# APPENDIX 5.2-3
## Dispersion Modeling Methodology

October 17, 2014

# WOODFIBRE LNG
# APPENDIX 5.2A

# Dispersion Model Methods

**Submitted to:**
Woodfibre LNG Limited
1020 - 1075 W. Georgia Street
Vancouver, B.C.
V6E 3C9

REPORT

**Report Number: 1314220006-108-Appendix 5.2A**

Golder Associates

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# 1.0 INTRODUCTION

Woodfibre LNG Limited (WLNG) has proposed to construct and operate a liquefied natural gas (LNG) production, storage, and marine carrier transfer facility (project) for the export of LNG on the west side of Howe Sound, British Columbia (BC). This report supplements Section 5.2 (Atmospheric Environment) of the Environmental Assessment. As a part of air assessment, the general approach used to evaluate the potential air quality effects of the project included the following steps. This appendix outlines the fourth and fifth steps (**bolded**), namely the approach used for dispersion modelling:

- Establish the existing air quality and meteorological conditions in the project study areas;
- Develop a representative site specific meteorological dataset for use in the dispersion modelling assessment;
- Quantify the air emissions from the project for the phase of activity (i.e.,, construction, operations, and decommissioning) likely to result in the highest overall changes to air quality;
- **Predict the concentrations and deposition rates of indicator compounds released from the project phase that will likely result in the highest overall changes to air quality using dispersion modelling;**
- **Use dispersion modelling to predict the concentrations and deposition rates of the other compounds required as inputs to other disciplines affected by changes in air quality (e.g., human health);** and
- Compare the predicted indicator compound concentrations to available criteria and standards, and assess the relevant significance of these effects.

# 2.0 MODEL SELECTION

Based on guidance provided in BC Modelling Guidelines (BCMOE 2008) and given the potential meteorological conditions induced by complex terrain, the most appropriate model to use for the air assessment is the CALPUFF model in three-dimensional (3D) mode.

## 2.1 CALPUFF Modelling System

The CALPUFF modelling system is comprised of three main components:

- CALMET, the meteorological model that generates CALPUFF ready meteorological files;
- CALPUFF, the transport and dispersion model that advects "*puffs*" of material emitted from sources to calculate hourly concentrations or fluxes at receptors of interest; and
- CALPOST, the post processor that is used to extract the data of interest from CALPUFF binary output files.

To predict ground-level concentrations using CALPUFF, a series of inputs are required. These inputs can be grouped into the following categories:

- dispersion meteorological data;
- terrain data;
- land use data;
- geophysical parameters;
- receptors;
- source configurations; and
- Source emission rates.

The details on dispersion meteorological data, terrain data, land use data, and geophysical parameters are discussed in Dispersion Meteorology Appendix 5.2(c) of the environmental assessment. The details on receptors, source configurations, and source emission rates are discussed separately in the following sections.

## 2.2 Modelling Approach

The BC Ministry for Environment (BCMOE) has established guidelines for undertaking air dispersion modelling for projects in the Province of BC (BCMOE 2008). These guidelines outlines recommended procedures and options for many elements throughout the modelling process including terrain and land use processing, handling of missing meteorological data, model selection, model switch selection, among others etc. To facilitate the model selection, emission source identification and the meteorological processing the BCMOE (2008) recommends the submission of a conceptual and detailed model plan. The conceptual model plan is a tool used to facility early communication between the proponent and the BCMOE and assists in avoiding errors, misdirected focus, rejection of modelled results and project delays.

The detailed model plan provides detailed information on the anticipated modelling approach, and is used to determine different sources of inputs, meteorological and geophysical data, the corresponding data treatments, and the different modelling outputs (BCMOE 2008). For the proposed project both a detailed and a conceptual model plan haves been submitted to the BCMOE for the project (Golder 2014a, 2014b).

Further information related to the approach used to develop the air dispersion modelling are further discussed in the following appendices of the environmental assessment:

- Appendix 5.2(b) – Air Emission Details;
- Appendix 5.2(c) - Dispersion Meteorology;
- Appendix 5.2(c) - Copies of the conceptual and detailed model plans; and
- Appendix 5.2(d) – Air Quality Baseline Report.

## 2.3 Dispersion Meteorological Inputs

The project is located at the mouth of a valley, with Howe Sound to the south of the project area. Because of the complex topography and the land water interface surrounding the facility, terrain effects such as slope flows, terrain blocking effects, and kinematic effects are expected to occur. Therefore, to ensure a full range of possible meteorological conditions are included, a one year data set for 2012 was generated using mesoscale meteorological (MM) model data as input. Using one year's worth of meteorological data is consistent with BCMOE (2008) recommendations when the data is produced from a MM model; this approach has been outlined and accepted in both the conceptual and detailed model plans submitted to the BCMOE (Golder 2014a and 2014b). Due to the complex terrain immediately surrounding the project (within the local assessment area), and because of the complex terrain (mountain and valley structures) regionally, CALPUFF was executed using the nested grid option.

The nested grid option in CALPUFF allows for two or more sets of CALMET generated meteorological data with different grid resolutions to be inputted into the dispersion model. The advantage of the nested grid option is that in areas of concern (i.e., complex terrain close to the Project) the model can be executed with a finer grid resolution than other areas in the CALPUFF domain. The two CALMET domains (grids) used in the assessment are described below:

- **Major domain** - meteorological dataset was an 85 kilometres (km) 83km domain with a 300 metre (m) spatial resolution; and
- **Nested domain** - meteorological dataset was a 15km by 20km domain close to project site with a 100m spatial resolution.

