+02	1.333E+02	3.719E+04	2.499E+00
71	8.177E+03	4.467E+06	3.001E+02	1.281E+02	3.574E+04	2.401E+00
72	7.856E+03	4.292E+06	2.884E+02	1.231E+02	3.433E+04	2.307E+00
73	7.548E+03	4.124E+06	2.771E+02	1.182E+02	3.299E+04	2.216E+00
74	7.252E+03	3.962E+06	2.662E+02	1.136E+02	3.169E+04	2.130E+00
75	6.968E+03	3.806E+06	2.558E+02	1.092E+02	3.045E+04	2.046E+00
76	6.695E+03	3.657E+06	2.457E+02	1.049E+02	2.926E+04	1.966E+00
77	6.432E+03	3.514E+06	2.361E+02	1.008E+02	2.811E+04	1.889E+00
78	6.180E+03	3.376E+06	2.268E+02	9.681E+01	2.701E+04	1.815E+00
79	5.938E+03	3.244E+06	2.179E+02	9.301E+01	2.595E+04	1.744E+00
80	5.705E+03	3.116E+06	2.094E+02	8.937E+01	2.493E+04	1.675E+00
81	5.481E+03	2.994E+06	2.012E+02	8.586E+01	2.395E+04	1.609E+00
82	5.266E+03	2.877E+06	1.933E+02	8.250E+01	2.302E+04	1.546E+00
83	5.060E+03	2.764E+06	1.857E+02	7.926E+01	2.211E+04	1.486E+00
84	4.861E+03	2.656E+06	1.784E+02	7.615E+01	2.125E+04	1.427E+00
85	4.671E+03	2.552E+06	1.714E+02	7.317E+01	2.041E+04	1.372E+00
86	4.488E+03	2.452E+06	1.647E+02	7.030E+01	1.961E+04	1.318E+00
87	4.312E+03	2.355E+06	1.583E+02	6.754E+01	1.884E+04	1.266E+00
88	4.142E+03	2.263E+06	1.521E+02	6.489E+01	1.810E+04	1.216E+00
89	3.980E+03	2.174E+06	1.461E+02	6.235E+01	1.739E+04	1.169E+00
90	3.824E+03	2.089E+06	1.404E+02	5.990E+01	1.671E+04	1.123E+00
91	3.674E+03	2.007E+06	1.349E+02	5.756E+01	1.606E+04	1.079E+00
92	3.530E+03	1.928E+06	1.296E+02	5.530E+01	1.543E+04	1.037E+00
93	3.392E+03	1.853E+06	1.245E+02	5.313E+01	1.482E+04	9.959E-01
94	3.259E+03	1.780E+06	1.196E+02	5.105E+01	1.424E+04	9.569E-01
95	3.131E+03	1.710E+06	1.149E+02	4.905E+01	1.368E+04	9.194E-01
96	3.008E+03	1.643E+06	1.104E+02	4.712E+01	1.315E+04	8.833E-01
97	2.890E+03	1.579E+06	1.061E+02	4.528E+01	1.263E+04	8.487E-01
98	2.777E+03	1.517E+06	1.019E+02	4.350E+01	1.214E+04	8.154E-01
99	2.668E+03	1.457E+06	9.793E+01	4.179E+01	1.166E+04	7.834E-01
100	2.563E+03	1.400E+06	9.409E+01	4.016E+01	1.120E+04	7.527E-01
101	2.463E+03	1.345E+06	9.040E+01	3.858E+01	1.076E+04	7.232E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
102	2.366E+03	1.293E+06	8.685E+01	3.707E+01	1.034E+04	6.948E-01
103	2.273E+03	1.242E+06	8.345E+01	3.561E+01	9.936E+03	6.676E-01
104	2.184E+03	1.193E+06	8.018E+01	3.422E+01	9.546E+03	6.414E-01
105	2.099E+03	1.146E+06	7.703E+01	3.288E+01	9.172E+03	6.163E-01
