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GFL ENVIRONMENTAL SERVICES INC.

237 BRANT STREET, HAMILTON ON, L8L 4E3

EMISSION SUMMARY AND DISPERSION MODELLING REPORT
NOVEMBER 2022 - VERSION 1.1

REPORT PREPARED FOR:
GFL ENVIRONMENTAL SERVICES INC.

REPORT PREPARED BY:
O2E INC.

O2E REF. NO. 22-024

NOVEMBER 1, 2022

DOCUMENT VERSION CONTROL

This Emission Summary and Dispersion Modelling (ESDM) Report documents the operations at the GFL Environmental Services Inc. Brant Street facility and has been prepared in accordance with s.26 of Ontario Regulation (O.Reg.) 419/05 to document compliance with s. 20 of O.Reg.419/05. The Report is a living document and should be kept up to date at all times. Therefore, it is necessary to have appropriate version control. This version control will allow facility personnel, compliance auditors, or the Ontario Ministry of the Environment, Conservation and Parks (Ministry) to track and monitor ESDM Report changes over time.

As facility operations change and sources are added or removed to the facility, this ESDM Report will need to be updated as required. These changes are to be documented by facility personnel in a modification log. Changes listed in the modification log will have to be incorporated to the ESDM Report, as necessary by GFL Environmental Services Inc. When the ESDM Report is updated, the version number will need to be changed by GFL Environmental Services Inc. to correspond with the information in the modification log.

Version	Date	Revision Description	Prepared By	Reviewed By
1.0	October 2022	Original Document	O2E Inc.	P. Cameron, XCG P. Weinwurm, Cobric
1.1	November 2022	Incorporated comments and edits provided by proponent	O2E Inc.	P. Cameron, XCG P. Weinwurm, Cobric

Ministry of the Environment,
Conservation and Parks

EMISSION SUMMARY AND DISPERSION MODELLING REPORT CHECKLIST

Company Name: GFL Environmental Services Inc.

Company Address: 237 Brant Street
Hamilton, Ontario, L8L 4E3

Location of Facility: As above

The attached Emission Summary and Dispersion Modelling Report was prepared in accordance with s.26 of O. Reg. 419/05 and the guidance in the MOE document "Procedure for Preparing an Emission Summary and Dispersion Modelling Report – Version 4.1" dated March 2018 and "Air Dispersion Modelling Guideline for Ontario – Version 3.0" dated February 2017 and the minimum required information identified in the check-list on the reverse of this sheet has been submitted.

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*This checklist is taken from the document titled "Procedure for Preparing an Emission Summary and Dispersion Modelling Report" dated March 2018

EMISSION SUMMARY AND DISPERSION MODELLING REPORT CHECKLIST

	Required Information			
			Submitted	Explanation/Reference
	Executive Summary and Emission Summary Table			
	1.1	Overview of ESDM	☒ Yes	Section 1
	1.2	Emission Summary Table	☒ Yes	Table 4
1.0	**Introduction and Facility Description**			
	1.1	Purpose and Scope of ESDM Report (when report only represents a portion of facility)	☐ Yes	Not Applicable
	1.2	Description of Processes and NAICS code(s)	☒ Yes	Section 1.2
	1.3	Description of Products and Raw Materials	☒ Yes	Section 1.3
	1.4	Process Flow Diagram	☒ Yes	Figure 4
	1.5	Operating Schedule	☒ Yes	Section 1.5
2.0	**Initial Identification of Sources and Contaminants**			
	2.1	Sources and Contaminants Identification Table	☒ Yes	Section 2.1, Table 1
3.0	**Assessment of the Significance of Contaminants and Sources**			
	3.1	Identification of Negligible Contaminants and Sources	☒ Yes	Section 3.1, Table 1
	3.2	Rationale for Assessment	☒ Yes	Section 3.2
4.0	**Operating Conditions, Emission Estimating and Data Quality**			
	4.1	Description of operating conditions, for each significant contaminant that results in the maximum POI concentration for that contaminant	☒ Yes	Section 4.1
	4.2	Explanation of Method used to calculate the emission rate for each contaminant	☒ Yes	Section 4.2
	4.3	Sample calculation for each method	☒ Yes	Appendix 2
	4.4	Assessment of Data Quality for each emission rate	☒ Yes	Section 4.3
5.0	**Source Summary Table and Property Plan**			
	5.1	Source Summary Table	☒ Yes	Table 2
	5.2	Site Plan (scalable)	☒ Yes	Figure 2
	5.3	Source Location Plan (scalable)	☒ Yes	Figure 3
6.0	**Dispersion Modelling**			
	6.1	Dispersion Modelling Input Summary Table	☒ Yes	Table 3
	6.2	Land use Zoning Designation Plan	☒ Yes	Appendix 4
	6.3	Dispersion Modelling Input and Output Files	☒ Yes	Appendix 4, attached
7.0	**Emission Summary Table and Conclusions**			
	7.1	Emission Summary Table	☒ Yes	Section 7.1, Table 4
	7.2	Assessment of Contaminants with no Ministry POI Limits	☒ Yes	Section 7.2
	7.3	Annual Assessment Values	☒ Yes	Section 7.3
	7.4	Conclusions	☒ Yes	Section 7.4
	Appendices (Provide supporting information or details such as…)			
	Summary of Modifications		☒ Yes	Appendix 1
	Source Description Sheets		☒ Yes	Appendix 2
	Supporting Documents		☒ Yes	Appendix 3
			☐ Yes	

PIBS 5357e *This checklist is taken from the document titled "Procedure for Preparing an Emission Summary and Dispersion Modelling Report" dated March, 2018

EXECUTIVE SUMMARY AND EMISSION SUMMARY TABLE

This ESDM report has been prepared to demonstrate compliance with Ontario Regulation 419/05 (O.Reg. 419/05) standards and limits for the GFL Environmental Services Inc. facility located at 237 Brant Street in Hamilton, Ontario (the Facility).

This report covers all sources at the Facility.

The ESDM report was prepared in accordance with s.26 of Ontario Regulation 419/05 (O.Reg.419/05). In addition, guidance in the Ministry of the Environment, Conservation and Parks (Ministry) publication "Procedure for Preparing an Emission Summary and Dispersion Modelling Report – Version 4.1" dated March 2018 (ESDM Procedure Document) PIBS #3614e04.1 was followed as appropriate.

Current and permitted operations at the Facility include the storage of paints and coatings, up to 515,000 L. Proposed operation eliminate storage of paints and coatings and include the installation of a High Temperature Metal Recovery (HTMR) Electric Arc Furnace Dust (EAFD) recycling technology to the Facility, and the associated receipt, storage and processing of class 143 (residues from steel making) solid hazardous waste. Ancillary operations include the operation of natural gas fired comfort heating equipment.

The Facility currently operates for 24 hours per day, 7 days per week for up to 52 weeks per year.

Facility operations are subject to s.20 of O.Reg.419/05 and the assessment of compliance has been completed using the approved dispersion model (AERMOD v19191) and the standards listed in Schedule 3 of O.Reg.419/05, as well as the applicable limits listed in the Ministry workbook, "Air Contaminants Benchmarks (ACB) List: Standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants", Version 2.0 dated April 2018 (ACB List).

The Facility is expected to release suspended particulate matter, metal species, volatile organic compounds, and the products of combustion. A complete list of sources is included in **Table 1**: Sources and Contaminant Identification Table. Source specifications and details of contaminant emissions are included in **Table 2**: Source Summary Table. Details related to the calculation of contaminant emission rates are provided in **Appendix 1**.

The maximum POI concentrations were calculated based on the operating conditions where all significant sources are operating simultaneously at their individual maximum rates of production. The maximum emission rates for each significant contaminant emitted from the significant sources were calculated in accordance with s.11 of O.Reg. 419/05 and the data quality assessment follow the process outlined in the requirements of the ESDM Procedure Document.

A POI concentration for each significant contaminant emitted from the Facility was calculated based on the calculated emission rates and the results of conservative dispersion factor calculations or the output from the approved dispersion model and the results are presented in the following Emission Summary Table.

The POI concentrations listed in the Emission Summary Table were compared against limits presented in the ACB list.

Contaminants released by the Facility that are not found on the ACB List or are above the de minimus threshold are considered to be “Contaminants with no Ministry POI Limits”. The facility does not release any “Contaminants with no Ministry POI Limits”.

All of the predicted POI concentrations for the assessed contaminants that are included in the ACB list are below the corresponding limits. The highest maximum POI concentration is approximately 94% of the 24-hour limit for Cadmium and Cadmium Compounds.

Emission Summary Table

Contaminant	CAS	Emission Rate (g/s)	Air Dispersion Model Used	Maximum Concentration (µg/m^3)	POI Limit (µg/m^3)	Limiting Effect	Averaging Period (Hours)	Limit Source	Percentage of Limit
Cadmium and compounds	7440-43-9	9.53E-05	AERMOD v19191	2.36E-02	0.025	Health	24	Standard	94%
Calcium oxide	1305-78-8	7.96E-03		2.55E+00	10	Corrosion	24	Standard	26%
Carbon	7440-44-0	2.53E-03		9.41E-01	1.75	Health	24	SL-JSL	54%
Chromium compounds (di, tri, metallic)	7440-47-3	1.64E-04		4.10E-02	0.5	Health	24	Standard	8%
Ferric oxide	1309-37-1	2.24E-02		5.52E+00	25	Soiling	24	Standard	22%
Lead and compounds	7439-92-1	1.02E-03		2.63E-01	0.5	Health	24	Standard	53%
	7439-92-1	1.02E-03		9.84E-02	0.2	Health	720	Standard	49%
Manganese and compounds	7439-96-5	1.64E-03		3.59E-01	0.4	Health	24	Standard	90%
Nickel and compounds	7440-02-0	2.71E-05		2.49E-03	0.04	Health	8760	Standard	6%
	7440-02-0	2.71E-05		2.49E-03	0.4	AAV	8760	AAV	0.6%
	7440-02-0	2.71E-05		6.69E-03	2	DAV	24	DAV	0.3%
Nitrogen oxides	10102-44-0	2.40E-01		6.53E+01	200	Health	24	Standard	33%
	10102-44-0	2.40E-01		1.04E+02	400	Health	1	Standard	26%
Potassium	7440-09-7	4.03E-04		9.96E-02	1	Health	24	SL-JSL	10%
Silicon dioxide	7631-86-9	4.07E-03		1.00E+00	5	Health	24	SL-MD	20%
Sodium (as Sodium monoxide)	12401-86-4	6.45E-04		1.59E-01	0.5	Health	24	SL-JSL	32%
Sulfur	7704-34-9	3.88E-04		9.83E-02	2.5	Health	24	SL-JSL	4%
Sulphur dioxide	7446-09-5	6.42E-03		1.48E+00	275	Health & Vegetation	24	Standard	1%
	7446-09-5	6.42E-03		2.64E+00	690	Health & Vegetation	1	Standard	0.4%
	7446-09-5	6.42E-03		5.35E-01	10	Vegetation	8760	Standard - 2023	5%
	7446-09-5	6.42E-03		2.64E+00	100	Health	1	Standard - 2023	3%
Suspended particulate matter	N/A(9)	5.55E-02		1.47E+01	120	Visibility	24	Standard	12%
Zinc	7440-66-6	1.55E-02		3.93E+00	120	Particulate	24	Standard	3%

Notes: Assessment of compliance with Annual Standards and Annual Assessment Values was determined by using the maximum annual POI concentration multiplied by 140% as advised by Technical Bulletin (O.Reg. 419/05) - Methodology for using "Assessment Values" for contaminants with Annual Air Standards.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

This Emission Summary and Dispersion Modelling (ESDM) report was prepared in accordance with s.26 of Ontario Regulation 419/05 (O.Reg.419/05). In addition, guidance in the Ministry of the Environment, Conservation and Parks (Ministry) Guideline A-10 “Procedure for Preparing an Emission Summary and Dispersion Modelling Report – Version 4.1” dated March 2018 (ESDM Procedure Document) PIBS #3614e04.1 was followed as appropriate.

1.1 Purpose and Scope of ESDM Report

This ESDM report has been prepared to demonstrate compliance with Ontario Regulation 419/05 Schedule 3 limits as well as the applicable limits listed in the Ministry workbook, "Air Contaminants Benchmarks (ACB) List: Standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants", Version 2.0 dated April 2018 (ACB List).

In addition, this ESDM report has been prepared to support an application to for an Environmental Compliance Approval (Air/Noise). This ESDM report covers all sources at the Facility.

1.2 Summary of Modifications

Appendix 1 contains the summary of changes that the ESDM Report has undergone through the various versions of the report.

1.3 Description of Processes and NAICS Codes

Current and permitted operations at the Facility include the storage of paints and coatings, up to 515,000 L. Proposed operations include the installation of a High Temperature Metal Recovery (HTMR) Electric Arc Furnace Dust (EAFD) recycling technology to the Facility, and the associated receipt, storage and processing of class 143 (residues from steel making) solid hazardous waste. Additional details on the HTMR process are provided below. The location of the Facility is presented in **Figure 1** – Area Location Plan. The site is defined in **Figure 2** – Site Plan. The location of the discharges from the sources is presented in **Figure 3** – Source Location Plan. The Facility is located in an industrial zoned area.

The applicable North American Industry Classification System (NAICS) codes for the site are 325189 - All other basic inorganic chemical manufacturing and 562110 – Waste collection.

1.3.1 EAFD Receiving and Storage

The raw material (i.e., feedstock to the HTMR process) electric arc furnace dust (EAFD) is delivered to the Site from steel mills in bulk bags or in bulk (via tanker trucks). The bulk bags containing EAFD are stored at the site in enclosed area. The bulk EAFD is stored in enclosed outdoor silos. Due to the dusty nature of the material transportation, storage and handling is designed to eliminate dust escaping into the atmosphere. The material from the silos is conveyed into Pelletizing Process.

1.3.2 Pelletizing

EAFD and additives are mixed and homogenized. The homogenized mixture is charged into a pelletizing drum via a screw conveyor. Liquid consisting of water and water-based binder is sprayed in the pelletizing drum to bind the particulate material. The rotary action of the pelletizing drum agglomerates the mixture into round pellets of the desired size. The water spray also acts as a dust suppressant inside the pelletizing drum. Slightly negative pressure is maintained in the drum during pelletizing by the general dust collector. The general dust collector also serves to control emissions generated from the two hoppers. The air from the dust collector serving the pelletizing process is released outdoors through the stack.

1.3.3 Pellet Dryer

The wet pellets from the pelletizer are fed into the natural gas direct fired dryer. The hot flue gas mixed with air is used to dry wet pellets to 0.5% moisture. The dried pellets are screened into the oversize, middle and undersize fractions. The oversize fraction is broken down by the delumper into smaller particles which goes back into the screen. The undersize fraction is reintroduced into the pelletizing process. The middle fraction of dried pellets is then transferred into the HTMR processing.

1.3.4 HTMR Processing

The key process step of zinc recovery from EAFD is based on the HTMR reactor. The dry pellets are indirectly heated in the HTMR reactor to induce a thermo-chemical reaction accompanied by metallic zinc volatilization. The reactor is an indirectly heated rotary tube furnace, which consists of a sealed rotary tube located within the furnace chamber. The furnace uses natural gas as the indirect source of energy to heat the rotary tube. Metals and oxides (such as zinc and lead oxides), along with halides and alkali metals vaporize and are carried into the process gas. The volatilization of metals from the pellets creates the desirable separation of zinc and other volatile metals from non-volatile metals. Non-volatile iron-rich material is called “slag”.

The slag pellets are cooled in the cooling section of the rotary tube and discharged into a hopper.

1.3.5 Zinc Collection System

The hot process gas from the HTMR reactor containing raw zinc product is cooled down to allow the solids to be collected in the zinc collector. The gas containing a small concentration of sulphur dioxide is purified in a sodium hydroxide scrubber system. The system consists of countercurrent flow of gas and sodium hydroxide solution which eliminates sulphur dioxide from the gas stream.

The collected particulates are referred to as raw zinc concentrate. Raw zinc concentrate includes metallic zinc, metal oxides (including zinc and lead oxide) and alkali metal salts. Raw zinc concentrate is transferred to the Zinc Purification System.

1.3.6 Zinc Purification System

Raw zinc concentrate is transferred to the Zinc Purification System to separate water soluble impurities from zinc and zinc oxide. Zinc oxide is removed from the liquid slurry by filtration. The filter cake is further washed with fresh water in the same filter to minimize the amount of the salts in the product. Water from filtration containing soluble salts is treated by osmosis and reused. A small amount of concentrated salt solution is disposed of.

The zinc filter cake is transferred into the Zinc Dryer. The dried zinc product is further sized by a delumper to customer particle size specifications.

1.3.7 Thermal Oxidizer, HRV, and Heat Recuperating System

The filtered and scrubbed gas stream from the zinc collection system enters the thermal oxidizer equipped with a Heat Recuperating Vessel (HRV). A gas stream from the zinc collection system having a carbon monoxide concentration of approximately 1% is abated by the thermal oxidizer, the exhaust from which is sent to the steam boiler or Mixing Chamber. In the Mixing Chamber the temperature of the gas stream is regulated by mixing the hot gas stream from the HRV with fresh ambient air. The mixed air from the Mixing Chamber is subsequently directed to the Pellet Dryer and Zinc Dryer.

1.4 Description of Products and Raw Materials

As noted above, primary processing operations include the recovery of zinc from electric arc furnace dust. Raw materials used by the Facility include the following: electric arc furnace dust, carbon based additives, calcium based additives, natural gas, and water. Final products include recovered zinc and zinc oxides.

1.5 Process Flow Diagram

Refer to **Figure 4** – Process flow diagram for a graphical representation of the manufacturing operation processes at the Facility.

1.6 Operating Schedule

The Facility is approved to receive waste 365 days a year, 24 hours per day. Due to continuous operation of steel companies, EAFD waste will be received 7 days per week, but only if necessary, during the weekend from 6 am to 8 pm. The EAFD processing operations will operate 24 hours per day, 365 days per year.

1.7 Facility Production Limit

The proposed annual production capacity for the Facility is up to 30 metric tonnes of electric arc furnace dust (EAFD) processed per day and up to 10,000 metric tonnes of EAFD processed per year.

2. INITIAL IDENTIFICATION OF SOURCES AND CONTAMINANTS

This section provides an initial identification of all the sources and contaminants emitted by the Facility.

2.1 Sources and Contaminants Identification Table

Table 1 – Sources and Contaminants Identification Table tabulates all the emission sources at the Facility; for example, the central pelletizing dust collector has been identified as a source.

The expected contaminants from each source are also identified in **Table 1**; for example, the expected contaminants from the central pelletizing dust collector are suspended particulate matter and metals. Each of the sources has been assigned a source reference identifier; for example, the central pelletizing dust collector has been identified as 1V2.

The location of each of the discharges or stacks associated with each source is presented in **Figure 3** – Source Location Plan.

3. ASSESSMENT OF THE SIGNIFICANCE OF CONTAMINANTS AND SOURCES

This section provides an explanation for each source and contaminant identified as negligible in **Table 1** – Sources and Contaminants Identification Table.

In accordance with s.8 of O.Reg. 419/05 emission rate calculations and dispersion modelling does not have to be completed for emissions from negligible sources or for the emissions of negligible contaminants from significant sources.

In keeping with the provisions of the ESDM Procedure Document, there are circumstances where it is appropriate and reasonable to identify the emission of a contaminant, or a source of contaminants, as negligible for the purpose of simplifying the site-wide assessment of emissions.

The Ministry has developed a guidance procedure for assessing the significance of sources and contaminants. This procedure includes:

- screening-out contaminants that are emitted in negligible amounts including:
    - contaminants from the combustion of natural gas and propane with the exception of nitrogen oxides;
    - identifying insignificant contaminants using an emission threshold based on dispersion factors provided in Appendix B, Table B-1 of the ESDM Procedure Document; and/or
    - the consideration of a group of contaminants rather than the sub-speciation;

- screening-out sources that emit contaminants in negligible amounts including:
    - sources on a list provided in Appendix B, Tables B-3A and B-3B of the ESDM Procedure Document; and/or
    - in some special cases, sources that in combination represent less than 5% of the total property-wide emissions of a contaminant;

- screening-out sources or contaminants based on Facility specific assessments; and

- screening-out fugitive dust emissions from on-site roadways and storage piles where:
    - fugitive dust from roadways and storage piles is anticipated but generally controlled with the implementation of a best management practices plan (typically for facilities included in Table 7-2 and 7-3 of ESDM Procedure Document; or
    - fugitive dust emissions from on-site roadways and storage piles for facilities that are not included Table 7-2 and 7-3 of ESDM Procedure Document.

3.1 Identification of Negligible Contaminants and Sources

In accordance with the guidance provided in the ESDM Procedure Document, the Sources and Contaminants Identification Table (**Table 1**) presents a summary of the rationale used to screen-out contaminants and/or sources at the Facility from the overall assessment. Supporting calculations and/or documentation for these negligible or insignificant contaminants and sources are provided in **Appendix 1** of this report, where required.

3.2 Rationale for Assessment

For each source identified in **Table 1** as being negligible, there is an accompanying documented rationale. Additional technical documentation supporting the conclusion of insignificance of a source is presented in **Appendix 1** of this report, where required.

In summary, the following screening was completed:

- Twenty-one (21) contaminants were screened from the assessment using the methodology described in Section 7.1.2 of the ESDM Procedure Document. Emission thresholds were developed for these contaminants and compared to the calculated Facility wide emission for each substance.
- Paved roadways have been screened from the assessment based on Section 7.4 of the ESDM Procedure Document. The Facility's NAICS code (325189) is not listed in either Table 7-2 or 7-3, therefore roadways have been considered to be a negligible source of emission.
- Fume hoods used to provide quality control and quality assurance testing have been screened from the assessment based on Section 7.2.1 of the ESDM Procedure Document which references specific examples of sources that emit contaminants in negligible amounts (Table B-3A). Included in this list are "fume hoods for laboratories that are used for quality control and quality assurance purposes at industrial facilities";
- General exhausts used for the purposes of maintaining the air and temperature balance within the Facility have been screened from the assessment based on Section 7.2.1 of the ESDM Procedure Document which references specific examples of sources that emit contaminants in negligible amounts (Table B-3B). Included in this list are sources that are exempt from requiring approval under O.Reg. 524/98 which includes " Any equipment, apparatus, mechanism or thing that is used for the ventilation of indoor air out of... a space that is used for laboratory analysis, the production, processing, repair, maintenance or storage of goods or materials, or the processing, storage, transfer or disposal of waste, if the equipment, apparatus, mechanism or thing does not discharge any contaminant produced by those activities, other than heat or noise, out of the space";

- Contaminants from the combustion of natural gas (with the exception of nitrogen oxides) have been screened from the assessment based on Section 7.1.1. “Combustion of Natural Gas and Propane” of the ESDM Procedure Document.

4. OPERATING CONDITIONS, EMISSION ESTIMATING AND DATA QUALITY

This section provides a description of the operating conditions used in the calculation of the emission estimates and an assessment of the data quality of the emission estimates for each significant contaminant from the facility. In accordance with s.8 of O. Reg. 419/05, emission rate calculations and dispersion modelling does not have to be completed for emissions from negligible sources or for the emissions of negligible contaminants from significant sources.

4.1 Description of Operating Conditions

Facility operations are subject to s.20 of O.Reg.419/05 and the assessment of compliance has been completed using the approved dispersion model (AERMOD v19191) and the standards listed in Schedule 3 of O.Reg.419/05, as well as the applicable limits published in the Ministry’s ACB List.

The Facility is operated on a continuous basis. As such, the maximum emissions scenario is based on all equipment operating at maximum capacity over a 1-hour, 24-hour, monthly, and annual averaging periods as follows:

- General dust collector (1V1) - Pelletizing: operating at the maximum volumetric flow rate for the duration of the averaging period. Metals emissions based on the maximum suspended particulate matter emission rate and maximum concentration of specific metals in the EAFD as determined by assays of the raw material used.
- Central dust collector (1V2) - Pelletizing: operating at the maximum volumetric flow rate for the duration of the averaging period. Metals emissions based on the maximum suspended particulate matter emission rate and maximum concentration of specific metals in the EAFD as determined by assays of the raw material used.
- Zinc dust collector (3V4) – Zinc Purification: operating at the maximum volumetric flow rate for the duration of the averaging period. Metals emissions based on the maximum suspended particulate matter emission rate and maximum concentration of specific metals in the zinc product as determined by assays of this material.
- SO_2 Scrubber – operating for the duration of each averaging period with an anticipated inlet loading of 0.7% (7,000 ppm) SO_2 and a manufacturer guaranteed scrubber efficiency of 99.9%.

- Thermal Oxidizer – operating for the duration of each averaging period with an anticipated inlet loading of 1% (10,000 ppm) CO and an estimated abatement efficiency of 98%.
- Raw material storage silos – operating with vent filters and the following fill rates:
  - EAFD Silo (1_1A) – 29.9 metric tonnes EAFD received per 24 hour period
  - EAFD Silo (1_1B) – 29.9 metric tonnes EAFD received per 24 hour period
  - Carbon Silo (1_2A) – 19.14 metric tonnes carbon additive received per 24 hour period
  - Carbon Silo (1_2B) – 19.14 metric tonnes carbon additive received per 24 hour period
  - Calcium Silo (1_3A) – 30.74 metric tonnes calcium additive received per 24 hour period
- Natural gas fired equipment – operating at their respective nameplate input capacity ratings for the duration of the averaging period

As all available emission factors and estimation techniques for the above noted processes are based on a mass of contaminant per unit of production use of the maximum rates noted above will result in the highest predicted emission rates and subsequent off-site concentrations. There are no specific factors or testing results to allow for the assessment of either start-up or shutdown scenarios. As such, use of the available emission factors for these start-up or shutdown scenarios would result in a lower predicted emission rate and off-site concentration relative to the maximum production scenario.

The averaging times for the operating condition are 1-hour, 24-hour, monthly, and annual. The operating condition used for the Facility is the scenario where all significant sources are operating simultaneously at their individual maximum rates of production. The individual maximum rates of production for each significant source of emissions correspond to the maximum emission rate during any given 1 hour, 24 hour, monthly, and annual period. The individual maximum rates of production and material use for each significant source of emission are described in detail in **Appendix 2**.

4.2 Explanation of the Methods Used to Calculate Emission Rates

Air emissions sources at the Facility include two cartridge dust collectors in the pelletizing area, one cartridge dust collector in the zinc purification area, storage silos, natural gas fired process heating equipment, and natural gas fired comfort heating equipment. The Facility is expected to release suspended particulate matter, metal species, and the products of natural gas combustion. A complete list of sources is included in **Table 1**: Sources and Contaminant Identification Table. Source specifications and details of contaminant emissions are included in **Table 2**: Source Summary Table. For example, emissions of nitrogen oxides from natural gas combustion sources are based on an emission factor (EF) technique. Details related to the calculation of contaminant emission rates are provided in **Appendix 2**.

4.3 Assessment of Data Quality

This section provides a description of the assessment of the data quality of the emission estimates for each significant contaminant released by the Facility.

The data quality assessment was completed in accordance with the requirements of O.Reg. 419/05. For example, the emission factor technique used to calculate emissions of Nitrogen Oxides released from natural gas combustion units is based on the nameplate capacity of the equipment and emission factors published by the U.S. EPA in AP-42. Therefore, the estimated emission rate will not underestimate the actual emission rate and will result in an estimated maximum POI concentration greater than the actual POI concentration. These sources have been assessed as having "Above Average" data quality which is consistent with the guidance provided in the ESDM Procedure Document.

For each contaminant, the proposed emission rate was estimated and the data quality of the estimate is documented in **Table 2** – Source Summary Table. The assessment of data quality for each source listed in **Table 2** is documented in **Appendix 2**.

5. SOURCE SUMMARY TABLE AND SITE PLAN

This section provides the table required by sub paragraph 8 and the site plan required by sub paragraph 9 of s.26(1) O. Reg. 419/05.

5.1 Source Summary Table

The emission rate estimates for each source of significant contaminants are documented in **Table 2**: Source Summary Table in accordance with requirements of sub paragraph 8 of s.26(1) of O. Reg. 419/05. For each source of significant contaminants the following parameters are referenced:

- Contaminant;
- Chemical Abstract Service (CAS) registry number;
- Source reference number;
- Source description;
- Stack parameters (flow rate, exhaust temperature, diameter, height above grade, height above roof);

- Location referenced to the UTM coordinate system presented on **Figure 3**: Roof Plan);
- Maximum emission rate,
- Averaging period;
- Emission estimating technique;
- Estimation data quality; and
- Percentage of overall emissions.

5.2 Site Plan

The location of the emission sources listed in **Table 2**: Source Summary Table is presented in **Figure 3**: Source Location Plan; the location of each of the sources is specified with the source reference identifier. The location of the property-line is indicated on **Figure 2** with the end points of each section of the property-line clearly referenced to a UTM coordinate system. The location of each source is referenced to the UTM coordinate system under a column in **Table 2:** Source Summary Table.

The heights of the structures that are part of the Facility are labelled as "El" in **Figure 3:** Source Location Plan.

6. DISPERSION MODELLING

This section provides a description of how the dispersion modelling was conducted for the Facility to calculate the maximum concentration at a POI.

The dispersion modelling was conducted in accordance with the Ministry publication "Air Dispersion Modelling Guideline for Ontario" PIBS 5165e02 (ADMGO).

The Facility is subject to s.20 of O.Reg. 419/05 and therefore the modelled impact of contaminant emissions can be assessed as 24 hour maximum POI concentrations. The appropriate models to assess the 24-hour maximum POI impact are the U.S. EPA models, in this case AERMOD Version 19191.

The emission rates used in the dispersion model meet the requirements of O. Reg. 419/05 which requires that the emission rates used in the dispersion model are at least as high as the maximum emission rate that the source of the contaminant is reasonably capable of for the relevant contaminant. The emission rates are described in detail in **Appendix 2**.

There is no child care facility, health care facility, senior's residence, long term care facility or educational facility located at the site. Furthermore, the nearest POI is located more than 5 metres from the building on which the point of emissions are located. As such, same structure contamination was not considered.

6.1 AERMOD Modelling

The U.S. Environmental Protection Agency (U.S. EPA) AERMOD modelling system (Version 19191) was used to predict the point of impingement concentrations.

The PRIME plume rise algorithms include vertical wind shear calculations (important for buoyant releases from short stacks [i.e., stacks at release heights within the recirculation zones of buildings]). The PRIME algorithm also allows for the wind speed deficit induced by the building to change with respect to the distance from the building. These factors improve the accuracy of predicted concentrations within building wake regions. The AERMOD modelling system is made up of the AERMOD dispersion model, the AERMET meteorological pre-processor and the AERMAP terrain pre-processor.

A key to the dispersion modelling files provided with this report is presented in the following table.

File Name	Run Type	Elimination of Meteorological Anomalies?	Substance(s)
AERMOD.isc	Substance Specific	Yes	Manganese and compounds
AERMOD.isc	Multichemical	No	Cadmium and compounds, calcium oxide, carbon, chromium compounds (di, tri, metallic), ferric oxide, lead and compounds, nickel and compounds, nitrogen oxides, potassium, silicon dioxide, sodium monoxide, sulfur, suspended particulate matter, zinc.

6.1.1 Meteorology and Land Use Data

The AERMET meteorological pre-processor (Version 19191) pre-processes actual surface and radiosonde meteorological data for the AERMOD dispersion model. Surface meteorological data in the form of hourly observations of wind speed, wind direction, temperature, cloud cover and humidity are typically obtained from the nearest surface/airport station. Radiosonde data used to generate mixing layer depth information is typically obtained from the nearest upper air station. The surface and upper air data are then processed through numerous stages of AERMET, where the final stage utilizes surrounding geophysical data (land use and terrain) from the site to ultimately create a 5-year hourly dataset that is ready to be used by AERMOD.

The meteorological data used in this assessment was a pre-processed regional dataset, which was provided by the Ministry for the surrounding land use and terrain (SUBURBAN).

6.1.2 Elimination of Meteorological Anomalies

As noted under Section 6.6 of the ADMGO, modelling applications using regional or local meteorological data sets may have extreme, rare and transient metrological conditions in the data sets that may be considered outliers. In an effort to remove these outliers, the Ministry allows for the elimination of the eight hours having the highest predicted concentrations in each meteorological year in the case of shorter averaging periods (e.g., 10 minute, half hour or one hour) and the elimination of the 24 hour period having highest predicted concentration in each meteorological year when assessing 24 hour concentrations. Elimination of meteorological anomalies was completed for Manganese and Manganese Compounds using the MAXTABLE function in the AERMOD View software package.

6.1.3 Coordinate System

Universal Transverse Mercator (UTM) coordinate system, as per Section 5.2.2 of the ADMGO was used to specify model object sources, buildings and receptors. All coordinates were defined in the World Geodetic Survey of 1984 (WGS84). All source, building, and property line coordinates are provided in **Figures 2**, and **3**.

6.1.4 Terrain

Relying on the assumption that terrain will affect air quality concentrations at individual receptors, AERMOD captures the essential physics of dispersion in complex terrain through the use of a separate height scale for each receptor. The height scale factor represents the terrain which would dominate flow in the vicinity of that receptor.

The height scale factor that is used by AERMOD is generated by a terrain pre-processor which is called AERMAP. The AERMAP terrain pre-processor (Version 11103) utilizes terrain data, or Canadian Digital Elevation Model (CDEM) data that was obtained from Ministry (7.5 minute format) in conjunction with a layout of receptors and sources to height scale factors which can be directly used in AERMOD. The following terrain data files were used in completing the modelling assessment:

- cdem_dem_030M.tif

The terrain data used in the current assessment is shown in **Figure 5**.

6.1.5 Source Data

As per Section 4.5 of the ADMGO the significant sources at the site were classified as point and volume sources. The source data required for each source was determined according to the procedures provided in the relevant Section of the guide and summarized in the Dispersion Modelling Source Summary Table (**Table 3**).

In summary, the significant sources at the site were modelled as follows:

- Point sources – include the process exhausts and natural gas fired heating units.

6.1.6 Downwash

Building wake effects were considered in this modelling study using the U.S. EPA's Building Profile Input Program for PRIME Version 04274 (BPIPPRM), another pre-processor to AERMOD. The inputs into this pre-processor include the coordinates and heights of the buildings and stacks. The information from BPIPPRM is used in the building wake effect calculation.

The PRIME algorithm also allows for the wind speed deficit induced by the building to change with respect to the distance from the building. These factors improve the accuracy of predicted concentrations within building wake zones that form in the lee of buildings.

6.1.7 Deposition and Depletion

The AERMOD dispersion model has the capability to account for wet and dry deposition and depletion of substances. This would realistically reduce airborne concentrations. These algorithms have not been implemented in the modelling which results in more conservative concentrations being predicted.

6.1.8 Averaging Times

The modelling supporting the application was completed based on the actual hours of operation at this facility. For example, under the current operating scenario, the Facility operates for 24 hours; therefore the maximum hourly emission rate calculated for the sources were modelled for 24 hours per day. In the case of the monthly and annual averaging periods, the maximum calculated 24 hour emission rate was assumed to be sustained for the duration of each averaging period. Assessment of compliance with the daily assessment value (DAV) and annual assessment value (AAV) for Nickel used the maximum 24 hour emission rate. In the case of the results of the annual assessment and comparison to the AAV, the predicted maximum concentration was multiplied by 140% as per the guidance provided in the Ministry's draft

Technical Bulletin entitled "Methodology for using Assessment Values for Contaminants with Annual Air Standards".

6.1.9 Receptors

Receptors were chosen based on recommendations provided in Section 7.1 of the ADMGO, which is in accordance with s.14 of O.Reg.419/05. Specifically, a nested receptor grid, centered around the outer edges of all the sources, was placed as follows:

a) 20 m spacing, within an area of 200 m by 200 m;
b) 50 m spacing, within an area surrounding the area described in (a) with a boundary at 300 m by 300 m outside the boundary of the area described in (a);
c) 100 m spacing, within an area surrounding the area described in (b) with a boundary at 800 m by 800 m outside the boundary of the area described in (a);
d) 200 m spacing, within an area surrounding the area described in (c) with a boundary at 1,800 m by 1,800 m outside the boundary of the area described in (a);
e) 500 m spacing, within an area surrounding the area described in (d) with a boundary at 4,800 m by 4,800 m outside the boundary of the area described in (a); and
f) 1000 m spacing, within an area surrounding the area described in (e) with a boundary at 7,300 m by 7,300 m outside of the boundary of the area described in (a).

In addition to using the nested receptor grid, receptors were also placed every 10 m along the property line.

The resulting maximum POI concentrations and aggregate emission rates are presented in the Emission Summary Table (**Table 4**).

7. EMISSION SUMMARY TABLE AND CONCLUSIONS

This section provides an interpretation of the results of the modelling assessment as required by the ESDM Procedure Document.

7.1 Emission Summary Table

A POI concentration for each significant contaminant emitted from the Facility was calculated based on the emission rates listed in **Table 2:** Source Summary Table and the outputs from the approved dispersion models presented in **Appendix 5**. The results are presented in **Table 4:** Emission Summary Table.

The POI concentrations listed in **Table 4** were compared against the limits presented in the Ministry's ACB List.

Of the 16 contaminants listed in **Table 4** that have Ministry Limits, all of the predicted POI concentrations are below the corresponding limits. The contaminant with the greatest percentage of the current POI Limit was predicted to be Cadmium and Cadmium Compounds with a value of approximately 94% of the limit at the maximum point of impingement.

7.2 Assessment of Contaminants with No Ministry POI Limits

Contaminants released by the Facility that are not found on the ACB List or are above the de minimus threshold concentration are considered to be "Contaminants with no Ministry POI Limits". The Facility does not release any "Contaminants with no Ministry POI Limits" in significant quantities.

7.3 Annual and Daily Assessment Values

The operating and modelling scenarios used to evaluate Facility emissions with respect to applicable annual and daily assessment values are as follows:

Annual Assessment Values – modelling was completed using the maximum 24 hour emission rate scenario sustained for the duration of the averaging period and the maximum predicted annual concentration from the 5 years of meteorological data multiplied by 140%.

Daily Assessment Values – modelling was completed using the maximum hourly emission rate scenario sustained for the duration of the averaging period without elimination of meteorological anomalies.

7.4 Conclusions

This ESDM report was prepared in accordance with s.26 of O.Reg. 419/05. In addition, guidance from the ESDM Procedure Document was followed as appropriate.

The assessment of compliance has been completed using s.20 of O.Reg.419/05 and using conservative dispersion factors, the approved dispersion model (AERMOD Version 19191) and the standards listed in Schedule 3 of O.Reg.419/05, as well as the applicable limits presented in the Ministry's ACB List.

The emission rate estimates for each source of significant contaminants are documented in **Table 2** – Source Summary Table. All of the emission rates listed in **Table 2** corresponds to the operating scenario where all significant sources are operating simultaneously at their individual maximum rates of production.

A POI concentration for each significant contaminant emitted from the Facility as calculated based on the calculated emission rates and the output from conservative dispersion calculations or the U.S. EPA model AERMOD v19191; the results are presented in **Table 4:** Emission Summary Table.

Of the 15 contaminants that have Ministry Limits, all of the predicted POI concentrations are below the corresponding limits. The contaminant with the greatest percentage of the current POI Limit was predicted to be Cadmium and Cadmium Compounds with a value of approximately 94% of the 24 hour limit at the maximum point of impingement.

The Facility does not release any “Contaminants with no Ministry POI Limits” in significant quantities.

This ESDM Report demonstrates that the Facility can operate in compliance with s.20 of O.Reg. 419/05.

8. REFERENCES

1. Ministry Document PIBS #3614e04.1, “Procedure for Preparing an Emission Summary and Dispersion Modelling Report, Version 4.1”, dated March 2018.
2. Ministry Document PIBS #5165e03, “Air Dispersion Modelling Guideline for Ontario, Version 3.0”, dated February 2017.
3. Ministry Workbook, "Air Contaminants Benchmarks (ACB) List: Standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants", Version 2.0, dated April 2018.

TABLES

Table 1: Sources and Contaminant Identification Table

Source Information			Expected Contaminants	Included in Modelling?	Rationale
Source ID	General Location	Source Description or Title		Significant (Yes or No?)	
PDC	Northwest portion of main building	General and Central Dust Collectors - Pelletizing	Aluminum	No	ESDM Procedure Document Section 7.1.2
			Aluminum oxide	No	ESDM Procedure Document Section 7.1.2
			Antimony	No	ESDM Procedure Document Section 7.1.2
			Arsenic and compounds	No	ESDM Procedure Document Section 7.1.2
			Barium	No	ESDM Procedure Document Section 7.1.2
			Boron	No	ESDM Procedure Document Section 7.1.2
			Cadmium and compounds	Yes	Not Applicable
			Calcium oxide	Yes	Not Applicable
			Carbon	Yes	Not Applicable
			Chlorine	No	ESDM Procedure Document Section 7.1.2
			Chromium compounds (di, tri, metallic)	Yes	Not Applicable
			Copper	No	ESDM Procedure Document Section 7.1.2
			Ferric oxide	Yes	Not Applicable
			Lead and compounds	Yes	Not Applicable
			Magnesium oxide	No	ESDM Procedure Document Section 7.1.2
			Manganese and compounds	Yes	Not Applicable
			Mercury	No	ESDM Procedure Document Section 7.1.2
			Molybdenum	No	ESDM Procedure Document Section 7.1.2
			Nickel and compounds	Yes	Not Applicable
			Phosphorus	No	ESDM Procedure Document Section 7.1.2
			Phosphorus pentoxide	No	ESDM Procedure Document Section 7.1.2
			Potassium	Yes	Not Applicable
			Selenium	No	ESDM Procedure Document Section 7.1.2
			Silicon dioxide	Yes	Not Applicable
			Silver	No	ESDM Procedure Document Section 7.1.2
			Sodium (as Sodium monoxide)	Yes	Not Applicable
			Sulfur	Yes	Not Applicable
			Sulphur Dioxide	Yes	Not Applicable
			Suspended particulate matter	Yes	Not Applicable
			Tin	No	ESDM Procedure Document Section 7.1.2
			Titanium	No	ESDM Procedure Document Section 7.1.2
			Titanium dioxide	No	ESDM Procedure Document Section 7.1.2
			Vanadium	No	ESDM Procedure Document Section 7.1.2
			Zinc	Yes	Not Applicable

Table 1: Sources and Contaminant Identification Table

Source Information			Expected Contaminants	Included in Modelling?	Rationale
Source ID	General Location	Source Description or Title		Significant (Yes or No?)	
ZDC	North centre of main building	Zinc Dust Collector - Zinc Purification	Aluminum	No	ESDM Procedure Document Section 7.1.2
			Antimony	No	ESDM Procedure Document Section 7.1.2
			Arsenic and compounds	No	ESDM Procedure Document Section 7.1.2
			Barium	No	ESDM Procedure Document Section 7.1.2
			Boron	No	ESDM Procedure Document Section 7.1.2
			Cadmium and compounds	Yes	Not Applicable
			Chromium compounds (di, tri, metallic)	Yes	Not Applicable
			Copper	No	ESDM Procedure Document Section 7.1.2
			Lead and compounds	Yes	Not Applicable
			Manganese and compounds	Yes	Not Applicable
			Mercury	No	ESDM Procedure Document Section 7.1.2
			Molybdenum	No	ESDM Procedure Document Section 7.1.2
			Nickel and compounds	Yes	Not Applicable
			Phosphorus	No	ESDM Procedure Document Section 7.1.2
			Potassium	Yes	Not Applicable
			Selenium	No	ESDM Procedure Document Section 7.1.2
			Silver	No	ESDM Procedure Document Section 7.1.2
			Sodium (as Sodium monoxide)	Yes	Not Applicable
			Sulfur	Yes	Not Applicable
			Suspended particulate matter	Yes	Not Applicable
			Tin	No	ESDM Procedure Document Section 7.1.2
			Titanium	No	ESDM Procedure Document Section 7.1.2
			Zinc	Yes	Not Applicable
SCRUB	North side of building - horizontal discharge	SO_2 Scrubber Air Vent	Sodium sulfate	No	ESDM Procedure Document Section 7.1.2
SILOS	Northwest side of main building	EAFD Storage Silos	Aluminum oxide	No	ESDM Procedure Document Section 7.1.2
			Cadmium and compounds	Yes	Not Applicable
			Calcium oxide	Yes	Not Applicable
			Carbon	Yes	Not Applicable
			Chlorine	No	ESDM Procedure Document Section 7.1.2
			Chromium compounds (di, tri, metallic)	Yes	Not Applicable
			Copper	No	ESDM Procedure Document Section 7.1.2
			Ferric oxide	Yes	Not Applicable
			Lead and compounds	Yes	Not Applicable
			Magnesium oxide	No	ESDM Procedure Document Section 7.1.2
			Manganese and compounds	Yes	Not Applicable
			Nickel and compounds	Yes	Not Applicable
			Phosphorus pentoxide	No	ESDM Procedure Document Section 7.1.2
			Potassium	Yes	Not Applicable
			Silicon dioxide	Yes	Not Applicable
			Sodium (as Sodium monoxide)	Yes	Not Applicable
			Sulfur	Yes	Not Applicable
			Suspended particulate matter	Yes	Not Applicable
			Titanium dioxide	No	ESDM Procedure Document Section 7.1.2
			Vanadium	No	ESDM Procedure Document Section 7.1.2
			Zinc	Yes	Not Applicable
		Carbon Storage Silos	Carbon	Yes	Not Applicable
			Sulfur	Yes	Not Applicable
			Suspended particulate matter	Yes	Not Applicable
		Calcium Storage Silo	Calcium oxide	Yes	Not Applicable
			Suspended particulate matter	Yes	Not Applicable
HRV	Northwest portion of main building	Thermal oxidizer with heat recovery	Carbon monoxide	No	ESDM Procedure Document Section 7.1.2
			Products of natural gas combustion	Yes - NOx Only	Not Applicable

Table 1: Sources and Contaminant Identification Table

Source Information			Expected Contaminants	Included in Modelling?	Rationale
Source ID	General Location	Source Description or Title		Significant (Yes or No?)	
NGC	Various	Process Natural Gas Combustion	Products of natural gas combustion	Yes - NOx Only	Not Applicable
NGCH	Various	Natural Gas Comfort Heat	Products of natural gas combustion	Yes - NOx Only	Not Applicable
LAB	East end of main building	Fume Hood - Lab	Volatile Organic Compounds	No	ESDM Procedure Document Table B-3A "Specific Examples of Sources that Emit Contaminants in Negligible Amounts" - Fume hoods for laboratories that are used for quality control and quality assurance purposes at industrial facilities.
COMP	North side of building - horizontal discharge	Air Compressor	None expected	No	ESDM Procedure Document Table B-3A "Specific Examples of Sources that Emit Contaminants in Negligible Amounts" - Exhaust of inert gases.
GEN	Various	General Exhausts	None expected	No	ESDM Procedure Document Table B-3B "Examples of Sources that may Emit Contaminants in Negligible Amounts" - Sources that are Exempt from Obtaining an ECA [O. Reg. 524/98: Environmental Compliance Approvals — Exemptions From Section 9 Of The Act]

