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Pollutant Emissions Test Report
McGill Enclosed Flare Exhaust
(EUENCLOSEDFLARE2-S2)

BFI Waste Services of North America, LLC
Northville, Michigan
SRN: N2688

August 3, 2016

Prepared for:
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EXECUTIVE SUMMARY

BFI Waste Services of North America, LLC (BFI) retained Air Quality Specialist, Inc. (AQSI) to conduct tests to measure the non-methane organic compound (NMOC), oxides of nitrogen (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen chloride (HCl), and volatile organic compound (VOC) concentrations, and calculate emissions rates, from one enclosed flare exhaust stack, identified as EUENCLOSEDFLARE2-S2, located at Arbor Hills Landfill in Northville, Michigan.

The purpose of the test program was to measure the pollutant emission rates from the enclosed flare for comparison to the emissions limitations contained in Michigan Department of Environmental Quality (MDEQ) Permit-to-Install (PTI) No. 179-13, and to measure NMOC and diluent concentrations to determine compliance with 40 *Code of Federal Regulations* (CFR), Part 60, Subpart WWW, 60.752(b)(2)(iii)(B), while the flare operated at the current maximum sustainable landfill gas flow rate.

AQSI conducted the fieldwork on June 8, 2016, and in accordance with the test plan, dated May 23, 2016. Mr. Mark Dziadosz with MDEQ reviewed and approved the test plan. Mr. Andrew Secord AQSI, and Mr. Steve Smith, Mr. Brandon Chase, and Mr. Sean Devereux with BTEC, Inc., conducted the field tests. Mr. Dziadosz and Ms. Dianne Kavanaugh-Vetort with MDEQ witnessed the bulk of the field test program.

The test results and compliance limits were:

Parameter	Result	Limit	Status
Exhaust NMOC Concentration (ppmv) – dry basis, as hexane, corrected to 3% oxygen	1.1	20.0	PASS
Exhaust NOx Emission Rate (lb/hr)	2.62	20.0	PASS
Exhaust NOx Emission Rate (tpy)	11.5	87.6	PASS
Exhaust CO Emission Rate (lb/hr)	2.29	27.6	PASS
Exhaust CO Emission Rate (tpy)	10.1	121	PASS
Exhaust SO_2 Emission Rate (lb/hr)	6.50	24.9	PASS
Exhaust SO_2 Emission Rate (tpy)	28.5	109	PASS
Exhaust HCl Emission Rate (lb/hr)	0.01	6.0	PASS
Exhaust HCl Emission Rate (tpy)	0.03	26.1	PASS
Exhaust VOC Emission Rate (lb/hr)	0.19	7.1	PASS
Exhaust VOC Emission Rate (tpy)	0.84	31.2	PASS

ppmv: Parts per million, volume basis
lb/hr: Pounds per hour
tpy: Tons per year

1.0 INTRODUCTION

BFI Waste Services of North America, LLC (BFI) retained Air Quality Specialist, Inc. (AQSI) to conduct tests to measure the non-methane organic compound (NMOC), oxides of nitrogen (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen chloride (HCl), and volatile organic compound (VOC) concentrations, and calculate emissions rates, from one enclosed flare exhaust stack, identified as EUENCLOSEDFLARE2-S2, located at Arbor Hills Landfill in Northville, Michigan.

The purpose of the test program was to measure the pollutant emission rates from the enclosed flare for comparison to the emissions limitations contained in Michigan Department of Environmental Quality (MDEQ) Permit-to-Install (PTI) No. 179-13, and to measure NMOC and diluent concentrations to determine compliance with 40 *Code of Federal Regulations* (CFR), Part 60, Subpart WWW, 60.752(b)(2)(iii)(B), while the flare operated at the current maximum sustainable landfill gas flow rate.

The test program consisted of 40 CFR 60, Appendix A, United States Environmental Protection Agency (USEPA) Reference Test Methods 1, 2B, 2C, 3A, 3C, 4, 6C, 7E, 10, 25A, 25C, 26, and 205.

AQSI conducted the fieldwork on June 8, 2016, and in accordance with the test plan, dated May 23, 2016. Mr. Mark Dziadosz with MDEQ reviewed and approved the test plan. Mr. Andrew Secord with AQSI, and Mr. Steve Smith, Mr. Brandon Chase, and Mr. Sean Devereux with BTEC, Inc., conducted the field tests. Mr. Dziadosz with MDEQ witnessed the bulk of the field test program. Mr. Chad Miller with Monitoring, Control, and Compliance, Inc. (MCC) supported flare operations, on behalf of BFI.

The name, address, and telephone number of the primary contact for further information about the tests and this test report is:

Name and Title	Company	Telephone
Mr. Andrew Secord Environmental Scientist	Air Quality Specialist, Inc. 672 N. Milford Road, Suite 152 Highland, Michigan 48357	(248) 887-7565

The name, address, and telephone number of the primary contact for further information about the enclosed flare is:

Name and Title	Company	Telephone/Fax
Ms. Christina Bossick Environmental Manager	BFI 5011 S. Lilley Road Canton, Michigan 48188	(734) 397-2790

2.0 SUMMARY OF RESULTS

AQSI measured pollutant concentrations from the McGill enclosed flare exhaust stack (EUENCLOSEDFLARE2-S2) on June 7 and 8, 2016.

