APPENDIX H

SCIENCE INTEGRITY KNOWLEDGE

SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT OF AIR QUALITY IMPACTS FOR THE PROPOSED BRANDON BIO-MEDICAL WASTE TREATMENT FACILITY

FINAL REPORT

September, 2013

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1.0 BACKGROUND

The Prairie Mountain Health Area is proposing to install a biomedical waste incinerator with air pollution control system at the Brandon Regional Health Centre (RWDI, 2013a). RWDI AIR Inc. (RWDI) was retained by Brandon Regional Health Centre to complete additional studies requiring consideration in the hazardous disposal site license application and assembly of the draft Environmental Assessment (EA) Report for the proposed Brandon Biomedical Waste Treatment Facility. As part of this process, Intrinsik Environmental Services Inc. (Intrinsik) was retained by RWDI to conduct a screening-level human health risk assessment (SLHHRA) to assess the potential human health implications associated with air emissions from the proposed treatment facility. Intrinsik's assessment was conducted based on the results of air dispersion modelling analysis and assessment of potential air quality impacts conducted by RWDI.

This report summarizes the work that was performed by Intrinsik, including the approach that was followed and the findings and conclusions that were reached.

1.1 Scope of the Screening-Level Risk Assessment

The SLHHRA was designed to provide a preliminary indication of the potential health risks that could be presented from exposure to a select group of air contaminants emitted from the proposed facility. The assessment was focused on the evaluation of human health risks associated with the inhalation of predicted ground-level air concentrations at the location of the maximum modelled concentration and various sensitive receptor locations. The SLHHRA was not meant to serve as a detailed site-specific evaluation but rather was limited to evaluation of chemicals of concern identified by RWDI, and exposure durations and receptor locations for which data were provided by RWDI in their Air Quality Results Memo and accompanying dataset (RWDI, 2013a,b).

This SLHHRA provides an evaluation of potential inhalation risks associated with facility-related sources of air emissions only. Background sources of the air contaminants within the area of the proposed facility and potential cumulative health risks were not considered within the scope of the SLHHRA. Further, the SLHHRA was not intended to evaluate potential health risks arising from on-site occupational exposures (*i.e.,* biomedical waste treatment facility operators) or other on-site receptors and did not examine potential multi-media pathways of exposure (*i.e.*, oral or dermal exposures) with the deposition of particulates onto soil in the area surrounding the proposed facility.

The results of this assessment are dependent on the quality and accuracy of the information (*i.e.*, air dispersion modelling results) supplied by RWDI.

2.0 SLHHRA METHODOLOGY AND ANALYSIS

The assessment proceeded step-wise following a conventional human health risk assessment (HHRA) "paradigm". The paradigm is well-known and widely-accepted by leading scientific and regulatory authorities, including Health Canada, Environment Canada, the Canadian Council of Ministers of the Environment (CCME), the US Environmental Protection Agency (US EPA), the Ontario Ministry of Environment (MOE), and other federal and provincial government agencies. The paradigm is illustrated in Figure 2-1, and is composed of the following steps:

i) problem formulation;

ii) exposure assessment;

iii) toxicity assessment; and,

iv) risk characterization.

A description of the various steps involved, with specific reference to the current assessment, is provided below.

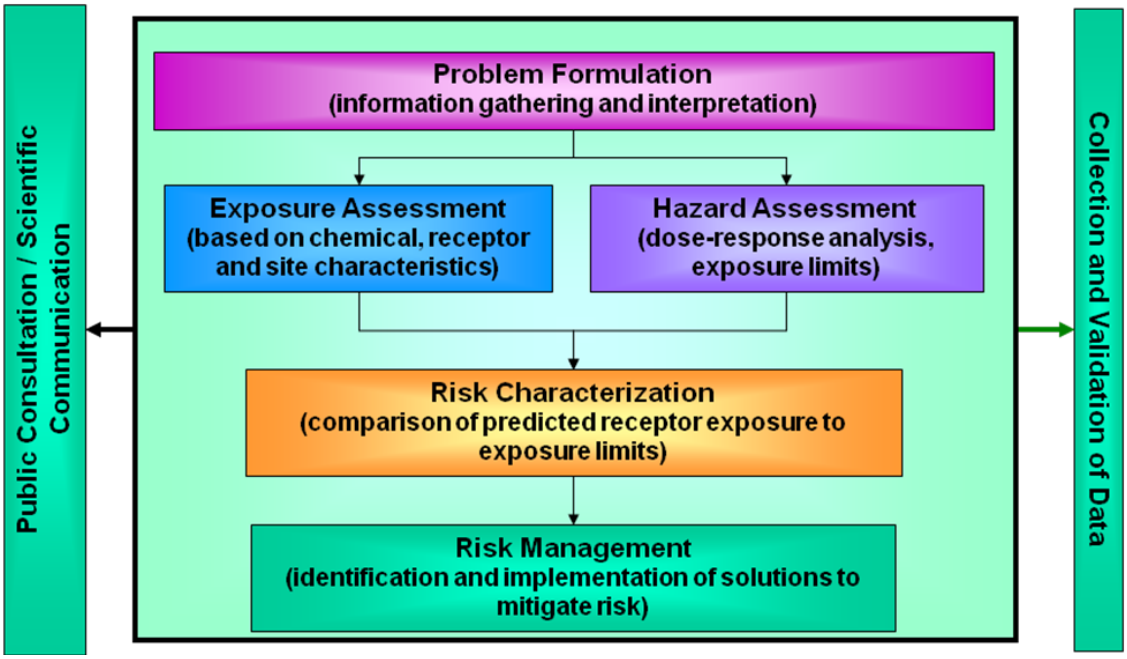

Figure 2-1 Overview of Standard Risk Assessment Framework

2.1 Problem Formulation

The first step in the HHRA process is an information gathering and interpretation stage that plans and focuses the study on critical areas of concern for the proposed project. Problem formulation defines the nature and scope of the work to be conducted, permits practical boundaries to be placed on the overall scope of work and ensures that the assessment is directed at the key areas and issues of concern.

The Problem Formulation step of the paradigm was principally concerned with defining the overall scope and nature of the SLHHRA, with consideration given to:

- characterization of the proposed facility;
- the air contaminants of interest (hereafter referred to as the chemicals of concern or COCs);
- the receptors of interest; and,
- the exposure scenarios and pathways to be assessed.

The following subsections describe the methodological details and outcomes of problem formulation, specific to identification of chemicals, receptors and pathways. Decisions with respect to the selection of each of the above items to be examined as part of the SLHHRA were made based on the data provided by RWDI for use in current the assessment.

2.1.1 Site Characterization: Emission Sources and Contaminants Identified for the Proposed Facility

Air contaminant sources included in the assessment of the proposed Brandon Biomedical Waste Treatment Facility include a new biomedical waste incinerator, natural gas-fired Cleaver Brooks Model boilers, diesel generators, and large and small dryers in laundry (RWDI, 2013a). General ventilation exhausts from the facility that only discharge uncontaminated air from the workspaces or process areas have been considered to be negligible and were not identified as sources from the facility (RWDI, 2013a). The location of the proposed biomedical waste incinerator is shown in Figure 2-2.

More specifically, sources in RWDI's air quality assessment included (RWDI, 2013a):

- A new biomedical waste incinerator exhausting to the atmosphere at a rate of 0.87 cubic meters per hour, through a 0.30 meter diameter stack height, which discharges at a height of 12 meters, above grade.
- Three natural gas-fired Cleaver Brooks Model boiler, designated Boiler850 (CB-200-700-150), Boiler600 (WT-200-CN2) and Boiler900 (WT–200-CN3) with maximum heat input of 29,291,000, 44,669,000 and 52,285,000 BTU/h, respectively.
    - Boiler (CB-200-700-150) exhausts to the atmosphere at an approximate volumetric flow rate of 3.4 cubic meters per second, exit velocity of 6.045 meter per second through a stack having an inner diameter of 0.85 meters, extending 25 meters above grade.
    - Boiler (W-200-CN2) exhausts to the atmosphere at an approximate volumetric flow rate of 5.24 cubic meters per second, exit velocity of 18.5 meter per second through a stack having an inner diameter of 0.6 meters, extending 25 meters above grade.
    - Boiler (W-200-CN3) exhausts to the atmosphere at an approximate volumetric flow rate of 6.12 cubic meters per second, exit velocity of 9.62 meter per second through a stack having an inner diameter of 0.9 meters, extending 25 meters above grade.
- Two diesel generators that burn 70 USgal/h of diesel at 100% load (each) and inner diameter of 0.3 meters, with the release height of 14.7 meters.
- Two large dryers in laundry – Washex Challenge (702239 and 702237), with maximum gas input of 22,000,000 BTU/h each, with 0.5 meters (18 or 20") diameter exhaust stacks, and height of 11.5 meters.

- Two small dryers in laundry – American Dryer Corp. (580021 and 580022), with maximum input of 550,000 BTU/h each, with 0.45 meters (18") diameter and high of 11.5 meters of exhaust stacks.

Figure 2-2 Site Location

Chemical parameters addressed as part of RWDI's air quality assessment of emission sources were limited to contaminants for which testing data were available from the Canadian Environmental Technology Verification Program (RWDI, 2013a). These parameters include:

- Particulate Matter (PM)
- Lead (Pb)
- Manganese (Mn)
- Chromium (Cr)
- Copper (Cu)
- Arsenic (As)
- Nickel (Ni)
- Cadmium (Cd)
- Mercury (Hg)
- Dioxin/Furan
- Sulphur Dioxide (SO_2)
- Nitrogen Oxides (NO_x)
- Carbon Monoxide (CO)
- Hydrogen Chloride (HCL)
- Hydrogen Fluoride (HF)
- Organic Compounds

2.1.2 Chemical Characterization

All chemicals included in the Air Quality Results Memo and accompanying dataset (RWDI, 2013a,b), with the exception of "Organic Compounds", were retained as COCs in the SLHHRA and were assessed *via* direct inhalation.

Criteria Air Contaminants (CACs)	***Metals/Other Inorganics***
• Carbon Monoxide (CO) • Nitrogen Oxides (NO_x) • Particulate Matter ($PM_{2.5}$) • Sulphur Dioxide (SO_2)	• Arsenic • Cadmium • Chromium • Copper • Hydrogen Chloride • Hydrogen Fluoride • Lead • Manganese • Mercury • Nickel
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)	
• 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) TEQ (as a surrogate for the Dioxins/Furans group)	

As indicated by RWDI (2013b), the Canadian Environmental Technology Verification Program did not speciate the compounds listed in the "Organic Compounds" group. Data for "Organic Compounds" were not considered within the SLHHRA since the breakdown of compounds within this group was not available.

