YUKON ENERGY

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September 24, 2008

Keith Maguire, Project Assessment Officer
Whitehorse Assessment District/Whitehorse Designated Office
Yukon Environmental & Socio-economic Assessment Board
7209B-7th Avenue
Whitehorse, YT Y1A 1R8

(Via YESAB Online Registry)

Dear Mr. Maguire,

RE: PROJECT PROPOSAL FOR RENEWAL OF AIR EMISSIONS PERMIT NO. 4201-60-010

Yukon Energy is pleased to submit for your consideration the project proposal for the renewal of the Corporation's existing Air Emissions Permit.

This submission has been provided electronically via the YESAB Online Registry, only. The application includes the associated Form 1, which has been completed and filed to the YESAB online registry as well. The supporting document attached to this letter, and referenced in Form 1, forms part of the proposal and is for use in the assessment and permitting processes.

Please do not hesitate to contact me at 867.393.5350 or by email: travis.ritchie@yec.yk.ca should there be any questions, comments, or concerns regarding the proposal.

Thank you for your time and consideration in this matter.

Yours Sincerely,

Travis Ritchie, P.Biol., CCEP
Manager, Environment

Attachment

AIR EMISSIONS PERMIT (NO. 4201-60-010) RENEWAL APPLICATION SUPPORTING DOCUMENT

September 24, 2008

YUKON ENERGY

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LIST OF ACRONYMS AND ABBREVIATIONS

CAC Common Air Contaminants of Concern

GHG Green House Gasses

GWh Gigawatt hour

Max POI Maximum Point of Impingement

MD Mayo-Dawson Power Generation and Transmission System

MW Megawatt

WAF Whitehorse-Aishihik-Faro Power Generation and Transmission System

YESAA *Yukon Environmental & Socio-economic Assessment Act*

YESAB Yukon Environmental & Socio-economic Assessment Board

YUB Yukon Utilities Board

1.0 INTRODUCTION

1.1 PROJECT OVERVIEW & DOCUMENT STRUCTURE

The Yukon Energy Corporation (Yukon Energy) is applying under Parts 6 and 9 of the *Environment Act* and Part V of the *Air Emissions Regulations* for a three-year renewal of Air Emissions Permit No. 4201-60-010 authorizing Yukon Energy to operate its existing diesel-fired electricity generating facilities in Dawson City, Faro, Mayo, and Whitehorse.

Yukon Energy seeks a renewal of the Permit on the same terms and conditions presently included therein, for a three-year term commencing on or before the expiration of the term of the existing Permit (which expires on December 31, 2008), and expiring on December 31, 2011.

The renewal is subject to an environmental and socio-economic effects assessment at the Designated Office level by the Yukon Environmental and Socio-economic Assessment Board (YESAB) under the *Yukon Environmental and Socio-economic Assessment Act* (*YESAA*).

Pursuant to that assessment, Yukon Energy requests a recommendation from the Designated Office to allow the Permit renewal to proceed, on the basis that the Project (i.e., the continuing operation of the Yukon Energy's diesel generating facilities during the 2009-2011 period in accordance with the terms and conditions of the Permit and the applicable provisions of the *Environment Act* and *Air Emissions Regulations*) will not have a significant adverse environmental or socio-economic effect within the meaning of section 56(1)(a) of *YESAA*.

This document provides supporting information for the Permit renewal process and the associated environmental and socio-economic assessment, and includes detailed information referenced in the *YESAA* Designated Office Evaluation Form 1, which has also been completed and is filed on the YESAB Online Registry.

The application for a renewed Air Emission Permit from the Yukon Government has also been completed, and is contained in Appendix A.

Section 1 of this document contains general application information including:

- The intent and structure of this document and related information;
- The proponent, Yukon Energy;
- The purpose of, and need for, the Project; and,
- An identification of the required assessment and regulatory approvals.

Section 2 of this document contains information regarding the assessment approach and scope, including:

- A brief description of the air quality studies conducted;
- The identification of valued components for focussed effects assessment; and,
- The context and criteria for determining the significance of any identified potential effects to the valued components.

Section 3 of this document contains information describing the character and location of our diesel generators, including:

- Operational requirements and ranges;
- A generation inventory;
- Site specific facility descriptions;
- A description of the typical emission character of the generators;
- Operational resource usage and waste generation; and,
- Brief comments on the applicable regulatory context under the *Public Utilities Act* and applicable legal and regulatory constraints on the operation of the facilities under the existing Permit and applicable environmental legislation.

Section 4 of this document contains information regarding the environmental setting in each community of operation, including:

- Community emissions inventories; and,
- Ambient air quality assessment for Whitehorse.

Section 5 of this document presents the effects assessment and includes:

- A description of the modelled diesel generation profiles;
- An identification of sensitive receptor sites in the vicinity of Yukon Energy's diesel operations;
- A discussion regarding the indicators and measures used to determine the significance of potential effects to receptors;
- A summary of the potential effects of diesel generation air emissions; and,
- Assessment conclusions respecting the significance of the potential effects.

In addition to the appendix referenced above, three additional appendices are included as follows:

- Appendix B contains a report describing the results and findings of an air quality assessment of Yukon Energy's diesel generation operations conducted by SENES Consultants Ltd.;
- Appendix C contains drawings for each of Yukon Energy's diesel plants in Yukon; and,
- Appendix D contains a copy of Yukon Energy's existing Air Emissions Permit for its diesel generation facilities.

1.2 PROPONENT INFORMATION

Yukon Energy is the Project proponent. Established in 1987, Yukon Energy is a public electric utility that operates as a business, at arm's length from the Yukon Government, and is wholly owned by the Yukon Development Corporation (a Crown corporation).

Yukon Energy's headquarters are located near the Whitehorse Rapids hydro plant in Whitehorse, with community offices in Mayo, Faro, and Dawson City. It employs approximately 80 highly skilled and motivated Yukoners who are committed to offering the highest quality service possible. Yukon Energy works hard to meet the challenge of providing electricity and related energy services to Yukoners in the most economical, yet environmentally and socially responsible way.

Yukon Energy is the main generator and transmitter of electrical energy in the Yukon, and works with its parent company, Yukon Development Corporation, to provide Yukoners with a sufficient supply of safe, reliable electricity and related energy services. Yukon Energy owns and operates the 138 kV WAF and 69 kV MD transmission grids as well as over 90% of the electric generation resources on these grids; it is also the public utility with primary responsibility for planning and development of new generation and transmission facilities in Yukon.

There are almost 15,000 electricity consumers in the territory. Yukon Energy directly serves about 1,800 of these customers, most of who live in and around Dawson City, Mayo and Faro. Indirectly, we provide power to approximately 15,000 other Yukon customers in Whitehorse, Carcross, Carmacks, Haines Junction, Ross River, Teslin, and soon Pelly Crossing, through the sale of energy to the Yukon Electrical Company Limited. Yukon Electrical buys wholesale power from Yukon Energy and sells it to retail customers in the territory via its own distribution network.

Yukon Energy has the capacity to generate approximately 116 megawatts (MW) of power:

- 75 MW of that capacity are provided by Yukon Energy's hydro generation facilities in Whitehorse, Mayo and Aishihik Lake (40 MW at Whitehorse, 30 MW at Aishihik, and 5 MW at Mayo);
- 39 MW of capacity are provided by Yukon Energy's diesel-fired generators, including seven generators in Whitehorse, two in Mayo, five in Dawson City, and four in Faro; and

- 0.8 MW of capacity are provided by two wind turbines located on Haeckel Hill near Whitehorse.

