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AIR QUALITY
DISPERSION MODELLING AND RISK ASSESSMENT
FOR CAPSTONE INFRASTRUCTURE CORPORATION
KNEEHILL SOLAR AND STORAGE SITE
BATTERY ENERGY STORAGE SYSTEM (BESS)

Prepared for:
Capstone Infrastructure Corporation
Suite 2930, 155 Wellington Street West
Toronto, Ontario M5V 3H1

Prepared by:
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Calgary, Alberta T2E 6V2

J2024-008R2

August 8, 2024

CLEAN AIR IS OUR PASSION…REGULATORY COMPLIANCE IS OUR BUSINESS

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Emission Quantification

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August 8, 2024 J2024-008R2

Capstone Infrastructure Corporation

SENT BY EMAIL: ybeshr@capstoneinfra.com

Attention: Mr. Yasser Beshr, Project Coordinator

Subject: **Air Quality Dispersion Modelling and Risk Assessment for Kneehill Solar and Storage Site BESS**

As requested by Capstone Infrastructure Corporation (Capstone), Calvin Consulting Group Ltd. (Calvin Consulting) has completed an Air Quality Dispersion Modelling and Risk Assessment (Assessment) in association with emissions from a potential Battery Energy Storage System (BESS) fire at the Kneehill Solar and Storage Site (Facility). This Facility will be located at Legal Subdivision (LSD) SW-13-032-24 W4M, ~2.6 km north-northwest of Three Hills, Alberta. The results of the Assessment are provided in this report.

If you require any additional information or have any comments or concerns pertaining to these results, please contact Ann Jamieson by email at ann.jamieson@calvinconsulting.ca or by phone at 403-560-7698. Thank you for the opportunity to work on this project.

Sincerely,
Calvin Consulting Group Ltd.

Nick Gingerysty, M.Sc.
Intermediate Consultant

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DISCLAIMER

Calvin Consulting Group Ltd. (Calvin Consulting) has prepared this report to provide Capstone Infrastructure Corporation (Capstone) with predicted maximum concentrations of air contaminants that may occur in the vicinity of the Kneehill Solar and Storage Site (Facility) Battery Energy Storage System (BESS) in the unlikely event of a fire. These maximum concentrations are estimated based on, but not limited to, the following:

- Data provided by Capstone, noting that in the absence of data for any emission source, estimated parameters were developed based on the professional expertise of Calvin Consulting personnel and our Associate, Dr. Stephen Ramsay, as outlined in Section 3.1 of this report

- Digital terrain data that are publicly available from the Government of Canada

- Historical meteorology data provided by the Alberta Government

- Estimates of land use percentages for land classes (e.g., vegetation cover, urban development, agricultural land, forest, etc.) within the selected modelling domain

- A computer modelling system developed by the United States Environmental Protection Agency (U.S. EPA)

Information, data, facts and the computer model provided by others and used in preparation of this report are assumed to be accurate without any verification or confirmation by Calvin Consulting.

As a result of the uncertainty and inherent variability in the preceding data and/or estimates, Calvin Consulting makes no representation or warranty with respect to this report or the information contained herein other than that Calvin Consulting has exercised reasonable skill, care and diligence in accordance with accepted practice and usual standards of thoroughness and competence for the Environmental Profession with respect to the collection, assessment and evaluation of the information used in the preparation of this report. Liability for the acceptance and implementation of the information and/or recommendations made in this report is limited to the actual dollar value of professional fees charged to Capstone by Calvin Consulting for the scope of work as indicated in this report.

EXECUTIVE SUMMARY

At the request of Capstone Infrastructure Corporation (Capstone), Calvin Consulting Group Ltd. (Calvin Consulting) and our Associate, Dr. Stephen Ramsay, have completed an Air Quality Dispersion Modelling and Risk Assessment (Assessment) pertaining to a potential fire event at a Battery Energy Storage System (BESS) location proposed for construction and operation in Alberta within the Kneehill Solar and Storage Site (Facility). Literature pertaining to these types of fires was reviewed to assess the types of contaminants that are likely emitted during this type of fire and to estimate emission rates for each contaminant of concern. Although various contaminants can be emitted in the event of a Lithium Iron Phosphate (LFP) fire, Hydrogen Fluoride (HF) and Carbon Monoxide (CO) are the main contaminants of concern.

Source and emission data were derived based on the literature review, including reported laboratory test data. Air quality dispersion modelling was performed taking into account local wind data, groundcover, terrain influences, on-site building influences and the location of the closest residences. The modelling results were then compared to the following:

- **Air Quality.** Alberta Ambient Air Quality Objectives (AAAQOs).
- **Occupational Health & Safety (OHS).** American Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH) Immediately Dangerous to Life or Health (IDLH) limits.
- **Public Health & Safety.** United States Environmental Protection Agency (U.S. EPA) National Advisory Committee for Acute Exposure Guideline Levels (AEGLs) for Hazardous Substances, as referenced by Health Protection Branch of Alberta Health in the January 2017 document entitled *Protective Action Criteria: A Review of Their Derivation, Use, Advantages and Limitations*.

The following conclusions pertain to this Assessment:

- **Air Quality.** In the unlikely event of a BESS fire, maximum predicted one-hour average concentrations of HF and Carbon Monoxide (CO), exceed the applicable AAAQO out to ~95 m and ~25 m from the Facility fenceline, respectively. However, maximum predicted air quality concentrations at the closest residences comply with the AAAQOs.
- **OHS.** From an OHS perspective, the applicable IDLH limits will not be exceeded onsite or beyond the Facility fenceline for the air contaminants of concern.
- **Public Health & Safety.** The maximum predicted HF concentrations are within the applicable three tiers of AEGLs for all averaging periods, as are the maximum predicted CO concentrations.
- **Risk Assessment.** In summary, with respect to a potential BESS fire, it is concluded that the risk of exposure to the public is insignificant or at the de minimis level.

GLOSSARY

AAAQO	Alberta Ambient Air Quality Objective
AEGL	Acute Exposure Guideline Level
AEPA	Alberta Environment and Protected Areas
AQMG	Air Quality Model Guideline
BESS	Battery Energy Storage System
BPIP	Building Profile Input Program
CDC	American Centers for Disease Control and Prevention
CO	Carbon Monoxide
HCl	Hydrogen Chloride
HF	Hydrogen Fluoride
IDLH	Immediately Dangerous to Life or Health
LFP	Lithium Iron Phosphate
$LiFePO_4$	Lithium Iron Phosphate
Li-ion	Lithium-Ion
LSD	Legal Subdivision
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NMC	Nickel Manganese Cobalt
U.S. EPA	United States Environmental Protection Agency
WRF	Weather Research and Forecasting

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1.0 INTRODUCTION

Capstone Infrastucture Corporation (Capstone) proposes to install a Battery Energy Storage System (BESS), which will be within the fenced area of the Kneehill Solar and Storage Site (Facility), ~2.6 km north-northwest of Three Hills, Alberta on Legal Subdivision (LSD) SW-13-032-24 W4M as indicated in Figure 1. Lithium Iron Phosphate (LFP or LiFePO4) batteries are proposed for use at this Facility. At the request of Capstone, Calvin Consulting Group Ltd. (Calvin Consulting) has completed an Air Quality Dispersion Modelling and Risk Assessment (Assessment) for potential emissions emitted from this BESS site in the event of a fire. To ensure maximum predicted concentrations were assessed for the various residential properties surrounding the Facility, a fire location within the Facility fenceline closest to the nearest residence was considered in this Assessment.

1.1 Project Description

The proposed 10.18 MW BESS consists of eight containers. A container consists of 48 modules and each module contains 69 SolBank 1.0 Lithium Iron Phosphate (LFP or $LiFePO_4$) battery cells. As indicated in Figure 2, the BESS containers will be installed in the southeast corner of the Facility.

1.2 Safety Features

Numerous safety standards have been developed to reduce the risk of BESS fires. A BESS installation must meet local building codes, utility regulations and industry standards. It is not the purpose of this study to review or apply the BESS safety standards. These standards are cited only to substantiate the fire modelling assumptions that rely on the fire spread-limiting effect of these standards. The following industry safety standards were developed to minimize the hazards associated with BESSs:

- **National Fire Protection Association (NFPA) 855 - Standard for the Installation of Stationary Energy Storage.** This standard establishes the requirements for design, construction, installation, commissioning, operation, maintenance and decommissioning of stationary energy storage systems. This standard applies to battery installations greater than 70 kW-h.