Table 2: Source Summary Table

Source Data		Stack Data								Emission Data						
Source ID	Process Description	Stack ID	Stack Gas Flow Rate	Stack Gas Temperature	Stack Diameter	Stack Height Above Grade	Stack Height Above Roof	UTM Coordinates (Easting, Northing)		Contaminant	Emission Rate	Data Quality	Averaging Period	Estimation Technique	Percentage of Overall Emission	CAS
			(m^3/s)	(deg C)	(m)	(m)	(m)	(m)			(g/s)		(hours)		(%)	
PDC	General Dust Collector - Pelletizing	1V1	3.305	20	0.508	18.3	2	594,621	4,790,819	Cadmium and compounds	8.79E-05	Average	24	EC	92%	7440-43-9
	Central Dust Collector - Pelletizing	1V2	2.597	100	0.465	18.3	2	594,623	4,790,819	Calcium oxide	6.06E-03	Average	24	EC	76%	1305-78-8
										Carbon	7.18E-04	Average	24	EC	28%	7440-44-0
										Chromium compounds (di, tri, metallic)	1.57E-04	Average	24	EC	95%	7440-47-3
										Ferric oxide	2.13E-02	Average	24	EC	95%	1309-37-1
										Lead and compounds	7.23E-04	Average	24	EC	71%	7439-92-1
										Manganese and compounds	1.49E-03	Average	24	EC	91%	7439-96-5
										Nickel and compounds	2.58E-05	Average	8760	EC	95%	7440-02-0
										Potassium	3.81E-04	Average	24	EC	94%	7440-09-7
										Silicon dioxide	3.88E-03	Average	24	EC	95%	7631-86-9
										Sodium (as Sodium monoxide)	6.10E-04	Average	24	EC	95%	12401-86-4
										Sulfur	3.50E-04	Average	24	EC	90%	7704-34-9
										Sulphur dioxide	6.42E-03	Average	24	EC	100%	7446-09-5
										Suspended particulate matter	4.60E-02	Average	8760	EC	83%	N/A(9)
										Zinc	1.29E-02	Average	24	EC	83%	7440-66-6
ZDC	Zinc Dust Collector - Zinc Purification	3V4	0.708	115	0.254	18.3	2	594660.84	4790806.67	Cadmium and compounds	2.97E-06	Average	24	EC	3%	7440-43-9
										Chromium compounds (di, tri, metallic)	1.30E-07	Average	24	EC	0.1%	7440-47-3
										Lead and compounds	2.58E-04	Average	24	EC	25%	7439-92-1
										Manganese and compounds	7.08E-05	Average	24	EC	4%	7439-96-5
										Nickel and compounds	6.97E-08	Average	8760	EC	0%	7440-02-0
										Potassium	3.39E-06	Average	24	EC	1%	7440-09-7
										Sodium (as Sodium monoxide)	4.47E-06	Average	24	EC	1%	12401-86-4
										Sulfur	2.41E-06	Average	24	EC	1%	7704-34-9
										Suspended particulate matter	3.54E-03	Average	24	EC	6%	N/A(9)
										Zinc	2.01E-03	Average	24	EC	13%	7440-66-6
SILOS	EAFD Storage Silos	1_1A	0.329	Ambient	0.254	14.8	0.5	594612.8	4790824.31	Cadmium and compounds	4.36E-06	Average	24	EC	5%	7440-43-9
		1_1B	0.329	Ambient	0.254	14.8	0.5	594607.36	4790826.16	Calcium oxide	3.00E-04	Average	24	EC	4%	1305-78-8
										Carbon	3.56E-05	Average	24	EC	1%	7440-44-0
										Chromium compounds (di, tri, metallic)	7.75E-06	Average	24	EC	5%	7440-47-3
										Ferric oxide	1.06E-03	Average	24	EC	5%	1309-37-1
										Lead and compounds	3.58E-05	Average	24	EC	4%	7439-92-1
										Manganese and compounds	7.39E-05	Average	24	EC	5%	7439-96-5
										Nickel and compounds	1.28E-06	Average	8760	EC	5%	7440-02-0
										Potassium	1.89E-05	Average	24	EC	5%	7440-09-7
										Silicon dioxide	1.92E-04	Average	24	EC	5%	7631-86-9
										Sodium (as Sodium monoxide)	3.02E-05	Average	24	EC	5%	12401-86-4
										Sulfur	1.73E-05	Average	24	EC	4%	7704-34-9
										Suspended particulate matter	2.28E-03	Average	24	EC	4%	N/A(9)
										Zinc	6.39E-04	Average	24	EC	4%	7440-66-6
	Carbon Storage Silos	1_2A	0.304	Ambient	0.254	14.8	0.5	594611.65	4790820.16	Carbon	1.78E-03	Average	24	EC	70%	7440-44-0
		1_2B	0.304	Ambient	0.254	14.8	0.5	594606.2	4790822.01	Sulfur	1.81E-05	Average	24	EC	5%	7704-34-9
										Suspended particulate matter	1.99E-03	Average	24	EC	4%	N/A(9)
	Calcium Storage Silo	1_3A	0.434	Ambient	0.305	9.9	0.4	594610.28	4790815.84	Calcium oxide	1.60E-03	Average	24	EC	20%	1305-78-8
										Suspended particulate matter	1.60E-03	Average	24	EC	3%	N/A(9)

Table 2: Source Summary Table

Source Data		Stack Data								Emission Data						
Source ID	Process Description	Stack ID	Stack Gas Flow Rate	Stack Gas Temperature	Stack Diameter	Stack Height Above Grade	Stack Height Above Roof	UTM Coordinates (Easting, Northing)		Contaminant	Emission Rate	Data Quality	Averaging Period	Estimation Technique	Percentage of Overall Emission	CAS
			(m^3/s)	(deg C)	(m)	(m)	(m)	(m)			(g/s)		(hours)		(%)	
NGC	Process Natural Gas Combustion	1V2	2.597	100	0.465	18.3	2	594623.3	4790818.89	Nitrogen oxides	3.71E-02	Above Average	1, 24	EF	15%	10102-44-0
		2V3	2.833	950	0.508	17.8	2	594634.32	4790816.57	Nitrogen oxides	7.41E-02	Above Average	1, 24	EF	31%	10102-44-0
		3V4	0.708	115	0.254	18.3	2	594660.84	4790806.67	Nitrogen oxides	6.18E-02	Above Average	1, 24	EF	26%	10102-44-0
NGCH	Natural Gas Comfort Heat	UH1	0.133	250	0.152	5.54	Sidewall	594631.32	4790825.23	Nitrogen oxides	6.72E-02	Above Average	1, 24	EF	28%	10102-44-0
		UH2	0.133	250	0.152	5.54	Sidewall	594643.69	4790821.52							
		UH3	0.133	250	0.152	5.54	Sidewall	594655.36	4790817.63							
		UH4	0.133	250	0.152	5.54	Sidewall	594667.38	4790813.57							
		UH5	0.133	250	0.152	5.54	Sidewall	594677.63	4790810.21							
		UH6	0.133	250	0.152	15.85	0.5	594618.41	4790804.2							
		UH7	0.133	250	0.152	15.85	0.5	594632.2	4790799.78							
		UH8	0.133	250	0.152	15.85	0.5	594642.98	4790796.77							
		UH9	0.133	250	0.152	15.85	0.5	594654.65	4790792.89							
		UH10	0.133	250	0.152	15.85	0.5	594660.84	4790790.94							
		UH11	0.133	250	0.152	15.85	0.5	594667.2	4790789							
		UH12	0.133	250	0.152	12.04	0.5	594608.52	4790788.64							
		UH13	0.133	250	0.152	12.04	0.5	594620.89	4790784.58							
		UH14	0.133	250	0.152	12.04	0.5	594631.5	4790781.04							
		UH15	0.133	250	0.152	12.04	0.5	594644.58	4790776.8							
		UH16	0.133	250	0.152	12.04	0.5	594661.54	4790771.14							
		UH17	0.133	250	0.152	15.01	0.5	594606.93	4790801.19							

Table 3: Dispersion Modelling Input Summary Table

Relevant Section of the Regulation	Section Title	Description of How the Approved Dispersion Model was Used
Section 8	Negligible Sources	Sources and contaminants were considered negligible in accordance with s.8 of O.Reg. 419. See the Sources and Contaminants Identification Table for more information.
Section 9	Same Structure Contamination	Not Applicable - GFL is the only company on the subject property.
Section 10	Operating Conditions	All equipment was assumed to be concurrently operating at maximum capacity. See Section 3.1 for additional details.
Section 11	Source of Contaminant Emission Rates	Emission rates were calculated using published emission factors, mass balance calculations and engineering calculations.
Section 12	Combined Effect of Assumptions for Operating Conditions and Emission Rates	The operating conditions were estimated in accordance with s. 10(1)1 and s.11(1)1 and are therefore considered to result in the highest POI concentration that the facility is capable of producing.
Section 13	Meteorological Conditions	Preprocessed regional meteorological data (SUBURBAN) used was obtained from Ministry website: for London Ontario for the years 1996 - 2000.
Section 14	Area of Modelling Coverage	Receptor grids were chosen based on recommendations provided in Section 7.1 of the ADMGO, the minimum placement based on Section 14 of O. Reg 419/05 was maintained.
Section 15	Stack Height for Certain New Sources of Contaminant	Not Applicable - Section 15 of O.Reg. 419 does not apply to the Facility.
Section 16	Terrain Data	Terrain files used for this assessment include the following: cdem_dem_030M.tif
Section 17	Averaging Periods	1 hour, 24 hour, monthly, and annual

Table 4: Emission Summary Table

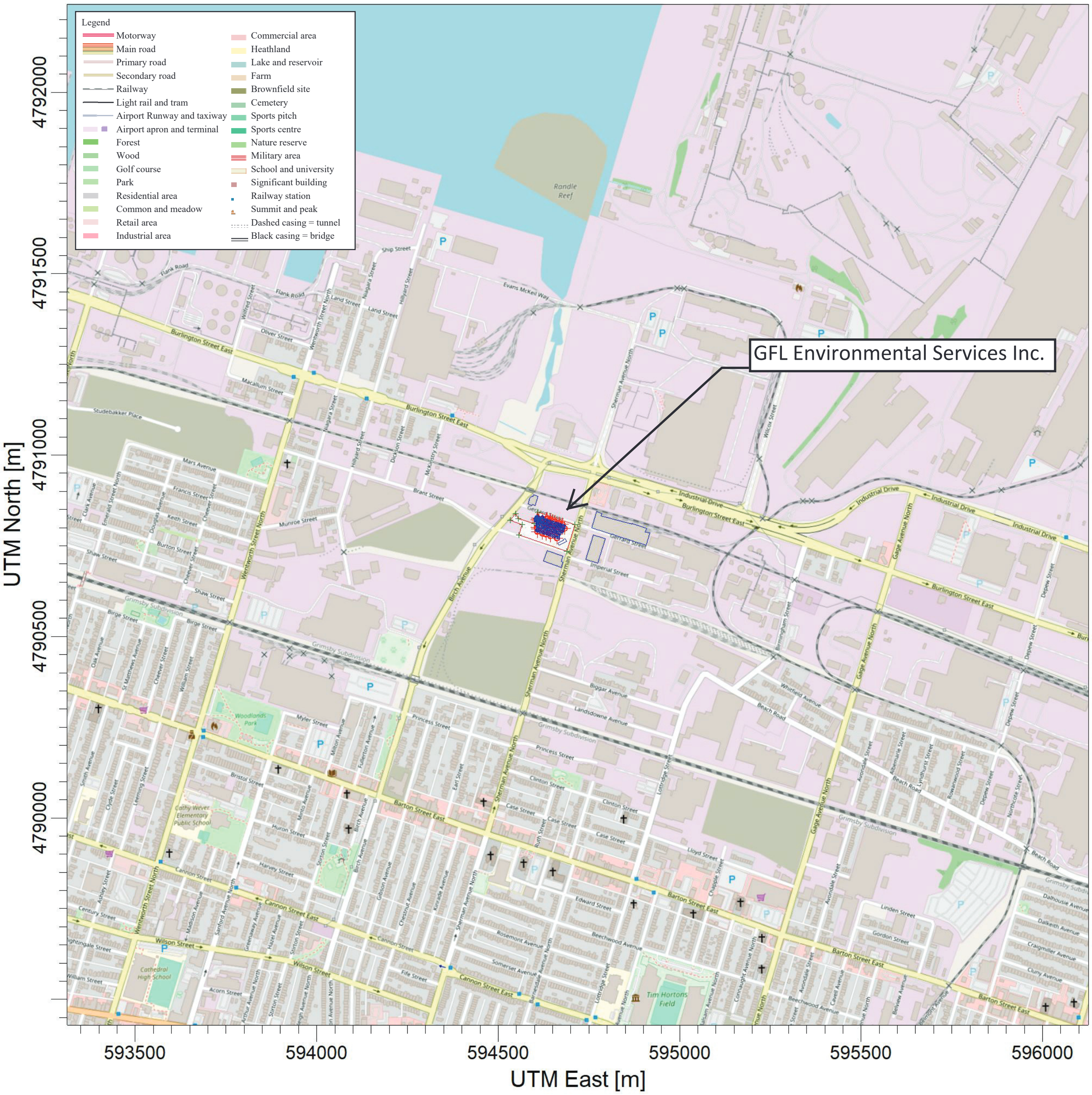
Contaminant	CAS	Emission Rate (g/s)	Air Dispersion Model Used	Maximum Predicted Concentration (µg/m^3)	POI Limit (µg/m^3)	Limiting Effect	Averaging Period (Hours)	Limit Source	Percentage of Limit (%)
Cadmium and compounds	7440-43-9	9.53E-05	AERMOD v19191	2.36E-02	0.025	Health	24	Standard	94%
Calcium oxide	1305-78-8	7.96E-03		2.55E+00	10	Corrosion	24	Standard	26%
Carbon	7440-44-0	2.53E-03		9.41E-01	1.75	Health	24	SL-JSL	54%
Chromium compounds (di, tri, metallic)	7440-47-3	1.64E-04		4.10E-02	0.5	Health	24	Standard	8%
Ferric oxide	1309-37-1	2.24E-02		5.52E+00	25	Soiling	24	Standard	22%
Lead and compounds	7439-92-1	1.02E-03		2.63E-01	0.5	Health	24	Standard	53%
	7439-92-1	1.02E-03		9.84E-02	0.2	Health	720	Standard	49%
Manganese and compounds	7439-96-5	1.64E-03		3.59E-01	0.4	Health	24	Standard	90%
Nickel and compounds	7440-02-0	2.71E-05		2.49E-03	0.04	Health	8760	Standard	6%
	7440-02-0	2.71E-05		2.49E-03	0.4	AAV	8760	AAV	0.6%
	7440-02-0	2.71E-05		6.69E-03	2	DAV	24	DAV	0.3%
Nitrogen oxides	10102-44-0	2.40E-01		6.53E+01	200	Health	24	Standard	33%
	10102-44-0	2.40E-01		1.04E+02	400	Health	1	Standard	26%
Potassium	7440-09-7	4.03E-04		9.96E-02	1	Health	24	SL-JSL	10%
Silicon dioxide	7631-86-9	4.07E-03		1.00E+00	5	Health	24	SL-MD	20%
Sodium (as Sodium monoxide)	12401-86-4	6.45E-04		1.59E-01	0.5	Health	24	SL-JSL	32%
Sulfur	7704-34-9	3.88E-04		9.83E-02	2.5	Health	24	SL-JSL	4%
Sulphur dioxide	7446-09-5	6.42E-03		1.48E+00	275	Health & Vegetation	24	Standard	1%
	7446-09-5	6.42E-03		2.64E+00	690	Health & Vegetation	1	Standard	0.4%
	7446-09-5	6.42E-03		5.35E-01	10	Vegetation	8760	Standard - 2023	5%
	7446-09-5	6.42E-03		2.64E+00	100	Health	1	Standard - 2023	3%
Suspended particulate matter	N/A(9)	5.55E-02		1.47E+01	120	Visibility	24	Standard	12%
Zinc	7440-66-6	1.55E-02		3.93E+00	120	Particulate	24	Standard	3%

Assessment of compliance with Annual Standards and Annual Assessment Values was determined by using the maximum annual POI concentration multiplied by 140% as advised by Technical Bulletin (O.Reg. 419/05) - Methodology for using "Assessment Values" for contaminants with Annual Air Standards.

FIGURES

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



COMMENTS:

Figure 1 - Area Location Plan

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

SCALE: 1:17,696

0 — 0.5 km

DATE:

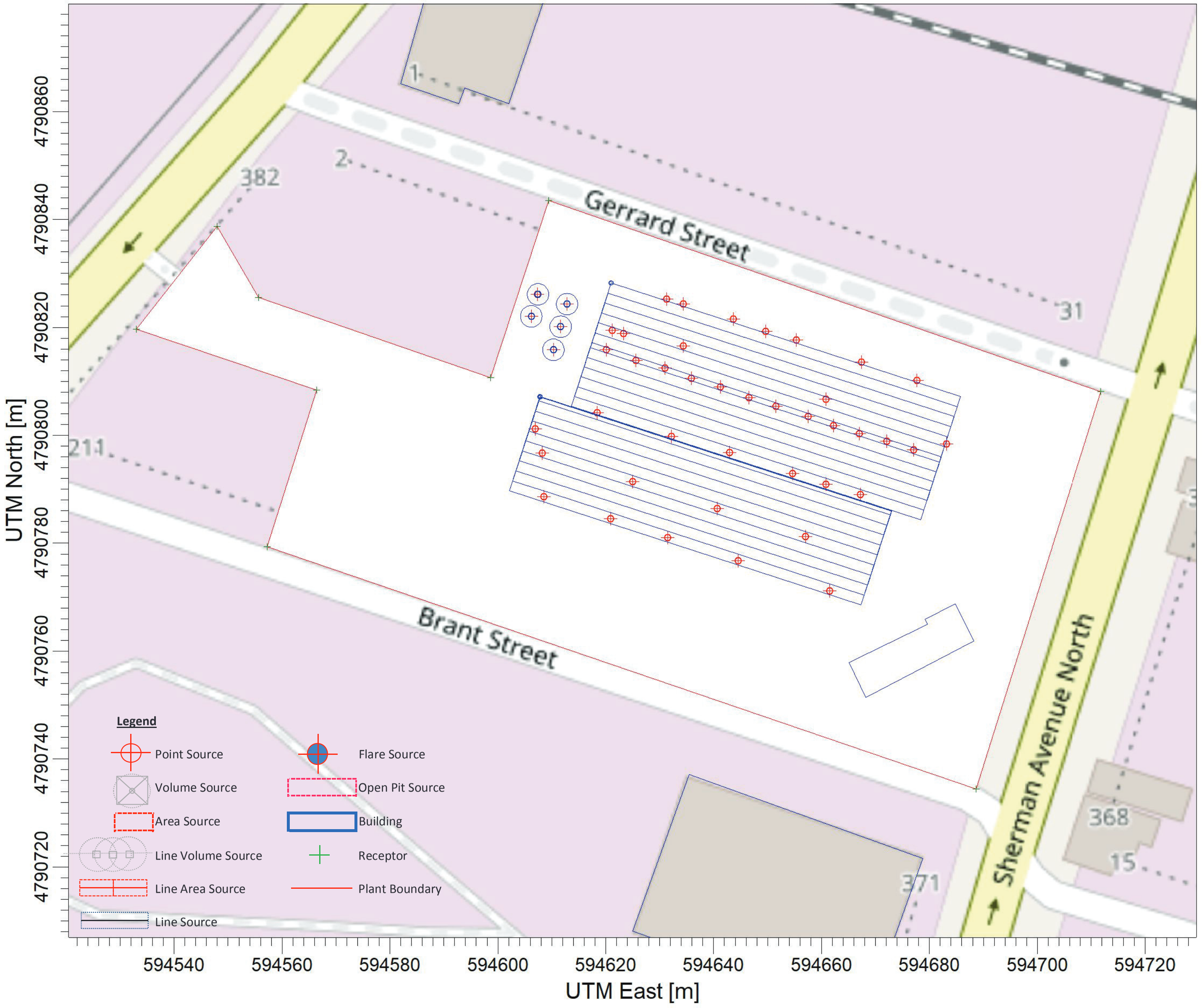
10/12/2022

PROJECT NO.:

22-024

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



COMMENTS:

Figure 2 - Site Plan

SOURCES:

46

RECEPTORS:

2420

N

COMPANY NAME:

O2E Inc.

MODELER:

TML

DATE:

10/12/2022

SCALE: 1:1,178

0 0.03 km

O2E Inc. ENVIRONMENTAL CONSULTANTS

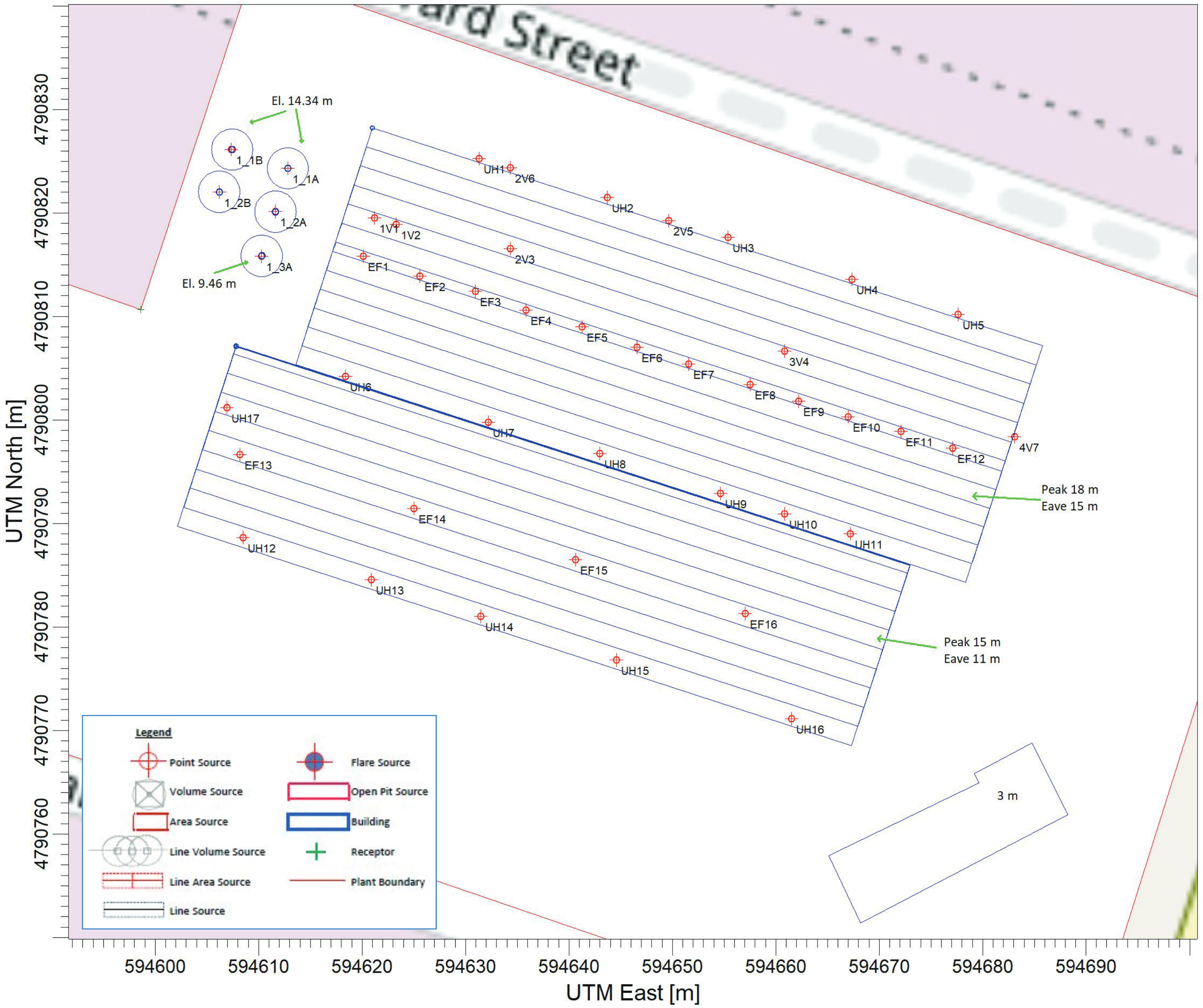
PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



COMMENTS:

Figure 3 - Source Location Plan

SOURCES:

46

RECEPTORS:

2420

N

COMPANY NAME:

O2E Inc.

MODELER:

TML

DATE:

10/12/2022

SCALE: 1:615

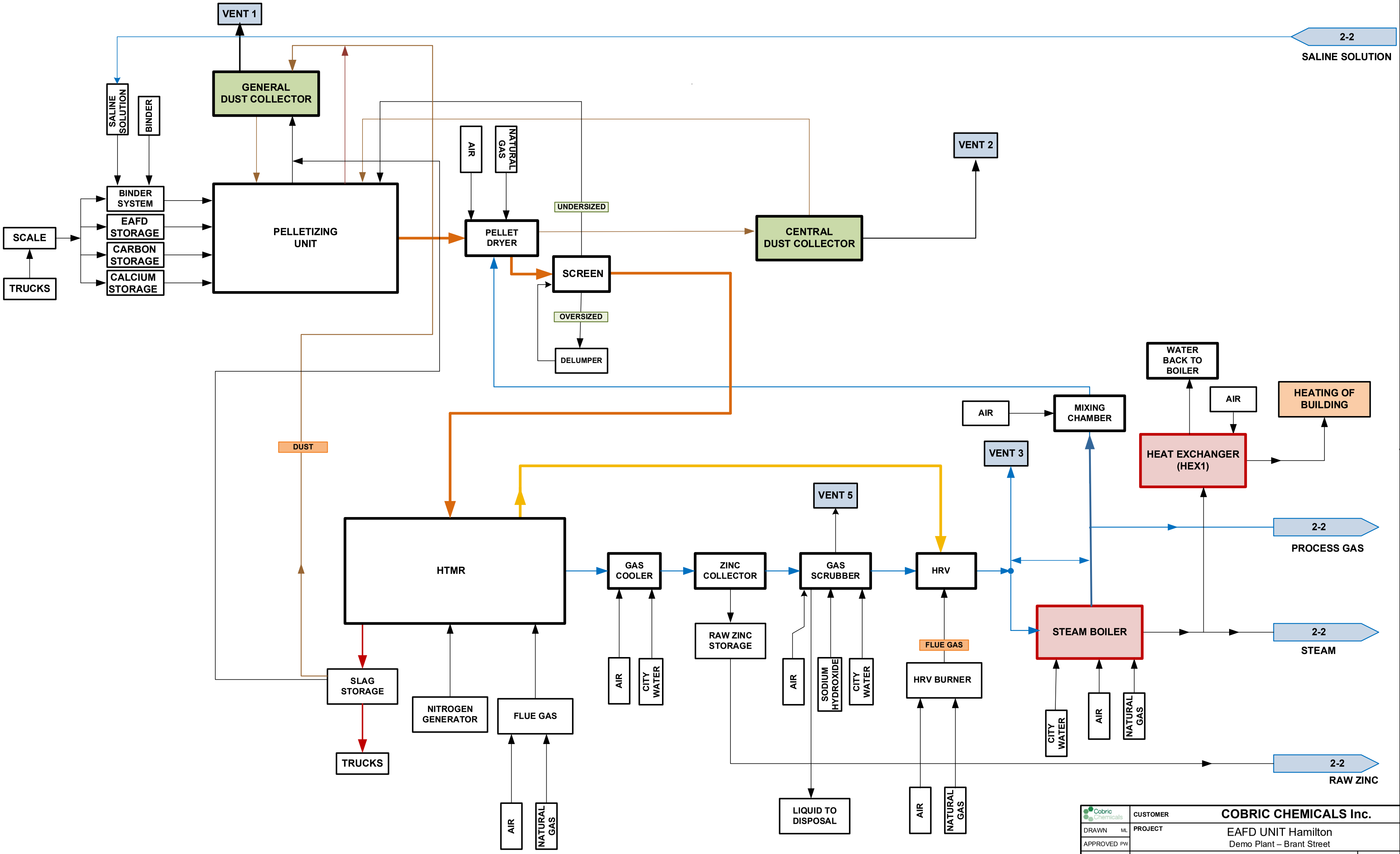
0 0.01 km

O2E Inc.
ENVIRONMENTAL CONSULTANTS

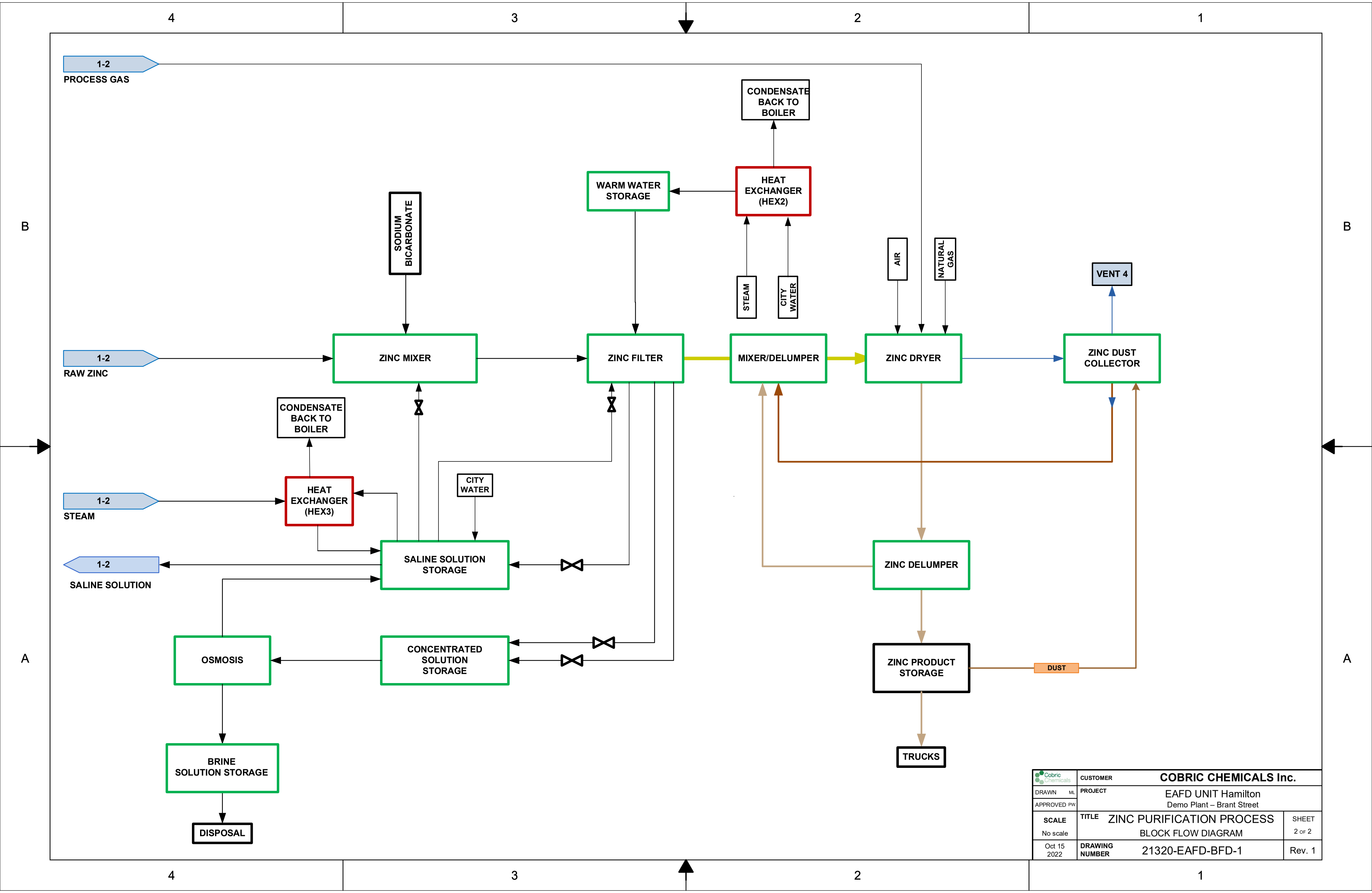
PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software



Cobric Chemicals	CUSTOMER	COBRIC CHEMICALS Inc.	
DRAWN ML	PROJECT	EAFD UNIT Hamilton Demo Plant – Brant Street	
APPROVED PW			
SCALE No scale	TITLE	PELLETIZING & HTMR PROCESSING BLOCK FLOW DIAGRAM	SHEET 1 of 2
Oct 15 2022	DRAWING NUMBER	21320-EAFD-BFD-1	Rev. 1



Cobric Chemicals

CUSTOMER COBRIC CHEMICALS Inc.

DRAWN ML

APPROVED PW

PROJECT EAFD UNIT Hamilton

Demo Plant – Brant Street

SCALE No scale

TITLE ZINC PURIFICATION PROCESS

BLOCK FLOW DIAGRAM

SHEET 2 OF 2

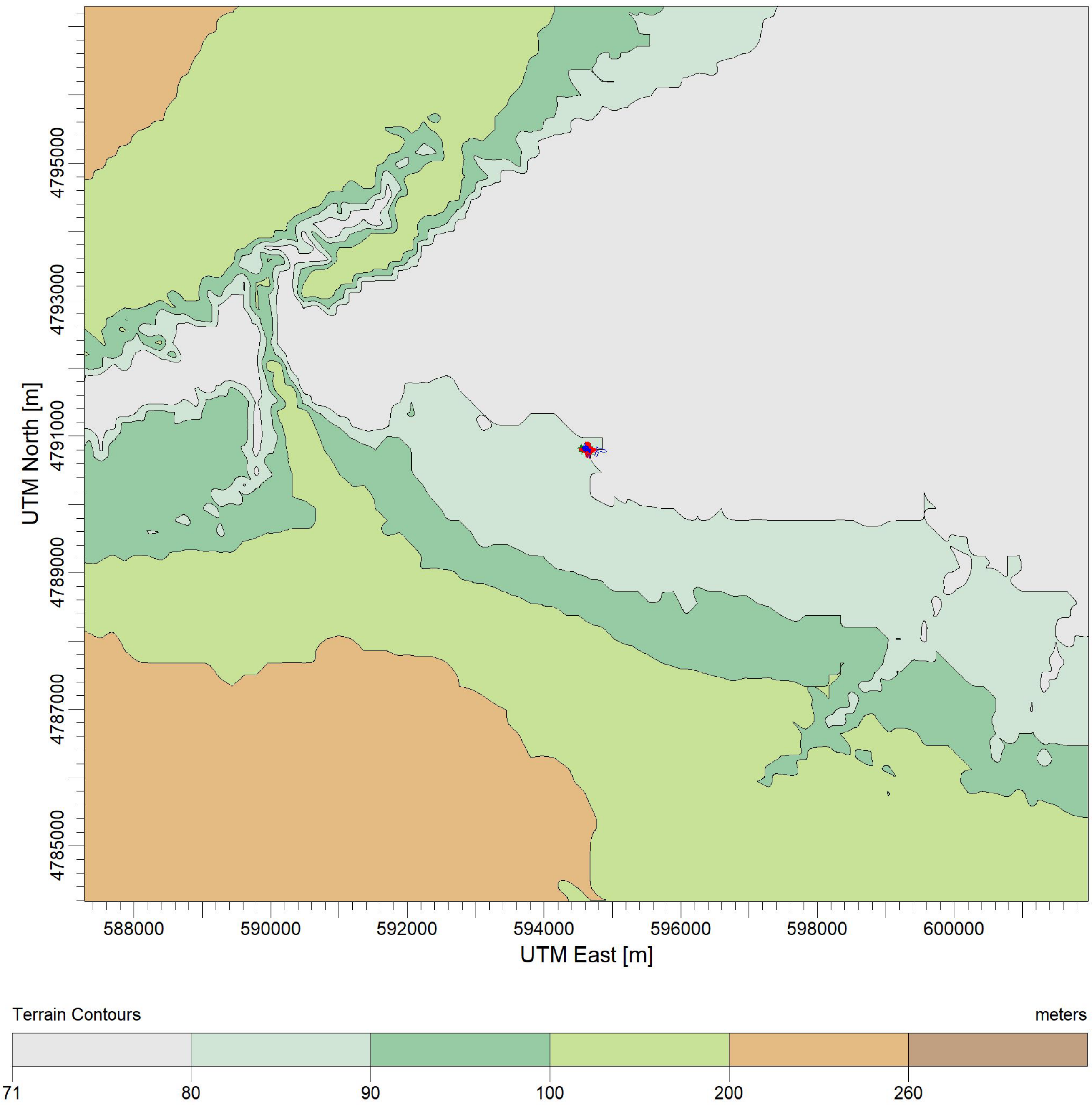
Oct 15 2022

DRAWING NUMBER 21320-EAFD-BFD-1

Rev. 1

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



COMMENTS:

Figure 5 - Terrain Data

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

SCALE:

1:92,392

0 3 km

DATE:

10/12/2022

PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

APPENDIX 1
MODIFICATION LOG

EMISSION SUMMARY AND DISPERSION MODELLING REPORT
MODIFICATION LOG

GFL Environmental Services Inc. – 237 Brant Street Operations

Date Changed	Description of Change	Emission Summary and Dispersion Modelling Report Changes
September 30, 2022	Original document	Original document
October 27, 2022	Incorporated changes to emission calculations for the SO2 scrubber and thermal oxidizer as well as editorial changes noted by the proponent.	Revised emission estimates to correct calculations of sulphur dioxide and sodium sulphate from the SO2 scrubber, included the thermal oxidizer used to abate carbon monoxide emissions from the process in the site calculations and inventory, updated modelling assessment to include sulphur dioxide emissions which were previously screened from the assessment as insignificant.

APPENDIX 2
SOURCE DESCRIPTION SHEETS

Source Description Sheet

Source PDC: Pelletizer Dust Collectors

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting, Northing) (m)	
General Dust Collector - Pelletizing	PDC	Northwest portion of main building	1V1	3.305	20	0.508	18.3	2	594621.2	4790819.5
Central Dust Collector - Pelletizing			1V2	2.597	100	0.465	18.3	2	594623.3	4790818.9

Specific Information

ECA: Proposed

Process Description:

EAFD and additives are mixed and homogenized. The homogenized mixture is charged into a pelletizing drum via a screw conveyor. Liquid consisting of water and water-based binder is sprayed in the pelletizing drum to bind the particulate material. The rotary action of the pelletizing drum agglomerates the mixture into round pellets of the desired size. The water spray also acts as a dust suppressant inside the pelletizing drum. Slightly negative pressure is maintained in the drum during pelletizing by the dust collector. The dust collector also serves to control emissions generated from the two hoppers. The air from the dust collector serving the pelletizing process is released outdoors through the General Dust Collector stack (1V1).

The wet pellets from pelletizer are fed into the directly heated Dryer. The hot flue gas mixed with air is used to dry wet pellets to 0.5% moisture. The dried pellets are screened into the oversize, middle and undersize fractions. The oversize fraction is broken down by Delumper into smaller particles which goes back into the screen. The undersize fraction is reintroduced into the pelletizing process. The middle fraction of dried pellets is then transferred into the HTMR processing. These processes are controlled by the Central Dust Collector (1V2).

Process Specifications:

The dust collectors controlling emissions from the pelletizing operations have the following specifications:

Specifications	General (1V1)	Central (1V2)
Make	Donaldson Torit	Donaldson Torit
Model	DFE 3-12	DFE 3-12
Type	Cartridge	Cartridge
Filter material	Ultra-web	Ultra-web
Filter area	424.8 m^2	424.8 m^2
Cleaning mechanism	Pulse jet	Pulse jet
Stack orientation	Vertical, unimpeded	Vertical, unimpeded

Emission Estimate:

As the controls for these processes are cartridge dust collectors (or extended media collectors) use of the Ministry's default outlet concentration for baghouse dust collectors is not applicable. As such, estimates of suspended particulate matter emissions from this source are based on a reduced inlet concentration of 10 mg/m ^{3} for the largest dust collector and 5 mg/m^3 for all other dust collectors a the site. This is supported by the information provided in the Air Pollution Control Technology Fact Sheets published by the U.S. EPA for both reverse pulse fabric filters (baghouses) and cartridge collectors where the collection effieciencies of each device are noted as follows: baghouses 99% (min), cartridge collectors 99.99% (min). This represents a 100 fold increase in collection efficiency with the cartridge dust collector relative to the baghouse dust collector. However, in order to maintain a degree of conservatism in the assessment, the default source concentrations noted in the ESDM Procedure Document have only been reduced by a factor of two. Copies of the U.S. EPA Pollution Control Technology Fact Sheets have been provided in Appendix 3. As these estimates are based on published control efficiencies and factors, a data quality rating of "Average" has been assigned. Emissions of metal species were based on the calculated suspended particulate matter emission rates and the maximum metal concentrations of the EAF dust processed by the facility as noted by assays completed on these materials. Copies of the assays have been provided in Appendix 3. As the metal emission estimates are based on the calculated suspended particulate matter emission rate, a data quality of "average" has been assigned.

Emission Calculations:

Suspended Particulate Matter

	General (1V1)	Central (1V2)
In stack concentration	10 mg/m³	5 mg/m³
Source flow rate	3.305 m³/s	2.597 m³/s
Emission rate	3.31E-02 g/s	1.30E-02 g/s

Supporting information for deviation from ESDM Procedure Document Guidance

MECP Default Concentration	20	mg/m^3
New "baghouse" minimum collection efficiency (U.S. EPA)	99%	
Calculated inlet concentration	2000	mg/m^3
New "cartridge" minimum collection efficiency (U.S. EPA)	99.99%	
Calculated outlet concentration	0.2	mg/m^3

Substance	CASRN	EAFD Concentration	General (1V1)	Central (1V2)	% of Site Emissions Total	% of Site Emissions 1V1	% of Site Emissions 1V2
		(%)	(g/s)	(g/s)	(%)	(%)	(%)
Aluminum oxide	1344-28-1	2.06%	6.80E-04	2.67E-04	95.28%	68.40%	26.88%
Cadmium and compounds	7440-43-9	0.191%	6.31E-05	2.48E-05	92.31%	66.27%	26.04%
Calcium oxide	1305-78-8	13.16%	4.35E-03	1.71E-03	76.11%	54.64%	21.47%
Carbon	7440-44-0	1.56%	5.16E-04	2.03E-04	28.38%	20.38%	8.01%
Chlorine	7782-50-5	2.469%	8.16E-04	3.21E-04	95.28%	68.40%	26.88%
Chromium compounds (di, tri, metallic)	7440-47-3	0.34%	1.12E-04	4.41E-05	95.20%	68.35%	26.85%
Copper	7440-50-8	0.203%	6.71E-05	2.64E-05	94.90%	68.13%	26.77%
Ferric oxide	1309-37-1	46.36%	1.53E-02	6.02E-03	95.28%	68.40%	26.88%
Lead and compounds	7439-92-1	1.57%	5.19E-04	2.04E-04	71.07%	51.02%	20.05%
Magnesium oxide	1309-48-4	6.21%	2.05E-03	8.06E-04	95.28%	68.40%	26.88%
Manganese and compounds	7439-96-5	3.24%	1.07E-03	4.21E-04	91.16%	65.44%	25.71%
Nickel and compounds	7440-02-0	0.056%	1.85E-05	7.27E-06	95.03%	68.23%	26.81%
Phosphorus pentoxide	1314-56-3	0.18%	5.95E-05	2.34E-05	95.28%	68.40%	26.88%
Potassium	7440-09-7	0.828%	2.74E-04	1.08E-04	94.48%	67.83%	26.65%
Silicon dioxide	7631-86-9	8.42%	2.78E-03	1.09E-03	95.28%	68.40%	26.88%
Sodium (as Sodium monoxide)	12401-86-4	1.3%	4.38E-04	1.72E-04	94.62%	67.93%	26.69%
Sulfur	7704-34-9	0.76%	2.51E-04	9.87E-05	90.23%	64.78%	25.45%
Suspended particulate matter	N/A(9)	100%	3.31E-02	1.30E-02	83.02%	59.60%	23.42%
Titanium dioxide	13463-67-7	0.19%	6.28E-05	2.47E-05	95.28%	68.40%	26.88%
Vanadium	7440-62-2	0.09%	2.97E-05	1.17E-05	95.28%	68.40%	26.88%
Zinc	7440-66-6	28.0%	9.26E-03	3.64E-03	82.98%	59.57%	23.41%

Source Description Sheet

Source ZDC: Zinc Product Dust Collector

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting, Northing) (m)	
Zinc Dust Collector - Zinc Purification	ZDC	North centre of main building	3V4	0.708	115	0.254	18.3	2	594660.8	4790806.7

Specific Information

ECA: Proposed

Process Description:

The hot process gas from the HTMR reactor containing raw zinc product is cooled down to allow the solids to be collected in the zinc collector. The gas containing a small concentration of sulphur dioxide is purified in a sodium hydroxide scrubber system. The system consists of countercurrent flow of gas and sodium hydroxide solution which eliminates sulphur dioxide from the gas stream. The collected particulates are referred to as Raw zinc concentrate. Raw zinc concentrate includes metallic Zinc, metal oxides (including zinc and lead oxide) and alkali metal salts. Raw zinc concentrate is transferred to the Zinc Purification System.

Raw zinc concentrate is transferred to the Zinc Purification System to separate water soluble impurities from zinc and zinc oxide. Zinc oxide is removed from the liquid slurry by filtration. The filter cake is further washed with fresh water in the same filter to minimize the amount of the salts in the product. Water from filtration containing soluble salts is treated by Osmosis and reused. A small amount of concentrated salt solution is disposed of. The zinc filter cake is transferred into the Zinc Dryer. The dried zinc product is further sized by a Delumper to customer particle size specifications

Process Specifications:

The dust collector controlling emissions from the zinc purification operations has the following specifications:

Specifications	ZDC (3V4)
Make	Donaldson Torit
Model	DFE 2-4
Type	Cartridge
Filter material	Ultra-web
Filter area	94.4 m^2
Cleaning mechanism	Pulse jet
Stack orientation	Vertical, unimpeded

Emission Estimate:

As the control for this process is a cartridge dust collector (or extended media collector) use of the Ministry's default outlet concentration for baghouse dust collectors is not applicable. As such, estimates of suspended particulate matter emissions from this source are based on a reduced inlet concentration of 10 mg/m^3 for the largest dust collector and 5 mg/m^3 for all other dust collectors a the site. This is supported by the information provided in the Air Pollution Control Technology Fact Sheets published by the U.S. EPA for both reverse pulse fabric filters (baghouses) and cartridge collectors where the collection effieciencies of each new device are noted as follows: baghouses 99% (min), cartridge collectors 99.99% (min). This represents a 100 fold increase in collection efficiency with the cartridge dust collector relative to the baghouse dust collector. However, in order to maintain a degree of conservatism in the assessment, the default source concentrations noted in the ESDM Procedure Document have only been reduced by a factor of two. Copies of the U.S. EPA Pollution Control Technology Fact Sheets have been provided in Appendix 3. As these estimates are based on published control efficiencies and factors, a data quality rating of "Average" has been assigned. Emissions of metal species were based on the calculated suspended particulate matter emission rates and the maximum metal concentrations of the zinc product manufactured by the facility as noted by assays completed on this material. A copy of the assay has been provided in Appendix 3. As the metal emission estimates are based on the calculated suspended particulate matter emission rate, a data quality of "average" has been assigned.

Emission Calculations:

Suspended Particulate Matter	ZDC (3V4)
In stack concentration	5 mg/m³
Source flow rate	0.708 m³/s
Emission rate	3.54E-03 g/s

Supporting information for deviation from ESDM Procedure Document Guidance

MECP Default Concentration	10 mg/m^3
New "baghouse" minimum collection efficiency (U.S. EPA)	99%
Calculated inlet concentration	1000 mg/m^3
New "cartridge" minimum collection efficiency (U.S. EPA)	99.99%
Calculated outlet concentration	0.1 mg/m^3

Substance	**CASRN**	**Zinc Product Concentration (%)**	**Emission Rate (g/s)**	**% of Site Emissions (%)**
Aluminum	7429-90-5	0.00341%	1.21E-07	100.00%
Antimony	7440-36-0	0.00376%	1.33E-07	100.00%
Arsenic and compounds	7440-38-2	0.00095%	3.36E-08	100.00%
Barium	7440-39-3	0.00073%	2.58E-08	100.00%
Boron	7440-42-8	0.00062%	2.19E-08	100.00%
Cadmium and compounds	7440-43-9	0.0839%	2.97E-06	3.12%
Chromium compounds (di, tri, metallic)	7440-47-3	0.00366%	1.30E-07	0.08%
Copper	7440-50-8	0.011%	3.89E-07	0.40%
Lead and compounds	7439-92-1	7.3%	2.58E-04	25.41%
Manganese and compounds	7439-96-5	2.0%	7.08E-05	4.33%
Mercury	7439-97-6	0.00128%	4.53E-08	100.00%
Molybdenum	7439-98-7	0.00088%	3.12E-08	100.00%
Nickel and compounds	7440-02-0	0.00197%	6.97E-08	0.26%
Phosphorus	7723-14-0	0.00063%	2.23E-08	100.00%
Potassium	7440-09-7	0.0958%	3.39E-06	0.84%
Selenium	7782-49-2	0.00117%	4.14E-08	100.00%
Silver	7440-22-4	0.0064%	2.27E-07	100.00%
Sodium (as Sodium monoxide)	12401-86-4	0.1262%	4.47E-06	0.69%
Sulfur	7704-34-9	0.0681%	2.41E-06	0.62%
Suspended particulate matter	N/A(9)	100%	3.54E-03	6.38%
Tin	7440-31-5	0.0225%	7.97E-07	100.00%
Titanium	7440-32-6	0.0002%	7.08E-09	100.00%
Zinc	7440-66-6	56.7%	2.01E-03	12.91%

Source Description Sheet

Source SCRUB: Scrubber

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting, Northing) (m)	
Air Vent - Scrubber	SCRUB	North side of building - horizontal discharge	2V6	0.014	40	0.075	5.5	Sidewall	594634.3	4790824.4
Scrubber exhaust		Northwest portion of main building	1V2	2.597	100	0.465	18.3	2	594623.3	4790818.9

Specific Information

ECA: Proposed

Process Description:

The hot process gas from the HTMR reactor containing raw zinc product is cooled down to allow the solids to be collected in the zinc collector. The gas containing a small concentration of sulphur dioxide is purified in a sodium hydroxide scrubber system. The system consists of countercurrent flow of gas and sodium hydroxide solution which eliminates sulphur dioxide from the gas stream. This stream will end up in gas used to dry pellets, central dust collector, Source 1V2. The collected particulates are referred to as Raw zinc concentrate. Raw zinc concentrate includes metallic Zinc, metal oxides (including zinc and lead oxide) and alkali metal salts. Raw zinc concentrate is transferred to the Zinc Purification System.

Source 2V6 is part of second reaction in which air delivered by an air blower is used to change sodium sulphite in scrubber solution to sodium sulphate. It has been assumed that the difference beetween the scrubber solution used and disposed is released via source 2V6.

Process Specifications:

The scrubber controlling sulphur dioxide emissions from the zinc purification operations has the following specifications:

Specifications

Make	Macrotek
Model	MP-24-12
Type	Vertical packed bed, countercurrent flow
Scrubbing solution	Sodium hydroxide
Recirculation rate	50 gallons per minute
Anticipated loading	0.7% SO_2
Guaranteed efficiency	99.9%

Emission Estimate:

Estimated emissions of sulphur dioxide from Stack 1V2 are based on anticipated SO2 loadings to the scrubber (0.7%) as noted on the scrubber specification sheet and the manufacturer's guaranteed abatement efficiency of 99.9%. A copy of the manufacturer's specifications is provided in Appendix 3. As this estimate is derived from fundamental scientific and engineering principles, a data quality rating of average has been assigned. Estimates of sodium sulphate emissions are based on the material balance of the quantity of scrubber liquid used and disposed on an hourly basis and a complete conversion of the sodium sulphite in the scrubbing solution to sodium sulphate. All scrubbing solution not recovered for disposal was assumed to be released via Stack 2V6. As this estimate is derived from fundamental scientific and engineering principles a data quality rating of average has been assigned.