As a conservative estimate, the modelled concentration data for particulate matter were assumed to be representative of fine particulate, below 2.5 µm in diameter (*i.e.,* PM2.5), (RWDI, 2013b).

2.1.3 Receptor Characterization

A human receptor is a hypothetical person (*e.g.*, infant, toddler, child, adolescent, or adult) who resides and/or works in the area being investigated and is, or could potentially be, exposed to the chemicals identified as being of potential concern. The assessment must be sufficiently comprehensive to ensure inclusion of those receptors with the greatest potential for exposure to COCs, and those who have the greatest sensitivity, or potential for developing adverse health outcomes from these exposures. The receptors of primary interest in the SLHHRA were people

who might reside near the proposed facility or who might frequent areas close to the facility for recreational, work-related or other purposes.

For the assessment of inhalation risks, as a straight comparison between predicted short term, acute (*e.g.*, for 1-hour, 8-hour and 24-hour exposure durations) and long term, chronic (*i.e.*, annual average exposures) air concentrations and the corresponding exposure limit is made, the resulting inhalation risk is receptor-independent (*i.e.*, the same value is calculated for all receptor types).

2.1.4 Exposure Scenarios and Pathways

Under a 'worst-case' exposure scenario, the location of the maximum modelled concentration (or the maximum point of impingement, MPOI) was evaluated in the SLHHRA. Maximum modelled concentrations were identified from off-site locations (*i.e.*, outside the property boundary depicted in Figure 2-2) within the air dispersion modelling domain. The modelling domain was 13.2 km x 13.2 km from the approximate midpoint of the property (RWDI, 2013b pers. comm.).

In addition to the location of the maximum modelled concentration, six discrete 'sensitive' receptor locations were selected for evaluation (Figure 3-3) since the proposed facility is to be located at the Brandon Regional Health Centre in an area with surrounding residential/community dwellings. These receptor locations were selected by RWDI (2013a,b).

Table 2-1 Discrete Receptor Locations

Location Code	*Receptor Identification*	*Easting*	*Northing*
R1	Retirement Home	432522.3676	5521390.427
R2	Residence	432893.5094	5521161.254
R3	Residence	432800.5382	432800.5382
R4	King George School	432893.1425	5521338.834
R5	Residence	433092.9034	5521129.812
R6	Residence	432690.0744	5521015.38

The primary exposure pathway evaluated in the SLHHRA was the inhalation of the COCs by individuals living, working or playing within the vicinity of the proposed treatment facility. Exposure pathways related to the deposition of COCs onto soils (*i.e.*, oral and dermal exposures) were not evaluated in the current assessment.

It is important to note that by assessing the most sensitive and highly exposed receptor locations (*e.g.*, the location of the highest potential inhalation exposures, toddlers living in the closest residence to the facility), one is inherently being protective of all other less sensitive or highly exposed receptor locations (*i.e.*, residences or schools at a greater distance from the facility). This is a standard tenant of risk assessment. As such, one does not need to assess every single residential location within the general vicinity of the facility to ensure an accurate evaluation of community risk – those not specifically assessed are accounted for by assessing those locations that are the most sensitive.

2.2 Exposure Assessment

The exposure assessment evaluated data related to all COCs, exposure scenarios and receptors identified in the problem formulation. The SLHHRA addressed only the inhalation pathway of exposure. Specific rates of exposure were not calculated but rather human exposures were conservatively assumed to be equal to ground-level air concentrations of COCs

(in µg/m^3). This inhalation exposure identified potential health risks from acute and chronic exposures (*via* direct air inhalation only) for all of the COC at each of the assessed human health receptor locations.

2.2.1 Estimation of Ground-Level Air Concentrations

Table 2-2 provides a summary of the predicted ground-level air concentrations for each COC at the location of the maximum modelled concentration and at the discrete receptor locations of interest. These ground-level air concentrations were used to evaluate potential health risks arising from acute and chronic exposures COCs in the vicinity of the proposed treatment facility.

Ground-level air concentrations (*i.e.*, exposure concentrations) for each of the COCs were predicted based upon the results of air dispersion modelling. Predicted annual average concentrations were predicted for all COCs. Predicted ground-level air concentrations for other exposure durations (*i.e.*, 1-hour, 8-hour, 24-hour and 30-day) were provided by RWDI (2013a) for only those COCs with associated Manitoba Ambient Air Quality Criteria.

It was assumed that ground-level air concentrations predicted for chromium and mercury represent a measure of total chromium and mercury, respectively. Based on guidance from RWDI (2013b), particulate matter was assumed to be all below 2.5 µm in diameter (*i.e.*, $PM_{2.5}$) as a conservative estimate. Further, speciation data for the air mixture of dioxins/furans was not provided. Therefore, it was assumed that the ground-level air concentration of dioxins/furans provided is equivalent to a total toxicity equivalent (TEQ) concentration for the mixture of dioxins and furans (i.e., conservatively assumed the provided concentration is equivalent to 100% 2,3,7,8-tetrachlorodibenzo-p-dioxin).

Table 2-2 Summary of Predicted Ground-Level Air Concentrations (µg/m^3)

Chemicals of Concern	*Maximum Concentration*	*Discrete (Sensitive) Receptor Locations*					
		R1	***R2***	***R3***	***R4***	***R5***	***R6***
1-Hour Concentrations							
Criteria Air Contaminants							
Carbon Monoxide	151	50	48	49	51	33	38
Hydrogen Chloride	1.0	0.69	0.37	0.56	0.41	0.20	0.52
Nitrogen Oxides	180	65	58	61	63	41	48
Sulphur Dioxide	2.3	1.6	0.85	1.3	0.94	0.46	1.2
Metals/ Inorganics							
Chromium	0.031	0.022	0.01152	0.01741	0.01269	0.00618	0.01632
8-Hour Concentrations							
Criteria Air Contaminants							
Carbon Monoxide	105	34	34	29	28	22	26
24-Hour Concentrations							
Criteria Air Contaminants							
Hydrogen Chloride	0.36	0.15	0.17	0.16	0.10	0.07	0.20
Hydrogen Fluoride	0.025	0.010	0.012	0.011	0.0067	0.0045	0.014
Nitrogen Oxides	79	32	29	23	27	19	22
Particulate Matter[a]	6.1	2.5	2.3	1.8	2.2	1.5	1.8
Sulphur Dioxide	0.84	0.34	0.40	0.37	0.23	0.15	0.46
Metals/Inorganics							
Arsenic	0.011	0.0046	0.0054	0.0049	0.0031	0.0020	0.0062
Cadmium	0.000023	0.0000091	0.000011	0.000010	0.0000061	0.0000041	0.0000124
Chromium	0.011	0.0046	0.0054	0.0049	0.0031	0.0020	0.0062
Copper	0.011	0.0046	0.0054	0.0049	0.0031	0.0020	0.0062
Lead	0.011	0.0046	0.0054	0.0049	0.0031	0.0020	0.0062
Manganese	0.011	0.0046	0.0054	0.0049	0.0031	0.0020	0.0062
Mercury	0.000068	0.000027	0.000032	0.000030	0.000018	0.000012	0.000037
Nickel	0.011	0.0046	0.0054	0.0049	0.0031	0.0020	0.0062
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)							
Dioxin/Furan	6.1E-10	2.5E-10	2.9E-10	2.7E-10	1.7E-10	1.1E-10	3.3E-10
30-Day Concentrations							
Hydrogen Fluoride	0.0061	0.0016	0.0040	0.0024	0.0018	0.0016	0.0018
Lead	0.00276	0.00071	0.00182	0.00108	0.00081	0.00071	0.00084
Annual Average Concentrations							
Criteria Air Contaminants							
Carbon Monoxide	9	2.0	4.6	2.5	2.7	2.9	1.6
Hydrogen Chloride	0.070	0.010	0.027	0.014	0.012	0.011	0.011
Hydrogen Fluoride	0.00480	0.00071	0.0019	0.0010	0.00083	0.00073	0.00074
Nitrogen Oxides	11	2.5	5.8	3.2	3.4	3.5	2.0

Table 2-2 Summary of Predicted Ground-Level Air Concentrations (µg/m^3)

Chemicals of Concern	*Maximum Concentration*	*Discrete (Sensitive) Receptor Locations*					
		R1	*R2*	*R3*	*R4*	*R5*	*R6*
Particulate Matter[a]	0.9	0.21	0.47	0.25	0.27	0.28	0.16
Sulphur Dioxide	0.161	0.024	0.063	0.032	0.028	0.025	0.025
Metals/ Inorganics							
Arsenic	0.00218	0.00032	0.00085	0.00044	0.00038	0.00033	0.00034
Cadmium	0.00000436	0.00000065	0.0000017	0.00000087	0.00000076	0.00000066	0.00000068
Chromium	0.00218	0.00032	0.00085	0.00044	0.00038	0.00033	0.00034
Copper	0.00218	0.00032	0.00085	0.00044	0.00038	0.00033	0.00034
Lead	0.00218	0.00032	0.00085	0.00044	0.00038	0.00033	0.00034
Manganese	0.00218	0.00032	0.00085	0.00044	0.00038	0.00033	0.00034
Mercury	0.0000131	0.0000019	0.0000051	0.0000026	0.0000023	0.0000020	0.0000020
Nickel	0.00218	0.00032	0.00085	0.00044	0.00038	0.00033	0.00034
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)							
Dioxin/Furan	1.2E-10	1.7E-11	4.6E-11	2.4E-11	2.0E-11	1.8E-11	1.8E-11

[a] Particulate matter assumed to be all below 2.5 µm in diameter (*i.e.*, $PM_{2.5}$) as a conservative estimate (RWDI, 2013b).

2.3 Toxicity Assessment

The toxicity assessment involves identifying and understanding potential health outcomes that can result from exposure to each COC and the conditions under which the outcomes might be observed. The toxicity, or hazard, assessment methodology is based on the fundamental 'dose-response' principle. That is, the response of biological systems to chemical exposures increases in proportion to the concentration of a chemical in critical target tissues where adverse health outcomes may occur. Careful consideration is given to understanding the influence of the amount, duration and frequency of exposure on the nature and severity of the health effects.