Yukon Energy currently uses its diesel-fired generators only as back-up, because most of the needs of customers on the WAF and MD transmission grids are satisfied by Yukon Energy's three hydro generating stations. For the vast majority of the time, the diesel generators do not operate; this is not forecast to change during the 2009-2011 period. However, Yukon Energy's diesel generation facilities are essential to its ability to provide a reliable supply of electricity to customers whenever demand outstrips hydro supply (e.g. as a result of planned maintenance, emergency repair, or peaking demand during cold temperatures).[1]

Yukon Energy is regulated principally under the Yukon *Business Corporations Act*, *Public Utilities Act*, and *Waters Act*, and the federal *Fisheries Act.* In particular, under the *Public Utilities Act*, Yukon Energy has an obligation to supply electricity service to its customers, and its rates and operations are subject to regulation by the Yukon Utilities Board. Yukon Energy's diesel generation facilities are also subject to regulation under the Yukon *Environment Act* and *Air Emissions Regulations*, as well as *YESAA*.

1.3 PROJECT/ACTIVITY PURPOSE AND NEED

Yukon Energy's diesel electric generating plants are installed and operated so as to ensure the overall WAF and MD systems, and so all customers on these systems can receive reliable power consistent with Yukon Energy's corporate and regulatory obligations.

Given the current generation mix (hydro, wind, and diesel) and system design, Yukon Energy's ability to operate the installed diesel plants, particularly during conditions where demand for electricity cannot be adequately met by hydro (e.g., planned maintenance,

[1] For example, Yukon Energy's reliance on the diesel generation facilities was essential when a major power outage occurred on the WAF grid in January 2006 due to a failure on the connection to the Aishihik hydro generating facility. If Yukon Energy had not had the ability to operate its diesel units in those circumstances, customers would have been left without power in the middle of the winter.

emergency repair, peaking demand during cold winter temperatures), is essential to avoid scenarios where there would be a requirement to impose blackout conditions to various customers. This is particularly relevant during times where the lack of such ability would at best be very inconvenient, and at worst dangerous to infrastructure and human health and safety, such as would be the case during cold winter temperatures.

1.4 REQUIRED AUTHORIZATIONS AND REGULATORY APPROVALS

Yukon Energy requires renewal of its existing Air Emissions Permit no. 4201-60-010 on or before December 31, 2008, in order to maintain the ability to operate its diesel generating facilities, and ensure the continuity of a reliable supply of power to Yukoners. The Permit is renewable by the Minister responsible for the Department of the Environment, for a period of up to three years, pursuant to section 12 of the *Air Emissions Regulations* under the *Environment Act*.

To renew the Permit, the Yukon Government must issue a decision document based on the environmental and socio-economic assessment of the renewal application under *YESAA*. An environmental and socio-economic assessment is required under Schedule 1, Part 4, Item 2(b) of the *Assessable Activities, Exceptions and Executive Committee Projects Regulations* under *YESAA,* because the Permit is for the “operation … of … a fossil fuel-fired electrical generating station”.

As noted in the Project Overview above, Yukon Energy is requesting a recommendation by the Designated Office to allow the Permit renewal to proceed, on the basis that the Project (i.e., the continuing operation of the Yukon Energy’s diesel generating facilities during the 2009-2011 period in accordance with the terms and conditions of the Permit and the applicable provisions of the *Environment Act* and *Air Emissions Regulations*) will not have a significant adverse environmental or socio-economic effect within the meaning of section 56(1)(a) of *YESAA*.

2.0 ASSESSMENT APPROACH & SCOPE

2.1 AIR QUALITY STUDIES

In 2008, SENES Consultants Ltd. was engaged to conduct an air quality assessment for Yukon Energy's diesel operations around Yukon in order to understand the potential effects of its operations and of other sources of emissions. The results of this assessment are summarized throughout this document, with the full report contained in Appendix B.

The components of the study include the following:

1. Emission inventories for the communities of Whitehorse, Dawson City, Faro and Mayo. **The inventories for each community are summarized in the context of Yukon Energy's operations in Section 4.0 – Environmental & Socio-economic Setting**. The inventories include the following components:
   a) Common Air Contaminants (CAC)
      i) nitrogen oxides (NO_x)
      ii) carbon monoxide (CO)
      iii) volatile organic compounds (VOC)
      iv) sulphur oxides (SO_x)
      v) inhalable particulate matter (PM_{10})
      vi) respirable particulate matter ($PM_{2.5}$)
      vii) ammonia (NH_4)
   b) Greenhouse Gases (GHG)
      i) carbon dioxide (CO_2)
      ii) methane (CH_4)
      iii) nitrous oxide (N_2O)
2. A summary of air quality monitoring data for Whitehorse during the period 2000-2005 based on the monitoring station in downtown Whitehorse operated by Environment Canada as part of the National Air Pollution Surveillance (NAPS)

network. **A summary of this data is presented in Section 4.0 - Environmental & Socio-economic Setting.**

3. Air dispersion modelling of emissions from the Yukon Energy diesel plant in Whitehorse were conducted based on normal and hypothetical operational scenarios. **The results of the modelling with regard to the emission character of the diesel generators are summarized in Section 3.0 – Facility Descriptions.**
4. A screening level human health risk assessment of the emissions from several generation profiles for the Whitehorse facility. **This information is discussed in Section 5.0 – Effects Assessment.**

To Yukon Energy's knowledge, the air emissions inventories prepared by SENES for the four communities, and SENES's further detailed modelling and analysis of air emissions in Whitehorse, together represent the most comprehensive and thorough study of the potential effect of air emissions that has ever been carried out in the Yukon.

Yukon Energy has undertaken this study in recognition of its corporate and regulatory obligations, and its general commitment to provide energy services to Yukoners in the most economical, yet environmentally and socially responsible way, as well as the specific concerns previously raised during the environmental and socio-economic assessment process for the Corporation's Carmacks-Stewart/Minto Spur Transmission Project, particularly with reference to the potential effect in Riverdale of $PM_{2.5}$ emissions from Yukon Energy's Whitehorse diesel facilities.

In that context, it should be noted that Yukon Energy in fact contemplates that the frequency and extent of operation of its Whitehorse diesel facilities is likely to be reduced in the future as a result of the Carmacks-Stewart/Minto Spur Transmission Project, because of Yukon Energy's possible future acquisition of the Minto diesel generators, which, once they are connected to the grid, would be put high in its stacking order relative to the other diesel facilities on the system. As such, if and when the Minto diesel facility is acquired by Yukon Energy and connected to the grid, the Corporation anticipates that it will then be able to rely on the Minto facility for back-up power generation in the event of an outage on the transmission system in priority over heavier reliance on diesel generation in Whitehorse, unless an outage occurs on the transmission line connecting Minto and Whitehorse.

Nevertheless, in assessing the potential effect of the Whitehorse diesel facilities, the Corporation has taken a conservative approach, and has not asked SENES to take into account any reduction in the level of operation of the Whitehorse facilities that may be contemplated as a result of Yukon Energy's possible future acquisition of the Minto diesels.

2.2 IDENTIFICATION OF VALUED COMPONENTS

For the purpose of identifying and assessing potential environmental and socio-economic effects, value may be attributed to a component of the environment and/or the socio-economic system for economic, social, environmental, aesthetic or ethical reasons.

Valued environmental and socio-economic components (or VESECs) are parts of the local environment and socio-economic fabric that are valued because of their ecological and/or socio-economic importance. VESECs can represent a class of species, a type of ecosystem, or an important component of a social and/or economic system, and are used in the assessment of potential effects arising from a project and associated activities.

Based on its understanding of the environmental and socio-economic setting of its generating facilities, and upon an examination of known and typical interests related to air emissions, Yukon Energy has identified Human Health and Safety to be the key valued component for the purpose of the environmental and socio-economic assessment of this Project.

Other components of the environment, such as water, soils, and general maintenance of environmental quality, are more appropriately related to such things as the potential for petroleum hydrocarbon releases, and have not been examined beyond the scoping stage of this assessment, as such matters are adequately addressed by operational and regulatory controls currently in place, and not by the Air Emissions Permit renewal which Yukon Energy is applying for at this time.