- **UL 9540 - Standard for Safety Energy Storage Systems and Equipment.** This standard establishes that electrical, electro-chemical, mechanical and thermal energy storage systems operate at an optimal level of safety. It also establishes safety requirements for the integrated components of an energy storage system.

- **UL 9540A - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.** This standard establishes quantitative data to characterize potential battery storage fire events. The standard also establishes battery storage system fire testing on the cell level, module level, unit level and installation level.

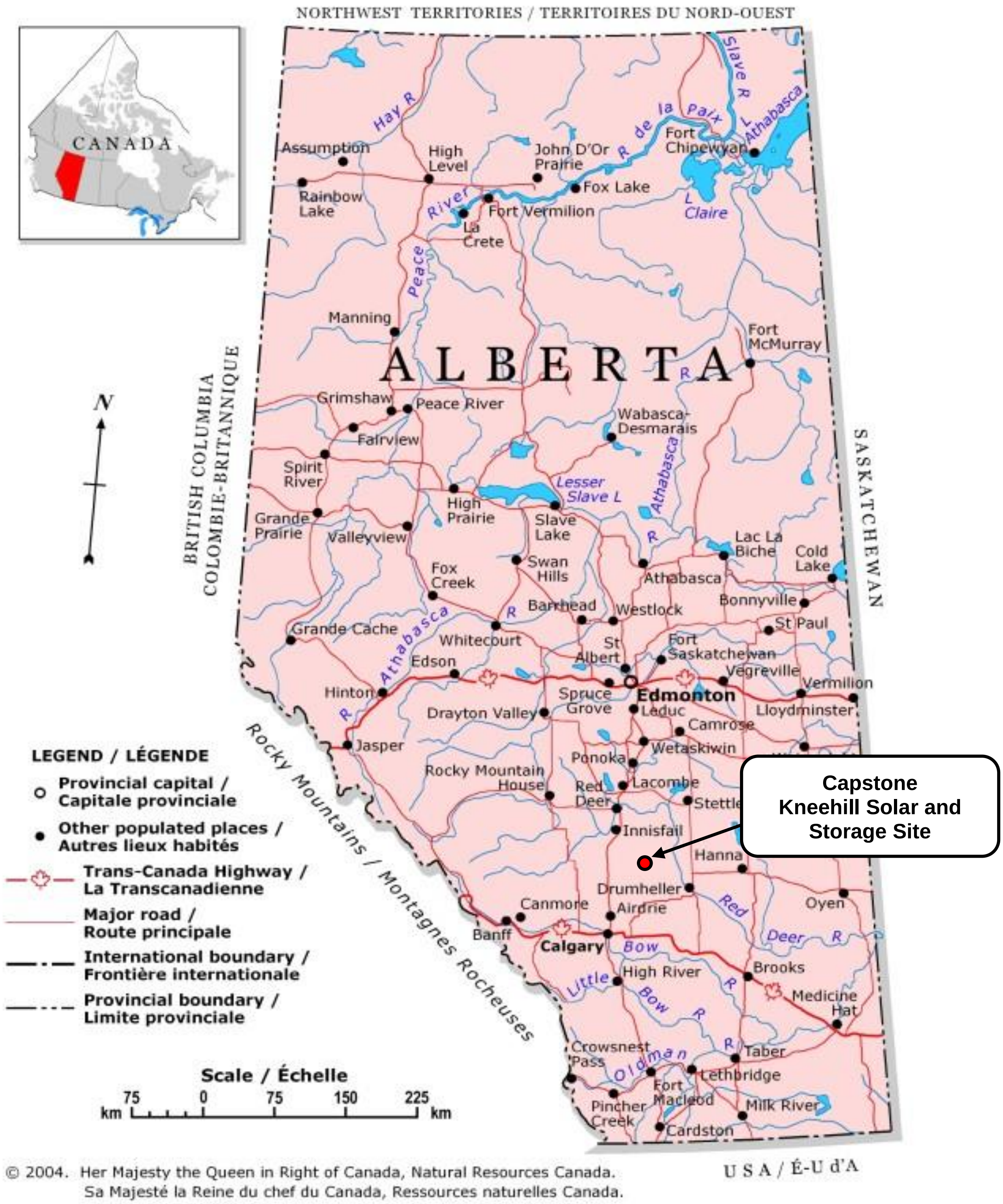

Figure 1 Proposed Facility location.

Figure 2 Aerial photograph indicating the Kneehill Solar and Storage Site fenceline and proposed BESS installation site.

Additionally, the project design will include numerous safety features to reduce the potential for fire and to suppress the spread of fire in the unlikely event that a fire was to occur in the electrical wiring, etc. Some of the safety features include the following:

- Fire-rated walls and doors in the BESS containers
- Liquid cooling system for battery cells in the BESS modules
- Gas and smoke detection in the BESS containers
- On-site control systems, including alarms, to continuously monitor and ensure operations remain within the design limits

1.3 Site Description

As previously indicated in Figure 2, the BESS installation site is located within the Facility fenceline, which is rectangular in shape with a maximum width of ~780 m on the north perimeter and a maximum length of ~770 m on the west perimeter. The BESS site is located in the southeast corner of the Facility. For modelling purposes, it was assumed that, as a worst-case scenario, a fire would occur in the container that is located closest to the nearest residence, which is located ~722 m east-southeast of the assumed fire location and emission source.

2.0 BACKGROUND INFORMATION

It is very important to note that there are several types of Lithium-Ion (Li-ion) batteries used worldwide. The materials in an LFP battery are less toxic than those in other types of Li-ion batteries, some of which contain cobalt and other hazardous substances. The sturdy iron phosphate crystal structure in the LFP batteries will not break down during charging or discharging, and therefore, will not cause leakage. Additionally, since LFP is a thermally and structurally stable chemical compound, LFP batteries will not spontaneously combust and moreover, in the unlikely event that the LFP batteries do ignite because of some external force, the fire will not spread easily from one module to another.

Unless constantly kept within specific environmental conditions and electrical parameters, some types of Li-ion cells can fail. This can lead to spontaneous combustion and a process know as thermal runaway. Thermal runaway is an exothermic reaction that causes the internal temperature of the battery to rise and may eventually ignite the electrolyte. As such, thermal runaway events can escalate into fires and a single failing cell can quickly overheat the surrounding cells, causing them to go into thermal runaway in turn. However, while LFP batteries will burn or smolder if exposed to extreme heat (i.e., temperatures ≥400ºC), these batteries are very difficult to ignite, do not easily continue to burn and the fire will not easily propagate, as can be the case with other types of Li-ion batteries, such as Lithium Nickel Manganese Cobalt (NMC) batteries that are used at other BESS projects and that have been widely reported in the media in relation to fires. As such, fire runaway events for the proposed BESS are highly unlikely.

Several authoritative studies detail the fire dynamics and resulting emissions from Li-ion battery cells. While extensive data are available for fires associated with NMC type batteries, which again are widely reported in the media in association with fires, until recently, less information and data have been available for LFP batteries since these are not generally a concern from a fire perspective. Recent information and test data specific to LFP batteries confirms that LFP batteries do not easily ignite and if ignited by an external source, the fire generally is neither well sustained nor will it easily propagate.

3.0 MODELLING ASSUMPTIONS

Under normal operating conditions, there will be no gaseous emissions from the BESS. However, in the unlikely event of a fire that causes ignition of the LFP batteries, gases could be emitted to the atmosphere. For the purpose of this Assessment, the analysis is limited to an assumed worst-case event, which is defined as the ignition of one module, noting that because of the safety features included in the BESS design, it is highly unlikely that an entire module or groups of modules would burn simultaneously.

Analysis of recent battery fire events reported in the media indicates that the percentage of cells involved at any one time in a fire ranged from 0.5 to 2%. The lower limit is associated with LFP cell fire dynamics, while the higher limit is associated with conventional NMC fire dynamics. For the purpose of this Assessment, it has conservatively been assumed that 10% of the LFP batteries in any one module would burn simultaneously until such time as all modules in a container have burned.

It should also be noted that for the case of the NMC cells, the fire dynamics indicate a cell combustion phase duration of approximately 1500 seconds and a peak temperature in excess of 800°C. For the LFP cells, the combustion phase duration is approximately 1200 seconds, with a peak temperature of approximately 400°C. From a fire dynamics perspective, there is evidence in the literature and from recent studies on LFP batteries that the lower LFP peak temperature affects the heat transfer process and combustion progress through the battery cells. Specifically, combustion does not propagate through an assembly of LFP batteries in the same manner fire will propagate through NMC batteries.