AQSI (BTEC) performed a verification of the calibration gas divider on June 7, 2016, in accordance with USEPA Method 205. The gas divider produced gas concentrations with less than 1% variability between triplicate gas dilutions, and generated a gas concentration that was accurate to within 1% of a Protocol 1 gas standard. The method criteria is less than 2% difference between dilutions, and less than 2% difference between the average dilution response and the Protocol 1 gas standard. The results demonstrate that the gas divider met the validation requirements of USEPA Method 205.

AQSI conducted preliminary measurements of the McGill enclosed flare exhaust stack on June 7, 2016. The purpose of the preliminary tests was to obtain baseline concentrations to verify instrument spans, conduct a stratification test, and conduct the NOx analyzer converter check. The flare was initially operated at approximately 4,100 standard cubic feet per minute (scfm), and at various combustion chamber set-point temperatures ranging from 1,650 °F to 1,825 °F.

Exhaust concentrations (primarily CO and diluent) were observed to vary from point-to-point, with CO frequently over-ranging the instrument span. This over-ranging occurred at every stepwise increase in set-point temperature, albeit to lesser degree.

AQSI conferred with BFI and suggested lowering the flow rate. Flow rate was reduced to approximately 3,600 scfm, the combustion chamber set-point temperature was reduced to 1,800 °F, and several stratification points were re-monitored.

These results demonstrated that the exhaust stack concentration profile was still stratified (i.e., individual points >10% of the mean concentration), thus necessitating 12-point traverses during the compliance tests, but the CO was no longer over-ranging.

AQSI conducted compliance pollutant (NMOC, NOx, CO, SO_2, HCL, and VOC) and diluent emission rate tests required by PTI 179-13 on June 8, 2016. BFI operated the enclosed flare at the current maximum sustainable landfill gas flow rate (approximately 3,700 scfm per USEPA Method 2 measurements, or 3,245 scfm per the installed process flow meters), and at a combustion chamber set-point temperature of 1,800 °F, as controlled off the bottom thermocouple (1,700 °F as recorded from the top thermocouple), for this series of tests.

The test results and compliance limits were:

Parameter	Result	Limit	Status
Exhaust NMOC Concentration (ppmv) – dry basis, as hexane, corrected to 3% oxygen	1.1	20.0	PASS
Exhaust NOx Emission Rate (lb/hr)	2.62	20.0	PASS
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Exhaust CO Emission Rate (lb/hr)	2.29	27.6	PASS
Exhaust CO Emission Rate (tpy)	10.1	121	PASS
Exhaust SO_2 Emission Rate (lb/hr)	6.50	24.9	PASS
Exhaust SO_2 Emission Rate (tpy)	28.5	109	PASS
Exhaust HCl Emission Rate (lb/hr)	0.01	6.0	PASS
Exhaust HCl Emission Rate (tpy)	0.03	26.1	PASS
Exhaust VOC Emission Rate (lb/hr)	0.19	7.1	PASS
Exhaust VOC Emission Rate (tpy)	0.84	31.2	PASS

ppmv: Parts per million, volume basis
lb/hr: Pounds per hour
tpy: Tons per year

The test results demonstrate that the enclosed flare meets the permitted pound per hour (lb/hr) and ton per year (tpy) emission limits for all pollutants at the tested flow rate and combustion chamber set-point temperature (3,700 scfm and 1,800 °F, respectively).

In addition, the average exhaust NMOC concentration was 1.1 parts per million (ppm), dry basis as hexane corrected to 3 percent oxygen. The emissions limit is an exhaust concentration less than 20 ppm by volume, dry basis as hexane, at 3 percent oxygen [40 CFR 60.752(b)(2)(iii)(B)]. The test results demonstrate that the enclosed flare meets the emission limit of 60.752(b)(2)(iii)(B) while operating at the current, maximum sustainable flow rate of 3,700 scfm, and with combustion chamber temperature controlled at 1,800 °F, by the bottom thermocouple.

3.0 SOURCE DESCRIPTION

Arbor Hills Landfill is an active municipal solid waste (MSW) landfill. Anaerobic bacteria decompose the emplaced waste. By-products of decomposition are methane (~45-55%, typical) and carbon dioxide (~30-40%, typical), with minor amounts of nitrogen (~15%, typical) and oxygen (<2%, typical), and trace amounts of other volatile organic compounds.

BFI employs a gas collection and control system to meet the requirements of Subpart WWW. Gas collection wells are installed in a grid pattern about the landfill. The wells are connected to a common header system. A blower produces a vacuum on the well field. Collected gas is routed to a third-party landfill gas-to-energy (LFGTE) plant. The McGill enclosed flare (EUENCLOSEDFLARE2-S2) serves as a back-up control device.

Landfill gas is delivered to a common header manifold by the blowers. The header manifold delivers landfill gas to the enclosed flare inlet via two (2) 11.25" ducts ('east' and 'west'). Each inlet duct is equipped with a process flow meter.

The enclosed flare exhaust stack is 136 inches inside diameter, and approximately 50 feet tall. The test ports are approximately 42 feet above ground level, and approximately 30 feet downstream from the nearest disturbance or bend (burner tips).

The enclosed flare EUENCLOSEDFLARE2-S2 was believed to be designed to meet the requirements of 60.753(b)(2)(iii) at a flow rate up to 4,600 scfm. On June 7, 2016, during preliminary measurements, a flow rate no greater than 4,100 scfm could be achieved with the gas blowers full open, which was likely due to the LFGTE plant operating during the same period of time. Furthermore, CO concentrations over-ranged at several stratification test traverse points at this flow rate, regardless of set-point temperature.