2.3 ANALYSIS & SIGNIFICANCE OF POTENTIAL EFFECTS

Section 56(1) of *YESAA* provides the legal framework for the Designated Office's analysis of potential effects on human health and safety of the operation of Yukon Energy's diesel generation facilities, and governs the recommendations to be made by the Designated Office as a result of that analysis, for the purpose of the environmental and socio-economic assessment of Yukon Energy's application to renew the Air Emissions Permit for the facilities for another three-year term.

In particular, under *YESAA*, the Designated Office must recommend that the Environment Minister renew Yukon Energy's Air Emissions Permit, to allow the Corporation to continue to operate its diesel generation facilities for the 2009-2011 under the terms and conditions of the renewed Permit, if the Designated Office is satisfied, that the continuing operation of the diesel generators (in accordance with the terms and conditions of the Permit and applicable requirements under the *Environment Act* and *Air Emissions Regulations*) "will not have significant adverse environmental or socio-economic effects" within the meaning of section 56(1)(a).[2]

In Part 4.3 of its November 2, 2007 Screening Report & Recommendation on Project Assessment 2006-0286 (Yukon Energy Corporation Carmacks-Stewart/Minto Spur Transmission Project) (at page 15), the YESAB Executive Committee commented as follows on YESAB's interpretation of section 56(1), and on the framework for analyzing whether an effect is "significant" and requires mitigation under section 56(1):

> "The determination of whether or not a particular effect is significant is undertaken in the context of the effect, and the circumstances encountered. In developing mitigative measures to address effects, the level of adversity (duration, magnitude, extent, reversibility) and

[2] The Designated Office also has the jurisdiction to recommend that the Permit be renewed subject to specified terms and conditions, if it is satisfied that the continuing operation of the diesel generators "will have significant adverse environmental or socio-economic effects…that can be mitigated by those terms and conditions" within the meaning of section 56(1)(b).

> acceptability (i.e., as linked to social expectations) are key criteria that facilitate the determination of which effects should be mitigated. Societal expectations are often a reflection of the adversity of an effect as compared to the level of effort required to address the effect.
>
> Two broad categories of effects exist along the spectrum of significance: insignificant, and significant …
>
> Category A [Insignificant] consists of those potential effects for which mitigation is not necessary. This category would include beneficial effects as well as adverse effects that are within established norms (e.g. natural variation of baseline conditions), and levels of acceptable change/societal expectations (e.g. effects from walking through the forest).
>
> Category B [Significant] consists of all those effects that do not fall under category A. In this category, there exists a broad spectrum of adverse effects that are considered significant, which may range from minor adverse effects outside of local environmental norms/societal expectations to major consequential effects. Mitigative measures have been recommended for all adverse effects in this category, as required by *YESAA*.

As explained in Part 12.0 of YESAB's "Guide to Socio-economic Effects Assessment", the significance of a Project's potential effects on a particular VESEC (such as human health and safety) should also be assessed under section 56(1) of *YESAA* with reference to any relevant effect attributes, which could include the direction of change (i.e., positive, neutral, negative, or both positive and negative), the magnitude of a potential effect, its geographic extent, duration, frequency, reversibility, and likelihood of occurrence, and the applicable socio-economic context.

Having regard to the foregoing:

- the determination of the "significance" of the potential effects of the continuing operation of Yukon Energy's diesel facilities on human health and safety requires the identification and assessment of both the potential beneficial and adverse effects;
- in that exercise, potential adverse effects should be assessed with reference to those effect attributes which are relevant to the level of adversity and acceptability of the effect;
- attributes relevant to the character of an effect may include the reasonably contemplated frequency, likelihood of occurrence, duration, magnitude, extent, and

reversibility of the effect over the three-year term of the renewed Permit (as referenced in one or both of the Carmacks-Stewart Screening Report and/or in YESAB's Guide to Socio-economic Effects Assessment); and

- the level of acceptability of an effect should also be assessed with reference to established environmental standards that have been developed in consideration of those common effect attributes (such as the Canada-Wide Standard for $PM_{2.5}$ concentrations) and reasonable societal expectations (as considered in the context of those environmental norms and relevant effect attributes).

It is clear from the foregoing that "significance" under section 56(1) of *YESAA* is not the same as statistical significance, in that an effect may be determined not to be significant for the purposes of section 56(1), even though it might be statistically significant (for example, if the effect is one of low probability and/or low frequency, and would be expected to be only temporary, of short-term duration, and reversible).

In considering the potential effects of emissions from Yukon Energy's diesel generation facilities, it should also be emphasized (as discussed further below) that potential adverse health effects are a function of overall ambient air quality, as opposed to emissions from a particular point source (such as the Corporation's diesel facilities). The effects are as a result of cumulative interactions, i.e., they are cumulative effects. In that context, relevant factors to be considered in assessing the level of acceptability of Yukon Energy's emissions must include (as examined further below):

- the relatively slight-to-insignificant extent to which Yukon Energy's facilities actually contribute to overall ambient concentrations of common air contaminants (CAC), in comparison to other community emission sources, such as local vehicular traffic, home heating (using either fuel oil or wood stoves), and other (non-Yukon Energy) industrial activity; and
- the increased presence of CAC from time to time resulting from natural variations in baseline conditions, such as forest fires, which are not within Yukon Energy's control, and against which the Corporation cannot reasonably be expected to mitigate.

The potential significance of Yukon Energy emissions must also be assessed primarily with reference to the contemplated operating profile of its diesel facilities over the 2009-2011 period, as opposed to higher levels of operations that could only occur in the event of an emergency situation such as a catastrophic failure or a sustained major outage affecting certain of the Corporation's key transmission or hydro generation facilities.

It should be emphasized that such an emergency situation is a very low probability event, which would occur, at most, very infrequently; further, if such an event does occur, it is very likely to be of short duration. These particular effect attributes (probability or likelihood, frequency, and duration) play an important role in determining the significance of potential effects in these circumstances.[3]

[3] Pursuant to section 49(1) of *YESAA*, an environmental and socio-economic assessment is not required for Yukon Energy to operate any of its facilities in such manner as may be required in response to such an emergency situation, to the extent there is an obvious and manifest need for Yukon Energy to be able to ensure a reliable supply of power to customers, particularly during the winter, in the overriding interest of protecting public welfare, health, and safety.

As such, any potential effects that could only reasonably be contemplated to arise in such an emergency situation should only play a limited role in the overall assessment under section 56(1) of YESAA, particularly to the extent that such effects would only be of short-term duration, infrequent, and reversible.

3.0 FACILITY DESCRIPTIONS

3.1 OPERATIONAL RANGES & REQUIREMENTS

As previously discussed, Yukon Energy's diesel electric generating plants are installed and operated so as to ensure the overall WAF and MD systems, and so all customers on these systems can receive reliable power consistent with Yukon Energy's corporate and regulatory obligations. Hydro generation stations on the Yukon grids are currently supplemented as necessary by a small amount of diesel for peaking or maintenance purposes.

The current need for diesel generation is related to several factors including:

- The need to meet demand for electricity during those times when hydro-electric facilities are taken offline for routine maintenance;
- The need to meet demand for electricity during those times when hydro-electric facilities are offline as a result of an emergency condition;
- The need to 'exercise' the particular diesel unit as a part of routine maintenance;

There is no expectation of any material increase in diesel generation from Yukon Energy's diesel generating plants over the next three years.

The regulatory context in which the diesel plants are used and relied on by Yukon Energy to satisfy its obligation to provide electricity service to its customers is described further below.

3.2 GENERATION INVENTORY

Yukon Energy maintains diesel generators in Whitehorse, Mayo, Dawson, and Faro. The Corporation also has two large mobile diesel units. Small, black start units are also deployed to provide onsite power in the event of power failures. The following table summarizes the Corporation's generation inventory from all sources excluding the small black start units, in all locations.