Sulphur Dioxide - Source 1V2

In stack concentration	18342.0 mg/m³
Manufacturer's guaranteed efficiency	99.9%
Process gas to scrubber	0.35 m³/s
Emission rate (abated)	6.42E-03 g/s

Sodium Sulfate - Source 2V6

	L/Hr
Scrubber liquid to disposal	111
Scrubber liquid used	113.7
Scrubber liquid released	2.7
(assume all released via 2V6)	

99.9% SO_2 collected in scrubber liquid	18323.6621	mg/m^3
	0.01832366	g/L
Molar ratio SO_2 to Sodium sulfate	2.21732969	
Sodium sulfate concentration in scrubber liquid	0.0406296	g/L
Sodium sulfate emission rate	3.05E-05	g/s

Source Description Sheet

Source SILOS: Raw Material Storage Silos

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting, Northing) (m)	
EAFD Storage - Pelletizing	SILOS	Northwest side of main building	1_1A	0.329	Ambient	0.254	14.8	0.5	594612.8	4790824.3
EAFD Storage - Pelletizing			1_1B	0.329	Ambient	0.254	14.8	0.5	594607.4	4790826.2
Carbon Additives Storage-Pelletizing			1_2A	0.304	Ambient	0.254	14.8	0.5	594611.6	4790820.2
Carbon Additives Storage-Pelletizing			1_2B	0.304	Ambient	0.254	14.8	0.5	594606.2	4790822.0
Calcium Additive Storage-Pelletizing			1_3A	0.434	Ambient	0.305	9.9	0.4	594610.3	4790815.8

Specific Information

ECA: Proposed

Process Description:

The raw material (i.e., feedstock to the HTMR process) electric arc furnace dust (EAFD) is delivered to the Site from steel mills in bulk bags or in bulk (via tanker trucks). The bulk bags containing EAFD are stored at the site in enclosed area. The bulk EAFD is stored in enclosed outdoor silos as are the additives used by the process. Due to the dusty nature of the material transportation, storage and handling is designed to eliminate dust escaping into the atmosphere. The material from the silos is conveyed into Pelletizing Process.

Process Specifications:

The storage silos have the following specifications:

Specifications	1_1A	1_1B	1_2A	1_2B	1_3A
Material stored	EAFD	EAFD	Carbon	Carbon	Calcium
Vent filters	Yes	Yes	Yes	Yes	Yes
Storage capacity (m^3)	96.3	96.3	96.3	96.3	49.7
Material density (Mg/m^3)	0.755	0.755	0.66	0.66	1.06
Storage capacity (Mg)	72.7	72.7	63.5	63.5	52.7
Maximum loads per day received	1	1	1	1	1
Load volume (m^3)	29	29	29	29	29
Maximum daily receving rate (Mg)	21.895	21.895	19.14	19.14	30.74
Suspended particulate matter EF* (kg/Mg)	0.0045	0.0045	0.0045	0.0045	0.0045
SPM emission rate	1.14E-03	1.14E-03	9.97E-04	9.97E-04	1.60E-03

* - U.S. EPA AP-42 Chapter 11.12 - Cement supplement unloading to elevated storage silo (pneumatic) - controlled

Emission Estimate:

Estimates suspended particulate matter emissions from silo loading were based on emission factors published by the U.S. EPA in AP-42 Chapter 11.12 for controlled pneumatic cement supplement uloading to an elevated silo. The silo filling operations and material handled at the facility are similar to those noted in the AP-42 chapter, as such, the use of the noted factor was deemed appropriate. The emission factor rating in the AP-42 chapter is "D" which corresponds to a marginal data quality rating. Estimates of metal species emissions are based on the calculated suspended particulate matter emission rate and the maximum concentration of the individual metals in the materials handled from either assays completed on the materials (EAFD) or safety data sheets (carbon, calcium). Copies of the material assays and safety data sheets are provided in Appendix 3. As these estimates are based on the calculated suspended particulate matter emission rate, a data quality rating of marginal has been assigned.

Emission Calculations - Metals - EAFD Silos

Substance	CASRN	EAFD Concentration (%)	1_1A (g/s)	1_1B (g/s)	% of Site Emissions (%)
Aluminum oxide	1344-28-1	2.06%	2.35E-05	2.35E-05	4.72%
Cadmium and compounds	7440-43-9	0.191%	2.18E-06	2.18E-06	4.57%
Calcium oxide	1305-78-8	13.16%	1.50E-04	1.50E-04	3.77%
Carbon	7440-44-0	1.56%	1.78E-05	1.78E-05	1.41%
Chlorine	7782-50-5	2.469%	2.82E-05	2.82E-05	4.72%
Chromium compounds (di, tri, metallic)	7440-47-3	0.34%	3.88E-06	3.88E-06	4.72%
Copper	7440-50-8	0.203%	2.31E-06	2.31E-06	4.70%
Ferric oxide	1309-37-1	46.36%	5.29E-04	5.29E-04	4.72%
Lead and compounds	7439-92-1	1.57%	1.79E-05	1.79E-05	3.52%
Magnesium oxide	1309-48-4	6.21%	7.08E-05	7.08E-05	4.72%
Manganese and compounds	7439-96-5	3.24%	3.69E-05	3.69E-05	4.52%
Nickel and compounds	7440-02-0	0.056%	6.39E-07	6.39E-07	4.71%
Phosphorus pentoxide	1314-56-3	0.18%	2.05E-06	2.05E-06	4.72%
Potassium	7440-09-7	0.828%	9.44E-06	9.44E-06	4.68%
Silicon dioxide	7631-86-9	8.42%	9.60E-05	9.60E-05	4.72%
Sodium (as Sodium monoxide)	12401-86-4	1.3%	1.51E-05	1.51E-05	4.69%
Sulfur	7704-34-9	0.76%	8.67E-06	8.67E-06	4.47%
Suspended particulate matter	N/A(9)	100%	1.14E-03	1.14E-03	4.11%
Titanium dioxide	13463-67-7	0.19%	2.17E-06	2.17E-06	4.72%
Vanadium	7440-62-2	0.09%	1.03E-06	1.03E-06	4.72%
Zinc	7440-66-6	28.0%	3.20E-04	3.20E-04	4.11%

Emission Calculations - Carbon Silos

Substance	CASRN	Concentration (%)	1_2A (g/s)	1_2B (g/s)	% of Site Emissions (%)
Carbon	7440-44-0	89.1%	8.88E-04	8.88E-04	70.21%
Sulfur	7704-34-9	0.91%	9.07E-06	9.07E-06	4.68%
Suspended particulate matter	N/A(9)	100%	9.97E-04	9.97E-04	3.60%

Emission Calculations - Calcium Silo

Substance	CASRN	Concentration (%)	1_3A (g/s)	% of Site Emissions (%)
Calcium oxide	1305-78-8	100%	1.60E-03	20.12%
Suspended particulate matter	N/A(9)	100%	1.60E-03	2.89%

Source Description Sheet

Source HRV: Thermal Oxizider with Heat Recovery

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting , Northing) (m)	
Thermal oxidizer with heat recovery	HRV	Northwest portion of main building	2V3	2.833	950	0.508	17.8	2	594634.3	4790816.6

Specific Information

Process Description: The HTMR process generates carbon monoxide (approximately 1% concentration in process exhaust gases) which is abated by thermal oxidation. The thermal oxidizer operates at temperatures in excess of 900^oC with a residence time of greater than 1 second. Heat recovery of the abated process gases is a secondary operation of the HRV with exhaust gases being released via Stack 2V3 or being sent to the steam boiler, zinc dryer, or pellet dryer as needed. For the purposes of this assessment, it has been assumed that the exhaust from the thermal oxidizer with heat recovery are released via Stack 2V3.

Process Specifications: The thermal oxidizer has the following specifications:

Make	Not available	
Model	Not available	
Fuel	Natural gas	
Thermal input capacity rating	1,500,000	Btu/hr
Chamber temperature	>900	^oC
Residence time	>1	second
Assumed efficiency	98%	U.S. EPA Air Pollution Control Technology Fact Sheet - Thermal Incineration

Emission Estimate:

Estimated emissions of carbon monoxide from the thermal oxidizer are based on the estimated concentration of this substance in the process exhausts being abated (i.e., 1% carbon monoxide), the estimated minimum thermal oxidizer abatement efficiency from the U.S. EPA Air Pollution Control Technology Fact Sheet - Thermal Incineration and the quantity of process gases abated in cubic metres per second. Estimated emissions of nitrogen oxides from the natural gas fired burners associated with the thermal oxidizer are accounted for under the Source Description Sheet "Source NGPH: Natural Gas Fired Process Heating Equipment". As the estimated emissions are derived from fundamental scientific and engineering principles, a data quality rating of average has been assigned.

Carbon Monoxide		
Estimated incoming concentration	1%	
	11456	mg/m^3
Process gas flow rate	0.572	m^3/s
Carbon monoxide to thermal oxidizer	6.553	g/s
Abatement efficiency	98%	
Carbon monoxide emissions	1.31E-01	g/s

Source Description Sheet

Source NGPH: Natural Gas Fired Process Heating Equipment

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (°C)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting , Northing) (m)	
Pellet dryer	NGPH	Various	1V2	2.597	100	0.465	18.3	2	594623.3	4790818.9
HTMR burners			2V3	2.833	950	0.508	17.8	2	594634.3	4790816.6
HRV burner			2V3	2.833	950	0.508	17.8	2	594634.3	4790816.6
Boiler			3V4	0.708	115	0.254	18.3	2	594660.8	4790806.7
Zinc dryer			3V4	0.708	115	0.254	18.3	2	594660.8	4790806.7

Specific Information

Process Description: Process natural gas fired furnaces, boilers and water heaters are used by the facility to provide heat and hot water to various operations at the site. The themal input capacity ratings of each unit are provided below.

Process Specifications:

Thermal Input Capacity Ratings

Description	Source ID	Stack ID	Input Capacity Rating (Btu/hr)	Fuel Type	Hours of Operation
Pellet dryer	NGPH	1V2	3,000,000	Natural Gas	24
HTMR burners		2V3	4,500,000	Natural Gas	24
HRV burner		2V3	1,500,000	Natural Gas	24
Boiler		3V4	2,600,000	Natural Gas	24
Zinc dryer		3V4	2,400,000	Natural Gas	24

Operating Scenario Maximum

Occurs during the concurrent operation of all equipment at their respective nameplate capacities for the duration of the averaging period. As the factors used to estimate emissions from these sources are based on a mass of contaminant per unit of fuel used, use of the thermal input capacities noted above will result in the highest predicted emission rates and subsequent off-site concentrations. There are no specific factors or estimation techniques to allow for the assessment of either start-up or shutdown scenarios. As such, use of the available emission factors for these scenarios would result in a lower predicted emission rate and off-site concentration relative to the maximum production scenario.

Emission Estimate:

Emissions of Nitrogen Oxides from natural gas combustion sources were based on the maximum thermal input capacity rating of each unit and emission factors published by the U.S. EPA in AP-42 Chapter 1.4 - Natural Gas Combustion. As per the information provided in the AP-42 chapter, a heating value of 1,020 Btu/scf was used to convert the thermal input capacity rating of each unit to a natural gas flow rate. U.S. EPA data qaulity ratings for the factors used are noted in the table below.

Assumed heating capacity of natural gas to be 1 020 Btu per scf

AP-42 Emission Factors (lbs/10^6 scf)

Capacity (Btu/hr)	Class	Controls	NOx	EPA Data Quality	Controls	NOx	EPA Data Quality
0	residential	Uncontrolled	94	B	Low NOx	NA	NA
300,000	small boilers	Uncontrolled	100	B	Low NOx	50	D
100,000,000	large boilers	Uncontrolled	190	A	Low NOx	140	A

Description	Source ID	Stack ID	Input Capacity (Btu/hr)	Input Capacity (scf/hr)	AP-42 Category	Controls	Parameter	Emission Factor (lbs/10^6 scf)	Emission Rate (lbs/hr)	Emission Rate (g/s)
Pellet dryer	NGPH	1V2	3,000,000	2941.2	small boilers	U	NOx	100	2.94E-01	3.71E-02
HTMR burners		2V3	4,500,000	4411.8	small boilers	U	NOx	100	4.41E-01	5.56E-02
HRV burner		2V3	1,500,000	1470.6	small boilers	U	NOx	100	1.47E-01	1.85E-02
Boiler		3V4	2,600,000	2549.0	small boilers	U	NOx	100	2.55E-01	3.21E-02
Zinc dryer		3V4	2,400,000	2352.9	small boilers	U	NOx	100	2.35E-01	2.96E-02
									Total	1.73E-01

Source Description Sheet

Source NGCH: Natural Gas Fired Comfort Heating Equipment

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting , Northing) (m)	
Natural gas fired space heaters	NGCH	Various	UH1	0.133	250	0.152	5.54	Sidewall	594631.3	4790825.2
			UH2	0.133	250	0.152	5.54	Sidewall	594643.7	4790821.5
			UH3	0.133	250	0.152	5.54	Sidewall	594655.4	4790817.6
			UH4	0.133	250	0.152	5.54	Sidewall	594667.4	4790813.6
			UH5	0.133	250	0.152	5.54	Sidewall	594677.6	4790810.2
			UH6	0.133	250	0.152	15.85	0.5	594618.4	4790804.2
			UH7	0.133	250	0.152	15.85	0.5	594632.2	4790799.8
			UH8	0.133	250	0.152	15.85	0.5	594643.0	4790796.8
			UH9	0.133	250	0.152	15.85	0.5	594654.7	4790792.9
			UH10	0.133	250	0.152	15.85	0.5	594660.8	4790790.9
			UH11	0.133	250	0.152	15.85	0.5	594667.2	4790789.0
			UH12	0.133	250	0.152	12.04	0.5	594608.5	4790788.6
			UH13	0.133	250	0.152	12.04	0.5	594620.9	4790784.6
			UH14	0.133	250	0.152	12.04	0.5	594631.5	4790781.0
			UH15	0.133	250	0.152	12.04	0.5	594644.6	4790776.8
			UH16	0.133	250	0.152	12.04	0.5	594661.5	4790771.1
			UH17	0.133	250	0.152	15.01	0.5	594606.9	4790801.2

Specific Information

Process Description:

Natural gas fired comfort heaters are used by the facility to maintain the temperature balance of the facility buildings.
The themal input capacity ratings of each unit are provided below.

Process Specifications:

Thermal Input Capacity Ratings

Source ID	Stack ID	Description	Input Capacity Rating (Btu/hr)	Fuel Type	Hours of Operation
NGCH	UH1	Space Heaters	320,000	Natural Gas	Seasonally as required
	UH2		320,000	Natural Gas	Seasonally as required
	UH3		320,000	Natural Gas	Seasonally as required
	UH4		320,000	Natural Gas	Seasonally as required
	UH5		320,000	Natural Gas	Seasonally as required
	UH6		320,000	Natural Gas	Seasonally as required
	UH7		320,000	Natural Gas	Seasonally as required
	UH8		320,000	Natural Gas	Seasonally as required
	UH9		320,000	Natural Gas	Seasonally as required
	UH10		320,000	Natural Gas	Seasonally as required
	UH11		320,000	Natural Gas	Seasonally as required
	UH12		320,000	Natural Gas	Seasonally as required
	UH13		320,000	Natural Gas	Seasonally as required
	UH14		320,000	Natural Gas	Seasonally as required
	UH15		320,000	Natural Gas	Seasonally as required
	UH16		320,000	Natural Gas	Seasonally as required
	UH17		320,000	Natural Gas	Seasonally as required
		Comfort Heating Total	5,440,000	Btu/hr	
			5,739,505	kJ/hr	

Operating Scenario Maximum
Occurs during the concurrent operation of all equipment at their respective nameplate capacities for the duration of the averaging period. As the factors used to estimate emissions from these sources are based on a mass of contaminant per unit of fuel used, use of the thermal input capacities noted above will result in the highest predicted emission rates and subsequent off-site concentrations. There are no specific factors or estimation techniques to allow for the assessment of either start-up or shutdown scenarios. As such, use of the available emission factors for these scenarios would result in a lower predicted emission rate and off-site concentration relative to the maximum production scenario.

Emission Estimate:

Emissions of Nitrogen Oxides from natural gas combustion sources were based on the maximum thermal input capacity rating of each unit and emission factors published by the U.S. EPA in AP-42 Chapter 1.4 - Natural Gas Combustion. As per the information provided in the AP-42 chapter, a heating value of 1,020 Btu/scf was used to convert the thermal input capacity rating of each unit to a natural gas flow rate. U.S. EPA data qaulity ratings for the factors used are noted in the table below.

Assumed heating capacity of natural gas to be 1 020 Btu per scf

AP-42 Emission Factors (lbs/10^6 scf)

Capacity (Btu/hr)	Class	Controls	NOx	EPA Data Quality	Controls	NOx	EPA Data Quality
0	residential	Uncontrolled	94	B	Low NOx	NA	NA
300,000	small boilers	Uncontrolled	100	B	Low NOx	50	D
100,000,000	large boilers	Uncontrolled	190	A	Low NOx	140	A

Source ID	Stack ID	Description	Input Capacity (Btu/hr)	Input Capacity (scf/hr)	AP-42 Category	Controls	Parameter	Emission Factor (lbs/10^6 scf)	Emission Rate (lbs/hr)	Emission Rate (g/s)
NGCH	UH1	Space Heaters	320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH2		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH3		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH4		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH5		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH6		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH7		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH8		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH9		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH10		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH11		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH12		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH13		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH14		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH15		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH16		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
	UH17		320,000	313.7	small boilers	U	NOx	100	3.14E-02	3.95E-03
									Total	6.72E-02

Source Description Sheet

Source GEN: General Exhausts

Description	Emission Source Identifier	Area	Stack ID	Exhaust Flow Rate (m^3/s)	Exit Gas Temp. (^oC)	Stack Diameter (m)	Height Above Grade (m)	Height Above Roof (m)	UTM Coordinates (Easting , Northing) (m)	
General exhausts	GEN	Various	EF1	16.855	30	1.422	19.24	1.00	594620.1	4790815.8
			EF2	16.855	30	1.422	19.24	1.00	594625.6	4790813.9
			EF3	16.855	30	1.422	19.24	1.00	594630.9	4790812.5
			EF4	16.855	30	1.422	19.24	1.00	594635.8	4790810.6
			EF5	16.855	30	1.422	19.24	1.00	594641.3	4790809.0
			EF6	16.855	30	1.422	19.24	1.00	594646.6	4790807.0
			EF7	16.855	30	1.422	19.24	1.00	594651.6	4790805.4
			EF8	16.855	30	1.422	19.24	1.00	594657.5	4790803.4
			EF9	16.855	30	1.422	19.24	1.00	594662.2	4790801.8
			EF10	16.855	30	1.422	19.24	1.00	594667.0	4790800.3
			EF11	16.855	30	1.422	19.24	1.00	594672.1	4790798.9
			EF12	16.855	30	1.422	19.24	1.00	594677.1	4790797.3
			EF13	9.403	30	1.27	14.65	0.98	594608.2	4790796.7
			EF14	9.403	30	1.27	14.65	0.98	594616.7	4790794.2
			EF15	9.403	30	1.27	14.65	0.98	594625.0	4790791.5
			EF16	9.403	30	1.27	14.65	0.98	594632.7	4790788.6

Specific Information

ECA Proposed

Process Description:

General exhausts are used to maintain the temperature and air balance in the facility's buildings.

Emission Estimate:

Emissions from the general exhausts have been deemed insignificant in accordance with Section 7.2.1 of the ESDM Procedure Document which notes in Table B-3 specific examples of sources that emit contaminants in negligible amounts. Included in this table are those sources identified under Ontario Regulation 524/98 which provides a list of equipment and processes that are exempt from requiring approval under Section 9 of the Environmental Protection Act. These exemptions include "Any equipment, apparatus, mechanism or thing that is used for the ventilation of indoor air out of a space...(which) does not discharge any contaminant produced by those activities, other than heat or noise, out of the space" which describes the function of the general exhausts.

Sample Calculations

Estimating Emissions using Published Emission Factors, Engineering Calculations and Mass Balance Equations

Central Dust Collector - Suspended Particulate Matter

$$E_r = \text{Source Flow Rate} \times \text{Concentration Factor} \times \text{Conversion Factors}$$

$$E_r = 2.597\,\frac{m^3}{s} \times 5\,\frac{mg}{m^3} \times \frac{1\,g}{1\,000\,mg}$$

$$E_r = 1.30E-02\,\frac{g}{s}$$

Central Dust Collector - Aluminum Oxide

$$E_r = \text{SPM Emission Rate x Metal Concentration in EAFD}$$

$$E_r = 1.30E-02\,\frac{g}{s} \times 2.06\%\text{Alumi numOxide}$$

$$E_r = 2.67E-04\,\frac{g}{s}$$

Scrubber Inlet Loading Concentration Conversion

$$C = \text{Concentration\%} \times \text{Conversion Factor} \times \text{Molecular Weight } SO_2 \div 24.45$$

$$C = 0.7\% \times \frac{10{,}000\text{ ppm}}{1\%} \times 64.066\,\frac{g}{mol} \div 24.45$$

$$C = 18{,}342\,\frac{mg}{m^3}$$

Scrubber - Sulphur Dioxide

$$E_r = \text{Source Concentrat ion} \times \text{Abatement Factor} \times \text{Flow Rate}$$

$$E_r = 18{,}342\,\frac{mg}{m^3} \times (1-0.999) \times 0.35\,\frac{m^3}{s}$$

$$E_r = 6.42E-03\,\frac{g}{s}$$

Scrubber - Sodium Sulphate

$$E_r = \text{Scrubber Liquid Released} \times \text{Source Concentrat ion} \times \text{Conversion Factors}$$

$$E_r = 2.7\,\frac{L}{hr} \times 1.83E-02\,\frac{g\,SO_2}{L} \times \frac{142.04\,{}^{g}\!/_{mol}\,Na_2SO_4}{64.06\,{}^{g}\!/_{mol}\,SO_2} \times \frac{1\,hr}{3600\,s}$$

$$E_r = 3.05E-05\,\frac{g}{s}$$

EAFD Silos - Suspended Particulate Matter

$$E_r = \text{Silo Fill Rate} \times \text{Emission Factor} \times \text{Conversion Factors}$$

$$E_r = 21.895\,\frac{Mg}{24\text{ hours}} \times 0.0045\,\frac{kgSPM}{Mg} \times \frac{1\text{ hour}}{3600\,s} \times \frac{1\,000\,g}{1\,kg}$$

$$E_r = 7.58E-05\,\frac{g}{s}$$

Natural Gas Pellet Dryer - Input Capacity Conversion

$$Q_{NG} = \text{Input Capacity Rating} \times \text{Natural Gas Heating Capacity}$$

$$Q_{NG} = 3{,}000{,}000\,\frac{\text{Btu}}{\text{hr}} \times \frac{1\,\text{ft}^3}{1020\,\text{Btu}}$$

$$Q_{NG} = 2{,}941.2\,\frac{\text{ft}^3}{\text{hr}}$$

Natural Gas Pellet Dryer - Hourly NOx Emission Rate

$$E_r = \text{Flow of Natural Gas} \times \text{Emission Factor} \times \text{Conversion Factor}$$

$$E_r = 2{,}941.2\,\frac{\text{ft}^3}{\text{hr}} \times \frac{100\,\text{lbs NOx}}{10^6\,\text{ft}^3} \times \frac{1\,\text{hr}}{3600\,\text{s}} \times \frac{454\,\text{g}}{1\,\text{lb}}$$

$$E_r = 3.71\text{E}-02\,\frac{\text{g}}{\text{s}}$$

APPENDIX 3
SUPPORTING INFORMATION

Dust Collector Information for XCG

Sep 25, 2022

Supplier:

Donaldson Company, Inc.
Industrial Air Filtration
PO Box 1299
Minneapolis, MN
55440-1299 U.S.A.

Zinc Dust Collector Model DFE 2-4

- UNIT INSTALLATION LOCATION: INDOOR
- FINISH COAT: STANDARD FINISH
- HOPPER: STANDARD HOPPER W/O ACCESS COVER
- LEGS: STANDARD LEGS (48/37)
- ELEMENTS: FILTER SELECTION - THERMO-WEB (Qty 4) P034308-016-429
- INLETS / OUTLETS: STANDARD (5-9IN DIA) - Size: 8"
- TYPE: GENERIC STRAIGHT EDGE
- SOLENOID ENCLOSURE: NEMA 4 110 VAC
- CONTROL BOX: DELTA P PLUS CONTROL W/TIMER (110/60/1 VAC)
- HOPPER OUTLET PACK: DRUM COVER (14" FLEX HOSE) W/O GATE W/LATCHES
- POWER PACK: TOP MOUNT TBI ADAPTOR - HP: 3-15 HP
- HOUSING FEATURES: HIGH TEMPERATURE 251-350°F

General dust collector Model DFE 3-12

- UNIT INSTALLATION LOCATION: INDOOR
- FINISH COAT: STANDARD FINISH
- HOPPER: STANDARD HOPPER W/O ACCESS COVER
- LEGS: STANDARD LEGS (48/25)
- ELEMENTS: FILTER SELECTION - THERMO-WEB (Qty 8) P034308-016-429
- INLETS / OUTLETS: STANDARD (10-16IN DIA) - Size: 14"
- TYPE: GENERIC STRAIGHT EDGE
- SOLENOID ENCLOSURE: NEMA 4 110 VAC
- CONTROL BOX: DELTA P PLUS CONTROL W/TIMER (110 VAC)
- HOPPER OUTLET PACK: DRUM COVER W/GATE W/LATCHES
- POWER PACK: TOP MOUNT TBI ADAPTOR - HP: 3-15 HP
- HOUSING FEATURES: HIGH TEMPERATURE 251-350°F

Donaldson
Torit®

DOWNFLO® EVOLUTION DUST COLLECTORS

UP TO **40%**
FEWER FILTERS
& SMALLER FOOTPRINT

EVOLUTIONARY DESIGN

THE ORIGINATORS OF THE CARTRIDGE COLLECTOR

The breakthrough performance of the Downflo® Evolution (DFE) family of cartridge dust collectors is the result of Donaldson Torit's relentless drive to improve its products and exceed customer expectations. Donaldson Torit put decades of industry experience to work to produce a new, best-in-class dust collector capable of reducing equipment size and number of required filters by up to 40% compared to a typical cartridge collector. A smaller collector helps lower the initial purchase price, reduces filter replacement costs, and opens up valuable manufacturing floor space.

This state of the art collector, coupled with Donaldson's industry-leading Ultra-Web® nanofiber filtration technology, is truly an intelligent design.

Revolutionary Airflow Management

Directs incoming air to an intelligent dropout zone for reduced filter loading

Breakthrough Filter Cleaning

MaxPulse™ Cleaning System delivers 27% more cleaning energy to filtration media

Industry-Leading Filtration Design

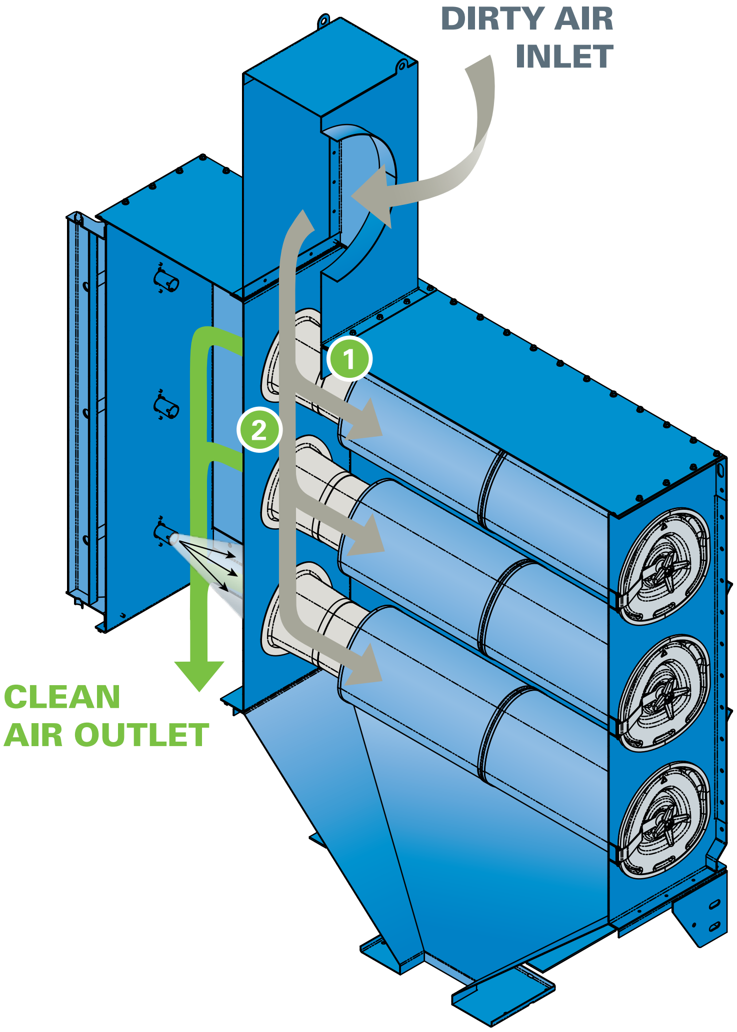
Positions more filtration media in beneficial locations and ensures easy, leak-free installation with Ultra-Web MERV15 media as standard

RESULTS

A smaller cartridge collector with fewer filters and the lowest cost of ownership

ENGINEERED AIRFLOW MANAGEMENT

The DFE's game-changing dust collection performance is achieved through a combination of design features that result in significant customer benefits.



INTELLIGENT DROPOUT ZONE

① **Metal venturis**

② **Dropout zone ensures**

- Pre-separation of heavy dust particles
- Lower pressure loss than baffle design used by competitors
- Minimal filter element abrasion

DOWNFLO EVOLUTION

INTELLIGENT DESIGN

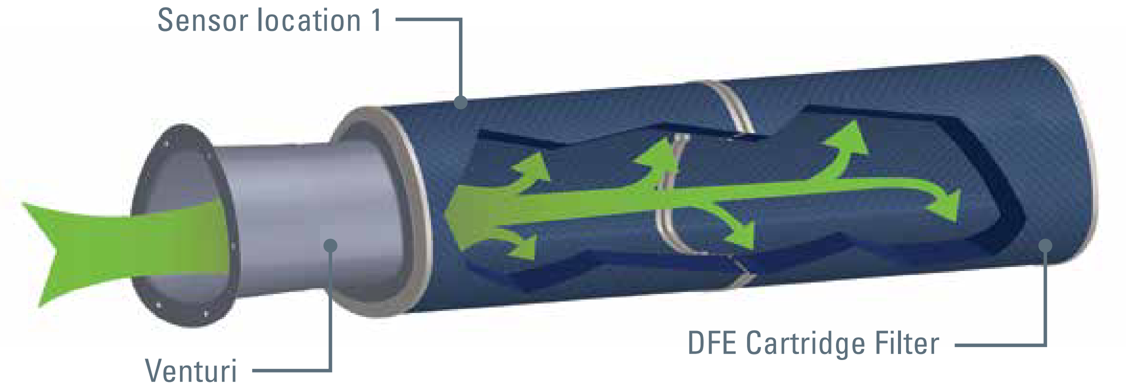
MAXPULSE™ CLEANING SYSTEM

SUPERIOR CLEANING PERFORMANCE

The DFE provides breakthrough cleaning performance resulting in improved filtration capacity without sacrificing filter life or taxing compressed air consumption. Typical pulse-jet cleaned dust collectors deliver only a fraction of the compressed air energy to clean the filtration media. The DFE's proprietary, MaxPulse Cleaning System minimizes energy loses by focusing on the cleaning air's exact path and delivers uniform cleaning energy to all effective filtration media.

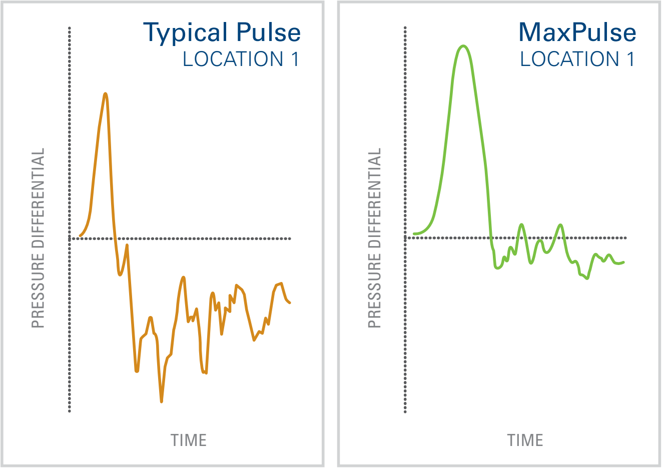
The cleaning action starts with the release of compressed air from the diaphragm valve through a unique, double-diverging pulse nozzle. The nozzle precisely controls the initial pulse expansion to minimize energy losses associated with uncontrolled compressed air expansion. Donaldson Torit's proprietary, pulse-shaping design distributes the cleaning energy evenly to match the unique shape of the filter.

After exiting the pulse nozzle, the cleaning air flows through smooth, easy transitions into the filter interior ensuring the compressed air expands naturally without abrupt, energy-wasting restrictions, sharp edges, or volume changes. More effective filtration media results in increased airflow capacities through Donaldson Torit dust collection equipment.



PROVEN IN PULSE TEST BENCH ANALYSIS

Significantly higher pulse pressures are recorded and sustained at critical locations along the filtration media profile. More uniform cleaning results in more effective filtration media over the life of the filter.



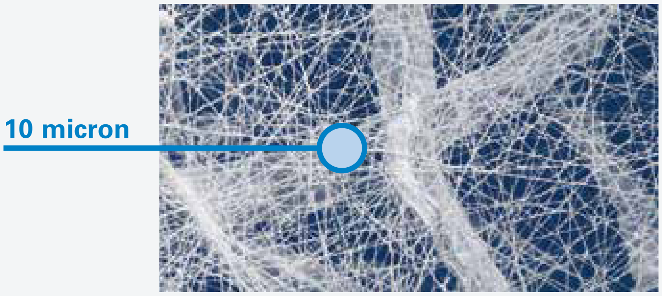
27% HIGHER

IMPULSE CLEANING ENERGY DELIVERED

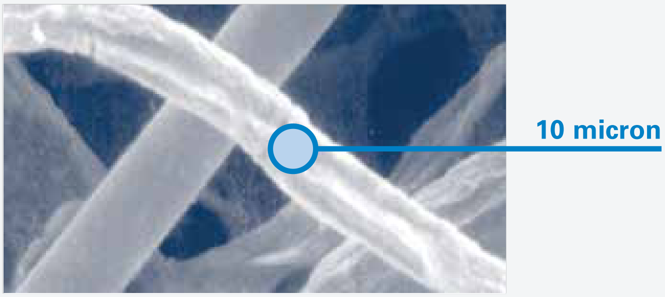
CARTRIDGE FILTER TECHNOLOGY

HIGH PERFORMANCE FILTERS

The DFE filter design is another indication of Donaldson Torit's commitment to technical research and development. The distinguishing factor in our filters is Ultra-Web filtration technology. Ultra-Web nanofiber media uses a layer of fibers 0.2 to 0.3 microns in diameter to capture contaminants on the surface of the media less than one micron in size. The resulting dust cake is easily cleaned off during the automated collector cleaning cycles providing cleaner air longer, with a minimum MERV* 15 efficiency rating based on ASHRAE 52.2 - 2007 test standards.



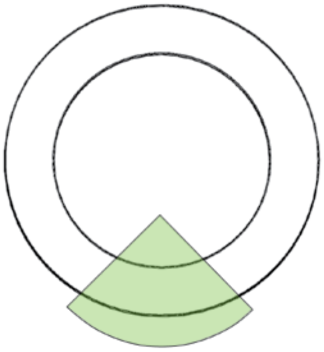
Nanofiber Media
(600x)
Nanofiber surface loading technology is available in all Ultra-Web and Fibra-Web filter cartridges.



Commodity Filter Media
(600x)
Conventional media has spaces of up to 60 µm between fibers, allowing dust to become deeply embedded.

TRIAGONAL FILTER SHAPE

The ultimate goal of any pulse-cleaned dust collector is to remove the contaminant from the airstream and get the contaminant into a containment vessel under the equipment's hopper. The DFE's unique shape positions more filter media at the bottom of the cartridge element so pulse-cleaning energy directs the ejected dust toward its ultimate destination – the containment vessel!



25%
ROUND FILTER

27%
DFE TRIAGONAL FILTER
The DFE triagonal filter features more filter media at the bottom of the cartridge element than any other cartridge on the market.

QUICK FILTER CHANGEOUT

The interior of the metal filter element endcaps features a specific profile that engages with the collection equipment's support yoke. The asymmetrical yoke design ensures proper filter installation, seal, and cleaning alignment.

① Loosen cover with 4-lobe knob. Knob has center lug enabling power tool operation.

② Open hinged filter access cover.

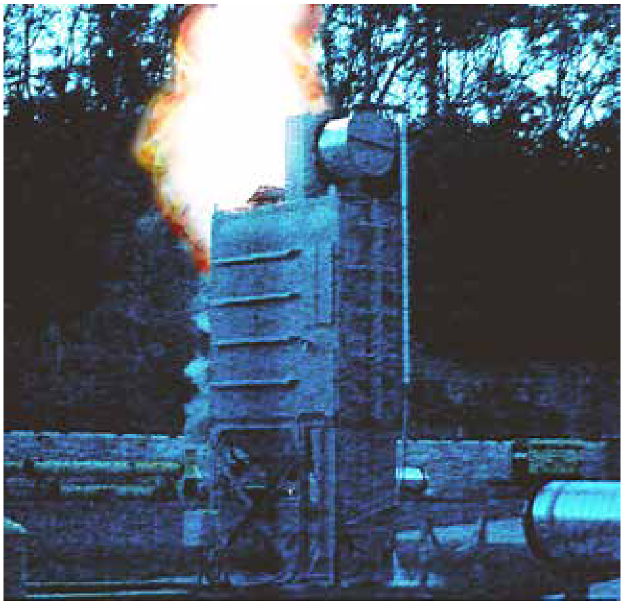
③ Filter supported by asymmetrical suspension yoke ensure proper installation for worry-free operation.

✱ No special tools are required, and you never have to enter a confined space or dirty air plenum to do the job.

COMBUSTIBLE DUST MANAGEMENT

DEFLAGRATION ISOLATION

Donaldson Torit's DFE assists operators' combustible dust management. A DFE collector was tested to determine if the collector could isolate a deflagration and stop flames or sparks from passing into the clean air plenum. When applied in conjunction with effective explosion protection strategies including inlet isolation and explosion venting, the performance results support conformance to Chapter 5 Performance-Based Design Option requirements of both NFPA 654 - to prevent the "extension of the flame front outside the compartment or equipment of origin except where intentionally vented to a safe location" [5.2.5 (2)] and NFPA 69 - to "limit the risk of flame spread from vessel to vessel via interconnecting ducts." [5.5.3.4]



TEST RESULTS[1]

- In all tests, the filters successfully isolated the deflagration and allowed no flame or sparks to pass into the clean air plenum.
- The filter media and support frames were found to be free from any plastic deformation due to deflagration loads at dirty air plenum pressures up to and including 8.3 psig.

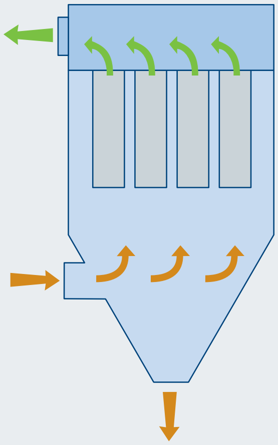
---

[1] Tests conducted on a Downflo Evolution (DFE) cartridge collector with standard FR Cartridge filter elements, top-mounted explosion vents, and without secondary filtration. Tests performed with airflow through the collector at typical air volumes. Tests repeated with no airflow through the unit. Tests used clean filters and were repeated with 'dirty' filters loaded with enough dust (cornstarch) to generate a 4-inch differential pressure across the filters and tubesheet. (Cornstarch dried to less than 2% moisture by weight was used as the dust / fuel for all tests.) Optical detectors sensitive in the IR band were mounted in multiple locations within the clean air plenum to determine flame transmission through the filter media.

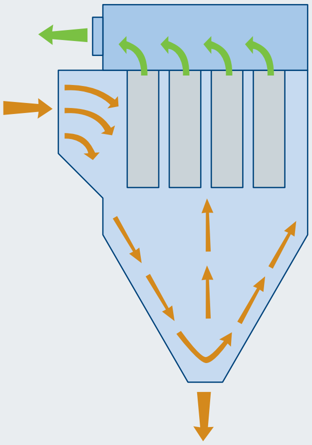
THE CONTINUING EVOLUTION OF CARTRIDGE COLLECTION

Donaldson Torit has been at the forefront of cartridge collection for over 40 years, and has developed game-changing solutions others can only attempt to imitate. Now, the game is changing again! With the DFE's airflow design, MaxPulse cleaning system, triangonal filter shape, and industry-leading Ultra-Web filtration media, customers benefit from a smaller collector containing fewer filters.

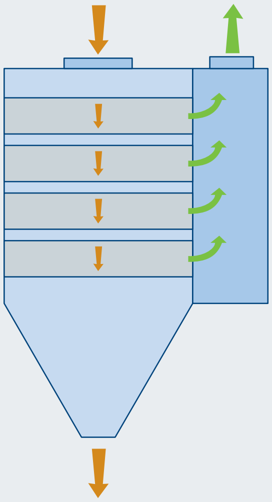
AIR-TO-MEDIA (AMR) RATIO EVOLUTION – WELD FUME



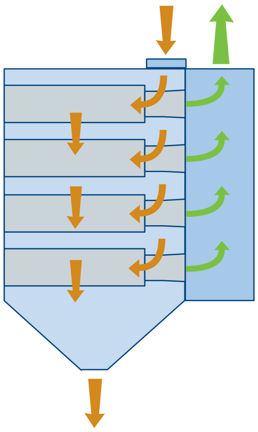
CARTRIDGE COLLECTOR
1970 – 1978
AMR 1.0 – 1.5



CARTRIDGE COLLECTOR
1978 – 1981
AMR 1.0 – 1.5



CARTRIDGE COLLECTOR
1981 – 2014
AMR 2.0 – 3.5



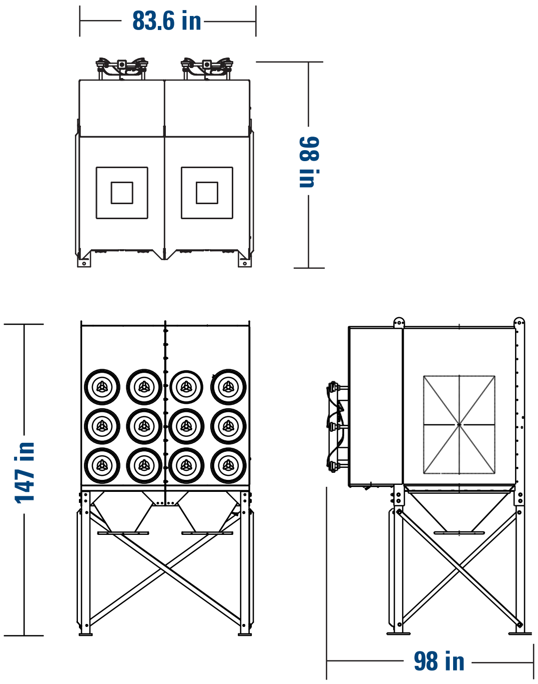
DFE COLLECTOR
2014
AMR 3.5 – 4.0

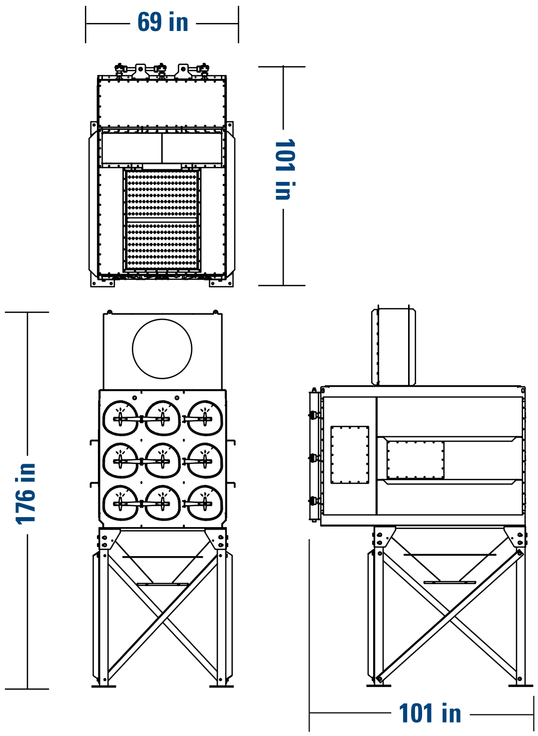
The graphic above shows an example of the Air-to-Media ratios for a typical weld fume application. The DFE features higher AMRs, smaller footprint, fewer filters, superior performance, and lowest cost of ownership!

UP TO 40%
FEWER FILTERS
& SMALLER FOOTPRINT

EQUIPMENT COMPARISON

The DFE dust collector has increased filtration capacity compared to traditional cartridge collectors. This advantage reduces required collector footprint, with fewer filters, and lowers the total cost of ownership.



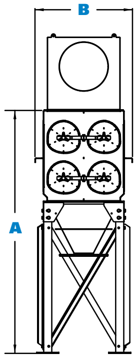


TRADITIONAL CARTRIDGE 3-24		DOWNFLO EVOLUTION 3-18
Automatic Shot Blast	Application	Automatic Shot Blast
10,500 cfm	Airflow	10,500 cfm
56.9 ft^2	Footprint	50.3 ft^2
147 in	Height	176 in
24	Filter Count	18
2	Hopper Outlets	1
13 scfm	Compressed Air	10 scfm

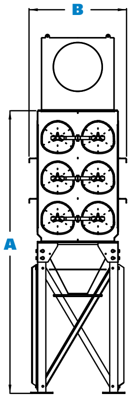
OPERATING CONDITIONS FOR DFE COLLECTORS

Seismic Spectral Acceleration	$S_S = 1.5$ g $S_1 = 0.6$ g per IBC 2009 FIG 1613.5
Basic Wind Speed and Exposure (mph/kph)	90/145 Exposure C per IBC 2009
Housing Rating (inches of H_2O/millimeters of H_2O)	-25 – +10 / -635 – +254
Compressed Air Required (psi/bar)	90-100/6.2-6.9
Operating Temperature	150°F/66°C
Housing Construction	3/16” (4.8mm) - 10-gauge steel
Control Voltage	120 VAC -or- 24 VDC

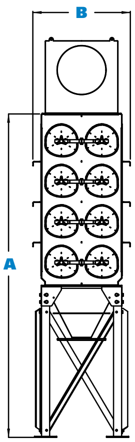
DIMENSIONS & SPECIFICATIONS



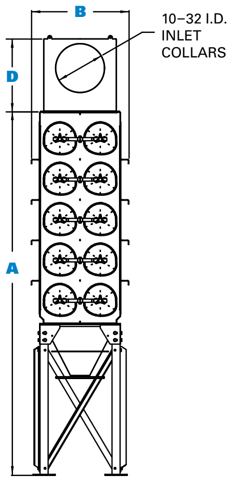
DFE 2-8



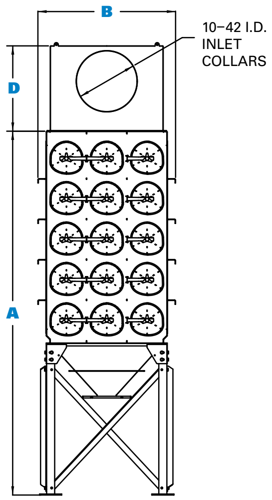
DFE 3-12



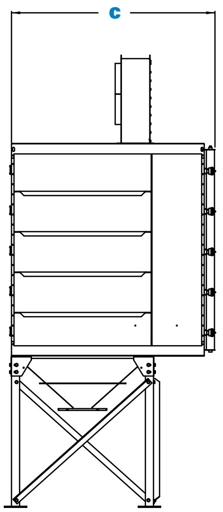
DFE 4-16



DFE 5-20



DFE 5-30



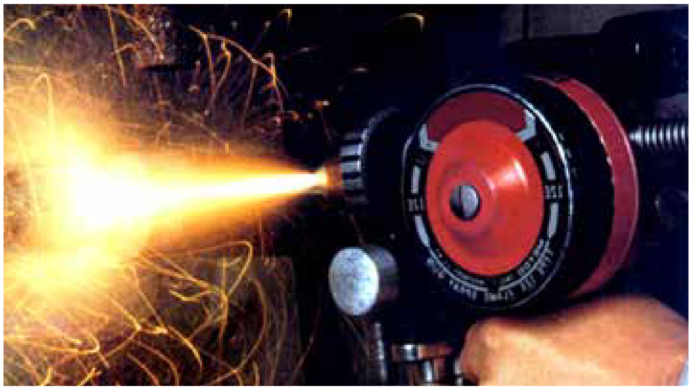
SIDE VIEW

DFE Model*	No. of Filters	Ultra-Web Filter Area		No. of Valves	Approx. Shipping Weight *		Dimensions					
							A		B		C	
		ft²	m²		lb	kg	in	mm	in	mm	in	mm
DFE 2-4	4	1,016	94.4	4	1,890	857	110	2,794	48	1,219	75	1,905
DFE 3-6	6	1,524	141.6	6	2,300	1,043	130	3,302	48	1,219	75	1,905
DFE 2-8	8	2,032	188.8	4	2,300	1,043	120	3,048	48	1,219	101	2,565
DFE 2-12	12	3,048	283.2	6	2,900	1,316	120	3,048	68	1,727	101	2,565
DFE 3-12	12	3,048	283.2	6	2,800	1,043	140	3,556	48	1,219	101	2,565
DFE 4-16	16	4,064	377.6	8	3,300	1,497	160	4,064	48	1,219	101	2,565
DFE 3-18	18	4,572	424.8	9	3,500	1,588	140	3,556	68	1,727	101	2,565
DFE 5-20	20	5,080	471.9	10	3,850	1,746	180	4,572	48	1,219	101	2,565
DFE 3-24	24	6,096	566.3	12	4,500	2,041	140	3,556	48	1,219	101	2,565
DFE 4-24	24	6,096	566.3	12	4,090	1,855	160	4,064	68	1,727	101	2,565
DFE 5-30	30	7,620	707.9	15	4,800	2,177	180	4,572	68	1,727	101	2,565
DFE 4-32	32	8,128	755.1	16	5,200	2,359	160	4,064	88	2,235	101	2,565
DFE 3-36	36	9,144	849.5	18	5,700	2,585	140	3,556	128	3,251	101	2,565
DFE 5-40	40	10,160	943.9	20	6,200	2,812	180	4,572	88	2,235	101	2,565
DFE 3-48	48	12,192	1,132.7	24	8,200	3,719	140	3,556	128	3,251	101	2,565
DFE 4-48	48	12,192	1,132.7	24	6,700	3,039	160	4,064	168	4,267	101	2,565
DFE 3-60	60	15,240	1,415.8	30	9,900	4,490	140	3,556	208	5,283	101	2,565
DFE 5-60	60	15,240	1,415.8	30	7,700	3,493	180	4,572	128	3,251	101	2,565
DFE 4-64	64	16,256	1,510.2	32	9,500	4,309	160	4,064	188	4,775	101	2,565
DFE 3-72	72	18,288	1,699.0	36	11,600	5,262	140	3,556	248	6,299	101	2,565
DFE 4-80	80	20,320	1,887.8	40	11,500	5,216	160	4,064	208	5,283	101	2,565
DFE 5-80	80	20,320	1,887.8	40	11,000	4,990	180	4,572	168	4,267	101	2,565

Inlet Size	D	
	in	mm
10 – 16	24.0	610
17 – 24	36.0	915
26, 28, 30, 32	42.0	1,067
34, 36, 38, 40, 42	48.0	1,219

* Without accessories or optional equipment.