Based on these observations, flow rate was reduced to approximately 3,600 scfm in the latter part of June 7, 2016, and the June 8, 2016, compliance tests were run at 3,700 scfm. A flow rate of 3,700 scfm should be considered the maximum flow rate.

The combustion chamber temperature and landfill gas flow to the burner of the enclosed flare is monitored and recorded at least once every 15 minutes. The enclosed flare is equipped with an automatic shutdown that activates if the minimum combustion chamber set-point temperature cannot be maintained.

The enclosed flare flow rate data from process flow meter recorder and manually recorded panel data, for June 7 and 8, 2016, is presented in Appendix A.

AQSI notes that only one (1) of the two (2) installed process flow meters (i.e., the unit serving the east inlet duct) was actually being recorded by the panel software.

In addition, each flow meter displayed flow rates that are approximately 210 to 250 scfm less than those measured by USEPA Method 2, for their respective ducts, and yielded a combined average difference of 450 scfm less than the Method 2 results.

AQSI notes that the Method 2 measurements were consistent and repeatable, the flow meters data was consistent and repeatable, and the difference between the Method 2 results and the flow meter results was consistent and repeatable, from test to test.

4.0 SAMPLE AND ANALYTICAL PROCEDURES

AQSI performed measurements in accordance with procedures specified in USEPA *Standards of Performance for New Stationary Sources* Reference Test Methods. The sample collection and analytical methods used in the test program are indicated in the table below.

Sample Method	Parameter	Analytical Method
USEPA Method 1 & 2C	Velocity and flow rate (inlet)	Field Data
USEPA Method 2B	Velocity and flow rate (exhaust)	Mass Balance
USEPA Method 3A	Oxygen and carbon dioxide	Instrument Analyzer(s)
USEPA Method 3C	Landfill gas composition and inlet moisture content	Gas Chromatography / Thermal Conductivity Detector (GC/TCD)
USEPA Method 4	Exhaust moisture content	Field Data
USEPA Method 6C	Sulfur dioxide	Ultra-violet (UV) Analyzer
USEPA Method 7E	Oxides of nitrogen	Chemiluminescence Analyzer
USEPA Method 10	Carbon monoxide	Non-dispersive Infrared (NDIR) Analyzer
USEPA Method 25A	Non-methane organic compounds (as total hydrocarbons – methane) and volatile organic compounds	Flame Ionization Analyzer (FIA)
USEPA Method 25C	Organic carbon (inlet)	Gas Chromatography / Flame Ionization Detector (GC/FID)
USEPA Method 26	Hydrogen chloride (inlet)	Ion Chromatography
USEPA Method 205	Gas divider verification	Precision and repeatability

AQSI used USEPA Method 1, *"Sample and Velocity Traverses for Stationary Sources,"* to determine the appropriate number and location of traverse points on the enclosed flares two (2) inlet ducts. AQSI calculated the traverse point locations by dividing the stack cross-section into equal areas (one traverse point for each area). The number of traverse points were determined by the distance to the nearest upstream and downstream flow disturbance, in equivalent stack diameters from the sample ports. Figure 1 depicts the inlet ducts traverse points.

AQSI used USEPA Method 2C, *"Determination of Stack Gas Velocity and Volumetric Flow Rate in Small Stacks and Ducts (Standard Pitot Tube),"* to measure velocity pressures and temperatures at each traverse point. AQSI used a standard pitot tube, with a coefficient of 0.99, positioned at each inlet traverse point. The velocity pressure and gas temperature were measured and recorded. Velocity pressure measurements were read from an inclined water-column manometer with increments of 0.01 inch of water. Temperature measurements were made with a pyrometer and thermocouple probe.

The average stack gas velocity is a function of the average velocity pressure, absolute stack gas pressure, average stack gas temperature, molecular weight of the wet stack gas, and pitot tube coefficient. The derivation of the average stack gas velocity was calculated using the equations stipulated in this test method. The actual stack gas flow rate was calculated using the average stack gas velocity and the cross-sectional area of the stack.

AQSI conducted velocity measurements on the 'east' and 'west' inlet ducts, during each pollutant emissions test. The individual measured flow rates were summed to calculate total inlet flow rate.

AQSI used USEPA Method 2B, *"Determination of Exhaust gas Volume Flow Rate from Gasoline Vapor Incinerators,"* to calculate the enclosed flare exhaust flow rate. The ratio of total organic carbon at the flare inlet and outlet was multiplied by the combined inlet volume to determine the exhaust volume flow rate. This method is applicable because there is not sufficient exhaust gas volume on the flare outlet to register a differential pressure on an inclined manometer. The exhaust volume flow rate data was used to calculate pollutant emission rates.

AQSI used Method 3C, *"Determination of Carbon Dioxide, Methane, Nitrogen, and Oxygen from Stationary Sources,"* and Method 25C *"Determination of Non-methane Organic Compounds in Landfill Gases,"* to determine the landfill gas composition and organic carbon (OC) concentrations. AQSI collect three, 60-minute, integrated samples of landfill gas from the McGill enclosed flare inlet.

AQSI submitted the samples to Triangle Environmental Services, Inc. (TES), Hillsborough, North Carolina, to analyze each sample for carbon dioxide, (CO_2), methane (CH_4), nitrogen (N_2), oxygen (O_2), and NMOC concentration. The OC concentration data was used for Method 2B exhaust volume flow rate calculations. Inlet moisture fraction was obtained from the Method 3C water vapor and barometric pressures. Figure 2 depicts the USEPA Method 3C/25C sample train.