Two basic and quite different chemical categories are commonly recognized by regulatory agencies, depending on the compound's mode of toxic action, and applied when estimating toxicological criteria for humans (FDA, 1982; US EPA, 1989). These are the threshold approach (or the no-observed-adverse-effect levels [NOAELs]/benchmark dose with extrapolation/uncertainty factor approach) typically used to evaluate non-carcinogens, and the non-threshold approach (or the mathematical model-unit risk estimation approach), typically used for carcinogenic compounds.

In the case of threshold chemicals (*i.e.*, non-carcinogens), a benchmark or threshold level must be exceeded for toxicity to occur. A NOAEL can be identified for threshold chemicals, which is the dose or amount of the chemical that results in no observable response in the most sensitive test species and test endpoint. The application of uncertainty or safety factors to the NOAEL provides an added level of protection, allowing for derivation of an "exposure limit" (or toxicity reference value, TRV) that is expected to be safe to sensitive individuals following exposure for a prescribed period of time. Non-threshold chemicals are capable of producing cancer by altering genetic material. Regulatory agencies such as Health Canada and the US EPA assume that any level of long term exposure to carcinogenic chemicals is associated with some "hypothetical cancer risk". As a result, regulatory agencies have typically employed acceptable ILCR levels (*i.e*., over and above baseline) between 1-in-100,000 and 1-in-1,000,000.

The terminology used to define threshold and non-threshold TRVs differs according to the source and type of exposure and often varies between regulatory jurisdictions. Generic nomenclature has been developed, with the following terms and descriptions commonly used.

Reference concentration (RfC): A reference concentration (or RfC) refers to the acceptable level of an airborne chemical for which the primary route of exposure is inhalation, and applies to either short term acute (*e.g.*, 1-hour or 24-hour) or long term chronic exposure periods. It is expressed as a concentration of the chemical in air (*i.e.,* micrograms per cubic metre, $\mu g/m^3$) and applies only to chemicals acting through a threshold mode of toxicological action.

For chemicals such as irritants and some combustion gases, short term or acute non-systemic toxicity is frequently observed at the points of entry into the body (*i.e.*, the respiratory tract, eyes, and skin, for air-borne contaminants). In these cases, because the toxicity is enacted simply by direct contact between the receptor and the contaminated medium, the concentration in the air to which the receptor is exposed is the important measure of exposure, rather than the internal dose associated with multiple exposure pathways. For chemicals with these characteristics, short term RfCs are used to characterize health risk, and are intended to be protective of the general population.

Unit risk value: The US EPA defines a unit risk value as "…the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/L in water, or 1 µg/m^3 in air…". A unit risk value of 3.0 x 10^{-5} per µg/m^3 would mean that under an upper worst-case estimate, three excess cancer cases are expected to develop per one hundred thousand (100,000) people, if exposed every day for a lifetime to 1 µg of the chemical per m^3 of air.

The principal outcome of the toxicity assessment is the determination of exposure limits for the COCs. The limits are typically based on guidelines, objectives or standards established by reputable government agencies charged with the protection of public health, and are deliberately set at levels providing protection of even vulnerable members of the population. Since the nature and dynamics of the responses can vary depending on the duration of exposure, it was necessary to assign limits considered to be protective against effects caused by short-term exposure (acute exposure limits) and longer-term exposure (chronic exposure limits).

Exposure limits from the following sources were considered in the SLHHRA:

- Canada-Wide Standards (CWS) and National Ambient Air Quality Objectives (NAAQO);
- Health Canada Toxicological Reference Values (TRVs);
- Ontario Ministry of Environment Ambient Air Quality Criteria (AAQC);
- US Environmental Protection Agency Integrated Risk Information System (IRIS);
- US Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels;
- World Health Organization (WHO) and the International Programme on Chemical Safety (IPCS);
- Office of Environmental Health Hazard Assessment, California Environmental Protection Agency (Cal EPA) reference exposure levels; and,
- Texas Commission on Environmental Quality (TCEQ) effects screening levels (ESLs) and reference values (ReVs).

Due to the screening-level nature of this assessment and the lack of data on speciation of COCs emitted from the proposed facility, a conservative approach was applied to the selection of exposure limits. When exposure limits for a particular COC were available from multiple regulatory agencies, the lowest, scientifically-defensible value with full supporting documentation was typically selected. The scientific basis, date of last major review (it must be based on up to date science), and relevance in terms of duration and route of exposure were also among considerations.

The acute, sub-chronic and chronic (non-carcinogenic and carcinogenic) inhalation exposure limits for each COC evaluated in the current assessment are provided below (Tables 2-3 and 2-4). It is recognized that these values do not generally correspond with those ambient air quality criteria applied in the Air Quality Results Memo by RWDI (2013a). In this report, RWDI typically compared modelled air concentrations to Manitoba's Ambient Air Quality Criteria. Manitoba's criteria were not selected as the most appropriate health-based exposure limits for the SLHHRA due to the general lack of supporting documentation regarding the derivation of these values. In some cases, Manitoba's AAQCs are considered outdated (*i.e.*, values have been adopted from other agencies but are no longer recommended by the source agency). For comparative purposes, Manitoba's Ambient Air Quality Criteria are provided in Table 2-5.

As discussed, annual average ground-level air concentrations were provided for all COCs while predicted ground-level air concentrations for other exposure durations were provided by RWDI (2013a) for only those COCs with associated Manitoba Ambient Air Quality Criteria. Inhalation exposure limits for corresponding exposure durations were considered in the SLHHRA. Therefore, acute (1-hour) inhalation assessments were not conducted for hydrogen fluoride, arsenic, copper, mercury or nickel despite the availability of applicable exposure limits since 1-hour ground-level air concentrations were not provided for these COCs.

2.3.1 Acute and Sub-chronic Inhalation Exposure Limits

The acute and sub-chronic (*i.e.*, 1-hour, 8-hour, 24-hour and 30-day exposure durations) non-carcinogenic inhalation exposure limits for each of the COCs, as well as the key critical health outcomes and regulatory source for each exposure limit, are provided in Table 2-3.

Table 2-3 Acute and Sub-chronic Non-carcinogenic Inhalation Exposure Limits

Chemical of Concern	*Exposure Limit ($\mu g/m^3$)*	*Duration*	*Basis or Critical Effect*	*Source*
Criteria Air Contaminants				
Carbon Monoxide	15,000	1-hour	Carboxyhemoglobin blood level of less than 1%	Health Canada, 2006
	6,000	8-hour	Carboxyhemoglobin blood level of less than 1%	Health Canada, 2006
Hydrogen Chloride	190	1-hour	Upper and lower respiratory symptoms (humans)	TCEQ, 2009a; 2013
	20	24-hour	Health-based	MOE, 2012
Nitrogen Oxides	200	1-hour	Effects in the pulmonary function of asthmatics	WHO, 2005; 2006
	200	24-hour	Respiratory irritant	WHO, 2005; 2006; MOE 2012
Particulate Matter ($PM_{2.5}$)	25	24-hour	Lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase	WHO, 2005; 2006
Sulphur Dioxide	450	1-hour	Respiratory irritant	Health Canada, 2006
	20	24-hour	Respiratory irritant	WHO, 2005; 2006
Metals/ Inorganics				
Arsenic	0.3	24-hour	Irritation, sensitization, immunosuppression, teratogenesis, genotoxicity and carcinogenicity in exposed individuals	MOE, 2004; 2012
Cadmium	0.025	24-hour	Kidney effects; cancer	MOE, 2007a; 2012
Chromium (total)	3.6[a]	1-hour	Increased precursor enzymes that are early indicators of lung damage	TCEQ, 2009b; 2013
	0.5[b]	24-hour	Health-based	MOE, 2012
Copper	50	24-hour	Health-based	MOE, 2012
Lead	0.5	24-hour	Neurological effects in children	MOE, 2007b; 2012
	0.2	30-day	Neurological effects in children	MOE, 2007b; 2012
Manganese	0.4[c]	24-hour	Health-based	MOE, 2012
Mercury (total)	2	24-hour	Health-based	MOE, 2012
Nickel	0.2[d]	24-hour	Health-based (carcinogenic and non-carcinogenic effects)	MOE, 2011a; 2012

Table 2-3 Acute and Sub-chronic Non-carcinogenic Inhalation Exposure Limits				
Chemical of Concern	***Exposure Limit ($\mu g/m^3$)***	***Duration***	***Basis or Critical Effect***	***Source***
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)				
2,3,7,8-TCDD TEQ	1.0E-07[e]	24-hour	Health-based (developmental effects)	MOE, 2011b; 2012

[a] Reference value for "all compounds except hexavalent chromium" (TCEQ, 2009b).
[b] Ambient air quality criteria for metallic, divalent and trivalent forms (MOE, 2012).s
[c] Ambient air quality criteria for manganese in TSP (MOE, 2012).
[d] Ambient air quality criteria for nickel in TSP (MOE, 2012).
[e] As per MOE (2012a), the AAQC for dioxins, furans, and dioxin-like PCBs requires the calculation of the total toxicity equivalent (TEQ) concentration for comparison to exposure limit of 0.1 pg TEQ/m^3.

2.3.2 Chronic Inhalation Exposure Limits

Chronic non-carcinogenic and carcinogenic inhalation exposure limits for each of the COCs (where available), as well as the key critical health outcomes and regulatory source for each exposure limit are provided in Table 2-4.