Figure 2 illustrates the overall fire progress through a BESS unit. As indicated in the figure, the emissions start at 0, rise to a maximum duration of the fire and then decrease to 0 again. However, for the purpose of modelling, it has been assumed that the maximum emission rate occurs as a continuous release, with worst-case parameters. The fire is assumed to be limited to one container, progressing through the cells (i.e., 10% of which would burn simultaneously, igniting more cells over time), until such time that all batteries in all modules within the container have burned. Again, this is a conservative assumption.

For fire modelling, the dispersion modelling source parameters include the emission rate of hazardous contaminants, source height, source diameter, source velocity, source temperature and other factors such as downwash effects from obstacles near the source. The Gaussian plume model used in the modelling (i.e., in this case, the U.S. EPA AERMOD model) assumes a point source and passive scalar dispersion in the horizontal direction only. Fire sources, such as the potential BESS battery fire, require source terms that convert the physical source parameters to suitable pseudo parameters for AERMOD.

These pseudo source parameters for the emission source are required because conventional regulatory air dispersion models, such as AERMOD, do not explicitly include sources such as fires. In fact, even the most common stack source requires pseudo source parameters, such as the final rise, to match the underlying assumptions of the Gaussian plume model.

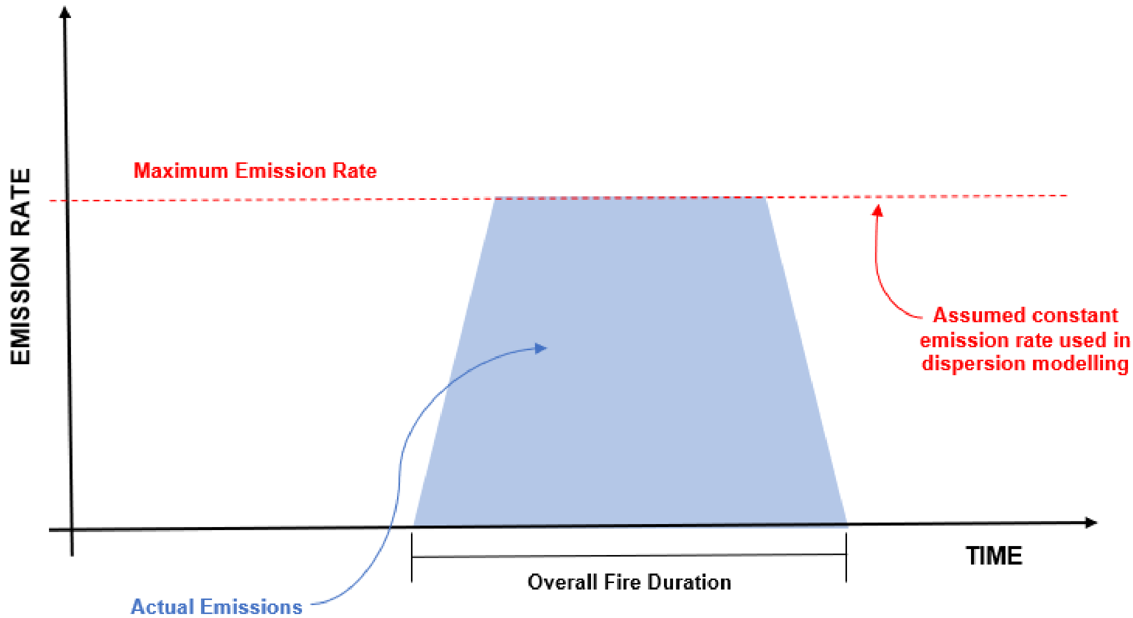

Figure 3 Illustration of actual emission rate versus emission rate used for modelling.

It is important to note the distinction between the initiation of a BESS fire and the fire dynamics of any potential continuing fire. The former is determined by a risk assessment framework. The latter is determined by a fire dynamics framework. There is also an important risk assessment component to evaluating the impact on receptors as modelled by a conventional regulatory air dispersion model (e.g., AERMOD).

The initiating event for a BESS battery fire has typically been assumed to be a thermal runaway event. Based on available literature and recent testing performed on LFP batteries, it can generally be assumed that the thermal runaway mechanism is not operative for the LFP battery chemistry. Thermal runaway in LFP battery systems can be induced artificially by external heating. However, the fire is not sustained after the heating is removed. High intensity events, such as an electrical arc, can also be an initiating event for a BESS battery fire. However, there is no plausible mechanism by which this high intensity arc can continue to influence the BESS battery. Furthermore, the fire dynamics modelling of the BESS battery is intended to predict the progress of the fire through the BESS battery system after fire has been initiated for LFP chemistry on a BESS. It is generally understood that the fire will not propagate in the LFP battery chemistry. This is principally because of the much lower temperatures of the LFP battery system at failure (i.e., 400°C).

3.1 Emission Parameters

Literature pertaining to BESS fires was reviewed to assess the types of contaminants that are likely emitted during this type of fire and to estimate emission rates for each contaminant of concern (see Section 10.0 for references). Very little information is available in the literature with respect to LFP batteries, which are the type of batteries proposed for this project. Although various contaminants can be emitted in the event of a BESS fire, Hydrogen Fluoride (HF) and Carbon Monoxide (CO) are the two main contaminants of concern from an environmental and health perspective. For example, although Hydrogen Chloride (HCl) might be emitted, these emissions would be in relatively the same concentration as HF, but since the Alberta Ambient Air Quality Objective (AAAQO) for HCl is 75 µg/m^3 and the AAAQO for HF is 4.9 µg/m^3 (i.e., 15 times lower than for HCl), HF is of more concern from a risk assessment perspective.

Similarly, CO is deemed to also be a contaminant of concern as a result of the potential for it to be emitted in high concentrations. Other compounds that might be emitted are either combustible and/or are of less concern from an environmental and human health perspective. As such, this risk assessment focuses on HF and CO, as previously stated.

The following emission quantification methodology was used for this project:

- An HF emission rate was derived from the readily-available literature regarding NMC batteries, taking into account the number and size of LFP batteries proposed for this Project.

- However, fire dynamic information compiled from recent studies on LFP batteries, along with the fire kinetics model were then used to adjust the HF production rate based on the known temperatures for LFP combustion as compared to NMC combustion.

The resulting HF emission rate is deemed to be conservative based on recent LFP battery test data and also accounts for possible small emissions of HF from collateral combustion sources, including wire insulation that may contain fluorocarbons. The HF emission rate and an emission rate for CO are indicated in Table 1, noting that both HF and CO are regulated by the AAAQOs. Table 1 also presents a summary of the following other source parameters that are required for modelling:

- **Height.** The height of the containers, as stated in the vendor design specifications, was used as the height of the release.

- **Diameter.** The diameter of the release was assumed to be equivalent to the approximate diameter of the ventilation vent on the roof of the containers.

- **Exit Temperature and Exit Velocity.** The values used in the modelling were selected to represent worst-case emission conditions.

Table 1 Source parameters used for modelling a potential fire at the BESS Facility.

Parameter		Value
Height	(m)	2.9
Pseudo Diameter	(m)	0.3
Exit Temperature	(K)	323
Exit Velocity	(m/s)	0.035
HF Emission Rate	(g/s)	0.00093
CO Emission Rate	(g/s)	0.88

4.0 MODELLING APPROACH

The Assessment was performed using the Alberta 2021 Air Quality Model Guideline (AQMG), U.S. EPA AERMOD v.23132 dispersion model, five years of meteorological data, terrain data and building downwash as required in Alberta for this type of assessment and as described in the following sections.

4.1 Meteorological Data

Meteorological data, including but not limited to wind data, were obtained from the Alberta Environment and Protected Areas (AEPA) Weather Research and Forecasting (WRF) Meteorological Data Repository as required by the 2021 Alberta AQMG. The data cover the period from 01-Jan-2015 to 31-Dec-2019, and are centred on the geographical point at 51.74°N and 113.283°W. As required in Alberta, five years of the data were processed in AERMET v.23132 to produce meteorological files suitable for use in AERMOD. These files include atmospheric stability and inversions, and take into account the effects of topography and ground cover.

Figure 4 provides a wind direction and wind speed frequency diagram (i.e., windrose) for the area based on the hourly-average WRF data. As indicated in the windrose, the hourly-average winds are predominantly from the northwest.