AQSI used USEPA Method 3A, "*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrument Analyzer Procedure),*" to measure exhaust gas O_2 and CO_2 concentration. The O_2 data was used for the correction of the measured NMOC concentration to dry basis, as hexane at 3 percent oxygen, per 60.752(b)(2)(iii(B). The CO_2 data was used for Method 2B exhaust volume flow rate calculations. Figures 3 and 4 depict the enclosed flare exhaust stack and instrument analyzers probe traverse points.

AQSI used USEPA Method 4, "*Determination of Moisture Content in Stack Gases,*" to measure exhaust gas moisture content. The moisture data was used to correct the exhaust gas NMOC concentration to dry-basis, and to correct the Method 2B exhaust scfm to dry standard cubic feet per minute (dscfm) for the other pollutant emission rates.

AQSI collected the Method 4 samples in triplicate, concurrent with the other pollutant sample collection. The Method 4 sample train (Figure 5) consisted of an unheated stainless steel probe, a length of Tygon tubing, the impingers, a sample umbilical line, a calibrated dry-gas meter, and pump. The gas sample was extracted from the stack at a fixed sample rate. The first two impingers were loaded with 100 milliliters (mL) of water, the third impinger was dry, and the last impinger was loaded with silica gel.

AQSI measured the impinger contents and re-weighed the silica gel, for moisture content calculation, after each test.

The Method 4 sample train was leaked-check prior to, and immediately after each moisture sample run in accordance with Method 5, Sections 8.4.2 and 8.4.4, respectively.

AQSI used USEPA Method 6C, "*Determination of Sulfur Dioxide Emissions from Stationary Sources (Instrument Analyzer Procedure),*" to measure exhaust gas SO_2 concentration, Method 7E, "*Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrument Analyzer Procedure),*" to measure exhaust NO_x concentration, and Method 10, "*Determination of Carbon Monoxide Emissions from Stationary Sources,*" to measure exhaust gas CO concentration.

The Method 3A / 6C / 7E / 10 sample train (Figure 6) consisted of a stainless steel probe, a Teflon® sample line maintained at ~275°F, a non-contact thermoelectric sample conditioner to remove moisture, a sample pump, a bypass manifold, and the four (O_2 & CO_2, SO2, NOx, and CO) instrument analyzers.

AQSI had estimated the approximate maximum average pollutant gas concentrations, in parts per million (ppm) as each respective pollutant, that met the emission limit criteria of the PTI by back-calculation from the lb/hr limit, and the estimated exhaust gas flow rate. AQSI operated each analyzer in the lowest fixed instrument range that provided both the best data resolution and also preserved any short-term or intermittent concentration spikes.

AQSI calibrated the 3A / 6C / 7E / 10 analyzers with three gases in the 0 – 100 percent of span for O_2 (range: 0 – 20 percent), CO_2 (range: 0 – 20 percent), SO2 (range: 0 – 90 ppm), NOx (range: 0 – 90 ppm), and CO (range: 0 – 450 ppm).

AQSI used an Environics computerized multi-gas calibrator ('gas divider') to dilute an available parameter-specific USEPA Protocol I calibration gas standard to produce gas concentrations that represent 80 – 100 percent and 40 – 60 percent of the selected instrument span for the pollutant and diluent measurement ranges. AQSI used a "Nitrogen Zero Air" (99.99% nitrogen) gas standard that represented less than 0.25 percent of each instrument span as the "zero air" and dilution gas.

The O_2 / CO_2 / SO_2 / NOx / CO concentration measurement system met the analyzer calibration error, sample system bias, and drift error requirements of Method 7E (i.e., Sections 8.2.3, 8.2.5, and 8.5).

AQSI used USEPA Method 25A, *"Determination of Total Gaseous Organic Concentration and Methane Concentration Using a Flame Ionization Analyzer (FIA),"* to measure the exhaust gas NMOC and VOC concentration. Figure 7 depicts the Method 25A sample train.

AQSI used a methane/non-methane hydrocarbon analyzer to measure stack gas total hydrocarbon and methane concentrations. The analyzer is equipped with dual flame ionization detectors. The first detector ionizes all hydrocarbons (including methane) in the sample stream, and produces a voltage signal proportional to the hydrocarbon concentration. The second detector is equipped with a catalyst that removes all hydrocarbons except methane. NMOC is the arithmetic difference between the total hydrocarbon concentration and the methane-only concentration.

AQSI calibrated each FIA detector with four gases in the 0 – 100 ppm range propane / methane: "Hydrocarbon Free Air" (<0.1 ppm methane), and three USEPA Protocol 1 propane / methane gas standards that represent 80 – 90 percent, 45 – 55 percent, and 25 – 35 percent of the analyzers 0 – 100 ppm range, respectively.

AQSI planned to report the NMOC concentration as the instantaneous difference between the total hydrocarbons (as methane), minus the methane, concentration. AQSI has chosen to report NMOC as total hydrocarbons, as propane, in accordance with good engineering practice, since 1) the total hydrocarbon detector was calibrated with propane, and 2), the total hydrocarbon and methane signals were relatively indistinguishable from each other, due to very low in-stack concentrations.

AQSI reports NMOC exhaust concentration, corrected to dry basis as hexane, at 3 percent oxygen, for comparison to 60.752(b)(2)(iii)(B) of the NSPS.