Table 1 Yukon Energy Generation Inventory

LOCATION	UNIT NO.	PRIME MOVER TYPE	PRIME MOVER MANUF.	PRIME MOVER MODEL	SERIAL NO.	NAME PLATE CAPACITY	MCR RATING (kW)	RPM	RAD TYPE	GEN. MANUF.	GEN. MODEL	GEN. SERIAL NO.	GEN. RATING (KVA)	GEN. VOLTAGE (V)	EXCITER TYPE	IN-SERVICE DATE	PLANNED RETIREMENT DATE	GROSS FUEL EFF (KWh/ltr)
Aishihik							30,000											
	AH1	hydro	Dom Eng.	Francis	1014	15,600	15,000	720	N/A	C.G.E.	AT1	52L439	1560	13800	Brush	1975		
	AH2	hydro	Dom Eng.	Francis	1015	15,600	15,000	720	N/A	C.G.E.	AT1	525L440	1560	13800	Brush	1975		
Faro							9,425											
	FD1	diesel	Mirrlees	KV16	64511	5,150	5,150	514	Remote	Brush		549201	6000	12000/6900	Brushless	1970		
	FD3	diesel	Caterpillar	3516	73Z0247	1,000	850	1200	Remote	Kato	Exciter			4160	Brushless	1989	2019	
	FD5	diesel	Caterpillar	3516	25Z01988	1,400	1,025	1800	Skid	Kato	Exciter			4160	Brushless	1990	2020	3.7
	FD7	diesel	Caterpillar	3612	9RC0071	3,000	2,400	900	Remote							1992	2027	3.9
Dawson							4,360											
	DD1	diesel	Caterpillar	3512	67Z00715	800	720	1200	Remote	Kato	A245800002	96650	1000	2400/4160	Brushless	1988	2018	3.7
	DD2	diesel	Caterpillar	3516	73Z00216	1,000	920	1200	Remote	Kato	A242520000	94740	1250	4160	Brushless	1987	2017	3.7
	DD3	diesel	Caterpillar	3516 TA	73200422	1,000	920	1200	Remote	Kato	A252100001	98297	1288	4160	Brushless	1990	2020	3.7
	DD4	diesel	Caterpillar	D399	35B1280	700	400	1200	Remote	Tamper		363/181/303	1000	4160	Brushless	1975	2005	3.1
	DD5	diesel	Caterpillar	3606	8RB00293	1,500	1,400	900	Remote	Ideal	type SAB	328778	1875	4160	Brushless	1996	2031	3.9
Mayo							7,100											
	MD1	diesel	Caterpillar	3516	73Z0307	1,000	850	1200	Remote	Kato	Exciter			4160	Brushless	1989	2019	
	MD2	diesel	Caterpillar	3516	73Z0294	1,000	850	1200	Remote	Kato	Exciter			4160	Brushless	1989	2019	3.7
not in service	MD3	diesel	Cummins	KTA	31107828	330	0	1800	Skid	BBC	527	C261389980	350	600	Brushless	1981	2011	3.0
	MH1	hydro	Dom Eng.	Francis	696	2,620	2,600	450	N/A	G.E.	78796	663667	2550	6900	Brush	1957	none	
	MH2	hydro	Dom Eng.	Francis	748	2,840	2,800	450	N/A	G.E.	72025	559905	2550	6900	Brush	1951	none	
Whitehorse							61,200											
	WH1	hydro	K.M.W.	Kaplan	2754	5,800	5,800	300	N/A	West.		459955	5800	6900	Brush	1958	none	
	WH2	hydro	K.M.W.	Kaplan	2753	5,800	5,800	300	N/A	West.		459954	5800	6900	Brush	1958	none	
	WH3	hydro	C.A.C.	Propeller	1234	8,400	8,400	200	N/A	C.G.E.		848297	8400	6900	Brush	1969	none	
	WH4	hydro	Dom Eng.	Propeller	1070	20,000	20,000	150	N/A	C.G.E.		0525L0509	2360	6900	Brush	1984	none	
	WD1	diesel	Mirrlees	KV12	63371	3,920	3,000	514	H/X	Brush		506411	4250	6900	Brushless	1968	2011	3.7
	WD2	diesel	Mirrlees	KV16	63381	5,150	4,200	514	H/X	Brush		506421	6000	6900	Brushless	1968	2009	3.7
	WD3	diesel	Mirrlees	KV16	64441	5,150	4,200	514	H/X	Brush		548561	6000	6900	Brushless	1970	2007	3.7
	WD4	diesel	EMD	20C	74H11151	2,500	2,250	900	Remote	EMD	A20T-24	74H11151	3000	4160	Brush	1975	2025	3.6
	WD5	diesel	EMD	20C	73J11044	2,500	2,250	900	Remote	EMD	A20T-24	73J11044	3000	4160	Brush	1975	2025	3.6
	WD6	diesel	EMD	20C	90D11025	2,700	2,500	900	Remote	EMD	PMG Exciter	174184911	3125	4160	Brushless	1990	2025	3.7
	WD7	diesel	Caterpillar	3612	9RC0108	3,300	2,800	900	Remote	Kato	A247680002	98548	4125	4160	Brushless	1991	2026	3.9
Haeckel Hill							810											
	WW1	wind	Bonus	MARK III			150									1993	2013	
	WW2	wind	Vestas				660									2000	2020	
Mobile Diesels							1,450											
	YM1	diesel	Caterpillar	3516	25Z01987	1,400	1,300	1800	Skid	Kato	Exciter			4160	Brushless	1990	2015	3.7
	YM2	diesel	J Deere		RG6081A073 016	150	150	1800	Skid	Stamford		W/08945	150	347/600		1999	2024	
Total Co 4 Capacity							**114,345**											

3.3 WHITEHORSE

3.3.1 Facility Overview

The Whitehorse diesel plant is located at the site of the Corporation's Whitehorse Rapids Power Development and adjacent the Whitehorse Rapids Dam. The legal description of the property is as follows:

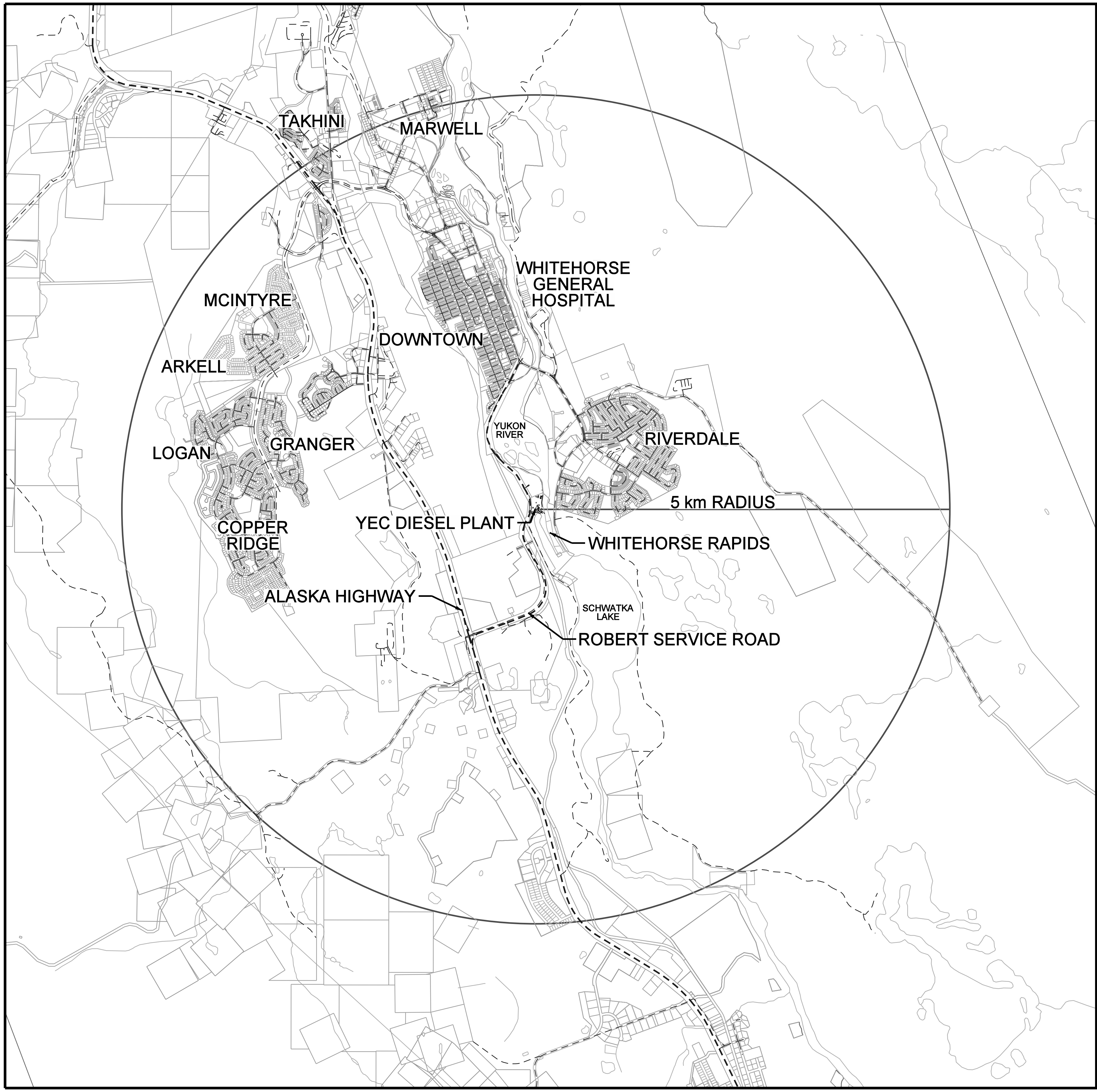
Lot 1022, Quad 105 D/11, Plan 73440 LTO, DCT No. 93Y377 - registered to Yukon Energy Corporation.