DFE SERIES APPLICATIONS



- **Metal Grinding**
- **Plasma Cutting**
- **Dry Bulk**
- **Pharmaceutical**

- **Thermal Spray**
- **Welding**
- **Metal Manufacturing**
- **Glass**
- **Food Processing**

STANDARD FEATURES & AVAILABLE OPTIONS

DFE 2-4 to 5-80

Collector Design	Std	Opt
Mild Steel Construction	✗	
MaxPulse™ Filter Cleaning System	✗	
Quick-Removal Access Covers	✗	
Inlets	✗	
Ledge-Free Hopper	✗	
Sprinkler Taps	✗	
Stainless Steel Construction		✗
High Temperature Construction		✗
Explosion Protected Models		✗
Direct Drive Fans		✗
Chamber and Exhaust Silencers		✗
High-Flow Inlet		✗
Air Management Modules		✗
Extended Dirty Air Plenum		✗
Steep-Sided Hopper		✗
2-Mod Hopper		✗
Sprinkler Heads		✗
Service Platform (OSHA compliant)		✗
Damper Pack		✗
Drum Sentry™ Drum-Full Indicator		✗
Lined Clean Air Plenum		✗
Bag-Out Kit (Filter & Discharge)		✗
Bag-In/Bag-Out Kit (Filter & Discharge)		✗
Cartridge Filters		
Ultra-Web® (MERV* 15)	✗	
Ultra-Web® FR (MERV* 15); Ultra-Web® SB (MERV* 15); Ultra-Web® AS (MERV* 15); Fibra-Web® (MERV 14); Thermo-Web™ (MERV 14); Torit-Tex™ (MERV 16); High Temp (MERV 13)		✗
HEPA/ASHRAE Afterfilters		✗

Paint System		
Prime Coated Interior	✗	
Textured Multi-Coat Paint Finish with 2,000-Hour Salt Spray Performance	✗	
Custom Color		✗
Premium Duty Finish		✗
Epoxy Coating		✗
Hopper Discharge		
Drum Cover and Hose		✗
Slide Gates		✗
Rotary Valves and Transitions		✗
Screw Conveyors		✗
Electrical Controls, Gauges & Enclosures		
Control Box w/Timer in NEMA 4 Enclosure	✗	
Magnehelic®** Gauge Controls	✗	
Delta P Control, Delta P Plus Control		✗
Dustronix™ Control Assembly		✗
Custom Panels		✗
Photohelic®** Gauge Standard and Weatherproof		✗
Basic Cold Climate Kit		✗
Heavy-Duty Cold Climate Kit		✗
Solenoid Enclosure (NEMA 7 & 9)		✗
Warranty		
10-Year Warranty	✗	

EPA-452/F-03-004

Air Pollution Control Technology Fact Sheet

Name of Technology: Paper/Nonwoven Filters - Cartridge Collector Type with Pulse-Jet Cleaning (also referred to as Extended Media)

Type of Technology: Control Device - Capture/Disposal

Applicable Pollutants: Particulate Matter (PM), including particulate matter less than or equal to 10 micrometers (µm) in aerodynamic diameter (PM_{10}), particulate matter less than or equal to 2.5 µm in aerodynamic diameter ($PM_{2.5}$), and hazardous air pollutants (HAPs) that are in particulate form, such as most metals (mercury is the notable exception, as a significant portion of emissions are in the form of elemental vapor).

Achievable Emission Limits/Reductions:

Older existing cartridge collector types have a range of actual operating efficiencies of 99 to 99.9% for PM_{10} and $PM_{2.5}$. Typical new equipment design efficiencies are between 99.99 and 99.999+% (EPA, 1998b). In addition, commercially available designs are able to control submicron PM (0.8 µm in diameter or greater) with a removal efficiency of 99.999+% (AAF, 1999; Torit, 1999). Several factors determine cartridge filter collection efficiency including gas filtration velocity, particle characteristics, filter media characteristics, and cleaning mechanism. In general, collection efficiency increases with increasing filtration velocity and particle size.

For a given combination of filter design and dust, the effluent particle concentration from a cartridge collector is nearly constant, whereas the overall efficiency is more likely to vary with particulate loading. For this reason, cartridge collectors can be considered to be constant outlet devices rather than constant efficiency devices. Constant effluent concentration is achieved because at any given time, part of the filter media is being cleaned. As a result of the cleaning mechanisms used in cartridge collectors, the collection efficiency is constantly changing. Each cleaning cycle removes at least some of the filter cake and loosens particles that remain on the filter. When filtration resumes, the filtering capability has been reduced because the lost filter cake and loose particles are pushed through the filter by the flow of gas. As particles are captured, the efficiency increases until the next cleaning cycle. Average collection efficiencies for cartridge collectors are usually determined from tests that cover a number of cleaning cycles at a constant inlet loading. (EPA, 1998a)

Applicable Source Type: Point

Typical Industrial Applications:

Cartridge collectors perform very effectively in many different applications. Common applications of cartridge filter systems with pulse-jet cleaning are presented in Table 1. In addition to these applications, cartridge collectors can be used in any process where dust is generated and can be collected and ducted to a central location.

Table 1. Typical Industrial Applications of Cartridge Collectors with Pulse-Jet Cleaning (EPA, 1997; Heumann, 1997)

Application	Source Category Code (SCC)
Fabricated Metal Products:	
Abrasive Blasting	3-09-002
Machining	3-09-300
Welding	3-09-005, 3-09-040...059
Pigment Grinding and Milling	3-01-014-30...41, 3-01-020-30...41, 3-01-035-50..54
Mineral Products:	
Cement Manufacturing	3-05-006...007
Coal Cleaning	3-05-010
Stone Quarrying and Processing	3-05-020
Other	3-05-003...999
Asphalt Manufacture	3-05-001...002
Grain Milling	3-02-007

Emission Stream Characteristics:

a. **Air Flow:** Cartridge collectors are currently limited to low air flow capacity applications. Standard cartridge collectors are factory-built, off the shelf units. They may handle air flow rates from less than 0.10 to more than 5 standard cubic meters per second (sm^3/sec) ((“hundreds” to more than 10,000 standard cubic feet per minute (scfm)). (EPA, 1998b)

b. **Temperature:** Temperatures are limited by the type of filter media and sealant used in the cartridges. Standard cartridges utilizing paper filter media can accommodate gas temperatures up to about 95°C (200°F) (EPA, 1998b). Cartridge filters utilizing synthetic, nonwoven media such as needle-punched felts fabricated of polyester or Nomex®, can withstand temperatures of up to 200°C (400°F) with the appropriate sealant material (IFF, 1999).

Spray coolers or dilution air can be used to lower the temperature of the pollutant stream. This prevents the temperature limits of the filter media from being exceeded. Lowering the temperature can result in higher humidity of the pollutant stream. Therefore, the minimum temperature of the pollutant stream must remain above the dew point of any condensable in the stream. The cartridge collector and associated ductwork should be insulated and possibly heated if condensation may occur. (EPA, 1998b)

c. **Pollutant Loading:** Typical inlet concentrations to cartridge collectors are 1 to 23 grams per cubic meter (g/m^3) (0.5 to 10 grains per cubic foot (gr/ft^3)) (EPA, 1998b). Cartridge filters, which utilize synthetic, nonwoven media such as needle-punched felts fabricated of polyester or Nomex®, are able to handle inlet concentrations up to 57 g/m^3 (25 gr/ft^3) (IFF, 1999).

d. **Other Considerations:** Moisture and corrosives content in the gas streams are the major design considerations. Standard cartridge filters can be used in pressure or vacuum service, but only within the range of about ± 640 millimeters of water column (25 inches of water column) (AWMA, 1992). Baghouses have been shown to be capable of reducing overall particulate emissions to less than 0.05 g/m^3 (0.010 gr/ft^3) (AWMA, 1992). Penetration of PM in cartridge collectors is generally many times less than in traditional baghouse designs (Heumann, 1997).

Emission Stream Pretreatment Requirements:

Because of the wide variety of filter types available to the designer, the inlet temperature of the waste stream usually does not require pretreatment. However, in some high temperature applications, the cost of high temperature-resistant cartridge filters must be weighed against the cost of cooling the inlet temperature with spray coolers or dilution air (EPA, 1998b). When much of the pollutant loading consists of relatively large particles, mechanical collectors such as cyclones may be used to reduce the load on the filter media, especially at high inlet concentrations (EPA, 1998b).

Cost Information:

Cost estimates, expressed in 2002 dollars, are presented below for cartridge collectors with pulse-jet cleaning. The cost estimates assume a conventional design under typical operating conditions. Auxiliary equipment, such as fans and ductwork, is not included. The costs are generated using EPA's cost-estimating spreadsheets for fabric filters (EPA, 1998b).

Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading. Cartridge collectors are currently limited to low flow rate applications. The capital cost for a cartridge collector is significantly lower than for a baghouse, however, the operational and maintenance (O&M) cost tends to be higher. The costs presented are for flow rates of 5 m^3/s (10,000 scfm) and 1.0 m^3/s (2,000 scfm), respectively, and a pollutant loading of 9 g/m^3 (4.0 gr/ft^3).

Pollutants that require an unusually high level of control or that require the filter media or the unit itself to be constructed of special materials, such as Nomex® or stainless steel, will increase the costs of the system (EPA, 1998b). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the O&M cost could increase by as much as 10%.

a. **Capital Cost:** \$15,000 to \$28,000 per sm^3/s (\$7 to \$13 per scfm)

b. **O & M Cost:** \$20,000 to \$52,000 per sm^3/s (\$9 to \$25 per scfm), annually

c. **Annualized Cost:** \$26,000 to \$80,000 per sm^3/s (\$13 to \$38 per scfm), annually

d. **Cost Effectiveness:** \$94 to \$280 per metric ton (\$85 to \$286 per short ton)

Theory of Operation:

Cartridge filters contain either a paper or nonwoven fibrous filter media. Paper media is generally fabricated of natural or synthetic materials such as cellulose and fiberglass. Nonwoven media is generally fabricated from synthetic materials such as Nomex®, polyester, or polypropylene (EPA, 1998a; Heumann, 1997). The media is supported by inner and outer wire frameworks. The waste gas stream is passed through the fibrous filter media causing PM in the gas stream to be collected on the media by sieving and other mechanisms. The dust cake that forms on the filter media from the collected PM can significantly increase collection efficiency (EPA, 1998a).

In general, the filter media is pleated to provide a larger surface area to volume flow rate. For this reason, cartridge filters are also referred to as extended media filters. Close pleating, however, can cause PM to bridge the pleat bottom, effectively reducing the surface area (EPA, 1998a). Corrugated aluminum separators are often employed to prevent the pleated media from collapsing (Heumann, 1997). The pleat depth can vary anywhere from 2.5 cm (1 inch) up to 40 cm (16 inches) (EPA, 1998a). Pleat spacing generally ranges between 12 to 16 pleats per inch, with certain conditions requiring fewer pleats, 4 to 8 pleats per inch (EPA,1998b).

There are a wide variety of cartridge designs and dimensions. Typical designs include flat panels, V-shaped packs or cylindrical packs (Heumann, 1997). Commercially available cylindrical packs are approximately 15 to 35 centimeters (cm) (6 to 14 inches) in diameter and 40 to 122 cm (16 to 48 inches) in length (EPA, 1998a).

The cartridge is closed at one end with a metal cap. The media is sealed to the cap using polyurethane plastic, epoxy, or other commercially available sealant. For certain applications, two cartridges may be placed in series. The cartridges are placed in a frame constructed of wood or metal. A neoprene or silicone gasket seals the frame to the clean air plenum of the collector. The cartridges may be mounted horizontally or vertically, if retrofitting a baghouse. (EPA, 1998a)

Replacement of the cartridges is generally performed outside of the collector. This reduces the risk of exposure to PM by the maintenance workers. This feature is especially important for HAP applications. The Occupational Safety and Health Administration (OSHA) requires special filter replacement procedures, commonly referred to as bag in/bag out procedures, for many HAP applications. (Heumann, 1997)

Operating conditions are important determinants of the choice of filter media and sealant used in the cartridges. Some filter media, such as cellulose paper filters, are useful only at relatively low temperatures of 95 to 150°C (200 to 300°F). For high-temperature flue gas streams, more thermally stable filter media, such as nonwoven polyester, polypropylene, or Nomex®, must be used (EPA, 1998a). A variety of commercially available sealants such as polyurethane plastic and epoxy will allow for operating temperatures up to150°C (300°F). Selected sealants such as heat cured Plasitcol® will withstand operating temperatures up to 200°C (400°F) (EPA, 1998a; IFF, 1999).

Practical application of cartridge collectors requires the use of a large media area in order to avoid an unacceptable pressure drop across the filter media. The number of cartridges utilized in a particular collector is determined by the choice of air-to-cloth ratio, or the ratio of volumetric air flow to filter media area (ICAC, 1999). The selection of air-to-cloth ratio depends on the particulate loading, particulate characteristics, and the cleaning method used. A high particulate loading will require the use of a larger number of cartridges in order to avoid forming a heavy dust cake, which results in an excessive pressure drop (ICAC, 1999). The paper and nonwoven filter media used in cartridge filters have a larger pressure drop across the filter than the woven fabric used in bags. For this reason, cartridge collectors are utilized at lower air flow rates and particulate loadings than traditional baghouse designs (Heumann, 1997).

Determinants of cartridge collector performance include the filter media chosen, the cleaning frequency and methods, and the particulate characteristics. Filter media can be chosen which will intercept a greater fraction of particulate, and some filter media are coated with a membrane with very fine openings for enhanced removal of submicron particulate. Such filter media tend to be more expensive. (ICAC, 1999)

Pulse-jet cleaning of cartridge filters is relatively new, having only been used for the past 30 years. This cleaning mechanism has consistently grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than traditional bag-type fabric filters. Pulse-jet cleaned cartridge filters can only operate as external cake collection devices. The cartridges are closed at the bottom, and open at the top. Particulate-laden gas flows into the collector, with diffusers often used to prevent oversized particles from damaging the filter media. The gas flows from the outside to the inside of the cartridges, and then out the gas exhaust. The particles are collected on the outside of the filter media and drop into a hopper below the cartridge after cleaning. (EPA, 1998b)

During pulse-jet cleaning, a short burst, 0.03 to 0.1 seconds in duration, of high pressure, 415 to 830 kiloPascals (kPa) (60 to 120 pounds per square inch gage (psig)), air is injected into the cartridges (EPA, 1998b; AWMA, 1992). The pulse is blown through a venturi nozzle at the top of the cartridges and establishes a shock wave that continues onto the bottom of the cartridges. The wave flexes the filter media, dislodging the dust cake. The cleaning cycle is regulated by a remote timer connected to a solenoid valve. The burst of air is controlled by the solenoid valve and is released into blow pipes that have nozzles located above the cartridges (EPA, 1998b).

There are several unique attributes of pulse-jet cleaning. Because the cleaning pulse is very brief, the flow of dusty gas does not have to be stopped during cleaning. The other cartridges continue to filter, taking on extra duty because of the cartridges being cleaned. In general, there is no change in filter pressure drop or performance as a result of pulse-jet cleaning. This enables the cartridge collectors with pulse-jet cleaning to operate on a continuous basis with solenoid valves as the only significant moving parts. Pulse-jet cleaning is also more intense and occurs with greater frequency than the other filter cleaning methods. This intense cleaning dislodges nearly all of the dust cake each time the cartridge is pulsed. As a result, pulse-jet filters do not rely on a dust cake to provide filtration. Paper and nonwoven filter media are used in pulse-jet cleaned cartridge collectors because they do not require a dust cake to achieve high collection efficiencies. (EPA, 1998b)

Since cartridges cleaned by the pulse-jet method do not need to be isolated for cleaning, the collector does not need extra compartments to maintain adequate filtration during cleaning. In addition, the pleating of the filter media provides increased filter area per housing volume. Consequently, cartridge collectors cleaned by the pulse-jet method can be smaller than traditional fabric filter baghouses in the treatment of the same amount of gas and dust (EPA, 1998b). A cartridge collector is approximately 4 times smaller than baghouse designs for similar gas streams (Heumann, 1997).

Advantages:

Cartridge filters in general provide high collection efficiencies on both coarse and fine (submicron) particulates. They are relatively insensitive to fluctuations in gas stream conditions. Efficiency and pressure drop are relatively unaffected by large changes in inlet dust loadings for continuously cleaned filters. Filter outlet air is very clean and may be recirculated within the plant in many cases (for energy conservation). PM is collected dry for subsequent processing or disposal. Corrosion and rusting of components are usually not problems. Operation is relatively simple. Unlike electrostatic precipitators, cartridge filter systems do not require the use of high voltage, therefore, maintenance is simplified and flammable dust may be collected with proper care. The use of selected fibrous or granular filter aids (precoating) permits the high-efficiency collection of submicron smokes and gaseous contaminants. Cartridge collectors are available in a large number of configurations, resulting in a range of dimensions and inlet and outlet flange locations to suit installation requirements. (AWMA, 1992)

Disadvantages:

Temperatures much in excess of 95°C (200°F) require special filter media, which can be expensive (EPA, 1998a). Certain dusts may require filter media treatments to reduce dust seepage, or in other cases, assist in the removal of the collected dust. Concentrations of some dusts in the collector, approximately 50 g/m^3 (22 gr/ft^3), may represent a fire or explosion hazard if a spark or flame is accidentally admitted. Cartridge filters can burn if readily oxidizable dust is being collected. Cartridge filters have relatively high maintenance requirements (e.g., periodic cartridge replacement). Filter life may be shortened at elevated temperatures and in the presence of acid or alkaline particulate or gas constituents. They cannot be operated in moist environments; hygroscopic materials, condensation of moisture, or tarry adhesive components may cause crusty caking or plugging of the filter media or require special additives. Medium pressure drop is required, typically in the range of 100 to 250 mm of water column (4 to 10 in. of water column) (AWMA, 1992).

A specific disadvantage of pulse-jet units that use very high gas velocities is that the dust from the cleaned cartridges can be drawn immediately to the other cartridges. If this occurs, little of the dust falls into the hopper and the dust layer on the cartridges becomes too thick. To prevent this, cartridge collectors with pulse-jet cleaning can be designed with separate compartments that can be isolated for cleaning. (EPA, 1998b)

Other Considerations:

Cartridge collectors are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators (STAPPA/ALAPCO, 1996). They are ideal for HAP applications due to the cartridge replacement procedure being performed outside the collector housing. For similar air flow rates, cartridge collectors are compact in size compared to traditional baghouses. The application of cartridge collectors is limited to low air flow rates (Heumann, 1997).

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EPA-452/F-03-025

Air Pollution Control Technology
Fact Sheet

Name of Technology: Fabric Filter - Pulse-Jet Cleaned Type
(also referred to as Baghouses)

Type of Technology: Control Device - Capture/Disposal

Applicable Pollutants: Particulate Matter (PM), including particulate matter less than or equal to 10 micrometers (µm) in aerodynamic diameter (PM_{10}), particulate matter less than or equal to 2.5 µm in aerodynamic diameter ($PM_{2.5}$), and hazardous air pollutants (HAPs) that are in particulate form, such as most metals (mercury is the notable exception, as a significant portion of emissions are in the form of elemental vapor).

Achievable Emission Limits/Reductions:

Typical new equipment design efficiencies are between 99 and 99.9%. Older existing equipment have a range of actual operating efficiencies of 95 to 99.9%. Several factors determine fabric filter collection efficiency. These include gas filtration velocity, particle characteristics, fabric characteristics, and cleaning mechanism. In general, collection efficiency increases with increasing filtration velocity and particle size.

For a given combination of filter design and dust, the effluent particle concentration from a fabric filter is nearly constant, whereas the overall efficiency is more likely to vary with particulate loading. For this reason, fabric filters can be considered to be constant outlet devices rather than constant efficiency devices. Constant effluent concentration is achieved because at any given time, part of the fabric filter is being cleaned. As a result of the cleaning mechanisms used in fabric filters, the collection efficiency is constantly changing. Each cleaning cycle removes at least some of the filter cake and loosens particles which remain on the filter. When filtration resumes, the filtering capability has been reduced because of the lost filter cake and loose particles are pushed through the filter by the flow of gas. As particles are captured, the efficiency increases until the next cleaning cycle. Average collection efficiencies for fabric filters are usually determined from tests that cover a number of cleaning cycles at a constant inlet loading. (EPA, 1998a)

Applicable Source Type: Point

Typical Industrial Applications:

Fabric filters can perform very effectively in many different applications. Common applications of fabric filter systems with pulse-jet cleaning are presented in Table 1, however, fabric filters can be used in most any process where dust is generated and can be collected and ducted to a central location.

Table 1. Typical Industrial Applications of Pulse-Jet Cleaned Fabric Filters
(EPA 1997; EPA, 1998a)

Application	Source Category Code (SCC)
Utility Boilers (Coal)	1-01-002...003
Industrial Boilers (Coal, Wood)	1-02-001...003, 1-02-009
Commercial/Institutional Boilers (Coal, Wood)	1-03-001...003, 1-03-009
Ferrous Metals Processing:	
Iron and Steel Production	3-03-008...009
Steel Foundries	3-04-007,-009
Mineral Products:	
Cement Manufacturing	3-05-006...007
Coal Cleaning	3-05-010
Stone Quarrying and Processing	3-05-020
Other	3-05-003...999
Asphalt Manufacture	3-05-001...002
Grain Milling	3-02-007

Emission Stream Characteristics:

a. **Air Flow:** Baghouses are separated into two groups, standard and custom, which are further separated into low, medium, and high capacity. Standard baghouses are factory-built, off the shelf units. They may handle from less than 0.10 to more than 50 standard cubic meters per second (sm^3/sec) ((“hundreds” to more than 100,000 standard cubic feet per minute (scfm)). Custom baghouses are designed for specific applications and are built to the specifications prescribed by the customer. These units are generally much larger than standard units, i.e., from 50 to over 500 sm^3/sec (100,000 to over 1,000,000 scfm). (EPA, 1998b)

b. **Temperature:** Typically, gas temperatures up to about 260•C (500•F), with surges to about 290•C (550•F) can be accommodated routinely, with the appropriate fabric material. Spray coolers or dilution air can be used to lower the temperature of the pollutant stream. This prevents the temperature limits of the fabric from being exceeded. Lowering the temperature, however, increases the humidity of the pollutant stream. Therefore, the minimum temperature of the pollutant stream must remain above the dew point of any condensable in the stream. The baghouse and associated ductwork should be insulated and possibly heated if condensation may occur. (EPA, 1998b)

c. **Pollutant Loading:** Typical inlet concentrations to baghouses are 1 to 23 grams per cubic meter (g/m^3) (0.5 to 10 grains per cubic foot (gr/ft^3)), but in extreme cases, inlet conditions may vary between 0.1 to more than 230 g/m^3 (0.05 to more than 100 gr/ft^3). (EPA, 1998b)

d. **Other Considerations:** Moisture and corrosives content are the major gas stream characteristics requiring design consideration. Standard fabric filters can be used in pressure or vacuum service, but only within the range of about ± 640 millimeters of water column (25 inches of water column). Well-designed and operated baghouses have been shown to be capable of reducing overall particulate emissions to less than 0.05 g/m^3 (0.010 gr/ft^3), and in a number of cases, to as low as 0.002 to 0.011 g/m^3 (0.001 to 0.005 gr/ft^3). (AWMA, 1992)

Emission Stream Pretreatment Requirements:

Because of the wide variety of filter types available to the designer, it is not usually required to pretreat a waste stream's inlet temperature. However, in some high temperature applications, the cost of high temperature-resistant bags must be weighed against the cost of cooling the inlet temperature with spray coolers or dilution air (EPA, 1998b). When much of the pollutant loading consists of relatively large particles, mechanical collectors such as cyclones may be used to reduce the load on the fabric filter, especially at high inlet concentrations (EPA, 1998b).

Cost Information:

Cost estimates are presented below for pulse-jet cleaned fabric filters. The costs are expressed in 2002 dollars. The cost estimates assume a conventional design under typical operating conditions and do not include auxiliary equipment such as fans and ductwork. The costs for pulse-jet cleaned systems are generated using EPA's cost-estimating spreadsheet for fabric filters (EPA, 1998b).

Costs are primarily driven by the waste stream volumetric flow rate and pollutant loading. In general, a small unit controlling a low pollutant loading will not be as cost effective as a large unit controlling a high pollutant loading. The costs presented are for flow rates of 470 m^3/sec (1,000,000 scfm) and 1.0 m^3/sec (2,000 scfm), respectively, and a pollutant loading of 9 g/m^3 (4.0 gr/ft^3).

Pollutants that require an unusually high level of control or that require the fabric filter bags or the unit itself to be constructed of special materials, such as Gore-Tex or stainless steel, will increase the costs of the system (EPA, 1998b). The additional costs for controlling more complex waste streams are not reflected in the estimates given below. For these types of systems, the capital cost could increase by as much as 75% and the operational and maintenance (O&M) cost could increase by as much as 20%.

- **a.** **Capital Cost:** \$13,000 to \$55,000 per sm^3/s (\$6 to \$26 per scfm)
- **b.** **O & M Cost:** \$11,000 to \$50,000 per sm^3/s (\$5 to \$24 per scfm), annually
- **c.** **Annualized Cost:** \$13,000 to \$83,000 per sm^3/s (\$6 to \$39 per scfm), annually
- **d.** **Cost Effectiveness:** \$46 to \$293 per metric ton (\$42 to \$266 per short ton)

Theory of Operation:

In a fabric filter, flue gas is passed through a tightly woven or felted fabric, causing PM in the flue gas to be collected on the fabric by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with a number of the individual fabric filter units housed together in a group. Bags are most common type of fabric filter. The dust cake that forms on the filter from the collected PM can significantly increase collection efficiency. Fabric filters are frequently referred to as baghouses because the fabric is usually configured in cylindrical bags. Bags may be 6 to 9 m (20 to 30 ft) long and 12.7 to 30.5 centimeters (cm) (5 to 12 inches) in diameter. Groups of bags are placed in isolable compartments to allow cleaning of the bags or replacement of some of the bags without shutting down the entire fabric filter. (STAPPA/ALAPCO, 1996)

Operating conditions are important determinants of the choice of fabric. Some fabrics (e.g., polyolefins, nylons, acrylics, polyesters) are useful only at relatively low temperatures of 95 to 150•C (200 to 300•F). For high-temperature flue gas streams, more thermally stable fabrics such as fiberglass, Teflon®, or Nomex® must be used (STAPPA/ALAPCO, 1996).

Practical application of fabric filters requires the use of a large fabric area in order to avoid an unacceptable pressure drop across the fabric. Baghouse size for a particular unit is determined by the choice of air-to-cloth ratio, or the ratio of volumetric air flow to cloth area. The selection of air-to-cloth ratio depends on the particulate loading and characteristics, and the cleaning method used. A high particulate loading will require the use of a larger baghouse in order to avoid forming too heavy a dust cake, which would result in an excessive pressure drop As an example, a baghouse for a 250 MW utility boiler may have 5,000 separate bags with a total fabric area approaching 46,500 m^2 (500,000 square feet). (ICAC, 1999)

Determinants of baghouse performance include the fabric chosen, the cleaning frequency and methods, and the particulate characteristics. Fabrics can be chosen which will intercept a greater fraction of particulate, and some fabrics are coated with a membrane with very fine openings for enhanced removal of submicron particulate. Such fabrics tend to be more expensive.

Pulse-jet cleaning of fabric filters is relatively new compared to other types of fabric filters, since they have only been used for the past 30 years. This cleaning mechanism has consistently grown in popularity because it can treat high dust loadings, operate at constant pressure drop, and occupy less space than other types of fabric filters. Pulse-jet cleaned fabric filters can only operate as external cake collection devices. The bags are closed at the bottom, open at the top, and supported by internal retainers, called cages. Particulate-laden gas flows into the bag, with diffusers often used to prevent oversized particles from damaging the bags. The gas flows from the outside to the inside of the bags, and then out the gas exhaust. The particles are collected on the outside of the bags and drop into a hopper below the fabric filter. (EPA, 1998a)

During pulse-jet cleaning, a short burst, 0.03 to 0.1 seconds in duration, of high pressure [415 to 830 kiloPascals (kPa) (60 to 120 pounds per square inch gage (psig))] air is injected into the bags (EPA, 1998a; AWMA, 1992). The pulse is blown through a venturi nozzle at the top of the bags and establishes a shock wave that continues onto the bottom of the bag. The wave flexes the fabric, pushing it away from the cage, and then snaps it back dislodging the dust cake. The cleaning cycle is regulated by a remote timer connected to a solenoid valve. The burst of air is controlled by the solenoid valve and is released into blow pipes that have nozzles located above the bags. The bags are usually cleaned row by row (EPA, 1998a).

There are several unique attributes of pulse-jet cleaning. Because the cleaning pulse is very brief, the flow of dusty gas does not have to be stopped during cleaning. The other bags continue to filter, taking on extra duty because of he bags being cleaned. In general, there is no change in fabric filter pressure drop or performance as a result of pulse-jet cleaning. This enables the pulse-jet fabric filters to operate on a continuous basis with solenoid valves as the only significant moving parts. Pulse-jet cleaning is also more intense and occurs with greater frequency than the other fabric filter cleaning methods. This intense cleaning dislodges nearly all of the dust cake each time the bag is pulsed. As a result, pulse-jet filters do not rely on a dust cake to provide filtration. Felted (non-woven) fabrics are used in pulse-jet fabric filters because they do not require a dust cake to achieve high collection efficiencies. It has been found that woven fabrics used with pulse-jet fabric filters leak a great deal of dust after they are cleaned. (EPA, 1998a)

Since bags cleaned by the pulse-jet method do not need to be isolated for cleaning, pulse-jet cleaned fabric filters do not need extra compartments to maintain adequate filtration during cleaning. Also, because of the intense and frequent nature of the cleaning, they can treat higher gas flow rates with higher dust loadings. Consequently, fabric filters cleaned by the pulse-jet method can be smaller than other types of fabric filters in the treatment of the same amount of gas and dust, making higher gas-to-cloth ratios achievable. (EPA, 1998a)

Advantages:

Fabric filters in general provide high collection efficiencies on both coarse and fine (submicron) particulates. They are relatively insensitive to fluctuations in gas stream conditions. Efficiency and pressure drop are relatively unaffected by large changes in inlet dust loadings for continuously cleaned filters. Filter outlet air is very clean and may be recirculated within the plant in many cases (for energy conservation). Collected material is collected dry for subsequent processing or disposal. Corrosion and rusting of components are usually not problems. Operation is relatively simple. Unlike electrostatic precipitators, fabric filter systems do not require the use of high voltage, therefore, maintenance is simplified and flammable dust may be collected with proper care. The use of selected fibrous or granular filter aids (precoating) permits the high-efficiency collection of submicron smokes and gaseous contaminants. Filter collectors are available in a large number of configurations, resulting in a range of dimensions and inlet and outlet flange locations to suit installation requirements. (AWMA, 1992)

Disadvantages:

Temperatures much in excess of 290•C (550•F) require special refractory mineral or metallic fabrics, which can be expensive. Certain dusts may require fabric treatments to reduce dust seepage, or in other cases, assist in the removal of the collected dust. Concentrations of some dusts in the collector, approximately 50 g/m^3 (22 gr/ft^3), may represent a fire or explosion hazard if a spark or flame is accidentally admitted. Fabrics can burn if readily oxidizable dust is being collected. Fabric filters have relatively high maintenance requirements (e.g., periodic bag replacement). Fabric life may be shortened at elevated temperatures and in the presence of acid or alkaline particulate or gas constituents. They cannot be operated in moist environments; hygroscopic materials, condensation of moisture, or tarry adhesive components may cause crusty caking or plugging of the fabric or require special additives. Respiratory protection for maintenance personnel may be required when replacing fabric. Medium pressure drop is required, typically in the range of 100 to 250 mm of water column (4 to 10 inches of water column). (AWMA, 1992)

A specific disadvantage of pulse-jet units that use very high gas velocities is that the dust from the cleaned bags can be drawn immediately to the other bags. If this occurs, little of the dust falls into the hopper and the dust layer on the bags becomes too thick. To prevent this, pulse-jet fabric filters can be designed with separate compartments that can be isolated for cleaning. (EPA, 1998a)

Other Considerations:

Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters therefore may be good candidates for collecting fly ash from low-sulfur coals or fly ash containing high unburned carbon levels, which respectively have high and low resistivities, and thus are relatively difficult to collect with electrostatic precipitators. (STAPPA/ALAPCO, 1996)

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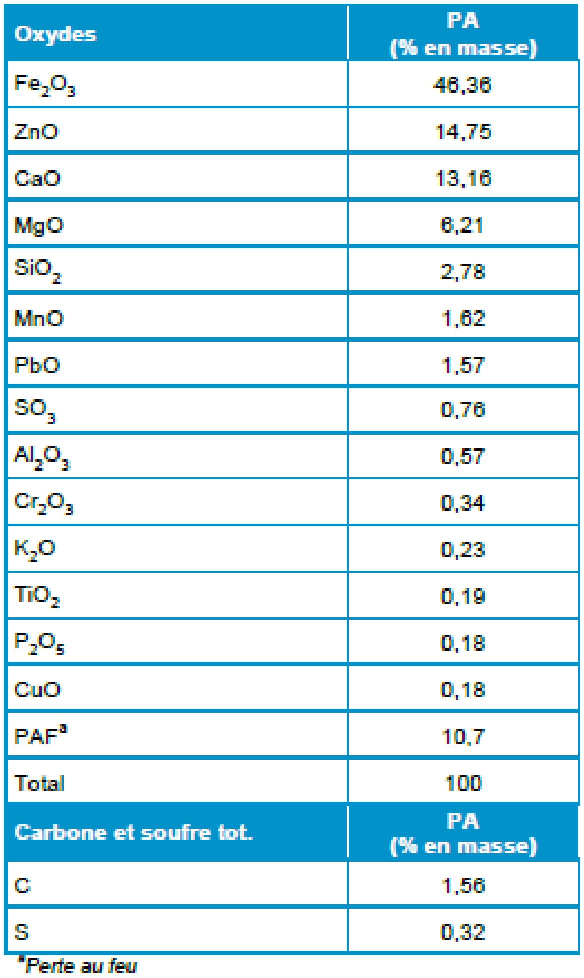
ArcelorMittal Produits Longs Canada
Electric Arc Furnace Dust

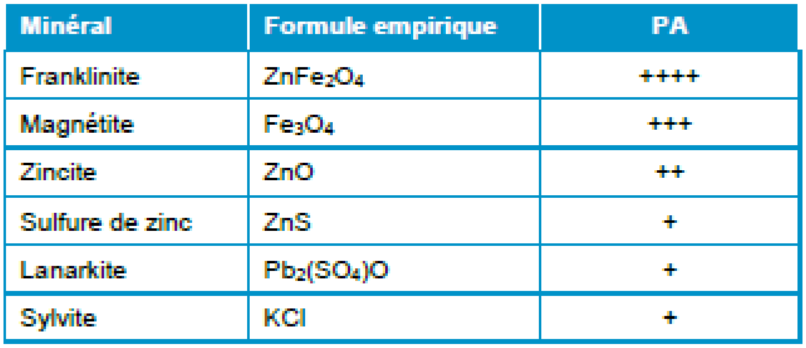
Chemical properties :



Oxydes	PA (% en masse)
Fe_2O_3	46,36
ZnO	14,75
CaO	13,16
MgO	6,21
SiO_2	2,78
MnO	1,62
PbO	1,57
SO_3	0,76
Al_2O_3	0,57
Cr_2O_3	0,34
K_2O	0,23
TiO_2	0,19
P_2O_5	0,18
CuO	0,18
PAF[a]	10,7
Total	100
Carbone et soufre tot.	**PA (% en masse)**
C	1,56
S	0,32

[a] *Perte au feu*

Mineralogy :



Minéral	Formule empirique	PA
Franklinite	$ZnFe_2O_4$	++++
Magnétite	Fe_3O_4	+++
Zincite	ZnO	++
Sulfure de zinc	ZnS	+
Lanarkite	$Pb_2(SO_4)O$	+
Sylvite	KCl	+

Par : J.P. Bernier
March 1st, 2021

Item 1

ARCELORMITTAL DOFASCO (PA)

Electric Arc Furnace Dust Analysis Monthly Composite Samples
% Dry Weight Basis

2015	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO2	%Al2O3	%Na	%Cl-	%C	%S	%K	%H2O
January	22.600	0.535	0.039	31.300	2.410	0.224	0.010	0.156	0.019	9.820	3.270	7.390	1.430	0.795	1.740	0.235	0.444	0.589	0.053
February	20.000	0.499	0.018	29.700	3.030	0.308	0.012	0.149	0.027	9.090	4.250	6.840	1.180	0.663	1.450	0.347	0.526	0.446	0.000
March	19.800	0.402	0.021	30.500	2.440	0.258	0.012	0.177	0.020	7.870	3.490	6.950	1.020	0.747	1.520	0.275	0.563	0.466	0.101
April	21.300	0.365	0.012	29.600	2.570	0.235	0.011	0.136	0.019	8.890	4.180	8.420	0.901	0.767	0.983	0.252	0.550	0.467	0.011
May	19.595	0.382	0.029	26.869	2.257	0.198	0.007	0.144	0.019	7.061	3.345	5.941	0.862	0.690	1.490	0.240	0.540	0.485	0.074
June	23.465	0.435	0.034	26.131	2.784	0.196	0.009	0.144	0.020	7.389	4.525	2.996	1.432	0.804	1.295	0.250	0.590	0.613	0.023
July	25.726	0.344	0.030	26.534	2.552	0.233	0.008	0.120	0.020	7.192	3.614	2.808	0.890	0.580	1.285	0.610	0.420	0.395	0.275
August	22.707	0.299	0.029	25.193	2.369	0.162	0.008	0.105	0.035	7.070	2.993	1.251	0.689	0.548	1.161	0.240	0.400	0.487	0.149
September	22.701	0.429	0.035	26.366	2.677	0.216	0.009	0.143	0.040	6.663	3.476	1.366	1.022	0.655	1.219	0.400	0.440	0.436	0.021
October	21.924	0.294	0.020	28.595	2.599	0.191	0.010	0.131	0.041	10.845	4.168	1.484	1.063	0.609	0.992	0.420	0.440	0.445	0.191
November	23.514	0.489	0.041	26.909	2.242	0.175	0.008	0.130	0.040	8.205	2.529	1.306	0.888	0.924	1.158	0.280	0.350	0.618	0.031
December	22.459	0.359	0.032	29.616	2.734	0.235	0.010	0.120	0.046	8.605	3.661	1.462	1.031	0.590	0.991	0.350	0.480	0.484	0.120
Average	22.227	0.395	0.028	28.150	2.568	0.220	0.010	0.137	0.029	8.290	3.681	4.026	1.033	0.687	1.255	0.336	0.480	0.487	0.094
Maximum	25.726	0.535	0.041	31.300	3.030	0.308	0.012	0.177	0.046	10.845	4.525	8.420	1.432	0.924	1.740	0.610	0.590	0.618	0.275
Minimum	19.595	0.294	0.012	25.193	2.242	0.162	0.007	0.105	0.019	6.663	2.529	1.251	0.689	0.548	0.983	0.235	0.350	0.395	0.000

2016	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO2	%Al2O3	%Na	%Cl-	%C	%S	%K	%H2O
January	24.361	0.353	0.033	27.640	2.443	0.263	0.011	0.125	0.043	8.091	3.142	1.401	0.996	0.491	1.128	0.480	0.440	0.530	0.130
February	25.362	0.338	0.028	27.061	2.689	0.290	0.013	0.149	0.040	7.996	3.901	1.545	0.888	0.658	1.323	0.400	0.550	0.523	0.756
March	22.598	0.504	0.034	26.193	2.311	0.196	0.009	0.123	0.039	6.789	3.243	1.272	0.747	0.712	1.452	0.390	0.630	0.573	0.106
April	20.963	0.374	0.032	27.582	2.374	0.202	0.012	0.117	0.043	6.759	3.237	1.463	0.808	0.815	1.439	0.450	0.510	0.471	0.089
May	22.770	0.397	0.026	22.211	2.058	0.200	0.009	0.110	0.039	6.664	3.244	0.737	0.872	0.775	1.357	0.510	0.640	0.554	0.358
June	23.921	0.456	0.034	28.763	2.526	0.258	0.008	0.143	0.043	7.470	3.758	1.587	0.962	0.975	1.108	0.550	0.470	0.537	0.009
July	26.682	0.461	0.035	24.434	2.175	0.246	0.006	0.142	0.047	7.697	3.482	1.441	0.937	0.930	1.372	0.630	0.640	0.493	0.085
August	20.064	0.421	0.028	23.553	2.317	0.215	0.005	0.129	0.034	7.065	3.423	1.070	0.868	1.247	1.310	0.610	0.700	0.482	0.330
September	27.649	0.644	0.038	27.450	2.185	0.239	0.010	0.141	0.041	9.598	3.837	1.310	0.965	1.075	1.311	0.530	0.550	0.589	0.227
October	22.946	0.392	0.033	28.027	2.253	0.229	0.008	0.133	0.090	7.858	3.371	1.137	0.886	0.946	1.197	0.570	0.610	0.437	0.147
November	24.906	0.363	0.034	32.082	2.612	0.273	0.009	0.122	0.043	8.479	3.970	1.470	0.839	0.938	0.970	0.440	0.500	0.500	0.076
December	28.026	0.424	0.033	32.892	2.865	0.299	0.010	0.139	0.044	8.973	4.454	1.691	1.043	1.110	1.158	0.440	0.480	0.544	0.113
Average	24.090	0.427	0.032	27.155	2.394	0.241	0.009	0.130	0.044	7.752	3.562	1.336	0.900	0.872	1.262	0.500	0.560	0.523	0.208
Maximum	28.026	0.644	0.038	32.892	2.865	0.299	0.013	0.149	0.090	9.598	4.454	1.691	1.043	1.247	1.452	0.630	0.700	0.589	0.756
Minimum	20.064	0.338	0.026	22.211	2.058	0.196	0.005	0.110	0.034	6.664	3.142	0.737	0.747	0.491	0.970	0.390	0.440	0.437	0.009

Item 1

ARCELORMITTAL DOFASCO (PA)

Electric Arc Furnace Dust Analysis Monthly Composite Samples
% Dry Weight Basis

2017	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO_2	%Al_2O_3	%Na	%Cl-	%C	%S	%K	%H_2O
January	24.702	0.420	0.031	31.403	2.515	0.272	0.008	0.122	0.041	10.880	5.918	3.172	1.742	1.054	1.177	0.350	0.470	0.496	0.147
February	23.211	0.401	0.026	31.163	2.359	0.236	0.009	0.111	0.036	7.025	3.690	1.603	0.871	0.862	1.081	0.440	0.490	0.403	0.089
March	23.123	0.573	0.025	30.646	2.972	0.288	0.001	0.146	0.043	8.450	3.629	1.459	1.046	0.697	1.090	0.460	0.420	0.358	0.146
April	25.380	0.522	0.023	29.400	2.957	0.286	0.001	0.128	0.039	7.690	3.582	1.600	0.822	0.598	1.162	0.380	0.420	0.323	0.043
May	19.385	0.342	0.025	34.237	2.728	0.243	0.011	0.144	0.002	6.164	3.283	1.386	0.848	0.700	0.945	0.470	0.480	0.342	0.000
June	23.542	0.402	0.026	31.882	2.752	0.253	0.013	0.148	0.022	8.353	4.191	1.559	1.082	1.003	1.248	0.720	0.600	0.429	0.315
July	23.604	0.497	0.022	30.573	2.344	0.243	0.011	0.146	0.032	6.716	3.589	1.437	0.907	0.914	1.255	0.390	0.610	0.424	0.151
August	24.319	0.545	0.032	28.063	2.508	0.275	0.012	0.142	0.039	7.270	3.019	1.644	0.980	1.013	1.548	0.530	0.540	0.487	0.333
September	24.216	0.580	0.029	28.957	2.572	0.269	0.012	0.154	0.038	7.589	3.135	1.803	0.853	0.930	2.469	0.510	0.600	0.491	0.356
October	23.942	0.674	0.032	28.859	2.468	0.283	0.012	0.165	0.041	7.618	3.728	1.711	1.248	1.274	1.831	0.420	0.510	0.732	0.311
November	22.926	0.621	0.027	29.547	2.531	0.307	0.012	0.176	0.037	6.668	3.779	1.551	0.958	1.167	2.038	0.400	0.480	0.669	0.304
December	25.848	0.528	0.037	30.402	2.588	0.299	0.011	0.160	0.042	7.292	3.598	1.593	1.270	1.295	1.553	0.600	0.500	0.601	0.089
Average	23.782	0.512	0.028	30.351	2.604	0.272	0.009	0.145	0.035	7.720	3.798	1.726	1.066	0.966	1.444	0.470	0.510	0.483	0.195
Maximum	25.848	0.674	0.037	34.237	2.972	0.307	0.013	0.176	0.043	10.880	5.918	3.172	1.742	1.295	2.469	0.720	0.610	0.732	0.356
Minimum	19.385	0.342	0.022	28.063	2.344	0.236	0.001	0.111	0.002	6.164	3.019	1.386	0.822	0.598	0.945	0.350	0.420	0.323	0.000