The NMOC sample system met all calibration error, linearity, and drift error requirements of Section 8.4 of Method 25A. Section 6.1.1 of Method 25A requires the instrument detector be operated at a temperature of >120°C (>250°F). AQSI maintained the FID detector block at a temperature of 190° ± 5°C (~375°F), per manufacturer guidelines. Section 6.1.3 of Method 25A requires the heated sample line to be operated at a temperature >110°C (230°F). AQSI operated and maintained all heated sample lines at 275°F (or higher) to prevent condensation of NMOC.

The pollutant and diluent concentrations from each instrument analyzer, as an analog (voltage) signal, were sent to the data acquisition system (DAS), where the signal output was recorded at 4-second intervals. The pollutant and diluent concentration results were averaged based on the overall duration of the test.

AQSI subcontractor (BTEC) imported the raw text files produced by the DAS into Microsoft® Excel, and then broke out test run and calibration drift data into individual sheets (tabs). AQSI used Excel to reduce the raw run data into 1-minute averages, per MDEQ request.

AQSI drift-corrected the average pollutant and diluent concentrations (except NMOC / VOC) to carry out pollutant emission rate calculations.

AQSI used USEPA Method 26, "*Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources (Non-Isokinetic Method)*," to measure exhaust gas HCl mass. The Method 26 sample train (Figure 8) consisted of a short length of unheated Teflon tubing (probe), the impingers, a sample umbilical line, a calibrated dry-gas meter, and pump. The gas sample was extracted from the stack at a fixed sample rate. The first two impingers were each loaded with 15 milliliters (mL) of 0.1 N H_2SO_4, the third impinger was dry, and the last impinger was loaded with silica gel.

AQSI measured the impinger contents and re-weighed the silica gel, for moisture content calculation, after each test. The contents of the first two impingers were placed into a sample container. The first two impingers, and the first impinger U-tube were rinsed with de-ionized water. The rinses were placed in the same container as the first two impinger catch contents. The sample container was sealed, labeled, and the liquid level marked. The samples were sent to Maxxam Analytics International Corporation for HCl analysis.

The third and fourth impinger contents were measured (for moisture content), but were not retained or analyzed (the only analyte of interest, HCl, was obtained from the first two impingers' contents).

The Method 26 sample train was leaked-check prior to, and immediately after each HCl sample run in accordance with Method 26.

The laboratory reported HCl results in units of mass (micrograms, µg). AQSI converted the reported mass to a concentration, milligrams per cubic meter (mg/m^3), by division of the reported mass by the corrected sample volume. The concentration was multiplied by the combined inlet flow rates, corrected to dry standard cubic feet per minute (dscfm), and coefficients, to obtain HCl emission rate to the flare, in pounds per hour (lb/hr). Combustion does not destroy chloride ions; the inlet HCl mass emission rate is equal to the exhaust HCl mass emission rate.

AQSI used USEPA Method 205, *"Verification of Gas Dilution Systems for Field Instrument Calibrations,"* to demonstrate that the gas divider accurately and repeatedly provides known concentrations of calibration gas by controlled dilution of a known Protocol 1 gas standard.

AQSI validated the gas divider by initial calibration of one instrument analyzer in a selected span range with blended gas standards, and then challenged the analyzer with a known Protocol 1 concentration, in accordance with USEPA Method 205. The challenge was repeated three times with the same generated concentrations for the initial verification. The measured concentrations were averaged.

The gas dilution system was deemed acceptable since no single response differed by more than 2 percent from the average instrument response, and, the average instrument response was within 2 percent of the predicted response.

The gas dilution system met the precision and accuracy requirements of Method 205.

5.0 RESULTS AND DISCUSSION

AQSI demonstrated the gas dilution system performance on June 7, 2016. AQSI chose to demonstrate the gas divider with the Method 25A FID, due to the inherent linearity of the FID. AQSI zeroed the FID with the "Hydrocarbon Free Zero Air" standard, and set the instrument span with a 89.4 ppm generated propane gas standard.

AQSI challenged the FID, in triplicate, with the generated dilutions. The instrument response to the triplicate 89.4 ppm dilutions was 89.3 ppm, 89.4 ppm, and 89.3 ppm, respectively. The instrument response to the triplicate 49.6 ppm dilutions was 49.7 ppm, 49.3 ppm, and 49.4 ppm, respectively.

The results demonstrate that all individual injections agree to within 0.6 % of the average response to each dilution, and that the average responses agreed to within 0.3 % to each dilution. The acceptance criteria are within 2 % for both parameters.

The FID was then challenged in triplicate with a 90.7 ppm Protocol 1 propane gas standard to check the accuracy of the dilution. The instrument response to the triplicate 90.7 ppm Protocol 1 propane standard was 90.8 ppm, 90.9 ppm, and 90.9 ppm, respectively. The average instrument response to the 90.7 ppm Protocol 1 gas standard was 90.9 ppm.

The results demonstrate that all individual injections agree to within 0.3 % of the average response to the 90.5 ppm standard, and that the average response (90.9 ppm) was within 0.2 % of the 90.7 ppm standard. The acceptance criterion is within 2% agreement.

These results demonstrate that the gas divider met the verification criteria of Method 205.