Approximate coordinates of the diesel plant:

- UTM Zone 8
- Northing: 6729200.0
- Easting: 497522.99

The diesel plant maintains seven units as described in Table 1.

The following figure provides an overview of the location of the diesel generators relative to the community of Whitehorse.



LEGEND

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UTM Zone 8 NAD83

Scale 1:50,000

1 0.5 0 1 2 Kilometers

Rev. No.	Date	Description	Approv'd
1	SEPT 4, 2008	INITIAL REVIEW	TR
2	SEPT 19, 2008	FINAL	TR

YUKON ENERGY CORPORATION

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
SUPPORTING DOCUMENTATION

FIGURE 1:
OVERVIEW OF YEC WHITEHORSE DIESEL PLANT AREA

Drawn: C.McGILLIVRAY	Date: SEPTEMBER 2008
Scale: 1:50000	Map Sheet No. 105D11
Revision Number: 2	Dwg Name: FIGURE 1

3.4 DAWSON CITY

3.4.1 Facility Overview

The Dawson City diesel plant is located near the entrance to downtown Dawson City. The legal description of the property is as follows:

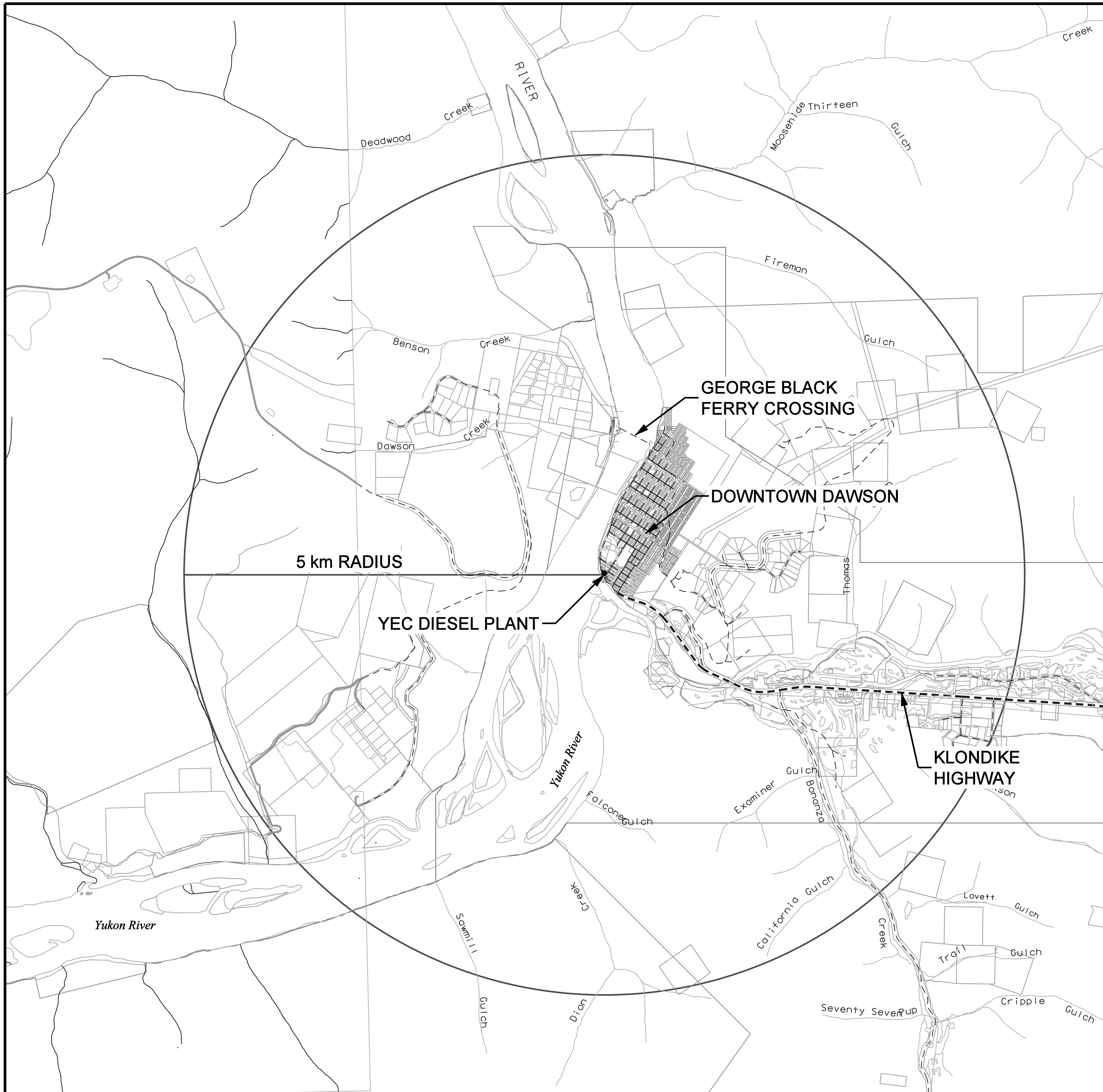
Lots 1 and 2, Block 11, Quad 116B/03, Plan 8395 LTO DCT No. 93Y380 - registered to Yukon Energy Corporation.

Approximate coordinates of the diesel plant:

- UTM Zone 7
- Northing: 7104026.7685
- Easting: 576156.199

The diesel plant maintains five units as described in Table 1.

The following figure provides an overview of the location of the diesel generators relative to the community of Dawson City.