The coordinates of the major and nested CALMET domains are presented in Table 1 and shown in Figure 1. For the project site, the meteorological data, specifically the wind speed and direction will be heavily influenced by the surrounding complex terrain and meteorological stations in neighbouring valleys may not be representative of the facility's meteorology. Therefore, CALMET was executed in no-observation mode and observation data (from nearby meteorology stations found in surrounding valleys) were used to validate the CALMET output. Fifth-Generation Mesoscale Model (MM5) data, generated by Golder Associates Ltd., was used as the initial guess field in CALMET.

Specific details related to the development and validation of the MM5 and the dispersion meteorology (major and nest domains) for the air quality assessment can be found in Appendix 5.2(c) of the environmental assessment.

**Table 1: CALMET and CALPUFF Domain Coordinates UTM Zone 10**

| Domain | Location | UTM Easting (m) | UTM Northing (m) |
|---|---|---|---|
| CALMET – Nested Domain | Southwest | 475,743 | 5,495,527 |
| | Southeast | 490,443 | 5,495,527 |
| | Northeast | 490,443 | 5,515,627 |
| | Northwest | 475,743 | 5,515,627 |
| CALMET – Major Domain | Southwest | 431,943 | 5,452,627 |
| | Southeast | 516,543 | 5,452,627 |
| | Northeast | 516,543 | 5,535,427 |
| | Northwest | 431,943 | 5,535,427 |

| Domain | Location | UTM Easting (m) | UTM Northing (m) |
|---|---|---|---|
| CALPUFF | Southwest | 434,943 | 5,467,327 |
| | Southeast | 513,543 | 5,467,327 |
| | Northeast | 513,543 | 5,532,427 |
| | Northwest | 434,943 | 5,532,427 |

## 2.4 CALPUFF Dispersion Model Inputs

The dispersion modelling assessment was conducted under two conditions during the operation phase of the Project: a normal operation case and an upset case. Normal operation conditions are considered the conditions under which the facility will operate for the vast majority of the time. Upset conditions are abnormal conditions where flaring of natural gas will take place. For the operation phase emission activities and sources are listed below:

- **Amine incinerator** - An amine treatment process will be used in for the removal of acid gas (e.g., carbon dioxide [CO2] and other sulphur compounds) contained in the feed gas prior to compression and refrigeration. A thermal oxidizer or incinerator will oxidize the sulphur compounds into a more stable and less toxic form (e.g., sulphur dioxide [$SO_2$]) before releasing them into the atmosphere. The thermal oxidation process will result in the emission of indicator and other compounds;
- **Process combustion** - Process heat requirement at the Project facility will be provided by a hot oil heater. The heater will burn natural gas, thus resulting in the emission of indicator and other compounds;
- **Flare pilots** - All emergency flare stacks at the Project will have a pilot flame that will burn all the time to ensure that relieved gases will be ignited during emergency. The pilot flame is sustained by burning of natural gas, and this will result in the emission of indicator and other compounds;
- **Fugitive emissions** - There is a potential for other compound emission releases during the LNG process that cannot be attributable to a specific location; these are known as fugitive emissions. Fugitive emissions occur over a general area and emissions may be the result of losses from pipe fittings, filling and empting of storage vessels, and release of remnant gases in a flare or a stack. Well managed and newly built facilities can limit the fugitive emission releases, but cannot entirely eliminate them with current best management practices and technology;
- **Combustion from HVAC equipment** - Natural gas combustion equipment is used to provide comfort heating to the facility for approximately six months of the year. Combustion of natural gas will result in the release on indicator and other compounds;
- **Marine vessel exhaust** - Passenger ferries and water taxies will travel between Squamish and the project site daily to transport employees. An LNG Tanker will be stationed at the facility, with an auxiliary engine running, as part of the LNG storage and shipping operations. Emission from these marine vessels will be indicator compounds due to the combustion of fuel;
- **Landfill** - Two closed landfills are located on-site. The landfills are historic facilities and were operational earlier on in the site's history. Due to the nature of material decomposition within the landfills, the landfills will emit other compounds during the operation, construction and decommissioning phases of the project;

- **Emergency Generators** - When power is unavailable at the facility emergency generators will be used to meet power demands. Emissions from emergency generators will result in the combustion of diesel and the release of indicator and other compounds; and
- **Flaring** - During upset conditions process gas will be flared. Emissions from flaring will be as a result of the combustion of process gas and the release of indicator and other compounds.

A breakdown of which sources are operational in each of the scenarios is provided in Table 2.

**Table 2: Summary of Modelling Scenarios**

| Emission Sources | Normal Operation | Upset Conditions |
|---|---|---|
| Amine Incinerator | ● | |
| Process Combustion | ● | |
| Flare Pilots | ● | |
| Fugitive Emissions | ● | ● |
| HVAC | ● | ● |
| Marine vessels | ● | ● |
| Landfills | ● | ● |
| Emergency generators | | ● |
| Flares | | ● |

For normal operations, it is assumed that the Project will operate continuously (24 hours per day and 365 days per year); therefore, the maximum hourly, daily and annual emission rates are assumed to be the same. This is a conservative assumption since some emission activities will not operate continuously; specifically marine vessels will only operate when Project employees travel between Squamish and the Project which will be only about three hours per day.