4.2 Terrain Data

Terrain data were obtained from the Government of Canada, Department of Natural Resources Geobase online portal, which provides public access to a base of quality geospatial data for all of Canada. The domain used for this Assessment incorporates topographic data from map tiles identified as 082P11, 082P12, 082P13and 082P14.

4.3 Modelling Receptors

As indicated in Figure 5, the following receptor grids were used in the modelling for the Air Quality Assessment, noting that additional receptors were also modelled for Occupational Health & Safety (OHS) Assessment as indicated later in this report:

- **Grid 1.** Every 20 m out to 1000 m from the center point of the BESS site.
- **Grid 2.** Every 50 m out to 3000 m from the center point of the BESS site.
- **Facility Fenceline.** Modelling was completed at receptors placed every 10 m along the Kneehill Solar and Storage Site fenceline.
- **Sensitive Receptors.** Modelling was completed at the closest residences.
- **Discrete Receptors.** The modelling was also completed at 100, 250, 400, 700 and 1000 m downwind distances from the assumed fire location for the purpose of comparison with the health and safety standards.

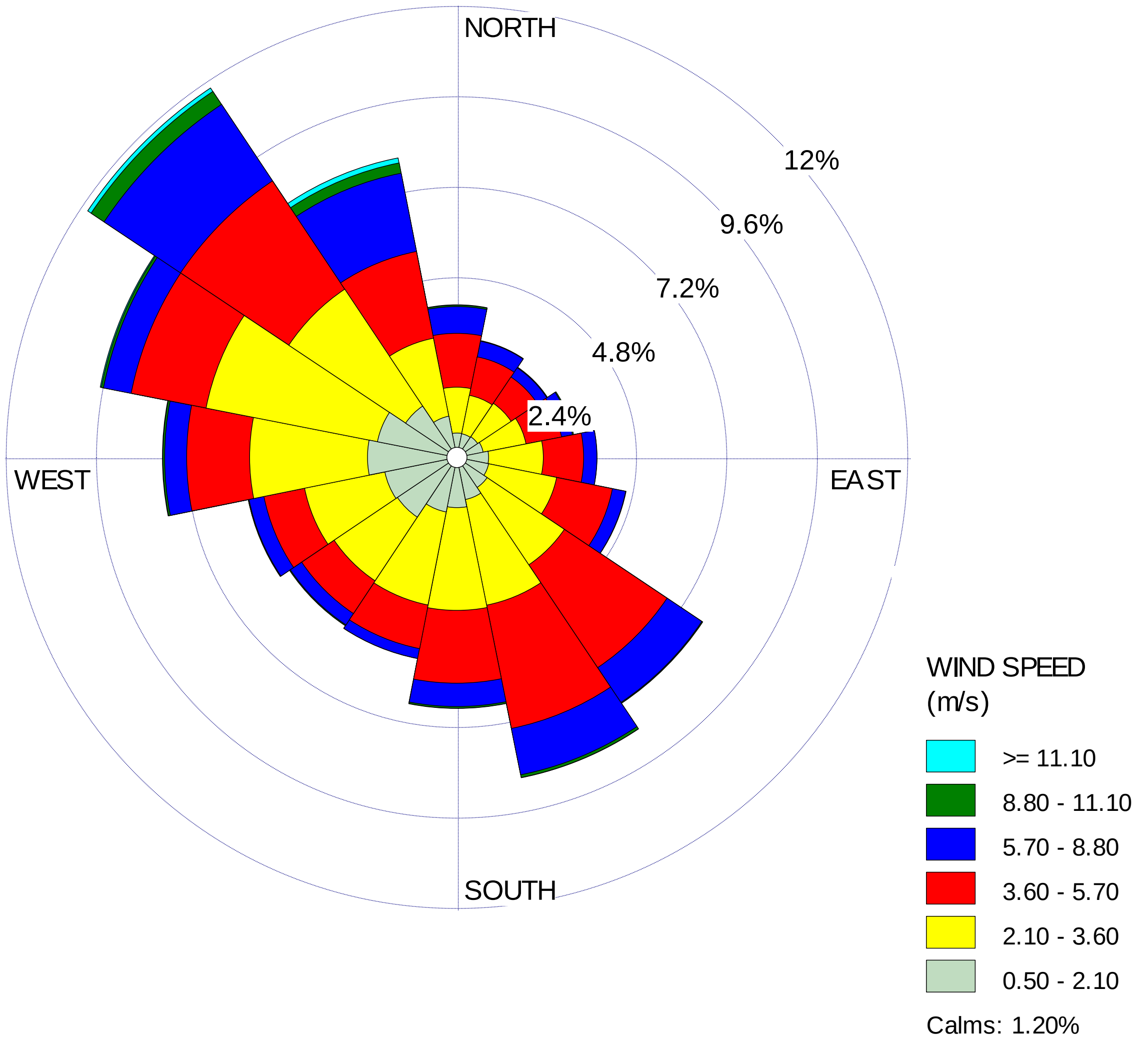

Figure 4 Windrose indicating the frequency of wind direction and wind speeds in the area.

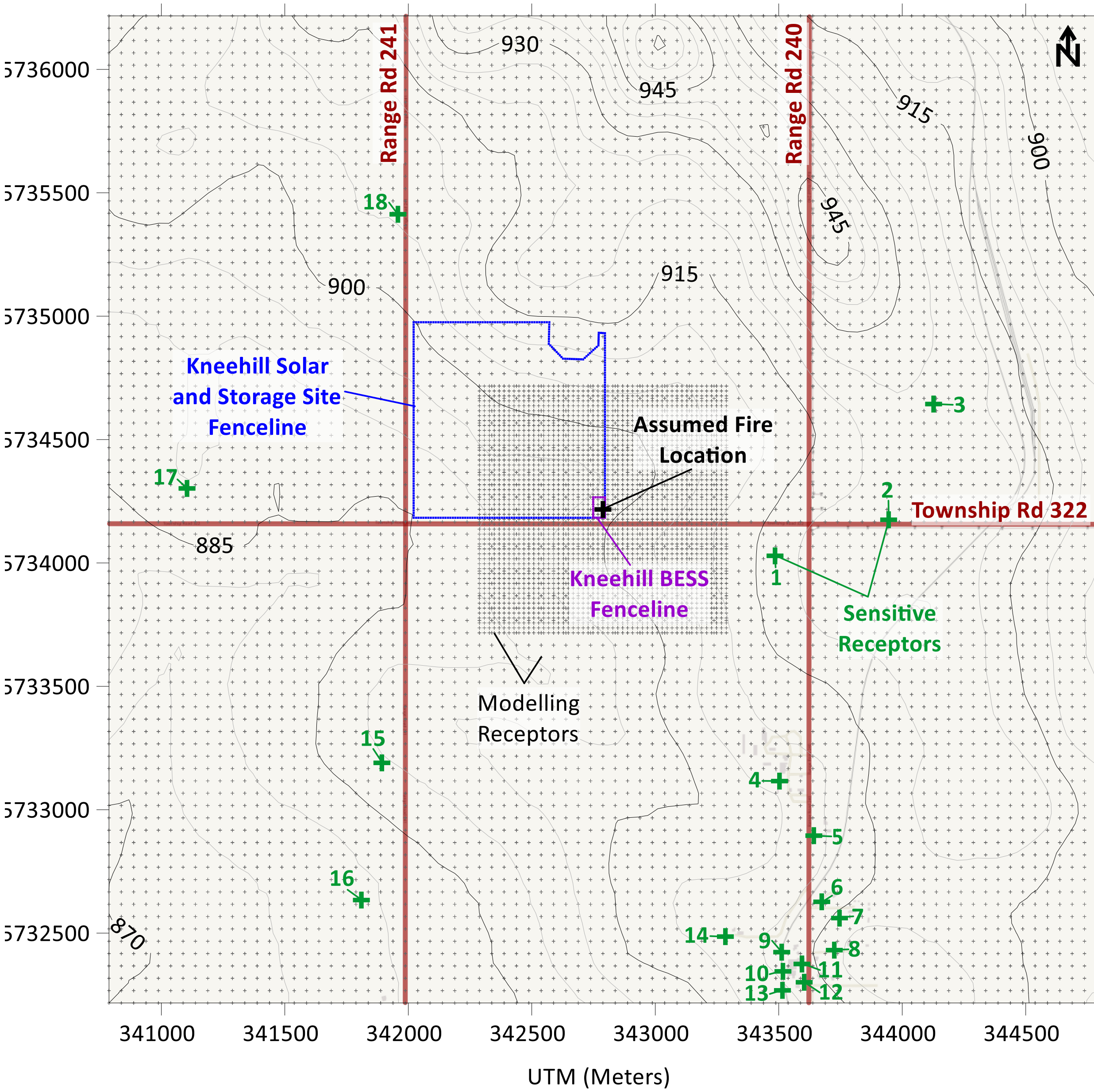

Figure 5 Location of dispersion modelling receptors, ground-level elevations (m) and nearest sensitive receptors to the assumed fire location at the proposed BESS site.