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YUKON ENERGY CORPORATION

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
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FIGURE 2:
OVERVIEW OF YEC DAWSON DIESEL PLANT AREA

Drawn:	C.McGILLIVRAY	Date:	SEPTEMBER 2008
Scale:	1:50000	Map Sheet No.	116B3
Revision Number:	2	Dwg Name:	FIGURE 2

3.5 MAYO

3.5.1 Facility Overview

The Mayo diesel plant is located adjacent the main community access road approximately 850 m north of the Stewart River. The legal description of the property is as follows:

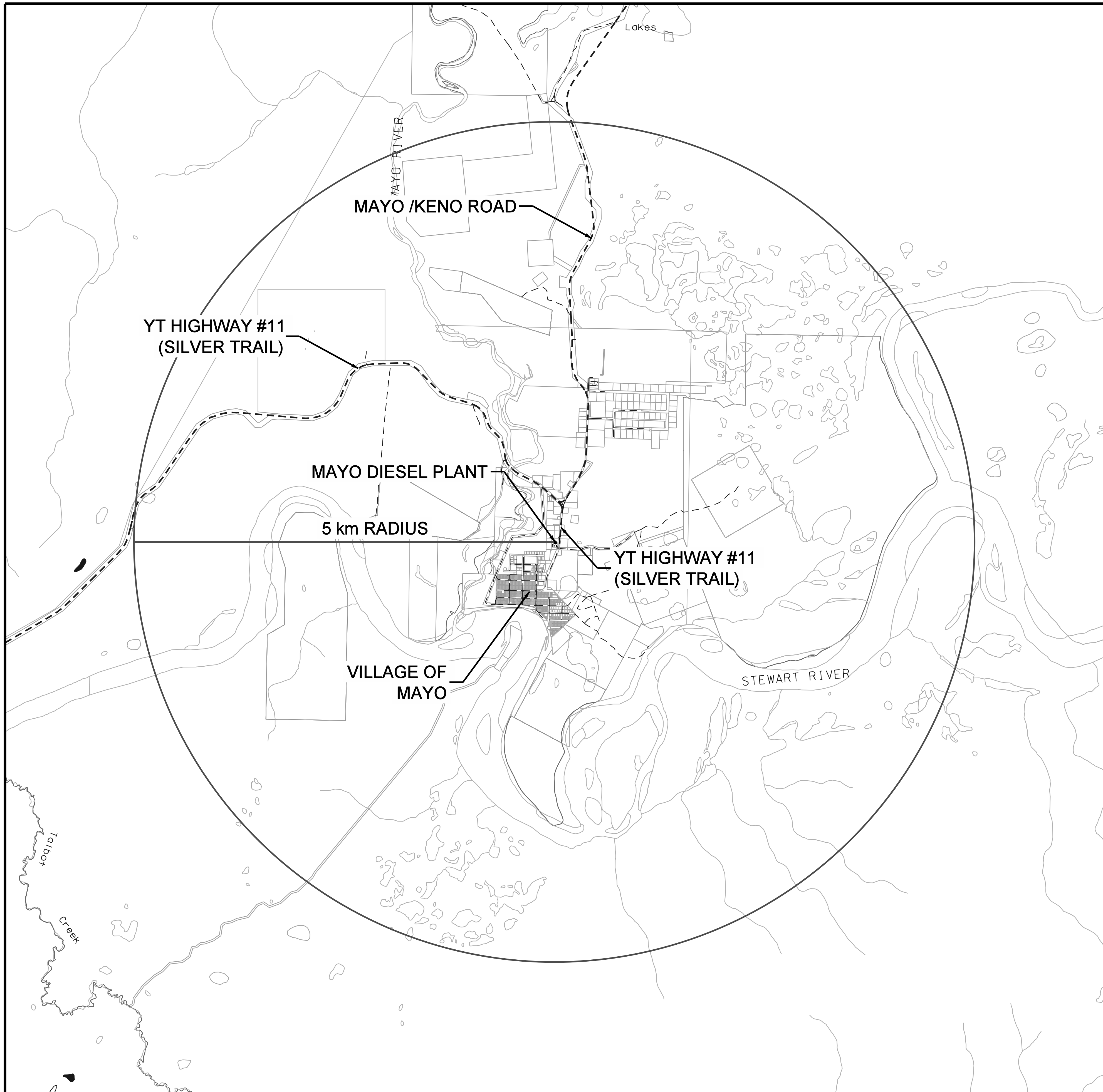
Lot 1000, Quad 105 M/12, Group 1004, Plan 61437 LTO DCT No. 93Y378 - registered to Yukon Energy Corporation.

Approximate coordinates of the diesel plant:

- UTM, Zone 8
- Northing: 7052505.0275
- Easting: 455892.8273

The diesel plant maintains two units as described in Table 1.

The following figure provides an overview of the location of the diesel generators relative to the community of Mayo.



LEGEND

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YUKON ENERGY CORPORATION

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
SUPPORTING DOCUMENTATION

FIGURE 3:
OVERVIEW OF YEC MAYO DIESEL PLANT AREA

Drawn: C.McGILLIVRAY	Date: SEPTEMBER 2008
Scale: 1:50000	Map Sheet No. 105M12
Revision Number: 2	Dwg Name: FIGURE 3

3.6 FARO

3.6.1 Facility Overview

The Faro diesel plant is located near the entrance to Faro off the mine access road. The legal description of the property is as follows:

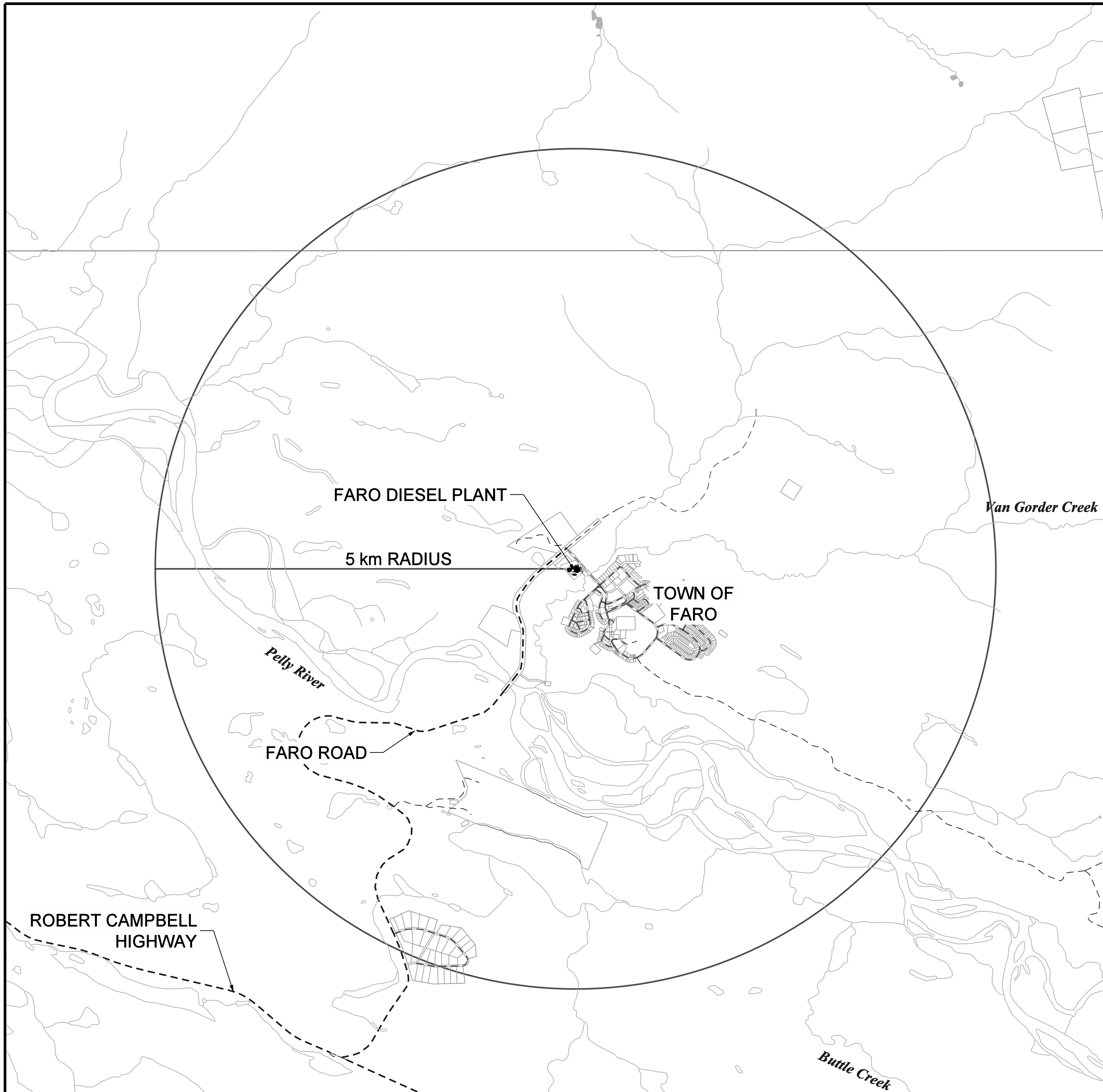
Lot 114, Quad 105 K/03, Plan 49716 LTO DCT No. 93Y377 - registered to Yukon Energy Corporation.