The upset scenario will have emissions activities that are both continuous and short term in duration (i.e., flaring of process gas). The upset scenario was executed using both the maximum hourly and daily emission rates. Maximum hourly emission rates were used to assess criteria for hourly and three hour averaging periods, while maximum daily emission rates were used to assess criteria for the 8-hour, 24-hour and annual averaging periods.

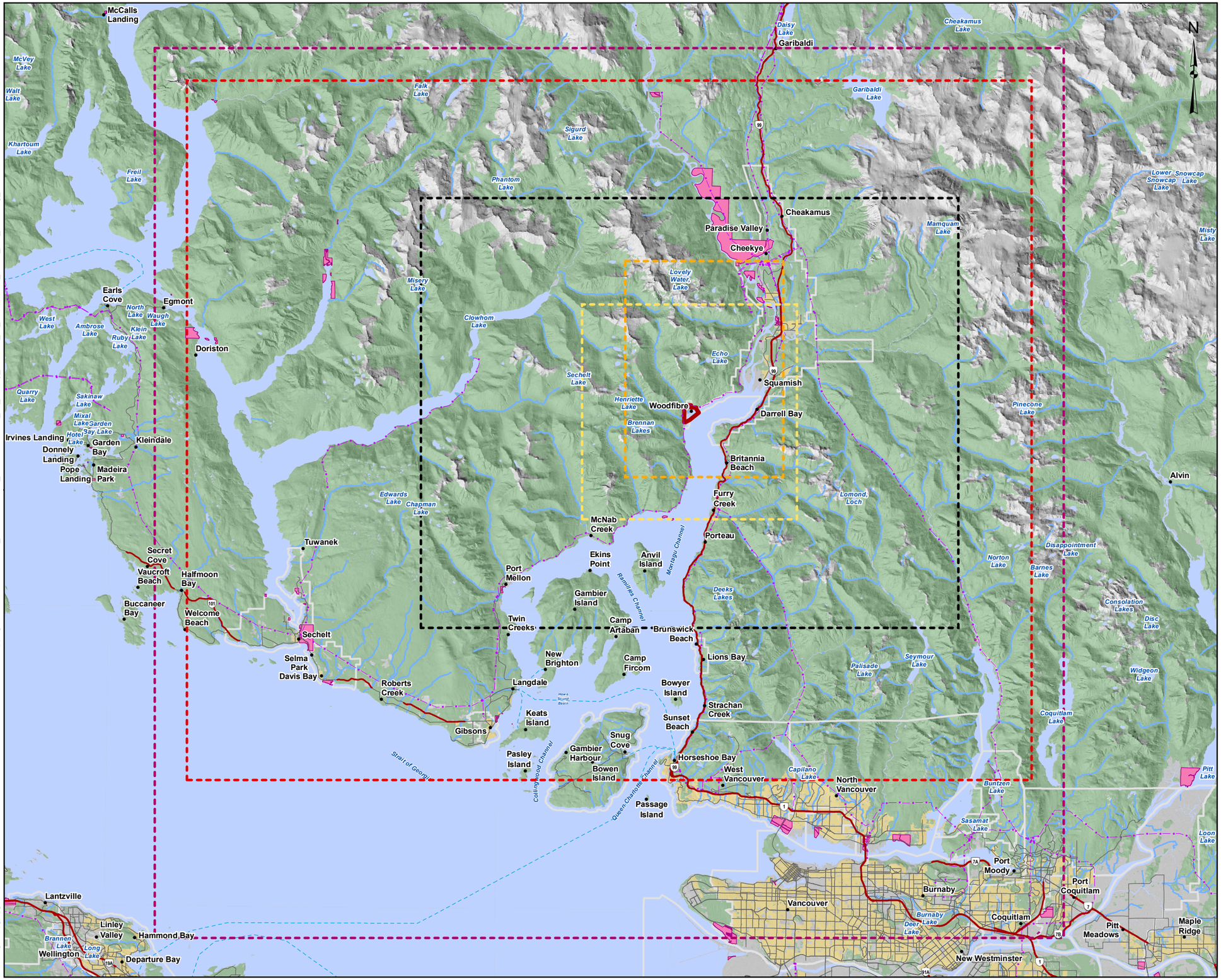
The methods used to estimate emission activities detailed in Table 2 are outlined in Appendix 5.2(b) of the environmental assessment.

### 2.4.1 Assessment Areas

The local assessment area (LAA) is a 20km by 20km area surrounding the project. This is the area within which greatest changes to air quality as a result of project effects are expected.

The regional assessment area (RAA) is approximately a 50km by 40km area centered on the project. This area corresponds to the area used for the dispersion modelling domain and for assessment of cumulative effects. The coordinates of the assessment areas are presented in Table 3 and the air quality assessment areas are illustrated in Figure 1. The CALPUFF domain encompasses the entire LAA and RAA. The LAA encompasses most of CALMET's nested domain.

The CALPUFF modelling domain is larger than the RAA because the CALPUFF modelling domain will encompass sensitive receptors that are important to other technical disciplines, namely human health.




PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - WoodfibreMapping\MXD\AirWOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_FIGURE_01_Assessment_Areas_and_Modelling_Domains.mxd Date: 10/16/2014 Time: 4:55:28 PM

**LEGEND**

- PROJECT AREA
- CALMET MAJOR DOMAIN
- CALMET NESTED DOMAIN
- CALPUFF DOMAIN
- ATMOSPHERIC ENVIRONMENT LAA
- ATMOSPHERIC ENVIRONMENT RAA
- FOREST AREA
- URBAN AREA
- INDIAN RESERVE
- MUNICIPAL BOUNDARY
- HIGHWAY
- ARTERIAL ROAD
- TRANSMISSION LINE (ELECTRIC)
- BC FERRIES ROUTE
- WATERCOURSE

**REFERENCE**

MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

**SCALE**

10 0 10

KILOMETRES

PROJECT

WOODFIBRE LNG LIMITED
WOODFIBRE, HOWE SOUND, B.C.

TITLE

# AIR QUALITY ASSESSMENT AREAS AND MODELLING DOMAINS

Golder Associates

| | | | | |
|---|---|---|---|---|
| PROJECT NO. 13-1422-0006 | | | PHASE 6000 TASK 6030 | |
| DESIGN | SD | 04 Sep. 2014 | SCALE: 1:350,000 | REV. 0 |
| GIS | DL | 26 Sep. 2014 | FIGURE 1 | |
| CHECK | JR | 16 Oct. 2014 | | |
| REVIEW | SC | 16 Oct. 2014 | | |

**Table 3: Air Quality Assessment Area Coordinates UTM Zone 10**

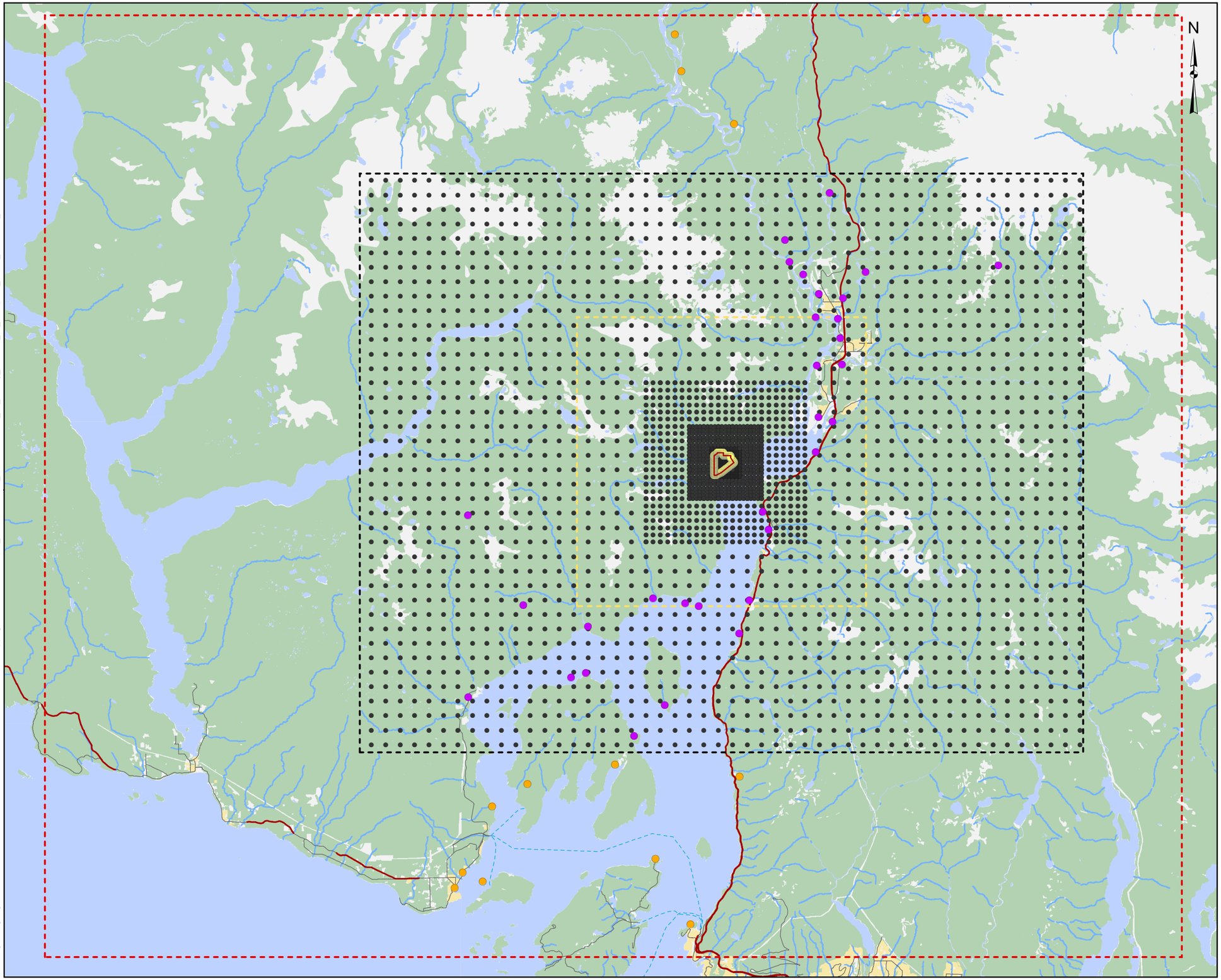
| Assessment Area | Location | UTM Easting (m) | UTM Northing (m) |
|---|---|---|---|
| Local Assessment Area | Southwest | 471,840 | 5,491,500 |
| | Southeast | 491,840 | 5,491,500 |
| | Northeast | 491,840 | 5,511,500 |
| | Northwest | 471,840 | 5,511,500 |
| Regional Assessment Area | Southwest | 456,840 | 5,481,500 |
| | Southeast | 506,840 | 5,481,500 |
| | Northeast | 506,840 | 5,521,500 |
| | Northwest | 456,840 | 5,521,500 |

### 2.4.2 Model Receptors

Model predicted concentrations resulting from on-site emissions were predicted at selected groups of receptors to provide a better understanding of the potential effects of the project. Receptor placement is consistent with the recommendations described in BC Modelling Guidelines (BCMOE 2008). Receptors include a standard nested receptor grid includes the following spacing:

- 50m spacing within 500m of source locations;
- 250m spacing within 2km of source locations;
- 500m spacing within 5km of source locations;
- 1,000m spacing beyond 5km of the source; and
- Receptors were also placed at 20m intervals along the project area.

Discrete receptors were placed at potentially sensitive areas (sensitive receptors) such as hospital, schools, recreational areas, first nation's territories and etc. Table 4 summarizes the location of discrete sensitive receptors. Figure 2 illustrates the gridded, fence-line and sensitive receptors used in the air quality assessment; Figure 2 also includes the sensitive receptors for the Human Health discipline located outside of the Atmospheric Environment RAA.




**LEGEND**

- PROJECT AREA
- CALPUFF DOMAIN
- ATMOSPHERIC ENVIRONMENT LAA
- ATMOSPHERIC ENVIRONMENT RAA
- FOREST AREA
- URBAN AREA
- HIGHWAY
- ARTERIAL ROAD
- BC FERRIES ROUTE
- WATERCOURSE
- HUMAN HEALTH RECEPTOR
- FENCELINE RECEPTOR
- SENSITIVE RECEPTOR
- GRIDDED RECEPTOR

**REFERENCE**

RECEPTOR LOCATIONS FROM GOLDER ASSOCIATES LTD PERSONNEL. MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

**SCALE**

5 0 5

KILOMETRES

PROJECT

WOODFIBRE LNG LIMITED
WOODFIBRE, HOWE SOUND, B.C.

TITLE

**RECEPTORS WITHIN CALPUFF DOMAIN**

Golder Associates

| PROJECT NO. 13-1422-0006 | | | PHASE 6000 TASK 6030 | |
|---|---|---|---|---|
| DESIGN | SD | 04 Sep. 2014 | SCALE: 1:260,000 | REV. 0 |
| GIS | DL | 26 Sep. 2014 | **FIGURE 2** | |
| CHECK | JR | 16 Oct. 2014 | | |
| REVIEW | SC | 16 Oct. 2014 | | |

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - Woodfibre\Mapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_FIGURE_02_Receptors_Within_CALPUFF_Domain.mxd Date: 10/16/2014 Time: 4:40:08 PM

**Table 4: Sensitive Receptors within the CALPUFF Domain and Location UTM Zone 10**

| Receptors | UTM Easting (m) | UTM Northing (m) |
|---|---|---|
| Squamish | 488,444 | 5,504,644 |
| Porteau Cove | 482,956 | 5,489,680 |
| Bowen Island | 477,166 | 5,474,096 |
| Lions Bay | 482,966 | 5,479,801 |
| Langdale | 465,863 | 5,477,734 |
| Horseshoe Bay | 479,592 | 5,469,590 |
| New Brighton | 468,316 | 5,479,272 |
| Britannia Beach | 484,988 | 5,496,856 |
| Furry Creek | 483,657 | 5,491,970 |
| Gibsons | 463,278 | 5,472,093 |
| Ch'iyakmesh | 486,428 | 5,515,378 |
| First Nations Cultural Site | 484,578 | 5,498,086 |
| Residence | 468,030 | 5,491,634 |
| Potlach Creek | 476,990 | 5,492,115 |
| KWUM KWUM | 479,216 | 5,491,787 |
| Tetrahedron Park | 464,210 | 5,497,848 |
| Anvil Island | 477,803 | 5,484,737 |
| Ekin's Point | 472,337 | 5,486,959 |
| Kaikalahun | 464,231 | 5,485,289 |
| McNab Creek Strata | 472,492 | 5,490,163 |
| Camp Artaban | 474,374 | 5,480,622 |
| Camp Latona | 471,321 | 5,486,657 |
| Residence on Gambier Island | 475,689 | 5,482,589 |
| Brackendale Provincial Park | 488,227 | 5,511,539 |
| Alice Lake Campground | 491,693 | 5,514,662 |
| Evans Lake Forest Education Centre/Paradise Valley Campground | 489,213 | 5,520,153 |
| Garibaldi Lake Campsite Area | 495,918 | 5,532,148 |
| Klahanie Campground/Stawamus Chief | 488,239 | 5,502,227 |
| Eagle Vista RV Resort and Campground | 490,054 | 5,508,293 |
| Elfin Lakes Shelter | 500,864 | 5,515,123 |
| Wonderland Valley Resort | 490,134 | 5,512,858 |
| Squamish Valley Campground | 482,612 | 5,524,920 |
| Schaltuuch | 465,209 | 5,472,541 |
| Chekwelp | 463,833 | 5,473,149 |
| Defence Island | 480,163 | 5,491,569 |

| Receptors | UTM Easting (m) | UTM Northing (m) |
|---|---|---|
| Stawamus | 489,410 | 5,504,316 |
| Yekwaupsum | 488,329 | 5,508,189 |
| Kowtain | 489,939 | 5,510,090 |
| Seaichem | 489,787 | 5,511,430 |
| Waiwakum | 488,464 | 5,513,143 |
| Poquiosin and Skamain | 487,383 | 5,514,494 |
| Cheakamus | 486,116 | 5,516,903 |
| Skowishin | 478,512 | 5,531,112 |
| Skowishin Graveyard | 478,939 | 5,528,555 |

### 2.4.3 Model Options

CALPUFF offers various switch options for users to customize model runs that best fit to each assessment. Model switch selection for the air quality assessment are generally consistent with the recommendations found in the BC Modelling Guidelines (BCMOE 2008). A summary of the CALPUFF recommended switch selection along with the switches to be used within the assessment are detailed in Appendix 5.2(b) of the environmental assessment.

As mentioned in Section 2.3, CALPUFF was executed using the nested grid option. This option allows for a finer meteorological data resolution in the area of interest, while still maintaining the ability to assess a larger domain using a coarser grid resolution. In other words, the nested grid option allows CALPUFF to balance a finer grid resolution near the Project, and also maintain a large modelling domain. Another advantage of the nested grid option is that puffs (emission plumes) can recirculation between the grids (i.e., between the major and nested domains).

### 2.4.4 Building Downwash

Building downwash is a phenomenon caused by air movement around buildings. Buildings or other solid structures may affect the flow of air in the vicinity of a source and cause eddies to form on the building's downwind side. In some situations stack emissions may be trapped in the wake of a building or other structures, which may result in elevated ground-level concentrations. In this assessment, BPIP-PRIME was used to determine building downwash parameters for point sources associated with the Project. BPIP-PRIME is an executable program which requires source and building information. The algorithm outlined in the BC Modelling Guidelines (BCMOE 2008) was used to determine which buildings to include in BPIP-PRIME's execution.

## 2.5 Source Parameterization

The CALPUFF modelling system requires sources to be characterized as point, line, area, or volume. The source type will depend on the configuration of individual sources. A summary of these source types are provided in Table 5.

**Table 5: Summary of Types of Sources in CALPUFF**

| Type | Example | Description |
|---|---|---|
| Point | Stacks | Releases from a specific source such as a stack or isolated vent. |
| Line | Building vents, roadways, marine vessel routes | Buoyant releases along a set path such as building vents or shipping routes. |
| Area | storage piles, open-pits | Used to model low-level or ground-level emissions with little or no plume rise. Input as square, rectangle, polygon, or circle |
| Volume | Windows, doors, conveying system transfer points, crushers/screeners, haul roads | Sources that initially disperse 3-dimensionally with no plume rise. |

Where appropriate, multiple sources can be combined to a single source. This is based on the following characteristics:

- the source characteristics of the individual stacks or vents must be similar;
- the emission rate from the individual release points must be similar; and
- the sources must be located over an area of volume that can be reasonably well defined.

### 2.5.1 Point Sources

Point sources were used to model releases from specific sources such as stacks and flares. The source location plan and a description of each point source can be seen from Figure 3 and Table 6. The facility has a single flare system with four flare stacks which are used during upset conditions to flare natural gas. The flares are only used in this manner for short periods of less than 24 hours at a time.

During the upset flaring event, only one flare will be in operation at any given time. For example when gas needs to be depressured, WWGF flare will be used, or if the system is shutting down, the LPCF flare will be used. In the modelling assessment, it was conservatively assumed that three flares are on during the upset scenario.