4.4 Building Downwash

The containers were treated as buildings for this assessment in order to account for building downwash effects. The U.S. EPA Building Profile Input Program (BPIP) was used to determine the effects of building downwash on dispersion of emissions from the modelled fire.

5.0 AMBIENT AIR QUALITY MODELLING RESULTS

The emissions from a potential fire were modelled and the associated predicted concentrations were compared to the hourly-average AAAQOs. The AAAQOs are designed to protect the most sensitive of species, noting that for some chemical substances, humans are less sensitive than other species.

5.1 HF Modelling Results

The AAAQO for HF is 4.9 µg/m^3. As indicated in Figure 6, in close proximity to the site (i.e., within 100 m of the assumed fire location and/or within ~95 m of the Facility fenceline), the maximum hourly-average ground-level HF concentrations are predicted to exceed the AAAQO. However, beyond this distance, all predicted HF concentrations are in compliance with the AAAQO.

As indicated in Figure 7, the overall maximum off-site hourly-average ground-level HF concentration is 26.0 µg/m^3 and is predicted to occur on the Facility fenceline, adjacent to the assumed fire location. This is further illustrated in Figure 8, which also indicates that in the vicinity of the closest residences, the maximum predicted HF concentrations are well within the AAAQO of 4.9 µg/m^3. Specifically, at the closest residence east of the BESS site, as indicated in Table 2, the maximum predicted concentration is 0.1996 µg/m^3.

5.2 CO Modelling Results

The AAAQO for CO is 15000 µg/m^3. As indicated in Figure 9, at distances beyond 100 m from the assumed fire location, all maximum hourly average ground-level CO concentrations are predicted to comply with the AAAQO. In fact, at distances beyond ~25 m from the Facility fenceline, all predicted CO concentrations are in compliance with the AAAQO.

As shown in Figure 10, the overall maximum predicted off-site hourly-average ground-level CO concentration is 24599.5 µg/m^3 and is predicted to occur on the Facility fenceline adjacent to the site assumed fire location. This is further illustrated in Figure 11, which also indicates that in the vicinity of the closest residences, the maximum predicted CO concentrations are well within the AAAQO of 15000 µg/m^3. Specifically, at the closest residence, east of the BESS site, as previously indicated in Table 2, the maximum concentration is 188.9 µg/m^3.

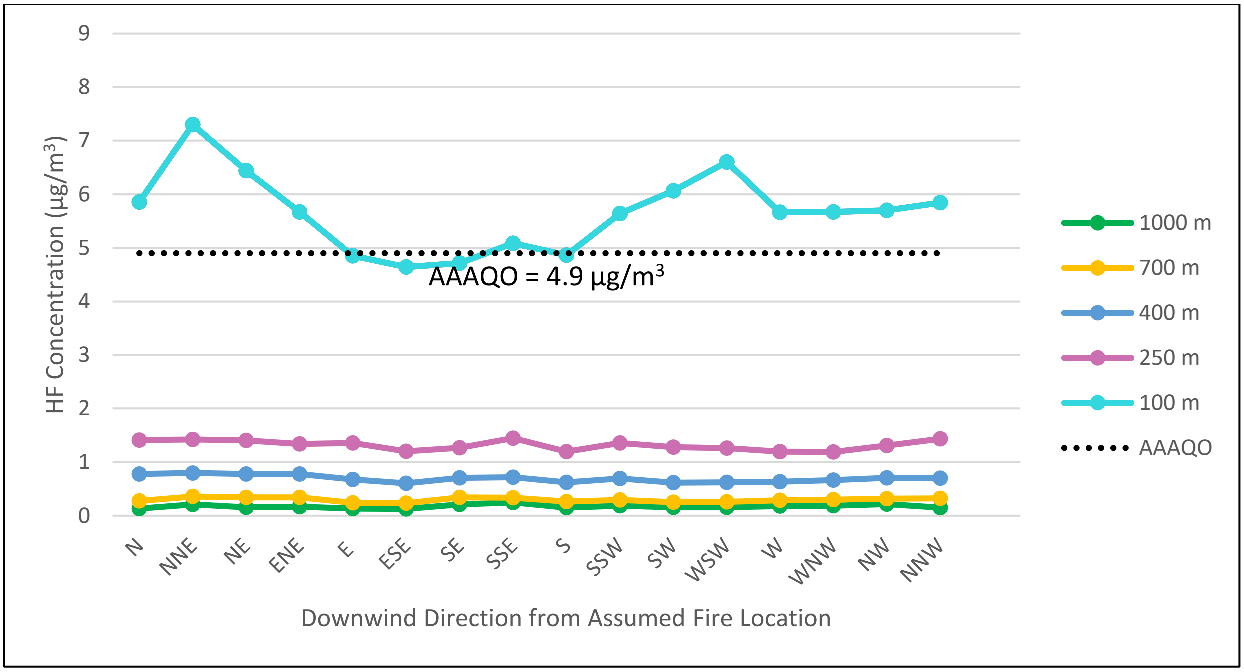

Figure 6 Predicted one-hour average HF concentrations (µg/m^3) associated with the BESS site at 100, 250, 400, 700 and 1000 m downwind of the assumed fire location.