Approximate coordinates of the diesel plant:

- UTM Zone 8
- Northing: 6901266.5646
- Easting: 585174.5418

The diesel plant maintains four units as described in Table 1.

The following figure provides an overview of the location of the diesel generators relative to the community of Faro.



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Scale 1:50,000

1 0.5 0 1 2 Kilometers

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YUKON ENERGY CORPORATION

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
SUPPORTING DOCUMENTATION

FIGURE 4:
OVERVIEW OF YEC FARO DIESEL PLANT AREA

Drawn: C.McGILLIVRAY	Date: SEPTEMBER 2008
Scale: 1:50000	Map Sheet No. 105K03
Revision Number: 2	Dwg Name: FIGURE 4

3.7 TYPICAL EMISSIONS CHARACTER

The Yukon Energy diesel generators can be characterized by use of activity-based emission rates. These emission rates require consideration of engine properties (age, type of engine), fuel specifications (in particular, sulphur content of diesel) and operating data (kWh produced over a defined period of time). The U.S. Environmental Protection Agency (EPA) maintains a compilation of emission factors called 'AP-42' that provides a general characterization of a multitude of emission sources commonly found in communities[4].

An investigation was conducted of published emission factors that could be used to represent the Yukon Energy engines. The table below provides emission factors representative of the Yukon Energy diesel engines in Whitehorse.

Table 2 Emission Factors for Yukon Energy Diesel Engines

		Air Contaminant Emission Factors (g/kWh)			
Engine Type	**Sulphur content (ppm)**	**NOx**	**SO2**	**CO**	**PM25**
YEC 4-stroke engines	50	15.00	2.46E-02	4.00	0.25
YEC 2-stroke engines	50	15.00	2.46E-02	2.50	0.35

The current average sulphur content of diesel used in the diesel plants is 50 parts per million (ppm). This level is lower than the current Environment Canada sulphur-in-fuel regulation for diesel sold in Canada for 'off-road' purposes[5].

3.8 OPERATIONAL RESOURCE USE & WASTE GENERATION

Each diesel plant maintains a permitted bulk fuel supply of ultra low sulphur diesel (50 parts per million). Fuel storage facilities meet National Fire Code standards and each is permitted by the Yukon Fire Marshall's Office pursuant to the *Environment Act* and *Fuel Storage Regulations*. Spill containment and response equipment is maintained in

[4] See http://www.epa.gov/oms/ap42.htm.

[5] See http://www.ec.gc.ca/cleanair-airpur/Pollution_Sources/Fossil_Fuels/.

appropriate locations and quantities at each site. Routine checks of the facilities are conducted to ensure appropriate containment and operation of the storage systems. Yukon Energy personnel are also trained in spill response. Yukon Energy maintains a policy to report any release of hazardous material to land in excess of five litres and, according to regulation, any release to a watercourse, no matter the volume.

In addition to air emissions, other wastes are generated at these facilities. For example waste oil, waste solvents, waste coolants, and used absorbents are all commonly generated. Storage and handling of these materials follows industry best practices and the wastes are disposed of annually, or more often, through permitted commercial recycling, reuse, and/or disposal contractors, such as the Yukon Government Special Waste Collection and Disposal Program, permitted waste oil collectors, and approved waste disposal facilities in each community.

3.9 REGULATORY CONTEXT

3.9.1 Regulation under the Public Utilities Act

Yukon Energy's diesel plants are operated as a critical component of the Corporation's facilities required to satisfy its obligation to supply electricity service to its customers under the *Public Utilities Act*. As such, the plants are regulated by the Yukon Utilities Board (YUB) both in terms of the requirement for installed capacity, and the ability of Yukon Energy to recover any costs spent on these facilities through electrical rates.

To satisfy Yukon Energy's obligations, the diesel plants must be designed and installed so as to ensure that the power systems are able to supply utility-grade reliable power to customers. This requires the diesel plants to meet the capacity planning criteria[6]

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[6] The criteria adopted by Yukon Energy and set out in the 20 year Resource Plan 2006-2025 are as follows:

1. **WAF and MD System-wide capacity planning criteria:** Each system (WAF and MD) will be planned not to exceed a Loss of Load Expectation (or LOLE) of two hours per year.
2. **Emergency (or "N-1") WAF and MD system capacity planning criteria:** Each grid system (WAF and MD) will be planned to be able to carry the forecast peak winter loads (excluding major industrial loads) under the largest single contingency (known as "N-1"). The N-1 criterion determines system capacity assuming the loss of the system's single largest generating or transmission-related generation source. In the case of WAF, this is presently the Aishihik transmission line, without which the WAF grid loses ability to access approximately 30 MW of generation.

reviewed by the YUB in its review of Yukon Energy's 20-year Resource Plan 2006-2025, and the consequent recommendations from the YUB to the Minister of Justice dated January 15, 2007.

As noted in that Resource Plan and reviewed in detail at the YUB's 2006 public hearing, Yukon Energy's systems as of 2006 were approaching the limits of the ability to provide utility-grade power (as measured by utility industry standard generation planning reliability criteria) given ongoing load growth on domestic systems and then-planned generation retirements. Yukon Energy, however, has since undertaken a major initiative to secure options for up to 25.4 MW of WAF capacity in a staged and flexible manner (comprising 6.4 MW of new capacity potentially acquired from the Minto mine site, 5 MW of refurbished capacity at the Faro diesel plant, and 14 MW from undertaking a rebuild and life extension program on 3 Mirrlees generators in Whitehorse, rather than retiring these units as earlier planned). The components of this plan have been reviewed by the YUB.

Absent the ability to meet these utility standard planning criteria in terms of the quantity of installed diesel on the system, and at the right locations on the system, as well as the ability to operate the diesels as required to the full capability of their rated output, Yukon Energy could experience one or more of the following conditions:

- In **very cold weather conditions**, Yukon Energy would be unable to meet the peak loads of the WAF system. This would give rise to interruptions of service on substantial components of the power grid, likely during peak load hours (e.g., daytime hours). Further, once such outages occur it becomes very difficult to resume service due to a condition known as 'cold load pick-up' where the generation available must be well in excess of the normal average load on a feeder in order to be able to restore service (due, for example, to the fact that after even a brief outage in such weather, basically every furnace fan or heat tape installed on the system will automatically be drawing load when the system is restored).

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3. **WAF and MD "community" criteria:** For communities on the WAF or MD grids, any location with a load large enough to justify a diesel unit of about 1 MW or more will be considered as a preferred location for new diesel units if that community does not already have back-up from another source (e.g., having an existing diesel unit). The new diesel units would provide grid support, and in times of line failures would provide local generation for the communities where they are located.

- In **unplanned system outages**, particularly in winter conditions, Yukon Energy would similarly be unable to supply load. Outages due to this factor could readily be of extended duration, such as the experience of January 29, 2006, where due to a major failure of the power cables at the Aishihik hydro plant, up to 6 WAF diesels operated for 2 days to maintain power to the system. For a further 8 days the WAF system operated in a constrained mode without diesels operating, but needed to be ready to operate at any time. The system was not fully restored to normal status until February 21, more than three weeks after the incident. Diesel generation was similarly used to supply substantial components of the load following the fire at the Whitehorse Rapids hydro plant in October 1997, and to various grid locations during forest fires (when transmission lines are at times required to be de-energized) in recent years.
- During **drought conditions**, even at the current load levels, the diesel units could be required for energy-related reasons to maintain service to load and ensure the WAF hydro plants can maintain their water levels within licenced ranges. For example, diesel generation for this purpose was required in the late winter of 1999 due to the severe drought conditions experienced at Aishihik in 1998. While this can lead to sustained diesel generation, the output is typically at a low level. For example, during the early part of 1999, the average output of all combined diesel generation on WAF was 3 MW, or less than 10% of the installed diesel capability on WAF.
- In **planned system outages**, such as transmission line maintenance, communities such as Faro and Dawson which are located away from the hydro plants require diesel generation to maintain continuity of service.