2018	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO_2	%Al_2O_3	%Na	%Cl-	%C	%S	%K	%H_2O
January	23.728	0.454	0.031	32.011	2.645	0.274	0.007	0.159	0.044	7.619	3.761	1.519	1.230	1.221	1.639	0.380	0.550	0.513	0.116
February	26.061	0.342	0.015	31.122	2.625	0.276	0.010	0.139	0.035	5.390	3.791	1.435	1.056	0.871	1.286	1.310	0.420	0.551	0.032
March	22.951	0.480	0.016	33.140	2.482	0.266	0.010	0.161	0.042	7.260	4.062	1.579	1.100	1.030	1.491	0.570	0.190	0.489	0.150
April	22.588	0.415	0.026	31.678	2.831	0.277	0.010	0.143	0.039	7.527	4.038	1.493	1.119	1.267	1.541	0.240	0.700	0.569	0.018
May	25.067	0.403	0.025	28.894	2.501	0.249	0.008	0.127	0.037	7.850	3.780	0.984	1.135	1.120	1.470	0.150	0.430	0.511	0.019
June	24.272	0.490	0.014	30.838	2.712	0.268	0.009	0.138	0.018	8.556	3.822	2.749	1.209	1.085	1.263	0.610	0.470	0.523	0.120
July	24.892	0.362	0.001	28.111	2.949	0.233	0.003	0.133	0.014	9.939	4.716	2.713	1.132	1.016	1.221	1.130	0.580	0.583	0.113
August	24.768	0.439	0.014	27.016	2.679	0.249	0.008	0.131	0.014	8.937	4.294	2.313	1.123	1.048	1.337	0.730	0.270	0.605	0.451
September	22.136	0.418	0.021	32.434	2.655	0.272	0.011	0.145	0.019	8.986	3.312	3.033	1.336	1.061	1.468	0.760	0.500	0.479	0.427
October	19.370	0.397	0.035	32.635	2.888	0.311	0.013	0.120	0.009	9.470	4.356	3.400	1.258	1.030	1.295	0.460	0.230	0.493	0.487
November	21.116	0.102	0.110	33.229	3.146	0.252	0.001	0.050	0.013	6.730	2.734	1.733	0.652	1.326	1.491	0.620	0.410	0.527	0.210
December	23.443	0.096	0.191	31.668	2.990	0.213	0.012	0.175	0.017	9.535	4.447	3.236	1.339	1.125	1.187	0.430	0.360	0.527	0.146
Average	23.394	0.370	0.041	30.977	2.755	0.262	0.008	0.136	0.026	8.155	3.965	2.149	1.139	1.101	1.392	0.600	0.420	0.533	0.187
Maximum	26.061	0.490	0.191	33.229	3.146	0.311	0.013	0.175	0.044	9.939	4.716	3.400	1.339	1.326	1.639	1.310	0.700	0.605	0.487
Minimum	19.370	0.096	0.001	27.016	2.482	0.213	0.001	0.050	0.009	5.390	2.734	0.984	0.652	0.871	1.187	0.150	0.190	0.479	0.018

Item 1

ARCELORMITTAL DOFASCO (PA)

Electric Arc Furnace Dust Analysis Monthly Composite Samples
% Dry Weight Basis

2019	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO2	%Al2O3	%Na	%Cl-	%C	%S	%K	%H2O
January	25.766	0.001	0.012	29.509	3.117	0.236	0.018	0.182	0.017	10.032	4.989	2.477	1.447	1.195	1.352	0.380	0.470	0.529	0.204
February	23.397	0.028	0.002	30.970	3.133	0.209	0.011	0.203	0.018	8.997	4.670	3.496	1.504	1.305	1.576	0.510	0.500	0.434	0.313
March	19.709	0.402	0.112	33.651	2.833	0.267	0.012	0.162	0.019	6.307	3.676	3.202	1.288	0.749	1.331	0.370	0.570	0.132	0.523
April	20.713	0.257	0.028	32.581	2.679	0.277	0.011	0.153	0.017	7.146	4.453	3.273	1.231	1.018	1.132	0.490	0.260	0.409	0.346
May	19.654	0.395	0.026	32.186	2.824	0.297	0.056	0.163	0.015	9.674	5.424	3.173	1.438	0.826	1.243	0.930	0.430	0.552	0.255
June	19.598	0.401	0.041	33.102	2.840	0.276	0.011	0.137	0.016	8.085	4.427	3.109	1.388	0.984	1.547	0.430	0.310	0.493	0.318
July	19.502	0.323	0.037	36.233	2.747	0.282	0.011	0.172	0.016	6.970	3.937	3.462	1.282	0.566	1.111	0.340	0.190	0.736	0.237
August	18.572	0.338	0.046	35.026	2.721	0.260	0.011	0.157	0.016	7.155	3.855	3.204	1.402	0.900	1.549	0.380	0.140	0.601	0.351
September	21.998	0.308	0.044	31.380	2.584	0.250	0.010	0.138	0.015	7.455	3.806	3.054	1.366	0.960	1.732	0.500	0.210	0.412	0.328
October	18.960	0.391	0.036	34.684	2.558	0.279	0.011	0.146	0.015	8.101	4.367	2.950	1.614	0.851	1.382	0.527	0.165	0.099	0.335
November	17.763	0.265	0.031	35.641	2.570	0.252	0.009	0.121	0.015	8.326	4.490	2.816	1.719	0.845	1.190	0.450	0.150	0.328	0.189
December	21.113	0.292	0.025	33.965	2.347	0.256	0.010	0.123	0.015	7.812	4.621	2.816	1.566	0.753	0.991	0.260	0.070	0.520	0.173
Average	20.508	0.285	0.038	33.351	2.738	0.262	0.015	0.155	0.016	7.979	4.392	3.075	1.440	0.901	1.325	0.457	0.285	0.433	0.298
Maximum	25.766	0.402	0.112	36.233	3.133	0.297	0.056	0.203	0.019	10.032	5.424	3.496	1.719	1.305	1.732	0.930	0.570	0.736	0.523
Minimum	17.763	0.001	0.002	29.509	2.347	0.209	0.009	0.121	0.015	6.307	3.676	2.477	1.231	0.566	0.991	0.260	0.070	0.099	0.173

2020	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO2	%Al2O3	%Na	%Cl-	%C	%S	%K	%H2O
January	19.532	0.356	0.036	33.823	2.802	0.302	0.010	0.160	0.017	7.487	4.548	3.360	1.626	0.851	1.385	0.385	0.188	0.263	0.203
February	20.069	0.283	0.024	32.853	2.867	0.309	0.008	0.165	0.017	7.524	4.965	3.328	1.753	0.774	1.254	0.490	0.180	0.264	0.261
March	20.080	0.334	0.031	32.678	2.862	0.307	0.011	0.156	0.017	7.785	4.457	3.334	2.057	1.059	1.489	0.610	0.160	0.523	0.072
April	23.473	0.711	0.031	29.078	2.845	0.300	0.010	0.164	0.012	7.792	4.925	3.255	1.515	1.056	1.154	0.970	0.650	0.828	0.164
May	17.257	0.454	0.055	34.489	3.186	0.292	0.012	0.189	0.015	7.536	4.597	3.311	1.489	1.111	1.341	0.390	0.360	0.493	0.119
June	18.614	0.304	0.037	33.829	2.822	0.290	0.009	0.155	0.017	8.039	5.387	0.330	1.647	1.073	1.348	0.240	0.190	0.709	0.159
July	20.203	0.443	0.045	34.109	2.501	0.271	0.011	0.162	0.015	8.511	4.920	3.150	1.487	1.118	1.447	0.210	0.120	0.280	0.329
August	22.983	0.334	0.047	30.867	2.809	0.282	0.010	0.176	0.013	8.341	5.325	2.919	1.577	0.807	1.288	0.500	0.360	0.322	0.326
September	21.641	0.366	0.055	30.750	2.583	0.272	0.009	0.198	0.013	8.457	4.519	3.315	1.477	0.910	1.391	1.440	0.070	0.555	0.365
October	21.617	0.286	0.035	29.381	3.240	0.314	0.011	0.142	0.015	9.296	5.352	3.094	1.649	0.689	0.857	1.310	0.160	0.118	0.246
November																			
December																			
Average	20.487	0.372	0.039	32.275	2.850	0.295	0.010	0.166	0.015	8.077	4.882	2.974	1.644	0.932	1.301	0.648	0.224	0.410	0.225
Maximum	23.473	0.711	0.055	34.489	3.240	0.314	0.012	0.198	0.017	9.296	5.387	3.360	2.057	1.118	1.489	1.440	0.650	0.828	0.365
Minimum	17.257	0.283	0.024	29.078	2.501	0.271	0.008	0.142	0.012	7.487	4.457	0.330	1.477	0.689	0.857	0.210	0.070	0.118	0.072

This information has been compiled from sources we believe to be reliable, but we assume no responsibility
or liability for the accuracy or for the result of any application of any information contained herein.

	%Zn	%Pb	%Cd	%Fe	%Mn	%Cr	%Ni	%Cu	%V	%CaO	%MgO	%SiO2	%Al2O3	%Na	%Cl-	%C	%S	%K	%H2O
Maximum	28.026	0.711	0.191	36.233	3.240	0.314	0.056	0.203	0.090	10.880	5.918	8.420	2.057	1.326	2.469	1.440	0.700	0.828	0.756

	Zinc Product	Raw Zinc
Elements	**mg/l**	**%**
As	9.5	0.00302%
Be	nd	
Cd	839	0.06770%
Cr	36.6	0.04370%
Co	nd	
Pb	**7.3%**	8.7%
Hg	12.8	0.00089%
Na	1262	4.0%
K	958	0.03810%
Tl	nd	
S	681	0.42880%
Ag	64.0	0.01610%
B	6.2	0.00218%
Ba	7.3	0.00240%
Se	11.7	0.00448%
Al	34.1	0.02670%
Cu	110	0.02620%
Mn	171	0.09150%
Mo	8.8	0.00151%
Ni	19.7	0.00648%
P	6.3	0.00297%
Sb	37.6	0.00478%
Ti	2.0	0.00718%
Zn	**56.7%**	46.9%
Sn	225	0.01230%

Subject: SO2 Scrubber
Macrotek Proposal No. 42-031

1. Design Concept

The Macrotek Packed Bed Scrubber utilizes a vertical counter-current design for highly efficient absorption of gases. In the vertical counter-current design, gas flows upward while scrubbing liquid flows down through banks of sprays.

The Scrubber will include a random packing section where the absorption of gases, in this case SO_2, occurs. The scrubbing liquid is introduced in a liquid spray distribution system which is located above the packing section.

A high efficiency mist eliminator removes entrained liquids. This is an essential step in the overall performance of the scrubber system.

Re-circulating liquid is sprayed vertically down, counter-current to the gas flow. A regulated amount of reagent (Caustic) will be mixed in the re-circulating liquid to maintain a set-point pH level. The SO2 in the off-gas will react with the reagent of choice, forming sodium salts.

The stoichiometry for this system is:

$$SO_2 + 2NaOH \Rightarrow Na_2SO_3 + H_2O$$

$$Na_2SO_3 + \tfrac{1}{2}O_2 \Rightarrow Na_2SO_4$$

The reaction product will be carried with other particulates in the re-circulating liquid.

The integral tank design for the re-circulating liquid also provides for venting of by-product gases from the tank through the absorber section. This is desired over a separate tank.

A centrifugal pump will provide the liquid re-circulation for the scrubber system.

2. Process Information and Vessel Sizing

Gas temperature: 80^0 C
Flow Rate: 1100 Nm^3/hr

Scrubber Feed Component	Weight %
SO2	0.7
Water	25
CO2	2.5
CO	2
Nitrogen	67.8
Oxygen	2
Particles	Trace

SO2 removal efficiency: 99.9%

3. Scope of Supply and Equipment Description

3.1 Scrubber Column

Model MP-24-12 Macrotek Packed Bed Scrubber, complete with the following design features:

- The general dimensions of the scrubber are:
    - Overall height: 22.5 feet
    - Diameter of scrubber: 2 feet
    - Packing height: 12 feet
- Vessel material of construction: SS 316L
- Mist eliminator included with CPVC wash nozzle assembly (bottom wash).
- All internal piping: CPVC
- All external stiffeners, if required: SS304
- Access ports, round flanges with SS316 covers
- Integral bottom sump for the re-circulating liquid

3.2 Re-Circulating Pumps

Macrotek will supply two (2) (one operating, one installed spare), SS316 Goulds Xylem or equal pumps with the following features:

- Manufacturer: Goulds Xylem or equal
- Model: TBA
- Capacity: 50 GPM

- Head: 30 psig
- Motor: 3HP, 575/3/60
- Material: SS316

3.3 Re-Circulating Piping

Macrotek will supply a full re-circulating piping package. Piping will be sch40 CPVC and will include all manual isolation and manual flow modulating valves. Valves will also be CPVC, ball valves will be used for isolation and diaphragm valves will be used for modulation.

Since a layout is not available at this time, the piping that we are including is on the following basis:

- Macrotek selects the location of the major equipment within our package, including vessels, pumps, heat exchangers, or any other equipment that impacts the piping
- All equipment will be on the same elevation
- No interferences with equipment/structures that are outside of Macrotek's scope
- The layout will be compact, but will also allow easy operator access for maintenance and monitoring of the system

Piping will be designed in accordance to B31.3 standards but will be fabricated in a NON-registered shop, and welding will be in accordance to CSA W59 standards. Registration to TSSA/CSA or ASME B31 and NDE testing has not been included. If the owner determines that it is a necessary requirement as determined by the fluid designation, Macrotek can provide the associated cost.

3.4 Controls and Instrumentation

Macrotek will supply field mounted controls.

3.5 Skid Packaging

Macrotek will supply a skid packaged system to minimize field work and installation time. The skid will include:

- One (1) painted carbon steel channel base and top plate
- Mounting of the re-circulating pump
- Installation and supporting of the re-circulating piping package, including:
  - piping between the pump inlet and skid boundary
  - piping between the pump outlet and skid boundary
  - piping of blowdown line to skid boundary (downstream piping by others)
  - piping from skid boundary water feed connection to the scrubber make-up water connection
- Final piping connections to the scrubber to be completed by others once the scrubber is installed
- Mounting of instruments and valves, excluding those which are connected to the top scrubber section

- Mounting of the scrubber control panel
- Wiring and conduit between skid-mounted instruments and equipment to the control panel

3.6 Caustic Metering Pump

Macrotek will supply one (1) Prominent or equal solenoid driven metering pump for caustic metering.

3.7 Air Blower

Macrotek will supply one (1) Air Products or equal, aluminum regenerative blower to inject air into the SO2 scrubber sump. The blower will have a capacity for 25 SCFM at 70” WC. Sparger feed piping by others.

4. Equipment and Services to be Supplied by Others

The following items are NOT in our scope:

- Mechanical and Electrical Installation
- Interconnecting Duct and Expansion Joints
- Fan and Fan Control Center including starters, overloads and ammeters
- Pump motor starters, VFDs, MCC
- Field wiring
- Re-agent preparation/storage, reagent pumps and all required controls
- Foundation Design
- All external piping and valves
- Utility piping and tubing, including but not limited to fresh water and plant air
- Tubing of field mounted instruments, including but not limited to differential pressure gauges and differential pressure transmitters
- Equipment first fills, unless otherwise stated
- Required Permits and Licenses
- Performance Testing or any other field testing
- Insulation if required
- Access Platforms and Ladders
- Stack

11.12 Concrete Batching

11.12.1 Process Description [1-5]

Concrete is composed essentially of water, cement, sand (fine aggregate) and coarse aggregate. Coarse aggregate may consist of gravel, crushed stone or iron blast furnace slag. Some specialty aggregate products could be either heavyweight aggregate (of barite, magnetite, limonite, ilmenite, iron or steel) or lightweight aggregate (with sintered clay, shale, slate, diatomaceous shale, perlite, vermiculite, slag pumice, cinders, or sintered fly ash). Supplementary cementitious materials, also called mineral admixtures or pozzolan minerals may be added to make the concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties. Typical examples are natural pozzolans, fly ash, ground granulated blast-furnace slag, and silica fume, which can be used individually with portland or blended cement or in different combinations. Chemical admixtures are usually liquid ingredients that are added to concrete to entrain air, reduce the water required to reach a required slump, retard or accelerate the setting rate, to make the concrete more flowable or other more specialized functions.

Approximately 75 percent of the U.S. concrete manufactured is produced at plants that store, convey, measure and discharge these constituents into trucks for transport to a job site. At most of these plants, sand, aggregate, cement and water are all gravity fed from the weight hopper into the mixer trucks. The concrete is mixed on the way to the site where the concrete is to be poured. At some of these plants, the concrete may also be manufactured in a central mix drum and transferred to a transport truck. Most of the remaining concrete manufactured are products cast in a factory setting. Precast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding. Concrete masonry, another type of manufactured concrete, may be best known for its conventional 8 x 8 x 16-inch block. In a few cases concrete is dry batched or prepared at a building construction site. Figure 11.12-1 is a generalized process diagram for concrete batching.

The raw materials can be delivered to a plant by rail, truck or barge. The cement is transferred to elevated storage silos pneumatically or by bucket elevator. The sand and coarse aggregate are transferred to elevated bins by front end loader, clam shell crane, belt conveyor, or bucket elevator. From these elevated bins, the constituents are fed by gravity or screw conveyor to weigh hoppers, which combine the proper amounts of each material.

11.12.2 Emissions and Controls [6-8]

Particulate matter, consisting primarily of cement and pozzolan dust but including some aggregate and sand dust emissions, is the primary pollutant of concern. In addition, there are emissions of metals that are associated with this particulate matter. All but one of the emission points are fugitive in nature. The only point sources are the transfer of cement and pozzolan material to silos, and these are usually vented to a fabric filter or “sock”. Fugitive sources include the transfer of sand and aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion from sand and aggregate storage piles. The amount of fugitive emissions generated during the transfer of sand and aggregate depends primarily on the surface moisture content of these materials. The extent of fugitive emission control varies widely from plant to plant. Particulate emission factors for concrete batching are give in Tables 11.12-1 and 11.12-2.

Types of controls used may include water sprays, enclosures, hoods, curtains, shrouds, movable and telescoping chutes, central duct collection systems, and the like. A major source of potential emissions, the movement of heavy trucks over unpaved or dusty surfaces in and around the plant, can be controlled by good maintenance and wetting of the road surface.

Predictive equations that allow for emission factor adjustment based on plant specific conditions are given in the Background Document for Chapter 11.12 and Chapter 13. Whenever plant specific data are available, they should be used with these predictive equations (e.g. Equations 11.12-1 through 11.12-3) in lieu of the general fugitive emission factors presented in Table 11.12-1, 11.12-2, and 11.12-5 through11.12-8 in order to adjust to site specific conditions, such as moisture levels and localized wind speeds.

11.12.3 Updates since the 5th Edition.

October 2001

– This major revision of the section replaced emissions factors based upon engineering judgment and poorly documented and performed source test reports with emissions tests conducted at modern operating truck mix and central mix facilities. Emissions factors for both total PM and total PM_{10} were developed from this test data.

June 2006

– This revision of the section supplemented the two source tests with several additional source tests of central mix and truck mix facilities. The measurement of the capture efficiency, local wind speed and fines material moisture level was improved over the previous two source tests. In addition to quantifying total PM and PM_{10}, $PM_{2.5}$ emissions were quantified at all of the facilities. Single value emissions factors for truck mix and central mix operations were revised using all of the data. Additionally, parameterized emissions factor equations using local wind speed and fines material moisture content were developed from the newer data.

February 2011

– This is an editorial revision of the section. Emissions factors in Tables 11.12-1, 11.12-2, 11.12-7 and 11.12-8 were corrected to agree with the emissions factors presented in the background report.

August 2011

- Equation 11.12-2 was corrected. An explanation was added under the equation.

January 2012

- This is an editorial revision of the section. Emissions factors for Uncontrolled factors in Table 11.12-3 for Total PM, PM_{10} and $PM_{10-2.5}$ were corrected to agree with the emissions factors presented in Table 11.12-2 and the emissions factors presented in the background report.

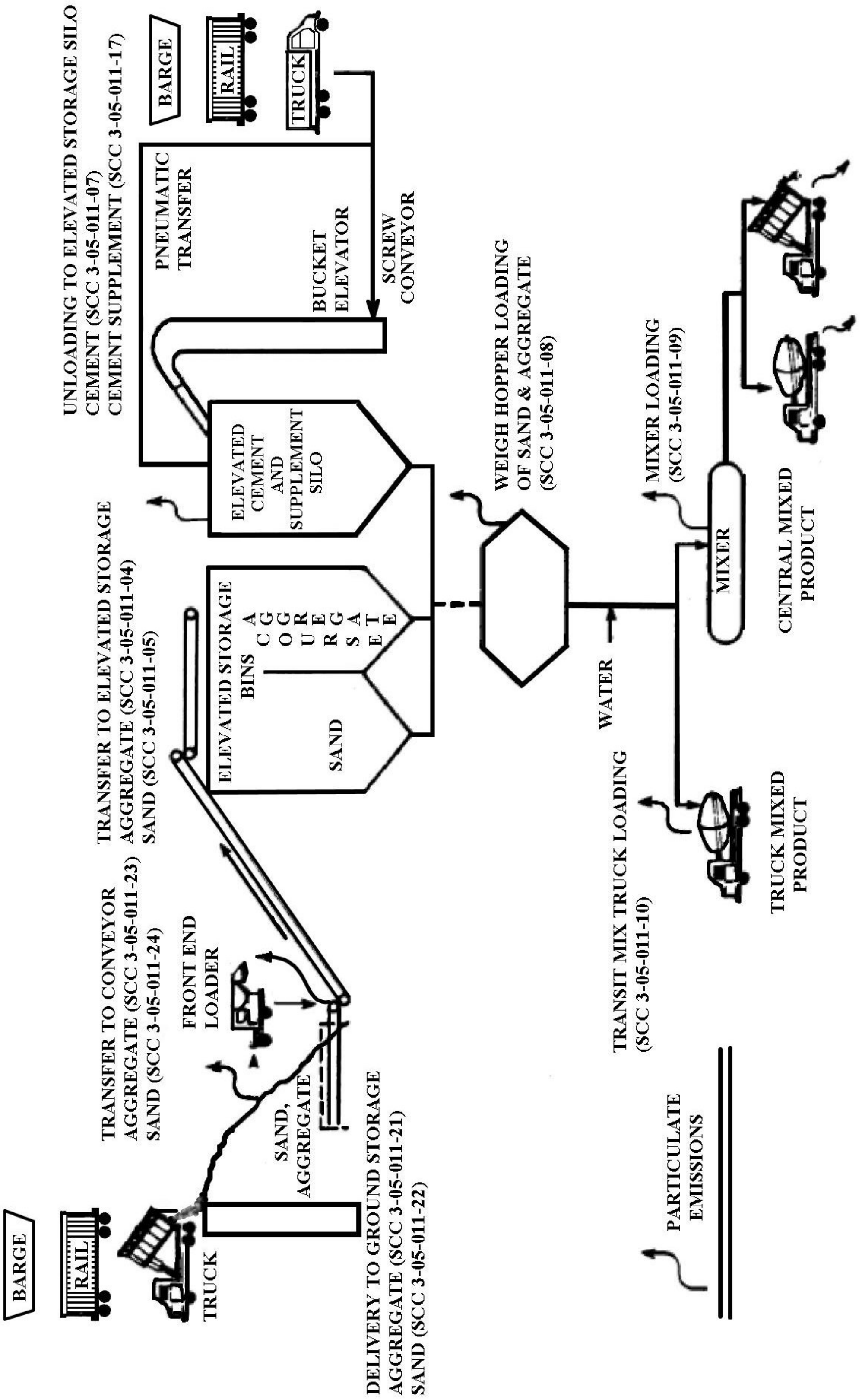


Figure 11.12-1. Typical Concrete Batching Process.

TABLE 11.12-1 (METRIC UNITS)
EMISSION FACTORS FOR CONCRETE BATCHING [a]

Source (SCC)	Uncontrolled				Controlled			
	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating
Aggregate transfer [b] (3-05-011-04,-21,23)	0.0035	D	0.0017	D	ND		ND	
Sand transfer [b] (3-05-011-05,22,24)	0.0011	D	0.00051	D	ND		ND	
Cement unloading to elevated storage silo (pneumatic)[c] (3-05-011-07)	0.36	E	0.24	E	0.00050	D	0.00017	D
Cement supplement unloading to elevated storage silo (pneumatic)[d] (3-05-011-17)	1.57	E	0.65	E	0.0045	D	0.0024	E
Weigh hopper loading [e] (3-05-011-08)	0.0026	D	0.0013	D	ND		ND	
Mixer loading (central mix)[f] (3-05-011-09)	0.286 or Eqn. 11.12-1	B	0.078 or Eqn. 11.12-1	B	0.0092 or Eqn. 11.12-1	B	0.0028 or Eqn. 11.12-1	B
Truck loading (truck mix)[g] (3-05-011-10)	0.559	B	0.155	B	0.049 or Eqn. 11.12-1	B	0.0131 or Eqn. 11.12-1	B
Vehicle traffic (paved roads)	See AP-42 Section 13.2.1, Paved Roads							
Vehicle traffic (unpaved roads)	See AP-42 Section 13.2.2, Unpaved Roads							
Wind erosion from aggregate and sand storage piles	See AP-42 Section 13.2.5, Industrial Wind Erosion							

ND = No data

[a] All emission factors are in kg of pollutant per Mg of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 846 kg course aggregate, 648 kg sand, 223 kg cement and 33kg cement supplement. Approximately 75 liters of water was added to this solid material to produce 1826 kg of concrete.

[b] Reference 9 and 10. Emission factors are based upon an equation from AP-42, section 13.2.4 Aggregate Handling And Storage Piles, equation 1 with $k_{PM\text{-}10}$ =.35, k_{PM} = .74, U = 10mph, $M_{aggregate}$ =1.77%, and M_{sand} = 4.17%. These moisture contents of the materials ($M_{aggregate}$ and M_{sand}) are the averages of the values obtained from Reference 9 and Reference 10.

[c] The uncontrolled PM & PM-10 emission factors were developed from Reference 9. The controlled emission factor for PM was developed from References 9, 10, 11, and 12. The controlled emission factor for PM-10 was developed from References 9 and 10.

[d] The controlled PM emission factor was developed from Reference 10 and Reference 12, whereas the controlled PM-10 emission factor was developed from only Reference 10.

[e] Emission factors were developed by using the AP-42 Section 13.2.4, Aggregate and Sand Transfer Emission Factors in conjunction with the ratio of aggregate and sand used in an average yard^3 of concrete. The unit for these emission factors is kg of pollutant per Mg of aggregate and sand.

[f] References 9, 10, and 14. The emission factor units are kg of pollutant per Mg of cement and cement supplement. The general factor is the arithmetic mean of all test data.

[g] Reference 9, 10, and 14. The emission factor units are kg of pollutant per Mg of cement and cement supplement. The general factor is the arithmetic mean of all test data.

TABLE 11.12-2 (ENGLISH UNITS)
EMISSION FACTORS FOR CONCRETE BATCHING [a]

Source (SCC)	Uncontrolled				Controlled			
	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating	Total PM	Emission Factor Rating	Total PM_{10}	Emission Factor Rating
Aggregate transfer [b] (3-05-011-04,-21,23)	0.0069	D	0.0033	D	ND		ND	
Sand transfer [b] (3-05-011-05,22,24)	0.0021	D	0.00099	D	ND		ND	
Cement unloading to elevated storage silo (pneumatic)[c] (3-05-011-07)	0.73	E	0.47	E	0.00099	D	0.00034	D
Cement supplement unloading to elevated storage silo (pneumatic)[d] (3-05-011-17)	3.14	E	1.10	E	0.0089	D	0.0049	E
Weigh hopper loading [e] (3-05-011-08)	0.0048	D	0.0028	D	ND		ND	
Mixer loading (central mix)[f] (3-05-011-09)	0.572 or Eqn. 11.12-1	B	0.156 or Eqn. 11.12-1	B	0.0184 or Eqn. 11.12-1	B	0.0055 or Eqn. 11.12-1	B
Truck loading (truck mix)[g] (3-05-011-10)	1.118	B	0.310	B	0.098 or Eqn. 11.12-1	B	0.0263 or Eqn. 11.12-1	B
Vehicle traffic (paved roads)	See AP-42 Section 13.2.1, Paved Roads							
Vehicle traffic (unpaved roads)	See AP-42 Section 13.2.2, Unpaved Roads							
Wind erosion from aggregate and sand storage piles	See AP-42 Section 13.2.5, Industrial Wind Erosion							

ND = No data

[a] All emission factors are in lb of pollutant per ton of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 1865 lbs course aggregate, 1428 lbs sand, 491 lbs cement and 73 lbs cement supplement. Approximately 20 gallons of water was added to this solid material to produce 4024 lbs (one cubic yard) of concrete.

[b] Reference 9 and 10. Emission factors are based upon an equation from AP-42, section 13.2.4 Aggregate Handling And Storage Piles, equation 1 with k_{PM-10} =.35, k_{PM} = .74, U = 10mph, $M_{aggregate}$ =1.77%, and M_{sand} = 4.17%. These moisture contents of the materials ($M_{aggregate}$ and M_{sand}) are the averages of the values obtained from Reference 9 and Reference 10.

[c] The uncontrolled PM & PM-10 emission factors were developed from Reference 9. The controlled emission factor for PM was developed from References 9, 10, 11, and 12. The controlled emission factor for PM-10 was developed from References 9 and 10.

[d] The controlled PM emission factor was developed from Reference 10 and Reference 12, whereas the controlled PM-10 emission factor was developed from only Reference 10.

[e] Emission factors were developed by using the Aggregate and Sand Transfer Emission Factors in conjunction with the ratio of aggregate and sand used in an average yard^3 of concrete. The unit for these emission factors is lb of pollutant per ton of aggregate and sand.

[f] References 9, 10, and 14. The emission factor units are lb of pollutant per ton of cement and cement supplement. The general factor is the arithmetic mean of all test data.

[g] Reference 9, 10, and 14. The emission factor units are lb of pollutant per ton of cement and cement supplement. The general factor is the arithmetic mean of all test data.

The particulate matter emissions from truck mix and central mix loading operations are calculated in accordance with the values in Tables 11.12-1 or 11.12-2 or by Equation 11.12-1[14] when site specific data are available.

$$E = k\,(0.0032)\left[\frac{U^{a}}{M^{b}}\right] + c \qquad \text{Equation 11.12-1}$$

E = Emission factor in lbs./ton of cement and cement supplement
k = Particle size multiplier (dimensionless)
U = Wind speed at the material drop point, miles per hour (mph)
M = Minimum moisture (% by weight) of cement and cement supplement
a, b = Exponents
c = Constant

The parameters for Equation 11.12-1 are summarized in Tables 11.12-3 and 11.12-4.

Table 11.12-3. Equation Parameters for Truck Mix Operations

Condition	Parameter Category	k	a	b	c
Controlled[1]	Total PM	0.8	1.75	0.3	0.013
	PM_{10}	0.32	1.75	0.3	0.0052
	$PM_{10-2.5}$	0.288	1.75	0.3	0.00468
	$PM_{2.5}$	0.048	1.75	0.3	0.00078
Uncontrolled[1]	Total PM	1.118			
	PM_{10}	0.310			
	$PM_{10-2.5}$	0.260			
	$PM_{2.5}$	0.050			

Table 11.12-4. Equation Parameters for Central Mix Operations

Condition	Parameter Category	k	a	b	c
Controlled[1]	Total PM	0.19	0.95	0.9	0.0010
	PM_{10}	0.13	0.45	0.9	0.0010
	$PM_{10-2.5}$	0.12	0.45	0.9	0.0009
	$PM_{2.5}$	0.03	0.45	0.9	0.0002
Uncontrolled[1]	Total PM	5.90	0.6	1.3	0.120
	PM_{10}	1.92	0.4	1.3	0.040
	$PM_{10-2.5}$	1.71	0.4	1.3	0.036
	$PM_{2.5}$	0.38	0.4	1.3	0

1. Emission factors expressed in lbs/tons of cement and cement supplement

To convert from units of lbs/ton to units of kilograms per mega gram, the emissions calculated by Equation 11.12-1 should be divided by 2.0.

Particulate emission factors per yard of concrete for an average batch formulation at a typical facility are given in Tables 11.12-5 and 11.12-6. For truck mix loading and central mix loading, the emissions of PM, PM-10, PM-10-2.5, and PM-2.5 are calculated by multiplying the emission factor calculated using Equation 11.12-2 by a factor of 0.282 to convert from emissions per ton of cement and cement supplement to emissions per yard of concrete. This equation is based on a typical concrete formulation of 564 pounds of cement and cement supplement in a total of 4,024 pounds of material (including aggregate, sand, and water). This calculation is summarized in Equation 11.12-2.

$$\text{PM, PM10, PM10 - 2.5, PM2.5 emissions}\left(\frac{\text{pounds}}{\text{yd}^3\text{ of concrete}}\right) = 0.282 * \quad (\text{Equation } 11.12-1 \text{ factor or Table } 11.12\text{ - }2 \text{ Factor})$$

Equation 11.12-2

*NOTE: August 8, 2011. The equation was corrected.
The basis of this conversion constant is:

EF (pounds / ton *cem*) * (ton *cem* / 2,000 pounds *cem*) * (564 pounds *cem* / yd^3 concrete) = EF (pounds / yd^3 concrete)

Where:

cem is the sum of cement (491 pounds) and cement supplement (73 pounds).

Metals emission factors for concrete batching are given in Tables 11.12-7 and 11.12-8. Alternatively, the metals emissions from ready mix plants can be calculated based on (1) the weighted average concentration of the metal in the cement and the cement supplement (i.e. flyash) and (2) on the total particulate matter emission factors calculated in accordance with Equation 11.12-3. Emission factors calculated using Equation 11.12-3 are rated D.

$$\text{Metal}_{\text{EF}} = \text{PM}_{\text{EF}}\left(\frac{\text{aC} + \text{bS}}{\text{C} + \text{S}}\right)$$

Equation 11.12-3

Where:

Metal_{EF} = Metal Emissions, Lbs. As per Ton of Cement and Cement Supplement
PM_{EF} = Controlled Particulate Matter Emission Factor (PM, PM10, or PM2.5) Lbs. per Ton of Cement and Cement Supplement
a = ppm of Metal in Cement
C = Quantity of Cement Used, Lbs. per hour
b = ppm of Metal in Cement Supplement
S = Quantity of Cement Supplement Used, Lbs. per hour

This equation is based on the assumption that 100% of the particulate matter emissions are material entrained from the cement and cement supplement streams. Equation 11.12-3 over-estimates total metal emissions to the extent that sand and fines from aggregate contribute to the total particulate matter emissions.

TABLE 11.12-5 (ENGLISH UNITS)
PLANT WIDE EMISSION FACTORS PER YARD OF TRUCK MIX CONCRETE [a]

	Uncontrolled		Controlled	
	PM (lb/yd^3)	PM-10 (lb/yd^3)	PM (lb/yd^3)	PM-10 (lb/yd^3)
Aggregate delivery to ground storage (3-05-011-21)	0.0064	0.0031	0.0064	0.0031
Sand delivery to ground storage (3-05-011-22)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to conveyor (3-05-011-23)	0.0064	0.0031	0.0064	0.0031
Sand transfer to conveyor (3-05-011-24)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to elevated storage (3-05-011-04)	0.0064	0.0031	0.0064	0.0031
Sand transfer to elevated storage (3-05-011-05)	0.0015	0.0007	0.0015	0.0007
Cement delivery to Silo (3-05-011-07 controlled)	0.0002	0.0001	0.0002	0.0001
Cement supplement delivery to Silo (3-05-011-17 controlled)	0.0003	0.0002	0.0003	0.0002
Weigh hopper loading (3-05-011-08)	0.0079	0.0038	0.0079	0.0038
Truck mix loading (3-05-011-10)	See Equation 11.12-2			

TABLE 11.12-6 (ENGLISH UNITS)
PLANT WIDE EMISSION FACTORS PER YARD OF CENTRAL MIX CONCRETE [a]

	Uncontrolled		Controlled	
	PM (lb/yd^3)	PM-10 (lb/yd^3)	PM (lb/yd^3)	PM-10 (lb/yd^3)
Aggregate delivery to ground storage (3-05-011-21)	0.0064	0.0031	0.0064	0.0031
Sand delivery to ground storage (3-05-011-22)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to conveyor (3-05-011-23)	0.0064	0.0031	0.0064	0.0031
Sand transfer to conveyor (3-05-011-24)	0.0015	0.0007	0.0015	0.0007
Aggregate transfer to elevated storage (3-05-011-04)	0.0064	0.0031	0.0064	0.0031
Sand transfer to elevated storage (3-05-011-05)	0.0015	0.0007	0.0015	0.0007
Cement delivery to Silo (3-05-011-07 controlled)	0.0002	0.0001	0.0002	0.0001
Cement supplement delivery to Silo (3-05-011-17 controlled)	0.0003	0.0002	0.0003	0.0002
Weigh hopper loading (3-05-011-08)	0.0079	0.0038	0.0079	0.0038
Central mix loading (3-05-011-09)	See Equation 11.12-2			

[a] Total facility emissions are the sum of the emissions calculated in Tables 11.12-4 or 11.12-5. Total facility emissions do not include road dust and wind blown dust. The emission factors in Tables 11.12-5 and 11.12-6 are based upon the following composition of one yard of concrete.

Coarse Aggregate	1865. pounds
Sand	1428. pounds
Cement	491. pounds
Cement Supplement	73. pounds
Water	20. gallons (167 pounds)

TABLE 11.12-7 (METRIC UNITS)
CONCRETE BATCH PLANT METAL EMISSION FACTORS [a]

	Arsenic	Beryllium	Cadmium	Total Chromium	Lead	Manganese	Nickel	Total Phosphorus	Selenium	Emission Factor Rating
Cement Silo Filling [b] (SCC 3-05-011-07)	8.38e-07	8.97e-09	1.17e-07	1.26e-07	3.68e-07	1.01e-04	8.83e-06	5.88e-05	ND	E
w/ Fabric Filter	2.12e-09	2.43e-10	ND	1.45e-08	5.46e-09	5.87e-08	2.09e-08	ND	ND	E
Cement Supplement Silo Filling [c] (SCC 3-05-011-17)	ND	ND	ND	ND	ND	ND	ND	ND	ND	E
w/ Fabric Filter	5.02e-07	4.52e-08	9.92e-09	6.10e-07	2.60e-07	1.28e-07	1.14e-06	1.77e-06	3.62e-08	E
Central Mix Batching [d] (SCC 3-05-011-09)	4.19e-06	ND	5.92e-09	7.11e-07	1.91e-07	3.06e-05	1.64e-06	1.01e-05	ND	E
w/ Fabric Filter	1.48e-07	ND	3.55e-10	6.34e-08	1.83e-08	1.89e-06	1.24e-07	6.04e-07	ND	E
Truck Loading [e] (SCC 3-05-011-10)	6.09e-06	1.22e-07	1.71e-08	5.71e-06	1.81e-06	3.06e-05	5.99e-06	1.92e-05	1.31e-06	E
w/ Fabric Filter	3.01e-07	5.18e-08	4.53e-09	2.05e-06	7.67e-07	1.04e-05	2.39e-06	6.16e-06	5.64e-08	E

ND=No data

[a] All emission factors are in kg of pollutant per Mg of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 846 Kg course aggregate, 648 kg sand, 223 kg cement and 33kg cement supplement. Approximately 75 liters of water was added to this solid material to produce 1826 kg of concrete.

[b] The uncontrolled emission factors were developed from Reference 9. The controlled emission factors were developed form Reference 9 and 10. Although controlled emissions of phosphorous compounds were below detection, it is reasonable to assume that the effectiveness is comparable to the average effectiveness (98%) for the other metals.

[c] Reference 10.

[d] Reference 9. The emission factor units are kg of pollutant per Mg of cement and cement supplement. Emission factors were developed from a typical central mix operation. The average estimate of the percent of emissions captured during each run is 94%.

[e] Reference 9 and 10. The emission factor units are kg of pollutant per Mg of cement and cement supplement. Emission factors were developed from two typical truck mix loading operations. Based upon visual observations of every loading operation during the two test programs, the average capture efficiency during the testing was 71%.

TABLE 11.12-8 (ENGLISH UNITS)
CONCRETE BATCH PLANT METAL EMISSION FACTORS [a]

	Arsenic	Beryllium	Cadmium	Total Chromium	Lead	Manganese	Nickel	Total Phosphorus	Selenium	Emission Factor Rating
Cement Silo Filling [b] (SCC 3-05-011-07) w/ Fabric Filter	1.68e-06 4.24e-09	1.79e-08 4.86e-10	2.34e-07 ND	2.52e-07 2.90e-08	7.36e-07 1.09e-08	2.02e-04 1.17e-07	1.76e-05 4.18e-08	1.18e-05 ND	ND ND	E E
Cement Supplement Silo Filling [c] (SCC 3-05-011-17) w/ Fabric Filter	ND 1.00e-06	ND 9.04e-08	ND 1.98e-10	ND 1.22e-06	ND 5.20e-07	ND 2.56e-07	ND 2.28e-06	ND 3.54e-06	ND 7.24e-08	E E
Central Mix Batching [d] (SCC 3-05-011-09) w/ Fabric Filter	8.38e-06 2.96e-07	ND ND	1.18e-08 7.10e-10	1.42e-06 1.27e-07	3.82e-07 3.66e-08	6.12e-05 3.78e-06	3.28e-06 2.48e-07	2.02e-05 1.20e-06	ND ND	E E
Truck Loading [e] (SCC 3-05-011-10) w/ Fabric Filter	1.22e-05 6.02e-07	2.44e-07 1.04e-07	3.42e-08 9.06e-09	1.14e-05 4.10e-06	3.62e-06 1.53e-06	6.12e-05 2.08e-05	1.19e-05 4.78e-06	3.84e-05 1.23e-05	2.62e-06 1.13e-07	E E

ND=No data

[a] All emission factors are in lb of pollutant per ton of material loaded unless noted otherwise. Loaded material includes course aggregate, sand, cement, cement supplement and the surface moisture associated with these materials. The average material composition of concrete batches presented in references 9 and 10 was 1865 lbs course aggregate, 1428 lbs sand, 491 lbs cement and 73 lbs cement supplement. Approximately 20 gallons of water was added to this solid material to produce 4024 lbs (one cubic yard) of concrete.

[b] The uncontrolled emission factors were developed from Reference 9. The controlled emission factors were developed form Reference 9 and 10. Although controlled emissions of phosphorous compounds were below detection, it is reasonable to assume that the effectiveness is comparable to the average effectiveness (98%) for the other metals.

[c] Reference 10.

[d] Reference 9. The emission factor units are lb of pollutant per ton of cement and cement supplement. Emission factors were developed from a typical central mix operation. The average estimate of the percent of emissions captured during each test run is 94%.

[e] Reference 9 and 10. The emission factor units are lb of pollutant per ton of cement and cement supplement. Emission factors were developed from two typical truck mix loading operations. Based upon visual observations of every loading operation during the two test programs, the average capture efficiency during the testing was 71%.

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Product Data Sheet
#2 PIPE ELIMINATOR

General Product Description

	Min	Max	Target
%Ash	0	21	☐
%Volatile	0	9	☐
%Moisture	0	2	☐
%Sulfur	0	1.6	☐
%Carbon (Fixed)	68	100	☐
%-200 Total (75 Micron)	90	100	☐
Wettability: YES			☐

Type: BLEND

Typical Analysis

(U.S. Standard Test Sieves)

%Ash	8.7
%Volatile	2.2
%Moisture	0.3
%Sulfur	0.91
%Carbon (Fixed)	89.1
%+100 Mesh (150 Micron)	0.36
%+200 Mesh (75 Micron)	6.95
%+325 Mesh (44 Micron)	11.74
%-325 Mesh (44 Micron)	80.95

Test Methods

% Ash	E4-1
% Fixed Carbon	E4-8
% Moisture	E4-2
% Sulfur	E4-9
% Volatile	E4-3
Sieve Analysis	E2-2
Wetability-yes	E4-16

The PDS lists percentages which are only guaranteed following specific agreement between Asbury Carbons and the customer. They are listed here only to indicate approximate physical and chemical analysis. Purchasers should thoroughly test and independently verify satisfactory results before application. The user assumes the risk and liability for loss, damage, or injury arising from the application of the goods furnished.

UNCONTROLLED DOCUMENT: Prior to placing an order based on this PDS, contact the Asbury Sales Department to confirm that the information contained herein is current.

Revision Level: 8 **Revision Date:** 6/5/2019

EPA-452/F-03-022

Air Pollution Control Technology
Fact Sheet

Name of Technology: Thermal Incinerator

This type of incinerator is also referred to as a direct flame incinerator, thermal oxidizer, or afterburner. However, the term afterburner is generally appropriate only to describe a thermal oxidizer used to control gases coming from a process where combustion is incomplete.

Type of Technology: Destruction by thermal oxidation

Applicable Pollutants: Primarily volatile organic compounds (VOC). Some particulate matter (PM), commonly composed as soot (particles formed as a result of incomplete combustion of hydrocarbons (HC), coke, or carbon residue) will also be destroyed in various degrees.

Achievable Emission Limits/Reductions:

VOC destruction efficiency depends upon design criteria (i.e., chamber temperature, residence time, inlet VOC concentration, compound type, and degree of mixing) (EPA, 1992). Typical thermal incinerator design efficiencies range from 98 to 99.99% and above, depending on system requirements and characteristics of the contaminated stream (EPA, 1992; EPA, 1996a). The typical design conditions needed to meet 98% or greater control or a 20 parts per million by volume (ppmv) compound exit concentration are: 870°C (1600°F) combustion temperature, 0.75 second residence time, and proper mixing. For halogenated VOC streams, 1100°C (2000°F) combustion temperature, 1.0 second residence time, and use of an acid gas scrubber on the outlet is recommended (EPA, 1992).

For vent streams with VOC concentration below approximately 2000 ppmv, reaction rates decrease, maximum VOC destruction efficiency decreases, and an incinerator outlet VOC concentration of 20 ppmv, or lower may be achieved (EPA, 1992).

Controlled emissions and/or efficiency test data for PM in incinerators are not generally available in the literature. Emission factors for PM in phthalic anhydride processes with incinerators are available, however. The PM control efficiencies for these processes were found to vary from 79 to 96% (EPA, 1998). In EPA's 1990 National Inventory, incinerators used as control devices for PM were reported as achieving 25 to 99% control efficiency of particulate matter 10 microns or less in aerodynamic diameter (PM_{10}) at point source facilities (EPA, 1998). Table 1 presents a breakdown of the PM_{10} control efficiency ranges by industry for recuperative incinerators (EPA, 1996b). The VOC control efficiency reported for these devices ranged from 0 to 99.9%. These ranges of control efficiencies are large because they include facilities that do not have VOC emissions and control only PM, as well as facilities which have low PM emissions and are primarily concerned with controlling VOC (EPA, 1998).

Table 1. Thermal Incinerator PM_{10} Destruction Efficiencies by Industry (EPA, 1996b)

Industry/Types of Sources	PM_{10} Control Efficiency (%)
Petroleum and Coal Products asphalt roofing processes (blowing, felt saturation); mineral calcining; petroleum refinery processes (asphalt blowing, catalytic cracking, coke calcining, sludge converter); sulfur manufacturing	25 - 99.9
Chemical and Allied Products carbon black manufacturing (mfg); charcoal mfg; liquid waste disposal; miscellaneous chemical mfg processes; pesticide mfg; phthalic anhydride mfg (xylene oxidation); plastics/synthetic organic fiber mfg; solid waste incineration (industrial)	50 - 99.9
Primary Metals Industries by-product coke processes (coal unloading, oven charging and pushing, quenching); gray iron cupola and other miscellaneous processes; secondary aluminum processes (burning/drying, smelting furnace); secondary copper processes (scrap drying, scrap cupola, and miscellaneous processes); steel foundry miscellaneous processes; surface coating oven	70 - 99.9
Electronic and Other Electric Equipment chemical mfg miscellaneous processes; electrical equipment bake furnace; fixed roof tank; mineral production miscellaneous processes; secondary aluminum roll/draw extruding; solid waste incineration (industrial)	70 - 99.9
Electric, Gas, and Sanitary Services internal combustion engines; solid waste incineration (industrial, commercial/ institutional)	90 - 98
Stone, Clay, and Glass Products barium processing kiln; coal cleaning thermal dryer; fabricated plastics machinery; wool fiberglass mfg	50 - 95
Food and Kindred Products charcoal processing, miscellaneous; corn processing, miscellaneous, fugitive processing, miscellaneous; soybean processing, miscellaneous	70 - 98
Mining asphalt concrete rotary dryer; organic chemical air oxidation units, sulfur production	70 - 99.6
National Security and International Affairs solid waste incineration (commercial/institutional and municipal)	70
Textile Mill Products plastics/synthetic organic fiber (miscellaneous processes)	88 - 95
Industrial Machinery and Equipment secondary aluminum processes (burning/drying, smelt furnace)	88 -98
Lumber and Wood Products solid waste incineration (industrial)	70
Transportation Equipment solid waste incineration (industrial)	70 - 95

Applicable Source Type: Point

Typical Industrial Applications:

Thermal incinerators can be used to reduce emissions from almost all VOC sources, including reactor vents, distillation vents, solvent operations, and operations performed in ovens, dryers, and kilns. They can handle minor fluctuations in flow, however, excess fluctuations require the use of a flare (EPA, 1992). Their fuel consumption is high, so thermal units are best suited for smaller process applications with moderate-to-high VOC loadings.

Incinerators are used to control VOC from a wide variety of industrial processes, including, but not limited to the following (EPA, 1992):

- Storing and loading/unloading of petroleum products and other volatile organic liquids;
- Vessel cleaning (rail tank cars and tank trucks, barges);
- Process vents in the synthetic organic chemical manufacturing industry (SOCMI);
- Paint manufacturing;
- Rubber products and polymer manufacturing;
- Plywood manufacturing;
- Surface coating operations:
  Appliances, magnetic wire, automobiles, cans, metal coils, paper, film and foil, pressure sensitive tapes and labels, magnetic tape, fabric coating and printing, metal furniture, wood furniture, flatwood paneling, aircraft, miscellaneous metal products;
- Flexible vinyl and urethane coating;
- Graphic arts industry; and
- Hazardous waste treatment storage, and disposal facilities (TSDFs).