AQSI conducted Stratification Tests in accordance with Section 8.1.2 of Method 7E on June 7, 2016. AQSI measured the diluent (O_2) concentration at each of 6 points in the enclosed flare exhaust, and from two (2) accessible test ports (east and south), for a total of 12 points. The stratification test results demonstrated that the stack was stratified (i.e., >10% stratified, per diluent (O_2) results), and Compliance Test Runs No. 1, 2, and 3 on June 8, 2016, were collected along a 6-point traverse from each the west and south test ports (12-points, total).

AQSI conducted NMOC concentration and NOx, CO, SO_2, HCl, and VOC emissions rate tests required PTI No. 179-13 on June 8, 2016.

BFI operated the enclosed flare at an approximate average landfill gas flow rate of 3,245 scfm as measured by the installed process flow meters, or approximately 3,700 scfm as measured by Method 2, and at a combustion chamber set-point temperature of 1,800 °F, for this series of tests.

Per agreement between AQSI and MDEQ, all exhaust mass emission rates were calculated from the higher inlet flow rate (i.e., Method 2 results), as this produces the highest exhaust gas flow rate and emission rates.

On June 8, 2016, the average NMOC exhaust concentration was 1.1 ppm, dry basis as hexane, corrected to 3 percent oxygen. The emission limit [40 CFR 60.752(b)(2)(iii)(B)] is an exhaust concentration less than 20 ppm by volume, dry basis as hexane, at 3 percent oxygen. The test results demonstrate that the enclosed flare meets the emission limit of 60.752(b)(2)(iii)(B) at the tested landfill gas flow rate and combustion chamber temperature.

On June 8, 2016, the average NOx emission rate was 2.62 lb/hr, or 11.48 tpy, at a calculated average exhaust gas flow rate of 25,725 dscfm. The NOx results meet the limits (20.0 lb/hr and 87.6 tpy, respectively) established by PTI No. 179-13.

On June 8, 2016, the average CO emission rate was 2.29 lb/hr, or 10.05 tpy, at a calculated average exhaust gas flow rate of 25,725 dscfm. The CO results meet the limits (27.6 lb/hr and 121 tpy, respectively) established by PTI No. 179-13.

On June 8, 2016, the average SO_2 emission rate was 6.50 lb/hr, or 28.5 tpy, at a calculated average exhaust gas flow rate of 25,725 dscfm. The SO_2 results meet the limits (24.9 lb/hr and 109 tpy, respectively) established by PTI No. 179-13.

On June 8, 2016, the average HCl emission rate was 0.01 lb/hr, or 0.03 tpy, at a calculated average inlet gas flow rate of 3,530 dscfm. The HCl results meet the limits (6.0 lb/hr and 21.6 tpy, respectively) established by PTI No. 179-13.

On June 8, 2016, the average VOC emission rate was 0.19 lb/hr, or 0.84 tpy, at a calculated average exhaust gas flow rate of 27,880 scfm. The VOC results meet the limits (7.1 lb/hr and 31.2 tpy, respectively) established by PTI No. 179-13.

AQSI notes that there were variations or anomalies in normal sample collection procedures:

1. At the conclusion of Test No. 1 (10:15) on June 8, 2016, MDEQ noted that the new utility flare was in operation. MDEQ requested that this fact be noted in this compliance report, along with any commentary on the potential of that flare's operation to introduce biases to the enclosed flare test. MDEQ was under the impression that the utility flare would be 'taking flow' that would otherwise go to the McGill flare.

   An examination of the flow rate records for the utility flare shows that the third party LFGTE plant personnel started the utility flare in the late afternoon (16:40) of June 7, 2016. The utility flare operated continuously (excepting one approximately 8-minute interval on June 8, 2016, 07:35 – 07:42, a suspected automatic shutdown / automatic re-start event), until being shutdown at 21:25 on June 8, 2016.

   On June 8, 2016, the McGill flare was operated at an average inlet volumetric flow rate of 3,696 scfm (3,700 scfm), with test-to-test flow rates varying less than 10 scfm from this average.

   During the McGill flare compliance tests on June 8, 2016, the utility flare operated at an average flow rate of 796 scfm (as recorded by the process flow meter), with a minimum average flow rate of 779 scfm, and a maximum average flow rate of 812 scfm. AQSI notes that the utility flare flow rates provided here are assumed to be approximately 275 scfm less than what would be measured by Method 2, based on the data subsequently obtained during the utility flare performance test conducted June 28, 2016.

   In summary, on June 8, 2016, the McGill enclosed flare was operated at the maximum landfill gas flow rate that it could handle and still function as an effective combustion and control device. The utility flare operation had no apparent impact on the landfill gas flow rate delivered to the McGill flare, and therefore no impact on the McGill flare test results.

2. The average total hydrocarbon concentration (as propane) was less than 1 ppm for these tests. As stated in the test plan, in the event that THC / CH_4 concentrations were low or indistinguishable from one another, AQSI would report NMOC/VOC as THC. Therefore, AQSI did not perform any "methane-subtraction" for this project; the reported NMOC/VOC concentration is the THC concentration, and since the average THC concentration was less than or equal to 1 ppm, all calculations were carried out using 1 ppm.

3. Mr. Dziadosz with MDEQ requested that this report include a brief discussion and comparison of the March 23, 2016, HCl results for the Zink flare (EUENCLOSEDFLARE1-S2) and the June 8, 2016, HCl results for the McGill flare (EUENCLOSEDFLARE2-S2). The reason for the request was that the HCl concentration was obtained on the exhaust of the Zink flare, while the HCl concentration was obtained on the inlet of the McGill flare.