Table 2-4 Chronic Non-carcinogenic and Carcinogenic Inhalation Exposure Limits						
Chemical of Concern	***Chronic Toxicity Reference Values***					
	Non-Carcinogenic Inhalation Exposure Limits ($\mu g/m^3$)			***Carcinogenic Inhalation Unit Risk Values ($\mu g/m^3)^{-1}$***		
	Value	***Basis or Critical Outcome***	***Source***	***Value***	***Basis or Critical Outcome***	***Source***
Criteria Air Contaminants						
Carbon Monoxide	NV	-	-	NC/NV	-	-
Hydrogen Chloride	9	Hyperplasia of nasal mucosa, larynx, and trachea (rats)	Cal EPA, 2008a	NC/NV	-	-
Hydrogen Fluoride	8.7	Increased bone density and skeletal fluorosis in workers	TCEQ, 2009a; 2013	NC/NV	-	-
Nitrogen Oxides	40	Increased risk of respiratory illness in children	WHO, 2005; 2006	NC/NV	-	-
Particulate Matter ($PM_{2.5}$)	8.8	Not provided	CCME, 2012	NC/NV	-	-
Sulphur Dioxide	29	Health and environmental effects	Health Canada, 2006	NC/NV	-	-
Metals/ Inorganics						
Arsenic	0.015	Decreased intellectual function in 10 year old children	Cal EPA, 2008b	0.00015	Occupational lung cancer	TCEQ, 2012
Cadmium	0.01	Kidney effects (10% increase in the prevalence of β2-microglobulin proteinuria)	ATSDR, 2012	0.0098	Detection of lung tumours (rats)	Health Canada, 2010
Chromium (total)	0.14[a]	Increased relative lung and trachea weight (rats)	TCEQ, 2012	0.011[b]	Lung cancer (humans)	Health Canada, 2010

Table 2-4 Chronic Non-carcinogenic and Carcinogenic Inhalation Exposure Limits						
Chemical of Concern	***Chronic Toxicity Reference Values***					
	Non-Carcinogenic Inhalation Exposure Limits (µg/m^3)			***Carcinogenic Inhalation Unit Risk Values (µg/m^3)$^{-1}$***		
	Value	***Basis or Critical Outcome***	***Source***	***Value***	***Basis or Critical Outcome***	***Source***
Copper	1	Respiratory and immunological effects	RIVM, 2001	NC/NV	-	-
Lead	0.2[c]	Neurological effects in children	MOE, 2007b; 2012	NC/NV	-	-
Manganese	0.09	Impairment of neurobehavioral function (humans)	Cal EPA, 2008b	NC/NV	-	-
Mercury (total)	0.03	Impairment of neurobehavioral function (humans)	Cal EPA, 2008b	NC/NV	-	-
Nickel	0.014[d]	Respiratory system; hematologic system	Cal EPA, 2012	0.0013[e]	Lung and nasal cancer; kidney, prostate and bucal cavity cancers	Health Canada, 2010
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)						
2,3,7,8-TCDD TEQ	4.0E-05	Increased mortality, decreased weight gain, lung and vascular changes (rats)	Cal EPA, 2008	NC/NV	-	-

NC/NV Non-carcinogenic and/or no value available.
[a] Reference value for "all compounds except hexavalent chromium" (TCEQ, 2009b).
[b] Inhalation unit risk for chromium (total),
[c] 30-day ambient air quality criteria adopted in absence of defensible chronic/annual average exposure limit.
[d] Value for nickel and nickel compounds (except nickel oxide).
[e] Value for oxidic (*i.e.*, nickel oxide, nickel–copper oxide, nickel silicate oxides, and complex oxides), sulphidic (*i.e.*, nickel subsulphide) and soluble (*i.e.,* includes water-soluble forms of nickel, primarily nickel sulphate and nickel chloride, as well as other more stable forms such as nickel-bearing sulphide minerals and nickel oxide).

2.3.3 Manitoba Ambient Air Quality Criteria

Manitoba Ambient Air Quality Criteria (AAQC) are summarized below (Table 2-5). With the exception of the 1-hour AAQC for hydrogen chloride, in all cases the Manitoba AAQC are less conservative than inhalation exposure limits adopted in the current assessment (see Tables 2-3 and 2-4). As such, a quantitative evaluation of risk based on the Manitoba's recommended AAQCs was not conducted. Acute (1-hour) inhalation risks for hydrogen chloride were calculated using both sets of exposure limits.

Table 2-5 Summary of Manitoba Ambient Air Quality Criteria (Government of Mantioba, 2005)				
Chemical of Concern	***AAQC (µg/m^3)[a]***	***Duration***	***Basis***	***Source***
Criteria Air Contaminants				
Carbon Monoxide	35,000	1-hour	Not provided	Fisheries and Environment Canada, November 1976. Criteria for National Air Quality Objectives; Federal - Provincial Committee on Air Pollution, 1982. Environment Canada. Unpublished.
	15,000	24-hour		

Table 2-5	Summary of Manitoba Ambient Air Quality Criteria (Government of Mantioba, 2005)			
Chemical of Concern	***AAQC ($\mu g/m^3$)[a]***	***Duration***	***Basis***	***Source***
Hydrogen Chloride	100	1-hour	Not provided	Environment Management Division, 1982. Tentative Guideline. Manitoba Department of Environment and Workplace Safety and Health.
Hydrogen Fluoride	0.85	24-hour	Not provided	Federal - Provincial Committee on Air Pollution, 1975. Environment Canada. Unpublished.
	0.35	30-day		
Nitrogen Dioxide	400	1-hour	Not provided	Fisheries and Environment Canada, November 1976. Criteria for National Air Quality Objectives; Federal - Provincial Committee on Air Pollution, 1982. Environment Canada. Unpublished.
	200	24-hour		
	100	annual arithmetic mean		
Particulate Matter ($PM_{2.5}$)	30	24-hour	Not provided	Canadian Council of Ministers of the Environment. 2000. Canada-Wide Standards for Particulate Matter (PM) and Ozone.
Sulphur Dioxide	900	1-hour	Not provided	Fisheries and Environment Canada, November 1976. Criteria for National Air Quality Objectives; Federal - Provincial Committee on Air Pollution, 1982. Environment Canada. Unpublished.
	300	24-hour		
	60	annual arithmetic mean		
Metals/ Inorganics				
Arsenic	0.3	24-hour	Not provided	Ontario Ministry of the Environment (MOE), September 2001. Summary of Point of Impingement Standards, Point of Impingement Guidelines, and Ambient Air Quality Criteria (AAQCs).
Cadmium	2	24-hour	Not provided	Ontario MOE, September 2001. Summary of Point of Impingement Standards, Point of Impingement Guidelines, and Ambient Air Quality Criteria (AAQCs). Standards Development Branch.
Chromium[b]	4.5 (as Cr+6)	1-hour	Not provided	Environment Management Division, 1985. Internal Tentative Guideline. Manitoba Department of Environment and Workplace Safety and Health.
Copper	50	24-hour	-	Ontario MOE, September 2001. Summary of Point of Impingement Standards, Point of Impingement Guidelines, and Ambient Air Quality Criteria (AAQCs). Standards Development Branch.
Lead	2	24-hour	Not provided	Hazardous Contaminants Branch, October 1993. Rationale for the Development of Soil, Drinking Water, and Air Quality Criteria for Lead. Ontario Ministry of Environment and Energy.
Manganese	NV	-	-	-
Mercury (total)	NV	-	-	-
Nickel	2	24-hour	Not provided	Ontario MOE, September 2001. Summary of Point of Impingement Standards, Point of Impingement Guidelines, and Ambient Air Quality Criteria (AAQCs). Standards Development Branch.
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)				
Dioxins/Furans	NV	-	-	-

NV No value
[a] Maximum Acceptable Level Concentrations
[a] Listed in Manitoba AAQC as chromic acid.

2.4 Risk Characterization

Risk characterization involves the estimation, description, and evaluation of risk associated with exposure to COPs by comparing the estimated exposure (identified in the exposure assessment) to the appropriate exposure limit (identified during the toxicity assessment). The risk characterization was concerned with quantifying the potential human health risks to potentially sensitive receptors who might reside near the proposed facility or who might frequent areas close to the facility (*e.g.*, for recreational, work-related or other purposes) and could be exposed COCs released in facility emissions. Risk estimates were segregated into acute/sub-chronic inhalation and chronic inhalation durations.

The methods used in the characterization of potential human health risks are detailed below, and results of the assessment are outlined in Section 3.0.

2.4.1 Concentration Ratios (CRs) for Non-carcinogens

Concentration ratio (CR) values were used to evaluate the acute and chronic health risk from exposure to non-carcinogenic chemicals *via* inhalation. CR values were calculated by dividing the predicted ground-level air concentration (for 1-hour, 24-hour or annual average exposure durations) by the appropriate exposure limit (*i.e.*, RfC), according to the following example equation:

$$CR_{duration} = \frac{[Air]_{duration}}{RfC_{duration}}$$

Where:

$CR_{duration}$	=	the duration-specific *CR* (unitless), calculated for 1-hour, 8-hour, 24-hour, 30-day and chronic durations, as appropriate
$[Air]_{duration}$	=	the predicted ground-level air concentration (µg/m^3) for the specific time duration
$RfC_{duration}$	=	the RfC (µg/m^3) for the specific time duration

An acceptable benchmark of 1.0 (*i.e.*, 100% of the exposure limit) was used in the SSLHRA. Acute and chronic CR values less than the selected benchmark (*i.e.*, CR ≤1.0), indicate that estimated COC concentrations in air are less than the applicable exposure limit or RfC. Thus, adverse health outcomes would not be expected to occur, even considering sensitive members of the population.

When predicted risks were greater than the benchmark level (*i.e.*, CR > 1.0), this may indicate the potential for adverse health outcomes in sensitive individuals or in some of the exposure scenarios considered. This outcome is referred to as an "exceedance" (*i.e.*, predicted ground-level air concentrations are greater than, or exceed, the corresponding exposure limit for that averaging period). Re-evaluation of such CRs is important since both the exposure estimates and the toxicological criteria are based on a series of conservative assumptions, particularly when considering the maximum "worst-case" exposure scenario (*i.e.*, the location of the maximum concentration).

Interpretation of the risk estimates proceeded as follows:

CR ≤1. Signifies that the estimated exposure is less than or equal to the exposure limit (i.e., the assumed safe level of exposure). This shows that negligible health risks are predicted. Added assurance of protection is provided by the high degree of conservatism (protection) incorporated in the derivation of the exposure limit.

CR >1. Signifies the exposure estimate exceeds the regulatory exposure limit. This suggests that the potential for an elevated level of risk may be present for some COC. The significance of which must be balanced against the high degree of conservatism incorporated in the risk assessment (i.e., the margin of safety is reduced but not removed entirely).

2.4.2 Incremental Lifetime Cancer Risks (ILCRs) for Carcinogens

In the case of non-threshold genotoxic carcinogenic chemicals, potential risks are expressed as incremental lifetime cancer risks (ILCRs). ILCR estimates represent the incremental risk of an individual within a given population developing cancer over his or her lifetime due to exposures from a specific carcinogenic chemical of concern. ILCRs consider risks related to a particular facility (facility only) in that the cancer risks are expressed on an incremental or additional basis as compared to cancer risks related to all sources.