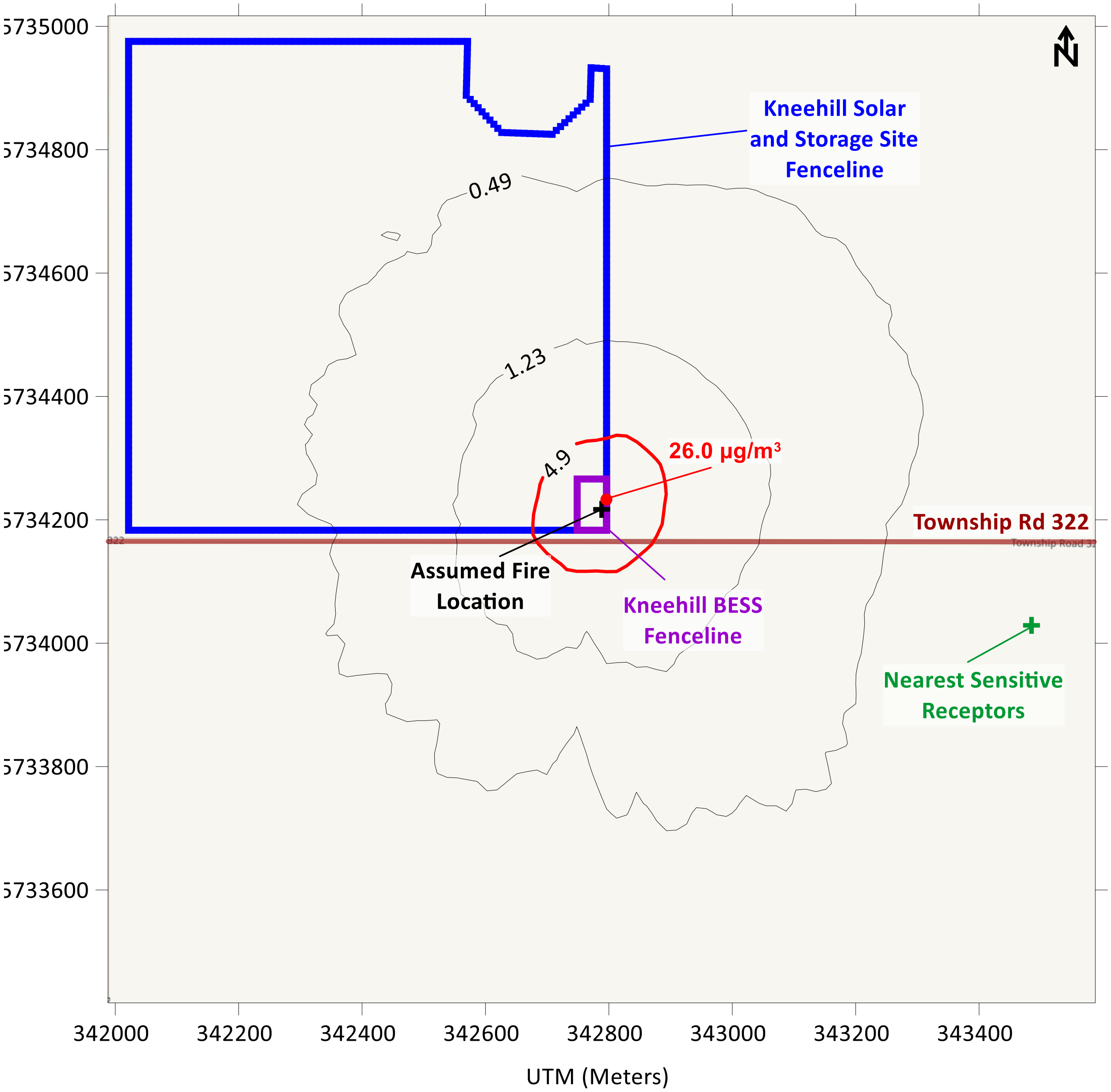

Figure 7 Maximum predicted hourly-average ground-level HF concentrations associated with a potential fire. Isopleths shown include 0.49, 1.23 and 4.9 µg/m^3.

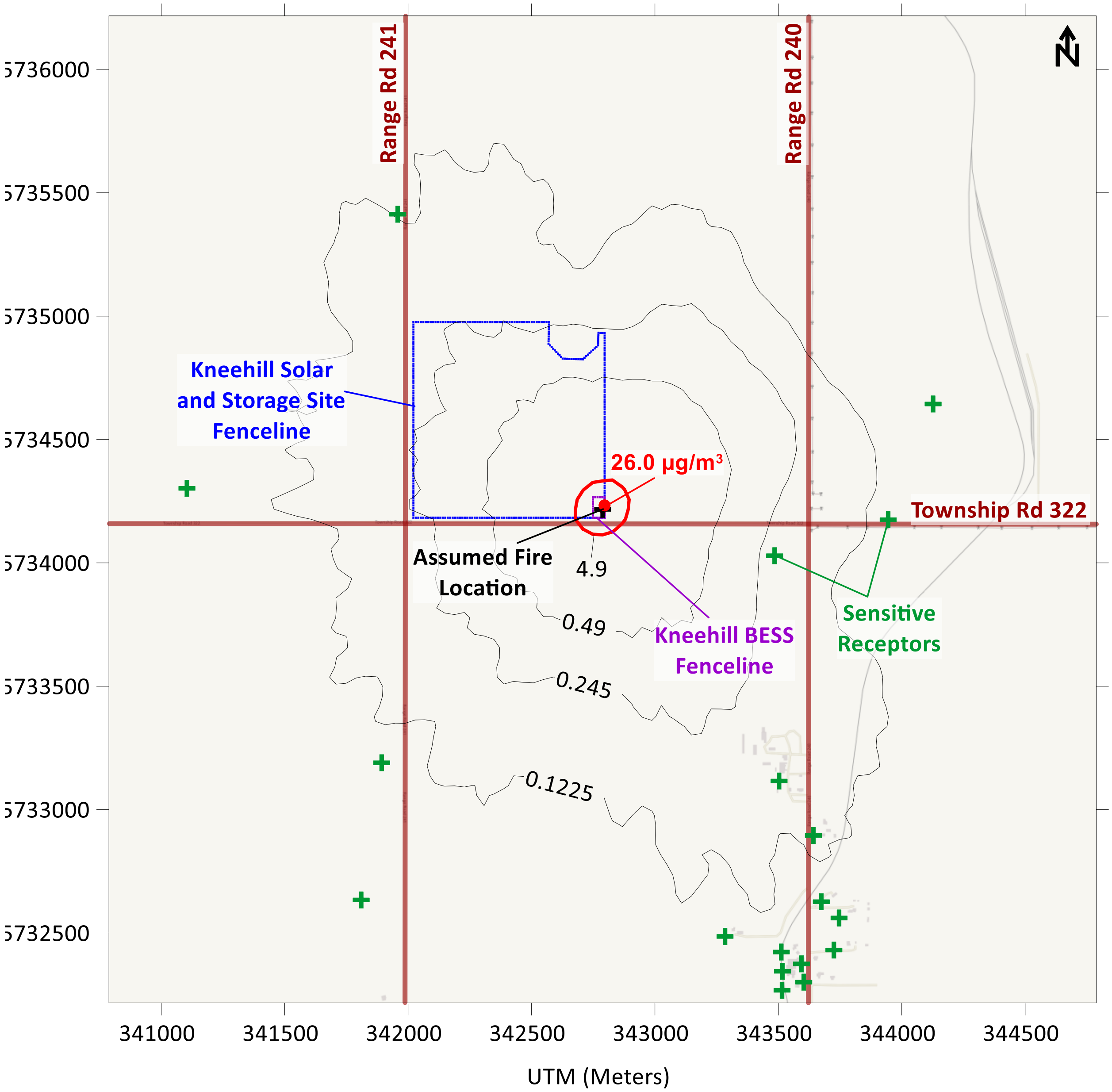

Figure 8 Maximum predicted hourly-average ground-level HF concentrations associated with a potential fire. Isopleths shown include 0.1225, 0.245, 0.49 and 4.9 µg/m^3.

Table 2 Predicted maximum hourly-average ground-level concentrations at sensitive receptors within 5 km of the assumed fire locations.

Sensitive Receptor	Location (UTM)		Location Relative to Assumed Fire		Maximum Predicted Concentration (µg/m^3)		AAAQO (µg/m^3)	
	Easting (m)	Northing (m)	Distance (m)	Direction	HF	CO	HF	CO
1	343485	5734029	722	ESE	0.1996	188.9	4.9	15000
2	343945	5734175	1157	E	0.1102	104.2		
3	344127	5734644	1405	ENE	0.0896	84.7		
4	343503	5733116	1313	SSE	0.1697	160.6		
5	343642	5732895	1574	SSE	0.1356	128.3		
6	343674	5732627	1820	SSE	0.0853	80.7		
7	343746	5732561	1913	SSE	0.0745	70.5		
8	343725	5732431	2017	SSE	0.0734	69.5		
9	343512	5732423	1934	SSE	0.1120	106.0		
10	343517	5732345	2009	SSE	0.0974	92.2		
11	343594	5732375	2010	SSE	0.0985	93.2		
12	343603	5732301	2082	SSE	0.0927	87.7		
13	343515	5732268	2080	SSE	0.0943	89.2		
14	343284	5732486	1801	SSE	0.0888	84.0		
15	341893	5733190	1362	SW	0.0924	87.4		
16	341810	5732634	1861	SSW	0.0703	66.5		
17	341104	5734302	1686	W	0.0924	87.4		
18	341958	5735413	1456	NW	0.1153	109.1		