   On March 23, 2016, the HCl concentration was obtained from the Zink flare exhaust, via a Method 4 / 26 sample train, and using standard-sized impingers. The analytical results included a high HCl blank value. AQSI did not blank-correct those HCl results in the Zink flare report, dated May 18, 2016. The March 23, 2016, HCl results for the Zink flare was an average emission rate of 0.16 lb/hr, or 0.72 tpy.

   On June 8, 2016, the HCl concentration was obtained from the McGill flare inlet, via a standard Method 26 train, using midget impingers. The analytical results showed a "non-detect" for HCL in the blank, so no blank-correction is necessary or warranted. The June 8, 2016, HCl results for the McGill flare was an average emission rate of 0.01 lb/hr, or 0.03 tpy.

   Based on these results, AQSI re-calculated the March 23, 2016, Zink flare HCl results using "blank-corrected" HCl concentrations. The "blank-corrected" HCl result for March 23, 2016, was an average emission rate of 0.02 lb/hr, or 0.11 tpy. Conversely, AQSI also calculated the McGill flare HCl emission rate using the March 23, 2016, Zink non blank-corrected HCl concentrations, and the McGill flare June 8, 2016, calculated exhaust gas flow rates. Under this scenario, the McGill flare HCl emission rate would be 0.24 lb/hr, or 1.04 tpy.

4. AQSI and MDEQ noted that the installed process flow meters for the McGill enclosed flare read low compared to Method 2 results. Each flow meter displayed flow rates that are approximately 210 to 250 scfm less than those measured by USEPA Method 2, for their respective ducts, and yielded a combined average difference of 450 scfm less than the Method 2 results.

   Per agreement between AQSI and MDEQ, all exhaust mass emission rates were calculated from the higher inlet flow rate (i.e., Method 2 results), as this produces the highest exhaust gas flow rate and emission rates.

5. AQSI notes that the flare process data file supplied by BFI only has one (1) of the process flow meters data being recorded ('east' flow meter). Both inlet flow meters register on the panel display. AQSI manually recorded both flow meters output every five minutes during the compliance test runs.

6. AQSI notes that the timestamp on the digital process data is approximately 2 hours and 5 minutes fast (best estimate looking at field notes vs. flow rate and/or temperature set-point changes on June 7, 2016). The digital process data is therefore annotated with notes of approximate, actual times events occurred.

The exhaust gas flow rates and emission rates presented on Tables 1 through 7 are calculated from the inlet flow rate, as measured from Method 2 data, as the process flow meters yielded lower flow rates than Method 2. Table 1 presents a summary of the results of the pollutant emissions rate tests on the enclosed flare exhaust stack. Table 2 presents the results of the enclosed flare exhaust NMOC concentration, dry basis as hexane, corrected to 3 percent oxygen. Tables 3, 4, 5, 6, and 7 present run-specific results of the NOx, CO, SO_2, HCL, and VOC emission rate tests, respectively.

Analyzer Run Data for Test Nos. 1, 2, and 3 presents the 1-minute average and 1-hour average of the enclosed flare exhaust uncorrected pollutants: NOx, CO, SO2 and NMOC/VOC (as THC) and diluent (O_2 and CO_2) concentrations vs. time over the course of each 60-minute sample run conducted on June 8, 2016. All test result average concentrations are consistent and repeatable.

Figure 1 depicts the flare inlet duct traverse points. Figure 2 depicts the USEPA Method 3C/25C landfill gas composition sample train. Figure 3 depicts a representative enclosed flare exhaust stack. Figure 4 depicts the flare exhaust stack CEMS test traverse points. Figure 5 depicts the USEPA Method 4 sample train. Figure 6 depicts the USEPA Method 3A / 6C / 7E / 10 pollutant and diluent sample train. Figure 7 depicts the USEPA Method 25A NMOC/VOC sample train. Figure 8 depicts the USEPA Method 26 hydrogen chloride sample train.

There was major maintenance performed on the enclosed flare within the 3 months prior to this emissions test event. BFI has worked with John Zink Company to refurbish the McGill flare. This work included the installation of two (2) new flame arrestors, cleaning the burner tips, and upgrading the fresh-air louvers.

Mr. Mark Dziadosz with MDEQ witnessed the bulk of the compliance test program.

AQSI quality assurance (QA) procedures included pre-test analyzer calibration error, linearity, system bias, and post-test drift error demonstrations on the Method 3A / 6C / 7E / 10 sample system, and pre-test analyzer calibration error, linearity, and post-test drift error demonstrations on the Method 25A sample system. All instrument analyzer systems passed these QA checks.

AQSI leak checked both the positive- and negative – pressure legs of the Method 2C apparatus (pitot tube, pitot lines, and manometer) before each velocity traverse. The inlet Method 3C/25C sample train was leak checked prior to each sample run. The moisture and hydrogen chloride sample trains were leak-checked before and after each test. All measurement systems passed their respective leak checks.

Raw field and computer-calculated data used in the determination of the enclosed flare exhaust velocities and moisture content, field notes, and enclosed flare process data is presented in Appendix A.

The laboratory analytical reports for the landfill gas composition and hydrogen chloride sample analysis is presented in Appendix B.

Equipment and analyzer calibration data sheets and computer-generated calibration sheets are presented in Appendix C. These sheets also include the Method 205 validation test data.

Sample calculations are presented in Appendix D.

Copies of the Microsoft® Excel spreadsheets used to produce the pollutant and diluent concentration results, CEMS test run data, CEMS post-cal data, and other ancillary files, are included on the compact disk located in the back-cover pocket.