For those carcinogenic chemicals evaluated as part of the SLHHRA (*i.e.,* arsenic), ILCR estimates resulting from direct air inhalation were calculated as follows:

$$ILCR = [Air]_{Facility} \times IUR$$

Where:

ILCR	=	the incremental (or additional) lifetime cancer risk (unitless)
$[Air]_{Facility}$	=	the predicted annual average ground-level air concentration (µg/m^3) for the specific chemical arising from emissions from specific facility type
IUR	=	the COC-specific inhalation unit risk (µg/m^3)$^{-1}$

The definition of a benchmark ILCR of is a policy-based decision (not a scientifically derived value), based on the assumption that any level of long term exposure to a carcinogenic compound is associated with some “hypothetical cancer risk”. A benchmark ILCR of 1-in-100,000 (1.0 x 10^{-5}) was selected in the current assessment based on Health Canada policy for risk assessments. An ILCR of 1-in-100,000 increases a person’s lifetime cancer risk from 0.40000 (based on the 40% lifetime probability of developing cancer in Canada) to 0.40001.

ILCR ≤ 1.0 x 10^{-5}. Signifies a negligible or *de minimus* incremental lifetime cancer risk (*i.e.*, less than one extra cancer case in a population of 100,000 people).

ILCR > 1.0 x 10^{-5}. Signifies the estimated exposure results in an incremental lifetime cancer risk greater than the acceptable regulatory-established cancer risk benchmark of 1-in-100,000 (*i.e.,* one extra cancer case in a population of 100,000 people). This suggests that the potential for an elevated level of risk may be present for some COPCs. The significance of the risk should be evaluated against the conservative assumptions used in the assessment.

3.0 RESULTS

The following section provides a summary of the results of the acute, sub-chronic and chronic assessment of inhalation risks. As noted previously, potential acute/sub-chronic human health inhalation risks were generally evaluated for 1-hour and 24-hour exposure periods as well as 8-hour exposure periods in the case of carbon monoxide and 30-day exposure periods in the case of hydrogen fluoride and lead. For the assessment of potential chronic human health risks, ground-level air concentrations were evaluated based upon an annual average exposure period.

3.1 Acute/Sub-Chronic Inhalation Assessment

Potential acute/sub-chronic human health inhalation risks were evaluated using 1-hour, 8-hour, 24-hour and 30-day (where relevant) exposures periods for individuals living, working or playing in the vicinity of the proposed facility. A summary of the predicted acute/sub-chronic non-cancer inhalation risks for each COC at the location of the maximum concentration and discrete receptor locations is provided in Table 3-1.

Results of the inhalation assessment indicated that predicted acute and sub-chronic risks were considered acceptable for each COC at the location of the maximum concentration and all discrete receptor locations.

Table 3-1 Acute/Sub-chronic Inhalation Risk Predictions

Chemicals of Concern	Maximum Concentration	Concentration Ratios (CRs)					
		R1	R2	R3	R4	R5	R6
1-Hour Concentrations							
Criteria Air Contaminants							
Carbon Monoxide	1.0E-02	3.3E-03	3.2E-03	3.3E-03	3.4E-03	2.2E-03	2.5E-03
Hydrogen Chloride	5.3E-03	3.6E-03	1.9E-03	2.9E-03	2.2E-03	1.1E-03	2.7E-03
Nitrogen Oxides	9.0E-01	3.3E-01	2.9E-01	3.1E-01	3.2E-01	2.1E-01	2.4E-01
Sulphur Dioxide[a]	5.1E-03	3.6E-03	1.9E-03	2.9E-03	2.1E-03	1.0E-03	2.7E-03
Sulphur Dioxide[b]	1.0E-02	6.9E-03	3.7E-03	5.6E-03	4.1E-03	2.0E-03	5.2E-03
Metals/ Inorganics							
Chromium	8.6E-03	6.1E-03	3.2E-03	4.8E-03	3.5E-03	1.7E-03	4.5E-03
8-Hour Concentrations							
Criteria Air Contaminants							
Carbon Monoxide	1.8E-02	5.7E-03	5.7E-03	4.8E-03	4.7E-03	3.7E-03	4.3E-03
24-Hour Concentrations							
Criteria Air Contaminants							
Hydrogen Chloride	1.8E-02	7.5E-03	8.5E-03	8.0E-03	5.0E-03	3.5E-03	1.0E-02
Hydrogen Fluoride[c]	2.9E-02	1.2E-02	1.4E-02	1.3E-02	7.9E-03	5.3E-03	1.6E-02
Nitrogen Oxides	4.0E-01	1.6E-01	1.5E-01	1.2E-01	1.4E-01	9.5E-02	1.1E-01
Particulate Matter[d]	2.4E-01	1.0E-01	9.2E-02	7.2E-02	8.8E-02	6.0E-02	7.2E-02
Sulphur Dioxide	4.2E-02	1.7E-02	2.0E-02	1.9E-02	1.2E-02	7.5E-03	2.3E-02
Metals/Inorganics							
Arsenic	3.7E-02	1.5E-02	1.8E-02	1.6E-02	1.0E-02	6.7E-03	2.1E-02
Cadmium	9.2E-04	3.6E-04	4.4E-04	4.0E-04	2.4E-04	1.6E-04	5.0E-04
Chromium	2.2E-02	9.2E-03	1.1E-02	9.8E-03	6.2E-03	4.0E-03	1.2E-02
Copper	2.2E-04	9.2E-05	1.1E-04	9.8E-05	6.2E-05	4.0E-05	1.2E-04
Lead	2.2E-02	9.2E-03	1.1E-02	9.8E-03	6.2E-03	4.0E-03	1.2E-02
Manganese	2.8E-02	1.2E-02	1.4E-02	1.2E-02	7.8E-03	5.0E-03	1.6E-02
Mercury	3.4E-05	1.4E-05	1.6E-05	1.5E-05	9.0E-06	6.0E-06	1.9E-05
Nickel	5.5E-02	2.3E-02	2.7E-02	2.5E-02	1.6E-02	1.0E-02	3.1E-02
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)							
Dioxin/Furan	6.1E-03	2.5E-03	2.9E-03	2.7E-03	1.7E-03	1.1E-03	3.3E-03
30-Day Concentrations							
Hydrogen Fluoride[c]	1.7E-02	4.6E-03	1.1E-02	6.9E-03	5.1E-03	4.6E-03	5.1E-03
Lead	1.4E-02	3.6E-03	9.1E-03	5.4E-03	4.1E-03	3.6E-03	4.2E-03

[a] Calculated using the 1-hour exposure limit for hydrogen chloride derived by the TCEQ (2009a; 2013).
[b] Calculated using Manitoba's 1-hour Ambient Air Criteria.
[c] Calculated using the Manitoba Ambient Air Criteria in the absence of a scientifically-defensible exposure limit for hydrogen fluoride.
[d] Particulate matter assumed to be all below 2.5 µm in diameter (*i.e.*, $PM_{2.5}$) as a conservative estimate (RWDI, 2013b).

3.2 Chronic Inhalation Assessment

3.2.1 Chronic Inhalation Non-Cancer Risks

Potential chronic human health inhalation risks were evaluated using annual average exposures for individuals living, working or playing in the vicinity of the proposed facility. A summary of the predicted chronic non-cancer inhalation risks for each COC at the location of the maximum concentration and discrete receptor locations is provided in Table 3-2.

Results of the inhalation assessment indicated that predicted chronic non-cancer risks were considered acceptable for each COC at the location of the maximum concentration and all discrete receptor locations.

Table 3-2 Chronic Non-Cancer Inhalation Risk Predictions

Chemicals of Concern	*Location of Maximum Concentration*	*Discrete (Sensitive) Receptor Locations*					
		R1	*R2*	*R3*	*R4*	*R5*	*R6*
Criteria Air Contaminants							
Carbon Monoxide	-	-	-	-	-	-	-
Hydrogen Chloride	7.8E-03	1.1E-03	3.0E-03	1.6E-03	1.3E-03	1.2E-03	1.2E-03
Hydrogen Fluoride	5.5E-04	8.2E-05	2.2E-04	1.1E-04	9.5E-05	8.4E-05	8.5E-05
Nitrogen Oxides	2.8E-01	6.3E-02	1.5E-01	8.0E-02	8.5E-02	8.8E-02	5.0E-02
Particulate Matter[a]	1.0E-01	2.4E-02	5.3E-02	2.8E-02	3.1E-02	3.2E-02	1.8E-02
Sulphur Dioxide	5.6E-03	8.3E-04	2.2E-03	1.1E-03	9.7E-04	8.6E-04	8.6E-04
Metals/ Inorganics							
Arsenic	1.5E-01	2.1E-02	5.7E-02	2.9E-02	2.5E-02	2.2E-02	2.3E-02
Cadmium	4.4E-04	6.5E-05	1.7E-04	8.7E-05	7.6E-05	6.6E-05	6.8E-05
Chromium	1.6E-02	2.3E-03	6.1E-03	3.1E-03	2.7E-03	2.4E-03	2.4E-03
Copper	2.2E-03	3.2E-04	8.5E-04	4.4E-04	3.8E-04	3.3E-04	3.4E-04
Lead	1.1E-02	1.6E-03	4.3E-03	2.2E-03	1.9E-03	1.7E-03	1.7E-03
Manganese	2.4E-02	3.6E-03	9.4E-03	4.9E-03	4.2E-03	3.7E-03	3.8E-03
Mercury	4.4E-04	6.3E-05	1.7E-04	8.7E-05	7.7E-05	6.7E-05	6.7E-05
Nickel	1.6E-01	2.3E-02	6.1E-02	3.1E-02	2.7E-02	2.4E-02	2.4E-02
Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (Dioxins/Furans)							
Dioxin/Furan	3.0E-06	4.3E-07	1.2E-06	6.0E-07	5.0E-07	4.5E-07	4.5E-07

Bolded CR values in shaded cells indicate predicted risks exceeded the CR benchmark of 1.0 (*i.e.*, predicted ground-level air concentrations exceeded inhalation exposure limits).

- Chronic inhalation risk not calculated due to the lack of an applicable chronic inhalation exposure limit.

[a] Particulate matter assumed to be all below 2.5 µm in diameter (*i.e.*, $PM_{2.5}$) as a conservative estimate (RWDI, 2013b).

3.2.2 Chronic Inhalation Incremental Lifetime Cancer Risks

Potential incremental lifetime cancer inhalation risks were evaluated using annual average exposures for individuals living, working or playing in the vicinity of the proposed facility. A summary of the predicted ILCR inhalation risks for each COC at the location of the maximum concentration and discrete receptor locations is provided in Table 3-3.

Results of the inhalation assessment indicated that predicted ILCRs were considered acceptable for each COC at all discrete receptor locations. An elevated ILCR related to exposures to chromium was predicted at the location of the maximum ground-level air concentrations (*i.e.*, the estimated ILCR is above the acceptable risk level of $1.0x10^{-5}$).

The significance of this risk prediction should be evaluated against the conservative assumptions used in the assessment (*i.e.*, the degree of protection afforded by the exposure limits and the degree of conservatism incorporated into the exposure estimates). Various conservative exposure assumptions were applied in the assessment of chronic inhalation risks at the location of the maximum ground-level air concentration (*i.e.*, MPOI):

- Due to the screening-level nature of the assessment, risk predictions were made without consideration of facility-specific operating conditions. It was conservatively assumed that the proposed facility would be continually operating and releasing air emission (*i.e.*, 24-hours/day, 7 days/week, 52 weeks/year). However, it is expected that the proposed facility will be in operation 3 days a week, 8 hours per day for 50 weeks per year (RWDI, 2013a pers. comm.).
- No assumptions were made regarding the typical operating lifetime of the proposed facility or the residential occupancy or job tenure of a potential receptor in the area surrounding the facility. Instead, it was conservatively assumed that a receptor would be exposed to COCs at the maximum ground-level air concentration for a lifetime. This is a conservative assumption since the anticipated lifetime of the proposed facility is 20 years (RWDI, 2013a pers. comm.). Additionally, US EPA (2011) recommends 13 years (mean) and 46 years (95th percentile) for population mobility (*i.e.*, the length of time a household is exposed in a particular location).
- Receptors were assumed not to leave the MPOI for their entire lifetime. It is highly unlikely that an individual would reside chronically at the MPOI since the location of the maximum concentration is subject to change across time. This assumption contributes to the overall conservatism of the exposure assessment.

Given the degree of conservatism incorporated into the exposure assessment, it is likely that chronic inhalation cancer risks related to chromium emissions from the proposed facility are overstated. No unacceptable cancer risk is anticipated.

Table 3-3 Chronic Inhalation Cancer Risk Predictions

Chemical of Concern	*Incremental Lifetime Cancer Risk (ILCR)*						
	Location of Maximum Concentration	*R1*	*R2*	*R3*	*R4*	*R5*	*R6*
Metals/ Inorganics							
Arsenic	3.27E-07	4.80E-08	1.28E-07	6.60E-08	5.70E-08	4.95E-08	5.10E-08
Cadmium	4.27E-08	6.37E-09	1.67E-08	8.53E-09	7.45E-09	6.47E-09	6.66E-09
Chromium (total)	**2.40E-05**	3.52E-06	9.35E-06	4.84E-06	4.18E-06	3.63E-06	3.74E-06
Nickel	2.83E-06	4.16E-07	1.11E-06	5.72E-07	4.94E-07	4.29E-07	4.42E-07

Bolded ILCRs in shaded cells indicate predicted risks exceeded the ILCR benchmark of 1.0×10^{-5} (*i.e.*, 1.0E-05).

4.0 LIMITATIONS, UNCERTAINTY AND CONSERVATIVE ASSUMPTIONS

A high degree of conservatism was incorporated into the SLHHRA as a means to accommodate, in part, the uncertainties that can surround screening assessments of this type which are necessarily predictive in nature as well as to minimize the likelihood that any health risks would be overlooked or understated. The uncertainty was accommodated largely through the use of conservative assumptions that emphasized worst-case conditions, with the overall premise being that if risks were not revealed for these worst-case circumstances, very little likelihood would exist for adverse health impacts to occur under conditions that might reasonably be expected, despite the uncertainty involved.

Key conservative assumptions are outlined in Table 4-1.

Table 4-1 Major Assumptions Used in the SLHHRA

Risk Assessment Paradigm	***Assumptions and Discussion of Conservatism***
Problem Formulation	Receptor Locations: Due to the generic nature of the current assessment, worst-case receptor locations (*i.e.*, location of maximum concentrations - the MPOI) were considered within the SLHHRA. Additionally, ground-level air concentrations were evaluated at discrete 'sensitive' receptor locations.
Toxicity Assessment	Exposure limits have been developed by regulatory agencies with sufficient conservatism assure protection of the sensitive and more susceptible individuals within the general population (*e.g.*, infants and young children, the elderly, individuals with compromised health). A considerable amount of conservatism is incorporated in the Exposures Limits. These benchmarks are deliberately set by regulatory agencies with the protection of sensitive individuals in mind. Typically, the benchmarks used in the assessment were derived from the most sensitive health-related endpoints, and then adjusted to account for differences in sensitivity to chemicals among individuals. The use of 'uncertainty/safety factors' is intended to to account for both inter- and intra-species variability in sensitivity to COPCs and respect the need to protect vulnerable individuals within the population.
Exposure Assessment	Worst-case (maximum) predicted ground-level air concentrations were used in the calculation of risk predictions.
	Maximum predicted short term (*i.e.*, for 1-hour, 8-hour, 24-hour exposure durations) ground level air concentrations at each receptor location were used to evaluate all acute inhalation risk estimates under the worst-case scenario. In reality, the frequency with which the maximum would occur at any one receptor location varies with respect to the COC and the receptor location. Individual exposure to a 1-hour, 8-hour, or 24-hour maximum ground-level air concentration requires that a receptor (person) be present at the same time and duration of the maximum predicted air concentration anywhere within the 13.2 km x 13.2 km modelling domain .
	Due to the screening-level nature of the assessment, risk predictions were made without consideration of facility-specific operating conditions. It was conservatively assumed that the proposed facility would be continually operating and releasing air emission. However, it is expected that the proposed facility will be in operation only 3 days a week, 8 hours per day for 50 weeks per year (RWDI, 2013a pers. comm.).
	Receptors were assumed not to leave the MPOI for their entire lifetime. It is highly unlikely that an individual would reside chronically at the MPOI since the location of the maximum concentration is subject to change across time. This assumption contributes to the overall conservatism of the exposure assessment.
	In the assessment of chronic inhalation risks, no assumptions were made regarding the typical operating lifetime of a facility or the residential occupancy or job tenure of a potential receptor in the area surrounding a facility. In the prediction of chronic risks, this is an extremely conservative approach (*i.e.*, emissions are released from a facility for an indefinite duration and an exposed receptor could work, live, or play within the area surrounding a facility for an entire lifetime).

As discussed, the SLHHRA was designed to provide a preliminary indication of the potential health risks that could be presented from exposure to a select group of air contaminants emitted from the proposed facility and was not meant to serve as a detailed site-specific evaluation. Key limitations of the assessment include:

- background sources of the air contaminants within the area of the proposed facility and potential cumulative health risks were not considered;
- parameters identified as COCs by RWDI (2013a) were evaluated; this list was limited to contaminants for which testing data were available from the Canadian Environmental Technology Verification Program;
- the inhalation assessment addressed only those exposure durations for which ground-level air concentrations were provided by RWDI (2013a,b); annual average ground-level air concentrations were provided for all COCs while predicted ground-level air concentrations for other exposure durations were for only those COCs with associated Manitoba Ambient Air Quality Criteria;
- data for "Organic Compounds" were not considered within the SLHHRA since the breakdown of compounds within this group was not available;
- consideration was given to potential inhalation risks only; potential multi-media pathways of exposure (*i.e.*, oral or dermal exposures) associated with the deposition of particulates onto soil in the area surrounding the proposed facility were not evaluated;
- discrete 'sensitive' receptor locations selected for evaluation were limited to those selected by RWDI (2013a,b); and,
- ground-level air concentrations were predicted for off-site locations within a modelling domain of 13.2 km x 13.2 km area from the approximate midpoint of the facility property; exposure to potential on-site receptors were not considered within the scope of the assessment.

The results of this assessment are dependent on the quality and accuracy of the information (*i.e.*, air dispersion modelling results) supplied by RWDI.

5.0 SUMMARY CONCLUSIONS

Acute/Sub-Chronic Inhalation Assessment Results

- Predicted acute and sub-chronic risks were considered acceptable for each COC (*i.e.,* no acute/sub-chronic impacts to human health are expected) at the location of the maximum concentration and all discrete receptor locations.

Chronic Inhalation Assessment Results

- Predicted chronic non-cancer risks were considered acceptable for each COC at the location of the maximum concentration and all discrete receptor locations.
- Results of the chronic inhalation assessment indicated that, with the exception of chromium, predicted cancer risks (ILCRs) were considered acceptable for each COC the location of the maximum concentration and all discrete receptor locations.
- An elevated ILCR related to exposures to chromium was predicted at the location of the maximum ground-level air concentrations. However, given the degree of conservatism incorporated into the exposure assessment, it is likely that chronic inhalation cancer risks related to chromium emissions from the proposed facility are overstated.

Overall, results of the inhalation assessment indicate that there are no acute/sub-chronic or chronic impacts to human health expected as a result of predicted maximum ground-level air concentrations or concentrations predicted at any of the discrete receptor locations resulting from modelled emissions from the proposed facility.

6.0 DOCUMENT SIGN-OFF

The SLHHRA has been performed in accordance with accepted practice and usual standards of thoroughness and competence for the profession of toxicology and environmental RA. The information, opinions and recommendations provided within the aforementioned report have been developed using reasonable and responsible practices, and the report was completed to the best of our knowledge and ability.

Intrinsik Environmental Sciences Inc.

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Glenn Ferguson, Ph.D., QP_{RA}
Vice President – Eastern Region / Senior Scientist

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APPENDIX A

AIR QUALITY RESULTS MEMO AND ASSOCIATED DATASET OF GROUND-LEVEL AIR CONCENTRATIONS

RWDI
CONSULTING ENGINEERS & SCIENTISTS

CANADA'S BEST MANAGED COMPANIES

Memorandum

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Date: **July 4, 2013** **RWDI Reference #:** 1301084

To: Glenn Ferguson
Intrinsik Environmental Services Inc. **E-Mail:** gferguson@intrinsik.com

From: Nicole Korba **E-Mail:** Nicole.Korba@rwdi.com

Re: **Air Quality Results Memo**
Brandon Bio-Medical Waste EA
Brandon, Manitoba

Dear Glenn,

RWDI was retained by Brandon Regional Health Centre to complete additional studies requiring consideration in the hazardous disposal site license application and assembly of the draft Environmental Assessment (EA) Report for the proposed Brandon Biomedical Waste Treatment Facility. This report provides a brief description of the assessment of potential air quality impacts resulting from the proposed treatment facility.

Discription of Sources and Contaminants

The Prairie Mountain Health Area is proposing to install a biomedical waste incinerator with air pollution control system at the Brandon Regional Health Centre. Representative emission data estimates were obtained from testing conducted by The Canadian Environmental Technology Verification Program, on an Eco Burn Inc. Bio Waste Oxidizer system. Exhaust parameter estimates (flow / temperature) were obtained from testing conducted by Scan American Corporation on an Envikraft medical waste incinerator installed at the Szczecin Hospital in Poland. This information is provided on Table 1.

Figure 1.1 (M2.3) provides the site plan of the facility. General ventilation exhausts from the facility that only discharge uncontaminated air from the workspaces or process areas have been considered to be negligible and were not identified as sources from the facility.

Sources included in the assessment are listed below:

- A new biomedical waste incinerator exhausting to the atmosphere at a rate of 0.87 cubic meters per hour, through a 0.30 meter diameter stack height, which discharges at a height of 12 meters, above grade,
- Three (3) natural gas-fired Cleaver Brooks Model boiler, designated Boiler850 (CB-200-700-150), Boiler600 (WT-200-CN2) and Boiler900 (WT–200-CN3) with maximum heat input of 29,291,000, 44,669,000 and 52,285,000 BTU/h, respectively.
    - Boiler (CB-200-700-150) exhausts to the atmosphere at an approximate volumetric flow rate of 3.4 cubic meters per second, exit velocity of 6.045 meter per second through a stack having an inner diameter of 0.85 meters, extending 25 meters above grade.
    - Boiler (W-200-CN2) exhausts to the atmosphere at an approximate volumetric flow rate of 5.24 cubic meters per second, exit velocity of 18.5 meter per second through a stack having an inner diameter of 0.6 meters, extending 25 meters above grade.

- Boiler (W-200-CN3) exhausts to the atmosphere at an approximate volumetric flow rate of 6.12 cubic meters per second, exit velocity of 9.62 meter per second through a stack having an inner diameter of 0.9 meters, extending 25 meters above grade.

- Two diesel generators that burn 70 USgal/h of diesel at 100% load (EACH) and inner diameter of 0.3 meters, with the release height of 14.7 meters.
- Two large dryers in laundry – Washex Challenge (702239 and 702237), with maximum gas input of 22,000,000 BTU/h each, with 0.5 meters (18 or 20") diameter exhaust stacks, and height of 11.5 meters.
- Two small dryers in laundry – American Dryer Corp. (580021 and 580022), with maximum input of 550,000 BTU/h each, with 0.45 meters (18") diameter and high of 11.5 meters of exhaust stacks.

A total of 16 contaminants were identified with respect to the facility, emitted from a total of 10 sources. Of the identified contaminants, 12 have limits under the Manitoba Ambient Air Quality Criteria. For those contaminants that do not have relevant limits under the Manitoba Ambient Air Quality Criteria, relevant standards from Ontario were used. One of the contaminants does not a published limit, as it reflects a mixture of hydrocarbons.

Dispersion Modelling Assessment

All sources were modelled as point sources in the AERMOD dispersion model. The AERMOD model is an advanced dispersion model that is currently the primary regulatory dispersion model supported by the U.S. EPA, and has been approved for use in Canada by several jurisdictions. AERMOD is a steady-state Gaussian model that is capable of handling multiple emission sources. Within the model, receptor grids as well as discrete receptor locations of interest can be considered. In lieu of specific modelling guidance from the Province of Manitoba, the modelling assessment was conducted in accordance with the Ontario Ministry of the Environment Guideline A11: "Air Dispersion Modelling Guideline for Ontario", March 2009.

Two modelling scenarios were considered. The first scenario assessed the impact due to emissions from the new incinerator only, where it was the only source of a contaminant. For this scenario, the incinerator emissions were set to a unit emission rate of 1 g/s, which allows the predicted concentration to be scaled using the emission actual rate for each contaminant. In effect, the dispersion model results can be expressed as a concentration in $\mu g/m^3$ per g/s of emission.

The second scenario assessed the actual emission rate from the incinerator with other sources of like emissions. A separate model run was conducted for each such contaminant.

The modelling assessment was conducted for 1-hour, 8-hour and 24-hour averaging periods.

Results

The results of the dispersion modelling analysis are provided on Table 2. Predicted concentrations for all of the contaminants were found to be less than their respective criteria at all receptors in the area.

Modelling input and output files have been provided on a compact disc included in Appendix A.

Kind Regards,

Nicole Korba
Project Manager

NCK/kta

TABLES

Table 1: Incinerator Source and Emission Data

Incinerator Exhaust Parameters	Value	Unit
Temperature	1100	ºC, Actual
	1373	K, Actual
	25	ºC, Actual
	298	K, Reference
Flow Rate	3159	Am³/h
	0.878	Am³/s
	685.6	Rm³/h
	0.190	Rm³/s
Assumed Diameter	0.30	m
Exit Velocity	12.414	m/s

R refers to 25ºC, 1 atm, 11% O2

Flow conversion to Reference conditions $\frac{0.878\ Am^3}{1\ s} \times \frac{298\ K, R}{1373\ K, A} = 0.190\ m^3/s$

Contaminant	In-Stack Concentration Value	Unit	Emission Rate Value	Unit
PM	28.7	mg/Rm³	0.0055	g/s
Pb + Mn + Cr + Cu + As + Ni	0.5	mg/Rm³	0.00010	g/s
Pb				
Mn				
Cr				
Cu				
As				
Ni				
Cd	0.001	mg/Rm³	0.00000019	g/s
Hg	0.003	mg/Rm³	0.00000057	g/s
Dioxin/Furan	0.027	ng I-TEQ/Rm³	5.14E-12	g/s
SO2	37	mg/Rm³	0.0070	g/s
NOx	167	mg/Rm³	0.032	g/s
CO	8	mg/Rm³	0.0015	g/s
HCl	16	mg/Rm³	0.0030	g/s
HF	1.1	mg/Rm³	0.00021	g/s
Organic Compounds	9	mg/Rm³	0.0017	g/s

Table 2: Results of Dispersion Modelling Assessment at Location of Maximum Modelled Concentration

Contaminant	Modelled 1-hour Concentration	Modelled 8-hour Concentraion	Modelled 24-hour Concentraion	Modelled 30-Day Concentraion	Modelled Annual Concentraion	Manitoba 1-Hour Criteria	Manitoba 8-Hour Criteria	Manitoba 24-Hour Criteria [1]	Manitoba 30-Day Criteria	Manitoba 70-Day Criteria	Manitoba Annual Criteria
PM (assumed to be all PM2.5)	--	--	6.1 µg/m³	--	0.9 µg/m³	--	--	30 µg/m³	--	--	--
Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--	No Value	No Value	No Value	No Value	No Value	No Value
Pb	--	--	0.011 µg/m³	0.00276 µg/m³	0.00218 µg/m³	--	--	2 µg/m³	1 µg/m³	--	--
Mn	--	--	0.011 µg/m³	--	0.00218 µg/m³	--	--	0.4 µg/m³	--	--	--
Cr	0.031 µg/m³	--	0.011 µg/m³	--	0.00218 µg/m³	4.5 µg/m³	--	--	--	--	--
Cu	--	--	0.011 µg/m³	--	0.00218 µg/m³	--	--	50 µg/m³	--	--	--
As	--	--	0.011 µg/m³	--	0.00218 µg/m³	--	--	0.3 µg/m³	--	--	--
Ni	--	--	0.011 µg/m³	--	0.00218 µg/m³	--	--	2 µg/m³	--	--	--
Cd	--	--	0.000023 µg/m³	--	0.00000436 µg/m³	--	--	2 µg/m³	--	--	--
Hg	--	--	0.000068 µg/m³	--	0.0000131 µg/m³	--	--	2 µg/m³	--	--	--
Dioxin/Furan	--	--	6.1E-10 µg/m³	--	1.2E-10 µg/m³	--	--	1.0E-07 µg/m³	--	--	--
SO2	2.3 µg/m³	--	0.84 µg/m³	--	0.161 µg/m³	900 µg/m³	--	300 µg/m³	--	--	60 µg/m³
NOx	180 µg/m³	--	79 µg/m³	--	11 µg/m³	400 µg/m³	--	200 µg/m³	--	--	100 µg/m³
CO	151 µg/m³	105 µg/m³	--	--	9 µg/m³	35000 µg/m³	15000 µg/m³	--	--	--	--
HCl	1.0 µg/m³	--	0.36 µg/m³	--	0.070 µg/m³	100 µg/m³	--	--	--	--	--
HF	--	--	0.025 µg/m³	0.0061 µg/m³	0.00480 µg/m³	--	--	0.85 µg/m³	0.35 µg/m³	0.20 µg/m³	--
Organic Compounds	--	--	0.203 µg/m³	--	0.0393 µg/m³	No Value	No Value	No Value	No Value	No Value	No Value
Incincerator Unit Emission Rate [2]	328 µg/m³	--	118 µg/m³	29.0 µg/m³	22.9 µg/m³	--	--	--	--	--	--

Notes:

[1] 24-hour criteria for manganese, mercury and dioxins/furans are taken from the Ontario's Ambient Air Quality Criteria.

[2] Concentration reflects a unit emission rate of 1 g/s from the incinerator stack, with no emissions from other sources.
This value can be expressed as µgm³ per g/s, and is used to scale the concentrations of contaminants emitted from the incinerator alone.