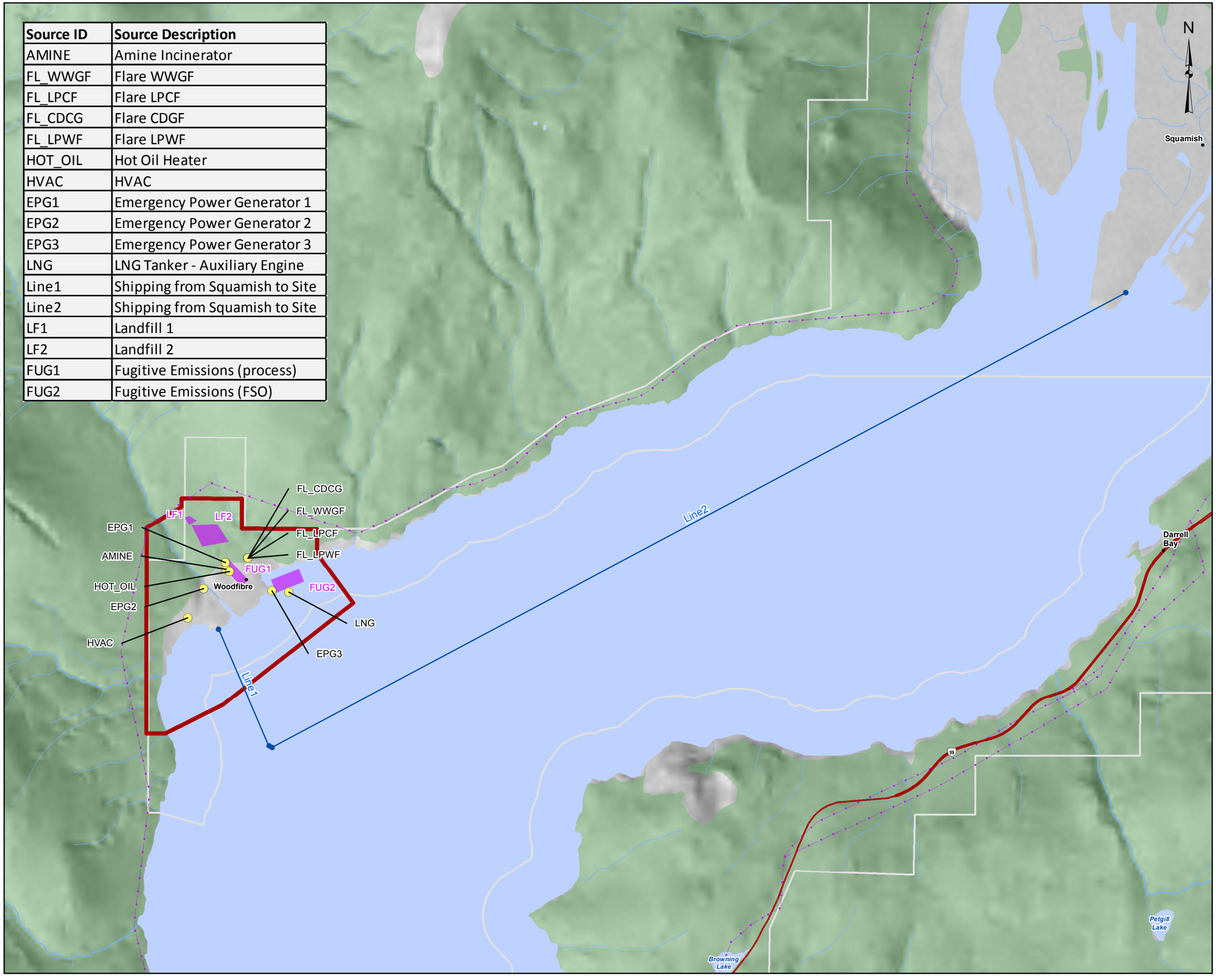
**Table 6: List of Point Sources**

| Emission Activity | Source Description | Emission Activity | Scenario | Base Elevation (m) | Stack Height (m) | Diameter (m) | Velocity (m/s) | Temperature (K) |
|---|---|---|---|---|---|---|---|---|
| Amine incinerator | Amine Incinerator | Amine incinerator | Normal | 21.5 | 40.0 | 1.700 | 3.52 | 1,453 |
| Flare pilot | Flare WWGF (Pilot) | Flare pilot | Normal | 34.6 | 100.0 | 0.762 | 0.51 | 1,273 |
| | Flare LPCF (Pilot) | Flare pilot | Normal | 34.6 | 100.0 | 1.016 | 0.35 | 1,273 |
| | Flare CDGF (Pilot) | Flare pilot | Normal | 34.6 | 100.0 | 1.219 | 0.29 | 1,273 |
| | Flare LPWF (Pilot) | Flare pilot | Normal | 34.6 | 100.0 | 0.406 | 1.43 | 1,273 |

| Emission Activity | Source Description | Emission Activity | Scenario | Base Elevation (m) | Stack Height (m) | Diameter (m) | Velocity (m/s) | Temperature (K) |
|---|---|---|---|---|---|---|---|---|
| Process combustion | Hot Oil Heater | Process combustion | Normal | 17.9 | 40.0 | 1.500 | 7.26 | 553 |
| Combustion from Heating, Venting, and Air Conditioning (HVAC) equipment | HVAC | Combustion from HVAC equipment | Normal and upset | 31.7 | 40.0 | 0.508 | 1.93 | 553 |
| Marine vessel exhaust | LNG Tanker – Auxiliary Engine | Marine vessel exhaust | Normal and upset | 16.3 | 10.0 | 0.203 | 71.01 | 738 |
| Flaring | Flare WWGF (Depressuring Feed Gas) | Flaring | Upset | 34.6 | 183.6 | 19.094 | 20.00 | 1,273 |
| | Flare LPCF (Shut down Tank RG) | Flaring | Upset | 34.6 | 143.8 | 9.702 | 20.00 | 1,273 |
| | Flare CDGF (Major Maintenance of MR Compressor Unit) | Flaring | Upset | 34.6 | 234.3 | 31.346 | 20.00 | 1,273 |
| Emergency Generator | Emergency Power Generation 1 | Emergency Generator | Upset | 31.4 | 10.0 | 0.203 | 71.01 | 738 |
| | Emergency Power Generation 2 | Emergency Generator | Upset | 22.4 | 10.0 | 0.203 | 286.73 | 796 |
| | Emergency Power Generation 3 | Emergency Generator | Upset | 19.9 | 10.0 | 0.203 | 71.01 | 738 |

Details regarding emission rates and calculation methods are discussed in Appendix 5.2(b) of the environmental assessment.

| Source ID | Source Description |
|---|---|
| AMINE | Amine Incinerator |
| FL_WWGF | Flare WWGF |
| FL_LPCF | Flare LPCF |
| FL_CDCG | Flare CDGF |
| FL_LPWF | Flare LPWF |
| HOT_OIL | Hot Oil Heater |
| HVAC | HVAC |
| EPG1 | Emergency Power Generator 1 |
| EPG2 | Emergency Power Generator 2 |
| EPG3 | Emergency Power Generator 3 |
| LNG | LNG Tanker - Auxiliary Engine |
| Line1 | Shipping from Squamish to Site |
| Line2 | Shipping from Squamish to Site |
| LF1 | Landfill 1 |
| LF2 | Landfill 2 |
| FUG1 | Fugitive Emissions (process) |
| FUG2 | Fugitive Emissions (FSO) |




**LEGEND**

- PROJECT AREA
- AREA SOURCE
- LINE SOURCE
- POINT SOURCE
- FOREST AREA
- MUNICIPAL BOUNDARY
- HIGHWAY
- TRANSMISSION LINE (ELECTRIC)
- WATERCOURSE

**REFERENCE**

AREA, LINE AND POINT SOURCES PROVIDED BY GOLDER ASSOCIATES LTD PERSONNEL. MUNICIPALITIES FROM GEOBC. BASE DATA FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HILLSHADE PROVIDED BY GOVERNMENT OF BRITISH COLUMBIA.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

**SCALE**

500 0 500
METRES

PROJECT
WOODFIBRE LNG LIMITED
WOODFIBRE, HOWE SOUND, B.C.