This report prepared by: _____
Andrew D. Secord
Environmental Scientist

This report reviewed by: _____
for Dana A. Oleniacz
President

August 3, 2016

TABLES

Table 1

Summary Pollutant Emissions Rate Test Results
BFI - Arbor Hills
McGill Flare Exhaust
Northville, Michigan
June 8, 2016

Pollutant (units)	NMOC Exhaust Concentration (ppmv - dry basis, as hexane) (ppm CH_4)		ppmv - limit
NMOC (ppmv)	**1.0**	**1.1**	*20.0*

Pollutant (units)	Average Emission Rates (lb/hr)	(limit)	(tpy)	(limit)
NOx (ppmv)	**2.62**	*20.0*	**11.48**	*87.6*
CO (ppmv)	**2.29**	*27.6*	**10.05**	*121*
SO2 (ppmv)	**6.50**	*24.9*	**28.5**	*109*
HCl (mg/m^3)	**0.01**	*6.0*	**0.03**	*26.1*
VOC (ppmv)	**0.19**	*7.1*	**0.84**	*31.2*

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift, as applicable.
lb/hr: pounds per hour
tpy: tons per year

AQS Inc.

Table 2

Non-methane Organic Compound Concentration Test Results
BFI - Arbor Hills
McGill Flare Exhaust
Northville, Michigan
June 8, 2016

Test No.	NMOC (ppm C_3H_8)	Stack Gas O_2 (%)	Moisture (%)	NMOC - corrected (ppm as hexane)
1	1.0	13.30	5.6	**1.2**
2	1.0	11.84	6.8	**1.1**
3	1.0	11.74	11.3	**1.1**
Averages:	**1.0**	**12.29**	**7.9**	**1.1**

NMOC: Non-methane organic compounds, as total hydrocarbons
ppm: parts per million (volume), averages < 1 ppm reported as 1 ppm
C_3H_8: propane
O_2: oxygen, drift-corrected concentration
%: percent
B_{ws}: % moisture / 100

Equation: $NMOC_{(hexane)} = [NMOC_{(propane)} * 17.9 / (20.9 - \%O_2)] / [2 * (1 - B_{ws})]$

AQS Inc.

Table 3

Oxides of Nitrogen Emissions Rate Test Results
BFI - Arbor Hills
McGill Flare Exhaust
Northville, Michigan
June 8, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (dscfm)	Emission Rates (lb/hr)	(tpy)
1	46.01	12.5	29,629.3	2.66	11.67
2	46.01	15.3	24,778.2	2.72	11.91
3	46.01	15.2	22,766.6	2.48	10.85
Averages:		**14.3**	**25,724.7**	**2.62**	**11.48**

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift.

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * dscfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3) = $1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

AQS Inc.

Table 4

Carbon Monoxide Emissions Rate Test Results
BFI - Arbor Hills
McGill Flare Exhaust
Northville, Michigan
June 8, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (dscfm)	Emission Rates (lb/hr)	(tpy)
1	28.01	17.9	29,629.3	2.31	10.14
2	28.01	27.3	24,778.2	2.95	12.93
3	28.01	16.3	22,766.6	1.62	7.08
Averages:		**20.5**	**25,724.7**	**2.29**	**10.05**

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift. Run averages were <1 ppm; reported as 1 ppm.

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * dscfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3) = $1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

Table 5

Sulfur Dioxide Emissions Rate Test Results
BFI - Arbor Hills
McGill Flare Exhaust
Northville, Michigan
June 8, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (dscfm)	Emission Rates (lb/hr)	(tpy)
1	64.07	22.26	29,629.3	6.58	28.84
2	64.07	27.03	24,778.2	6.69	29.29
3	64.07	27.46	22,766.6	6.24	27.34
Averages:		**25.6**	**25,724.7**	**6.50**	**28.49**

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift.

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * dscfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3) = $1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

AQS Inc.

Table 6

Hydrogen Chloride Emissions Rate Test Results
BFI - Arbor Hills
McGill Flare Inlet
Northville, Michigan
June 8, 2016

Test No.	Molecular Weight	Concentration (mg/m^3)	Flow Rate (dscfm)	Emission Rates (lb/hr)	(tpy)
1	36.46	0.51	3,520.6	0.007	0.03
2	36.46	0.51	3,535.3	0.007	0.03
3	36.46	0.45	3,534.9	0.006	0.03
Averages:		**0.49**	**3,530.3**	**0.01**	**0.03**

mg/m^3: milligrams per cubic meter

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = mg/m^3 * dscfm * Constant

Constant = 60 minutes/hour / (453,600 milligrams/pound * 35.31 ft^3/m^3)
= $3.746*10^{-6}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

Table 7

Non-methane Organic Compound Emissions Rate Test Results
BFI - Arbor Hills
McGill Flare Exhaust
Northville, Michigan
June 8, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (scfm)	Emission Rates (lb/hr)	(tpy)
1	44.10	1.0	31,387	0.22	0.94
2	44.10	1.0	26,586	0.18	0.80
3	44.10	1.0	25,667	0.18	0.77
Averages:		**1.0**	**27,880**	**0.19**	**0.84**

ppmv: parts per million (volume), in equivalents of the calibration gas (proane), wet-basis
Note: Run averages <1 ppm were reported as 1 ppm.

scfm: standard cubic feet per minute (wet)

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * scfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3)
$= 1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds