AECOM

Appendix F

Air Quality Assessment Report Update

AECOM

Air Quality Assessment Report

Wanipigow Sand Extraction Project - Update

Canadian Premium Sand

60663147

November 2022

Delivering a better world

Statement of Qualifications and Limitations

The attached Report (the “Report”) has been prepared by AECOM Canada Ltd. (“AECOM”) for the benefit of the Client (“Client”) in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the “Agreement”).

The information, data, recommendations and conclusions contained in the Report (collectively, the “Information”):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the “Limitations”);
- represents AECOM’s professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

AECOM shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. AECOM accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

AECOM agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but AECOM makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

Without in any way limiting the generality of the foregoing, any estimates or opinions regarding probable construction costs or construction schedule provided by AECOM represent AECOM’s professional judgement in light of its experience and the knowledge and information available to it at the time of preparation. Since AECOM has no control over market or economic conditions, prices for construction labour, equipment or materials or bidding procedures, AECOM, its directors, officers and employees are not able to, nor do they, make any representations, warranties or guarantees whatsoever, whether express or implied, with respect to such estimates or opinions, or their variance from actual construction costs or schedules, and accept no responsibility for any loss or damage arising therefrom or in any way related thereto. Persons relying on such estimates or opinions do so at their own risk.

Except (1) as agreed to in writing by AECOM and Client; (2) as required by-law; or (3) to the extent used by governmental reviewing agencies for the purpose of obtaining permits or approvals, the Report and the Information may be used and relied upon only by Client.

AECOM accepts no responsibility, and denies any liability whatsoever, to parties other than Client who may obtain access to the Report or the Information for any injury, loss or damage suffered by such parties arising from their use of, reliance upon, or decisions or actions based on the Report or any of the Information (“improper use of the Report”), except to the extent those parties have obtained the prior written consent of AECOM to use and rely upon the Report and the Information. Any injury, loss or damages arising from improper use of the Report shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

AECOM: 2015-04-13

Quality Information

Prepared by

[redacted]

Piotr Staniaszek, Ph.D.
Senior Air Quality Specialist
Global Air Quality Modelling Specialty Lead
Piotr.Staniaszek@aecom.com

Reviewed by

[redacted]

Randy Rudolph, M.Sc.
Senior Air Quality Scientist
Randy.Rudolph@aecom.com

Distribution List

# Hard Copies	PDF Required	Association / Company Name
	✓	Canadian Premium Sand
	✓	AECOM Canada Ltd.

AECOM Canada Ltd. APEGA Permit to Practice No.: P10450

Prepared for:

Canadian Premium Sand
Suite 400, 522 – 11th Avenue SW
Calgary, Alberta T2R 0C8

Prepared by:

Piotr Staniaszek, Ph.D.
Senior Air Quality Specialist
Global Air Quality Modelling Specialty Lead
M: 403-463-9682
E: Piotr.Staniaszek@aecom.com

AECOM Canada Ltd.
48 Quarry Park Blvd. SE., Suite 300
Calgary, AB   T2C 5P2
Canada

T: 403.254.3301
F: 403.351.1678
www.aecom.com

Table of Contents

Figures

Tables

Appendices

List of Units

μg/m³............	Microgram per cubic metres
g	Gram
g/hp-h	Grams per horsepower per hour
g/L	Grams per litre
g/MMBtu	Grams per Metric Million British Thermal Unit
g/s	Grams per second
g/s/m²...........	Grams per second per square metres
GW	Giga Watt
GW-h............	Giga Watt per hour
hp	Horsepower
K..................	Kelvin
kg	Kilogram
kg/d	Kilogram per day
kg/h	Kilogram per hour
kg/L	Kilogram per Litre
kg/t	Kilogram per tonne
km	Kilometres
km/d	Kilometres per day
km/h	Kilometres per hour
kW-hr	Kilo Watt per hour
L	Litre
L/h	Litres per hour
lb/hp-h	Pound per horsepower per hour
m	Metres
m/s	Metres per second
m².................	Square metres
m³.................	Cubic metres
mm	Millimetres
MMBtu	Metric Million British Thermal Unit
Mm/y	Millimetres per year
Mt	Million of tonnes
ppm..............	Parts per million
ppb...............	Parts per billion
t	Tonnes
t/h	Tonnes per hour
t/y	Tonnes per year
VKT	Vehicle kilometres travelled

1. Introduction

1.1 Overview

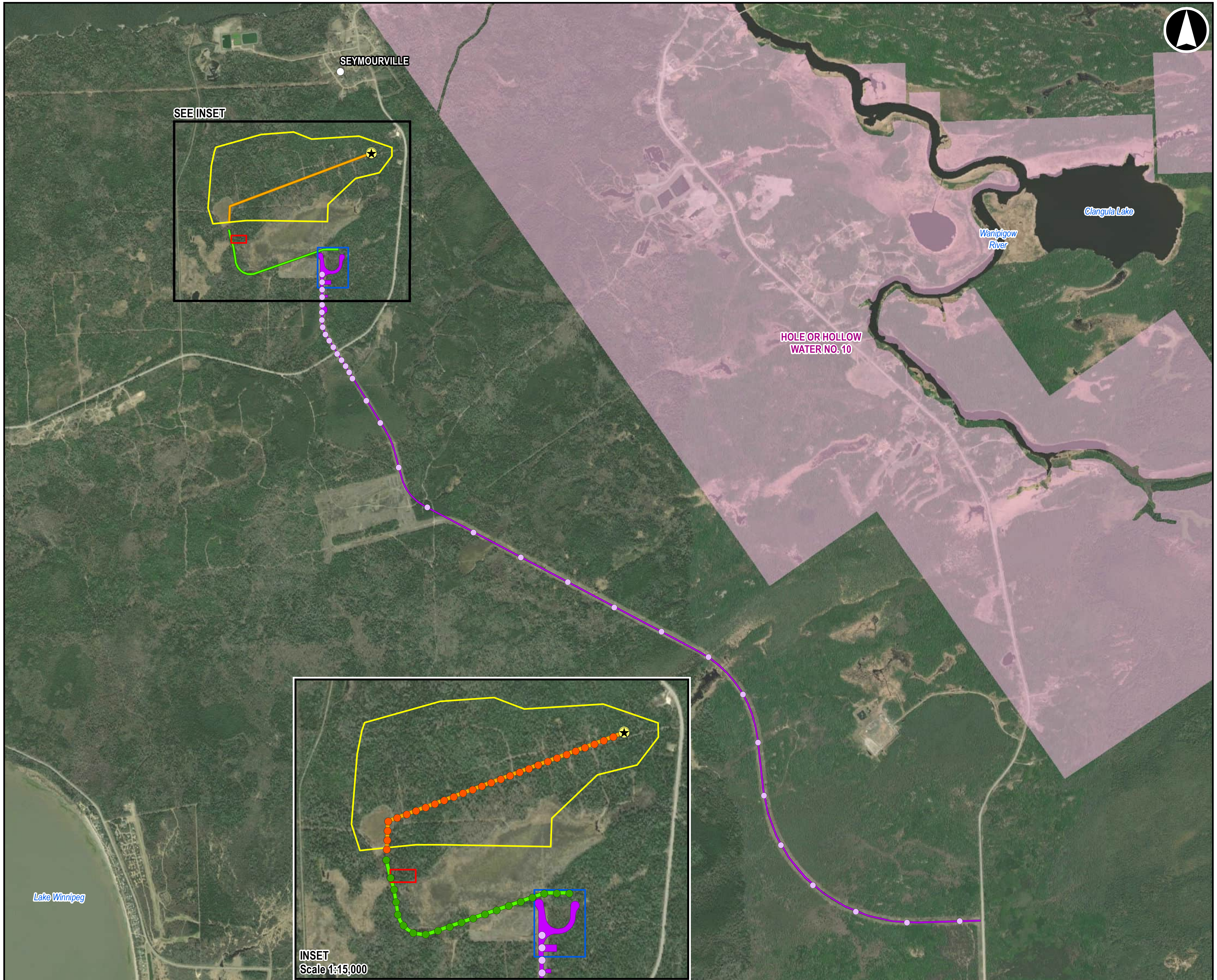
Canadian Premium Sand Inc. (CPS) was issued an Environment Act Licence (EAL) No. 3285 on May 16, 2019 for the Wanipigow Sand Extraction Project (the Project). The EAL was issued based on Project description information provided in an Environment Act Proposal (EAP) submitted to Manitoba Sustainable Development (now Manitoba Environment, Climate and Parks [MECP]), Environmental Assessment Branch (EAB) on December 18, 2018, and subsequent additional information provided to the EAB throughout the EAP review process. Pertinent documentation regarding the review and licencing of this Project, including a copy of the EAP (AECOM 2018) and air dispersion modelling report (appendix E of the EAP) is available in the Manitoba Sustainable Development Public Registry.

The Wanipigow Sand Extraction Project (the Project) consists of sequential quarrying operations (also referred to as ’pit’ or ’pits’) for silica sand extraction and a wet plant for sand processing. CPS is proposing to revise the Project design for the purpose of providing silica sand to a proposed CPS Solar Glass Manufacturing Facility (‘solar glass plant’) in Selkirk, Manitoba. Therefore, CPS is submitting a Notice of Alteration (NoA) to MECP to request approval from the EAB for the revised Project. The solar glass plant project will be reviewed by the EAB under a separate Environment Act Licence application as a Class 2 manufacturing facility.

A component of the Project environmental assessment information requirements for the NoA includes an air quality assessment to determine the impact of potential emissions from the altered Project on the off-site air quality. This report provides the assessment during the operations phase. The air quality assessment is divided into air dispersion modelling assessment and green house gas (GHG) emissions assessment.

Key components of the revised Project will include (see **Figure 1**):

- The active quarry pits
- Quarry gravel haul road (1.16 km long) connecting the quarry and the working pile
- Working pile (close to slurry line feeder)
- Quarry gravel access road (2.16 km) between quarry area and wet plant
- Produced wet sand stockpile (pile with sand to be transported by truck to solar glass plant)
- Gravel Project access road (7 km long) from wet plant to intersect with the existing Hollow Water Main Road.



Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Quarry Access Road Volume Source
- Wet Plant Area/Wet Sand Pile Access Road Volume Source
- Quarry Haul Road Volume Source

General Features

- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

LOCATION OF SOURCES

0 0.25 0.5 0.75 1
Kilometres

Datum: NAD 1983 UTM Zone 14N

Aug, 2022	PN#: 60663147	1:25,000 * when printed 11"x17"

Figure 1

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map

2. Site Description

2.1 Project Location

The Project is on the east side of Lake Winnipeg, 125 km north-northeast of solar glass plant (Selkirk) and 158 km from Winnipeg. The travel distance from the Project to the solar glass plant through the road system is 169 km.

The approximate latitude and longitude co-ordinates of the wet plant is: 51°; 10', 21" N and 96°; 19' 44" W (UTM Zone 14U 686,716 m E; 5,672,401 m N). This is the location of the main emission source: produced wet sand stockpile (unloading and loading of produced sand onto B-Train trucks).

The communities closest to the Project are Seymourville, Wanipigow (Hollow Water), Pelican Inlet Development and Marina, and Ayers Cove Eagles Nest (**Figure 2**).

2.2 Project Description Overview

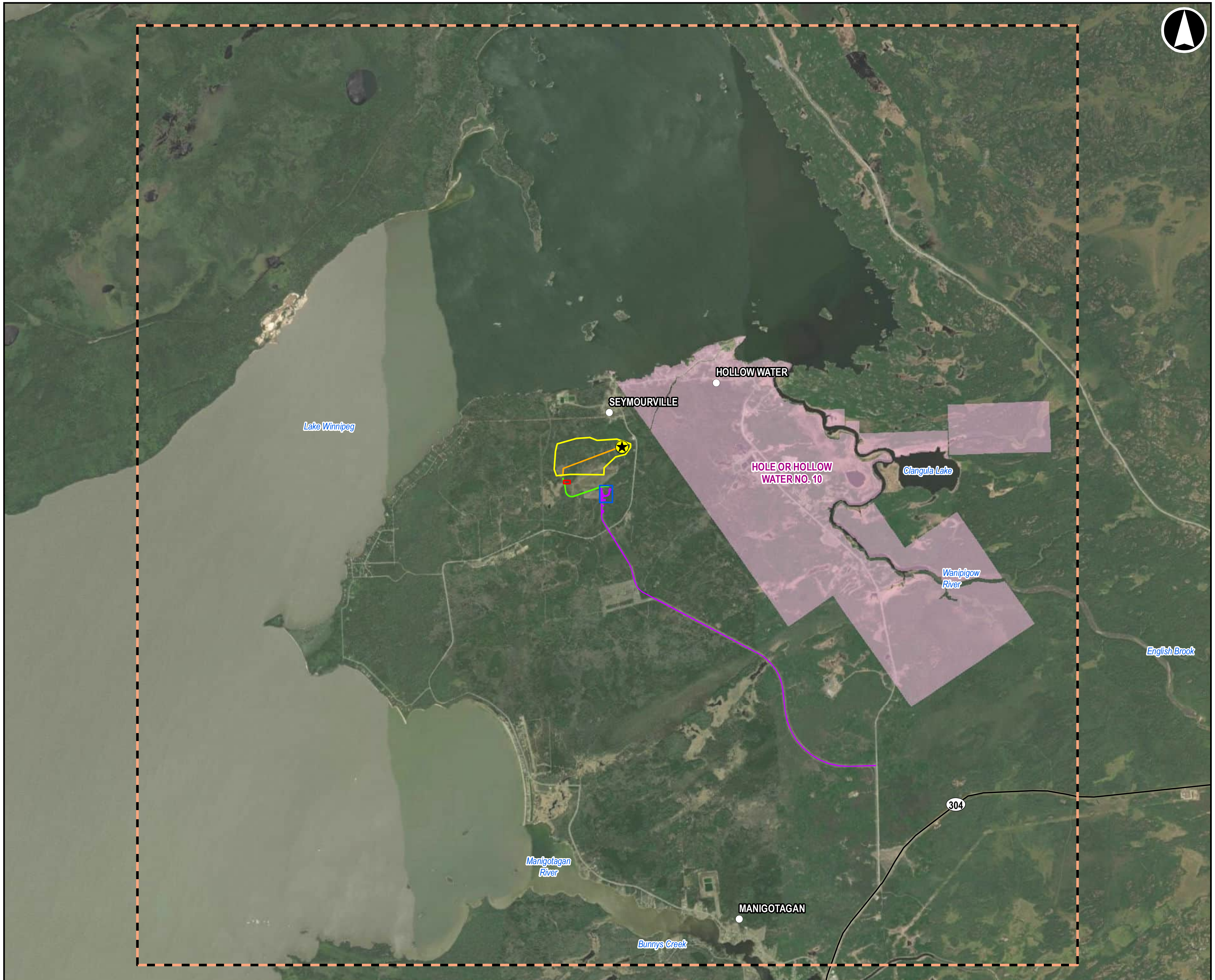
Figure 1 illustrates the location of activities at the Project. Sand is extracted from the pit which would be located over 400 m south of the Seymourville community. This pit location was chosen for air dispersion modelling as the worst case for neighbouring communities.

Wet sand will be extracted using an excavator (CAT 336). Sand is loaded onto articular haul trucks (CAT 725) and transported 1.12 km and unloaded at the working pile. A modified CAT 725 will water gravel haul roads and areas around stockpiles on dry hot days, and a grader (CAT 120 AWD) will occasionally clear haul roads of bigger rocks and other debris.

At the working pile near the slurry line feeder, the bulldozer CAT D6 will blend the extracted sand. . A front-end loader (CAT 972) will load mixed material at the feeder and then raw sand will be mixed with water and slurry will be pumped to wet plant through a closed pipeline (water & slurry lines).

Quarry preparation for operation will start in February. Vegetation and snow will be cleared, soil and overburden will be stripped. At that time bulldozer CAT D6 will be used to root-rake and windrow topsoil. The grader will also support stripping operations. Topsoil and overburden will be loaded by excavator onto articulating trucks and transported to stockpiles. Since these operations will be performed when soil will be covered by snow and/or frozen, dust emissions will be much lower than during normal quarry pit operations. During stripping, the wet plant will not operate.

Normal Project operations (7 months) will occur from April to the end of October. From early November to mid-December, the pit will be remediated by dumping wet plant waste (around 47% of excavated material is either solid or fine particulate waste) and then covered by overburden and stripped soil. Details regarding the revised Project wastes and waste management are provided in the NoA. During quarry pit remediation (November to mid-December), ground and particulate emissions at the Project site will be lower due to the expected presence of snow. Overburden and soil piles, and the remediated pit, will be re-vegetated in spring.



Legend

- Quarry Active Pit
- Modelling Domain (15 km x 15 km)
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

WANIPIGOW MINE AND WET PLANT LOCATION

0 1 2 3 4
Kilometres

Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure 2

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map

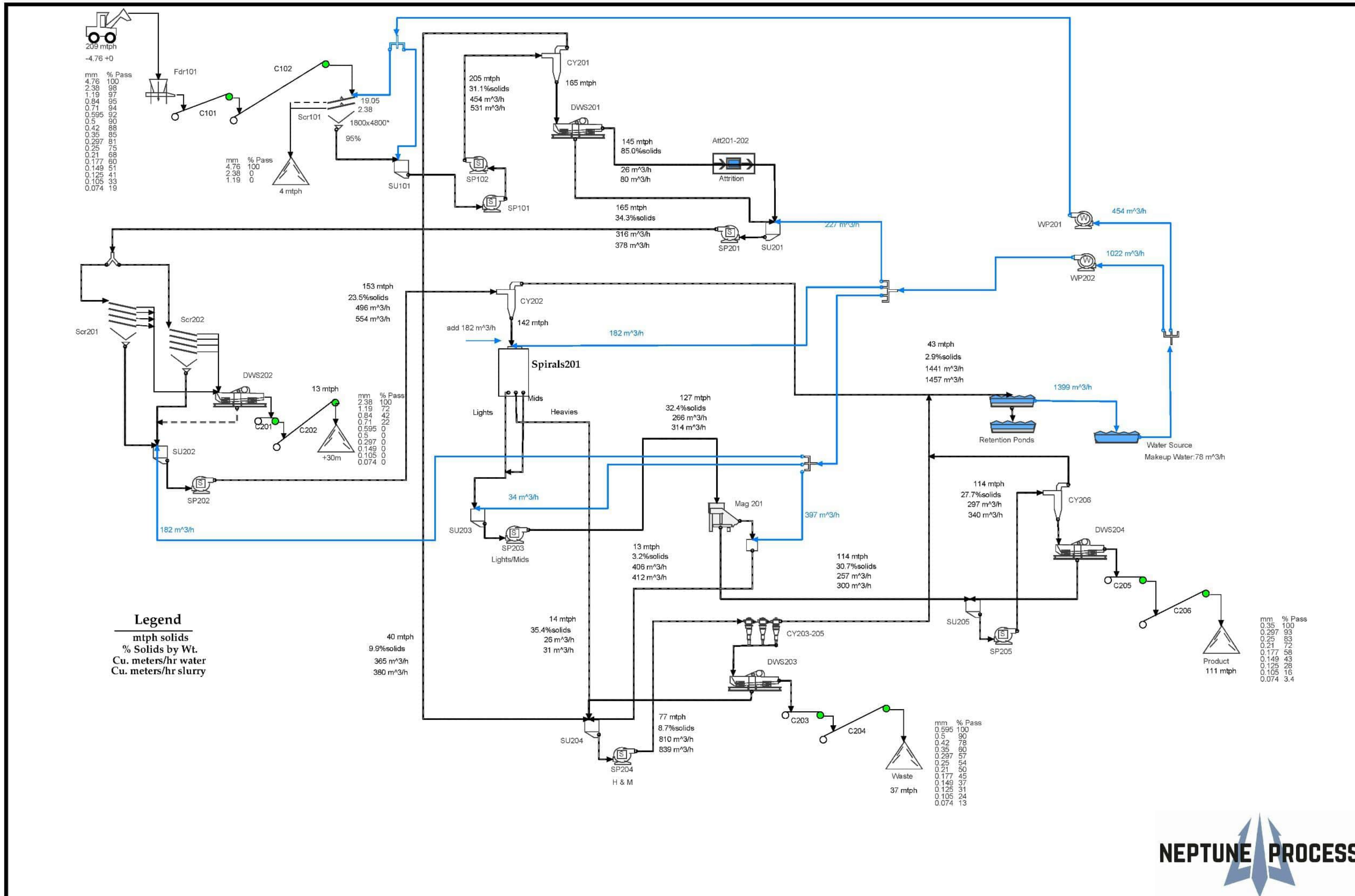
Date Saved: 11/3/2022 User Name: Stephanie.Clark

The wet plant maximum capacity production is presented in **Figure 3**. Maximum input to the wet plant is 209 t/h. Therefore, maximum mining production will be 418 t/h. The Project daily production efficiency is 75% and for 24-hour operations it is assumed that the Project will be effectively working for 18 hours and idling for the remaining 6 hours. The wet plant maximum capacity output is 111 t/h of wet sand. The solid waste production will be around 54 t/h and remaining fine waste (44 t/h) will be pumped as slurry to a settling pond.

The cleaned and sized high-quality produced wet sand from the wet plant is delivered by closed conveyor and placed onto the stockpile by a stacker. The extracted material has a high moisture content (from 3.2% to 45%). The measurements at three sites with the highest number of test holes (233 test holes) had a weighted average moisture content of 20% (CPS, 2022). However, the produced wet sand product stockpile will have water partially removed. The sand transported to the solar glass plant will have moisture content ranging from 2% to 4% (average 3%). The sand working pile, solid waste produced by the wet plant, and sand produced in the plant, placed by the stacker on the produced wet sand stockpile was assumed to have moisture content 18% (Process Flow Diagram Mass Balance prepared by McLanahan Corporation). The working pile will be watered or covered during hot dry days in summer, and we assumed that 18% moisture content will be maintained.

The produced wet sand pile will be covered at three sides (and roof). There will be an opening through the southern part of the pile where one wheel loader (CAT 980) will be used to fill B-Train trucks for sand transport to the solar glass plant in Selkirk. Sand transport to the solar glass plant will occur year-round, but traffic will vary from month to month. It was conservatively assumed that wet sand transport to the solar glass plant will be on 5 days/week basis and 16 hours/day. A 5 days/week cycle results in a more conservative emission estimate since the same amount of material transported in a 7-day week is transported in five days. The maximum number of trips with wet sand from the quarry (44), planned for April to June, was chosen as the worst case and modelled for 365 days a year.

Figure 3: Wanipigow Wet Plant Production Numbers



Calculation results may differ due to variations in operating conditions and application of crushing and screening equipment. This information does not constitute an express or implied warranty, but shows results of calculations based on information provided by customers or equipment manufacturers. Use this information for estimating purposes only. ***All calculations performed by AggFlow. http://www.AggFlow.com***	Turnkey Processing Solutions 21316 TPS - Canadian Premium Sands Chuck Baxter Plant Stage #1: Project #: 122637 Revision #: 627430 Date: May/4/2022

3. Regulations, Guidelines, and Air Quality Criteria

3.1 Regulations and Guidelines

Modelling followed the *Draft Guidelines for Air Quality Dispersion Modelling Manitoba* (MCWS 2006), supplemented (where needed) by guidelines from Alberta (AEP 2021) and the United States (US EPA 2021). Predicted model results were compared against the *Manitoba Ambient Air Quality Criteria* (MAAQC 2005)**.** A summary of the documents used is shown in **Table 1**.

Table 1: Air Quality Related Regulations and Guidelines

Guideline	Reference	Rationale
Draft Guidelines for Air Dispersion Modelling in Manitoba	MCWS (2006)	This guideline is a resource that provides consistency in dispersion modelling across all regulatory applications.
Alberta Air Quality Modelling Guideline	AEP (2021)	This dispersion modelling guideline provides guidance on appropriate surface characteristics and receptor grids to supplement the Manitoba guidelines.
Manitoba Ambient Air Quality Criteria (MAAQC)	MAAQC (2005)[1]	Manitoba provides a listing of Ambient Air Quality Criteria and Guidelines for various air pollutants.
US EPA AERMOD Implementation Guide	US EPA (2021)	This guideline is a resource that helps with the use of the related air quality modelling modules and programs (AERMOD, AERMAP, AERMET, AERSURFACE, AERSCREEN) and the required additional information

Notes: 1. The link to this site can be found at the most current Manitoba government website: https://www.gov.mb.ca/sd/pubs/climate-air-quality/factsheet_airquality_monitoring.pdf

3.2 Air Quality Criteria

The evaluation of ambient air quality typically relies on comparison of modelled concentrations to regulatory thresholds (standards/objectives/criteria). The regulatory thresholds are designed by the local, provincial, or federal authority to be conservative and protective of air quality. The *Maximum Acceptable Level Concentration* provided by Manitoba Ambient Air Quality Criteria *(*MAAQC 2005) were used in this assessment.

The target parameters for the study include:

- Particulate Matter with a diameter of 2.5 micrometres and less ($PM_{2.5}$)
- Particulate Matter with a diameter of 10 micrometres and less (PM_{10})
- Total Suspended Particulate (TSP)
- Carbon Monoxide (CO)
- Nitrogen Dioxide (NO_2)
- Sulfur Dioxide (SO_2).

The applicable air quality criteria are summarized in **Table 2**.

Table 2: Ambient Air Quality Criteria

Compound	Averaging Period	MAAQC[1] ($\mu g/m^3$)
Particulate Matter with a diameter of 2.5 micrometres and less ($PM_{2.5}$)	24-hour	30
Particulate Matter with a diameter of 10 micrometres and less (PM_{10})	24-hour	50
Total Suspended Particulate Matter (TSP)	24-hour Annual	120 70
Silica Respirable (<10 µm), Quartz	24-hour	5[2]
Carbon Monoxide (CO)	1-hour 8-hour	35,000 15,000
Nitrogen Dioxide (NO_2)	1-hour 24-hour Annual	400 200 100
Sulphur Dioxide (SO_2)	1-hour 24-hour Annual	900 300 60

Notes: 1. All values, except silica, are from the "Maximum Acceptable Level" Concentration provided by MAAQC (2005).
2. Ontario MOE (2012)

4. Dispersion Modelling Methodology

The air emissions from the Project were assessed based on information provided by CPS. These air emissions were used in the AERMOD dispersion model to assess maximum predicted ground-level concentrations.

4.1 The Choice of Air Dispersion Model

Air dispersion models are important tools that can be used to assess the likelihood of airborne contaminants from the facility impacting a particular location such as the nearest residences. The use of these tools comes with a certain amount of uncertainty. Dispersion models mathematically predict the behaviour of emitted plumes by accounting for: emission rates, physical characteristics of the release, geometry and location of the sources as related to receptor locations, terrain effects, meteorology, and atmospheric dispersion.

An approved regulatory dispersion model used in Manitoba is AERMOD as outlined in the *Draft Guidelines for Air Quality Dispersion Modelling in Manitoba (MCWS, 2006)*. Given the likelihood that the highest modelled concentrations will occur in the near field (within 1 km), AERMOD was chosen for this assessment. AERMOD (Model Version 18081) was also selected for this application because of its ability to account for:

- Directional and seasonal variations in land use
- Dispersion in a mixed urban/forested environment and
- Limited terrain influences.

Based on the *Draft Guidelines for Air Quality Dispersion Modelling in Manitoba* (MCWS, 2006) the area within 3 km the Project as forest.

In addition, AERMET (Version 21112) and AERMAP (Model Version 9.6.5), AERMOD's meteorological and terrain pre-processors, were employed to process meteorological data and terrain data inputs for AERMOD.

Modelling was conducted in accordance with the 2006 *Draft Guidelines for Air Quality Dispersion Modelling in Manitoba (MCWS 2006)*, where applicable. Where the Guidelines did not address a particular modelling element, the Alberta *Air Quality Modelling Guideline (AEP 2021)* and the US EPA *AERMOD Implementation Guide (US EPA 2021)* were used as guidance.

4.2 Dispersion Model Boundaries

The modelled ground-level concentrations from the Project and comparison with MAAQC were investigated within two defined boundaries.

4.2.1 Spatial Boundary

The study area for this assessment was the zone of influence of the Project-related air emissions, including potential sensitive receptors nearest to the site. Since the quarry active pit, wet plant, and haul road and access roads are sources based on the ground, the modelling domain was chosen as 15 km X 15 km. The appropriateness of this boundary selection was confirmed by the model outputs which showed that maximum concentrations were found within 0.5 km of the site. Model receptor points are described in **Section 4.4.2**.

4.2.2 Temporal Boundary

Temporal boundaries for this assessment were developed in consideration of continuous operations and emissions from the approximate 30-year life of the Project.

The temporal boundary includes several time-averaging periods in accordance with the time periods outlined for the identified MAAQC presented in **Table 2**.

4.3 Dispersion Model Meteorology

Air quality is dependent on the rate of pollutant emissions into the atmosphere and the ability of the atmosphere to disperse the pollutant emissions. The dispersion of air pollutants is affected by local meteorological patterns. The wind direction controls the path that air pollutants follow from the point of emission to the receptors. In addition, wind speeds affect the time taken for pollutants to travel from source to receptor and the distance over which air pollutants travel. As a result, wind speeds also impact the dispersion of air pollutants; therefore, it is important to consider local meteorological patterns when assessing potential air quality effects from an emission source. Five years (2017-2021) of site specific, WRF-preprocessed, AERMET-ready, 4-km resolution, meteorological data was purchased from Lakes Environmental for the Project location.

Figure 4 presents a windrose comprised of the meteorological data used in the model (Jan 1, 2017 – Dec 31, 2021); the windrose indicates the predominant winds are from north/northwest and northwest (around 22% of the time) and that the winds are calm approximately 0.44% of the time. Calm is defined as less than the starting threshold of the anemometer (0.5 m/s). From **Figure 5** wind speeds are higher than 8.8 m/s 2.8% of the time (such strong winds have potential for wind generated dust emissions from quarry pit and stockpiles), and most wind speeds (around 80%) are below 5.7 m/s.

AERMOD does not have the ability to model calm winds. As such, these events were not assessed as part of the dispersion modelling analysis. Conversely, AERMOD is conservative (over-predicts) during very low-speed but non-calm periods.

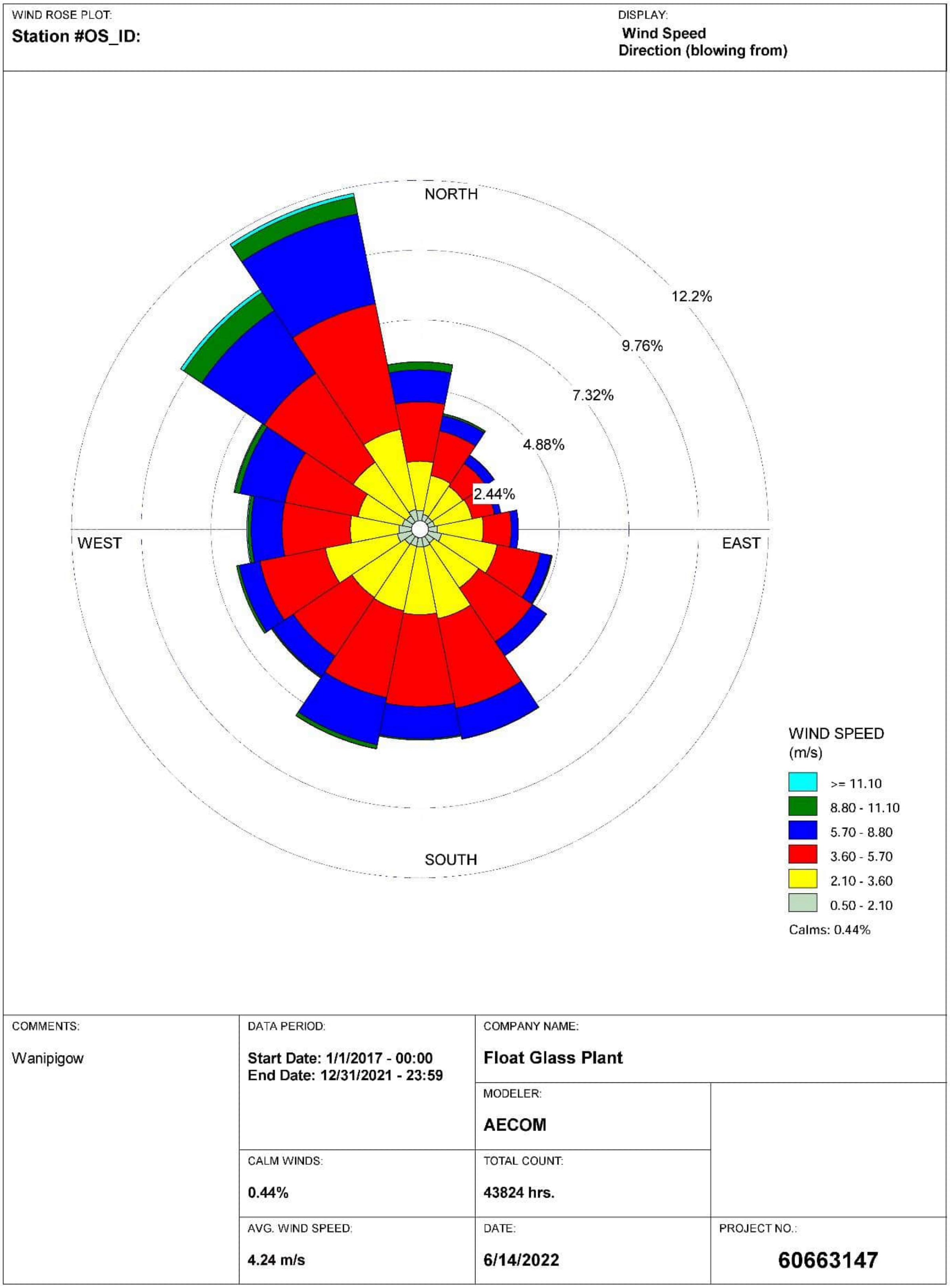
AERMET produces surface scalar parameters and vertical profiles of meteorological data that were used as an input for AERMOD. To quantify the boundary layer parameters needed by AERMOD, AERMET also requires specification of site-specific land use characteristics including surface roughness (z_o), albedo (r) and Bowen ratio (B_o). These site characteristics are used by AERMET, along with the meteorological data to help characterize the atmospheric boundary layer and dispersion.

The boundary layer parameters are calculated on an hourly basis and are contained in AERMET's surface file. The surface file is read into AERMOD and then these values are used to quantify the atmospheric dispersion. The land use surface characteristics surrounding the Project were quantified based on specific land use surface characteristics provided to AERMET.

The AERMOD Implementation Guide (AIG) (US, EPA 2021) recommends that the surface characteristics be determined based on digitized land cover data. US EPA has developed a tool called AERSURFACE (US EPA 2021) that can be used to determine the site characteristics based on digitized land cover data in accordance with the recommendations from the AIG discussed above (**Figure 6**). The following four seasonal categories are supported by AERSURFACE, with the applicable months of the year specified for this assessment.

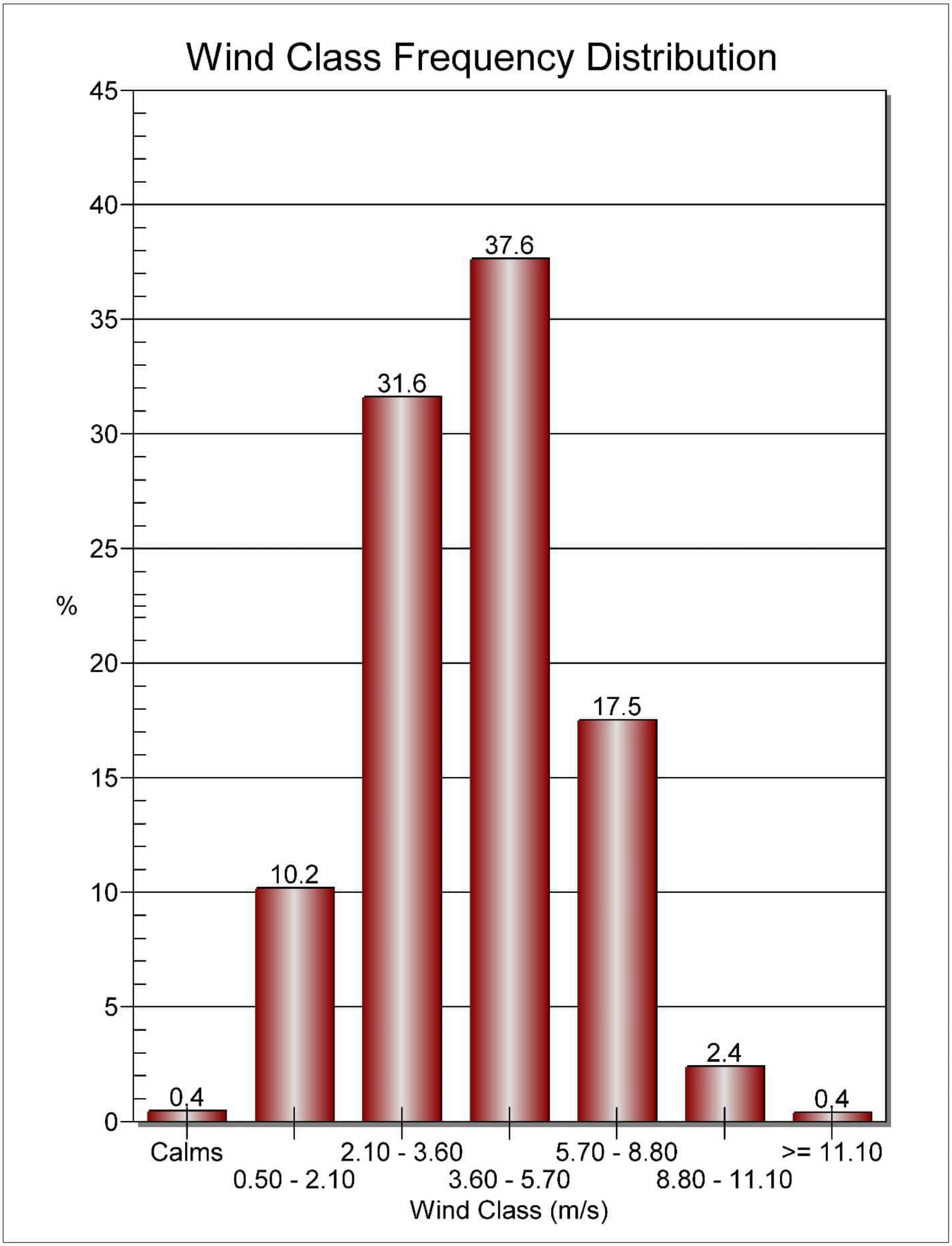
1. "Spring": when vegetation is emerging or partially green. This applies for 1–2 months after the last killing frost (May – June)
2. "Summer": when vegetation is lush and healthy (July – August)
3. "Autumn": periods when freezing conditions are common, deciduous trees are leafless, crops are not yet planted or are already harvested (bare soil exposed), grass surfaces are brown, and no snow is present (September, October); and
4. "Winter": for snow-covered surfaces and subfreezing temperatures (November – April).

Figure 4: Windrose of Meteorological Data at the Project Location (January 1, 2017 to December 31, 2021)



WRPLOT View - Lakes Environmental Software

Figure 5: Wind Class Frequency Distribution of Meteorological Data (January 1, 2017 to December 31, 2021)



WRPLOT View 9.8.0 - Lakes Environmental Software

The calculated albedo, Bowen ratio, and surface roughness values for this specific assessment were based on GeoBase digital land use data (NRCan 2020a). Digital terrain files with a 1:50,000 scale (NRCan 2020b) was used to generate elevations for receptors and sources.

4.4 Background Ambient Air Quality

Background air quality information is added to modelled concentrations to appropriately assess the cumulative impacts of the Project. The background concentrations of the modelled parameters were obtained from a combination of the Thompson, Winnipeg (Ellen Street), and Flin Flon Air Quality Stations. These stations were selected based on their distance to the Project and data availability. Thomson station is farther northwest (approximately 517 km) but has similar setting as the Project (wet, humid area surrounded by forest). Winnipeg is closer but it is a large urban centre and dust measurement at Ellen Station is affected by local sources (roads; parking lots, residential heating etc.). Thompson Station does not have data for NO_2, CO, and SO_2. Only Flin Flon Station has SO_2 measurements. The background conditions at the applicable averaging periods were calculated as 90th percentile annual concentrations, averaged from the most recent years with valid (>75% completeness). The annual background is annual average for the most recent (valid data) years. The ambient background air quality data are summarized in the **Table 3**. Silica is not measured at stations in Manitoba and the background concentration was assumed to be zero.

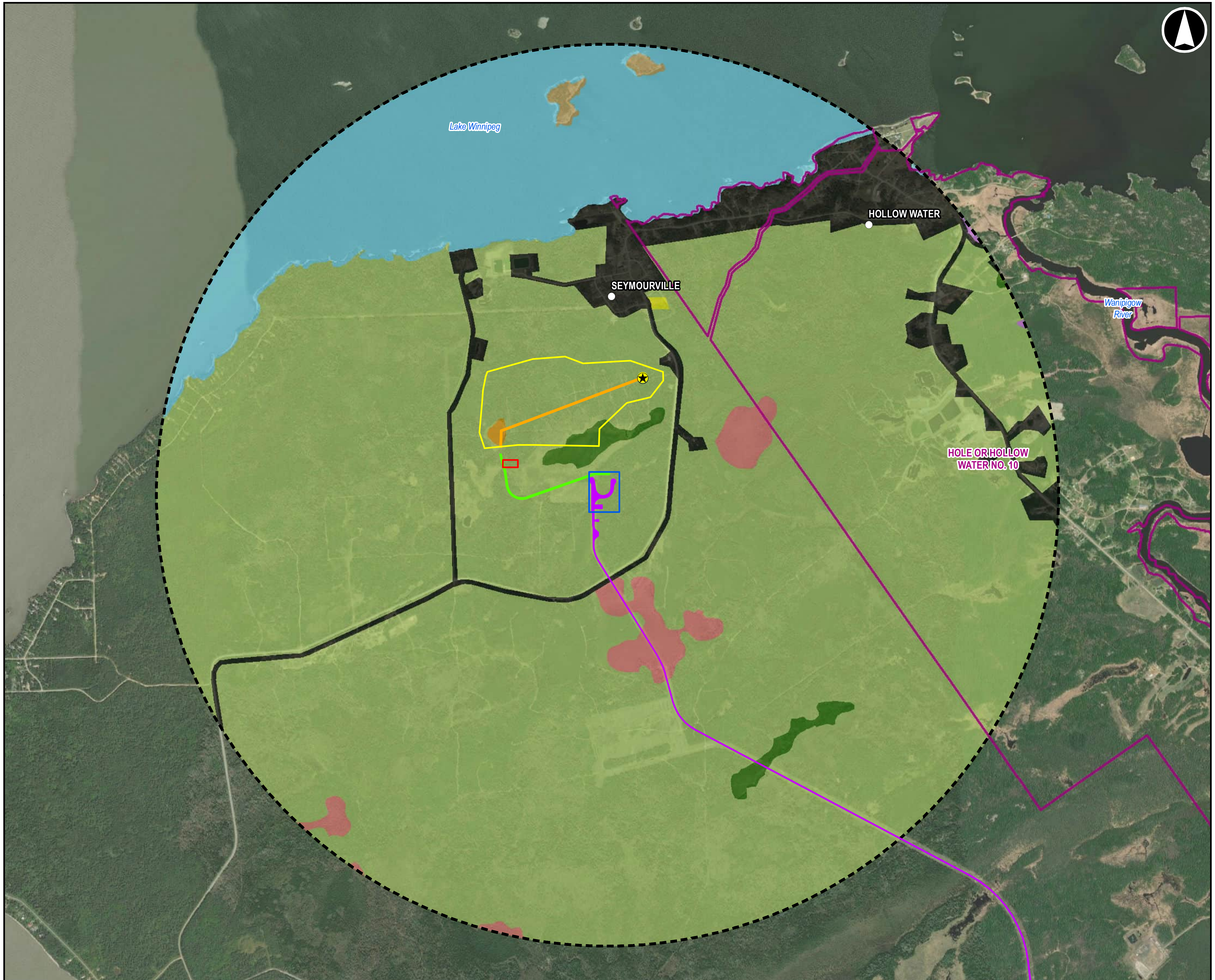
Table 3: Ambient Background Air Quality Concentrations(1)

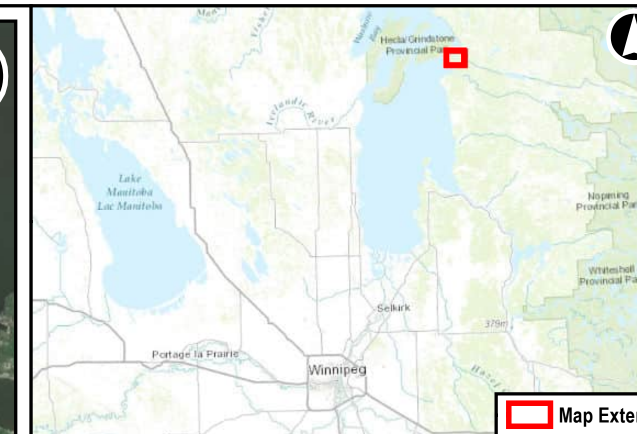
Pollutant	Data Source Location	Averaging Period	Ambient Background Air Quality (µg/m^3)	Objective and/or Guideline (µg/m^3)
$PM_{2.5}$	Thompson (2018, 2019)	24-hour	3.9	30
PM_{10}	Thompson (2018, 2019)	24-hour	8.4	50
TSP (2)	Thompson (2018, 2019)	24-hour Annual mean	16.7 9.6	120 70
CO	Ellen Street, Winnipeg (2018)	1-hour 8-hour	173 115	35,000 15,000
NO_2	Ellen Street, Winnipeg (2019, 2020, 2021)	1-hour 24-hour Annual Mean	24 17 11	400 200 100
SO_2(3)	Flin Flon (2018)	1-hour 24-hour Annual mean	4.5 4.1 2.0	900 300 60

Notes: 1. The 90th percentile for all averaging periods were applied to the background concentrations.
*2. No data was available for TSP background concentration. PM_{10} background concentration was used to calculate TSP=2*PM_{10} instead.*
3. Flin Flon Station data was used for SO_2 since no measurements are made at the Ellen Street and Thompson Stations. Measurements of dust at Flin Flon produced low-quality data, with many $PM_{2.5}$ measurements higher than PM_{10}.

4.5 Land Use and Terrain Characteristics

According to the AERMOD user guide (US EPA 2021), the model should be based on the dominant land use category within 3 km of the wet plant boundary. **Figure 6** provides the land use identified within 3 km where approximately 80% of the land use falls within the category of deciduous forests. The surface roughness, albedo and Bowen ratios for land use and seasons are default values outlined in the Alberta Modelling Guideline (AEP 2021).





Legend

- ★ Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- 3 km Buffer

Land Use

- Fields (Agriculture)
- Marsh Muskeg
- Meadow
- Protection Forest
- Treed Muskeg
- Developed
- Forested
- Water
- Willow/Alder

General Features

- First Nation Reserve

AIR QUALITY ASSESSMENT CANADIAN PREMIUM SANDS

LAND USE WITHIN 3 KM OF THE WET PLANT LOCATION

0 0.25 0.5 0.75 1
Kilometres

Datum: NAD 1983 UTM Zone 14N

Aug, 2022	PN#: 60663147	1:25,000 * when printed 11"x17"

Figure 6

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map

4.6 Receptors

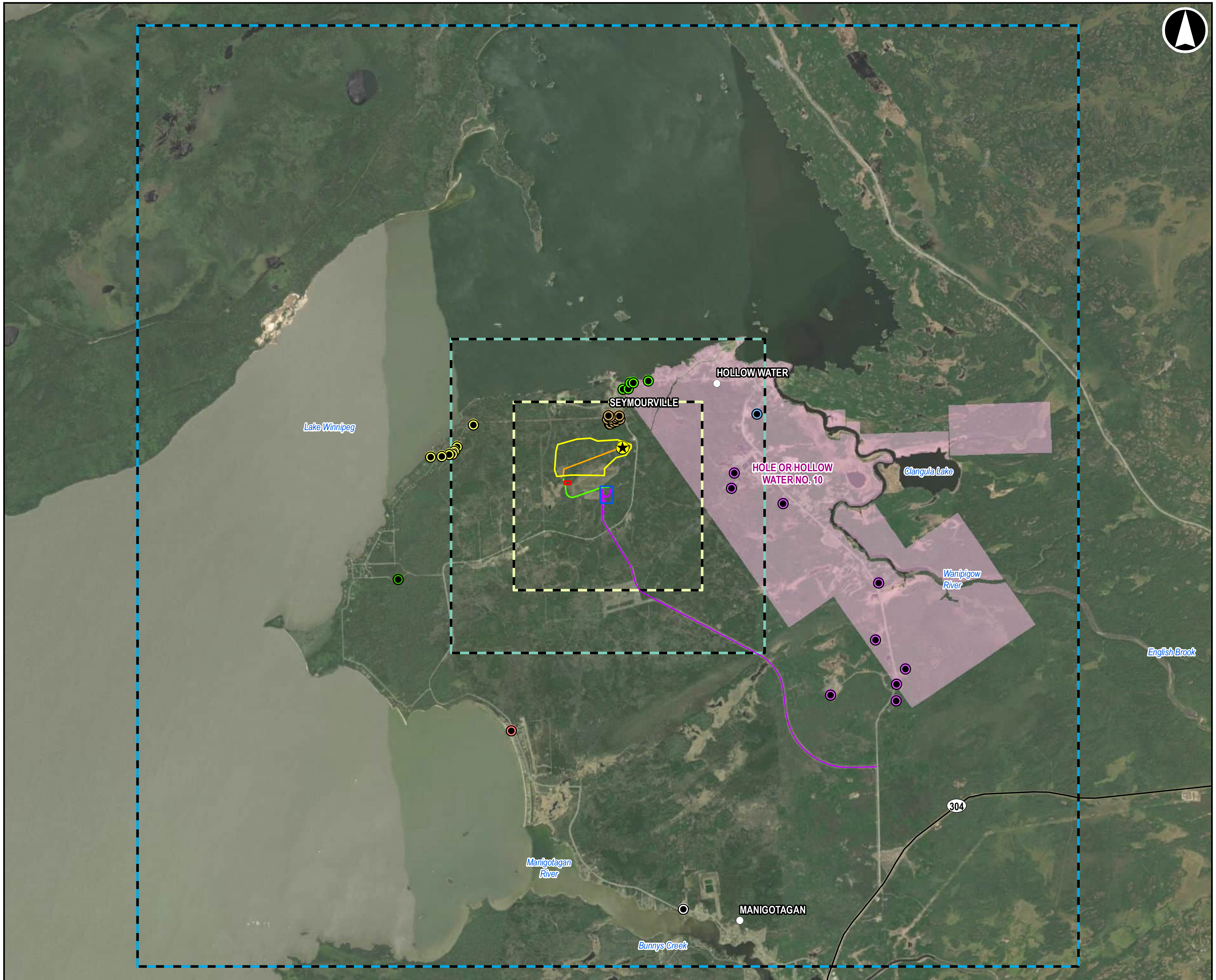
The receptor grid was designed to ensure that the model captures the maximum modelled concentrations associated with the facility emissions. A Cartesian receptor grid was developed to capture the maximum modelled ground-level concentrations associated with the emission sources. The modelled receptor grid with the following spacing and distances was used, as per the Draft of Guidelines for Air Dispersion Modelling in Manitoba (MCWS, 2006) and Alberta Air Quality Model Guideline (AEP, 2021):

- 100 m receptor spacing within 1.5 km from the wet plant (3 km X 3 km) and along the Project boundary
- 250 m receptor spacing within 2.5 km from the wet plant (5 km X 5 km) and
- 500 m spacing within 7.5 km from the wet plant (15 km X 15 km).

Additionally, the following sensitive receptors were identified and included in this model. **Table 4** illustrates the co-ordinates and distance from the Project boundary. Some receptors are far away from the Project, but they could be affected by gravel Project access road transport emissions (**Figure 7**).

Table 4: Sensitive Receptor Details

Discrete Receptor	Receptor ID	Approximate Distance from Wet Plant (m)	Approximate Distance from the Quarry (m)	UTM Co-ordinate	
				(mE)	(mN)
Seymourville	S1	1,161	392	686,743	5,673,561
	S2	1,162	384	686,758	5,673,562
	S3	1,192	384	686,809	5,673,589
	S4	1,207	379	686,851	5,673,600
	S5	1,252	402	686,913	5,673,637
	S6	1,237	472	686,713	5,673,638
	S7	1,238	439	686,780	5,673,637
	S8	1,259	434	686,838	5,673,654
	S9	1,283	448	686,864	5,673,675
	S10	1,300	452	686,903	5,673,687
	S11	1,273	482	686,756	5,673,673
	S12	1,296	514	686,731	5,673,696
Wanipigow (Hollow Water) North	HWN1	1,735	879	686,964	5,674,118
	HWN2	1,750	884	687,042	5,674,120
	HWN3	1,846	979	687,072	5,674,212
	HWN4	1,860	989	687,124	5,674,215
	HWN5	1,958	1,085	687,362	5,674,249
SE Child & Family Services	SECFS	2,720	2,182	689,095	5,673,718
Hollow Water Reserve South	HWS1	2,053	1,825	688,733	5,672,781
	HWS2	1,977	1,860	688,688	5,672,537
	HWS3	2,800	2,718	689,514	5,672,294
	HWS4	4,842	5,089	690,987	5,670,119
	HWS5	4,755	5,187	690,268	5,669,239
	HWS6	4,532	4,630	691,035	5,671,029
	HWS7	4,532	4,630	691,035	5,671,029
	HWS8	5,485	5,752	691,463	5,669,653
	HWS9	5,489	5,797	691,320	5,669,412
	HWS10	5,637	5,975	691,318	5,669,145
Pelican Inlet	PIN1	2,531	2,653	684,313	5,673,195
	PIN2	2,552	2,699	684,269	5,673,126
	PIN3	2,571	2,734	684,237	5,673,081
	PIN4	2,617	2,784	684,187	5,673,072
	PIN5	2,720	2,900	684,073	5,673,042
	PIN6	2,893	3,079	683,894	5,673,036
	PIN7	2,430	2,412	684,574	5,673,549
Ayres Cove Eagle Nest	ACEN	3,591	4,189	683,376	5,671,081
Montago Bay RV Park	MBRV	4,036	4,907	685,181	5,668,668
Wood'N Bell Hotel	WNBH	6,685	7,475	687,924	5,665,826



Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- 100 m spacing within 1.5 km from the Plant (3 km X 3 km) and along the Mine and Plant Boundary
- 250 m spacing within 2.5 km from the Plant (5 km X 5 km)
- 500 m spacing within 7.5 km from the Plant (15 km X 15 km)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

RECEPTOR GRID

0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure 7

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map

4.7 Nitrogen Dioxide Modelling

Maximum predicted NO_X concentrations were conservatively assumed as 100% which is referred to by Alberta Modelling Guidelines modelling (AEP 2021) as the Total Conversion Method (TCM). If TCM exceeds the MAAQC for NO_2 then the other methods can be used. In this assessment, conversion of NO_X to NO_2 is estimated using the Ozone Limiting Method (OLM).

In general, high temperature combustion processes primarily produce NO that can be converted to NO_2 in the atmosphere through reactions with tropospheric ozone:

$$NO + O_3 \rightarrow NO_2 + O_2$$

OLM states that if the ambient ozone concentration is greater than 90% of the predicted NOx, then it is assumed that all the NO_x is converted to NO_2. Otherwise, the NO_2 concentration is equal to the sum of the ozone and 10% of the predicted NO_x concentration. That is:

$$\text{If } [O_3] > 0.9\ [NO_x]\text{, then } [NO_2] = [NO_x]$$
$$\text{Otherwise, } [NO_2] = [O_3] + 0.1\ [NO_x]$$

These guidelines were established through the consideration of lowest observable effect levels on sensitive receptors.

Predicted concentrations of NOx were converted to NO_2 using 90th percentile 1-hour, 24-hour and annual average ozone values measured at the Thompson and Flin Flon Stations as provided in **Table 5**. An ozone background (averaged over five years of data) of 38.4 ppb was used for 1-hour NO_2 results, 35.1 ppb for 24-hour results, and 25.7 ppb for annual NO_X to NO_2 conversion.

Table 5: Summary of Ozone Concentration Data Obtained from Ellen St Station

Statistics	Ozone Concentration (ppb)				
	2018 Thompson	2019 Thompson	2018 Flin Flon	2021 Flin Flon	Average
Data Completion (%)	99	93	100	100	98
Maximum 1- hr	62.5	56.3	59.3	48.1	56.6
90th Percentile 1 -hr	41.5	39.8	38.3	33.9	**38.4**
90th Percentile 24-hr	37.3	35.3	37.0	30.7	**35.1**
Annual Average	28.6	23.9	27.1	23.3	**25.7**

4.8 Effect of Vegetation Cover on Modelling of Particulates

Vegetation reduces the speed of wind blowing through it and enhances turbulence, both of which increase the deposition of particulates near the source. This enhanced deposition reduces concentrations remaining in the air.

The AERMOD model does not sufficiently account for deposition in forested areas compared to measurements reported in the literature (Appendix A, Section A7). For this reason, an 80% reduction due to dense forest was applied to particulate predictions resulting from the Project sources which is considered applicable for plume path lengths of 200 m or more within dense forest. The 80% reduction is considered a minimum adjustment by Appendix A references. This adjustment was not applied to background concentrations since natural background was calculated from observations not from dispersion modelling results.

5. Project Emissions

5.1 Sources and CAC Emissions

The air quality modelling assessment was based on Project description information provided by CPS and published emission factors to capture potential emissions from the quarry pit, wet plant, gravel, and paved roads. The details of emission calculations (including samples of calculations) are provided in **Attachment A.** The following section summarizes emission scenarios, source parameters and emissions used for modelling. These air emissions were used in the AERMOD dispersion model to assess maximum predicted TSP, PM_{10}, silica in PM_{10}, $PM_{2.5}$, NO_2, CO, and SO_2 ground-level concentrations.

The following emission sources were identified at the Project:

- Quarry active pit: active pit extraction of sand and loading on articulate dump trucks (CAT 725) using excavator (CAT 336); unloading of wet plant waste from articulated haul trucks to spread and backfill (continuous remediation)
- Wind generated emissions from two actively disturbed quarry pit surfaces: 1) pit extraction area with moisture 20% and 2) remediation area with moisture 18%
- Quarry haul road (1.12 km) between the quarry and the working pile: emissions from articulate haul trucks transporting sand to working pile and the wet plant waste to old quarry area
- Some articulated haul trucks (CAT 725), after dumping of raw sand, will continue travel on gravel quarry access road (1 km) to return with solid wet plant waste to the old quarry pit for remediation
- All gravel roads (and areas around stockpiles) are serviced by modified CAT 725 water truck and CAT 120 AWD grader
- Working pile: a bulldozer (CAT D6) will blend material for more consistent feed and some material will be fed to into a feeder with a CAT 972M front end loader
- Material from the feeder will be pumped as slurry to the wet plant
- Wet plant – produced wet sand stockpile: Unloading of high-quality produced sand using a stacker. Sand will be stored on the produced wet sand stockpile. Unloading of the wet plant solid waste on articulated haul trucks
- A portion of the produced wet sand will be loaded onto B-Train trucks (average annual 30.3 t load) with CAT 980 loader and transported on gravel wet plant access road and then on paved roads to the solar glass plant
- Wind generated emissions from both actively disturbed quarry pit surfaces,
- Wind generated emissions from the actively disturbed working pile and
- Wind generated emissions from two areas at the wet sand product stockpile: 1) area disturbed by unloading produced sand on stockpile – moisture content 18% and 2) area disturbed by loading sand onto B-Train trucks – moisture content 3%,
- Wind generated emissions from the flat area around the working pile and around produced wet sand stockpile, pulverized by truck and loader wheels, and
- The gravel Project access road is around 7 km long and total distance between wet plant and solar glass plant is around 169 km (162 km of paved roads).

The model developed for this study considered emissions from material transfer points (loading / unloading), unpaved roads, and equipment/vehicle exhausts. AERMOD was used to predict ambient air concentrations outside the Project component footprint. Modelled concentrations were compared with the *Manitoba Ambient Air Quality Criteria* (MAAQC 2005) and Ontario MOE (2012) in the case of silica.

Additionally, a greenhouse gas (GHG) assessment was completed based on the Project components that would contribute appreciably to GHGs including:

- Emissions from the mobile fleet considering estimated annual diesel/gasoline consumption: loaders, grader, dozer, and light duty truck fleet;
- Indirect emissions from electricity use in operations based on estimated consumption and the GHG intensity of the grid;
- the wet plant will be idling in winter (5 months) when equipment will be serviced, and wet plant will be periodically run for short times to ensure readiness for summer (7 months) full scale operation. Idling emissions will be much smaller (lower electricity demand).

Wind-driven emissions from stockpiles will be low. Quarry site material is moist (20% moisture - CPS, 2022), and working pile moisture content will be around 18%. The AP42 emission factors (US EPA, 2006a) were developed for dry areas and they are not dependent on moisture content. To obtain more realistic wind generated emissions, for wet stockpiles and wet flat areas, the emission factors for loading of one tonne of material were calculated for moisture contents 3%, 18% and 20% and unit wind speed (1 m/s). The ratios of loading emission factors for moisture content 18% (working pile) and 20% (the quarry active pit) over loading emission factor for moisture content 3% (produced wet sand stockpile) were applied to wind generated emissions from working pile, flat area around these stockpiles, and the quarry active pit area.

In addition, the silt content, which controls the ability to emit dust to the air, of mined material should be low. For example, municipal waste sand according to AP42 US EPA (2006b) has 2.6% silt content average, limestone 1% and crushed limestone 1.6%. The extracted from quarry and produced wet sand silt content is unknown. However, the produced wet sand is washed sand grains of specific diameter. The silt content for the processed sand will be much lower than the silt content of the sand in the working pile prior to processing at the wet plant.

According to US EPA (2006a), wind erosion emissions are negligible below wind speed thresholds. For wind erosion to occur, the threshold wind velocity measured at 10 m above ground should be above 25 m/s for roadbed material (scoria) and above 19 m/s for overburden. The threshold velocity is 10 m/s for fine coal on a concrete pad (which is quite unlike washed and sized sand final product). However, for this assessment, the threshold velocity was assumed, conservatively, to range from 8.2 m/s to 10.8 m/s (average 9.5 m/s). More details of emission calculations can be found in Appendix A.

The source model input parameters and source locations are summarized in **Table 6** (constant emissions) and **Table 8** and **Table 9** (wind speed dependent emissions). All sources, except the quarry, were modelled as volume sources. The quarry active pit was modelled in AERMOD as an OPENPIT source within a 50 m X 50 m active area, with average depth of 25 m below grade.

Table 6: Modelled Area (Quarry) and Volume Constant Sources Parameters

Source Name	Source ID	UTM X (m)	UTM Y (m)	Elevation (mASL[1])	Effective Height (m)	SigmaY (m)	SigmaZ (m)	Emission Rate (g/s/ Source)					
								$PM_{2.5}$	PM_{10}	TSP	NOx	SO_2	CO
Quarry Pit (1 Source - OPENPIT) 50 m X 50 m area (Excavator)	MINE	686,952	5,673,183	216.0	4.1	-	3.8	6.8E-04	7.0E-04	7.0E-04	0.0145	3.1E-04	0.0077
Working Pile (Bulldozer, Loader)	FEEDER	686,003	5,672,676	243.0	3.3	5.8	3.0	0.0031	0.0191	0.112	0.0255	5.4E-04	0.0127
Produced Wet Sand Stockpile (Loader)	WPLANT	686,716	5,672,401	244.0	3.4	11.6	3.2	9.3E-04	9.4E-04	9.4E-04	0.0195	4.1E-04	0.0103
Gravel Quarry Haul Road (28 Sources) (Quarry to Working Pile)	MHAUL1 MHAUL28	686,908 686,005	5,673,166 5,672,718	241.0 242.0	2.9	18.6	2.7	0.0061	0.0581	0.227	0.0066	1.3E-04	0.0035
Gravel Quarry Access Road (19 Sources) (Wet Plant to Working Pile)	FEDPLT1 FEDPLT19	686,732 686,020	5,672,544 5,672,605	243.1 244.0	2.9	23.3	2.7	0.0011	0.010	0.039	0.0012	2.1E-05	6.2E-04
Part 1 - Gravel Project Access Road (16 Sources) (Wet Plant to Hollow Water Highway) 50 m Spaced	ACCRD1 ACCRD16	686,623 686,826	5,672,377 5,671,687	245.0 245.0	2.3	23.3	2.1	0.0067	0.0669	0.263	2.8E-04	3.6E-07	1.3E-04
Part 2 - Gravel Project Access Road (2 Sources) 175 m Spaced	ACCRD17 ACCRD18	686,918 687,010	5,671,540 5,671,393	245.0 245.0	2.3	81.4	2.1	0.0179	0.179	0.700	7.4E-04	9.5E-07	3.4E-04
Part 3 - Gravel Project Access Road (16 Sources) 350 m Spaced	ACCRD19 ACCRD45	687,132 690,856	5,671,096 5,668,083	242.1 230.0	2.3	162.8	2.1	0.0357	0.357	1.400	0.0015	1.9E-06	6.9E-04

Note: 1. ASL – Above Sea Level

Table 7: Hourly Emission Factors (Unitless)

Hour	Quarry Pit	Gravel Project Access Road; Produced Sand Stockpile	Gravel Quarry Access Road	Working Pile					Gravel Quarry Road					
	All Compounds	All Compounds	All Compounds	$NO_X = SO_2$	CO	$PM_{2.5}$	PM_{10}	TSP	SO_2	NO_X	CO	$PM_{2.5}$	PM_{10}	TSP
0 to 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
4	0	0	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
5	0	0	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
6	0	0	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
7	0	1	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	0	1	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
19	0	1	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
20	0	1	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
21	0	1	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
22	0	1	1	0.7623	0.8109	0.2948	0.0487	0.0083	0.1214	0.1434	0.1398	0.1368	0.1350	0.1341
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8: Modelled Area and Volume Wind Speed Dependent Sources Parameters and Maximum Loading, Unloading, and Wind Generated Emissions

Point Source Name	Source ID	UTM X (km)	UTM Y (km)	Elevation (mASL[1])	Effective Height (m)	Sigma Y (m)	Sigma Z (m)	Maximum Emission Rate (g/s/ Source)		
								$PM_{2.5}$	PM_{10}	TSP
Quarry (1 Source OPENPIT)	MINEWSP	686,952	5,673,183	216.0	4.1	-	3.8	0.0462	0.306	0.638
Working Pile (1 Source)	FEEDERWSP	686,065	5,672,666	243.0	3.3	5.8	3.0	0.0633	0.420	0.868
Produced Wet Sand Stockpile (1 Source)	WPLANTWSP	686,716	5,672,401	244.0	3.4	11.6	3.2	0.1278	0.847	1.750

Note: 1. ASL – Above Sea Level

The following were assumed for the modelling assessment:

- All quarry emission sources were modelled based on 10-hour/365 days/year maximum operation of the quarry (including hauling), for the wet plant maximum capacity, and the maximum traffic on gravel Project access road. The wet Plant was modelled for 20 hours/day and 365 days/year operation. However, the quarry and wet plant will operate for 7 months.
- B-Train trucks will transport produced wet sand for 12 months. During this time up to 44 trips daily will be made for up to 3 months (and in remaining months there will be 26 to 39 trips/day) assuming five days/week cycle. A total of 44 trips/day 365 days a year was modelled.
- Quarry preparation for a new active pit (stripping of soil and overburden) and old pit reclamation (backfill with wet plant waste and with overburden covered by soil) will be done within 3.5 winter months annually. The wet plant and working pile will be not operate in that period. Emissions from this phase will be lower than normal operations of quarry, working pile, wet plant, and haul roads.
- All emission sources were assumed to be operating simultaneously.
- All emissions were based on maximum Project capacity:
    1. There will be 445 t/h working pile input (10-hour working day) and quarry production output. Based on CPS Material Flow metrics, it was assumed the quarry active pit produces at most 6.5% more raw material than required (two days storage over 1 month of operation), to allow for proper blending of sand from different locations at the working pile.
    2. There will be 209 t/h wet plant input (20-hour work day);
    3. There will be 111 t/h wet plant produced wet sand output (20-hour day);
    4. There will be 54 t/h solid waste output (20-hour day); and
    5. The remaining 44 t/h slurry fines will be not an emission source
- Water truck was assumed to work every second hour (12 hours/day), even during rain or snow (in case of snowfall, the water truck will be replaced with a grader).
- Dust reduction was 80% due to watering for gravel roads and flat areas (for loading/unloading pads around the working pile and the produced wet sand stockpile at the wet plant).
- The partial sheltering of the produced wet sand stockpiles by three walls building reduced dust emission by 30%.
- Grader will travel up to 4 hours/day (as needed – grader may be not needed on some days).
- Loading, unloading emissions were modelled using wind speed (and moisture content) dependent emission factors.
- Wind speed generated, erosion emissions were calculated and modelled using US EPA (2006a) procedure for high stockpiles and flat areas.
- Since the Project will be surrounded by dense forest, all particulate predictions were reduced by 80% (US EPA, 1998).

Wind speed dependent emissions were modelled using variable emission factors in AERMOD (**Table 9**). AERMOD used the highest emissions for the highest wind speed, and emissions within lower wind speed brackets were scaled down according to emission ratios. More detailed descriptions of all assumptions used for emission estimates are provided in Appendix A.

5.2 Sources of Silica Emissions

PM_{10} emissions from sources containing silica were modelled separately. It was calculated that extracted sand is 96.3% silica and produced wet sand is 99.5% silica (CPS, 2021). The main sources of silica emissions summarized in **Table 10** are:

- Quarry active pit area: loading of material onto trucks by excavator
- Quarry active pit area: wind-generated dust from disturbed surfaces (excavated quarry surface and reclaimed old pit surface)
- Working pile: bulldozing of material on the stockpile
- Working pile: unloading of material from the quarry, and loading onto the feeder
- Working pile: wind-generated dust from the tall stockpile and area around the stockpile pulverized by wheels of trucks and loader
- Produced wet sand stockpile: unloading of produced wet sand from the wet plant using stacker and loading onto trucks to transport to solar glass plant
- Produced wet sand stockpile: wind-generated dust from the tall stockpile from the area where material from the wet plant is dumped (18% moisture content), from the area where produced sand is loaded onto B-Train trucks (moisture content 3%) and from the area around the pile pulverized by wheels of trucks and loader.

The same variable emission factors in AERMOD presented in **Table 7** and **Table 9** were used for modelling of silica. Average sand content in clay, silt, and silt till (base of unpaved roads covered by gravel) is below 18.1% (CPS, 2021). Gravel covering roads will have negligible sand (silica) content.

Table 9: Wind Speed Dependent Emission Factors (Multiply Maximum Emissions)

Point Source Name	Compound	0-1.54 m/s	1.54-3.09 m/s	3.09-5.14 m/s	5.14-8.23 m/s	8.23-10.8 m/s	>10.8 m/s
Quarry Active Pit (1 Source OPENPIT)	$PM_{2.5}$	0.0171	0.0714	0.1508	0.2834	0.5057	1
	PM_{10}	0.0170	0.0711	0.1503	0.2824	0.5045	1
	TSP	0.0125	0.0522	0.1103	0.2072	0.3538	1
Working Pile (1 Source)	$PM_{2.5}$	0.0147	0.0614	0.1297	0.2436	0.4243	1
	PM_{10}	0.0146	0.0612	0.1292	0.2427	0.4231	1
	TSP	0.0149	0.0625	0.1320	0.2480	0.4300	1
Produced Wet Sand Stockpile (1 Source)	$PM_{2.5}$	0.0137	0.0574	0.1212	0.2278	0.3680	1
	PM_{10}	0.0137	0.0572	0.1208	0.2269	0.3968	1
	TSP	0.0140	0.0585	0.1236	0.2323	0.4041	1

Table 10: Modelled Area and Volume Silica Emission Sources Parameters

Point Source Name	Source ID	UTM X (km)	UTM Y (km)	Elevation (mASL[1])	Effective Height (m)	Sigma Y (m)	Sigma Z (m)	Maximum Emission Rate (g/s/ Source)
								PM_{10}
Quarry (1 Source OPENPIT)	MINEWSP	686,952	5,673,183	241.0	4.1	-	3.8	0.3061[2]
Working Pile (1 Source - Bulldozer)	FEEDER	686,003	5,672,676	243.0	3.3	5.8	3.0	0.01792[3]
Working Pile Unloading/ Loading (1 Source)	FEEDERWSP	686,065	5,672,666	243.0	3.3	5.8	3.0	0.4195[2]
Produced Wet Sand Stockpile (1 Source)	WPLANTWSP	686,716	5,672,401	244.0	3.4	11.6	3.2	0.8472[2]

Note: *1. ASL – Above Sea Level*
2. Variable emission factors from ***Table 9***
3. Variable emission factor from ***Table 7***

5.3 GHG Emissions

Table 11 summarizes estimated annual GHG emissions from the Project sources. A GHG emission inventory was developed considering both direct and indirect emissions associated with the Project operations. The total annual GHG emission calculation was completed using the information provided by CPS as well as recommended emission factors from Canada's Greenhouse Gas Quantification Requirements (EC 2021), US EPA (1996) for non-road trucks and equipment, NIR (2022) for electricity indirect emissions, and US EPA MOVES model for on-road trucks emissions. Detailed GHG calculations are provided in Appendix A, Section A4.

Table 11: GHG Emissions from Operations

Emission Sources	Annual Usage Rate Value	Unit	Total Annual CO2eq Emissions (t/y)
Direct Emission			
The Project Equipment, Diesel Burning	573,577	L/y	1,798.0
Sand Transport (168.8 km and 7,081 trips/year)	1,195,273	Km/y	2,943.5
		Total Direct	4,741.6
Indirect			
Electricity Usage	5,287,400	kW-hr	6.3
		Total Indirect	6.3
		Total	***4,748***
		Manitoba, Total for 2019	***22,600,000***
		Canada Total for 2019	***738,000,000***

Diesel fuel consumption was calculated using Hourly Fuel Consumption Tables from Caterpillar (2019), Owning & Operating Cost Section.

Electricity annual consumption was calculated using factors and methods presented in CPS (2021). Annual electricity consumption was estimated as 5.29 GW. The most recent NIR (2022) emission factor for Manitoba (Table A13-8): 1.2 t of CO_{2eq}/GW-h from year 2019 (and 2020) was used to calculate indirect emissions.

For comparison of Project emissions to provincial and federal totals, emissions for 2019 in Manitoba and Canada were used, since 2020 data are affected by COVID pandemic economic downturn (lower than in previous years). Indirect emission factors for electricity usage in Manitoba are very low, since electricity is produced mainly by hydropower generating stations and natural gas burning.

6. Dispersion Modelling Results

6.1 Introduction

AERMOD (version 19191) was executed with emission rates for the emission sources in **Table 6** to **Table 10**. Background concentrations were taken from data at the Winnipeg (Ellen Street), Thompson, and Flin Flon air quality monitoring stations.

The following conservative assumptions were applied in the modelling assessment:

- Emissions assumed the quarry will operate 10 hours/day, the wet plant will work 20 hours/day and wet sand will be transported to the solar glass plant 16 hours/day. All sources were modelled for 365-day operations, although the quarry and plant will work for 7 months each year and transport will occur 5 days/week.
- GHG emissions were calculated for 7 months of wet plant operations (20 working hours and 4 hours idling), and 5 months of idling in winter (reduced electricity consumption and very limited operations)
- All emission sources were assumed to operate simultaneously. There may be a short period (two days to two weeks) when the quarry will operate alone before plant start-up.
- Wet sand plant access road was modelled for 365 days/year as dry and uncontrolled. In winter and unusually wet springs and falls, the access road will be frozen and/or moist due to snowfall and road dust emissions will be significantly reduced.
- All production numbers are maximum operational levels for the Project. The Project will not work at these high levels of production for extended periods. The average production of the Project will be 72% of maximum numbers over 7 months of operations.
- Produced wet sand loading and transport were modelled, conservatively, for 44 trips/day and 365 days/year. In reality, such intensive trucking will be maintained for only 12 weeks (3 months) and 5 days/week. The amount of wet sand loaded and transported for the remaining 9 months will be 26 to 39 trips/day (5 days/week). The number of daily trips (and emissions) will be even lower if material is transported seven days/week.
- In unusually wet springs and falls, with rain or snow or frozen ground, dust emissions from the quarry pit, stockpiles, gravel quarry and gravel quarry access roads will be lower than calculated and modelled in this assessment. Emissions of particulate will be lower than emissions calculated with dust control due to watering.

The following approaches to mitigation of particulate emissions were incorporated into the model (more detailed information is in Appendix A):

- Gravel roads, wet plant, the flat area around the stockpile, and the working pit feeder flat area are watered on hot dry days with 80% average particulate emission suppression efficiency.
- Produced wet sand stockpile area is covered on all sides except the southern wall, where loader and trucks enter. Dust emissions were reduced by 30%.
- Wind speed generated emissions. We assumed an active area for quarry active pit, working pile, and produced wet sand stockpile that was conservatively large (Appendix A, Section A6), but also that sand is coarse (fines removed) and is disturbed or deposited continuously over a working day.

- Wind speed generated emission factors (USEPA, 2006b) were developed for dry areas. The average moisture content of the quarry surface (at quarry active pit location), and the working pile where sand from quarry is unloaded, will be around 20%. Moisture content of the working pile where sand is loaded onto the slurry feeder, quarry pit (old pit remediation area), and produced wet sand pile where produced sand is unloaded from wet plant will be 18%. Moisture content of the produced wet sand stockpile, where sand is loaded onto B-Train trucks, will be 3%. For this reason, the wind generated emissions were calculated for the produced wet sand stockpile with moisture content 3%, and emissions for areas with higher moisture content were scaled according to emission factors for loading and unloading which are moisture dependent.
- The working pile can be covered with tarps, or sprayed with water on dry, hot, summer days, to preserve the high moisture content.
- Pit backfill will be covered with topsoil and re-vegetated.
- Predicted dust concentrations are reduced by 80% at all receptors outside the operating area, because the entire site is surrounded by dense forest (see Appendix A for rationale).

Mitigation was assumed to apply equally to all particle sizes. No mitigation was applied to vehicle exhaust emissions beyond that associated with medium-age Tier 4 diesel engines.

6.2 Model Results

The maximum modelled ground-level concentrations resulting from emissions from the Project are shown in **Table 12** to **Table 15**. These tables contain particulate predictions with and without the 80% reduction in concentrations due to vegetation. Attachment B Figures B1 to B7 provide additional information showing isopleths of 1-hour and 24-hour average predictions of NO_2, 24-hour predictions of $PM_{2.5}$, PM_{10}, 24-hour, annual average predictions of TSP, and 24-hour predictions of silica in PM_{10}, with vegetative reduction where applicable. The remaining predictions were near background and not included in isopleths figures.

The model did not predict any exceedances of the MAAQC associated with the Project operations (except for silica in PM_{10} exceeding the Ontario MOE limit).

- Predictions of CO (8-hour and 1-hour averages) and SO_2 1-hour average were less than 1% of MAAQC and predictions of SO_2 24-hour and annual are less than 3.5% of MAAQC.
- Maximum concentrations of NO_2 for 1-hour and 24-hour averages (less than 28% and 19% of MAAQC, respectively) were predicted close to the southwest corner of the quarry footprint (Figure B1 and Figure B2) 115 m southwest of the working pile in the working pile area.
- The maximum predicted 24-hour average concentrations of $PM_{2.5}$ and PM_{10} were 22% and 83% of MAAQC and were found near the wet plant access road (Figures B3, and Figure B4, respectively) 177 m south of the produced sand stockpile and B-Train truck loading area.
- The maximum predicted 24-hour average concentrations of TSP was 99% of MAAQC and located near the wet plant access road, 400 m south of the produced sand stockpile and B-Train truck loading area (Figure B5).
- The annual average TSP prediction (43% of MAAQC) occurs close to the wet plant access, 177 m south of the produced sand stockpile and B-Train truck loading area (Figure B6).

- As expected from surface-based emission sources, predicted concentrations decrease rapidly with distance from the source. The maximum project predictions of gaseous emissions at the closest community to sand extraction operations (i.e., Seymourville) are below background concentrations.
- The maximum particulate predictions at Seymourville are also much lower than MAAQC. $PM_{2.5}$, PM_{10} 24-hour and TSP annual average predictions (without background) are lower than respective background concentrations. The maximum predicted 24-hour TSP 24-hour concentration including natural background is 30% of MAAQC.
- Maxima at special receptors in Seymourville were predicted around 450 m from the active pit source (around 350 m from the north quarry boundary). Thick forest between the fence line and houses will reduce concentrations of particulate.

The maximum predicted concentration of silica is above the Ontario AAQC and occurred below 100 m northeast of the working pile (Figure B7). The prediction falls below the Ontario criteria within 200 m of the south quarry boundary with reduction due to vegetation. Without reduction to vegetation, the predictions above the Ontario criteria occur within 600 m from the quarry boundary and within 300 m of the produced wet sand loading area (1 µg/m^3 contour in Figure B7). Maximum predictions at the nearest residences are 10% of the criteria with reduction due to vegetation, and 51% of the criteria without reduction.

The model predicts maxima on 'worst-case emission scenario' days and meteorological conditions. The worst-case emissions assumed the Project operates on maximum load for 365 days/year and that heavy-duty vehicles travel the gravel access road every day. The access road was modelled as an unmitigated source but is in very wet terrain and the road sections near the wet plant, where TSP, PM_{10}, and $PM_{2.5}$ maxima were predicted, may be watered on dry days. The worst-case emissions were applied to five years of meteorological data, including the specific conditions that contribute to worst case predictions. In practice, it is unlikely the worst-case emissions occur coincidently with worst-case meteorology. For example, the maximum predicted concentration of silica (8.27 µg/m^3) was predicted on Christmas Day (December 24, 2018), when the wet plant and working pile will not operate. The second highest silica concentration (8.21 µg/m^3) was also predicted in winter (February 09, 2019).

Finally, the model did not incorporate natural dust suppression from rain and snow. According to the Canadian Climate Normals (EC 2022a) for Winnipeg, there are 125 days annually with precipitation 0.2 mm or above. Thus, natural dust suppression will occur about 34% of the time and contribute to further emission reduction.

Table 12: Maximum Predicted Concentrations of Particulates

Compounds	Averaging Period	Background Concentration (μg/m³)	Maximum Predicted Concentration - No Vegetation Effect (μg/m³)	Maximum Predicted Concentration - Using Vegetation Effect (μg/m³)	Maximum Predicted Concentration (Vegetation) + Background (μg/m³)	MAAQC (μg/m³)
$PM_{2.5}$	24-hour	3.9	14.2	2.8	6.7	30
PM_{10}	24-hour	8.4	165	33	41	50
Silica PM_{10}	24-hour	0	41.4	8.3	8.3	5*
TSP	24-hour	16.7	510	102	119	120
	Annual mean	9.6	104	20.8	30.4	70

*Note: * Ontario MOE criteria*

Table 13: Maximum Predicted Concentrations of Gaseous Emissions

Compounds	Averaging Period	Background Concentration (μg/m³)	Maximum Predicted Concentration (μg/m³)	Maximum Predicted Concentration + Background (μg/m³)	MAAQC (μg/m³)
CO	1-hour	173	67	240	35,000
	8-hour	115	24	139	15,000
NO_x	1-hour	24	131	155	400
	24-hour	17	19	36	200
	Annual Mean	11	1.4	12.4	100
NO_2-OLM	1-hour	24	85	109	400
	24-hour	17	19	36	200
	Annual Mean	11	1.4	12.4	100
SO_2	1-hour	4.5	2.7	7.2	900
	24-hour	4.1	0.40	4.5	300
	Annual mean	2.0	0.03	2.03	60

Table 14: Maximum Particulate Predictions at Sensitive Receptors

Compounds	Averaging Period	Background Concentration (μg/m³)	Maximum Predicted Concentration at Sensitive Receptors (μg/m³)			Location	MAAQC (μg/m³
			Maximum – NO Vegetation Reduction	Maximum – with Vegetation Reduction	Maximum with Vegetation + Background		
$PM_{2.5}$	24-hour	3.9	2.3	0.5	4.4	Seymourville 430 m NNW of Pit	30
PM_{10}	24-hour	8.4	25.3	5.1	13.5	Seymourville 430 m NNW of Pit	50
Silica PM_{10}	24-hour	0	2.5	0.5	0.5	Seymourville 460 m N of Pit	5*
TSP	24-hour	16.7	96.6	19.3	36	Seymourville 430 m NNW of Pit	120
	Annual mean	9.6	8.8	1.8	11.4	Seymourville 430 m NNW of Pit	70

*Note: * Ontario MOE criteria*

Table 15: Maximum Gaseous Compounds Predictions at Sensitive Receptors

Compounds	Averaging Period	Background Concentration (µg/m³)	Maximum Predicted Concentration at Sensitive Receptors (µg/m³)		Location	MAAQC (µg/m³
			Maximum	Maximum + Background		
CO	1-hour	173	12	185	Seymourville 430 m NNW from Quarry Pit	35,000
	8-hour	115	3	118	Seymourville 550 m NNW from Quarry Pit	15,000
NO_2 - TCM	1-hour	24	22	46	Seymourville 430 m NNW from Quarry Pit	400
	24-hour	17	2.3	19.3	Seymourville 430 m NW from Quarry Pit	200
	Annual Mean	11	0.2	11.2	Seymourville 430 m NW from Quarry Pit	100
NO_2-OLM	1-hour	24	22	46	Seymourville 430 m NNW from Quarry Pit	400
	24-hour	17	2	19	Seymourville 430 m NW from Quarry Pit	200
	Annual Mean	11	0.2	11.2	Seymourville 430 m NW from Quarry Pit	100
SO_2	1-hour	4.5	0.5	5.0	Seymourville 430 m NNW from Quarry Pit	900
	24-hour	4.1	0.05	4.15	Seymourville 430 m NW from Quarry Pit	300
	Annual mean	2.0	0.0	2.0	Seymourville 430 m NW from Quarry Pit	60

7. Conclusions

7.1 Air Quality

The dispersion modelling assessment predicted no exceedances of the MAAQC for particulate matter (TSP, PM_{10}, and $PM_{2.5}$) or gases from combustion (CO, NO_2 and SO_2) at any off-site location near the quarry and wet plant.

There is no MAAQC for silica and the Ontario criterion was used. The assessment predicted silica exceedances close to the working pile and/or the wet plant (no exceedances were predicted near the quarry active pit or Seymourville). All highest concentrations were predicted between November and March when there will be no working pile and wet plant operations. The only emissions near the wet plant will be loading of the produced wet sand onto trucks and wind driven emissions which will be lower due to the high moisture content (the produced wet sand stockpile may be frozen and snow covered). The maximum silica concentration (8.3 $\mu g/m^3$) was predicted in winter conditions (December 24, 2018).

It is concluded that the Operations Phase of the Project is likely to have minimal impacts on the air quality of the region, for the following reasons:

- The model used in the assessment is generally considered to be conservative
- The area within which exceedances of regulatory thresholds for silica particulates were predicted is small, extending no more than 200 m from the southern border of the quarry, with reduction due to vegetation (Figure B7).
- All exceeded concentrations were predicted in winter, when working pile and wet plant will not operate.
- Exceedances were not predicted at residences. The magnitude of the vegetation adjustment to reduce predicted dust and silica concentrations is likely underestimated at nearest residences.
- The effects of precipitation to reduce emissions were not considered.

AECOM recommends that a Dust Management Plan be developed that minimizes the potential for predicted exceedances of silica particulates. The Dust Management Plan should include sampling silica in PM_{10} and analysis for silica within these samples.

7.2 GHG

The Project is estimated to generate 4,748 t of CO_2e annually which is 0.021% of the reported Manitoba emissions in 2018 which were 22.6 Mt CO_2e (Climate Change Connection 2022), and 0.0006% of the reported 738 Mt CO_2e from Canada in 2019 (EC, 2022).

8. References

Alberta Environment and Parks (AEP), 2021:
Air Quality Model Guidelines (October 2021). Retrieved from: https://open.alberta.ca/publications/air-quality-model-guideline-2021

Canadian Premium Sand (CPS), 2021:
Sand Treatment Plant Project – FEED Report, prepared by cm.project.ing GmbH, October 2021

Canadian Premium Sand (CPS), 2022:
Wanipigow Sand Project – Geotechnical Investigation Data Report, prepared by AECOM Canada Ltd., February 24, 2022

Caterpillar, 2019:
Caterpillar Performance Handbook Version #49, September, 2019: https://wagnerequipment.com/wp-content/uploads/2020/02/SEBD0351_ED49_Bookmarks_Sept_2019.pdf

Climate Change Connection, 2022:
Manitoba GHG emission trend 1990-2020, retrieved from: http://climatechangeconnection.org/emissions/manitoba-ghg-emissions/ Website updated May 12, 2022.

Environment Canada (EC), 2021:
Canada's Greenhouse Gas Quantification Requirements (Dec 2021), retrieved from: https://publications.gc.ca/collections/collection_2022/eccc/En81-28-2021-eng.pdf

Environment Canada (EC), 2022:
Greenhouse gas emissions, Canada, 1990 to 2020, retrieved from: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

Manitoba Ambient Air Quality Criteria (MAAQC), 2005:
Manitoba Objectives and Guidelines for Various Air Pollutants
https://www.gov.mb.ca/sd/envprograms/airquality/pdf/criteria_table_update_july_2005.pdf

Manitoba Conservation and Water Stewardship (MCWS), 2006:
Draft Guidelines for Air Quality Dispersion Modelling Manitoba (MCWS, November 2006)

Manitoba Hydro, 2021:
Greenhouse Gas Emission Factors (April 2021), retrieved from: https://www.hydro.mb.ca/environment/pdf/ghg-emission-factors.pdf

National Inventory Report (NIR), 2022:
1990-2020: Greenhouse gas Sources and Sinks in Canada. Canada's Submission to the United Nations Framework Convention on Climate Change. Part 3, Submitted April 14, 2022.

Natural Resources Canada (NRCan), 2020a:
Land Use Categories shape files supplied by the NRCan website: ftp://ftp.geogratis.gc.ca/pub/nrcan_rncan/vector/geobase_lcc_csc/shp_en/*.* Natural Resources Canada, Earth and Sciences Sector. Data accessed in May 2020

Natural Resources Canada (NRCan), 2020b:
Canadian Digital Elevation Data. Natural Resources Canada, Earth and Sciences Sector. The 1-Degree and 15-Minute DEMs available automatically in WebGIS have been retrieved by using the integrated feature in the Terrain Processor of the AERMOD-View. Data accessed in May 2020

Ontario Ministry of Environment (MOE), 2012:
Ontario's Ambient Air Quality Criteria. Standards Development Branch, April 2012.

United States Environmental Protection Agency (US EPA), 1995:
11.19.1 Sand and Gravel Processing (AP-42: Compilation of Air Emissions Factors, November 1995), retrieved from: https://www3.epa.gov/ttnchie1/ap42/ch11/final/c11s19-1.pdf

USEPA, 1996:
Section 3.3 Gasoline and Diesel Engines (AP-42: Compilation of Air Emissions Factors, September 1996) prepared by Eastern Research Group. retrieved from: https://www3.epa.gov/ttnchie1/ap42/ch03/bgdocs/b03s03.pdf

US EPA, 1998:
Emission Factor Documentation for Section 13.2.2 (Unpaved Roads), Fifth Edition (AP-42). EPA Purchase Order 7D-1554-NALX; MRI Project No. 4864, Prepared by MRI for US EPA Office of Air Quality Planning and Standards Emission Factor and Inventory Group Research Triangle Park.

US EPA, 2006a:
Section 13.2.5 Industrial Wind Erosion (AP-42: Compilation of Air Emissions Factors, November 2006), retrieved from:
https://www.epa.gov/sites/default/files/2020-10/documents/13.2.5_industrial_wind_erosion.pdf

US EPA, 2006b:
Section 13.2.4 Aggregate Handling and Storage Piles (AP-42: Compilation of Air Emissions Factors, November 2006), retrieved from: https://www3.epa.gov/ttnchie1/ap42/ch13/final/c13s0204.pdf

USEPA, 2021:
AERSURFACE User's Guide. (EPA-454/B-08-001, January 2008 (Revised January 2021). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

Appendix A

Emissions Estimates Details

Table of Contents

Figures

Tables

A1. Introduction

This attachment summarizes methods used to estimate emissions from the revised Wanipigow Sand Extraction Project (the Project) during normal operations. Description details of the revised Project are provided in a Notice of Alteration to the Manitoba Environmental Assessment Branch regarding Environment Act Licence (EAL) No. 3285.

Section 2.2 of the Air Dispersion Modelling report summarizes Project activities. The Project will be supplying sand to be used in glass production for a proposed solar glass plant in Selkirk, Manitoba, which is proposed to be constructed and operated in two phases (the second phase will increase glass production and therefore increase sand raw material required).Therefore, the maximum sand production requirement to supply sand for the second phase of the proposed solar glass plant was selected for modelling purposes. The location of the quarry active pit was chosen for the area marked year 4 of the quarry operation in Figure A1. This location is the closest to nearby residences at least 400 m north of the active pit block and has a longer haul road than in other year of the quarry operation. The Project operations will be done in 7 months (from April to the end of October).

Every few years, from mid February to mid April, a new active pit block will be prepared for mining by removing vegetation and stripping of the soil and overburden. The stripped material will be stored to be used in November to mid-December for quarry pit reclamation. There will be bulldozer, excavator and haul trucks involved in pit preparation and reclamation. However, these operations will be conducted when temperatures are below freezing and when there will be considerable snow fall. The ground will be wet/frozen, and particulate emissions are expected to be much lower than it would be during other times of year. The amount of removed soil, clay, and till will also be much lower than the amount of sand that is extracted . The quarry active pit preparation and pit reclamation will be completed within 3-4 (or 3.5) months while the quarry and wet plant will operate for 7 months.

For these reasons, it was assumed that normal Project operation (including the Project gravel access road) is the worst-case scenario. This case was modelled for 365-day operations although the Project gravel access road emissions assumed usage 16 hours/day and five days/week. It should be also noted that active quarry pit location changes during the 7 months of operations, and most of the time the pit will be further away from Seymourville than the location that was considered for the purposes of modelling.

The following compounds were modelled and assessed. Fugitive dust particulate emissions include:

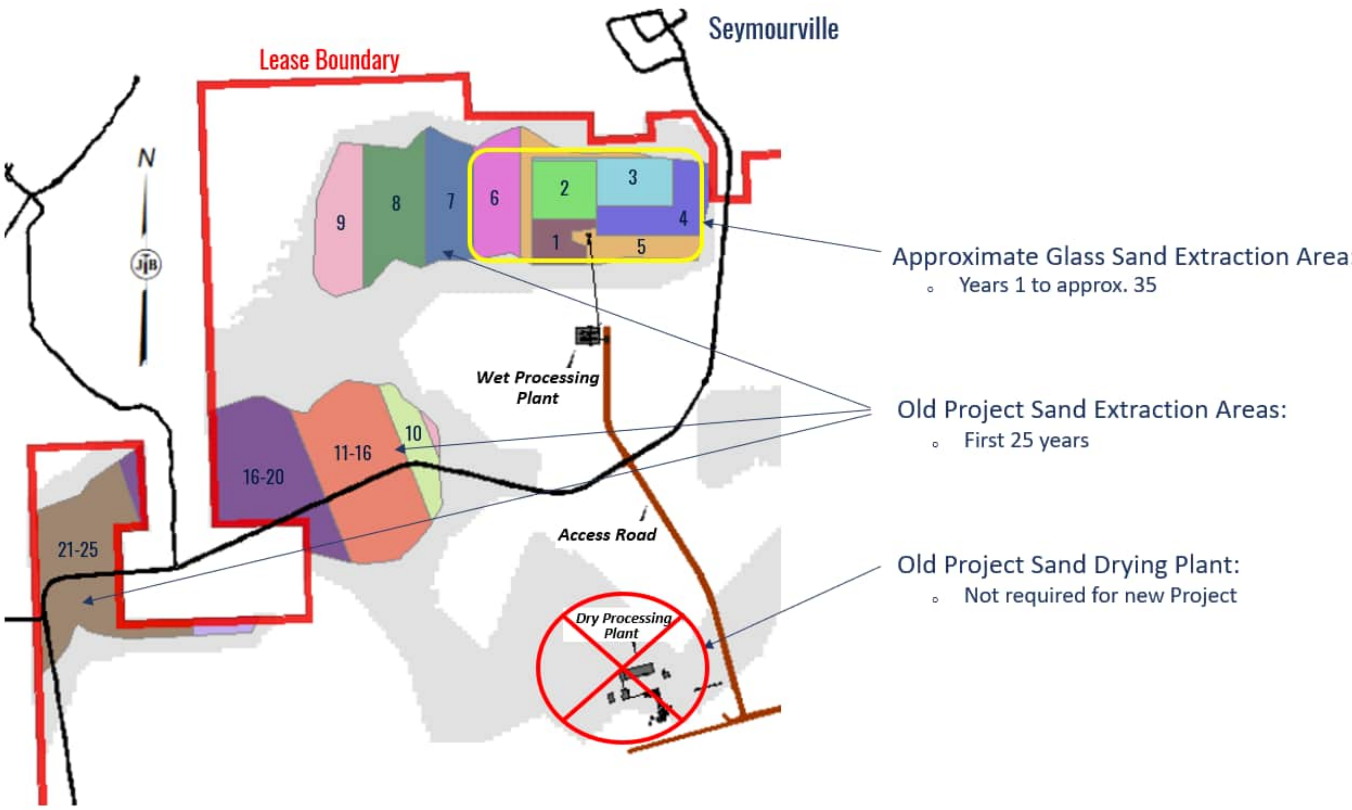
- Particulate matter with diameter less than 2.5 µm ($PM_{2.5}$)
- Particulate matter with diameter less than 10 µm (PM_{10})
- Particulate matter with diameter less than 30 µm – Total Suspended Particulates (TSP)
- Silica (SiO_2), which is a part of PM_{10} emissions.

Diesel combustion equipment will emit particulate and gases, of which the following compounds were modelled:

- Sulphur Dioxide (SO_2),
- Nitrogen Oxides (NO_X),
- Carbon Monoxide (CO),
- Particulate emissions, mainly PM_{10} and $PM_{2.5}$, from diesel combustion.

This attachment summarizes emissions from all sources and identifies the highest emission sources for a given compound. The main emission sources are haul trucks, excavator, bulldozers, loaders, and other diesel combustion equipment. Emissions have been estimated based on available information, and were calculated using conservative assumptions, which represent the highest hourly, daily, and annual values.

Figure A1: Updated Sand Extraction Areas



A2. Supporting Information for Dust Emission Calculations

A2.1 Material Properties

Table A1 summarizes the material properties used for the emission estimates. For emission estimation purposes, the United States Environmental Protection Agency (US EPA) defines silt content as the fraction of particles smaller than 75 µm in diameter *available to be emitted from the haul road or pit surface* (US EPA, 2006a).

Table A1: Material Properties

Property / Material	Moisture Content (%)	Silt Content (%)
Gravel Roads	-	4.8
Raw Sand Extracted at Active Pit and Dumped onto Working Pile	20	-
Working Pile	18	-
Final Wet Sand Unloaded onto Stockpile after Processing at the Wet Plant & Solid Plant Waste	18	-
Final Wet Sand in Stockpile just prior to transportation off-site (water content naturally drains/evaporates/decreases over an approximate 2 to 4 week time period)	3	-
Final Wet Sand Transported to Solar Glass Manufacturing Plant	3	-

The choice of haul road silt content (4.8%) is based on measurements from roads at sand and gravel processing facilities listed in Compilation of Air Pollutant Emissions Factors (AP-42) prepared by US EPA (Table 13.2.2-1, US EPA 2006a). This value is higher than the silt content for limestone (average 1%), crushed limestone (1.6%) and various limestone products (3.9%) (Table 13.2.4-1; US EPA 2006b). Limestone from the quarry will be used as gravel cover of roads.

Raw sand had an average moisture content of 20% (CPS, 2022). From all 306 test holes at eight sites, within the exploration area, the range in moisture content for sand was 3.2% to 45%. The measurements at three sites with the highest number of test holes (233 test holes) had a weighted average moisture content of 20%. For clay, the range of measured moisture content was 10.2% to 69.7% (weighted average for 159 measurements was 37% - CPS, 2022). From 51 measurements of moisture content in silt till and silt, the weighted moisture content was 23% (9% to 38.5% range). In summary, the area of the Project and surrounding areas are very moist. The moisture content from within exploration area can be applied to the project site (the closest active pit to Seymourville village).

It was assumed that processed sand, loaded on B-Train trucks and transported to solar glass plant, has an 3% moisture content. It was also assumed that average moisture content on the wet plant stockpile was also 3%. It was assumed that working pile material has moisture content 18%. The processed sand, dumped from the wet plant onto the final wet sand stockpile, and plant waste was assumed to have 18% moisture content.

A2.2 Hours of Operation

To supply the proposed solar glass plant in Selkirk with sand, the quarry will operate 10 hours, wet plant 20 hours and B-Train trucks delivering sand to solar glass plant for 16 hours; 5 days a week). Quarry, wet plant for sand processing and working pile will not operate in winter (November to March – 5 months). Modelled and anticipated hours of operations are summarized in **Table A2**.

Table A2: Modelled and Anticipated Hours of Operation

Operation / Time	Hours/Day Working	Hours/Day Modelled
Excavator CAT336 at Active Quarry Pit (Diesel Burning)	10	10
Loading of Raw Sand at Quarry and Dumping on the Working Pile (Fugitive Dust, Dependent on Wind Speed Emissions)	10	24
Wind Generated Fugitive Dust Emissions from the Active Quarry Pit, from the Working Pile and from the Wet Sand Pile	24	24
Articulated Trucks between Quarry Active Pit and Working Pile (Diesel Burning and Fugitive Dust)	10	10
Loading at the Plant Dumping of the Solid Plant Waste on Old Quarry Pit (Fugitive Emissions, Wind Speed Dependent)	20	24
Articulated Trucks Transporting Solid Waste from Wet Plant to Old Quarry Pit (Remediation - Diesel Burning and Fugitive Dust)	20	20
Bulldozer CATD6 at Working Pile (Diesel Burning and Fugitive Dust)	10	10
Front End Loader (CAT 972M) on Working Pile (Diesel Burning Emissions)	20	20
Loading of the Raw Sand into the Slurry Feeder (Wind Speed Dependent Fugitive Dust Emissions)	20	24
Dumping of the Wet Sand on the Pile (Wind Speed Dependent Fugitive Emissions)	20	24
Loader (CAT980) at the Wet Sand Pile (Diesel Burning)	16	16
Loading of the Wet Sand on the B-Train Trucks (Wind Speed Dependent Fugitive Dust Emissions)	16	24
B-Train Stacks Delivering Wet Sand to the Solar Glass Plant (Diesel Burning and Fugitive Dust Emissions)	16	16
Water Truck (Diesel Combustion and Fugitive Dust Emissions) on Quarry Roads	10	20
Grader (Diesel Combustion and Fugitive Dust Emissions) on Quarry Roads	2	20

Wind speed dependent fugitive dust emissions were based on anticipated working hours but spread over 24 hours (for example, loading and unloading of sand). These emissions were calculated for actual working day hours but spread over 24 hours. Wind-generated emissions were calculated and modelled for 24 hours/day. All wind speed dependent emissions were modelled using wind speed dependent emission factors in AERMOD. Transport emissions and equipment emissions from diesel combustion (e.g., loaders, bulldozer) were modelled using time-dependent (hour of the day) factors in AERMOD.

A2.3 Material Production

Annual sand demand for the solar glass plant is up to 285,000 tonnes/year (t/y). Maximum daily wet sand flint transported to the solar glass plant is calculated assuming maximum number of truck trips for a five day/week and 16 hours/day cycle. The maximum 44 one-way trips per day (planned for April to June) could have been used for modelling. However, there can be days with even more haul traffic on the road. Conservatively, three one-way trips/hour were modelled (48 trips per 16-hour day = 1,456 t of produced wet sand per day). This hauling rate exceeds the annual demand and therefore provides a conservative prediction.

Sand production is expected to be over 285,000 t/y. Maximum hourly production was based on the *CPS Flow (Metric) R3* numbers published on May 4, 2022. Daily maximum numbers were based on 10 hours effective quarry work (modelled using hourly emission factors in AERMOD) and 20 hours effective wet plant work. Based on CPS Material Flow metrics, it was assumed the quarry active pit produces at most 6.5% more than required raw material (two days storage over 1 month of operation), to allow for proper blending of sand from different locations at the working pile. However, the overall amount of material delivered from the quarry to the working pile annually should approximate the material processed at the wet plant. The final wet sand stockpile will grow over 7 months of wet plant operation to 160,000 t and then be depleted by wet sand transport over the winter.

Table A3 summarizes the annual and maximum daily and hourly material production numbers estimated for the Project.

Table A3: Material Production Numbers

Material	Annual Maximum (t/y)	Daily Maximum (t/d)	Hourly Maximum (t/h)
Total Sand Extracted and Dumped to Working Pile (10 h/d)	536,622	4,450	445
Total Blended Sand Loaded to the Plant Feeder (20 h/d)	536,622	4,180	209
Final Wet Sand (20 h/d)	285,000	2,220	111
Wet Plant Waste Sand Used as Pit Backfill (20 h/d)	138,560	1,080	54
Slurry Fines (NOT an Emission Source)	112,973	880	44
Wet Sand Transported to Solar Glass Plant (16 h/d – 5 days/week)	285,000	1,456	91

A2.4 Reduction of Dust Emissions due to Watering

Heavy equipment and vehicle traffic along gravel haul roads during sand extraction operations are the primary source of dust emissions. To mitigate the impact of road dust, facility operators often implement operational procedures aimed at suppressing emissions, such as the watering. Operation during frozen or snow-covered road conditions also minimizes road dust emissions.

Per climatological data obtained from the weather stations in Winnipeg and Thompson, Manitoba , periods of snow cover extend from November to April; however, in remote areas (e.g., Thompson station) it can be as early as October and as late as May (EC, 2022a).

Table A4 summarizes emission reduction data presented by the Emission Factor Documentation (US EPA 1998a) for US EPA AP 42 Section 13.2.2 (Unpaved Roads) (US EPA 2006a) from many observations, with mean reductions for $PM_{2.5}$, PM_{10}, and TSP measurements from 79 to 91%. The average annual precipitation in the Project area is above 500 mm (Winnipeg Airport: 521 mm/y; Thompson: 509 mm/y). This impacts the fugitive dust calculation presented in this assessment, as dust emissions would be lower than those used to obtain the emission factors in US EPA (AP42). For example, in US EPA (1998b) (which is an example applicable to Western Surface Coal Mining), emission factors were developed for mines and quarries based on annual precipitation levels of 280 mm/y to 403 mm/y, which is less than precipitation levels recorded at stations near the Project. As it was mentioned in Section A2.1 area around the Project is relatively moist.

Table A4: Reduction of Dust Emissions due to Naturally occurring or Anthropogenic Dust Control Measures

Place/Industry	Equipment/ Control Method	Emission Reduction of $PM_{2.5}$ (%)	Emission Reduction of PM_{10} (%)	Emission Reduction of TSP (%)
California[a] /Road Construction	Scraper / Watering	-	79	-
Wyoming[b] / Coal Mines	Haul Trucks / Watering	-	54	41
North Caroline[c] / Stoney Quarry	Haul Trucks / Watering	-	94	-
Michigan[d] / Coal Yard at Power Plant	Scraper / Watering	79	80	80
Ohio[e] / Iron & Steel Plant	Haul Trucks / Watering	87	-	78
Ohio[e] / Iron & Steel Plant	Haul Trucks / Coherex	91	-	95
Indiana[f] / Iron & Steel Plant	Haul Trucks / Petro-Tac	79	91	81
Missouri[f] / Iron & Steel Plant	Haul Trucks / Watering	72	92	89
Missouri[f] / Iron & Steel Plant	Haul Trucks / Coherex	89	92	83
Wyoming, New Mexico, North Dakota[g] / Coal Mines	Haul Trucks / Watering	61	-	73
Wyoming, New Mexico, North Dakota[g] / Coal Mines	Haul Trucks / $CaCl_2$	24	-	88
Median		79	91	81

Notes: (a) South Coast AQMD (1996)
(b) US EPA (1994)
(c) National Stone Association (1994)
(d) MRI (1985)
(e) US EPA (1983a)
(f) US EPA (1983b)
(g) US EPA (1981) (poor quality data: average of controlled emissions measured at Wyoming and New Mexico over average of uncontrolled emissions measured at Wyoming, New Mexico, and North Dakota)

For this assessment, it was assumed that 80 % of haul road particulate emissions would be mitigated by watering or natural precipitation.

A3. Fugitive Dust Emissions

A3.1 Loading/Unloading Emissions

The emission factor formula for loading and unloading of sand was sourced from AP 42 Section 13.2.4 (Aggregate Handling and Storage Piles) US EPA (2006b):

$$TSP\left(\frac{kg}{t}\right) = \frac{0.0016 * 0.74 * \left[\frac{U}{2.2}\right]^{1.3}}{\left[\frac{M}{2}\right]^{1.4}}$$

$$PM_{10}\left(\frac{kg}{t}\right) = \frac{0.35}{0.74} * TSP\left(\frac{kg}{t}\right)$$

$$PM_{2.5}\left(\frac{kg}{t}\right) = \frac{0.053}{0.74} * TSP\left(\frac{kg}{t}\right)$$

Where:

- U is mean wind speed (m/s)
- M is moisture content (%) (**Table A1**)

Loading / unloading emissions are wind speed dependent and modelled using wind speed dependent emission factors. The equations have an “A” rating (excellent) for aggregate handling. The meteorological conditions at the Project were obtained from AERMET files. The hourly wind speed was used to calculate emissions for wind speed bins: 0 to 1.54 m/s; 1.54 to 3.09 m/s; 3.09 to 5.14 m/s; 5.14 to 8.23 m/s; 8.23 to 10.8 m/s and above 10.8 m/s.

Example 1: Following is an example emission calculation of TSP emissions from final wet sand (moisture content 3%) loading into trucks, using a wind speed dependent emission factor with a wind speed of 6.69 m/s (average of AERMET wind speed category bounds of 5.14 and 8.23 m/s):

$$TSP\left(\frac{kg}{t}\right) = \frac{0.0016 * 0.74 * \left[\frac{6.69\ m/s}{2.2}\right]^{1.3}}{\left[\frac{3.0}{2}\right]^{1.4}} = 0.0285$$

The average wind speed above 10.8 m/s was estimated as 13.7 m/s using maximum winds in the area obtained from AERMET (16.5 m/s). Since it is not possible to have wind speed dependent emissions and hourly variable emissions at the same time in AERMOD, emissions were calculated for planned hours of operation during each day and then spread over 24 hours. This approach is reasonable because the lowest regulatory averaging period for particulate is 24 hours. Usually, meteorological conditions for dispersion are worse at night and assigning emissions to this period is conservative.

During dry, hot, summer conditions, the working pile can be sprayed with water or partially covered with tarps to prevent drying. For this reason, the moisture content 18% was used for this pile. According to Australian NPI (2012) water sprays reduce loading and unloading emissions by 50%. Due to the moisture content of material on the stockpile, this dust reduction factor was not used in emission calculations.

The product wet sand stockpile will be enclosed on three sides. Only the southern side will be opened to provide access to loader and B-Train trucks. Australian NPI (2012) suggests 99% dust reduction if the stockpile is totally enclosed. Since this pile is not fully enclosed, a 30% reduction for wind-generated emissions for piles with wind breaks was used. Loading of material onto stockpile using variable height stacker warranted a 25% dust emission reduction. Combining stacker and partially sheltered stockpile effects, a 30% dust reduction was used for all particulate emissions from this stockpile.

Table A5 presents the maximum 1-hour wind speed dependent emissions calculated for loading and unloading. **Table A6** lists maximum 24-hour wind speed dependent emissions calculated for sand loading and unloading. **Table A7** lists total annual average emissions from five years of data (total emissions divided by 5 years) calculated for loading and unloading.

Table A5: Loading and Unloading Wind Speed Dependent Maximum 1-Hour Average Emissions Used in Model

Operation	TSP 1-Hour Maximum (kg/h)	PM_{10} 1-Hour Maximum (kg/h)	$PM_{2.5}$ 1- Hour Maximum (kg/h)
Raw Sand – Loading / Unloading Quarry and Working Pile (Moisture 20%) (10 h/d spread over 24 h)*	1.870	0.884	0.134
Loading of Sand on Feeder (Moisture 18%) (20 h/d spread over 24 h)	1.015	0.480	0.073
Loading of Plant Solid Waste on Truck / Unloading on Reclamation Site (Moisture 18%) %) (20 h/d spread over 24 h)*	0.525	0.248	0.038
Unloading on Product Wet Sand Stockpile (Moisture 18%) (20 h/d spread over 24 h)	0.377	0.179	0.027
Loading of Product Wet Sand on Trucks (Moisture 3%) (16 h/d spread over 24 h)	3.04	1.439	0.218

*Note: * Loading emissions were doubled to account for unloading*

Table A6: Loading and Unloading Wind Speed Dependent Maximum 24-Hour Emissions

Operation	TSP 24-Hour Maximum (kg/d)	PM_{10} 24-Hour Maximum (kg/d)	$PM_{2.5}$ 24- Hour Maximum (kg/d)
Raw Sand – Loading / Unloading Quarry and Working Pile (Moisture 20%) (10 h/d spread over 24 h)*	44.8	21.2	3.21
Loading of Sand on Feeder (Moisture 18%) (20 h/d spread over 24 h)	24.4	11.6	1.75
Loading of Plant Solid Waste on Truck / Unloading on Reclamation Site (Moisture 18%) %) (20 h/d spread over 24 h)*	12.6	5.96	0.90
Unloading on Product Wet Sand Stockpile (Moisture 18%) (20 h/d spread over 24 h)	9.1	4.28	0.65
Loading of Product Wet Sand on Trucks (Moisture 3%) (16 h/d spread over 24 h)	73.0	34.5	5.23

*Note: * Loading emissions were doubled to account for unloading*

Table A7: Loading and Unloading Wind Speed Dependent Annual Emissions

Operation	TSP Annual Total (t/y)	PM_{10} Annual Total (t/y)	$PM_{2.5}$ Annual Total (t/y)
Raw Sand – Loading / Unloading Quarry and Working Pile (Moisture 20%) (10 h/d spread over 24 h)*	4.31	2.04	0.309
Loading of Sand on Feeder (Moisture 18%) (20 h/d spread over 24 h)	2.35	1.11	0.168
Loading of Plant Solid Waste on Truck / Unloading on Reclamation Site (Moisture 18%) %) (20 h/d spread over 24 h)*	1.21	0.57	0.087
Unloading on Product Wet Sand Stockpile (Moisture 18%) (20 h/d spread over 24 h)	0.87	0.41	0.063
Loading of Product Wet Sand on Trucks (Moisture 3%) (16 h/d spread over 24 h)	7.03	3.33	0.504

*Note: * Loading emissions were doubled to account for unloading*

A3.2 Bulldozing Operations

Working pile bulldozing emissions are based on AP 42 Table 11.9-2 (US EPA 1998b) for bulldozing of overburden:

$$TSP\left(\frac{kg}{h}\right) = \frac{2.6 * (s)^{1.2}}{(M)^{1.3}}$$

$$PM_{10}\left(\frac{kg}{h}\right) = \frac{0.45 * 0.75 * (s)^{1.5}}{(M)^{1.4}}$$

$$PM_{2.5}\left(\frac{kg}{h}\right) = 0.105 * TSP\left(\frac{kg}{h}\right)$$

where:

- *s* is the silt content of the material (%)
- *M* is the moisture content of the material (%) (**Table A1**)

One bulldozer will be blending sand at working pile close to the feeder. TSP emission factor for sand bulldozing is:

$$TSP\left(\frac{kg}{h}\right) = \frac{2.6 * (4.8)^{1.2}}{(18)^{1.3}} = 0.399$$

Emissions of one bulldozer working effectively for 10 hours at the working pile:

$$TSP\left(\frac{kg}{d}\right) = 1\ bulldozer * 0.325\left(\frac{kg}{h}\right) * 10\left(\frac{h}{d}\right) = 5.85$$

Table A8 summarizes bulldozer emission factors and total emissions for one bulldozer working at the working pile for 10 hours/day. Emissions were modelled using hourly variable emissions in AERMOD (8:00 am to 6:00 pm).

Table A8: Working Pile Bulldozing Emission Factors (kg/h) and Emissions – kg/10-hour day (kg/d)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor for Bulldozing of Working Pile	kg/h	0.399	0.0645	0.00645
Daily Emissions from Bulldozing	kg/d	3.99	0.645	0.0645

A3.3 Vehicle Parameters (Wheel Entrainment Emissions)

Table A9 summarizes parameters of vehicles (grader, water truck, articulated dump non-road trucks, B-Train on road trucks) travelling on roads. Emissions depend on total vehicle kilometres travelled (VKT).

Articulated dump trucks on the quarry haul road will work 10 hours/day (7:00 am to 5:00 pm). The quarry haul road is a road within the quarry to get raw sand from the quarry face to the working pile and the slurry feeder. Solid plant waste will be transported by the same trucks from the wet plant to the quarry for remediation. The road from the plant to the working pile is called the “quarry access road”.

Table A9: Parameters of Vehicles Transporting Material on Roads (during 24-hour day)

Vehicle	Total Modelled VKT (per Day)	One-Way Distance (km)	Two-way Trips/Day	Vehicle Load (t)	Average Vehicle Weight (t)
Articulated Dump Truck on Quarry Haul Road CAT725 (10 h/d)	430	1.16	186	24	35
Articulated Dump Truck on Waste Sand CAT725 (10 h/d between 7:00 am and 5:00 pm)	99	2.16	23	24	35
Articulated Dump Truck on Waste Sand CAT725 (10 h/d between 2:00 am and 7:00 am and between 6:00 pm and 11:00 pm)	95	2.16	22	24	35
Water Truck (CAT725)	44	2.16	6	24	35
Grader CAT120 AWD	18	2.16	4	-	-
B-Train On-Road Project Access Road (7 km)	448	7.0	48	30.3	38.7

The quarry gravel haul road from the quarry to the working pile used for modelling was 1.16 km long and the quarry access road was 1 km. Most of the time, the quarry will be closer to the working pile and the haul distance will be shorter. Assuming three trucks, each carrying 24 t of sand and 445 t/h maximum quarry production for a 10-hour effective workday:

445 t/h*10 hours / 24 t/truck = 186 trips/day = 186 trips/day/3 trucks =62 one-way trips/day/truck

The total daily two-way distance travelled by articulated dump trucks with mined sand was:

314 trips/day* 2* 1.16 km = 429.7 km/d

All numbers were conservatively rounded up (430 km/d).

The average distance from the wet plant to the quarry pit is approximately 2.16 km (one way). For 54 t/h of wet plant sand waste (1,080 t/d), it was calculated there will be 45 one-way trips per day. This transport will be completed during wet plant operation, and is modelled from 2:00 am to 11:00 pm. We split this transport into two parts: 23 trips with waste during quarry operations and 22 trips in the remaining 10 hours.

It was assumed the water truck will operate on dry days along gravel haul roads, where articulated dump trucks also operate, at most every 2 hours (maximum 10 trips per 20-h day, 44 km per day, if needed). The Plant gravel access road was unwatered, but CPS may water the section nearest the Plant on dry and hot days.

The B-Train trucks have nominal vehicle load around 40 t, but loads will be 25 to 40 t. According to solar glass plant demand and monthly daily trips, the average vehicle load was assumed as 30.3 t and with weight of empty truck 23.5 t, the modelled average of loaded and empty trucks was 38.7 t.

The grader will be called when needed for road maintenance. It was assumed it will travel at most two hours per 20-hour day (no more than 18 km total). Grader emissions were spread over the 20-hour workday.

A3.4 Grader Emissions

Particulate emission factors for from graders are listed in NPI (2012) and US EPA (1998b):

$$TSP\left(\frac{kg}{VKT}\right) = 0.0034 * S^{2.5}$$

$$PM_{10}\left(\frac{kg}{VKT}\right) = 0.0034 * S^{2.0}$$

$$PM_{2.5}\left(\frac{kg}{VKT}\right) = 0.031 * TSP\left(\frac{kg}{VKT}\right)$$

where:

- *S* is grader velocity (assumed as 11.4 km/h which is average speed used to measure emissions to obtain emission factors equations)

Table A10 summarizes grader travel emission factors and total emissions for grader on roads.

Table A10: Grader Travel Emission Factors (kg/VKT) and Emissions Unmitigated and Assuming 80% Watering Efficiency - kg/20-hour day (kg/d)

Emission Factors / Emissions	Unit	TSP	PM_{10}	$PM_{2.5}$
Emission Factor	kg/VKT	1.49	0.437	0.046
Emissions - Unmitigated	kg/d	25.7	7.53	0.0.797
Emissions – Mitigated by Watering	kg/d	5.14	1.51	0.159

A3.5 Gravel Road Fugitive Dust Emissions

Transportation emissions from vehicles hauling sand from the active quarry pit to the working pile, hauling waste from the wet plant to the old quarry pit, and hauling wet sand on the Plant access road (toward paved roads leading to the solar glass plant) on gravel roads can be calculated using equations from US AP 42, Table 13.2.2-2 (Unpaved Roads) (US EPA 2006a):

$$TSP\left(\frac{kg}{VKT}\right) = 4.9 * 0.2819 * \left(\frac{s}{12}\right)^{0.7} * \left(\frac{W}{2.7}\right)^{0.45}$$

$$PM_{10}\left(\frac{kg}{VKT}\right) = 1.5 * 0.2819 * \left(\frac{s}{12}\right)^{0.9} * \left(\frac{W}{2.7}\right)^{0.45}$$

$$PM_{2.5}\left(\frac{kg}{VKT}\right) = 0.10 * PM_{10}\left(\frac{kg}{VKT}\right)$$

where:

- *s* - is the silt content of the road surface (4.8% - **Table A1**)
- *W* – is average weight of vehicle fleet (**Table A9**)

Below is a sample of calculations for an articulated dump truck delivering raw sand to working pile. The emission factor for the gravel haul road is (silt content 4.8% and average vehicle weight 35 t):

$$TSP\left(\frac{kg}{VKT}\right) = 4.9 * 0.2819 * \left(\frac{4.8}{12}\right)^{0.7} * \left(\frac{1.10231 * 35.12}{3.0}\right)^{0.45} = 2.36$$

Using VKT = 726 km/d:

- 2.36 (kg/VKT) * 429.7 km/d = 1,013 kg/d
- Mitigated by Watering: 1,013 * (1-80/100) = 203 kg/d of TSP

Table A11 summarizes articulated dump tracks haul truck emissions with and without watering (VKTs listed in **Table A9**).

Table A11: Truck Fugitive Emission Factors (kg/VKT) and Emissions Unmitigated and Assuming 80% Watering Efficiency (kg/d)

Emission Factors / Emissions(1)	Unit	TSP	PM_{10}	$PM_{2.5}$
Articulated Truck Emission Factor	Kg/VKT	2.36	0.586	0.0586
B-Train Truck Emission Factor	Kg/VKT	2.40	0.612	0.0612
Emissions – Un-Mitigated Raw Sand Transport	Kg/d	1,013	252	25.2
Emissions – Mitigated Raw Sand Transport	Kg/d	203	50.4	5.04
Emissions – Un-Mitigated Waste Sand Transport	Kg/d	457	114	11.4
Emissions – Mitigated Waste Sand Transport	Kg/d	91.4	22.7	2.27
Emissions – Un-Mitigated Water Truck	Kg/d	102	25	2.53
Emissions – Mitigated Water Truck	Kg/d	20	5.1	0.51
Emissions – Un-Mitigated Product Wet Sand Transport	Kg/d	1,613	411	41.1

Note: Emissions at the Project site

The 7 km wet plant gravel access road was modelled as an industrial road (US EPA 2006a). Modelling this road as a public road would produce much lower emission factors (and emissions). However, there will be few light duty vehicles on this access road. Local traffic (which may use access road) will produce much smaller emissions which are considered part of background concentrations.

The Plant access road was modelled as unmitigated. However, it may be watered on hot, dry summer days.

A3.6 Fugitive Dust Emissions from Exposed Surfaces

The fugitive dust emissions from exposed surfaces at the active quarry pit, final wet sand stockpile, working pile (feeder area), and areas around piles can be calculated using equations taken from US AP 42, Section 13.2.5 (Industrial Wind Erosion) (US EPA 2006c). Wind-generated emissions were calculated using hourly wind speeds for wind speeds 8.23 to 10.8 m/s and over 10.8 m/s.

To calculate wind-driven emissions from open surfaces and stockpiles, it is necessary to find daily disturbed areas. Areas not disturbed during a day lose their emission potential and start to be covered by crust.

Two separate parts of the active quarry were identified:

- There is 4,450 t/d of sand extracted from the pit. Using 1.5 t/m^3 density – there will be 2,967 m^3 of sand mined and assuming a pit strip depth 3 m, the disturbed area will be 989 m^2. This part of the quarry pit will have average moisture content 20%.

- Where 54 t/h*20 h = 1,080 t/d of solid waste from wet plant is dumped. Similar calculations, using the same material density and remediation strip 3 m deep, estimate active area to be 240 m^2. This part of the quarry pit has moisture content 18%.

To estimate the working pile active area, it was assumed that 4,450 t/d of the raw sand will be dumped and bulldozed, and 4,180 t/d will be loaded on the slurry feeder. The total disturbed volume (8,630 t/d) corresponds to 1,918 m^2 area.

There are two separate active areas at the produced wet sand stockpile:

- Maximum disturbed daily area by spreading of wet produced sand (2,220 t/d) by stacker (moisture content 18%). This area is estimated as 493 m^2.
- The second disturbed area is at the stockpile where drier sand (3% moisture content) is loaded onto B-Train trucks. Assuming 3 trucks/h*16 h/d*30.3 t/truck = 1,456 t/d and the area is 324 m^2.

In addition there are flat areas around the working pile and around the product wet sand stockpile, with sand spilled from the piles and pulverized by wheels of loaders and trucks. Each area was estimated as 50 m long and 10 m wide (500 m^2 of disturbed daily area). Loading areas will be watered on dry, hot days with particulate emission reduction by 80%.

Wind erosion is caused by wind gusts not by average wind speed. To obtain estimate of wind gust from 1-hour average wind measured at 10 m above the ground level, wind speed is multiplied by 1.24 factor: $U^{+}=1.24*U_{10}$ (EC, 2022a). For flat areas, to obtain velocity at ground level (friction velocity): $U^* = 0.053*U^+$.

For friction velocity at stockpiles, according to experimental studies stockpile is divided into three (or four) sub-areas where wind speed is higher or lower. For example, wind will be much lower (multiply U^+ by 0.2) around the base of pile or at shadow of the pile and lower emissions are expected. The wind will be the highest around the top of the file: $0.9*U^+$ and it will be for sure emitting dust at higher wind speeds. Wind in the middle of the pile will have wind speed will be $0.6*U^+$ and may also emit dust. These multiplication factors are denoted as U_s/U_r (= 0.2, 0.6, and 0.9). The friction velocity is calculated for every sub-area: $U^* = 0.1*U_s/U_r*U^+$. For this assessment B1 stockpile and orientation in respect to wind (Figure 13.2.5-2 from US EPA, 2006c) was used dividing stockpile at following sub-areas:

- Sub-area a): U_s/U_r = 0.2, 36% of total stockpile area
- Sub-area b): U_s/U_r = 0.6, 50% of total stockpile area
- Sub-area c): U_s/U_r = 0.9, 14% of total stockpile area

According to methods described in US EPA (2006c) and EC (2022a), particulate emissions from wind erosion are zero when the wind speeds are relatively low, and the calculated friction velocity is lower than threshold friction velocity: $U^* \leq U^*_t$. Threshold friction velocity for roadbed material (scoria) is U^*_t = 1.33 m/s, for overburden: 1.02 m/s and for un-crusted coal pile: 1.12 m/s, scraper trucks on coal pile: is U^*_t = 0.62 m/s (Table 13.2.5-2: US EPA; 2006c). For this assessment, conservatively, threshold friction velocity for wind generated emissions from sub-area c) of stockpile was assumed as U_t^* = 0.91 m/s and for flat areas U_t^* = 0.6 m/s. **Table A12** summarizes these parameters.

Particulate emissions from the product wet sand pile and adjacent loading flat area are partially sheltered from wind (30% particulate emissions reduction – NPI, 2012: emission reduction for wind breaks).

Table A12: Wind Data for Wind Generated Emission Calculation

Activity	Wind Speed at 10 m U_{10} (m/s)	Friction Velocity at Stockpile Area C) U* (m/s)	Friction Velocity Flat Area U* (m/s)
Maximum Velocity from AERMET 5 Years of Data	16.5	1.84	1.09
Model Lowest Velocity to Cause Emissions	8.23	0.9185	0.6011
Assumed Friction Threshold Velocity U_t*	8.2	0.91	0.60

In the case of flat areas, hourly emissions can be calculated by following equation:

$$TSP\left(\frac{g}{s}\right) = \left(\frac{\text{Area}}{60 * 60}\right) * (58 * (\mathrm{U}^* - U_t^*)^2 + 25 * (\mathrm{U}^* - U_t^*)\ )$$

$$PM_{10}\left(\frac{g}{s}\right) = 0.50 * \ TSP\left(\frac{g}{s}\right)$$

$$PM_{2.5}\left(\frac{g}{s}\right) = 0.075 * \ TSP\left(\frac{g}{s}\right)$$

Where: Area is active surface area (or sub-area for stockpiles);
U* is friction velocity; and
U^*_t is threshold friction velocity

Table A13 summarizes maximum 1-hour, **Table A14** summarizes maximum 24-hour, and **Table A15** summarizes total annual wind generated emissions.

Table A13: Wind Generated Maximum 1-Hour Wind Speed Dependent Emissions

Activity	TSP 1-Hour Maximum (kg/h)	PM_{10} 1-Hour Maximum (kg/h)	$PM_{2.5}$ 1- Hour Maximum (kg/h)
Product Wet Sand Stockpile – Loading on Trucks Part	1.560	0.780	0.117
Product Wet Sand Stockpile – Unloading from Plant Part	0.194	0.097	0.015
Final Wet Sand Stockpile Flat Loading Area	0.863	0.432	0.065
Working Pile	1.075	0.538	0.081
Working Pile Loading/Unloading Flat Area	0.100	0.050	0.008
Active Quarry Pit Excavated Surface	0.858	0.429	0.064
Quarry Pit Reclamation Area	0.241	0.120	0.018

Table A14: Wind Generated Maximum 24-hour Wind Speed Dependent Emissions

Activity	TSP 24-Hour Maximum (kg/d)	PM_{10} 24-Hour Maximum (kg/d)	$PM_{2.5}$ 24- Hour Maximum (kg/d)
Product Wet Sand Stockpile – Loading Area	37.4	18.7	2.808
Product Wet Sand Stockpile – Unloading from Plant Part	4.65	2.32	0.349
Final Wet Sand Stockpile Flat Loading Area	20.7	10.4	1.554
Working Pile	25.8	12.9	1.935
Working Pile Loading/Unloading Flat Area	2.41	1.20	0.181
Active Quarry Pit Excavated Surface	20.6	10.3	1.545
Quarry Pit Reclamation Area	5.78	2.89	0.434

Table A15: Wind Generated Average Annual Total Wind Speed Dependent Emissions

Activity	TSP Total Annual (kg/y)	PM_{10} Total Annual (kg/y)	$PM_{2.5}$ Total Annual (kg/y)
Product Wet Sand Stockpile – Loading on Trucks Part	204	102	15.3
Product Wet Sand Stockpile – Unloading from Plant Part	25.3	12.6	1.90
Final Wet Sand Stockpile Flat Loading Area	90.1	45.1	6.76
Working Pile	140	70.2	10.5
Working Pile Loading/Unloading Flat Area	10.5	5.24	0.79
Active Quarry Pit Excavated Surface	89.6	44.8	6.72
Quarry Pit Reclamation Area	25.2	12.6	1.89

A4. Emissions from Diesel Combustion

The following section outlines the approach taken to estimate emissions generated by diesel combustion from the Project equipment such as excavators, loaders, bulldozer, grader, and trucks. Subsequent sections list emission factors, parameters, and maximum hourly emissions of SO_2, NOx, CO, THC (VOC), $PM_{2.5}$, PM_{10}, and TSP.

A4.1 Non-Road Combustion Emissions

Table A16 lists Project diesel-powered non-road equipment based on Source Classification Code (SCC) with age (tier), power, and fuel consumption to calculate emissions from combustion. The list of equipment was provided by CPS. Fuel consumption was taken from Caterpillar (2019) for medium load application for equipment working.

Table A16: Source Classification Code (SCC) Parameters, Power, Age, and Fuel Consumption of Diesel-Powered Equipment

SCC	Equipment	Fleet Size	Tier	Engine Net Power (hp)	Fuel Consumption (L/h)	
					Idling	Working
2270002051	Articulated Dump Trucks CAT725	3	4	342	11.6	18.1
2270002036	Excavator CAT336	1	4	314	15.3	21.3
2270002060	Cat 972M Wheel Loader	1	4	336	12.3	15.8
2270002051	Water Truck CAT725 Modified	1	4	342	11.6	18.1
2270002048	Grader CAT120 AWD	1	4 Interim	139	9.2	13.7
2270002060	Cat 980 Wheel Loader	1	4	420	15.8	20.5
2270002069	Bulldozer CATD6	1	4	215	15.3	24.5

Fuel consumption was used to calculate GHG emissions.

The equipment production year indicates the engine efficiency (tier), based on equipment specifications. Usually, newer engines have lower emissions. **Table A17** summarizes Brake Specific Fuel Consumption (BSFC) values and engine Load Factors (LF). BSFC is a measure of the fuel efficiency of a combustion engine which burns fuel and produces rotational power. The methodology for the calculation of emission factors in NONROAD model was taken from US EPA (2010; 2008). Steady state, zero-hour emission factors (EF_{raw}) and BSFC, listed in the emission database on the NONROAD model website (part of the archive for the MOVES model), are already adjusted by the Transient Adjustment Factor (TAF). Transient mode of engine operation better reflects engine load, speed of vehicle and other parameter changes (e.g., during loader transit, lifting material, un-loading and moving). The transient mode emission factors (EF_{raw}) are obtained by multiplying steady state emission factors (E_{ss}) by TAF.

Engine Load Factor (LF) is defined as portion of the rated engine power that is utilized during engine operation. This factor is specific to the equipment type and independent on engine size and rated engine power.

Table A17: Load Factors (LF) and Brake Specific Fuel Consumption (BSFC) of Diesel-Powered Equipment

Equipment	LF	BSFC (lb/hp-h)
Articulated Dump Trucks CAT725	0.59	0.367
Excavator CAT336	0.59	0.371
Cat 972M Wheel Loader	0.59	0.371
Water Truck CAT725 Modified	0.59	0.367
Grader CAT120 AWD	0.59	0.371
Cat 980 Wheel Loader	0.59	0.371
Bulldozer CATD6	0.59	0.371

In US EPA (2010), Equation 1 and Equation 2 (Page 6) were used to calculate emission factors for CO, NO_X, and HC (which was assumed as equivalent to THC in in this document). Diesel combustion emission factors of NO_X, CO, and THC adjusted for deterioration are calculated by the following equation (Page 6; Equation 1, US EPA 2010):

$$EF_{adjusted}\ (g/hp\text{-}h) = EF_{raw} * DF$$

Where:

- EF_{raw} – Emission Factor NO_X, CO, or THC (g/hp-h from data in US EPA 2008)
- DF – Deterioration Factor (unitless) (function of the technology type and age of the engine) for NO_X, CO, and THC.

$$DF = 1 + A * \frac{(cumulative\ hours * LF)}{median\ life\ at\ full\ load\ in\ hours}$$

Where *A* is relative deterioration factor (% of emission increase / % of useful life). The maximum deterioration factors (*DF*) were used in the calculation assuming all Project equipment has worked more hours than their median life.

Table A18 lists relative deterioration factors for nonroad diesel engines, dependant on Tiers (Table A6, page A16, US EPA 2010).

Table A18: Relative Deterioration Factor (*A*) of Nonroad Diesel Powered Equipment

Compound	Tier 1	Tier 2	Tier 3 & 4
THC	0.036	0.034	0.027
CO	0.101	0.101	0.151
NO_X	0.024	0.009	0.008
PM_{10}	0.473	0.473	0.473

An example of calculations for adjusted emission factor for NO_X emitted by CAT 725 haul truck (Tier 4, net power 342 hp) is:

$$EF_{adjusted}\ (g/hp\text{-}h) = 0.28 * 1.008 = 0.282$$

The diesel combustion emission factor for SO_2 were obtained by the following equation (Equation 7 at Page 24 of US EPA 2010):

$$SO_2 = \{[BSFC * 453.6 * (1- 0.30) – THC] * 0.01 * 2 * 0.0015\}$$

Where:

- BSFC – Brake Specific Fuel Consumption (lb/hp-h)
- 453.6 – Conversion factor from pounds to grams
- 0.30 – Fraction of fuel sulphur converted to direct PM (for Tier 4 engines)
- THC – Total Hydrocarbon
- 0.01 – Conversion factor from weight percent to weight fraction
- 2 – Grams of SO_2 formed from a gram of sulphur
- 0.0015 – Weight percent of sulphur in ultra-low sulphur diesel (15 ppm)

An example of calculations for adjusted emission factor for SO_2 emitted by CAT 725 articulated dump truck (Tier 4, net power 342 hp) is:

$$SO_2 = \{[0.367 * 453.6 * (1- 0.30) – 0.134] * 0.01 * 2 * 0.0015\} = 0.00349 \text{ g/hp-h}$$

SO_2 adjusted emission factors are calculated using ultra low sulphur diesel - ULSD (15 ppm sulphur). This fuel is currently available and required to be used in all mines and quarries. **Table A19** summarizes deterioration-adjusted emission factors used to calculate combustion emissions from diesel burning equipment.

Table A19: Deterioration-Adjusted Emission Factors

Equipment	THC (g/hp-h)	SO_2 (g/hp-h)	NO_x (g/hp-h)	CO (g/hp-h)	TSP (g/hp-h)	PM_{10} (g/hp-h)	$PM_{2.5}$ (g/hp-h)
Articulated Dump Trucks CAT725	0.134	0.00349	0.282	0.150	0.014	0.014	0.013
Excavator CAT336	0.134	0.00353	0.282	0.150	0.014	0.014	0.013
Cat 972M Wheel Loader	0.134	0.00353	0.282	0.150	0.014	0.014	0.013
Water Truck CAT725 Modified	0.134	0.00349	0.282	0.150	0.014	0.014	0.013
Grader CAT120 AWD	0.195	0.00353	2.520	1.001	0.324	0.324	0.314
Cat 980 Wheel Loader	0.134	0.00353	0.282	0.150	0.014	0.014	0.013
Bulldozer CATD6	0.134	0.00353	0.282	0.127	0.014	0.014	0.013

Table A20 summarizes diesel combustion emissions calculated for equipment used in the modelling.

The maximum hourly emissions (g/s) presented in **Table A20**, were calculated for particulates, NO_X, CO, and THC using following equation:

$$\text{Emission (g/s)} = LF * EF_{adjusted} * PR * EN / (3600 \text{ s/h})$$

Where:

- LF – Load Factor from **Table A17**
- $EF_{adjusted}$ – Adjusted Emission Factor (g/hp-h) from **Table A19**
- PR – Engine Power Rating (hp) (**Table A16**)
- EN – Number of Engines (**Table A16**)

An example of calculations for emissions of NO_X emitted by three CAT 725 articulated dump trucks idling within one hour (Tier 4, net power 342 hp) is:

$$\text{Emission (g/s)} = 0.59 * 0.282 \text{ g/hp-h} * 342 \text{ hp} * 3 \text{ trucks} / (3600 \text{ s/h}) = 0.0475$$

The maximum hourly emissions (g/s) presented in **Table A20** were calculated for SO_2 using following equation:

$$\text{Emission (g/s)} = EF_{adjusted} * PR * EN / (3600 \text{ s/h})$$

Where:

- $EF_{adjusted}$ – Adjusted SO_2 Emission Factor (g/hp-h) from **Table A19**
- PR – Engine Power Rating (hp) (**Table A16**)
- EN – Number of Engines (**Table A16**)

An example of calculations for adjusted emission factor for SO_2 emitted by three CAT 725 articulated dump trucks (Tier 4, net power 342 hp) is:

Emission (g/s) = 0.00349 g/hp-h * 342 hp / (3600 s/h) = 0.00100

Table A20: Emissions from Diesel Combustion

Equipment	THC (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)	TSP (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)
Articulated Dump Trucks CAT725 10 h between 7:00 am and 5:00 pm	0.1560	0.00692	0.32984	0.17486	0.01584	0.01584	0.01536
Articulated Dump Trucks (10 h between 1:00 am to 6:00 am and 6:00 pm to midnight)	0.0168	0.00075	0.03559	0.01887	0.00171	0.00171	0.00166
Excavator CAT336 (10 h)	0.00687	0.00031	0.01452	0.00770	0.00070	0.00070	0.00068
Cat 972M Wheel Loader (20 h)	0.00735	0.00033	0.01554	0.00824	0.00075	0.00075	0.00072
Water Truck CAT725 Modified (20 h)	0.00374	0.00017	0.00791	0.00419	0.00038	0.00038	0.00037
Grader CAT120 AWD (20 h)	0.00044	0.00001	0.00574	0.00228	0.00074	0.00074	0.00072
Cat 980 Wheel Loader (16 h)	0.00919	0.00041	0.01943	0.01030	0.00093	0.00093	0.00090
Bulldozer CATD6 (10 h)	0.00470	0.00021	0.00995	0.00446	0.00048	0.00048	0.00046
TOTAL							
Hourly Maximum TOTAL (g/s)	0.2052	0.0090	0.4385	0.2309	0.0215	0.0215	0.0209
Daily Maximum TOTAL (kg/d)	8.00	0.350	17.3	9.06	0.86	0.86	0.84

A4.2 On-Road Combustion Emissions

Combustion emissions from B-Train trucks were based on the US EPA MOVES model which considers vehicle type as well as driving conditions. **Table A21** summarizes emission factors and daily maximum emissions for trucks travelling on the gravel Wet Plant access road (7 km, maximum 3 trips/h *16 h/day = 48 one-way trips per day, with average speed of 80 km/hour).

Table A21: Combustion Emissions from B-Train Trucks

Transport / Compounds	THC	SO_2	NO_x	CO	TSP	PM_{10}	$PM_{2.5}$
Long-Haul Trucks Emission Factor (g/VKT)	0.130	0.0033	2.54	1.18	0.116	0.116	0.0611
Long-Haul Trucks Emissions (g/s)	0.00152	0.00004	0.0296	0.0137	0.00135	0.00135	0.00071
Long-Haul Trucks Emissions (kg/day)	0.088	0.0022	1.17	0.792	0.078	0.078	0.041

A5. Summary of Emissions

Table A22 summarizes the total maximum daily emissions from the Project operations. Normal quarry pit operations occur from April 01 to October 31 and stripping for the new active pit block and dumping of overburden and soil into the reclamation area from November 1 to December 15 and then from February 01 to March 31 of each year. The highest maximum daily emissions are expected from the non-road vehicles on the unmitigated gravel Plant access road hauling wet sand toward paved roads leading to the solar glass plant.

Table A22: Summary of Maximum Daily Emissions

Emissions	THC (kg/d)	SO_2 (kg/d)	NO_x (kg/d)	CO (kg/d)	TSP (kg/d)	PM_{10} (kg/d)	$PM_{2.5}$ (kg/d)
Active Quarry Pit							
Diesel Combustion (Excavator CAT336)	0.25	0.011	0.52	0.28	0.03	0.03	0.024
Loading (CAT336) of Raw Sand on Trucks (Wind Speed Dependent)	0	0	0	0	22.4	10.6	1.60
Unloading from Trucks of Waste Sand (Wind Speed Dependent)	0	0	0	0	6.3	2.98	0.451
Wind Generated from Quarry Pit Surface – Excavation Area	0	0	0	0	20.6	10.3	1.545
Wind Generated from Quarry Pit Surface – Reclamation Area	0	0	0	0	5.78	2.89	0.434
Maximum Daily TOTAL for Active Pit	**0.25**	**0.01**	**0.52**	**0.28**	**55.1**	**26.8**	**4.06**
Working Pile Area							
Diesel Combustion (CATD6, CAT972M)	0.70	0.031	1.48	0.75	0.071	0.071	0.069
Raw Sand Trucks Unloading on Working Pile (Wind Speed Dependent)	0	0	0	0	22.40	10.60	1.60
Raw Sand Loading (CAT972M) on Feeder (Wind Speed Dependent)	0	0	0	0	24.4	11.6	1.75
Fugitive Bulldozer (CATD6) Blending Sand	0	0	0	0	3.99	0.65	0.07
Wind Generated from Working Pile	0	0	0	0	25.8	12.9	1.935
Wind Generated from Flat Area Base of the Working Pile	0	0	0	0	2.41	1.2	0.181
Maximum Daily TOTAL for Working Pile Area	**0.70**	**0.03**	**1.48**	**0.75**	**79.1**	**37.0**	**5.60**
Wet Plant Area							
Diesel Combustion (CAT980)	0.53	0.02	1.12	0.59	0.054	0.054	0.052
Final Wet Sand Conveyor Unloading on Final Wet Sand Stockpile (Wind Speed Dependent)	0	0	0	0	9.10	4.28	0.65
Final Wet Sand Loading (CAT980) on B-Train Truck (Wind Speed Dependent)	0	0	0	0	73.0	34.5	5.23
Waste Sand Loading on Trucks (Wind Speed Dependent)	0	0	0	0	6.30	2.98	0.45
Wind Generated from Wet Sand Stockpile – Truck Loading Area	0	0	0	0	37.4	18.7	2.808
Wind Generated from Wet Sand Stockpile - Unloading from Plant Area	0	0	0	0	4.65	2.32	0.349
Wind Generated from Flat Area Base of the Final Wet Sand Stockpile	0	0	0	0	20.7	10.4	1.554
Maximum Daily TOTAL for Wet Plant Area	**0.53**	**0.02**	**1.12**	**0.59**	**151.2**	**73.2**	**11.09**
Gravel Roads							
Diesel Combustion Dump Trucks CAT725	6.22	0.28	13.16	6.97	0.63	0.63	0.61
Diesel Combustion Water Truck CAT725	0.27	0.01	0.57	0.30	0.03	0.03	0.03
Diesel Combustion Grader CAT120 AWD	0.032	0.001	0.413	0.164	0.053	0.053	0.052
Diesel Combustion B-Train Trucks	0.088	0.002	1.706	0.79	0.078	0.078	0.041
Fugitive - Dump Trucks (CAT725) Raw Sand from Pit to Working Pile	0	0	0	0	197.6	50.4	5.04
Fugitive - Dump Trucks (CAT725) Waste Sand from the Plant to Pit	0	0	0	0	89.2	22.7	2.27
Fugitive – Water Truck (CAT725)	0	0	0	0	19.8	5.1	0.51
Fugitive – Grader (CAT120 AWD)	0	0	0	0	5.14	1.51	0.16
Fugitive B-Train Trucks – 7 km (Unmitigated)	0	0	0	0	1,613	411	41
Maximum Daily TOTAL for Gravel Roads	**6.61**	**0.29**	**15.84**	**8.23**	**1,926**	**492**	**49.82**
TOTAL for Wanipigow Sand Extraction Project	**8.09**	**0.35**	**19.0**	**9.9**	**2,211**	**629**	**71**

A6. GHG Annual Emissions

A6.1 Non-road Emissions of GHG

Emissions of carbon dioxide (CO_2) and methane (CH_4) from diesel (and gasoline) combustion can be calculated using emission factors in AP 42 Tables 3.3-1 and 3.3-2 (Gasoline and Diesel Industrial Engines) (US EPA 1996b). Emission factors in AP 42 are in units of lb/MMBtu. According to US EPA (1996b) suggested values for diesel properties are:

1. Diesel Higher Heating Value (HHV) 19,300 Btu/lb
2. Diesel fuel density 7.1 lb/US Gallon (or 0.85 kg/L of diesel fuel)

Using the above values, the conversion factor can be calculated as: 1 lb/MMBtu = 16.42 g/L of diesel fuel. Emission factors for small and large engines were determined by the approximate horsepower for each individual operation (small engines are smaller or equal to 600 hp). All equipment working at the Project has engines lower than 600 hp.

Emissions of nitrous oxide (N_2O) were calculated using BCENV (2021) (Table 8 – Off-Road Vehicle / Equipment). The emissions of CO_2 and CH_4 are higher (more conservative) using US EPA (2006b).

Table A23 summarizes GHG emission factors (bold letters) used to calculate combustion emissions from the Project diesel combustion equipment. **Table A24** presents global warming for GHG emitted from diesel burning equipment, assuming 100 years horizon, from IPCC (2012):

Table A23: GHG Emission Factors Used for Emission Calculations

Compound	Emission Factors US EPA (1996a) (g/L)	Emission Factors BCENV (2021) (g/L)
CO_2	**2,693**	2,690
CH_4	**5.75**	0.15
N_2O	-	**1.00**

Table A24: GHG Climate Change Potentials (100-year Horizon)

Compound	Global Warming Potential IPCC (2012)
CO_2	1
CH_4	25
N_2O	298

Using emission factors from **Table A23** and fuel consumptions from **Table A16**, GHG emissions were calculated and summarized in **Table A25**:

Table A25: GHG Emissions from Diesel Combustion

Equipment	Working (hours/year)	Annual Diesel Consumption (L/y)	CO_2 (t/y)	CH_4 (ty)	N_2O (t/y)	CO_{2eq} (t/y)
Articulated Dump Trucks CAT725	11,680	210,824	567.8	1.21	0.211	661
Excavator CAT336 - Quarry	3,180	67,575	182.0	0.39	0.068	212
Cat 972M Wheel Loader Working Pile	4,280	67,624	212.0	0.39	0.068	212
Water Truck CAT725 Modified	224	4,043	10.9	0.02	0.004	13
Grader CAT120 AWD	1,896	25,880	69.7	0.15	0.026	81
Cat 980 Wheel Loader Final Wet Sand Product	5,840	119,720	322.4	0.69	0.120	375
Bulldozer CATD6	3,180	77,910	209.8	0.45	0.078	244
Total	**30,280**	**573,577**	**1,545**	**3.21**	**0.574**	**1,798**

In calculation of equipment working hours, it was assumed bulldozer, and excavator, work for 10 hours a day, for 10.5 months of the year (318 days). In winter they work, together with grader, on stripping the new quarry pit and remediating the old pit. The grader, in summer, will work for maximum 4 hours a day, and the water truck will work 20 hours a day. Loaders will work for 7 months only (214 days a year – work for 10 hours or 20 hours). Three articulated dump trucks work for 10 months 10 hours/day. In winter (three months) they work on stripping the new quarry pit and remediating the old pit. For the remaining 7 months, they work for 10 hours transporting raw sand from the quarry active pit to the working pile. It was assumed one articulated truck will work for an additional 10 hours/day transporting solid waste from the plant to the old quarry pit for remediation.

A6.1.1 On-Road Combustion Emissions

Combustion emissions from B-Train trucks are based on the US EPA MOVES model which considers vehicle type as well as driving conditions. **Table A26** summarizes emission factors and daily maximum emissions for trucks travelling on the gravel Wet Plant access road (7 km, maximum 44 one-way trips per day, with average speed of 80 km/hour):

Table A26: Combustion GHG Emissions from B-Train Trucks

Transport / Compounds	GHG_{eq}
Long-Haul Trucks Emission Factor (g/VKT)	973.8
Long-Haul Trucks Emissions (g/s)	10.4
Long-Haul Trucks Emissions (kg/day)	600

Annual GHG emissions from B-Train trucks transporting sand to the solar glass plant are summarized in **Table A27.**

Table A27: Annual GHG Emissions from B-Train Trucks

	One Way Distance (km)	Travel Speed (km/hour)	Number of Trips per Year	GHG_{eq} Emission Factor (g/VKT)	GHG_{eq} (t/year)
Long-Haul Trucks Wet Plant Access Road	7	80	9,395	973.77	122
Long-Haul Trucks Transport to Solar Glass Plant	161.8	90	9,395	926.07	2,815

Total number of trips per year was obtained by division of annual solar glass plant sand demand (285,000 t) by the average annual B-Train payload 30.3 t (285,000 t/year/30.336 t = 9,395 trips/year).

A6.1.2 Indirect GHG Emissions

GHG indirect emissions from annual electrical consumption was calculated using factors and methods presented in CPS (2021). Plant electricity consumption for working days was calculated assuming 7 months of plant operation at 20 hours per day (1,115 kW-h) and idling for remaining 4 hours per day. Winter emissions assumed 5 months of operations 24 hours/day (115 kW-h for idling). The emission factor = 1.2 t GHG_{eq} / GW from NIR (2022) was used to calculate GHG_{eq} annual emissions. **Table A28** summarizes electricity consumption and GHG_{eq} annual emissions.

Table A28: Indirect Annual GHG Emissions from Electricity Usage

	Consumption from Process Equipment (kW-h)	Miscellaneous (e.g., Gates, Lights, Scales) (kW-h)	Summer hours (7 Months) (hours/day)	Winter (5 Months) (hours/day)	Electricity Consumption (GW/y)	GHG_{eq} (t/y)
Wet Plant Working	1,100	15	20	0	4.77	5.73
Plant Idling	100	15	4	24	0.52	0.62
TOTAL					**5.29**	**6.34**

Plant electricity consumption and GHG_{eq} emissions during idling are significantly lower than the Plant operating electricity and emissions. The estimate assumed the Plant operates two lines for maximum wet plant capacity to provide solar glass plant in Selkirk with sand sufficient to run two furnaces producing glass.

A7. Summary of GHG Emissions

Table A29 summarizes the total maximum annual GHG emissions from the Project operations. A GHG emission inventory was developed considering both direct and indirect emissions associated with the Project operations. The total annual GHG emission calculation was completed using the information provided by CPS as well as recommended emission factors from Canada's Greenhouse Gas Quantification Requirements (EC 2021), US EPA (1996) for non-road trucks and equipment, NIR (2022) for electricity indirect emissions, and US EPA MOVES model for on-road trucks emissions.

Table A29: GHG Emissions from Operations

Emission Sources	Annual Usage Rate Value	Unit	Total Annual CO2eq Emissions (t/y)
Direct Emission			
The Project Equipment, Diesel Burning	573,577	L/y	1,798.0
Sand Transport (168.8 km and 9,395 trips/year)	1,195,273	Km/y	2,943.5
		Total Direct	4,741.6
Indirect			
Electricity Usage	5,287,400	kW-hr	6.3
		Total Indirect	6.3
		Total	***4,748***
		Manitoba, Total for 2019	***22,600,000***
		Canada Total for 2019	***738,000,000***

Overall, the Project is estimated to generate 4,748 tonnes of CO_2e annually (which is 0.021% of the reported emissions in 2019 which were 22.6 Mt CO_2e from Manitoba (Climate Change Connection, 2020), and 0.0006% of the reported 738 Mt CO_2e from Canada in 2019 (Environment Canada, 2020). Project emissions were compared to provincial and federal 2019 total emissions, since 2020 and 2021 data are affected by the COVID pandemic economic downturn and are lower than previous years.

A8. Modelled Source Parameters

Previous sections identified emissions for all emission sources as well as the basis for the emissions. This section documents the forms of those emissions in the dispersion model.

Table A30 summarizes parameters associated with sources in the active pit. Active quarry pit was modelled using OPENPIT module in AERMOD, since average depth of the pit is around 25 m below the ground. **Table A31** lists the volume sources associated with the equipment emissions, loading, unloading, and wind driven emissions from working pile and final wet sand stockpile. **Table A32** lists the parameters associated with line sources which were modelled as arrays of volume sources to represent emissions from roads.

Table A30: Modelled OPENPIT Source Parameters – Active Pit Block

Parameter / Source	Active Pit Block – Excavator Loading of Sand
OPENPIT Source Location of SW Corner	
UTM14 (m W)	686,927
UTM14 (m S)	5,673.208
Elevation (m ASL)	216
OPENPIT Source Parameters	
Length (m)	50
Width (m)	50
Depth (m)	25
Effective Height – E_h (m)	4.1
Initial Vertical Source Dimension: σ_z (m)	3.8

Table A31: Modelled Volume Sources Parameters

Parameter / Source	Working Pile Bulldozer, Loader Gaseous Emissions	Working Pile Wind Generated	Final Wet Sand Stockpile
Volume Source Location of Centre			
UTM14 (km E)	686,003	686,065	686,716
UTM14 (km N)	5,672,676	5,672,666	5,672,401
Elevation (m ASL)	243	243	244
Volume Source Parameters			
Effective Height – E_h (m)	3.3	3.3	3.4
Initial Lateral Volume Source Dimension: σ_{xy} (m)	5.8	5.8	11.6
Initial Vertical Volume Source Dimension: σ_z (m)	3.0	3.0	3.2

Table A32: Modelled Line Source Parameters

Parameter / Source	Haul Road (Working Pile to Active Pit)	Quarry Access Road	Project Access Road Part 1	Project Access Road Part 2	Project Access Road Part 3
Start / End Location UTM 14 (m E)	686,005 686,908	686,732 686,020	686,623 686,826	686,918 687,010	687,132 690,856
Start / End Location UTM 14 (m N)	5,672,718 5,673,166	5,672,544 5,672,605	5,672,377 5,671,687	5,671,540 5,671,393	5,671,096 5,668,083
Start - End Elevation (m ASL)	242 - 241	243 - 244	245 - 245	245 - 245	242 - 230
Effective Height – E_h (m)	2.9	2.9	2.3	2.3	2.3
Initial Lateral Volume Source Dimension: σ_{xy} (m)	18.6	23.3	23.3	81.4	162.8
Initial Vertical Volume Source Dimension: σ_z (m)	2.7	2.7	2.1	2.1	2.1
Approximate Total Length (km)	1.16	1.00	0.80	0.35	5.95
Average Distance Between Volume Sources (m)	40	50	50	175	350
Number of Volume Sources	28	19	16	2	17

A9. Effect of Vegetation on Dust Concentrations

A9.1 Introduction

Several studies have surveyed the effects of vegetation on dust reduction. For example, studies of the dust reduction due to vegetation around poultry farms identified a two-year study (Malone and Donnelly, 2001; Malone, 2004), in which a 9-m wide belt of three rows of dense evergreen trees less than 5 m high located 15 m from a barn fan reduced total dust concentrations across the belt by 50%. The reduction was due to a substantial reduction in wind speed through the belt which apparently enhanced deposition of material from the plume.

Measurements from towers placed at progressively farther distances from a haul road proved that long grass substantially removed PM_{10} (Zhu et al., 2012). At 84 m from the road, concentrations decreased to 13% of near-road concentrations which were measured 8 m from the road; at 160 m concentrations decreased to 7.5%. In desert conditions (bare land), concentrations 136 m from the road decreased to 67% of near-road (12 m) concentrations (Zhu et al., 2012). This decrease was attributed to enhanced deposition due to surface roughness. Particle deposition velocities increased with increased surface roughness.

Dust plume profiling tests conducted by Midwest Research Institute (MRI) showed that tall vegetation (oak and cedar trees) bordering an emission source captures fugitive dust (PM_{10} and $PM_{2.5}$) in the range of 50% over a transport distance of 25 m from an unpaved road (Cowherd et al., 2006). These rates significantly exceed the levels represented in standard air plume dispersion models used for regulatory compliance purposes, where in the current work, near-source effects were modelled with standard grid sizes in the range of 50 m or more.

Desert Research Institute (DRI) measured the removal of PM_{10} dust emitted from an unpaved road at 50 m and 100 m downwind (Gillies et al., 2002). There results, obtained for unstable conditions over sparsely vegetated terrain, indicated that there was no measurable removal of PM_{10} 100 m downwind of the source. That is, nearly all PM_{10} emitted from the unpaved road was available for transport beyond that distance, which was in good agreement with the predictions from a Gaussian model.

In contrast, similar measurements during night-time stable conditions over very rough terrain measured an 85% removal (15% remaining) of PM_{10} within the first 95 m downwind of an unpaved road (Veranth et al., 2003). The Gaussian model (ISC3) appeared to substantially over predict the transportable fraction of PM_{10} under those conditions.

According to Cowherd et al. (2006), the vegetation capture factor is independent of particulate size (factors were very similar for PM_{10} and $PM_{2.5}$). The same paper also showed vegetation reduced the mass in plumes by 41-67% within a few tens of metres from a road source.

A9.2 Treatment in Models

Numerous studies conducted by MRI and DRI (Cowherd et al., 2006; Etyemezian et al., 2003; Cowherd et al., 2003) in the southwestern US have assessed dust plume dispersion perpendicular to haul roads; specifically, the capacity of surrounding vegetation or terrain features to abate dust emissions. The results of these studies are summarized by the United States Environmental Protection Agency (US EPA – Pace, 2005) using composite fugitive dust capture fractions (CF) for five basic land cover types as in **Table A33**. The CF are similar for particulate matter with radius below 10 µm (PM_{10}) and with radius below 2.5 µm ($PM_{2.5}$) (Cowherd, 2006; Etyemezian et al., 2003).

Table A34 compares composite CF by land use category recommended by US EPA to CF values originally proposed by the Western Regional Modelling and Analysis Platform (WRAP) and then updated based on the WRAP emission inventory (Cowherd, 2007). For example, the roughness created by forests essentially traps dust emissions and restricts transport outside this area according to US EPA and the newest WRAP recommendations.

Table A33: Recommended Capture Fractions (CF, %) for Five Land Cover Types (Pace, 2005)

Land Cover Type	Average Height (m)	Recommended CF (%)	Estimated CF Range (%)	Comment
Forest	18-20	100%	80 to 100%	Forested areas will capture dust effectively
Urban	5 – 50+	50%	25 to 75%	Structures are interspersed with open areas
Scrub, Sparsely Wooded & Grasses	1 – 2	25%	10 to 40%	Portion of plume is below sparse vegetation
Agricultural (seasonal)	1 - 2	25%	10 to 40%	Portion of plume is below crop (seasonally)
Barren / Water	0	0%	0 to 10%	Impediment-free surfaces are unable to capture dust

Table A34: Comparison of Capture Fractions (CF, %) Recommended by US EPA (Pace, 2015) to Values Recommended by WRAP (Cowherd, 2007)

Land Cover Type	Original CF (%) (Recommended)	Original Used by WRAP - CF (%)	Updated in WRAP - CF (%)
Forest	100%	70%	100%
Urban	50%	70%	100%
Shrubland	25%	40%	25%
Grassland	25%	30%	25%
Agriculture	25%	15%	25%
Barren / Water	0%	3%	0%

Capture fractions were originally developed to apply to grid modelling of regional impacts; however, the modelling deficiencies (Cowherd, 2007) apply to plume models as well as grid models when used to estimate the impact of haul roads in open pit mines and quarries. These deficiencies include source representation, treatment of near-source plume loss, and treatment of pit trapping.

Vegetation like dense forest, or even roughness of terrain, may cause an increase of deposition and a concurrent 80% or more reduction of particulate concentrations in the air.

A10. Appendix References

Air & Waste Management Association (A&WMA), 1992:
Air Pollution Engineering Manual. Anthony J. Buonicore and Wayne T Davies (eds). Van Nostran Reinhold.

British Columbia Ministry of Environment (BCENV), 2015:
British Columbia Air Quality Dispersion Modelling Guideline. British Columbia Ministry of Environment, Environmental Protection Division, Environmental Standards Branch, Clean Air Section, Victoria, British Columbia, Canada.

British Columbia Ministry of Environment (BCENV), 2021:
2020 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions. British Columbia Ministry of Environment and Climate Change Strategy, April 2021, Victoria, British Columbia, Canada: https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf

Canadian Premium Sand (CPS), 2021:
Sand Treatment Plant Project – FEED Report, prepared by cm.project.ing GmbH, October 2021

Canadian Premium Sand (CPS), 2022:
Wanipigow Sand Project – Geotechnical Investigation Data Report, prepared by AECOM Canada Ltd., February 24, 2022

Caterpillar, 2019:
Caterpillar Performance Handbook Version #49, September, 2019: https://wagnerequipment.com/wp-content/uploads/2020/02/SEBD0351_ED49_Bookmarks_Sept_2019.pdf

Climate Change Connection, 2022:
Manitoba GHG emission trend 1990-2020, retrieved from: http://climatechangeconnection.org/emissions/manitoba-ghg-emissions/ Website updated May 12, 2022.

Chow J.C. and J.G. Watson, 1998:
Guideline on Speciated Particulate Monitoring. Desert Research Institute document prepared for Neil Frank and Jim Homolya; Office of Air Quality Planning and Standards (MD-14) US EPA, Research Triangle Park, North Caroline 27711.

Cole, C.F. and A.J. Fabrick, 1984:
Surface mine pit retention. J Air Poll. Control Assoc. 34(6): 674-675.

Countess, R., 2001:
Methodology for estimating fugitive windblown and mechanically resuspended road emissions applicable for regional scale air quality modelling. Final Report to the Western Governor's Association, Westlake Village, California.

Cowherd Jr., C. and D.L. Gebhart, 2003:
Paper #69393 "*Vegetative Capture of Dust from Unpaved Roads,*" Proceedings of 97th Annual Conference and Exhibition. Air & Waste Management Association, San Diego, CA, June 2003.

Cowherd Jr., C., M.A. Grelinger and D.L. Gebhart, 2006:
Development of an emission reduction tern for near-source depletion. 15th International Emission Inventory Conference, New Orleans.

Cowherd, C., 2009:
Transportability Assessment of Haul Road Dust Emissions. Sent to US EPA, August 21, 2009.

Cowherd Jr., C., 2012:
Modelling Concerns for Fugitive Sources in the Iron, Steel, and Mining Industries. Presentation at Modelling Conference in Research Triangle Park, North Caroline, March 13, 2013

Environment Canada (EC), 2021:
Canada's Greenhouse Gas Quantification Requirements (Dec 2021), retrieved from: https://publications.gc.ca/collections/collection_2022/eccc/En81-28-2021-eng.pdf

Environment Canada (EC), 2022a:
1981-2010 Canadian Climate Normals (attended in June, 2022), retrieved from: https://climate.weather.gc.ca/climate_normals/index_e.html

Environment Canada (EC), 2022b:
Tools for Calculating Emissions for National Pollutant Release Inventory (NPRI) (attended in June, 2022), retrieved from: Stockpiles and exposed area wind erosion calculator: guide to reporting - Canada.ca

Environment Canada (EC), 2022c:
Greenhouse gas emissions, Canada, 1990 to 2020, retrieved from: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

Etyemezian, V., J. Gillies, H. Kuhns, D. Nikolic, and J. Watson, 2003:
Field Testing and Evaluation of Dust Deposition and Removal Mechanisms – Final Report. Desert Research Institute, Reno, NV; January, 2003.

Etyemezian, V., S. Ahonen, D. Nikolic, J. Gillies, H. Kuhns, D. Gillette and J. Veranth 2004:
Deposition and Removal of Fugitive Dust in the Arid Southwestern United States: Measurements and Model Results. JWMA 54: p. 1099-1111.

Gillies, J., P. Arnott, V. Etyemezian, H. Kuhns, E. McDonald, H. Moosmuller, G. Schwemmer, D. Gillette, W. Nickling and T. Wilkerson, 2002:
Characterizing and Quantifying Local and Regional Particulate Matter Emissions from Department of Defense Installations. Report prepared by DRI, Reno, NV for DoD/SERDP

Gillies J., V. Etyemezian, H. Kuhns, D. Nikolic and D. Gillette, 2003:
Effects of vehicle characteristics on unpaved road dust emissions. 12th International Symposium on Transport and Air Pollution, Arcueil, France.

Intergovernmental Panel on Climate Change (IPCC), 2018:
Climate Change 2007; The Physical Science Basis. The Working Group I contribution to the IPCC Fourth Assessment Report – Errata: https://www.ipcc.ch/site/assets/uploads/2018/05/ar4-wg1-errata.pdf

Kornelius, G. and L.W. Burger, 2006:
Vehicle Movement as a Source of Fugitive Dust: A Review. In Proceeding of the National Conference Climate Change and Air Quality Management, National Association for Clean Air (NACA).

Kornelius, G. and L.W. Burger, 2011:
Vehicle Movement as a Source of Fugitive Dust: A Review.
https://www.academia.edu/24616084/Vehicle_Movement_as_a_Source_of_Fugitive_Dust_A_Review

Kuhns, H., J. Gillies, V. Etyemezian, D. Dubois, S. Ahonen, D. Nikolic and C. Durham, 2005:
Spatial variability of unpaved road dust PM_{10} emission factors near El Paso, Texas. JWMA 55 (1) p. 3-12.

Luscar Ltd., 1999:
Air Quality Evaluation of the Proposed Mine Permit Extension. Luscar Ltd. – Coal Valley Mine. Prepared by Cirrus Consultants.

Malone, B., 2004:
Using Trees to Reduce Dust and Odour Emissions from Poultry Farms. Proceedings 2004 Poultry Information Exchange, Surfers Paradise, Queensland, Australia. pp. 33-38.

Malone, G.W. and D. Donnelly, 2001:
The benefits of planting trees around poultry farms. University of Delaware Extension Bulletin #159.

Midwest Research Institute (MRI), 1985:
Fugitive Emission Measurement of Coal Yard Traffic at a Power Plant – Confidential Client.

National Inventory Report (NIR), 2022:
1990-2020: Greenhouse gas Sources and Sinks in Canada. Canada's Submission to the United Nations Framework Convention on Climate Change. Part 3, Submitted April 14, 2022.

National Pollution Inventory (NPI), 2012:
Emission Estimation Technique Manual for Mining Version 3.1; January 2012.

National Stone Association, 1994:
PM-10 Emission Factors for a Haul Road at a Granite Stone Crushing Plant. Washington, D.C., December 1994 (Referred at US EPA, 1998b).

Ontario Ministry of Environment (MOE), 2012:
Ontario's Ambient Air Quality Criteria. Standards Development Branch, April 2012.

Pace, T.G., 2005:
Methodology to Estimate the Transportable Fraction (TF) of Fugitive Dust Emissions for Regional and Urban Scale Air Quality Analyses. US EPA Publication, Research Triangle Park, North Carolina. August 3, 2005.

Reed, W.R., 2003:
An improvement model for prediction of PM_{10} for surface mining operations. Ph.D. Dissertation, Virginia Polytechnic Institute and State University. Blacksburg, Virginia.

Reed, W.R., 2005:
Significant Dust Dispersion Models for Mining Operations. Department of Health and Human Services, Centre for Disease Control (CDC) Information Circular 9478.
http://www.cdc.gov/niosh/mining/pubs/pdfs/2005-138.pdf

South Coast AQMD, 1996:
Improvement of Specific Emission Factors (BACM Project 1), Contract No. 95040.

Staniaszek P. and R.C. Rudolph, 2020:
Particle Depletion Modelled by CALPUFF in Plumes from Mines Surrounded by Dense Vegetation. Accepted for A&WMA's 113th Annual Conference and Exhibition. June 2020.

Thompson, R.J. and A.T. Visser, 2001:
Mine haul road fugitive dust emission and exposure characteristics. Report submitted to SIMRAC.

US EPA. 1981. *Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources .* EPA Contract No. 68-03-2924, Assignment I-06, Research Triangle Park, North Carolina (Referred at US EPA, 1998b).

US EPA, 1983a:
Iron and Steel Plant Open Source Fugitive Emission Control Evaluation, EPA Contract No. 68-02-3177, Assignment 4, Research Triangle Park, North Carolina.

US EPA, 1983b:
Extended Evaluation of Unpaved Road Dust Suppressants in the Iron and Steel Industry, EPA Contract No. 68-02-3177, Assignment 14, Research Triangle Park, North Carolina.

US EPA, 1994:
Surface Coal Mine Emission Factor Study, EPA Contract No. 68-D2-0165, Assignment I-06, Research Triangle Park, North Carolina.

US EPA, 1995:
User’s Guide for the Industrial Source Complex (ISC3) Dispersion Models. Volume II - Description of Model Algorithms. EPA-454/B-95-003b. Office of Air Quality Planning and Standards. Emissions, Monitoring and Analysis Divisions. Research Triangle Park, North Carolina.

US EPA, 1996a:
Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 1996b:
Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 3.3 Gasoline and Diesel Industrial Engines, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 1998a:
Emission Factor Documentation for Section 13.2.2 (Unpaved Roads), Fifth Edition (AP-42). EPA Purchase Order 7D-1554-NALX; MRI Project No. 4864, Prepared by MRI for US EPA Office of Air Quality Planning and Standards Emission Factor and Inventory Group Research Triangle Park.

US EPA, 1998b:
Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 11.9 Western Surface Coal Mining, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 2004:
Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 11.19.2: Crushed Stone Processing and Pulverized Mineral Processing, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 2006a:

Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 13.2.2: Unpaved Roads, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 2006b:

Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 13.2.4: Aggregate Handling and Storage Piles, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 2006c:

Section 13.2.5 Industrial Wind Erosion (AP-42: Compilation of Air Emissions Factors, November 2006), retrieved from:
https://www.epa.gov/sites/default/files/2020-10/documents/13.2.5_industrial_wind_erosion.pdf

US EPA, 2008:

Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression Ignition. Prepared by the Office of Transportation and Air Quality, Research Triangle Park, NC. Report No. NR-009c.

US EPA, 2010:

Exhaust and Emission Factors for Nonroad Engine Modelling – Compression-Ignition. Assessment and Standards Division Office of Transportation and Air Quality. EPA-420-R-10-018; NR-009d, July 2010.

US EPA, 2011:

Compilation of Air Pollutant Emission Factors: Volume I Stationary Point and Area Sources. Part 13.2.1: Paved Roads, Fifth Edition (AP 42). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

US EPA, 2018:

Emission Factors for Greenhouse Gas Inventories (Last Modified 9 March 2018).
https://www.epa.gov/sites/default/files/2018-03/documents/emission-factors_mar_2018_0.pdf

US EPA, 2020:

Website accessed in 2020. https://archive.epa.gov/epa/moves/nonroad-model-nonroad-engines-equipment-and-vehicles.html#other%20documentation

Veranth, J.M., G. Seshadri and E. Pardyjak, 2003:

Vehicle-Generated Fugitive Dust Transport: Analytic Models and Field Study, Atmos Environ. 37:2295-2303.

Watson, J.G. and J.C. Chow, 2000:

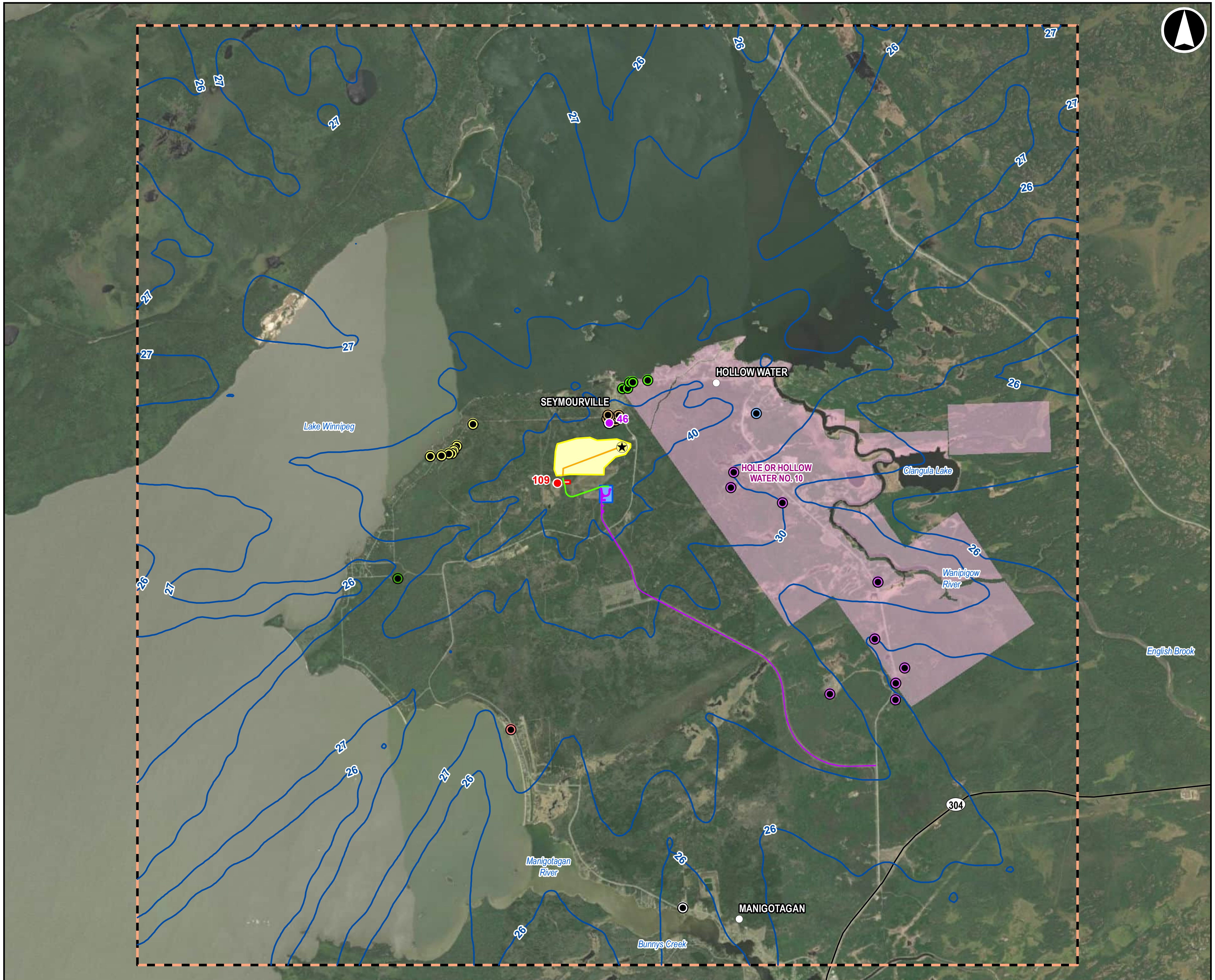
Reconciling urban fugitive dust emission inventory and ambient source contribution estimates: summary of current knowledge and needed research. Desert Research Institute document 6110.4F.

Zhu D., J. Gillies, H. Kuhns, J. Engelbrecht, V. Etyemezian and G. Nikolich, 2012:

Influence of Surface Roughness on Particle Deposition. Proceedings of Air & Waste Management Association (AWMA) 105th - Annual Conference and Exhibition, San Antonio, Texas.

Appendix B

Isopleths



Legend

- ★ Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration ($\mu g/m^3$)
- Maximum Concentration at Sensitive Receptor ($\mu g/m^3$)

MAAQC = 400 $\mu g/m^3$

- Concentration Contour ($\mu g/m^3$)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

PREDICTIONS OF MAXIMUM 1-HOUR AVERAGE CONCENTRATION OF NO_2

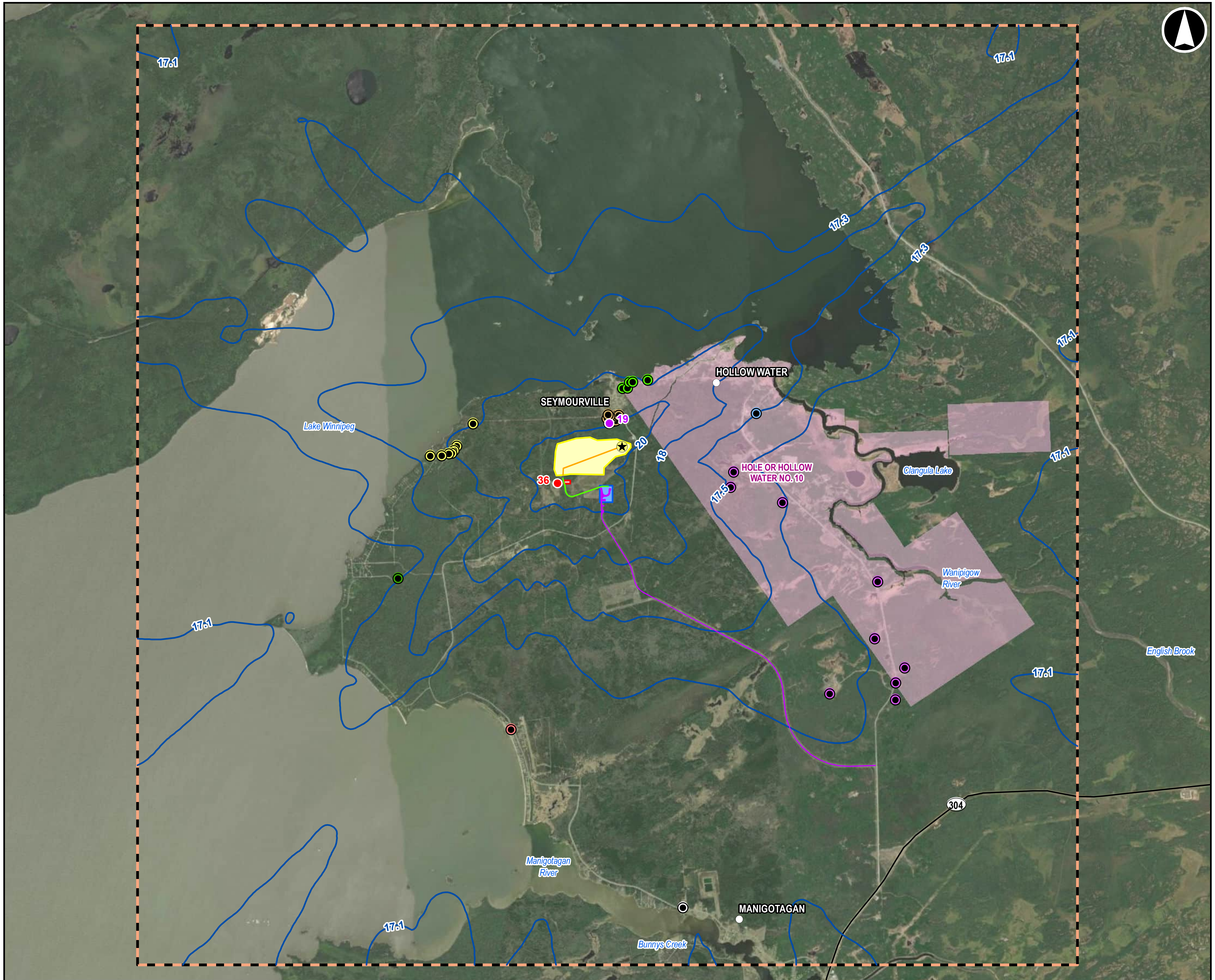
0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

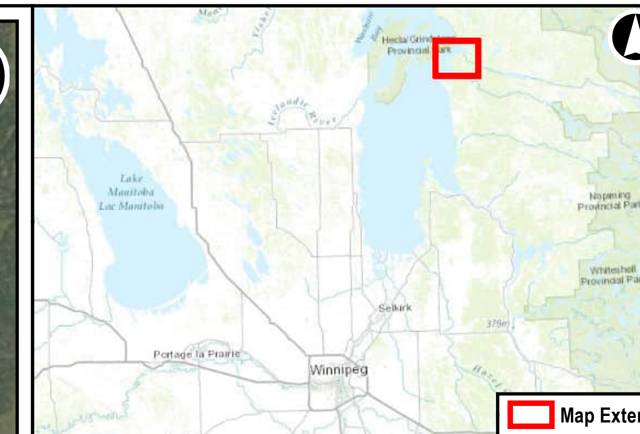
Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B1

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map





Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration ($\mu g/m^3$)
- Maximum Concentration at Sensitive Receptor ($\mu g/m^3$)

MAAQC = 200 $\mu g/m^3$

- Concentration Contour ($\mu g/m^3$)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

PREDICTIONS OF MAXIMUM 24-HOUR AVERAGE CONCENTRATION OF NO_2

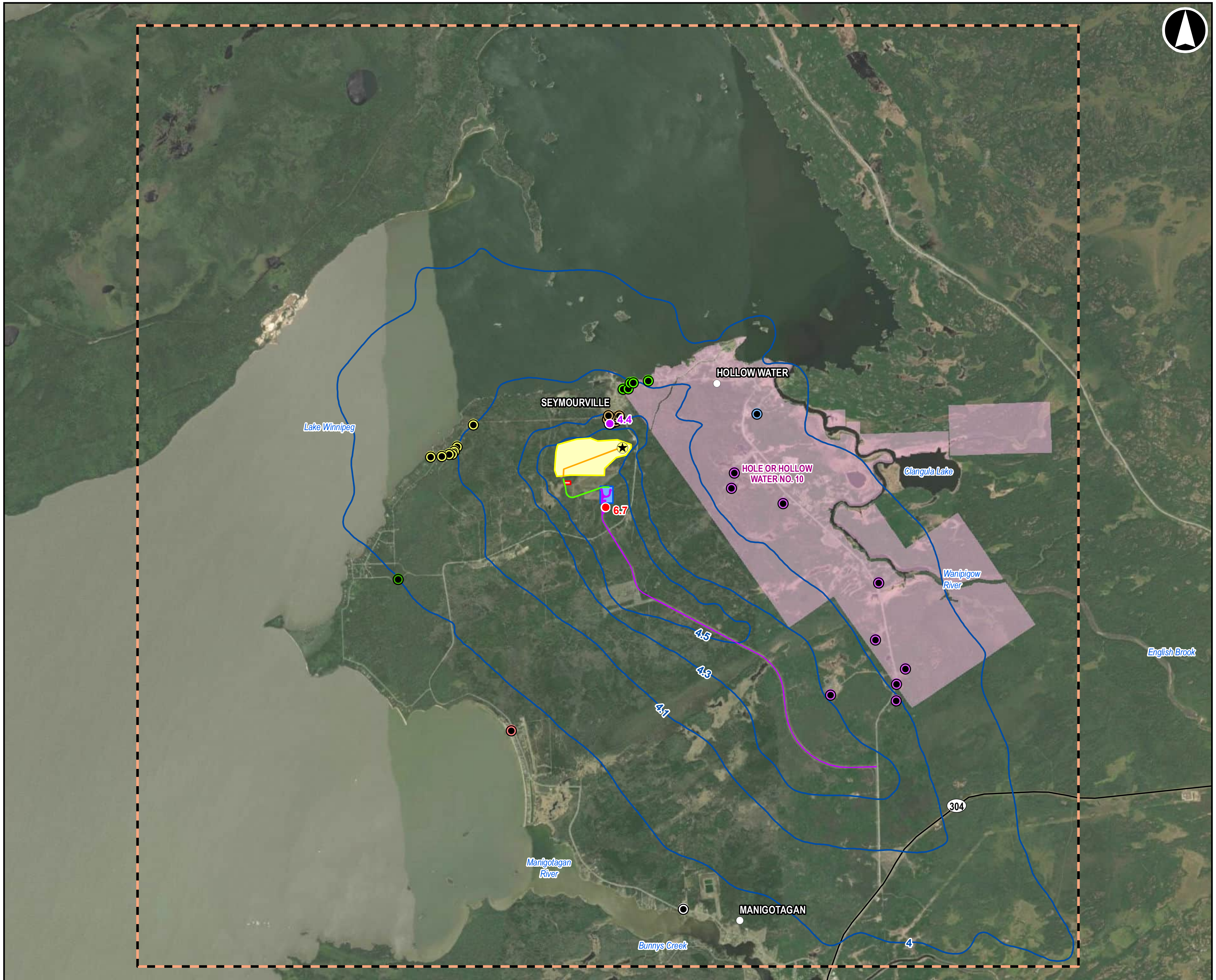
0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B2

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map



Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration ($\mu g/m^3$)
- Maximum Concentration at Sensitive Receptor ($\mu g/m^3$)

MAAQC = 30 $\mu g/m^3$

- Concentration Contour ($\mu g/m^3$)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

PREDICTIONS OF MAXIMUM 24-HOUR AVERAGE CONCENTRATION OF $PM_{2.5}$

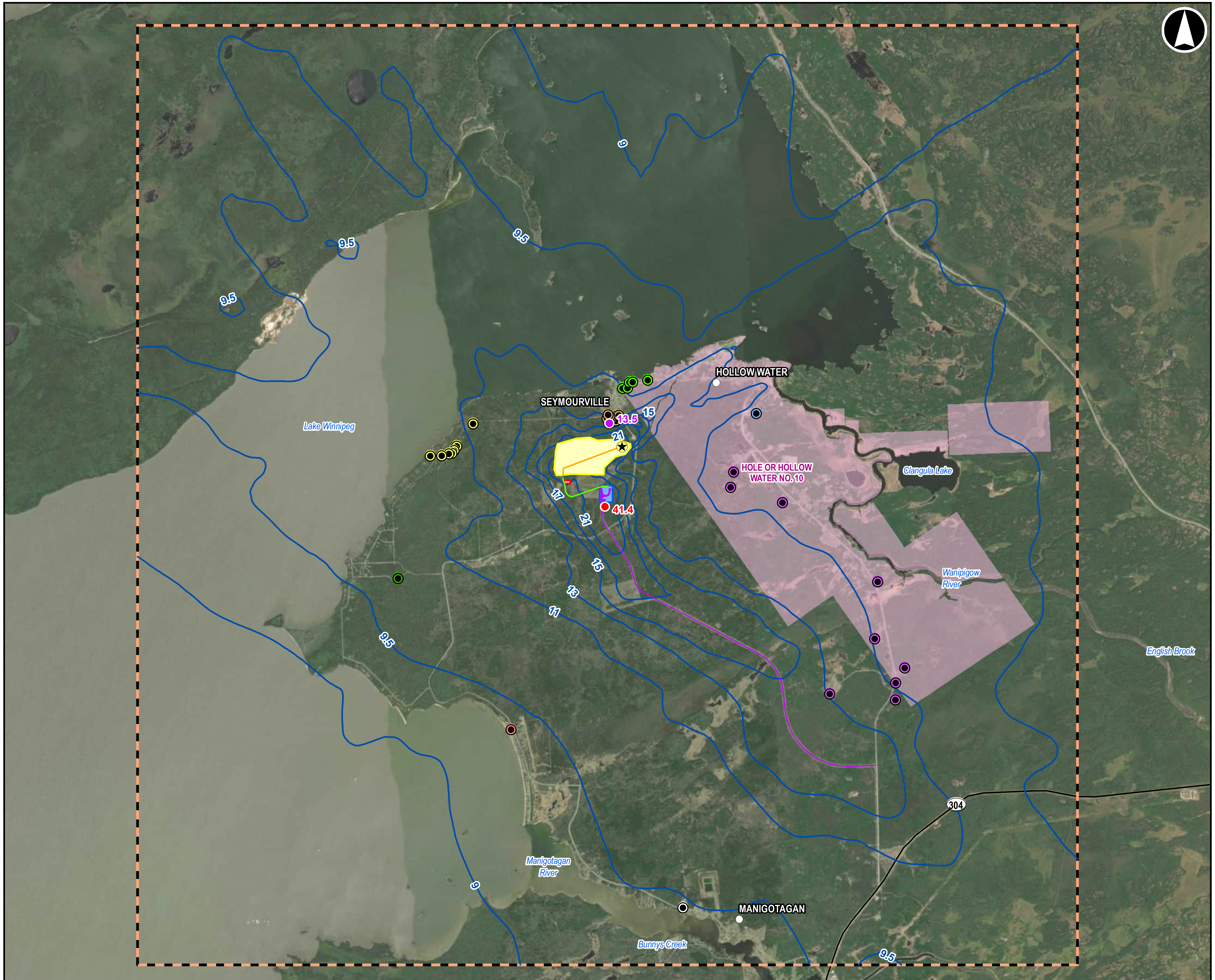
0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

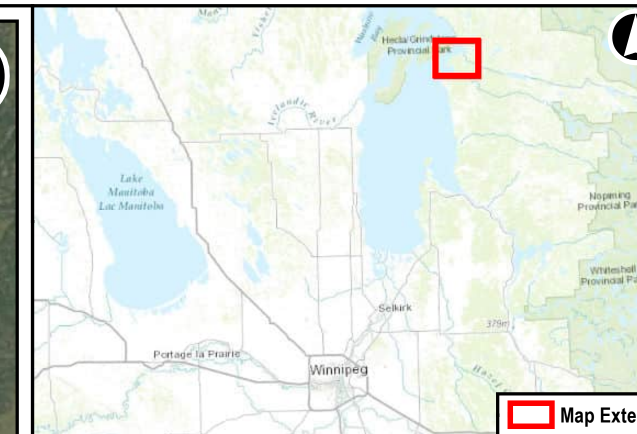
Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B3

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map





Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration ($\mu g/m^3$)
- Maximum Concentration at Sensitive Receptor ($\mu g/m^3$)

MAAQC = 50 $\mu g/m^3$

- Concentration Contour ($\mu g/m^3$)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

PREDICTIONS OF MAXIMUM 24-HOUR AVERAGE CONCENTRATION OF PM_{10}

0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B4

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map

Date Saved: 11/3/2022 User Name: Stephanie.Clark

Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration (μg/m³)
- Maximum Concentration at Sensitive Receptor (μg/m³)

MAAQC = 120 μg/m³

- Concentration Contour (μg/m³)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

PREDICTIONS OF MAXIMUM 24-HOUR AVERAGE CONCENTRATION OF TSP

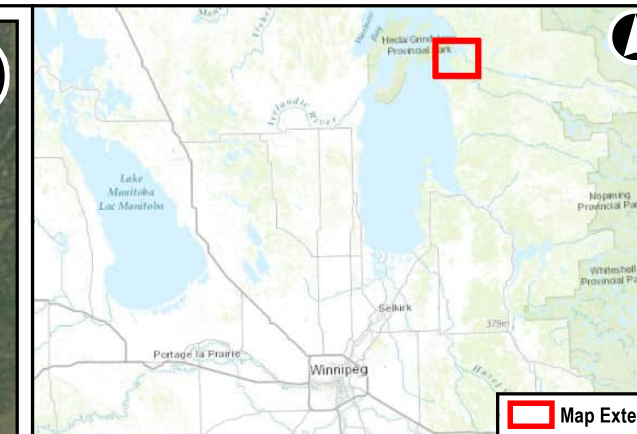
0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B5

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map



Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration ($\mu g/m^3$)
- Maximum Concentration at Sensitive Receptor ($\mu g/m^3$)

MAAQC = 70 $\mu g/m^3$

- Concentration Contour ($\mu g/m^3$)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

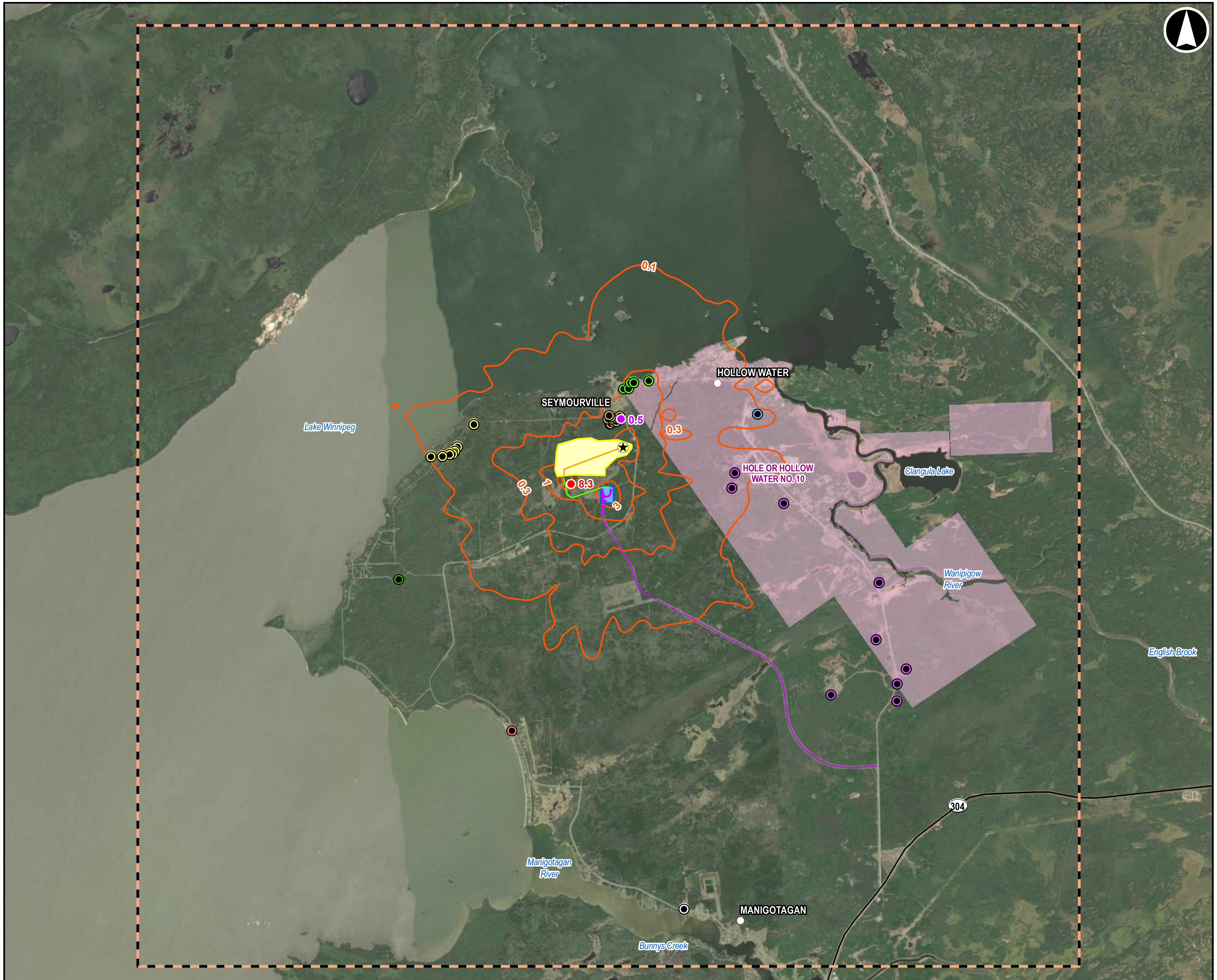
PREDICTIONS OF MAXIMUM ANNUAL AVERAGE CONCENTRATION OF TSP

0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B6

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map



Legend

- Quarry Active Pit
- Feeder Area/Working Pile
- Quarry Area
- Wet Plant Area/Wet Sand Pile
- Quarry Access Road
- Wet Plant Area/Wet Sand Pile Access Road
- Quarry Haul Road
- Modelling Domain (15 km x 15 km)
- Maximum Modelled Concentration (µg/m^3)
- Maximum Concentration at Sensitive Receptor (µg/m^3)

Ontario MOE = 5 µg/m^3

- Concentration Contour (µg/m^3)

Sensitive Recptors

- Ayres Cove Eagle Nest
- Hollow Water Reserve South
- Montago Bay RV Park
- Pelican Inlet
- SE Child & Family Services
- Seymourville
- Wanipigow (Hollow Water) North
- Wood'N Bell Hotel

General Features

- Highway
- First Nation Reserve

AIR QUALITY ASSESSMENT
CANADIAN PREMIUM SANDS

PREDICTIONS OF MAXIMUM 24-HOUR AVERAGE CONCENTRATION OF SILICA IN PM_{10}

0 1 2 3 4
Kilometres
Datum: NAD 1983 UTM Zone 14N

Nov, 2022	PN#: 60663147	1:60,000 * when printed 11"x17"

Figure B7

AECOM

Data Sources: Canvec, MLI
Imagery: Esri World Imagery Basemap
Key Map: Esri World Topographic Map

Piotr Staniaszek, Ph.D.
Senior Air Quality Specialist
Global Air Quality Modelling Specialty Lead
M: 403-463-9682
E: Piotr.Staniaszek@aecom.com

AECOM Canada Ltd.
48 Quarry Park Blvd. SE., Suite 300
Calgary, AB   T2C 5P2
Canada

T: 403.254.3301
F: 403.351.1678
www.aecom.com