Table 3: Results of Dispersion Modelling Assessment at Discrete Receptors

Receptor	Contaminant	Modelled 1-hour Concentration	Modelled 8-hour Concentraion	Modelled 24-hour Concentraion	Modelled 30-Day Concentraion	Modelled Annual Concentraion
R1	PM (assumed to be all PM2.5)	--	--	2.5 µg/m³	--	0.21 µg/m³
	Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--
	Pb	--	--	0.0046 µg/m³	0.00071 µg/m³	0.00032 µg/m³
	Mn	--	--	0.0046 µg/m³	--	0.00032 µg/m³
	Cr	0.022 µg/m³	--	0.0046 µg/m³	--	0.00032 µg/m³
	Cu	--	--	0.0046 µg/m³	--	0.00032 µg/m³
	As	--	--	0.0046 µg/m³	--	0.00032 µg/m³
	Ni	--	--	0.0046 µg/m³	--	0.00032 µg/m³
	Cd	--	--	0.0000091 µg/m³	--	0.00000065 µg/m³
	Hg	--	--	0.000027 µg/m³	--	0.0000019 µg/m³
	Dioxin/Furan	--	--	2.5E-10 µg/m³	--	1.7E-11 µg/m³
	SO2	1.6 µg/m³	--	0.34 µg/m³	--	0.024 µg/m³
	NOx	65 µg/m³	--	32 µg/m³	--	2.5 µg/m³
	CO	50 µg/m³	34 µg/m³	--	--	2.0 µg/m³
	HCl	0.69 µg/m³	--	0.15 µg/m³	--	0.010 µg/m³
	HF	--	--	0.010 µg/m³	0.0016 µg/m³	0.00071 µg/m³
	Organic Compounds	--	--	0.082 µg/m³	--	0.0058 µg/m³
	Incincerator Unit Emission Rate [1]	226.83 µg/m³	--	47.90 µg/m³	7.48000 µg/m³	3.40 µg/m³
R2	PM (assumed to be all PM2.5)	--	--	2.3 µg/m³	--	0.47 µg/m³
	Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--
	Pb	--	--	0.0054 µg/m³	0.00182 µg/m³	0.00085 µg/m³
	Mn	--	--	0.0054 µg/m³	--	0.00085 µg/m³
	Cr	0.01152 µg/m³	--	0.0054 µg/m³	--	0.00085 µg/m³
	Cu	--	--	0.0054 µg/m³	--	0.00085 µg/m³
	As	--	--	0.0054 µg/m³	--	0.00085 µg/m³
	Ni	--	--	0.0054 µg/m³	--	0.00085 µg/m³
	Cd	--	--	0.000011 µg/m³	--	0.0000017 µg/m³
	Hg	--	--	0.000032 µg/m³	--	0.0000051 µg/m³
	Dioxin/Furan	--	--	2.9E-10 µg/m³	--	4.6E-11 µg/m³
	SO2	0.85 µg/m³	--	0.40 µg/m³	--	0.063 µg/m³
	NOx	58 µg/m³	--	29 µg/m³	--	5.8 µg/m³
	CO	48 µg/m³	34 µg/m³	--	--	4.6 µg/m³
	HCl	0.37 µg/m³	--	0.17 µg/m³	--	0.027 µg/m³
	HF	--	--	0.012 µg/m³	0.0040 µg/m³	0.0019 µg/m³
	Organic Compounds	--	--	0.10 µg/m³	--	0.015 µg/m³
	Incincerator Unit Emission Rate [1]	121.00 µg/m³	--	56.70 µg/m³	19.12000 µg/m³	8.89 µg/m³
R3	PM (assumed to be all PM2.5)	--	--	1.8 µg/m³	--	0.25 µg/m³
	Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--
	Pb	--	--	0.0049 µg/m³	0.00108 µg/m³	0.00044 µg/m³
	Mn	--	--	0.0049 µg/m³	--	0.00044 µg/m³
	Cr	0.01741 µg/m³	--	0.0049 µg/m³	--	0.00044 µg/m³
	Cu	--	--	0.0049 µg/m³	--	0.00044 µg/m³
	As	--	--	0.0049 µg/m³	--	0.00044 µg/m³
	Ni	--	--	0.0049 µg/m³	--	0.00044 µg/m³
	Cd	--	--	0.000010 µg/m³	--	0.00000087 µg/m³
	Hg	--	--	0.000030 µg/m³	--	0.0000026 µg/m³
	Dioxin/Furan	--	--	2.7E-10 µg/m³	--	2.4E-11 µg/m³
	SO2	1.3 µg/m³	--	0.37 µg/m³	--	0.032 µg/m³
	NOx	61 µg/m³	--	23 µg/m³	--	3.2 µg/m³
	CO	49 µg/m³	29 µg/m³	--	--	2.5 µg/m³
	HCl	0.56 µg/m³	--	0.16 µg/m³	--	0.014 µg/m³
	HF	--	--	0.011 µg/m³	0.0024 µg/m³	0.0010 µg/m³
	Organic Compounds	--	--	0.089 µg/m³	--	0.0079 µg/m³
	Incincerator Unit Emission Rate [1]	182.82 µg/m³	--	51.93 µg/m³	11.30000 µg/m³	4.59 µg/m³
R4	PM (assumed to be all PM2.5)	--	--	2.2 µg/m³	--	0.27 µg/m³
	Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--
	Pb	--	--	0.0031 µg/m³	0.00081 µg/m³	0.00038 µg/m³
	Mn	--	--	0.0031 µg/m³	--	0.00038 µg/m³
	Cr	0.01269 µg/m³	--	0.0031 µg/m³	--	0.00038 µg/m³
	Cu	--	--	0.0031 µg/m³	--	0.00038 µg/m³
	As	--	--	0.0031 µg/m³	--	0.00038 µg/m³
	Ni	--	--	0.0031 µg/m³	--	0.00038 µg/m³
	Cd	--	--	0.0000061 µg/m³	--	0.00000076 µg/m³
	Hg	--	--	0.000018 µg/m³	--	0.0000023 µg/m³
	Dioxin/Furan	--	--	1.7E-10 µg/m³	--	2.0E-11 µg/m³
	SO2	0.94 µg/m³	--	0.23 µg/m³	--	0.028 µg/m³
	NOx	63 µg/m³	--	27 µg/m³	--	3.4 µg/m³
	CO	51 µg/m³	28 µg/m³	--	--	2.7 µg/m³
	HCl	0.41 µg/m³	--	0.10 µg/m³	--	0.012 µg/m³
	HF	--	--	0.0067 µg/m³	0.0018 µg/m³	0.00083 µg/m³

Table 3: Results of Dispersion Modelling Assessment at Discrete Receptors

Receptor	Contaminant	Modelled 1-hour Concentration	Modelled 8-hour Concentraion	Modelled 24-hour Concentraion	Modelled 30-Day Concentraion	Modelled Annual Concentraion
	Organic Compounds	--	--	0.055 µg/m³	--	0.0068 µg/m³
	Incincerator Unit Emission Rate [1]	133.28 µg/m³	--	32.14 µg/m³	8.53000 µg/m³	3.97 µg/m³
R5	PM (assumed to be all PM2.5)	--	--	1.5 µg/m³	--	0.28 µg/m³
	Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--
	Pb	--	--	0.0020 µg/m³	0.00071 µg/m³	0.00033 µg/m³
	Mn	--	--	0.0020 µg/m³	--	0.00033 µg/m³
	Cr	0.00618 µg/m³	--	0.0020 µg/m³	--	0.00033 µg/m³
	Cu	--	--	0.0020 µg/m³	--	0.00033 µg/m³
	As	--	--	0.0020 µg/m³	--	0.00033 µg/m³
	Ni	--	--	0.0020 µg/m³	--	0.00033 µg/m³
	Cd	--	--	0.0000041 µg/m³	--	0.00000066 µg/m³
	Hg	--	--	0.000012 µg/m³	--	0.0000020 µg/m³
	Dioxin/Furan	--	--	1.1E-10 µg/m³	--	1.8E-11 µg/m³
	SO2	0.46 µg/m³	--	0.15 µg/m³	--	0.025 µg/m³
	NOx	41 µg/m³	--	19 µg/m³	--	3.5 µg/m³
	CO	33 µg/m³	22 µg/m³	--	--	2.9 µg/m³
	HCl	0.20 µg/m³	--	0.07 µg/m³	--	0.011 µg/m³
	HF	--	--	0.0045 µg/m³	0.0016 µg/m³	0.00073 µg/m³
	Organic Compounds	--	--	0.037 µg/m³	--	0.0060 µg/m³
	Incincerator Unit Emission Rate [1]	64.85 µg/m³	--	21.35 µg/m³	7.48000 µg/m³	3.48 µg/m³
R6	PM (assumed to be all PM2.5)	--	--	1.8 µg/m³	--	0.16 µg/m³
	Pb + Mn + Cr + Cu + As + Ni	--	--	--	--	--
	Pb	--	--	0.0062 µg/m³	0.00084 µg/m³	0.00034 µg/m³
	Mn	--	--	0.0062 µg/m³	--	0.00034 µg/m³
	Cr	0.01632 µg/m³	--	0.0062 µg/m³	--	0.00034 µg/m³
	Cu	--	--	0.0062 µg/m³	--	0.00034 µg/m³
	As	--	--	0.0062 µg/m³	--	0.00034 µg/m³
	Ni	--	--	0.0062 µg/m³	--	0.00034 µg/m³
	Cd	--	--	0.0000124 µg/m³	--	0.00000068 µg/m³
	Hg	--	--	0.000037 µg/m³	--	0.0000020 µg/m³
	Dioxin/Furan	--	--	3.3E-10 µg/m³	--	1.8E-11 µg/m³
	SO2	1.2 µg/m³	--	0.46 µg/m³	--	0.025 µg/m³
	NOx	48 µg/m³	--	22 µg/m³	--	2.0 µg/m³
	CO	38 µg/m³	26 µg/m³	17 µg/m³	--	1.6 µg/m³
	HCl	0.52 µg/m³	--	0.20 µg/m³	--	0.011 µg/m³
	HF	--	--	0.014 µg/m³	0.0018 µg/m³	0.00074 µg/m³
	Organic Compounds	--	--	0.11 µg/m³	--	0.0061 µg/m³
	Incincerator Unit Emission Rate [1]	171.33 µg/m³	--	65.08 µg/m³	8.79000 µg/m³	3.55 µg/m³

Notes:

[1] Concentration reflects a unit emission rate of 1 g/s from the incinerator stack, with no emissions from other sources.
This value can be expressed as µgm³ per g/s, and is used to scale the concentrations of contaminants emitted from the incinerator alone.

FIGURES

Site Plan Showing Source and Receptor Locations

Map Projection: NAD 1983 UTM Zone 14N.

Brandon Biomedical Waste Treatment Facility - Brandon, MB

Project #1301084

True North

Drawn by:	NBN	Figure:	1
Approx. Scale:	1:4,000		
Date Revised:	Jun. 26, 2013		

RWDI