Emission Stream Characteristics:

a. **Air Flow:** Typical gas flow rates for thermal incinerators are 0.24 to 24 standard cubic meters per second (sm^3/sec) (500 to 50,000 standard cubic feet per minute (scfm)) (EPA, 1996a).

b. **Temperature:** Most incinerators operate at higher temperatures than the ignition temperature, which is a minimum temperature. Thermal destruction of most organic compounds occurs between 590°C and 650°C (1100°F and 1200°F). Most hazardous waste incinerators are operated at 980°C to 1200°C (1800°F to 2200°F) to ensure nearly complete destruction of the organics in the waste (AWMA, 1992).

a. **Pollutant Loading:** Thermal incinerators can be used over a fairly wide range of organic vapor concentrations. For safety considerations, the concentration of the organics in the waste gas must be substantially below the lower flammable level (lower explosive limit, or LEL) of the specific compound being controlled. As a rule, a safety factor of four (i.e., 25% of the LEL) is used (EPA, 1991, AWMA, 1992). The waste gas may be diluted with ambient air, if necessary, to lower the concentration. Considering economic factors, thermal incinerators perform best at inlet concentrations of around 1500 to 3000 ppmv, because the heat of combustion of hydrocarbon gases is sufficient to sustain the high temperatures required without addition of expensive auxiliary fuel (EPA, 1995).

d. **Other Considerations:** Incinerators are not generally recommended for controlling gases containing halogen- or sulfur-containing compounds, because of the formation of hydrogen chloride, hydrogen fluoride gas, sulfur dioxide, and other highly corrosive acid gases. It may be necessary to install a post-oxidation acid gas treatment system in such cases, depending on the outlet concentration. This would likely make incineration an uneconomical option. (EPA, 1996a). Thermal incinerators are also not generally cost-effective for low-concentration, high-flow organic vapor streams (EPA, 1995).

Emission Stream Pretreatment Requirements:

Typically, no pretreatment is required, however, in some cases, a concentrator (e.g., carbon or zeolite adsorption) may be used to reduce the total gas volume to be treated by the more expensive incinerator.

Cost Information:

The following are cost ranges (expressed in 2002 dollars) for packaged thermal incinerators of conventional design under typical operating conditions, developed using EPA cost-estimating spreadsheets (EPA, 1996a) and referenced to the volumetric flow rate of the waste stream treated. The costs do not include costs for a post-oxidation acid gas treatment system. Costs can be substantially higher than in the ranges shown when used for low to moderate VOC concentration streams (less than around 1000 to 1500 ppmv). As a rule, smaller units controlling a low concentration waste stream will be much more expensive (per unit volumetric flow rate) than a large unit cleaning a high pollutant load flow. Operating and Maintenance (O & M) Costs, Annualized Cost, and Cost Effectiveness are dominated by the cost of supplemental fuel required.

a. **Capital Cost:** \$53,000 to \$190,000 per sm^3/sec (\$25 to \$90 per scfm)

b. **O & M Cost:** \$11,000 to \$160,000 per sm^3/sec (\$5 to \$75 per scfm), annually

c. **Annualized Cost:** \$17,000 to \$208,000 per sm^3/sec (\$8 to \$98 per scfm), annually

d. **Cost Effectiveness:** \$440 to \$3,600 per metric ton (\$400 to \$3,300 per short ton), annualized cost per ton per year of pollutant controlled

Theory of Operation:

Incineration, or thermal oxidation is the process of oxidizing combustible materials by raising the temperature of the material above its auto-ignition point in the presence of oxygen, and maintaining it at high temperature for sufficient time to complete combustion to carbon dioxide and water. Time, temperature, turbulence (for mixing), and the availability of oxygen all affect the rate and efficiency of the combustion process. These factors provide the basic design parameters for VOC oxidation systems (ICAC, 1999).

A straight thermal incinerator is comprised of a combustion chamber and does not include any heat recovery of exhaust air by a heat exchanger (this type of incinerator is referred to as a recuperative incinerator).

The heart of the thermal incinerator is a nozzle-stabilized flame maintained by a combination of auxiliary fuel, waste gas compounds, and supplemental air added when necessary. Upon passing through the flame, the waste gas is heated from its preheated inlet temperature to its ignition temperature. The ignition temperature varies for different compounds and is usually determined empirically. It is the temperature at which the combustion reaction rate exceeds the rate of heat losses, thereby raising the temperature of the gases to some higher value. Thus, any organic/air mixture will ignite if its temperature is raised to a sufficiently high level (EPA, 1996a).

The required level of VOC control of the waste gas that must be achieved within the time that it spends in the thermal combustion chamber dictates the reactor temperature. The shorter the residence time, the higher the reactor temperature must be. The nominal residence time of the reacting waste gas in the combustion chamber is defined as the combustion chamber volume divided by the volumetric flow rate of the gas. Most thermal units are designed to provide no more than 1 second of residence time to the waste gas with typical temperatures of 650 to 1100°C (1200 to 2000°F). Once the unit is designed and built, the residence time is not easily changed, so that the required reaction temperature becomes a function of the particular gaseous species and the desired level of control (EPA, 1996a).

Studies based on actual field test data, show that commercial incinerators should generally be run at 870°C (1600°F) with a nominal residence time of 0.75 seconds to ensure 98% destruction of non-halogenated organics (EPA, 1992).

Advantages:

Incinerators are one of the most positive and proven methods for destroying VOC, with efficiencies up to 99.9999% possible. Thermal incinerators are often the best choice when high efficiencies are needed and the waste gas is above 20% of the LEL.

Disadvantages:

Thermal incinerator operating costs are relatively high due to supplemental fuel costs.

Thermal incinerators are not well suited to streams with highly variable flow because of the reduced residence time and poor mixing during increased flow conditions which decreases the completeness of combustion. This causes the combustion chamber temperature to fall, thus decreasing the destruction efficiency (EPA, 1991).

Incinerators, in general, are not recommended for controlling gases containing halogen- or sulfur-containing compounds because of the formation of highly corrosive acid gases. It may be necessary to install a post-oxidation acid gas treatment system in such cases, depending on the outlet concentration (EPA, 1996a). Thermal incinerators are also not generally cost-effective for low-concentration, high-flow organic vapor streams (EPA, 1995).

Other Considerations:

Thermal incinerators are not usually as economical, on an annualized basis, as recuperative or regenerative incinerators because they do not recover waste heat energy from the exhaust gases. This heat can be used to preheat incoming air, thus reducing the amount of supplemental fuel required. If there is additional heat energy available, it can be used for other process heating needs.

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1.4 Natural Gas Combustion

1.4.1 General[1-2]

Natural gas is one of the major combustion fuels used throughout the country. It is mainly used to generate industrial and utility electric power, produce industrial process steam and heat, and heat residential and commercial space. Natural gas consists of a high percentage of methane (generally above 85 percent) and varying amounts of ethane, propane, butane, and inerts (typically nitrogen, carbon dioxide, and helium). The average gross heating value of natural gas is approximately 1,020 British thermal units per standard cubic foot (Btu/scf), usually varying from 950 to 1,050 Btu/scf.

1.4.2 Firing Practices[3-5]

There are three major types of boilers used for natural gas combustion in commercial, industrial, and utility applications: watertube, firetube, and cast iron. Watertube boilers are designed to pass water through the inside of heat transfer tubes while the outside of the tubes is heated by direct contact with the hot combustion gases and through radiant heat transfer. The watertube design is the most common in utility and large industrial boilers. Watertube boilers are used for a variety of applications, ranging from providing large amounts of process steam, to providing hot water or steam for space heating, to generating high-temperature, high-pressure steam for producing electricity. Furthermore, watertube boilers can be distinguished either as field erected units or packaged units.

Field erected boilers are boilers that are constructed on site and comprise the larger sized watertube boilers. Generally, boilers with heat input levels greater than 100 MMBtu/hr, are field erected. Field erected units usually have multiple burners and, given the customized nature of their construction, also have greater operational flexibility and NO_x control options. Field erected units can also be further categorized as wall-fired or tangential-fired. Wall-fired units are characterized by multiple individual burners located on a single wall or on opposing walls of the furnace while tangential units have several rows of air and fuel nozzles located in each of the four corners of the boiler.

Package units are constructed off-site and shipped to the location where they are needed. While the heat input levels of packaged units may range up to 250 MMBtu/hr, the physical size of these units are constrained by shipping considerations and generally have heat input levels less than 100 MMBtu/hr. Packaged units are always wall-fired units with one or more individual burners. Given the size limitations imposed on packaged boilers, they have limited operational flexibility and cannot feasibly incorporate some NO_x control options.

Firetube boilers are designed such that the hot combustion gases flow through tubes, which heat the water circulating outside of the tubes. These boilers are used primarily for space heating systems, industrial process steam, and portable power boilers. Firetube boilers are almost exclusively packaged units. The two major types of firetube units are Scotch Marine boilers and the older firebox boilers. In cast iron boilers, as in firetube boilers, the hot gases are contained inside the tubes and the water being heated circulates outside the tubes. However, the units are constructed of cast iron rather than steel. Virtually all cast iron boilers are constructed as package boilers. These boilers are used to produce either low-pressure steam or hot water, and are most commonly used in small commercial applications.

Natural gas is also combusted in residential boilers and furnaces. Residential boilers and furnaces generally resemble firetube boilers with flue gas traveling through several channels or tubes with water or air circulated outside the channels or tubes.

1.4.3 Emissions[3-4]

The emissions from natural gas-fired boilers and furnaces include nitrogen oxides (NO_x), carbon monoxide (CO), and carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), volatile organic compounds (VOCs), trace amounts of sulfur dioxide (SO_2), and particulate matter (PM).

Nitrogen Oxides -

Nitrogen oxides formation occurs by three fundamentally different mechanisms. The principal mechanism of NO_x formation in natural gas combustion is thermal NO_x. The thermal NO_x mechanism occurs through the thermal dissociation and subsequent reaction of nitrogen (N_2) and oxygen (O_2) molecules in the combustion air. Most NO_x formed through the thermal NO_x mechanism occurs in the high temperature flame zone near the burners. The formation of thermal NO_x is affected by three furnace-zone factors: (1) oxygen concentration, (2) peak temperature, and (3) time of exposure at peak temperature. As these three factors increase, NO_x emission levels increase. The emission trends due to changes in these factors are fairly consistent for all types of natural gas-fired boilers and furnaces. Emission levels vary considerably with the type and size of combustor and with operating conditions (e.g., combustion air temperature, volumetric heat release rate, load, and excess oxygen level).

The second mechanism of NO_x formation, called prompt NO_x, occurs through early reactions of nitrogen molecules in the combustion air and hydrocarbon radicals from the fuel. Prompt NO_x reactions occur within the flame and are usually negligible when compared to the amount of NO_x formed through the thermal NO_x mechanism. However, prompt NO_x levels may become significant with ultra-low-NO_x burners.

The third mechanism of NO_x formation, called fuel NO_x, stems from the evolution and reaction of fuel-bound nitrogen compounds with oxygen. Due to the characteristically low fuel nitrogen content of natural gas, NO_x formation through the fuel NO_x mechanism is insignificant.

Carbon Monoxide -

The rate of CO emissions from boilers depends on the efficiency of natural gas combustion. Improperly tuned boilers and boilers operating at off-design levels decrease combustion efficiency resulting in increased CO emissions. In some cases, the addition of NO_x control systems such as low NO_x burners and flue gas recirculation (FGR) may also reduce combustion efficiency, resulting in higher CO emissions relative to uncontrolled boilers.

Volatile Organic Compounds -

The rate of VOC emissions from boilers and furnaces also depends on combustion efficiency. VOC emissions are minimized by combustion practices that promote high combustion temperatures, long residence times at those temperatures, and turbulent mixing of fuel and combustion air. Trace amounts of VOC species in the natural gas fuel (e.g., formaldehyde and benzene) may also contribute to VOC emissions if they are not completely combusted in the boiler.

Sulfur Oxides -

Emissions of SO_2 from natural gas-fired boilers are low because pipeline quality natural gas typically has sulfur levels of 2,000 grains per million cubic feet. However, sulfur-containing odorants are added to natural gas for detecting leaks, leading to small amounts of SO_2 emissions. Boilers combusting unprocessed natural gas may have higher SO_2 emissions due to higher levels of sulfur in the natural gas. For these units, a sulfur mass balance should be used to determine SO_2 emissions.

Particulate Matter -

Because natural gas is a gaseous fuel, filterable PM emissions are typically low. Particulate matter from natural gas combustion has been estimated to be less than 1 micrometer in size and has filterable and condensable fractions. Particulate matter in natural gas combustion are usually larger molecular weight hydrocarbons that are not fully combusted. Increased PM emissions may result from poor air/fuel mixing or maintenance problems.

Greenhouse Gases -[6-9]

CO_2, CH_4, and N_2O emissions are all produced during natural gas combustion. In properly tuned boilers, nearly all of the fuel carbon (99.9 percent) in natural gas is converted to CO_2 during the combustion process. This conversion is relatively independent of boiler or combustor type. Fuel carbon not converted to CO_2 results in CH_4, CO, and/or VOC emissions and is due to incomplete combustion. Even in boilers operating with poor combustion efficiency, the amount of CH_4, CO, and VOC produced is insignificant compared to CO_2 levels.

Formation of N_2O during the combustion process is affected by two furnace-zone factors. N_2O emissions are minimized when combustion temperatures are kept high (above 1475°F) and excess oxygen is kept to a minimum (less than 1 percent).

Methane emissions are highest during low-temperature combustion or incomplete combustion, such as the start-up or shut-down cycle for boilers. Typically, conditions that favor formation of N_2O also favor emissions of methane.

1.4.4 Controls[4,10]

NO_x Controls -

Currently, the two most prevalent combustion control techniques used to reduce NO_x emissions from natural gas-fired boilers are flue gas recirculation (FGR) and low NO_x burners. In an FGR system, a portion of the flue gas is recycled from the stack to the burner windbox. Upon entering the windbox, the recirculated gas is mixed with combustion air prior to being fed to the burner. The recycled flue gas consists of combustion products which act as inerts during combustion of the fuel/air mixture. The FGR system reduces NO_x emissions by two mechanisms. Primarily, the recirculated gas acts as a dilutent to reduce combustion temperatures, thus suppressing the thermal NO_x mechanism. To a lesser extent, FGR also reduces NO_x formation by lowering the oxygen concentration in the primary flame zone. The amount of recirculated flue gas is a key operating parameter influencing NO_x emission rates for these systems. An FGR system is normally used in combination with specially designed low NO_x burners capable of sustaining a stable flame with the increased inert gas flow resulting from the use of FGR. When low NO_x burners and FGR are used in combination, these techniques are capable of reducing NO_x emissions by 60 to 90 percent.

Low NO_x burners reduce NO_x by accomplishing the combustion process in stages. Staging partially delays the combustion process, resulting in a cooler flame which suppresses thermal NO_x formation. The two most common types of low NO_x burners being applied to natural gas-fired boilers are staged air burners and staged fuel burners. NO_x emission reductions of 40 to 85 percent (relative to uncontrolled emission levels) have been observed with low NO_x burners.

Other combustion control techniques used to reduce NO_x emissions include staged combustion and gas reburning. In staged combustion (e.g., burners-out-of-service and overfire air), the degree of staging is a key operating parameter influencing NO_x emission rates. Gas reburning is similar to the use of overfire in the use of combustion staging. However, gas reburning injects additional amounts of natural gas in the upper furnace, just before the overfire air ports, to provide increased reduction of NO_x to NO_2.

Two postcombustion technologies that may be applied to natural gas-fired boilers to reduce NO_x emissions are selective noncatalytic reduction (SNCR) and selective catalytic reduction (SCR). The SNCR system injects ammonia (NH_3) or urea into combustion flue gases (in a specific temperature zone) to reduce NO_x emission. The Alternative Control Techniques (ACT) document for NO_x emissions from utility boilers, maximum SNCR performance was estimated to range from 25 to 40 percent for natural gas-fired boilers.[12] Performance data available from several natural gas fired utility boilers with SNCR show a 24 percent reduction in NO_x for applications on wall-fired boilers and a 13 percent reduction in NO_x for applications on tangential-fired boilers.[11] In many situations, a boiler may have an SNCR system installed to trim NO_x emissions to meet permitted levels. In these cases, the SNCR system may not be operated to achieve maximum NO_x reduction. The SCR system involves injecting NH_3 into the flue gas in the presence of a catalyst to reduce NO_x emissions. No data were available on SCR performance on natural gas fired boilers at the time of this publication. However, the ACT Document for utility boilers estimates NO_x reduction efficiencies for SCR control ranging from 80 to 90 percent.[12]

Emission factors for natural gas combustion in boilers and furnaces are presented in Tables 1.4-1, 1.4-2, 1.4-3, and 1.4-4.[11] Tables in this section present emission factors on a volume basis (lb/10^6 scf). To convert to an energy basis (lb/MMBtu), divide by a heating value of 1,020 MMBtu/10^6 scf. For the purposes of developing emission factors, natural gas combustors have been organized into three general categories: large wall-fired boilers with greater than 100 MMBtu/hr of heat input, boilers and residential furnaces with less than 100 MMBtu/hr of heat input, and tangential-fired boilers. Boilers within these categories share the same general design and operating characteristics and hence have similar emission characteristics when combusting natural gas.

Emission factors are rated from A to E to provide the user with an indication of how “good” the factor is, with “A” being excellent and “E” being poor. The criteria that are used to determine a rating for an emission factor can be found in the Emission Factor Documentation for AP-42 Section 1.4 and in the introduction to the AP-42 document.

1.4.5 Updates Since the Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section are summarized below. For further detail, consult the Emission Factor Documentation for this section. These and other documents can be found on the Emission Factor and Inventory Group (EFIG) home page (http://www.epa.gov/ttn/chief).

Supplement D, March 1998

- Text was revised concerning Firing Practices, Emissions, and Controls.
- All emission factors were updated based on 482 data points taken from 151 source tests. Many new emission factors have been added for speciated organic compounds, including hazardous air pollutants.

July 1998 - minor changes

- Footnote D was added to table 1.4-3 to explain why the sum of individual HAP may exceed VOC or TOC, the web address was updated, and the references were reordered.

Table 1.4-1. EMISSION FACTORS FOR NITROGEN OXIDES (NO_x) AND CARBON MONOXIDE (CO) FROM NATURAL GAS COMBUSTION[a]

Combustor Type (MMBtu/hr Heat Input) [SCC]	NO_x[b]		CO	
	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
Large Wall-Fired Boilers (>100) [1-01-006-01, 1-02-006-01, 1-03-006-01]				
Uncontrolled (Pre-NSPS)[c]	280	A	84	B
Uncontrolled (Post-NSPS)[c]	190	A	84	B
Controlled - Low NO_x burners	140	A	84	B
Controlled - Flue gas recirculation	100	D	84	B
Small Boilers (<100) [1-01-006-02, 1-02-006-02, 1-03-006-02, 1-03-006-03]				
Uncontrolled	100	B	84	B
Controlled - Low NO_x burners	50	D	84	B
Controlled - Low NO_x burners/Flue gas recirculation	32	C	84	B
Tangential-Fired Boilers (All Sizes) [1-01-006-04]				
Uncontrolled	170	A	24	C
Controlled - Flue gas recirculation	76	D	98	D
Residential Furnaces (<0.3) [No SCC]				
Uncontrolled	94	B	40	B

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. Emission factors are based on an average natural gas higher heating value of 1,020 Btu/scf. To convert from $1b/10^6$ scf to lb/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Expressed as NO_2. For large and small wall fired boilers with SNCR control, apply a 24 percent reduction to the appropriate NO_X emission factor. For tangential-fired boilers with SNCR control, apply a 13 percent reduction to the appropriate NO_X emission factor.

[c] NSPS=New Source Performance Standard as defined in 40 CFR 60 Subparts D and Db. Post-NSPS units are boilers with greater than 250 MMBtu/hr of heat input that commenced construction modification, or reconstruction after August 17, 1971, and units with heat input capacities between 100 and 250 MMBtu/hr that commenced construction modification, or reconstruction after June 19, 1984.

TABLE 1.4-2. EMISSION FACTORS FOR CRITERIA POLLUTANTS AND GREENHOUSE GASES FROM NATURAL GAS COMBUSTION[a]

Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
CO_2[b]	120,000	A
Lead	0.0005	D
N_2O (Uncontrolled)	2.2	E
N_2O (Controlled-low-NO_X burner)	0.64	E
PM (Total)[c]	7.6	D
PM (Condensable)[c]	5.7	D
PM (Filterable)[c]	1.9	B
SO_2[d]	0.6	A
TOC	11	B
Methane	2.3	B
VOC	5.5	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. TOC = Total Organic Compounds. VOC = Volatile Organic Compounds.

[b] Based on approximately 100% conversion of fuel carbon to CO_2. $CO_2[lb/10^6 \text{ scf}] = (3.67)(CON)(C)(D)$, where CON = fractional conversion of fuel carbon to CO_2, C = carbon content of fuel by weight (0.76), and D = density of fuel, $4.2x10^4$ $lb/10^6$ scf.

[c] All PM (total, condensible, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the PM emission factors presented here may be used to estimate PM_{10}, $PM_{2.5}$ or PM_1 emissions. Total PM is the sum of the filterable PM and condensible PM. Condensible PM is the particulate matter collected using EPA Method 202 (or equivalent). Filterable PM is the particulate matter collected on, or prior to, the filter of an EPA Method 5 (or equivalent) sampling train.

[d] Based on 100% conversion of fuel sulfur to SO_2.
Assumes sulfur content is natural gas of 2,000 grains/10^6 scf. The SO_2 emission factor in this table can be converted to other natural gas sulfur contents by multiplying the SO_2 emission factor by the ratio of the site-specific sulfur content (grains/10^6 scf) to 2,000 grains/10^6 scf.

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor (lb/10^6 scf)	Emission Factor Rating
91-57-6	2-Methylnaphthalene[b, c]	2.4E-05	D
56-49-5	3-Methylcholanthrene[b, c]	<1.8E-06	E
	7,12-Dimethylbenz(a)anthracene[b,c]	<1.6E-05	E
83-32-9	Acenaphthene[b,c]	<1.8E-06	E
203-96-8	Acenaphthylene[b,c]	<1.8E-06	E
120-12-7	Anthracene[b,c]	<2.4E-06	E
56-55-3	Benz(a)anthracene[b,c]	<1.8E-06	E
71-43-2	Benzene[b]	2.1E-03	B
50-32-8	Benzo(a)pyrene[b,c]	<1.2E-06	E
205-99-2	Benzo(b)fluoranthene[b,c]	<1.8E-06	E
191-24-2	Benzo(g,h,i)perylene[b,c]	<1.2E-06	E
207-08-9	Benzo(k)fluoranthene[b,c]	<1.8E-06	E
106-97-8	Butane	2.1E+00	E
218-01-9	Chrysene[b,c]	<1.8E-06	E
53-70-3	Dibenzo(a,h)anthracene[b,c]	<1.2E-06	E
25321-22-6	Dichlorobenzene[b]	1.2E-03	E
74-84-0	Ethane	3.1E+00	E
206-44-0	Fluoranthene[b,c]	3.0E-06	E
86-73-7	Fluorene[b,c]	2.8E-06	E
50-00-0	Formaldehyde[b]	7.5E-02	B
110-54-3	Hexane[b]	1.8E+00	E
193-39-5	Indeno(1,2,3-cd)pyrene[b,c]	<1.8E-06	E
91-20-3	Naphthalene[b]	6.1E-04	E
109-66-0	Pentane	2.6E+00	E
85-01-8	Phenanathrene[b,c]	1.7E-05	D
74-98-6	Propane	1.6E+00	E

TABLE 1.4-3. EMISSION FACTORS FOR SPECIATED ORGANIC COMPOUNDS FROM NATURAL GAS COMBUSTION (Continued)

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
129-00-0	Pyrene[b, c]	5.0E-06	E
108-88-3	Toluene[b]	3.4E-03	C

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by 16. To convert from $1b/10^6$ scf to lb/MMBtu, divide by 1,020. Emission Factors preceeded with a less-than symbol are based on method detection limits.

[b] Hazardous Air Pollutant (HAP) as defined by Section 112(b) of the Clean Air Act.

[c] HAP because it is Polycyclic Organic Matter (POM). POM is a HAP as defined by Section 112(b) of the Clean Air Act.

[d] The sum of individual organic compounds may exceed the VOC and TOC emission factors due to differences in test methods and the availability of test data for each pollutant.

TABLE 1.4-4. EMISSION FACTORS FOR METALS FROM NATURAL GAS COMBUSTION[a]

CAS No.	Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
7440-38-2	Arsenic[b]	2.0E-04	E
7440-39-3	Barium	4.4E-03	D
7440-41-7	Beryllium[b]	<1.2E-05	E
7440-43-9	Cadmium[b]	1.1E-03	D
7440-47-3	Chromium[b]	1.4E-03	D
7440-48-4	Cobalt[b]	8.4E-05	D
7440-50-8	Copper	8.5E-04	C
7439-96-5	Manganese[b]	3.8E-04	D
7439-97-6	Mercury[b]	2.6E-04	D
7439-98-7	Molybdenum	1.1E-03	D
7440-02-0	Nickel[b]	2.1E-03	C
7782-49-2	Selenium[b]	<2.4E-05	E
7440-62-2	Vanadium	2.3E-03	D
7440-66-6	Zinc	2.9E-02	E

[a] Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. Emission factors preceeded by a less-than symbol are based on method detection limits. To convert from $lb/10^6$ scf to $kg/10^6$ m^3, multiply by l6. To convert from $lb/10^6$ scf to 1b/MMBtu, divide by 1,020.

[b] Hazardous Air Pollutant as defined by Section 112(b) of the Clean Air Act.

References For Section 1.4

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5. J. L. Muhlbaier, "Particulate and Gaseous Emissions From Natural Gas Furnaces and Water Heaters", *Journal Of The Air Pollution Control Association*, December 1981.

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8. S. D. Piccot, *et al.*, *Emissions and Cost Estimates For Globally Significant Anthropogenic Combustion Sources Of* NO_x*,* N_2O*,* CH_4*, CO, and* CO_2*,* EPA Contract No. 68-02-4288, Research Triangle Park, NC: Radian Corporation, 1990.

9. *Sector-Specific Issues and Reporting Methodologies Supporting the General Guidelines for the Voluntary Reporting of Greenhouse Gases under Section 1605(b) of the Energy Policy Act of 1992* (1994) DOE/PO-0028, Volume 2 of 3, U.S. Department of Energy.

10. J. P. Kesselring and W. V. Krill, "A Low-NO_x Burner For Gas-Fired Firetube Boilers", *Proceedings: 1985 Symposium On Stationary Combustion* NO_x *Control, Volume 2*, EPRI CS-4360, Electric Power Research Institute, Palo Alto, CA, January 1986.

11. *Emission Factor Documentation for AP-42 Section 1.4—Natural Gas Combustion*, Technical Support Division, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, 1997.

12. *Alternate Control Techniques Document -* NO_x *Emissions from Utility Boilers*, EPA-453/R-94-023, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1994.

MATERIAL MASS BALANCE EAFD

SYSTEM INPUTS							
EAFD	1.240	T/hr	29.8	T/day	9969.6	T/year	78.5%
Additives	0.340	T/hr	8.2	T/day	2733.6	T/year	21.5%
Water to Pelletizing	0.320	T/hr	7.7	T/day	2572.8	T/year	16.8%
Water in brine disposal	0.110	T/hr	2.6	T/day	883.7	T/year	
Water in Zinc filter cake	0.117	T/hr	2.8	T/day	939.4	T/year	
Total Water Consumption	0.547	T/hr	10.32	T/day	3456.47	T/year	
Total Input	2.127	T/hr	48.24	T/day	16159.67	T/year	
SYSTEM OUTPUTS - Production Rate							
Raw Zinc	0.248	T/hr	6.0	T/day	1993.9	T/year	20%
Zinc Product after Drying	0.236	T/hr	5.7	T/day	1896.4	T/year	19.0%
Slag	0.950	T/hr	22.8	T/day	7638.0	T/year	76.6%
Disposal of brine solution	0.141	T/hr	3.4	T/day	1132.9	T/year	22.0%
Salts	0.031	T/hr	0.7	T/day	249.2	T/year	13%
Output	1.61	T/hr	38.54	T/day	12910.46	T/year	

Notes:

Plant operation days/year	335		
	24		
Raw Zinc Concentration in EAFD	20%		
Salts in EAFD	2.5%		
Salt in Raw Zinc	12.5%		
Water in brine solution to disposal	78%		
Salt in brine solution to disposal	22%		
Moisture in Zinc Product	8%		
Salt in water to osmosis	4.1%	First wash	
Concentrated solution to osmosis	0.75	T/hr	From first wash
Amount of clean water from Osmosis	0.64	T/hr	
Amount of water disposed	0.110	T/hr	
% of water to be recycled	85%		
Moisture in zinc filter cake	35%		
Zinc product no moisture	0.217	T/hr	
Raw Zinc Slurry in Zinc Mixer	25%		
Amount of warm water to Zinc Mixer	0.744	T/hr	
Amount of water to wash filter cake	0.351	T/hr	
Washing filter cake	3	times	
Total Amount of water to be heated.	1094.5	kg/hr	

APPENDIX 4

DISPERSION MODELLING AND ZONING INFORMATION

Conservative Factor Dispersion Modelling

Distance From Source (m)	Urban Dispersion Factor ($\mu g/m^3$ per g/s)	Rural Dispersion Factor ($\mu g/m^3$ per g/s)
20	8700	10000
40	6300	8100
60	4600	5900
80	3400	5100
100	2600	4500
150	1400	3500
200	900	2800
250	600	2300
300	450	1900
350	350	1700
400	300	1500
450	250	1300
500	200	1150
600	150	950
700	120	800
800	90	650
900	80	575
1000	70	500

3.5 m

Factor		
Hourly	10,000.0	$\mu g/m^3$ per g/s emission
24-Hour	4,107.2	$\mu g/m^3$ per g/s emission
10 Minute	16,505.9	$\mu g/m^3$ per g/s emission
1/2-Hour	12,141.9	$\mu g/m^3$ per g/s emission
30-day	1,584.7	$\mu g/m^3$ per g/s emission
Annual	787.2	$\mu g/m^3$ per g/s emission

Contaminant	CAS	POI Limit (µg/m^3)	Limiting Effect	Averaging Period (Hours)	Limit Source	50% POI Limit (µg/m^3)	Calculated Emission Threshold (g/s)	Facility Emission Rate (g/s)	Significance (Er>Et)	Modelling Required?
Aluminum	7429-90-5	12	Health	24	SL-JSL	6	1.46E-03	1.21E-07	Insig.	No
Aluminum oxide	1344-28-1	120	Particulate	24	Guideline	60	1.46E-02	9.94E-04	Insig.	No
Antimony	7440-36-0	25	Health	24	Standard	12.5	3.04E-03	1.33E-07	Insig.	No
Arsenic and compounds	7440-38-2	0.3	Health	24	Guideline	0.15	3.65E-05	3.36E-08	Insig.	No
Barium	7440-39-3	10	Health	24	Guideline	5	1.22E-03	2.58E-08	Insig.	No
Boron	7440-42-8	120	Particulate	24	Standard	60	1.46E-02	2.19E-08	Insig.	No
Cadmium and compounds	7440-43-9	0.025	Health	24	Standard	0.0125	3.04E-06	9.53E-05	Sig.	Yes
Calcium oxide	1305-78-8	10	Corrosion	24	Standard	5	1.22E-03	7.96E-03	Sig.	Yes
Carbon	7440-44-0	1.75	Health	24	SL-JSL	0.875	2.13E-04	2.53E-03	Sig.	Yes
Carbon monoxide	630-08-0	6000	Health	0.5	Standard	3000	2.47E-01	1.31E-01	Insig.	No
Chlorine	7782-50-5	10	Health	24	Standard	5	1.22E-03	1.19E-03	Insig.	No
	7782-50-5	230	Odour	0.167	Guideline	115	6.97E-03	1.19E-03	Insig.	No
Chromium compounds (di, tri, metallic)	7440-47-3	0.5	Health	24	Standard	0.25	6.09E-05	1.64E-04	Sig.	Yes
Copper	7440-50-8	50	Health	24	Standard	25	6.09E-03	9.85E-05	Insig.	No
Ferric oxide	1309-37-1	25	Soiling	24	Standard	12.5	3.04E-03	2.24E-02	Sig.	Yes
Lead and compounds	7439-92-1	0.5	Health	24	Standard	0.25	6.09E-05	1.02E-03	Sig.	Yes
	7439-92-1	0.2	Health	720	Standard	0.1	6.31E-05	1.02E-03	Sig.	Yes
Magnesium oxide	1309-48-4	120	Particulate	24	Standard	60	1.46E-02	3.00E-03	Insig.	No
Manganese and compounds	7439-96-5	0.4	Health	24	Standard	0.2	4.87E-05	1.64E-03	Sig.	Yes
Mercury	7439-97-6	2	Health	24	Standard	1	2.43E-04	4.53E-08	Insig.	No
Molybdenum	7439-98-7	120	Particulate	24	Guideline	60	1.46E-02	3.12E-08	Insig.	No
Nickel and compounds	7440-02-0	0.04	Health	8760	Standard	0.02	2.54E-05	2.71E-05	Sig.	Yes
Nitrogen oxides	10102-44-0	200	Health	24	Standard	100	2.43E-02	2.40E-01	Sig.	Yes
	10102-44-0	400	Health	1	Standard	200	2.00E-02	2.40E-01	Sig.	Yes
Phosphorus	7723-14-0	0.5	Health	24	SL-MD	0.25	6.09E-05	2.23E-08	Insig.	No
Phosphorus pentoxide	1314-56-3	1	Health	24	SL-JSL	0.5	1.22E-04	8.70E-05	Insig.	No
Potassium	7440-09-7	1	Health	24	SL-JSL	0.5	1.22E-04	4.03E-04	Sig.	Yes
Selenium	7782-49-2	10	Health	24	Guideline	5	1.22E-03	4.14E-08	Insig.	No
Silicon dioxide	7631-86-9	5	Health	24	SL-MD	2.5	6.09E-04	4.07E-03	Sig.	Yes
Silver	7440-22-4	1	Health	24	Standard	0.5	1.22E-04	2.27E-07	Insig.	No
Sodium (as Sodium monoxide)	12401-86-4	0.5	Health	24	SL-JSL	0.25	6.09E-05	6.45E-04	Sig.	Yes
Sodium sulfate	7757-82-6	15	Health & Particulate	24	SL-JSL	7.5	1.83E-03	3.05E-05	Insig.	No
Sulfur	7704-34-9	2.5	Health	24	SL-JSL	1.25	3.04E-04	3.88E-04	Sig.	Yes
Sulphur Dioxide	7446-09-5	275	Health & Vegetation	24	Standard	137.5	3.35E-02	6.42E-03	Sig.	Yes
	7446-09-5	690	Health & Vegetation	1	Standard	345	3.45E-02	6.42E-03	Sig.	Yes
	7446-09-5	10	Vegetation	8760	Standard - 2023	5	6.35E-03	6.42E-03	Sig.	Yes
	7446-09-5	100	Health	1	Standard - 2023	50	5.00E-03	6.42E-03	Sig.	Yes
Suspended particulate matter	N/A(9)	120	Visibility	24	Standard	60	1.46E-02	5.55E-02	Sig.	Yes
Tin	7440-31-5	10	Health	24	Standard	5	1.22E-03	7.97E-07	Insig.	No
Titanium	7440-32-6	120	Particulate	24	Standard	60	1.46E-02	7.08E-09	Insig.	No
Titanium dioxide	13463-67-7	34	Health	24	Guideline	17	4.14E-03	9.18E-05	Insig.	No
Vanadium	7440-62-2	2	Health	24	Standard	1	2.43E-04	4.35E-05	Insig.	No
Zinc	7440-66-6	120	Particulate	24	Standard	60	1.46E-02	1.55E-02	Sig.	Yes

Results Summary

GFL Environmental Services Inc.
237 Brant Street Facility

Cadmium and compounds - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.04275	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.02362	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.00863	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.00631	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Calcium oxide - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	5.45770	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/3/1996, 20
24-HR	1ST	2.55130	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.91938	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.66494	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Carbon - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	2.40502	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	7/16/1997, 4
24-HR	1ST	0.94148	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	11/10/1996, 24
MONTH	1ST	0.29638	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.20233	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Results Summary

GFL Environmental Services Inc.
237 Brant Street Facility

Chromium compounds (di, tri, metallic) - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.07389	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.04054	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.01476	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.01078	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Ferric oxide - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	10.07041	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	5.52392	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	2.01120	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		1.46925	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Lead and compounds - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.45140	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.26251	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.09842	ug/m^3	594657.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.07222	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Results Summary

GFL Environmental Services Inc.
237 Brant Street Facility

Manganese and compounds - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.73387		594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.40664		594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.14877		594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.10882		594677.31	4790795.05	80.00	0.00	80.00	

Manganese and compounds - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.73366	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.40654	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.14873	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	7/31/1998, 24
ANNUAL		0.10879	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Nickel and compounds - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.01219	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.00669	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.00244	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.00178	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Results Summary

GFL Environmental Services Inc.
237 Brant Street Facility

Nitrogen oxides - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	104.39174	ug/m^3	594601.31	4790818.88	80.00	0.00	80.00	8/14/1996, 8
24-HR	1ST	65.34375	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	30.42302	ug/m^3	594657.31	4790795.05	80.00	0.00	80.00	
ANNUAL		23.03130	ug/m^3	594657.31	4790795.05	80.00	0.00	80.00	

Potassium - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.18130	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.09964	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.03631	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.02653	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Silicon dioxide - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	1.82765	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	1.00244	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.36499	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.26663	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Results Summary

GFL Environmental Services Inc.
237 Brant Street Facility

Sodium (as Sodium monoxide) - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.28990	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.15928	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.05804	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.04241	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Sulfur - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.18049	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	0.09839	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	0.03532	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.02586	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Sulphur dioxide - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	2.64222		594697.31	4790795.05	80.00	0.00	80.00	7/20/1998, 8
24-HR	1ST	1.47894		594677.31	4790795.05	80.00	0.00	80.00	12/2/1997, 24
MONTH	1ST	0.52075		594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		0.38182		594677.31	4790795.05	80.00	0.00	80.00	

Results Summary

GFL Environmental Services Inc.
237 Brant Street Facility

Suspended particulate matter - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	27.04321	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	14.71467	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	5.31287	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		3.89632	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

Zinc - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	6.94710	ug/m^3	594697.31	4790795.05	80.00	0.00	80.00	8/23/1996, 6
24-HR	1ST	3.92659	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	2/21/1998, 24
MONTH	1ST	1.45001	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	
ANNUAL		1.06304	ug/m^3	594677.31	4790795.05	80.00	0.00	80.00	

*** THE MAXIMUM 100 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
Manganese and Manganese Compounds

RANK BY YEAR	YEAR	RANK	CONC	YYYYMMDDHH	XR	YR	TYPE	Ontario Reg. 419/05
1	1998	1	0.40654	1998022124	594677.3	4790795	DC	Discarded
1	1997	2	0.3978	1997120224	594677.3	4790795	DC	Discarded
1	2000	3	0.38078	2000071624	594677.3	4790795	DC	Discarded
1	1996	4	0.36093	1996082324	594677.3	4790795	DC	Discarded
2	**1998**	**5**	**0.35872**	**1998012424**	**594677.3**	**4790795**	**DC**	**Highest**
2	1997	6	0.35763	1997042524	594677.3	4790795	DC	
2	1996	7	0.35763	1996111924	594677.3	4790795	DC	
2	2000	8	0.35601	2000030324	594677.3	4790795	DC	
3	2000	9	0.35341	2000100924	594697.3	4790795	DC	
3	1996	10	0.35297	1996081624	594677.3	4790795	DC	
3	1997	11	0.35264	1997120724	594677.3	4790795	DC	
4	2000	12	0.35067	2000100924	594677.3	4790795	DC	
4	1997	13	0.35028	1997091324	594677.3	4790795	DC	
3	1998	14	0.3494	1998021924	594677.3	4790795	DC	
4	1998	15	0.34732	1998091024	594677.3	4790795	DC	
5	1997	16	0.34606	1997020124	594677.3	4790795	DC	
6	1997	17	0.34265	1997120724	594697.3	4790795	DC	
5	1998	18	0.34154	1998121724	594677.3	4790795	DC	
1	1999	19	0.33694	1999052724	594677.3	4790795	DC	Discarded
6	1998	20	0.33448	1998040624	594677.3	4790795	DC	
7	1998	21	0.334	1998030424	594677.3	4790795	DC	
7	1997	22	0.333	1997122324	594697.3	4790795	DC	
8	1998	23	0.33224	1998021924	594697.3	4790795	DC	
8	1997	24	0.33075	1997020124	594697.3	4790795	DC	
4	1996	25	0.33071	1996061524	594677.3	4790775	DC	
2	1999	26	0.32879	1999110724	594677.3	4790795	DC	
5	1996	27	0.32726	1996111924	594697.3	4790795	DC	
9	1998	28	0.32456	1998022424	594677.3	4790775	DC	
9	1997	29	0.3235	1997052224	594677.3	4790795	DC	
10	1998	30	0.32293	1998052624	594677.3	4790795	DC	
6	1996	31	0.3221	1996061424	594677.3	4790795	DC	
10	1997	32	0.32178	1997050724	594677.3	4790795	DC	
5	2000	33	0.32149	2000100324	594677.3	4790795	DC	
7	1996	34	0.32143	1996111024	594697.3	4790795	DC	
6	2000	35	0.31977	2000071024	594677.3	4790795	DC	
11	1998	36	0.31939	1998110624	594702.5	4790811	DC	
12	1998	37	0.31912	1998061724	594677.3	4790795	DC	
11	1997	38	0.31779	1997121724	594697.3	4790795	DC	
12	1997	39	0.31755	1997020724	594677.3	4790795	DC	
13	1997	40	0.31742	1997042624	594677.3	4790795	DC	
8	1996	41	0.31703	1996112024	594677.3	4790795	DC	
13	1998	42	0.31673	1998022024	594677.3	4790795	DC	

*** THE MAXIMUM 100 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
Manganese and Manganese Compounds

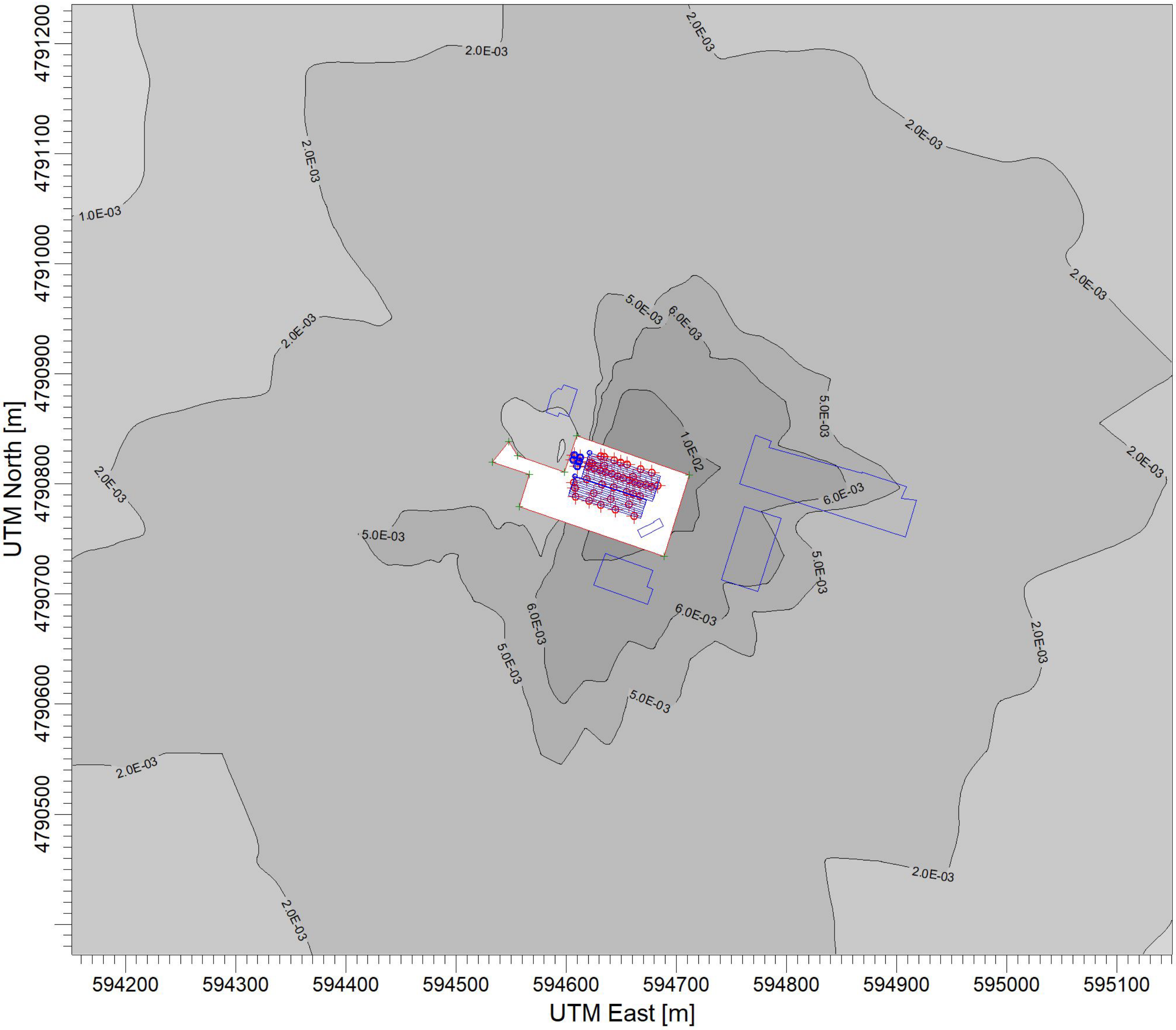
RANK BY YEAR	YEAR	RANK	CONC	YYYYMMDDHH	XR	YR	TYPE	Ontario Reg. 419/05
3	1999	43	0.31568	1999032924	594677.3	4790795	DC	
14	1997	44	0.31504	1997082324	594677.3	4790795	DC	
15	1997	45	0.31502	1997121724	594702.5	4790811	DC	
14	1998	46	0.31442	1998091024	594697.3	4790795	DC	
9	1996	47	0.31358	1996072624	594677.3	4790775	DC	
7	2000	48	0.31254	2000081024	594677.3	4790795	DC	
8	2000	49	0.3123	2000033024	594677.3	4790795	DC	
10	1996	50	0.31191	1996091524	594693.2	4790815	DC	
11	1996	51	0.31153	1996071024	594677.3	4790795	DC	
16	1997	52	0.31014	1997061024	594677.3	4790795	DC	
15	1998	53	0.30844	1998110624	594693.2	4790815	DC	
12	1996	54	0.30808	1996080124	594677.3	4790795	DC	
4	1999	55	0.30791	1999080224	594677.3	4790775	DC	
16	1998	56	0.30712	1998110724	594677.3	4790795	DC	
13	1996	57	0.30661	1996091524	594697.3	4790815	DC	
17	1997	58	0.30609	1997052024	594677.3	4790795	DC	
14	1996	59	0.30411	1996111024	594677.3	4790795	DC	
17	1998	60	0.30388	1998013024	594677.3	4790775	DC	
15	1996	61	0.30385	1996121324	594677.3	4790795	DC	
16	1996	62	0.30381	1996071624	594677.3	4790815	DC	
17	1996	63	0.30349	1996091524	594677.3	4790815	DC	
18	1998	64	0.30278	1998112624	594677.3	4790795	DC	
18	1996	65	0.30265	1996051224	594677.3	4790795	DC	
19	1998	66	0.30199	1998060624	594677.3	4790795	DC	
20	1998	67	0.30187	1998110624	594697.3	4790815	DC	
9	2000	68	0.30152	2000072124	594677.3	4790795	DC	
19	1996	69	0.3011	1996110824	594677.3	4790795	DC	
10	2000	70	0.30011	2000101024	594702.5	4790811	DC	
11	2000	71	0.30006	2000123124	594677.3	4790775	DC	
20	1996	72	0.29963	1996091524	594683.9	4790818	DC	
21	1998	73	0.29922	1998070124	594677.3	4790795	DC	
22	1998	74	0.29908	1998030424	594697.3	4790795	DC	
23	1998	75	0.29906	1998012424	594697.3	4790795	DC	
21	1996	76	0.29874	1996091024	594677.3	4790775	DC	
22	1996	77	0.298	1996111824	594677.3	4790795	DC	
23	1996	78	0.29764	1996071024	594697.3	4790795	DC	
12	2000	79	0.29728	2000072224	594677.3	4790795	DC	
13	2000	80	0.29676	2000030324	594697.3	4790795	DC	
24	1996	81	0.29672	1996070924	594677.3	4790795	DC	
25	1996	82	0.29671	1996051324	594677.3	4790795	DC	
26	1996	83	0.29654	1996120924	594677.3	4790795	DC	
18	1997	84	0.29528	1997042524	594657.3	4790795	DC	