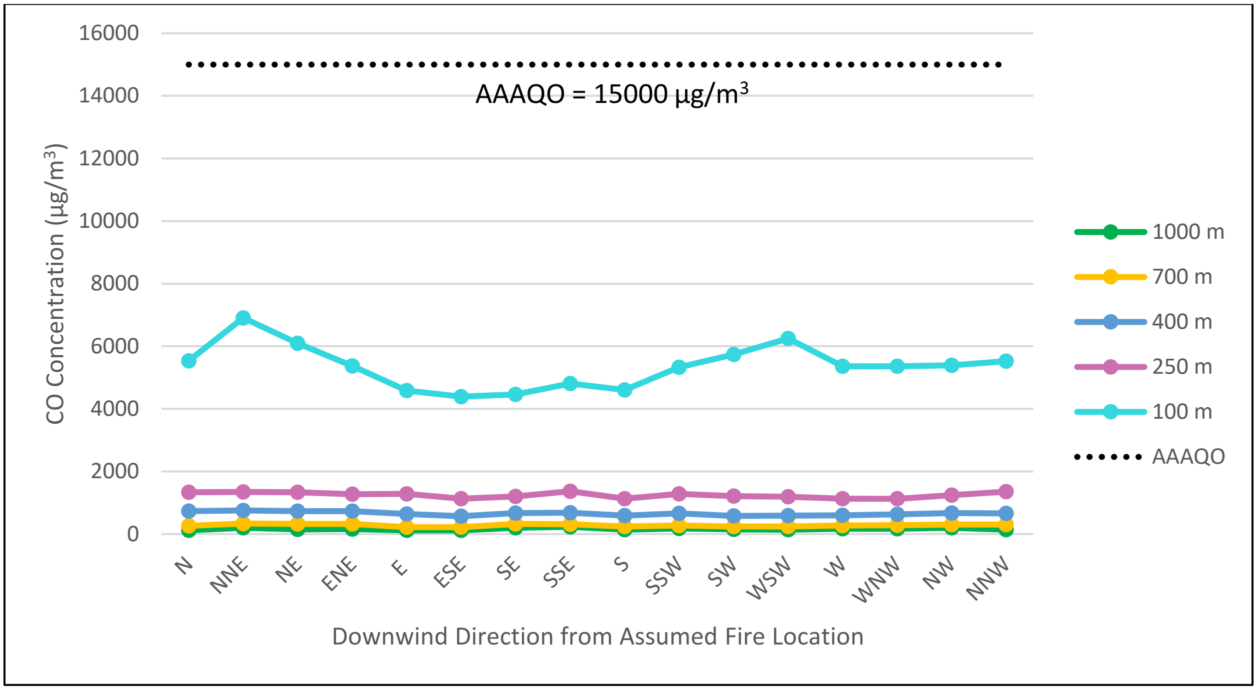

Figure 9 Predicted one-hour average CO concentrations (µg/m³) associated with the BESS site at 100, 250, 400, 700 and 1000 m downwind of the assumed fire location.

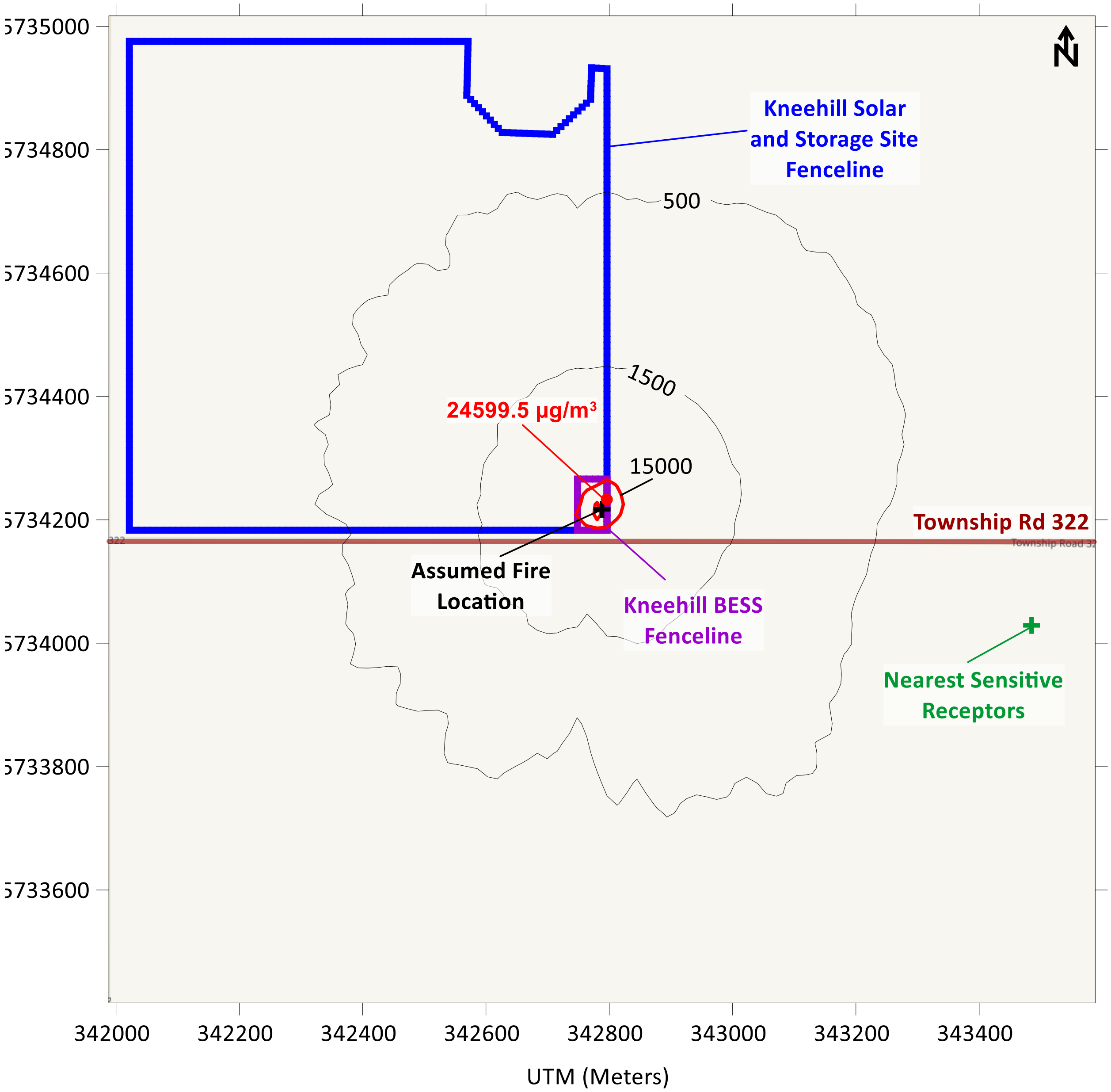

Figure 10 Maximum predicted hourly-average ground-level CO concentrations associated with a potential fire. Isopleths shown include 500, 1500 and 15000 µg/m^3.

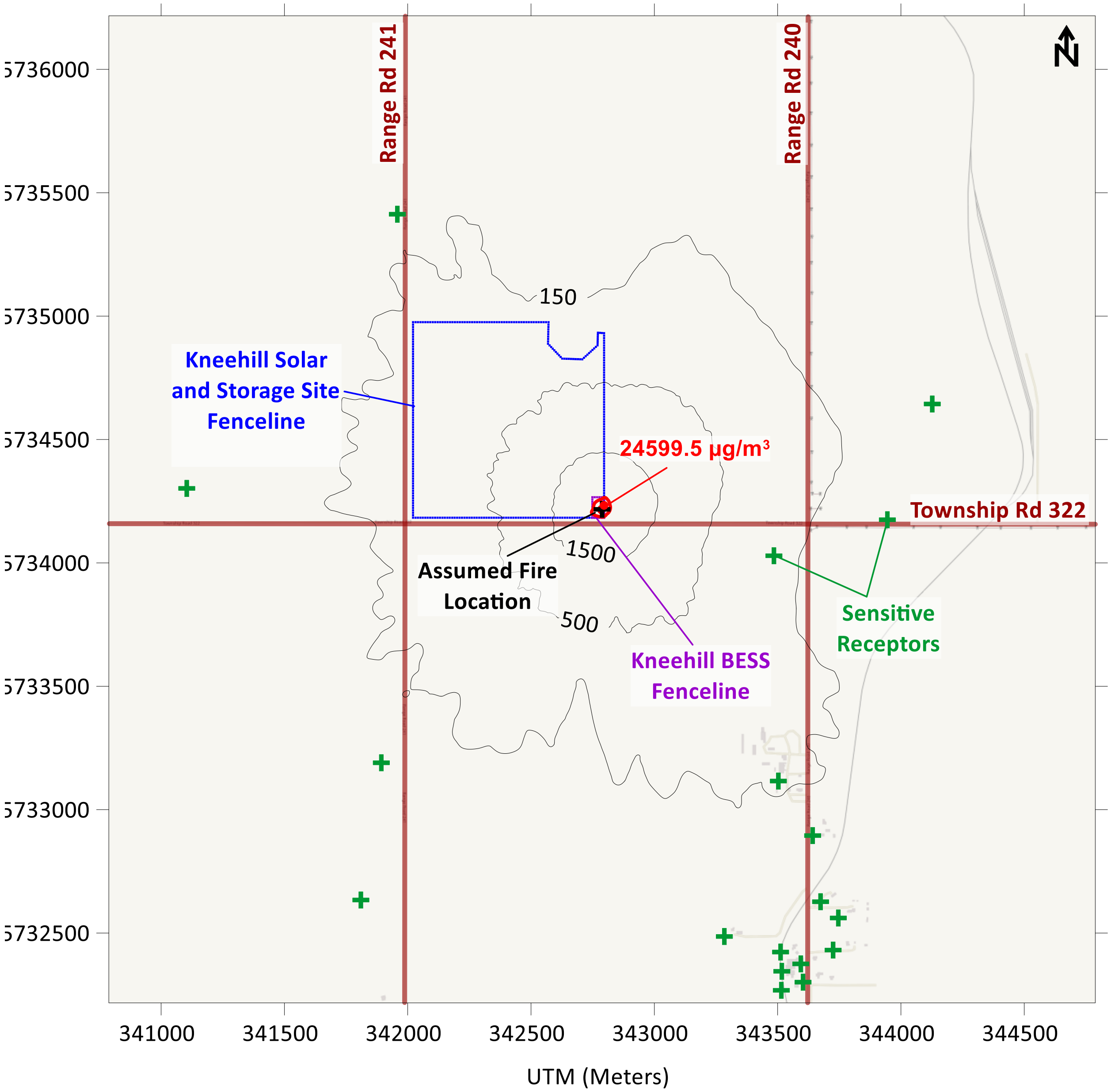

Figure 11 Maximum predicted hourly-average ground-level CO concentrations associated with a potential fire. Isopleths shown include 150, 500 and 1500 µg/m³.