TITLE
**SOURCE LOCATION PLAN**

Golder Associates

| PROJECT NO. 13-1422-0006 | | | PHASE 6000 TASK 6030 | |
|---|---|---|---|---|
| DESIGN | SD | 04 Sep. 2014 | SCALE: 1:25,000 | REV. 0 |
| GIS | DL | 26 Sep. 2014 | **FIGURE 3** | |
| CHECK | JR | 16 Oct. 2014 | | |
| REVIEW | SC | 16 Oct. 2014 | | |

PATH: \\golder.gds\gal\Vancouver\CAD-GIS\VAN\2013\13-1422\13-1422-0006 - WoodfibreMapping\MXD\Air\WOODFIBRE_ATMOSPHERIC_ENVIRONMENT_Air_Quality_FIGURE_03_Source_Location_Plan.mxd Date: 10/16/2014 Time: 4:44:30 PM

### 2.5.2 Line Sources

Line sources were used to model releases along the marine vessel route between Squamish and the Project. The source location plan and a description of each line source can be seen from Figure 3 and Table 7. The marine vessels are water taxis and passenger ferries which carry personnel to and from the Project. The emissions from the marine vessels will be modelled along the vessels' travel path. However, line source inputs into the CALPUFF model can only be input as straight lines. To represent the marine vessel's travel path from the Project to Squamish two line sources were used; therefore, emission rates from the marine vessel exhaust emission activities were split over the two line sources.

**Table 7: List of Line Sources**

| Emission Activity | Source Description | Scenario | Length (m) | Release Height (m) |
|---|---|---|---|---|
| Marine vessel exhaust | Water taxi and ferry traveling from Squamish to Site | Normal and upset | 885.3 | 5.0 |
| | Water taxi and ferry traveling from Squamish to Site | Normal and upset | 6491.6 | 5.0 |

Details regarding emission rates and calculation methods are discussed in Appendix 5.2(b) of the environmental assessment.

### 2.5.3 Area Sources

Area sources are used to model low level or ground releases such as landfills. In general, area sources result in much higher ground-level concentrations than those of volume or point sources. The source location plan and a description of each area source can be seen in Figure 3 and Table 8. There are two landfills onsite; therefore, two area sources were used to model the landfill emission activity one area source for each landfill.

Fugitive emissions of natural gas are expected to be emitted from all project related processes. The two main processing areas are the on land equipment and the Floating Storage and Offloading facility (FSO). Therefore, two areas sources were used to represent fugitive emissions activities, one that represents the on land processing area and the other the FSO area.

**Table 8: List of Area Sources**

| Emission Activity | Source Description | Scenario | Source Surface Area ($m^2$) | Base Elevation (m) | Release Height (m) | Area Source Initial Sigma Z (m) |
|---|---|---|---|---|---|---|
| Landfill | Landfill 1 | Normal | 2,482 | 108.3 | 5.0 | 0.0 |
| | Landfill 2 | Normal | 23,604 | 77.1 | 5.0 | 0.0 |
| Fugitive emissions | Fugitive Emissions (process) | Normal | 12,561 | 2.9 | 5.0 | 0.0 |
| | Fugitive Emissions (Floating Storage and Offloading Unit) | Normal | 18,304 | 17.1 | 17.0 | 0.0 |

Details regarding emission rates and calculation methods are discussed in Appendix 5.2(b) of the environmental assessment.

## 3.0 CLOSING

The CALPUFF air dispersion model was the model of choice for assessing the effects the Project will have on downwind receptors. Modelling options are consistent with guidelines recommended by BCMOE (2008). Two datasets of dispersion meteorology were prepared and inputted into CALPUFF using the nested grid option. The selected modelling domain is expected to be sufficiently large to include all potentially sensitive receptors that may be affected by on-site sources. Emission activities documented in Appendix 5.2(b) of the environmental assessment were assigned to emission sources and inputted into the model.

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# 4.0 REFERENCES

BCMOE (British Columbia Ministry of Environment), (2008); Guidelines for Air Quality Dispersion Modelling in British Columbia. Environmental Protection Division Environmental Quality Branch Air Protection Section.

Golder (Golder Associates Ltd., (2014a); Woodfibre LNG Project Conceptual Air Dispersion Model Plan. Technical Memorandum submitted to Ministry of Environment.

Golder, (2014b); Woodfibre LNG Project – Detailed Air Dispersion Model Plan. Technical Memorandum submitted to Ministry of Environment.

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| Africa | + 27 11 254 4800 |
| Asia | + 86 21 6258 5522 |
| Australasia | + 61 3 8862 3500 |
| Europe | + 356 21 42 30 20 |
| North America | + 1 800 275 3281 |
| South America | + 56 2 2616 2000 |

solutions@golder.com
www.golder.com

**Golder Associates Ltd.**
**500 - 4260 Still Creek Drive**
**Burnaby, British Columbia, V5C 6C6**
**Canada**
**T: +1 (604) 296 4200**


Golder Associates