*** THE MAXIMUM 100 24-HR AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
Manganese and Manganese Compounds

RANK BY YEAR	YEAR	RANK	CONC	YYYYMMDDHH	XR	YR	TYPE	Ontario Reg. 419/05
27	1996	85	0.2948	1996071624	594683.9	4790818	DC	
24	1998	86	0.29458	1998041724	594677.3	4790795	DC	
19	1997	87	0.29443	1997041924	594677.3	4790795	DC	
28	1996	88	0.29337	1996061524	594657.3	4790795	DC	
20	1997	89	0.29299	1997122324	594677.3	4790795	DC	
14	2000	90	0.29297	2000070424	594677.3	4790775	DC	
15	2000	91	0.29278	2000091524	594677.3	4790795	DC	
25	1998	92	0.29272	1998091224	594677.3	4790795	DC	
26	1998	93	0.29266	1998041724	594697.3	4790795	DC	
5	1999	94	0.29221	1999041424	594677.3	4790795	DC	
21	1997	95	0.29159	1997042524	594677.3	4790775	DC	
16	2000	96	0.29129	2000101824	594677.3	4790795	DC	
22	1997	97	0.29122	1997041724	594677.3	4790775	DC	
27	1998	98	0.29089	1998042024	594677.3	4790795	DC	
17	2000	99	0.29071	2000101924	594677.3	4790795	DC	
6	1999	100	0.29052	1999032924	594697.3	4790795	DC	

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 2.4E-02 [ug/m^3] at (594677.31, 4790795.05)

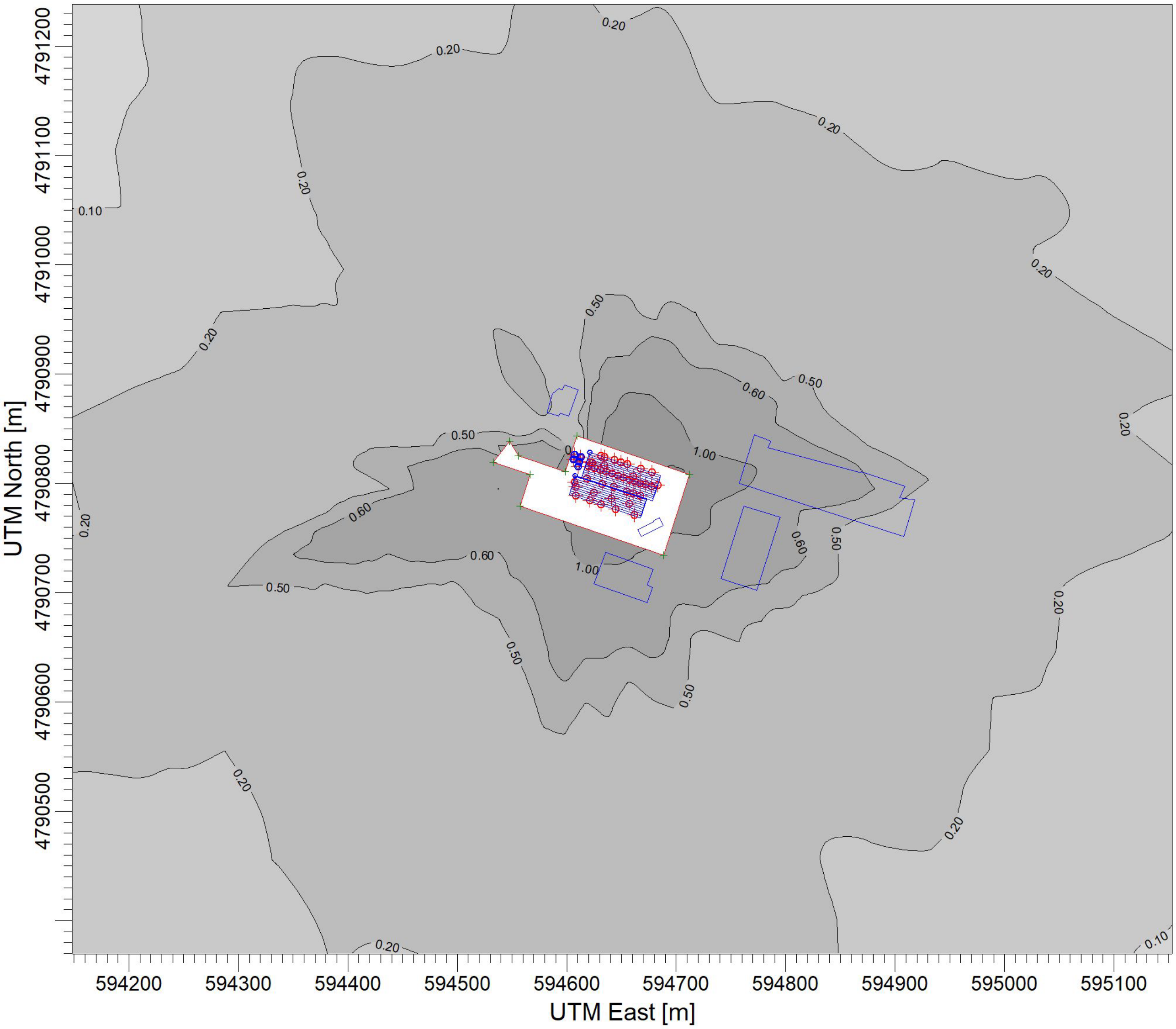
2.3E-04	5.0E-04	6.0E-04	1.0E-03	2.0E-03	5.0E-03	6.0E-03	1.0E-02	2.0E-02	2.4E-02

COMMENTS: Cadmium	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	O2E Inc. ENVIRONMENTAL CONSULTANTS
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,280 0 — 0.2 km	
	MAX: **2.4E-02 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

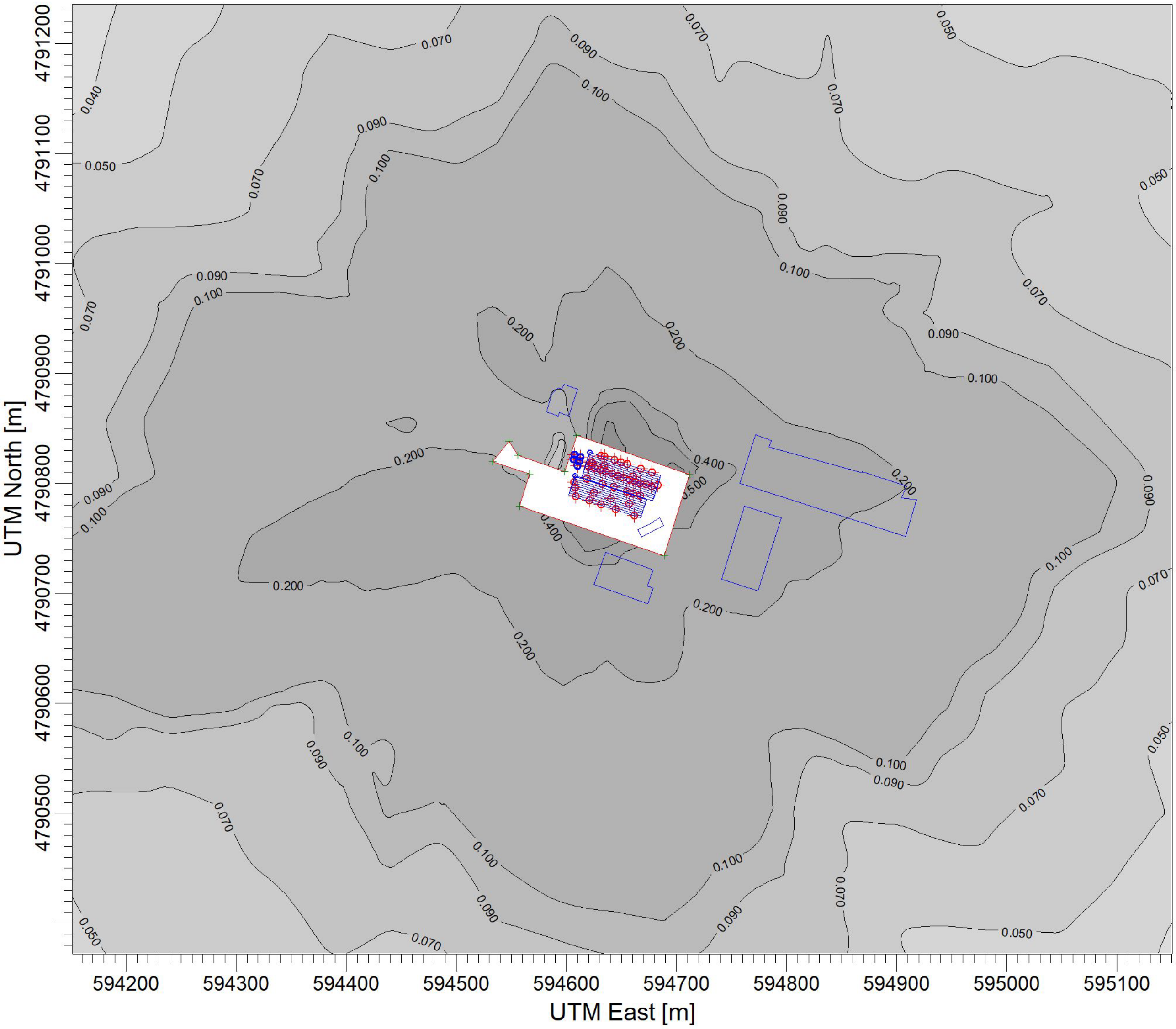
Max: 2.55 [ug/m^3] at (594677.31, 4790795.05)

0.03	0.05	0.06	0.10	0.20	0.50	0.60	1.00	2.00	2.55

COMMENTS: Calcium Oxide	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,319 0 0.2 km	
	MAX: **2.55 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 0.941 [ug/m^3] at (594697.31, 4790795.05)

0.009 0.010 0.020 0.040 0.050 0.070 0.090 0.100 0.200 0.400 0.500 0.700 0.900 0.941

COMMENTS:
Carbon

SOURCES:
46

COMPANY NAME:
O2E Inc.

RECEPTORS:
2420

MODELER:
TML

OUTPUT TYPE:
Concentration

SCALE:
1:6,281
0 0.2 km

o2e Inc.
ENVIRONMENTAL CONSULTANTS

MAX:
0.941 ug/m^3

DATE:
10/12/2022

PROJECT NO.:
22-024

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility

PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 4.1E-02 [ug/m^3] at (594677.31, 4790795.05)

4.0E-04 5.0E-04 8.0E-04 1.0E-03 3.0E-03 5.0E-03 6.0E-03 8.0E-03 1.0E-02 4.0E-02 4.1E-02

COMMENTS:

Chromium compounds (di, tri, metallic)

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

O2E Inc. ENVIRONMENTAL CONSULTANTS

OUTPUT TYPE:

Concentration

SCALE: 1:6,280

0 0.2 km

MAX:

4.1E-02 ug/m^3

DATE:

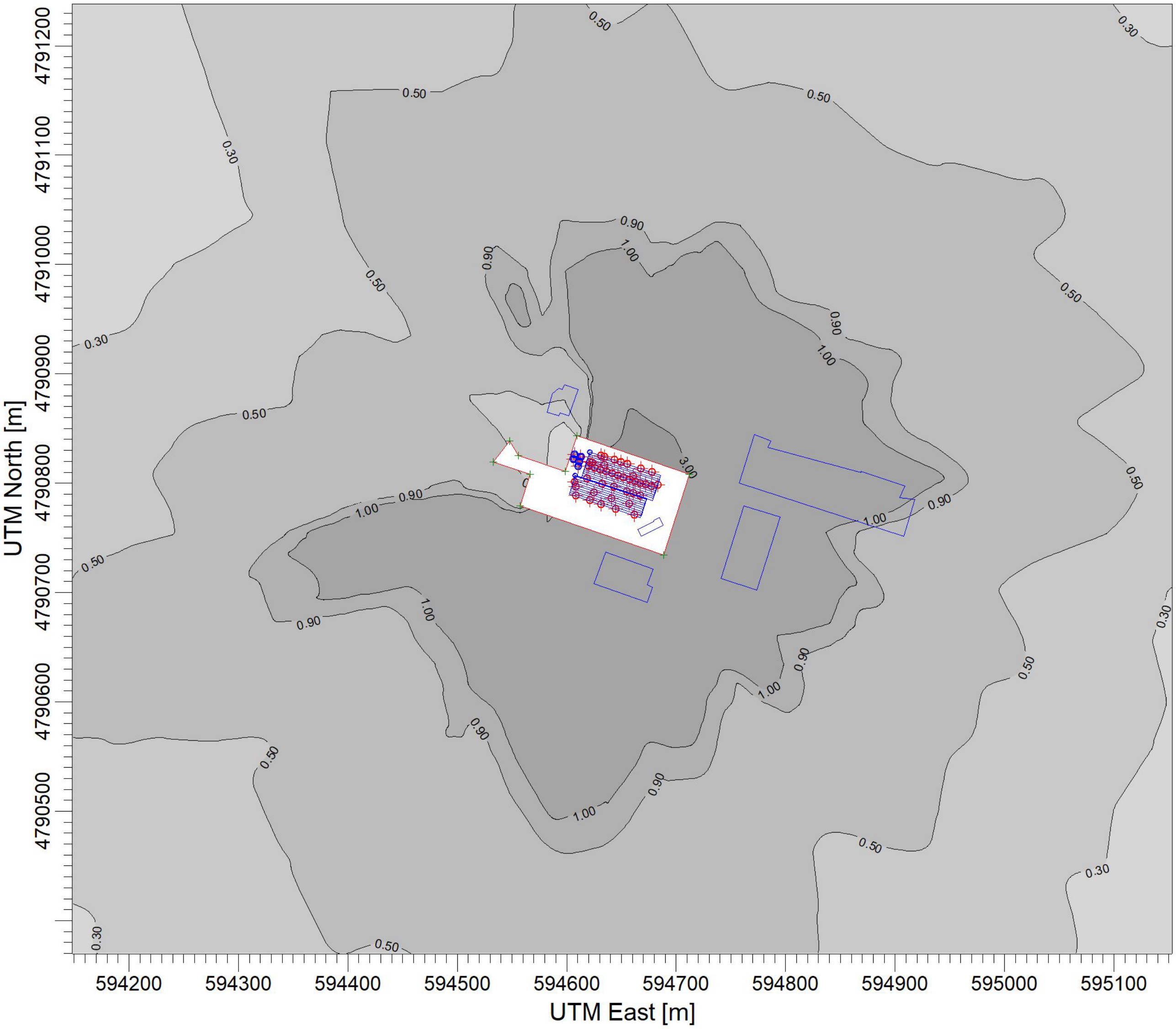
10/12/2022

PROJECT NO.:

22-024

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 5.52 [ug/m^3] at (594677.31, 4790795.05)

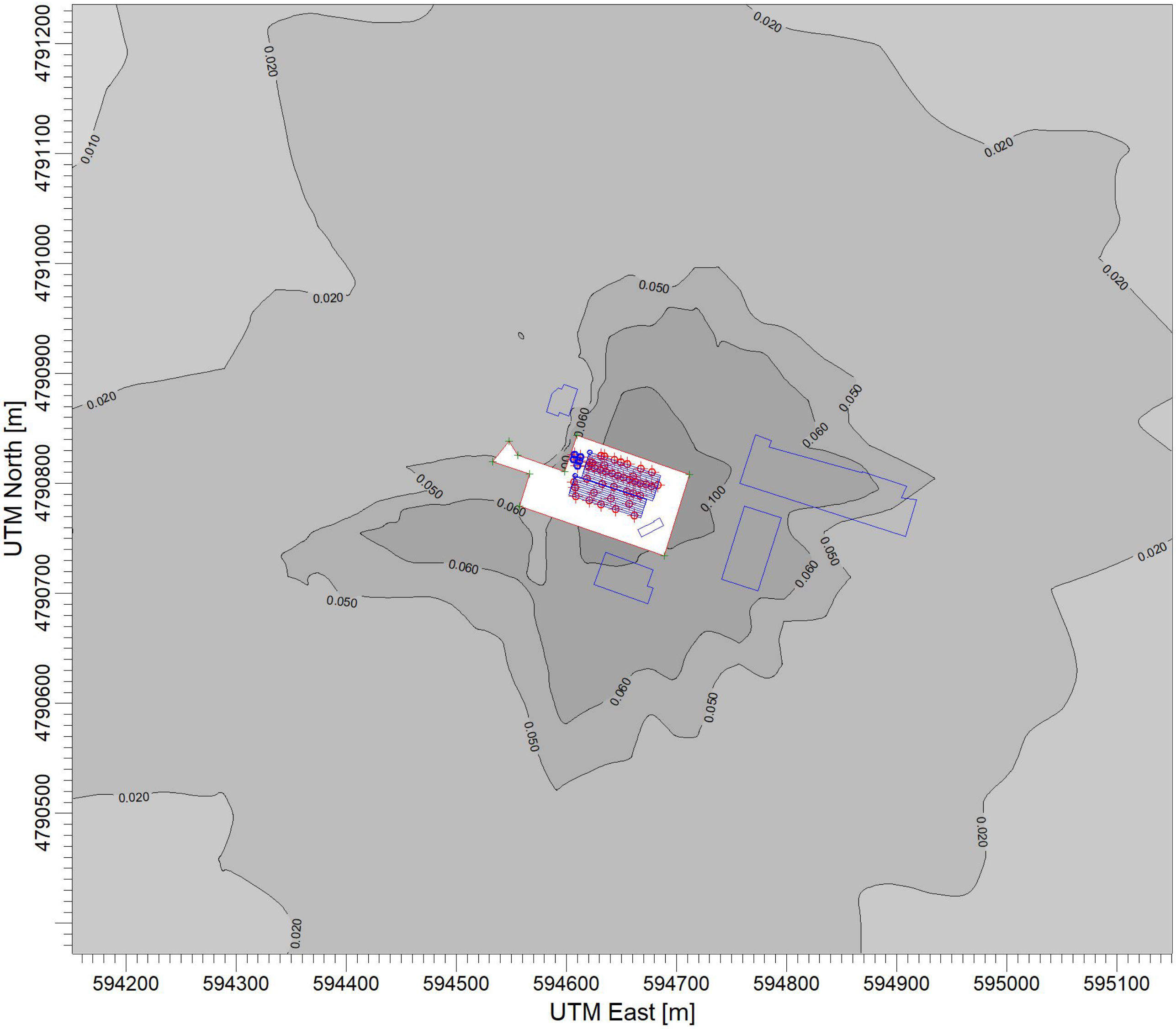
0.06 0.09 0.10 0.30 0.50 0.90 1.00 3.00 5.00 5.52

COMMENTS: Ferric Oxide	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,319 0 0.2 km	
	MAX: **5.52 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 0.263 [ug/m^3] at (594677.31, 4790795.05)

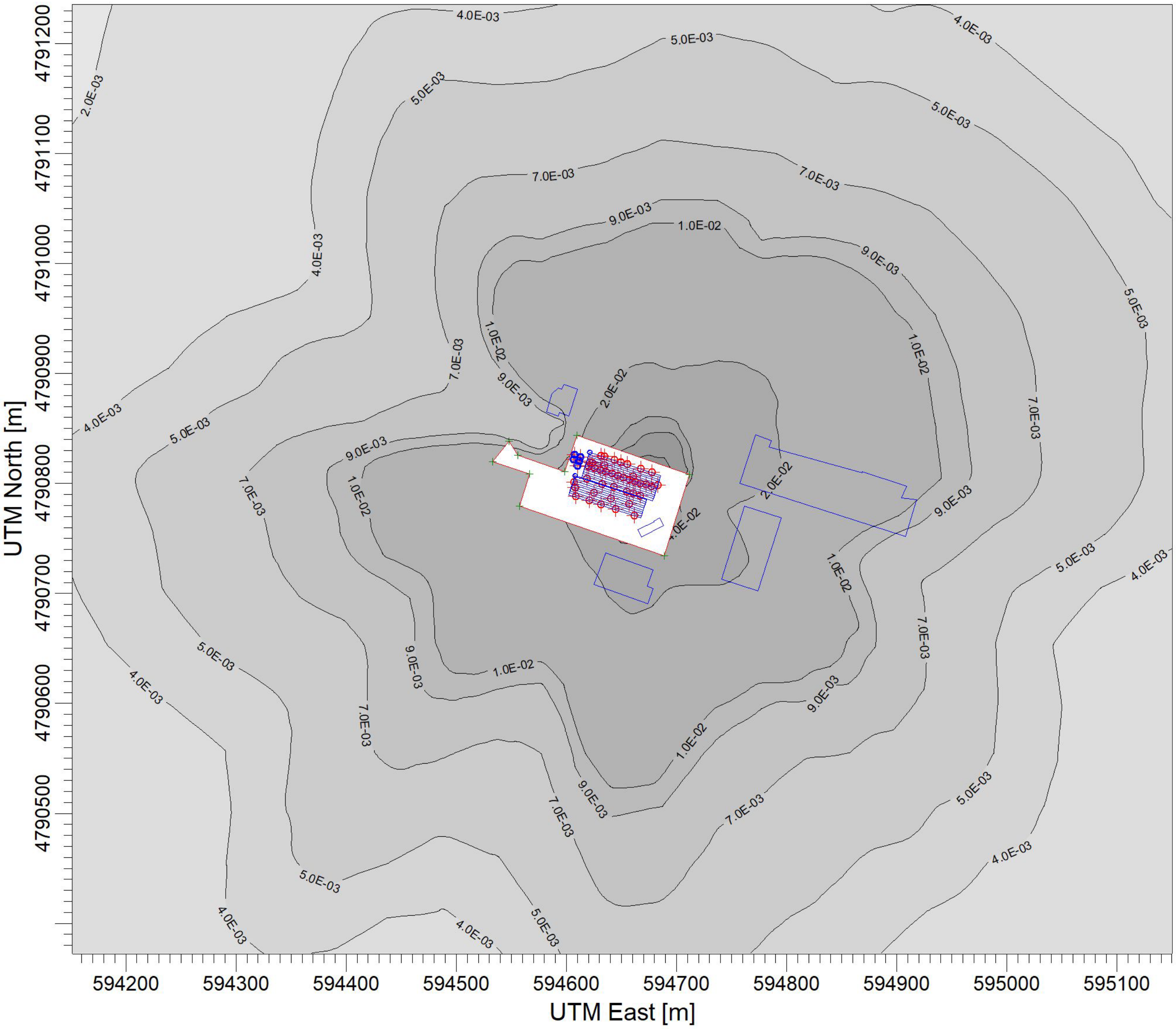
0.003	0.005	0.006	0.010	0.020	0.050	0.060	0.100	0.200	0.263
▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

COMMENTS: Lead 24 hour averaging period	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	O2E Inc. ENVIRONMENTAL CONSULTANTS
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,281 0 0.2 km	
	MAX: **0.263 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH MONTH VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 9.8E-02 [ug/m^3] at (594657.31, 4790795.05)

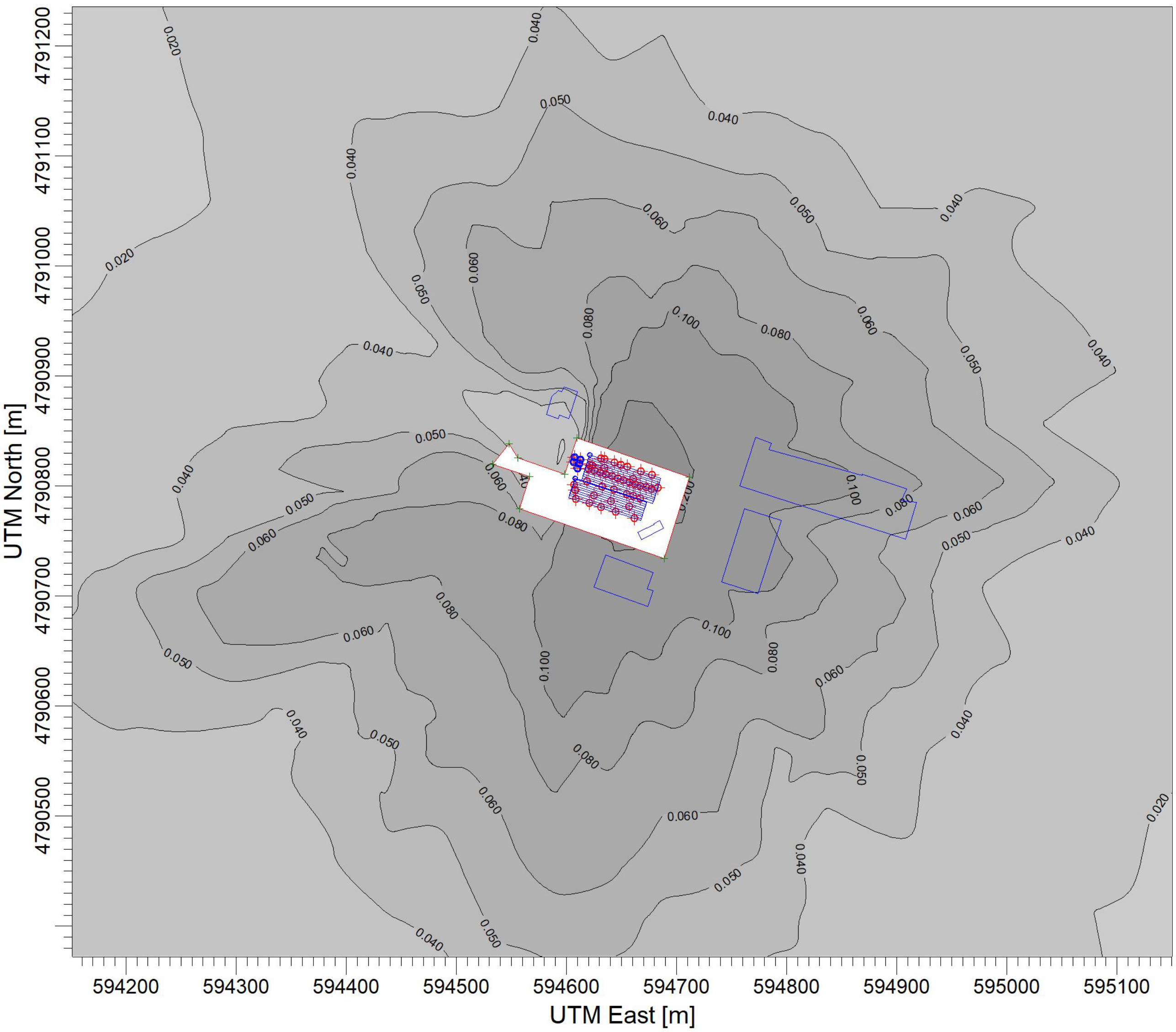
9.8E-04	1.0E-03	2.0E-03	4.0E-03	5.0E-03	7.0E-03	9.0E-03	1.0E-02	2.0E-02	4.0E-02	5.0E-02	7.0E-02	9.0E-02	9.8E-02

COMMENTS: Lead Monthly averaging period	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,280 0 0.2 km	
	MAX: **9.8E-02 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 0.407 [ug/m^3] at (594677.31, 4790795.05)

0.004 0.005 0.006 0.008 0.010 0.020 0.040 0.050 0.060 0.080 0.100 0.200 0.400 0.407

COMMENTS:

Manganese

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

OUTPUT TYPE:

Concentration

SCALE: 1:6,281

0 0.2 km

o2e Inc.
ENVIRONMENTAL CONSULTANTS

MAX:

0.407 ug/m^3

DATE:

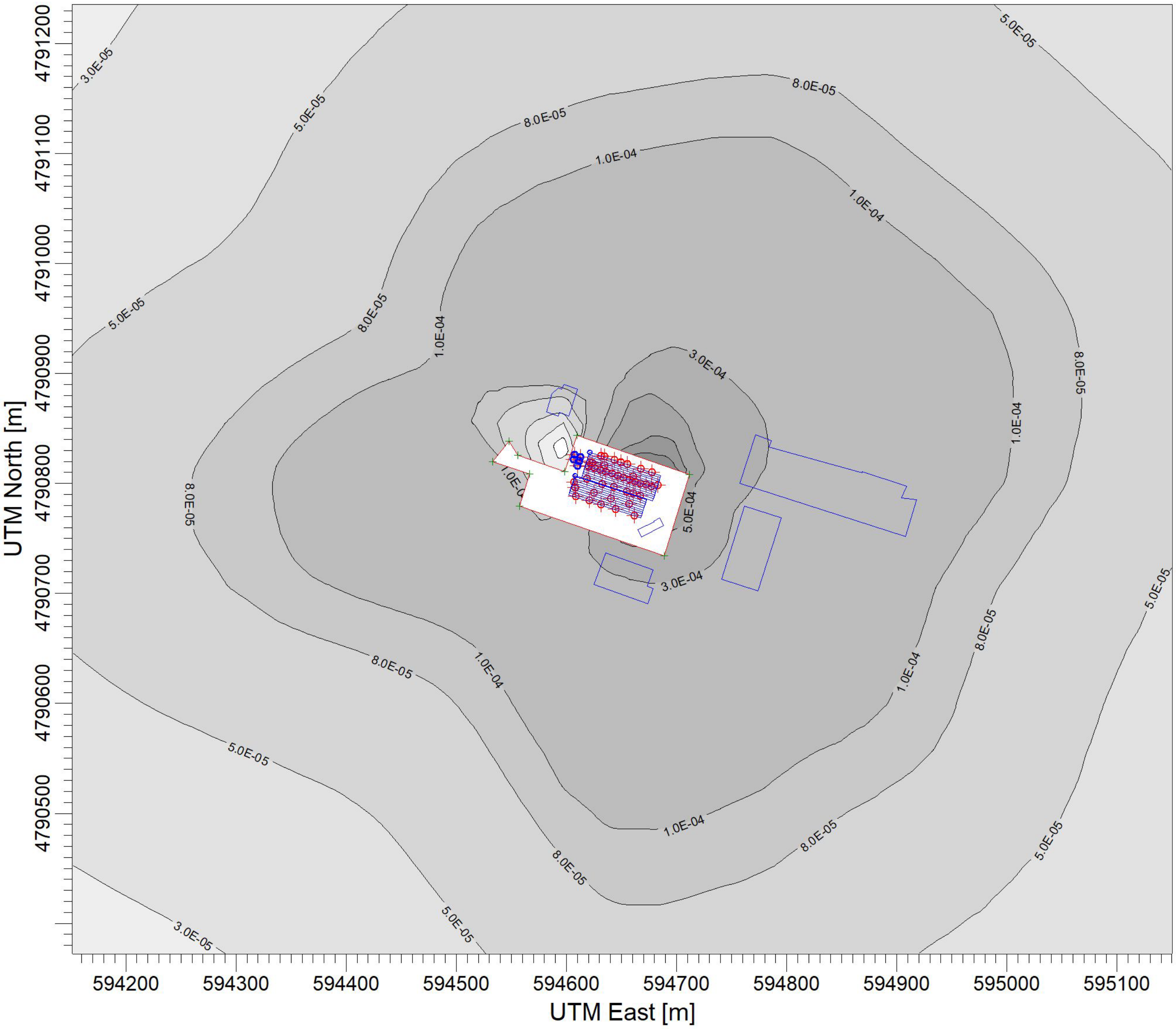
10/12/2022

PROJECT NO.:

22-024

PROJECT TITLE:

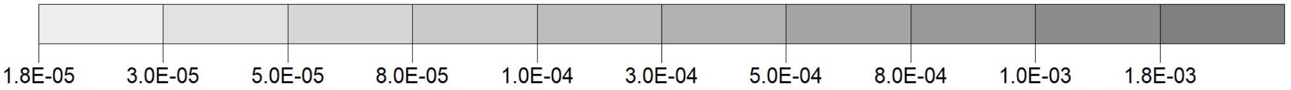
GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 1.8E-03 [ug/m^3] at (594677.31, 4790795.05)

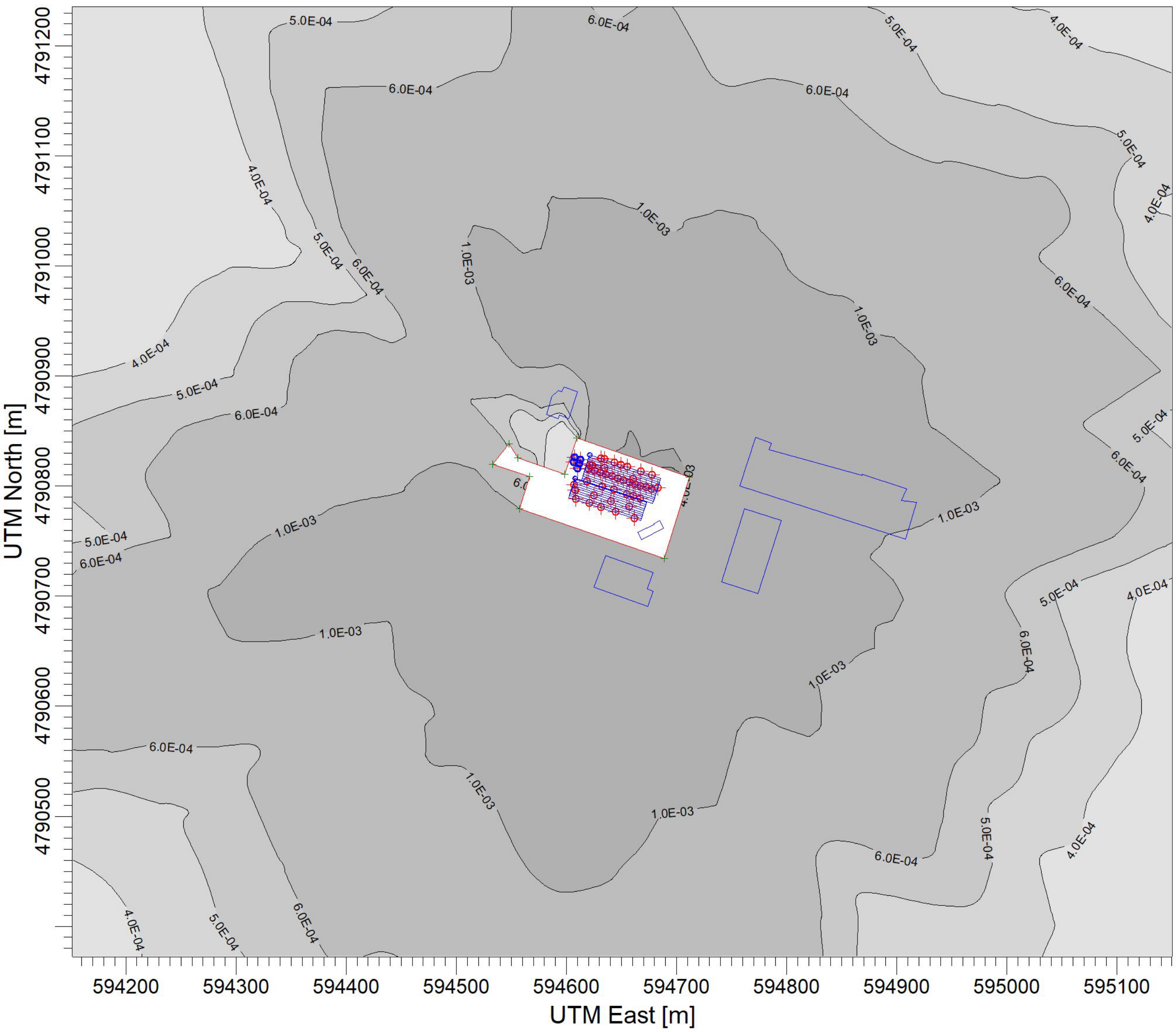


COMMENTS: Nickel Annual averaging period	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	O2e Inc. ENVIRONMENTAL CONSULTANTS
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,280 0 0.2 km	
	MAX: **1.8E-03 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 6.7E-03 [ug/m^3] at (594677.31, 4790795.05)

6.7E-05 1.0E-04 4.0E-04 5.0E-04 6.0E-04 1.0E-03 4.0E-03 5.0E-03 6.0E-03 6.7E-03

COMMENTS:

Nickel
24 hour averaging period

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

OUTPUT TYPE:

Concentration

SCALE:

1:6,280

0 0.2 km

MAX:

6.7E-03 ug/m^3

DATE:

10/12/2022

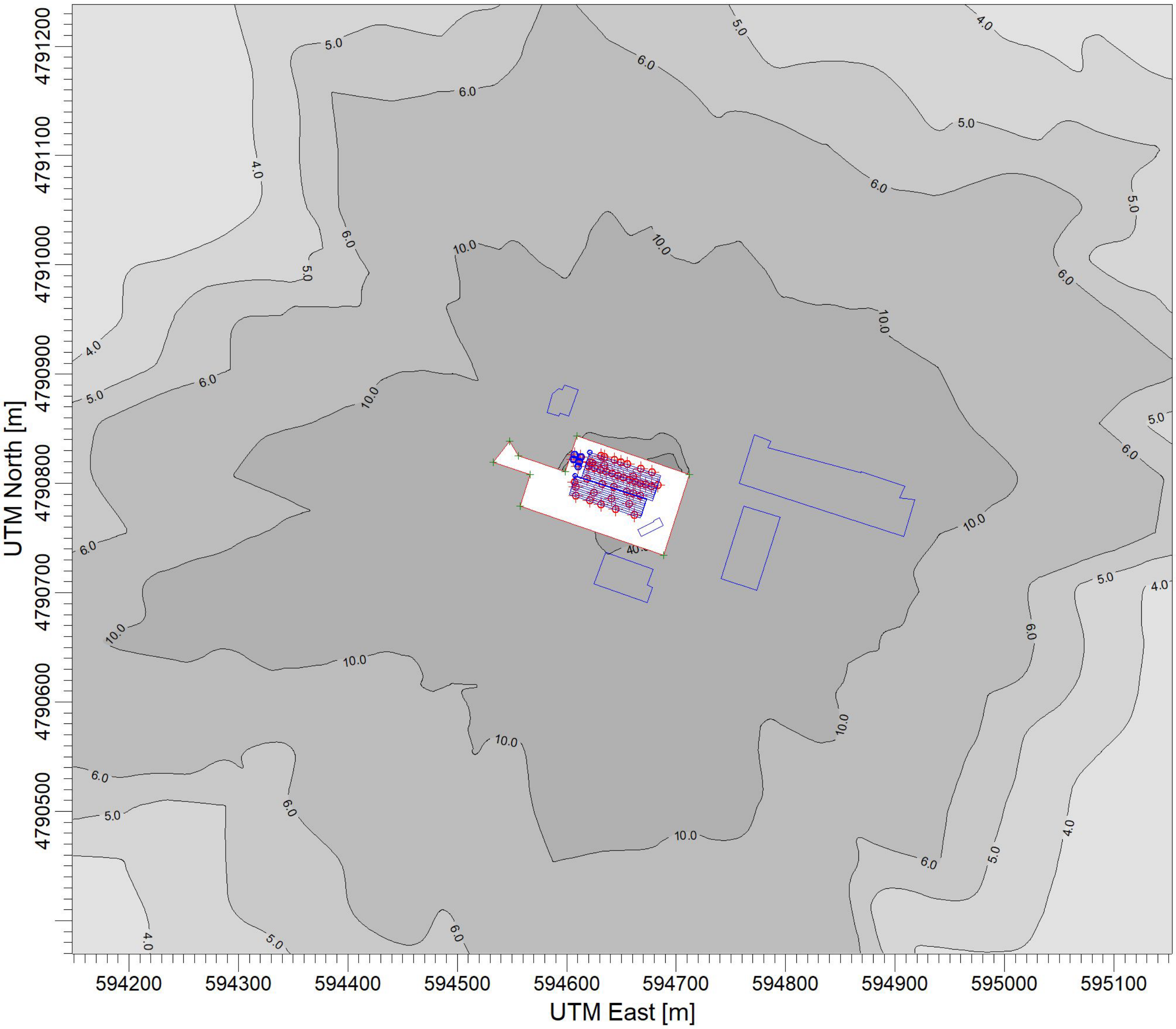
PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 65.3 [ug/m^3] at (594677.31, 4790795.05)

0.7	1.0	4.0	5.0	6.0	10.0	40.0	50.0	60.0	65.3

COMMENTS:

Nitrogen Oxides
24 hour averaging period

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

OUTPUT TYPE:

Concentration

SCALE:

1:6,319

0 ▬▬▬ 0.2 km

MAX:

65.3 ug/m^3

DATE:

10/12/2022

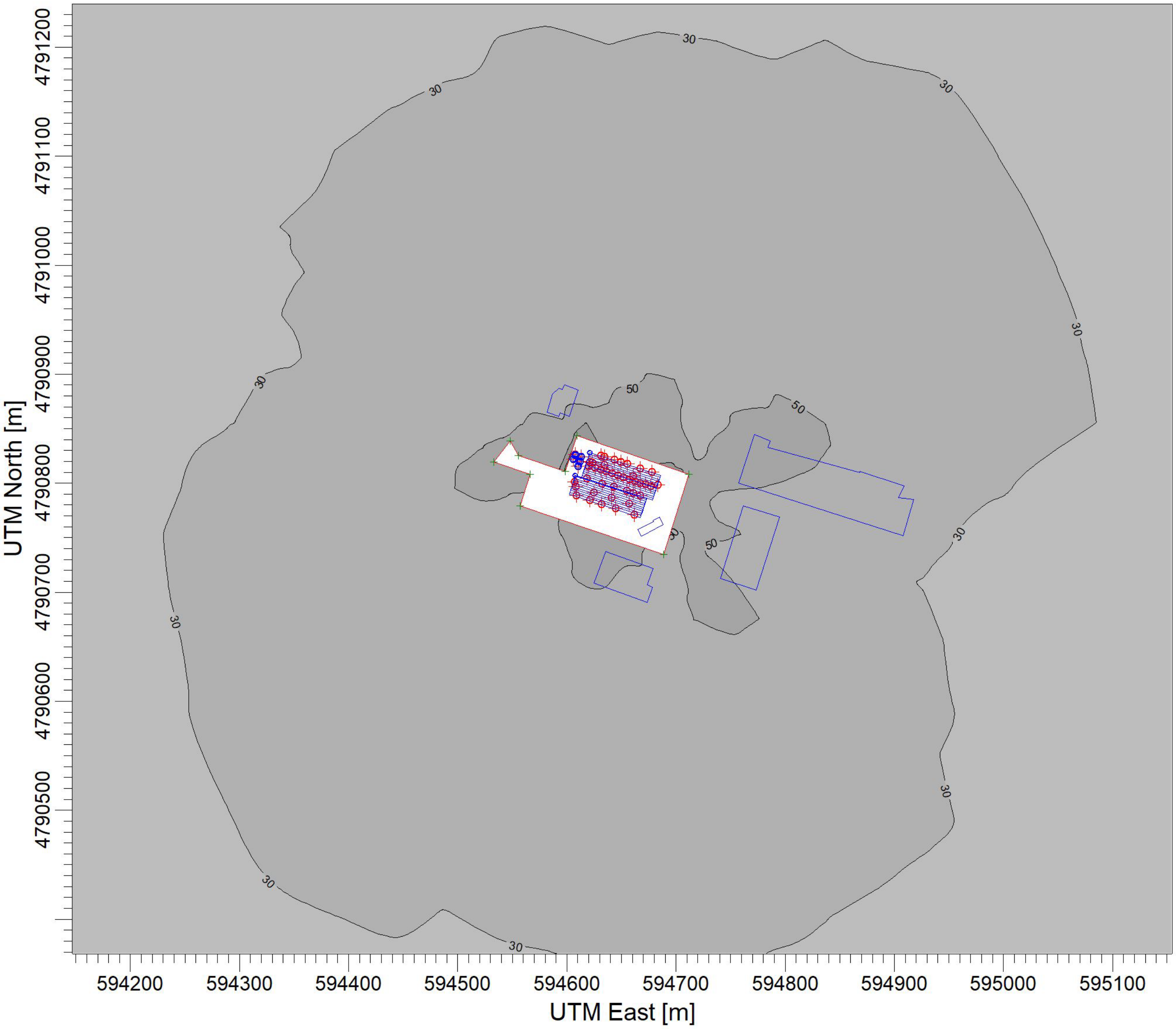
PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

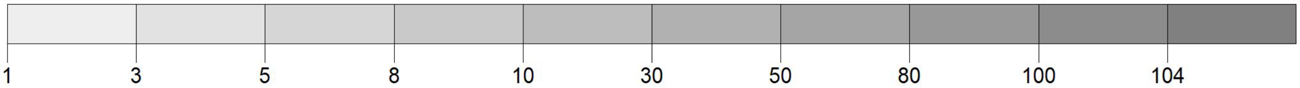
GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 104 [ug/m^3] at (594601.31, 4790818.88)



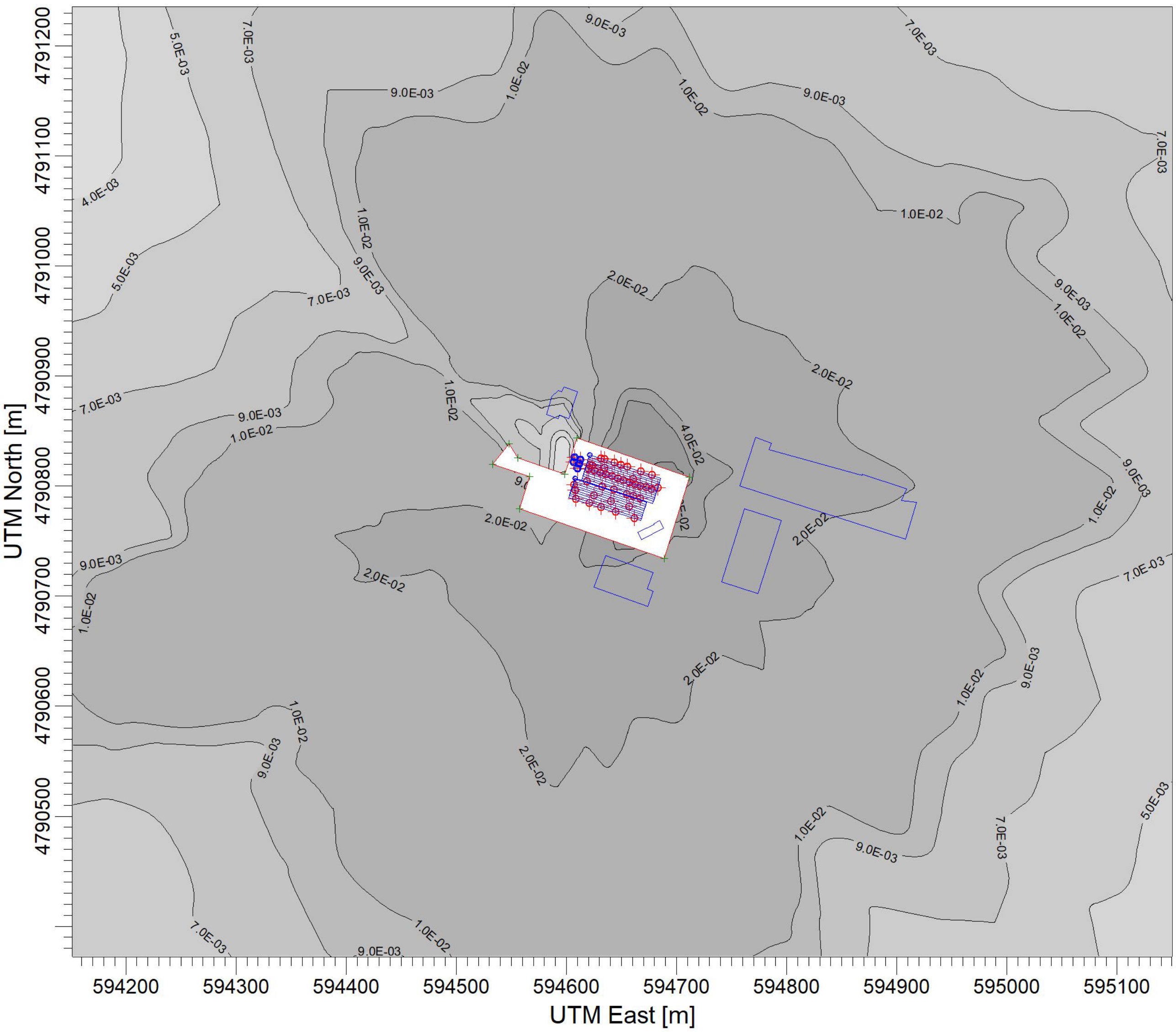
COMMENTS: Nitrogen Oxides 1 hour averaging period	SOURCES: **46**	COMPANY NAME: **O2E Inc.**
	RECEPTORS: **2420**	MODELER: **TML**
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,338 0 0.2 km
	MAX: **104 ug/m^3**	DATE: **10/12/2022**
		PROJECT NO.: **22-024**

O2E Inc. ENVIRONMENTAL CONSULTANTS

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 1.0E-01 [ug/m^3] at (594677.31, 4790795.05)