6.0 OHS MODELLING RESULTS

While the 9th highest ground-level concentration is the value required to be reported in Alberta for Air Quality Assessment purposes, the overall maximum predicted hourly-average concentrations were modelled for the OHS aspects of the Project. This modelling was conducted using a 1 m by 1 m receptor grid within the Facility fenceline and out to 1 km beyond the Facility fenceline (i.e., within the area where site personnel and/or emergency response personnel may be present in the event of a fire). The results were compared to the CDC NIOSH IDLH values for HF and CO, noting that these IDLH limits are widely accepted worldwide as workplace standards. Until 1994, the IDLH limits were associated with a 30-minute averaging time. However, the current IDLH limits do not have an associated averaging time, but rather the NIOSH document states that these limits should not be exceeded in areas where workers are not wearing respiratory protection. As such, for the purpose of this Assessment, a conservative exposure duration of one minute was assumed.

Given that the minimum averaging period that can be run in AERMOD is one hour, the one-hour averages from the modelling were converted to one-minute average concentrations using the methodology indicated in the 2021 Alberta AQMG. The resulting one-minute average concentrations were compared to the IDLH as indicated in Table 3 and as indicated in the table, all maximum predicted one-minute average concentrations are well within the IDLH limits at all on-site and off-site locations.

Table 3 Maximum predicted one-minute average concentrations as compared to the applicable IDLH.

Contaminant	One-Minute Average Maximum Predicted Concentration (ppm)		IDLH (ppm)
	On-Site[(a)]	Off-Site	
HF	0.2	0.1188	**30**
CO	167.4	80.3	**1200**

(a) Modelled with 1 m spacing on site.

Table 4 presents the maximum one-minute average predicted concentrations at distances beyond the BESS Facility fenceline. As indicated in the table, all predicted off-site contaminant concentrations are well within the corresponding IDLH limits.

Table 4 Maximum predicted one-minute average concentrations at varying downwind distances from the assumed fire location.

Contaminant	One-Minute Average Maximum Predicted Concentration (ppm)					IDLH (ppm)
	100 m	250 m	400 m	700 m	1000 m	
HF	0.0323	0.0066	0.0037	0.0017	0.0011	**30**
CO	21.8	4.4	2.5	1.1	0.7	**1200**

7.0 PUBLIC HEALTH & SAFETY MODELLING RESULTS

To address potential public health & safety concerns, the overall maximum predicted modelling results were also compared to the U.S. EPA National Advisory Committee for AEGLs for Hazardous Substances, as referenced by Health Protection Branch of Alberta Health in the January 2017 document entitled *Protective Action Criteria: A Review of Their Derivation, Use, Advantages and Limitations*. The AEGLs have three tiers of limits, which are as follows:

- **AEGL-1.** The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation or certain asymptomatic non-sensory effects. However, these effects are not disabling, and are transient and reversible upon cessation of exposure.

- **AEGL-2.** The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

- **AEGL-3.** The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

The three AEGL tiers each are associated with averaging times ranging from 10 minutes to 8 hours.

7.1 HF Modelling Results

As indicated in Table 5, all maximum predicted HF concentrations at and beyond the site fenceline (i.e., in areas that the public could access) are predicted to comply with the applicable public health & safety AEGLs. As such, no public health & safety issue is predicted to occur in the area as a result of HF emissions in the unlikely event of a BESS fire.

7.2 CO Modelling Results

As indicated in Table 6, all maximum predicted CO concentrations at or beyond the fenceline (i.e., in areas that the public could access) are also predicted to comply with the applicable AEGLs for averaging periods.

Table 5 Maximum predicted HF concentrations as compared to the applicable AEGLs.

AEGL Level	Averaging Time									
	10-Minute		30-Minute		One-Hour		4-Hour		8-Hour	
	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)
AEGL-1	0.0624	**1**	0.0459	**1**	0.0378	**1**	0.0269	**1**	0.0215	**1**
AEGL-2		**95**		**34**		**24**		**12**		**12**
AEGL-3		**170**		**62**		**44**		**22**		**22**

Table 6 Maximum predicted CO concentrations as compared to the applicable AEGLs.

AEGL Level	Averaging Time									
	10-Minute		30-Minute		One-Hour		4-Hour		8-Hour	
	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)	Max Conc (ppm)	AEGL (ppm)
AEGL-1[(a)]	42.1	**-[(a)]**	31.0	**-[(a)]**	25.5	**-[(a)]**	18.2	**-[(a)]**	14.5	**-[(a)]**
AEGL-2		**420**		**150**		**83**		**33**		**27**
AEGL-3		**1700**		**600**		**330**		**150**		**130**

[(a)] There is no AEGL-1 for CO.

8.0 RISK ASSESSMENT

Fire risks, including emissions, from various types of Li-ion batteries, including LFP, have been studied extensively. LFP batteries are generally accepted as having lower probability of fire and decreased emissions if a fire does occur as compared to other commonly used battery types. To ensure conservative estimates of emissions from an LFP battery fire, this Assessment considered worst-case conditions.

Risk is estimated according to the following:

Risk = Probability of Occurrence x Consequences

Regulatory dispersion models, such as AERMOD, assume a continuous plume (i.e., the plume is operating continuously). No fire in a battery system continues indefinitely. The fire is a transient event, typically of short duration. Therefore, this is a conservative assumption that implies the fire is always burning regardless of the prevailing meteorological conditions, in particular, the wind direction.

From a risk assessment perspective, it is obvious that a receptor can only be affected by the emissions from the hypothetical fire if the wind direction aligns with that receptor (i.e., the fire is upwind). It is also important to note that from a risk assessment perspective, this is equivalent to assuming a common cause limit for the risk.

If it is assumed that the fire will be burning at the source limit, regardless of the wind direction, this is a conservative assumption. In fact, when this is analyzed objectively in a risk assessment framework, because of the low probability of occurrence of a fire, combined with the probability that the wind will be in the direction of a particular receptor, this in fact results in a double jeopardy situation. In short, this results in the joint probability of two statistically independent processes of low probability. Hence, this results in a very low probability for the receptor to be exposed to any potential emissions.

Given the safety features of the BESS being considered for this Project and the low probability of a BESS fire from LFP batteries, coupled with the off-site maximum predicted concentrations, the risk to the public and area residents in association with this BESS Facility is deemed to be insignificant or at the de minimis level.

9.0 CONCLUSIONS

The following conclusions pertain to this Assessment:

Air Quality. In the unlikely event of a BESS fire, maximum predicted HF concentrations at or beyond ~95 m from the Facility fenceline are in compliance with the AAAQO. Similarly, maximum predicted CO concentrations at or beyond ~25 m beyond the Facility fenceline are also in compliance.

- **OHS.** From an OHS perspective, all maximum concentrations onsite and beyond the BESS Facility fenceline are predicted to comply with applicable IDLH limits.

- **Public Health & Safety.** The maximum predicted offsite HF and CO concentrations are within the applicable three tiers of AEGLs for all averaging periods.

- **Risk Assessment.** In summary, with respect to a potential BESS fire, it is concluded that beyond the fenceline, the risk of exposure to the public is insignificant or at the de minimis level.

10.0 REFERENCES

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