106	2.016E+03	1.102E+06	7.401E+01	3.159E+01	8.812E+03	5.921E-01
107	1.937E+03	1.058E+06	7.111E+01	3.035E+01	8.467E+03	5.689E-01
108	1.861E+03	1.017E+06	6.832E+01	2.916E+01	8.135E+03	5.466E-01
109	1.788E+03	9.770E+05	6.564E+01	2.802E+01	7.816E+03	5.251E-01
110	1.718E+03	9.387E+05	6.307E+01	2.692E+01	7.509E+03	5.046E-01
111	1.651E+03	9.019E+05	6.060E+01	2.586E+01	7.215E+03	4.848E-01
112	1.586E+03	8.665E+05	5.822E+01	2.485E+01	6.932E+03	4.658E-01
113	1.524E+03	8.325E+05	5.594E+01	2.387E+01	6.660E+03	4.475E-01
114	1.464E+03	7.999E+05	5.374E+01	2.294E+01	6.399E+03	4.300E-01
115	1.407E+03	7.685E+05	5.164E+01	2.204E+01	6.148E+03	4.131E-01
116	1.352E+03	7.384E+05	4.961E+01	2.117E+01	5.907E+03	3.969E-01
117	1.299E+03	7.094E+05	4.767E+01	2.034E+01	5.675E+03	3.813E-01
118	1.248E+03	6.816E+05	4.580E+01	1.955E+01	5.453E+03	3.664E-01
119	1.199E+03	6.549E+05	4.400E+01	1.878E+01	5.239E+03	3.520E-01
120	1.152E+03	6.292E+05	4.228E+01	1.804E+01	5.034E+03	3.382E-01
121	1.107E+03	6.045E+05	4.062E+01	1.734E+01	4.836E+03	3.250E-01
122	1.063E+03	5.808E+05	3.903E+01	1.666E+01	4.647E+03	3.122E-01
123	1.022E+03	5.581E+05	3.750E+01	1.600E+01	4.464E+03	3.000E-01
124	9.815E+02	5.362E+05	3.603E+01	1.538E+01	4.289E+03	2.882E-01
125	9.430E+02	5.152E+05	3.461E+01	1.477E+01	4.121E+03	2.769E-01
126	9.060E+02	4.950E+05	3.326E+01	1.419E+01	3.960E+03	2.660E-01
127	8.705E+02	4.755E+05	3.195E+01	1.364E+01	3.804E+03	2.556E-01
128	8.364E+02	4.569E+05	3.070E+01	1.310E+01	3.655E+03	2.456E-01
129	8.036E+02	4.390E+05	2.950E+01	1.259E+01	3.512E+03	2.360E-01
130	7.721E+02	4.218E+05	2.834E+01	1.209E+01	3.374E+03	2.267E-01
131	7.418E+02	4.052E+05	2.723E+01	1.162E+01	3.242E+03	2.178E-01
132	7.127E+02	3.893E+05	2.616E+01	1.116E+01	3.115E+03	2.093E-01
133	6.847E+02	3.741E+05	2.513E+01	1.073E+01	2.993E+03	2.011E-01
134	6.579E+02	3.594E+05	2.415E+01	1.031E+01	2.875E+03	1.932E-01
135	6.321E+02	3.453E+05	2.320E+01	9.902E+00	2.763E+03	1.856E-01
136	6.073E+02	3.318E+05	2.229E+01	9.514E+00	2.654E+03	1.783E-01
137	5.835E+02	3.188E+05	2.142E+01	9.141E+00	2.550E+03	1.713E-01
138	5.606E+02	3.063E+05	2.058E+01	8.782E+00	2.450E+03	1.646E-01
139	5.386E+02	2.943E+05	1.977E+01	8.438E+00	2.354E+03	1.582E-01
140	5.175E+02	2.827E+05	1.900E+01	8.107E+00	2.262E+03	1.520E-01
141	4.972E+02	2.716E+05	1.825E+01	7.789E+00	2.173E+03	1.460E-01