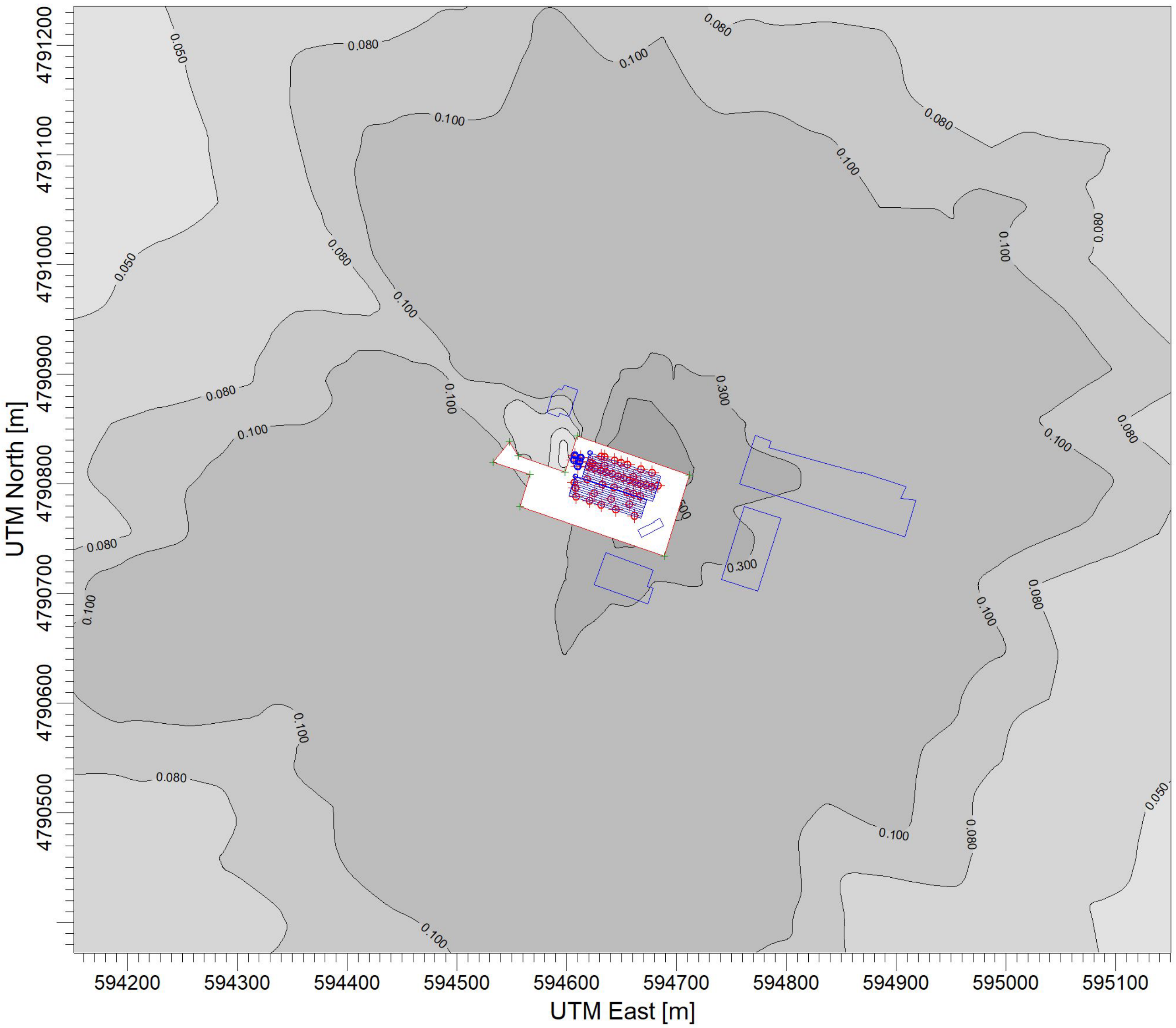
9.9E-04 1.0E-03 2.0E-03 4.0E-03 5.0E-03 7.0E-03 9.0E-03 1.0E-02 2.0E-02 4.0E-02 5.0E-02 7.0E-02 9.0E-02 1.0E-01

COMMENTS: Potassium	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	ENVIRONMENTAL CONSULTANTS
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,280 0 — 0.2 km	
	MAX: **1.0E-01 ug/m^3**	DATE: **10/12/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 1.002 [ug/m^3] at (594677.31, 4790795.05)

0.010 0.030 0.050 0.080 0.100 0.300 0.500 0.800 1.000 1.002

COMMENTS:

Silicon Dioxide

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

OUTPUT TYPE:

Concentration

SCALE: 1:6,281

0 0.2 km

MAX:

1.002 ug/m^3

DATE:

10/12/2022

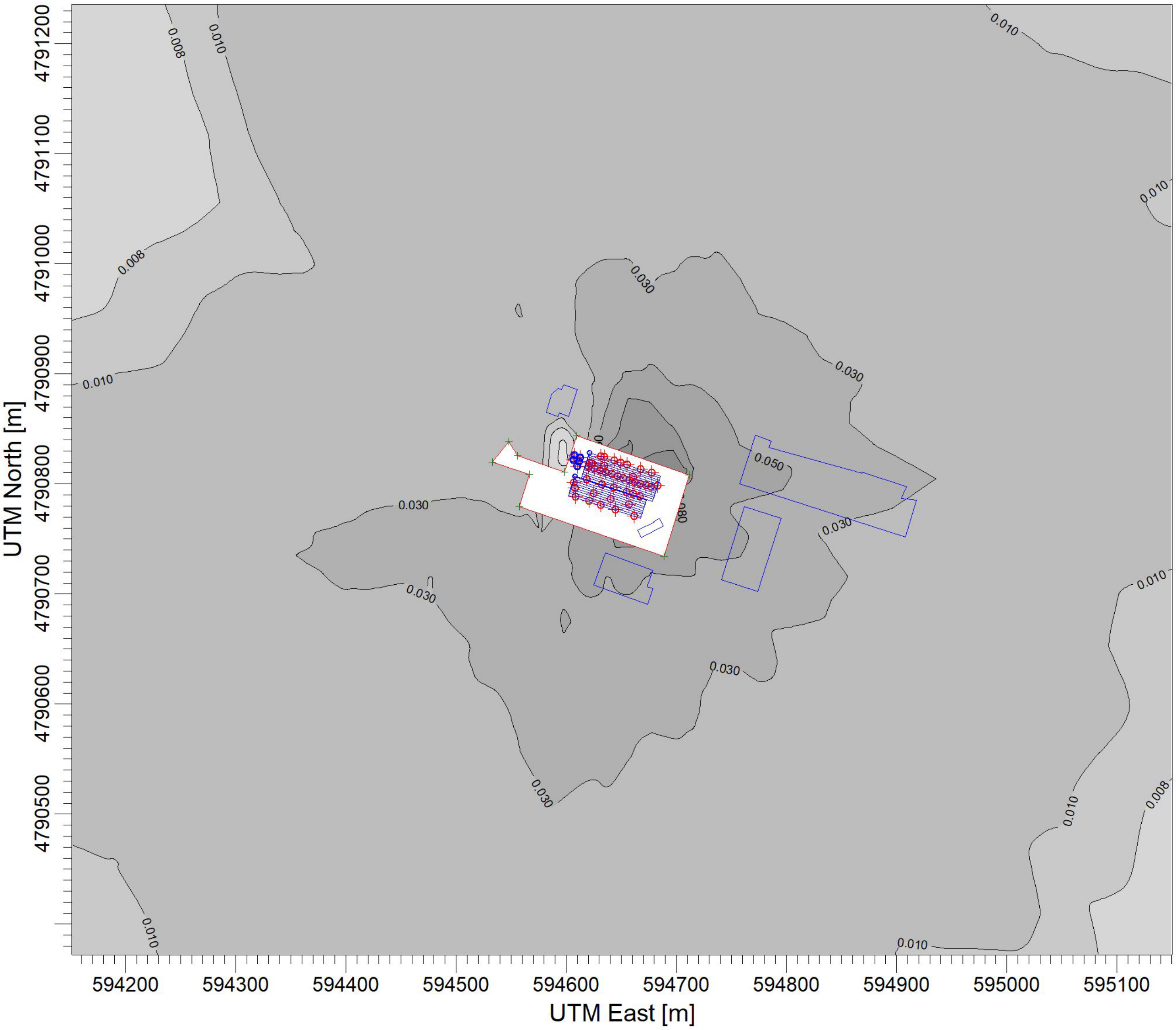
PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

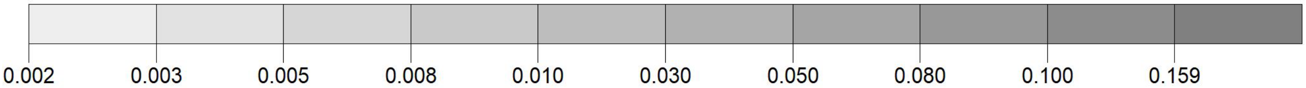
GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 0.159 [ug/m^3] at (594677.31, 4790795.05)



COMMENTS: Sodium Monoxide	SOURCES: **46**	COMPANY NAME: **O2E Inc.**
	RECEPTORS: **2420**	MODELER: **TML**
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,281 0 0.2 km
	MAX: **0.159 ug/m^3**	DATE: **10/12/2022**

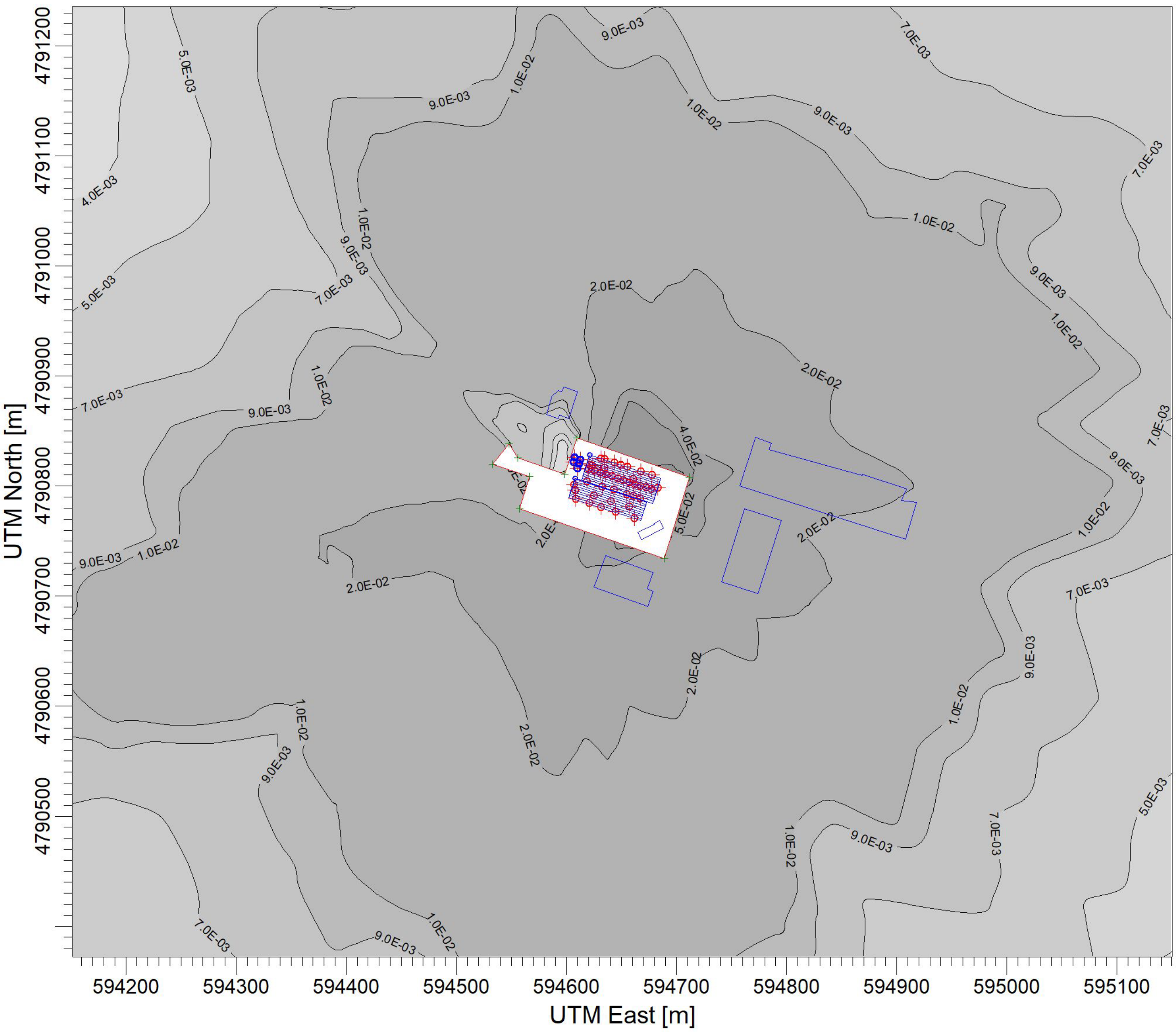
o2e Inc. ENVIRONMENTAL CONSULTANTS

PROJECT NO.:

22-024

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL ug/m^3

Max: 9.8E-02 [ug/m^3] at (594677.31, 4790795.05)

9.8E-04 1.0E-03 2.0E-03 4.0E-03 5.0E-03 7.0E-03 9.0E-03 1.0E-02 2.0E-02 4.0E-02 5.0E-02 7.0E-02 9.0E-02 9.8E-02

COMMENTS: Sulfur	SOURCES: **46**	COMPANY NAME: **O2E Inc.**
	RECEPTORS: **2420**	MODELER: **TML**
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,280 0 0.2 km
	MAX: **9.8E-02 ug/m^3**	DATE: **10/12/2022**

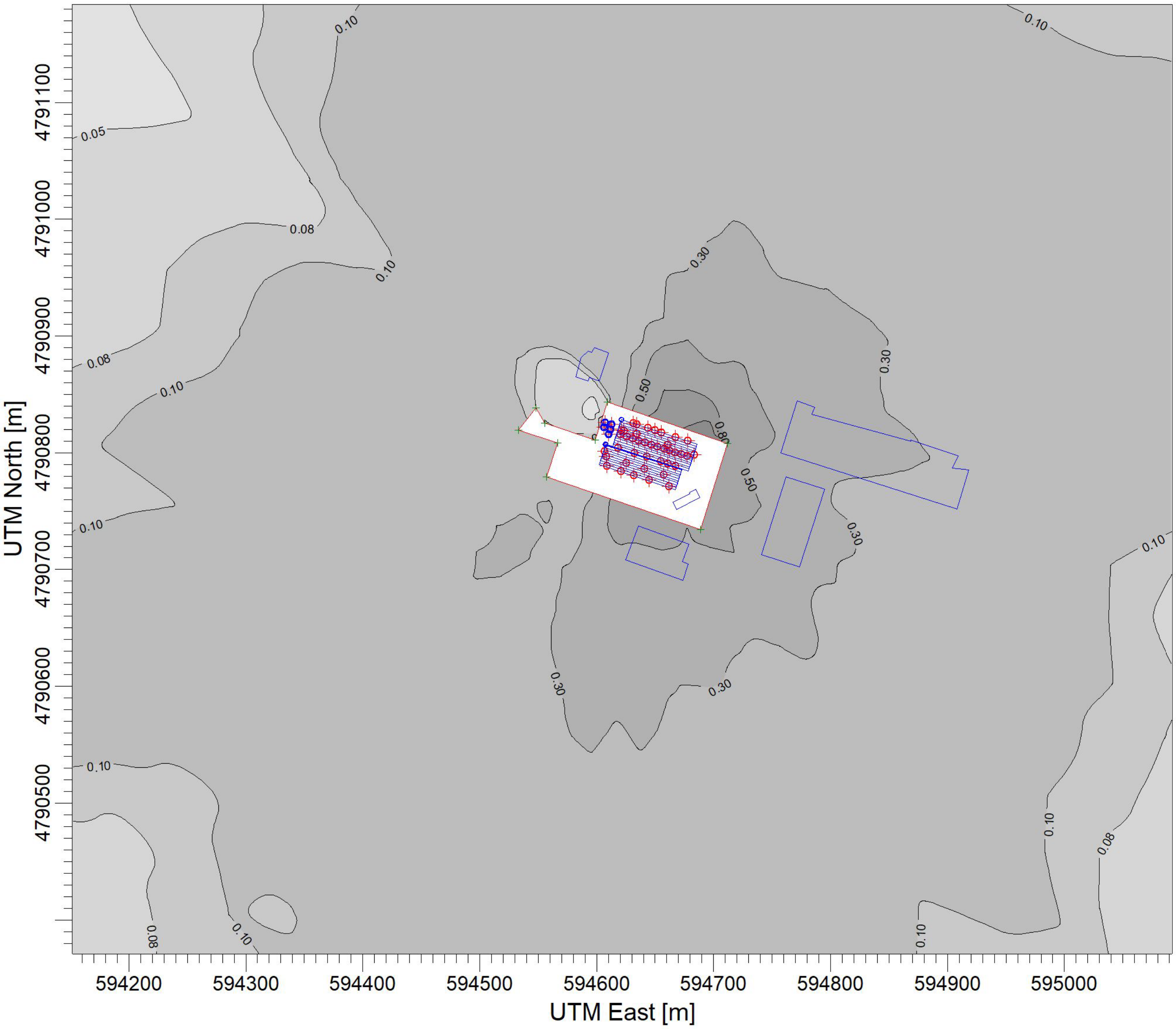
O2E Inc. ENVIRONMENTAL CONSULTANTS

PROJECT NO.:
22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 1.48 [ug/m^3] at (594677.31, 4790795.05)

0.01 0.03 0.05 0.08 0.10 0.30 0.50 0.80 1.00 1.48

COMMENTS:

Sulphur Dioxide
24 hour averaging period

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

OUTPUT TYPE:

Concentration

SCALE:

1:5,914

0 0.2 km

MAX:

1.48 ug/m^3

DATE:

10/26/2022

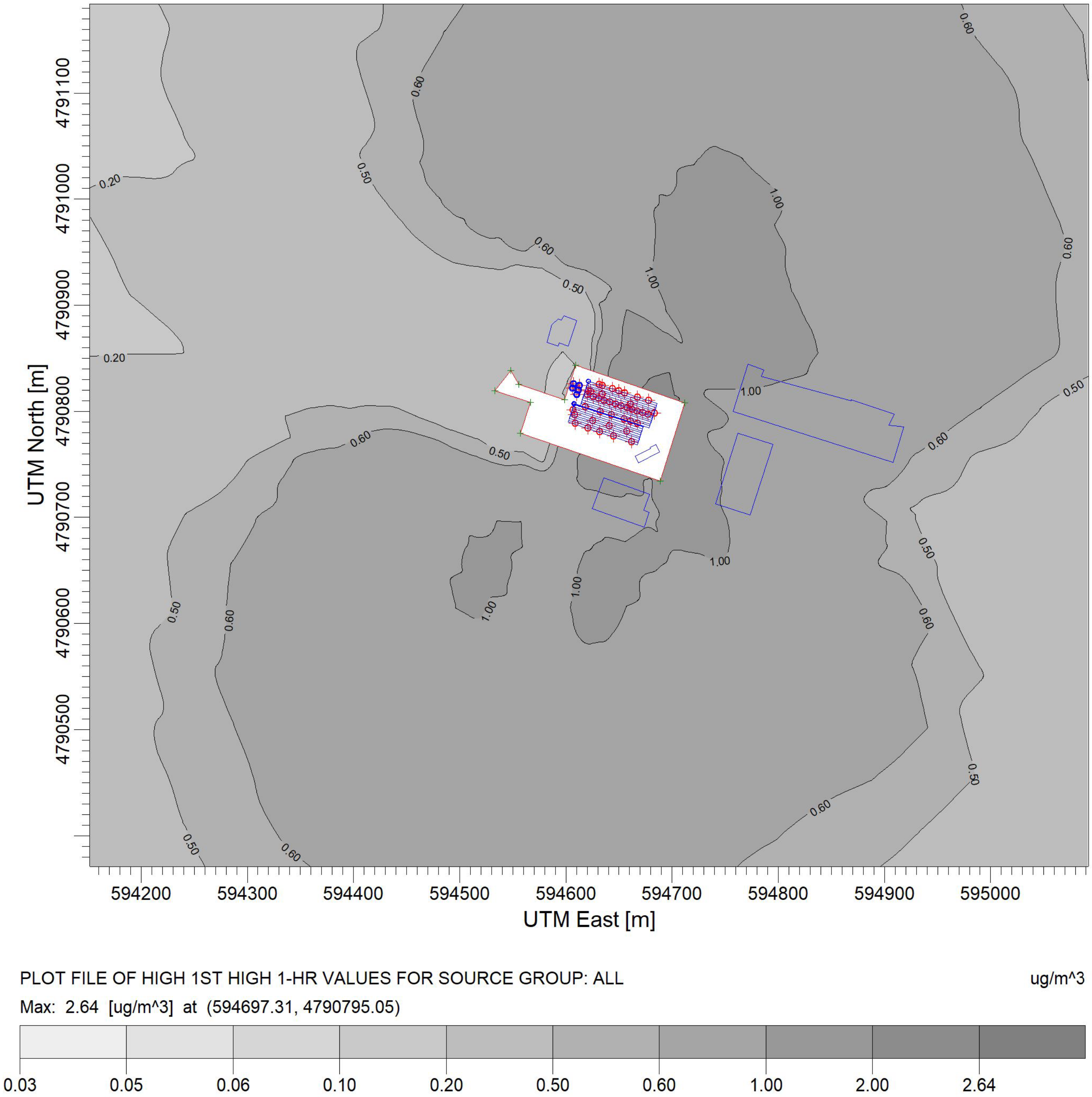
PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL

Max: 2.64 [ug/m^3] at (594697.31, 4790795.05)

COMMENTS:

Sulphur Dioxide
1 hour averaging period

SOURCES:

46

COMPANY NAME:

O2E Inc.

RECEPTORS:

2420

MODELER:

TML

O2E Inc. ENVIRONMENTAL CONSULTANTS

OUTPUT TYPE:

Concentration

SCALE: 1:5,914

0 0.2 km

MAX:

2.64 ug/m^3

DATE:

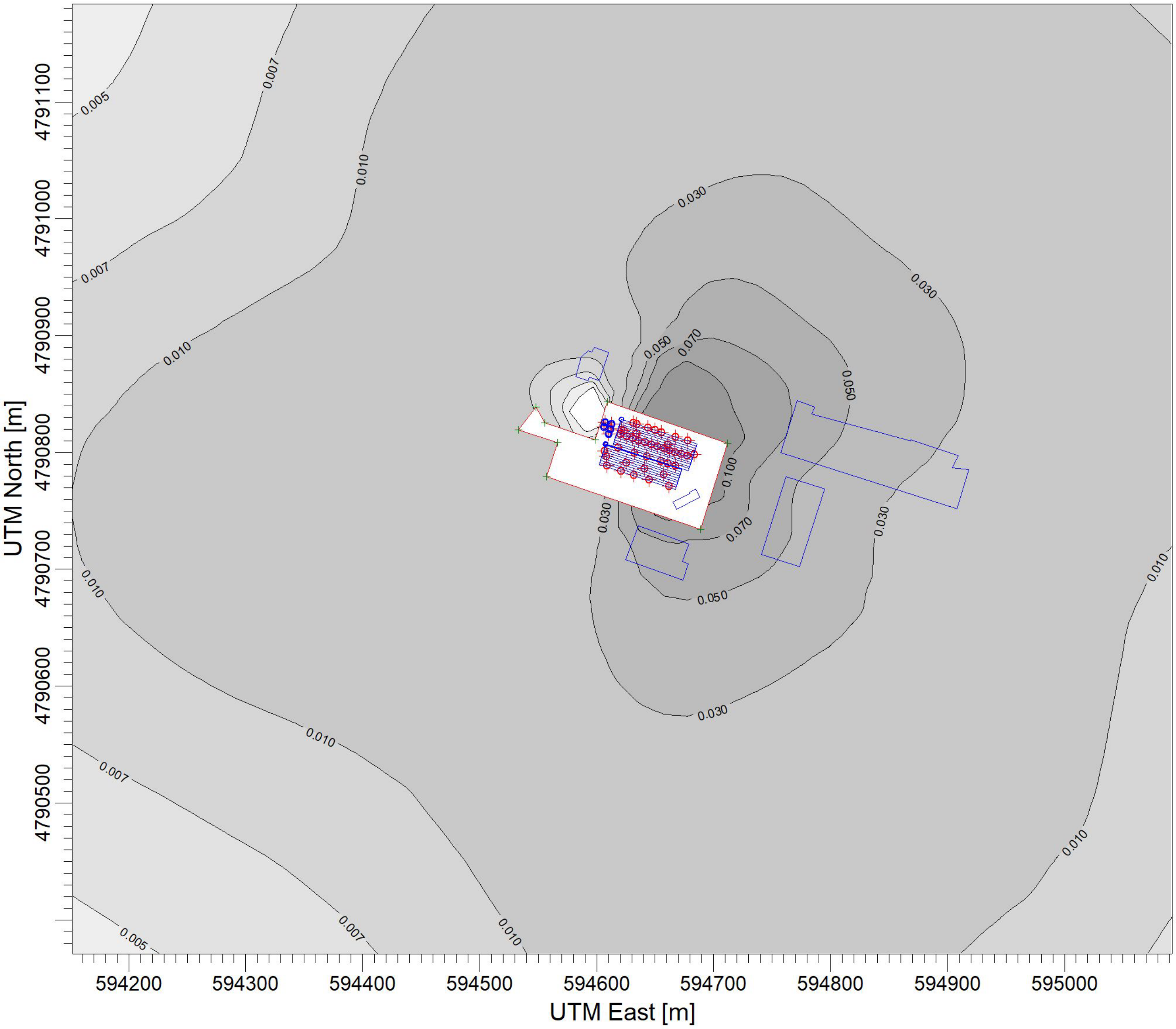
10/26/2022

PROJECT NO.:

22-024

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 0.382 [ug/m^3] at (594677.31, 4790795.05)

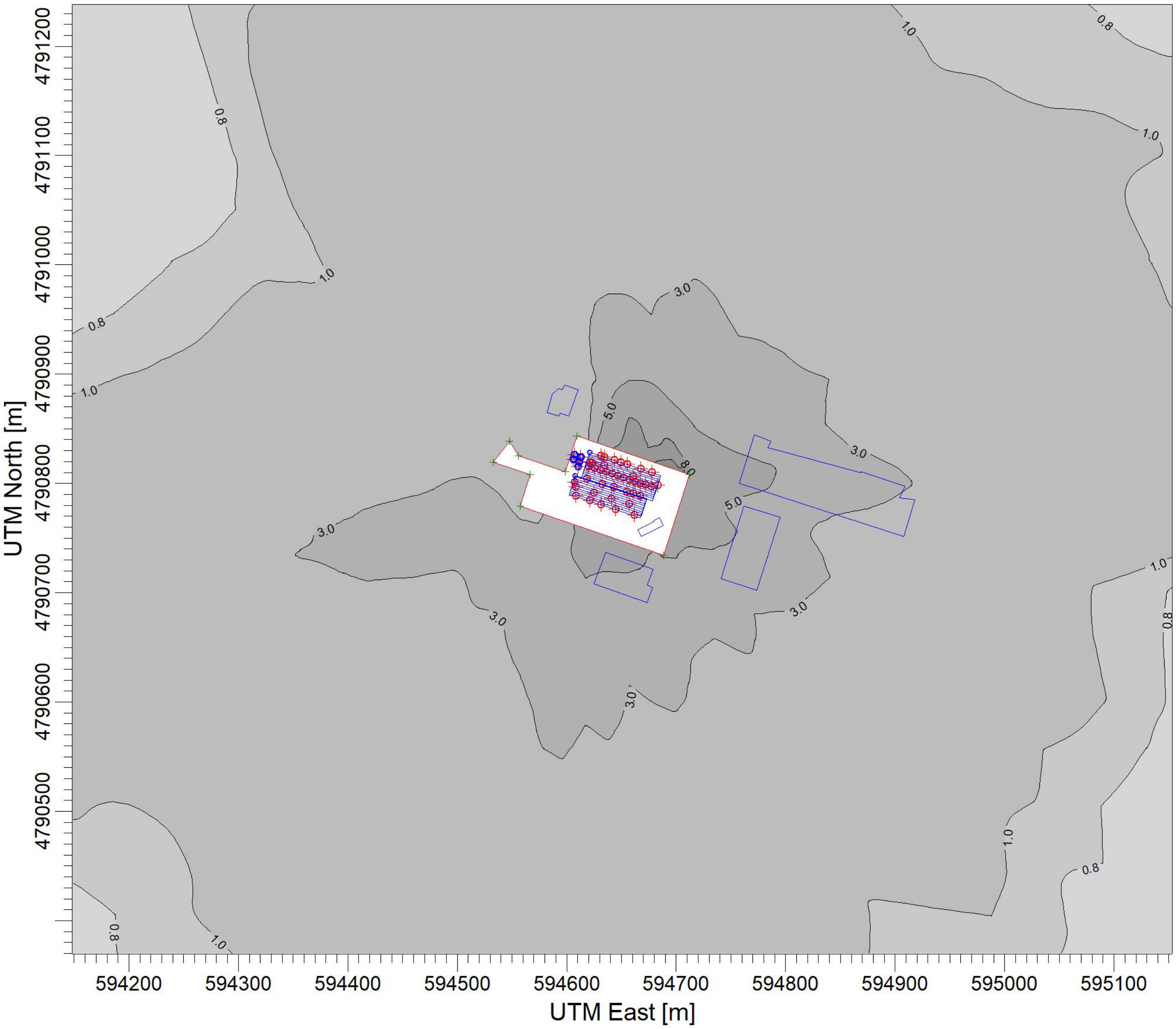
0.004 0.005 0.007 0.010 0.030 0.050 0.070 0.100 0.300 0.382

COMMENTS: Sulphur Dioxide Annual averaging period	SOURCES: **46**	COMPANY NAME: **O2E Inc.**	
	RECEPTORS: **2420**	MODELER: **TML**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,914 0 ▬▬ 0.2 km	O2E Inc. ENVIRONMENTAL CONSULTANTS
	MAX: **0.382 ug/m^3**	DATE: **10/26/2022**	PROJECT NO.: **22-024**

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL   ug/m^3

Max: 14.7 [ug/m^3] at (594677.31, 4790795.05)

0.1 0.3 0.5 0.8 1.0 3.0 5.0 8.0 10.0 14.7

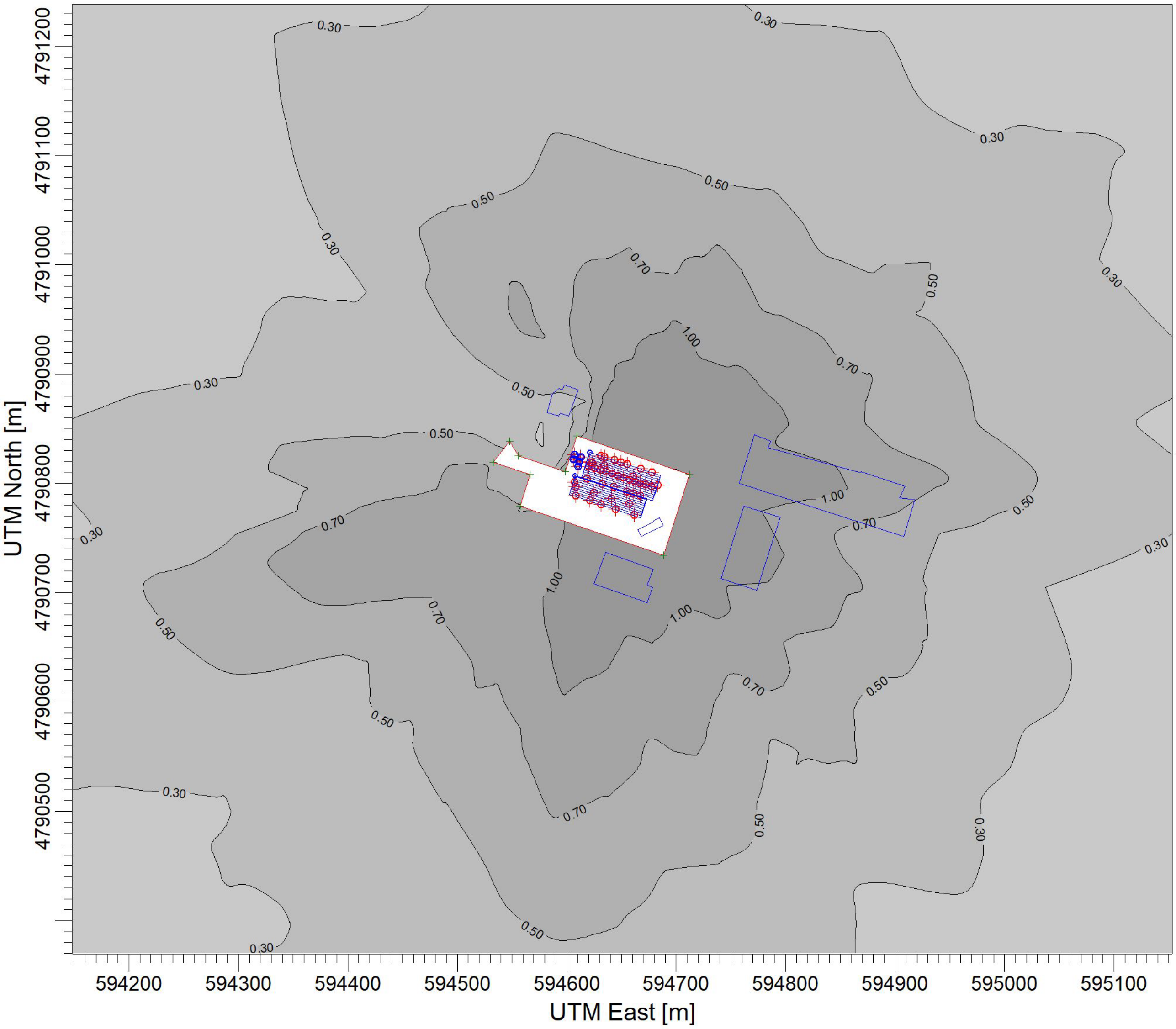
COMMENTS: Suspended Particulate Matter	SOURCES: **46**	COMPANY NAME: **O2E Inc.**
	RECEPTORS: **2420**	MODELER: **TML**
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,319 0 0.2 km
	MAX: **14.7 ug/m^3**	DATE: **10/12/2022**

PROJECT NO.:
22-024

AERMOD View - Lakes Environmental Software

PROJECT TITLE:

GFL Environmental Services Inc.
237 Brant Street Facility



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 3.93 [ug/m^3] at (594677.31, 4790795.05)

0.04 0.05 0.07 0.10 0.30 0.50 0.70 1.00 3.00 3.93

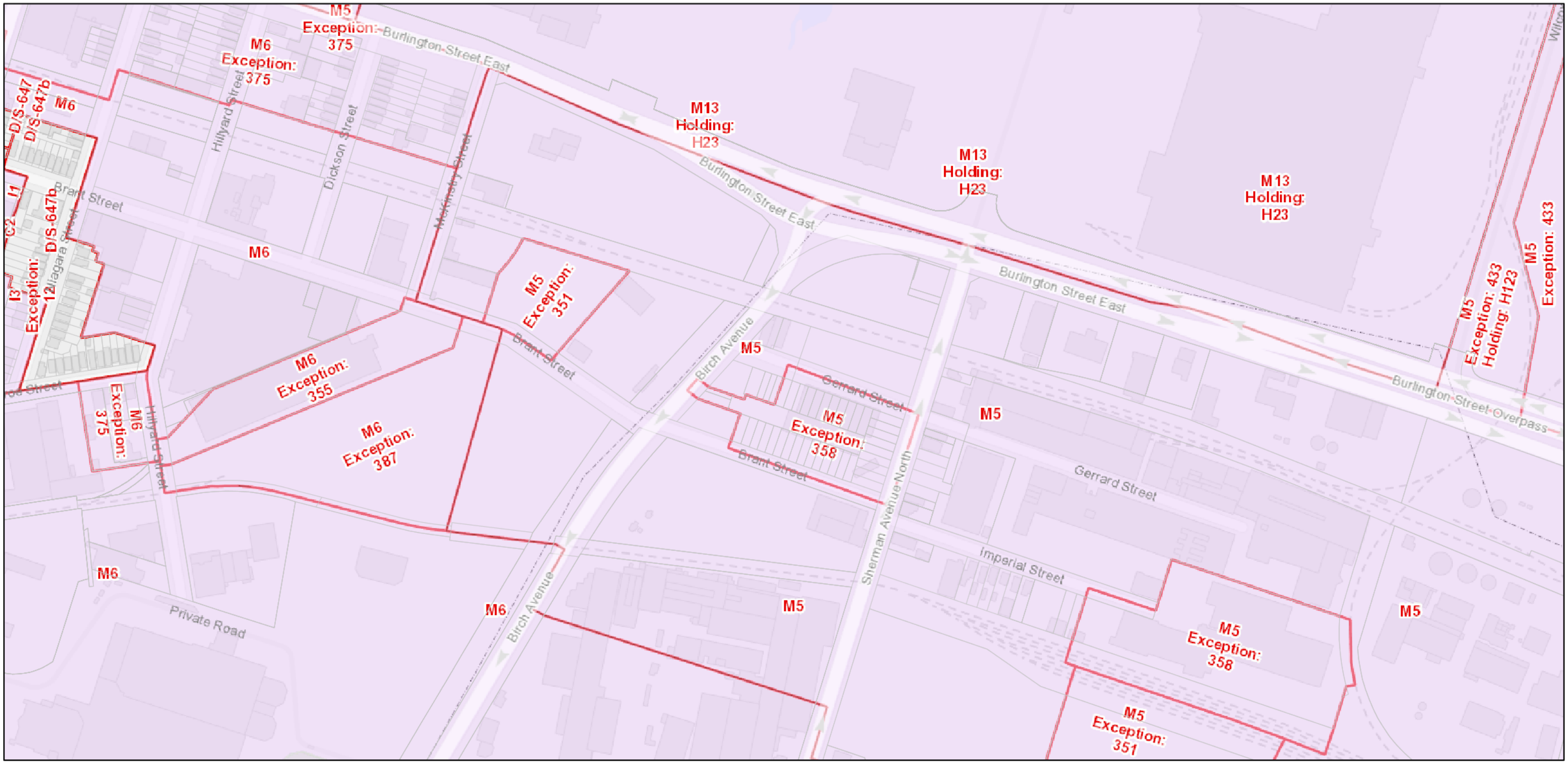
COMMENTS: Zinc	SOURCES: **46**	COMPANY NAME: **O2E Inc.**
	RECEPTORS: **2420**	MODELER: **TML**
	OUTPUT TYPE: **Concentration**	SCALE: 1:6,319 0 0.2 km
	MAX: **3.93 ug/m^3**	DATE: **10/12/2022**

PROJECT NO.:

22-024

AERMOD View - Lakes Environmental Software

Interactive Zoning



10/13/2022, 2:07:05 PM

▭ Property Parcels

▭ Council Approved - Zoning Boundaries

▭ Zoning Boundaries

▭ Temporary Use Zone

▭ Interim Control Bylaw Zone

1:4,514

0 0.04 0.07 0.15 mi

0 0.05 0.1 0.2 km

City of Hamilton, City of Hamilton - Web GIS Framework

2.1 ESTABLISHMENT OF CLASSIFICATIONS AND ZONES

For the purpose of this By-law, the following land use classifications and zones are hereby established:

a) **Downtown Classification**

Zones	Zone Symbol
Downtown Central Business District Zone	D1
Downtown Mixed Use – Pedestrian Focus Zone	D2 (By-law No. 18-114, May 9, 2018
Downtown Mixed Use Zone	D3
Downtown Residential Zone	D5
Downtown Multiple Residential Zone	D6

b) **Open Space and Parks Classification**

Zones	
Neighbourhood Park Zone	P1
Community Park Zone	P2
City Wide Park Zone	P3
Open Space Zone	P4
Conservation/Hazard Land Zone	P5 (By-law 06-166, June 14, 2006)
Conservation/Hazard Land – Rural Zone	P6
Conservation/Hazard Land – Rural Zone	P7
Conservation/Hazard Land – Rural Zone	P8 (By-law 15-173, July 10, 2015, OMB Approval May 3, 2016)

c) **Institutional Classification**

Zones	
Neighbourhood Institutional Zone	I1
Community Institutional Zone	I2
Major Institutional Zone	I3 (By-law 07-101, March 28, 2007)

d) **Industrial Classification**

Zones	
Research and Development Zone	M1 (By-law 07-043, February 15, 2007)
General Business Park Zone	M2 (By-law 10-128, May 26, 2010)
Prestige Business Park Zone	M3 (By-law 10-128, June 28, 2011)
Business Park Support Zone	M4
General Industrial Zone	M5

Light Industrial Zone	M6 (By-law 10-128, May 26, 2010)
Airside Industrial Zone	M7 (By-law 10-288, October 13, 2010, OMB Approval April 10, 2015)
Airport Related Business Zone	M8 (By-law 10-288, October 13, 2010, OMB Approval April 10, 2015)
Airport Reserve Zone	M9 (By-law 10-288, October 13, 2010, OMB Approval April 10, 2015)
Airport Light Industrial Zone	M10 (By-law 10-288, October 13, 2010, OMB Approval April 10, 2015)
Airport Prestige Business Park Zone	M11 (By-law 10-288, October 13, 2010, OMB Approval April 10, 2015)
Extractive Industrial	M12 (By-law 15-173, July 10, 2015, OMB Approval May 3, 2016)
Shipping and Navigation (Port Lands) Zone	M13 (By-law 18-092, April 11, 2018)
Shipping and Navigation (East Port) Zone	M14 (By-law 18-092, April 11, 2018)

e) **Rural Classification**
Zones

Agriculture	A1
Rural	A2
Settlement Residential	S1
Settlement Commercial	S2
Settlement Institutional	S3
Existing Rural Commercial	E1
Existing Rural Industrial	E2 (By-law 15-173, July 10, 2015, OMB Approval May 3, 2016)

f) **Utility Classification**
Zones

Airport	U1 (By-law No. 15-236, October 14, 2015, OMB Approval August 22, 2016)
Utility Zone	U2 (By-law No. 18-114, May 9, 2018
Parking	U3 (NOT FINAL AND BINDING By-law No.

17-240, November 8, 2017)

g) **Transit Oriented Corridor**
<u>Zones</u>

Transit Oriented Corridor Mixed Use Medium Density	TOC1
Transit Oriented Corridor Local Commercial	TOC2
Transit Oriented Corridor Multiple Residential	TOC3
	(By-law No. 16-265 October 12, 2016 OMB Approved May 1, 2017))
Transit Oriented Corridor Mixed Use High Density	TOC4
	(By-law No. 18-032, February 14, 2018)

h) **Commercial and Mixed Use Zone Classification**
<u>Zones</u>

Residential Character Commercial Zone	C1
Neighbourhood Commercial Zone	C2
Community Commercial Zone	C3
Mixed Use High Density Zone	C4
Mixed Use Medium Density Zone	C5
Mixed Use Medium Density – Pedestrian Focus Zone	C5a
District Commercial Zone	C6
Arterial Commercial Zone	C7
	(By-law No. 17-240, November 8, 2017)

i) **Waterfront Zones**

Multiple Residential	WF1
Mixed Use	WF2
Prime Retail Streets	WF3

(By-law No. 17-095-LPAT-01, May 24, 2017)

2.2 USE OF ZONE SYMBOLS

The zone symbols as set out in Subsection 2.1 may be used in text or appear on the Schedule “A” - Zoning Maps to represent the Zones.

2.3 INCORPORATION OF ZONING MAPS

The location, extent and boundaries of all the said Zones are shown in Schedule "A" - Zoning Maps. Maps numbered 1-228, 382-384, 412-415, 444-447, 480-484, 514-518, 548-551, 580-582, 611-613, 642, 680, 715-716, 743-744, 749-751, 753, 779-780, 784-785, 787-793, 817-830, 833-835, 857-877, 899-920, 941-962, 983-1006, 1027-1052, 1074-1101, 1121-1153, 1172-1207, 1226-1260, 1278-1307, 1309-1313, 1331-1353, 1357, 1359, 1363-1365, 1383-1406, 1433-1457, 1481-1484, 1487-1506, 1528-1531, 1535-1542, 1544-1552, 1573-1574, 1580-1585, 1590-1597, 1627-1629, 1634-1641, 1670-1671, 1676-1678, 1681-1682, 1710-1711, 1717, 1747-1749, 1784-1786, 1818-1819, 1884-1885, 1887, 1909-1912, 1932-1935, and 1954-1957 inclusive, and all notations, references and other information shown hereon, are all hereby incorporated in and are declared to form part of this By-law. Notwithstanding the provisions of this Section, municipal addresses, shown on the Schedule "A" – Zoning Maps, may be changed without an amendment to this By-law being required. The Key Maps inserted before Schedule "A" – Zoning Maps shall not constitute part of this By-law and have been included for reference only.
(By-law 06-166, June 14, 2006; By-law 07-049, February 15, 2007; By-law 07-101, March 28, 2007; By-law 07-111, April 11, 2007; By-law 10-288, October 13, 2010; By-law 15-118, April 10, 2015, OMB approval; By-law 15-173, July 10, 2015, OMB Approval May 3, 2016)

2.4 INCORPORATION OF SCHEDULES

Schedule "A", Schedule "B", Schedule "C", Schedule "D", Schedule "E" and Schedule "F" attached hereto, are hereby incorporated in and declared to form part of this By-law.

a) Schedule "A" – Zoning Maps

b) Schedule "B" – Property Details

Where a numerical reference enclosed by a triangle appears in Schedule "A" - Zoning Maps, reference shall be made to Schedule "B" – Property Details, which detail more particularly shows the boundary of the zone and the lands affected by such zone boundary. The said numerical reference represents the map number annexed within Schedule "B" – Property Details.

c) Schedule "C" – Special Exceptions

Where a numerical reference enclosed by a circle appears in Schedule "A" - Zoning Maps, the Special Exception provisions as set out in Schedule "C" – Special Exceptions apply to all of the lands encompassed within the zone boundary denoted with the arrow indicator. The circled numerical reference represents the subsection number in Schedule “C” – Special Exceptions with the special By-law provisions as set out thereunder.

d) Schedule “D” – Holding Provisions

Where a circle “H” followed by a numerical reference appears in Schedule “A” - Zoning Maps, the holding provisions apply to all of the lands encompassed within the zone boundary denoted with the arrow indicator. The circled numerical reference represents the subsection number in Schedule “D” with the holding provisions set out thereunder.

Until the "H" provision is removed from the lands through an amendment to this By-law, pursuant to the provisions of the Official Plan, and following completion of the matters as set out in the relevant Subsection of Schedule “D” – Holding Provision, permitted uses shall be restricted to only those uses referenced in said Subsection. Upon removal of the "H", the lands may be used in accordance with the provisions of the zone applicable to the lands.

e) Schedule “E” – Temporary Use Provision

Where a circled numerical reference followed by a “T” appears in Schedule “A” - Zoning Maps, the temporary use provisions apply to all of the lands encompassed within the zone boundary denoted with the arrow indicator. The circled numerical reference represents the Subsection number in Schedule “E” – Temporary Use Provision with the temporary use provisions set out thereunder.

Upon the expiry of the time period authorized by the Temporary Use By-law as set out in the relevant Subsection, the temporary use of the land permitted under said By-law shall cease.

f) Schedule “F” – Special Figures

Schedule “F” – Special Figures exists where figures referenced in the text provisions of this By-law are used to more clearly identify the properties affected by the area applicable regulations required by this By-law.

2.5 INCORPORATION OF APPENDICES

The following appendices do not form part of this By-law but are included for information purposes only. Any additions to, deletions of, or alterations to Appendices do not require a zoning by-law amendment.

a) Appendix A - Illustrations

2.6 INTERPRETATION OF ZONE BOUNDARIES

Where any uncertainty exists as to the location of any boundary of any zone shown in Schedule “A” – Zoning Maps, the following principals shall apply to the interpretation of such boundary:

a) Unless otherwise shown, a street, laneway, railway right-of-way or watercourse shall be included within the zone of the adjoining lot(s) on the sides thereof, and where such street, laneway, railway right-of-way or watercourse serves as a boundary between two or more zones, the centre line of such street, laneway, right-of-way or watercourse shall be deemed to be the boundary between zones;

b) Where a zone boundary is intercepted by a street name, shown in Schedule “A” – Zoning Maps, the zone boundary line shall be deemed to be a continuous zone boundary through the street name reference;

c) Where any zone boundary is not shown to be following a street, laneway, railway right-of-way or watercourse and where the boundary appears to follow the limit of a lot as existing as of the effective date of this By-law or any relevant amending by-law, such lot limit shall be deemed to be the zone boundary;

d) Where any zone boundary is left uncertain after reference to Schedule “A” – Zoning Maps or Schedule “B” – Property Details, or the application of Subsections 2.5(a), 2.5(b) or 2.5(c) of this By-law, and the distance from existing lot lines or streets is not indicated on Schedule “A” – Zoning Maps or Schedule “B” – Property Details, such zone boundary shall be determined by the use of the scale of the Zoning Maps referenced Schedule “A” of this By-law;

e) Wherever it may occur, the City Limit is the boundary of the zone adjacent to it; and,

f) Where a lot is divided into more than one zone, each such portion of the lot shall be used in accordance with the provisions of this By-law for each of the applicable zones.

2.7 INTERPRETATION OF THE BY-LAW

2.7.1 Use of Tables

a) Tables form part of the By-law

b) Notations

i) Permitted Use Table
   1. √ – The use is permitted
   2. Blank cell – The use is not permitted

ii) Regulations Table
   1. Blank cell – No regulation applies
   2. Number in brackets – One or more additional regulations apply and are listed at the bottom of the Table.
   3. m – Metre
   4. m2 – Square Metres
   5. % – Percent
   6. n/a – Not Applicable

2.7.2 Reference Aids

a) Reference aids as tables of contents, marginal notes, headers, footers, headings, and illustrations are included in this By-law for convenience and reference only and do not form part of this By-law.

b) For greater certainty, illustrations are used as examples to show the application of a regulation and shall not be construed to have general application beyond their context.

(By-law No. 21-070, May 12, 2021)