If Yukon Energy's ability to use and operate the diesel generators were to be constrained during the 2009-2011 period in any way that could prevent the Corporation from being able to rely on the facilities to provide a reliable supply of back-up power to customers in accordance with utility standard planning criteria, such constraints could result in one or more of the foregoing situations arising, in which Yukon Energy would be unable to supply customers with power in accordance with its obligations under the *Public Utilities Act*. This would present an obvious and acute risk of harm to human health and safety, particularly during cold winter temperatures.

3.9.2 Legal & Regulatory Constraints under Environment Act and Air Emissions Regulations

Aside from the regulation of Yukon Energy's diesel facilities by the YUB under the *Public Utilities Act*, Yukon Energy's use and reliance on the diesel facilities is constrained by certain requirements under the existing Permit for the facilities, and under the *Environment Act* and the *Air Emissions Permit*, which requirements do not interfere with Yukon Energy's ability to supply power to customers in a way that satisfies utility standard planning criteria.

In particular, the facilities are subject to the following requirements under Yukon Energy's existing Permit:

- Yukon Energy is required to comply with any applicable requirements in all federal, territorial and municipal legislation, including the *Environment Act* and the *Air Emissions Regulations* (Part 1, section 1);
- All associated personnel (employees, contractors or volunteers) are required to be knowledgeable of the conditions and requirements specified in the permit (Part 1, section 2);
- Yukon Energy is required to allow an environmental protection officer, at any reasonable time, to enter any place or premise under Yukon Energy's ownership or occupation, other than a private dwelling, to inspect any activity which is subject to the Permit (Part 1, section 3);
- Yukon Energy is required to notify the Environmental Programs Branch (Branch) before any significant change of circumstances at a permitted operation, site or business, including without limitation: (a) closure of the facility; (b) ownership of the facility; (c) addition of new equipment; or (d) release of air contaminants other than as authorized by the Permit (Part 1, section 4);
- Yukon Energy is prohibited from releasing or allowing the release of any air contaminant to such extent or degree as may: (a) cause or be likely to cause irreparable damage to the natural environment; or (b) in the opinion of a health officer, cause actual or imminent harm to public health or safety (Part 1, section 5);

- Yukon Energy is required to maintain and operate, in accordance with manufacturer's procedures, fuel burning equipment, process equipment, emission control devices, and testing and monitoring equipment as necessary to provide optimum control of air contaminant emission during all operating periods (Part 2, section 1);
- Yukon Energy is prohibited from allowing visible emissions from the source to exceed an opacity of 40% as measured by: (a) an observer determining the opacity; or (b) another method of determining the opacity as prescribed by the Branch (Part 2, section 2);
- Yukon Energy is prohibited from burning fuel with a sulphur content greater than 1.1% by weight without prior written permission from the Branch (Part 2, section 3);
- Yukon Energy is required to contact either an environmental protection officer or the Yukon Spill Report Centre as soon as possible in the circumstances in the event of an unauthorized release or emission (Part 3, section 1);
- Yukon Energy is required to ensure that emergency procedures are posted and that all associated personnel are familiar with those procedures (Part 3, section 2); and
- Yukon Energy is required to maintain records for at least three years and to make them available on request for inspection by an environmental protection officer (Part 3, section 3).

Yukon Energy assumes that all of the foregoing requirements will be included as terms and conditions of the renewed Permit for the diesel facilities, and will continue to constrain Yukon Energy's use and operation of the facilities. As such, these requirements must be considered to be attributes of the Project for the purpose of the assessment of any potential effect arising from the continuing operation of the facilities during the 2009-2011 period.

Yukon Energy is also subject to all applicable requirements and prohibitions under the *Environment Act* and *Air Emissions Regulations*, including:

- the general prohibition under section 6 of the *Regulations* against Yukon Energy releasing or allowing the release of any contaminant to such extent or degree as may: (a) cause or be likely to cause irreparable damage to the natural environment; or (b) in the opinion of a health officer, cause actual or imminent harm to public health or safety;

- the authority of an environmental protection officer under section 12(4) of the *Regulations* to conduct periodic inspections of Yukon Energy's facilities to ensure compliance with the terms and conditions of the Permit;
- the authority of an environmental protection officer to issue a "hold order" under section 153 of the *Act*, or an "environmental protection order" under section 159 of the *Act*, in any of the circumstances described in those sections;
- the authority of the Minister to issue an "environmental protection order" under section 160 of the *Act*; and
- the overriding authority of the Minister to suspend or cancel the Permit under section 91 of the *Act*, if Yukon Energy contravenes a term or condition or the Permit or a provision of the *Act* or *Regulations*, or if, in the Minister's opinion, Yukon Energy's operation of its diesel facilities "has caused or is likely to cause irreparable or costly damage to the natural environment", or if, on the advice of a health officer, it is the Minister's opinion that Yukon Energy's operation or its diesel facilities "has caused or is likely to cause a threat to public health or safety".

It should be emphasized that if, during the term of the renewed Permit, a situation arises in which the continuing operation of Yukon Energy's could ever cause actual or imminent harm to public health or safety because of any change in circumstances or operating conditions that is not contemplated at this time, the *Environment Act* and *Regulations* will give overriding authority to an environmental protection officer and/or the Minister, in the circumstances specified, to require Yukon Energy to cease operating one or more of the diesel units, or take other action that may be deemed necessary to prevent, remedy or otherwise mitigate that harm.

The assessment of any potential effect arising from the continuing operation of the facilities during the 2009-2011 period must also take into account these overriding safeguards under the *Environment Act* and *Regulations*, which will also continue to constrain Yukon Energy's use and operation of the facilities, and will provide an appropriate and sufficient safeguard against any effects that are not reasonably contemplated at this time to arise during the 2009-2011 period.

4.0 ENVIRONMENTAL & SOCIO-ECONOMIC SETTING

4.1 GENERAL

For the purposes of the assessment and its focus on air quality and human health, the human environment is considered to be very similar across each of the four communities in which Yukon Energy maintains diesel generators. It is assumed that there are no material differences among the four communities with respect to common human components such as a population of male, female, child, adult, and elderly persons with a common community health profile, the presence of common community infrastructure such as homes, schools, hospitals or nursing stations, communal recreation areas, etc. It is also assumed that there are no material differences in other socio-economic characteristics.

As noted previously, the key valued component identified for detailed assessment relative to this application is human health and safety. Human health and safety, with regard to the potential effects of diesel generation, is a function of overall ambient air quality (as opposed to emissions from any particular point source). Therefore the focus of this section is on describing the existing environment by comprehensively describing the likely sources of air emissions in each of the communities.

No pre-existing air emission inventories were available for use in the assessment, so individual inventories were developed for each community in which Yukon Energy maintains diesel generators. These inventories assisted in developing an understanding of other community air emission sources and their relative contributions to the environment.

These inventories provide a backdrop for understanding the role and relationship of individual emission sources within the communities. The actual inventories are presented in the SENES report in Appendix B and represent an activity based emission inventory for the year 2006, which was chosen as a sample year due to the availability of data. The overall emissions from the activity within the communities would not significantly differ for 2005 or 2007.

The annual emission tables within the SENES report summarize approximately 120 unique sources for each community for a series of Common Air Contaminants (CAC) and Greenhouse Gas (GHG) Emissions. Not every community has every emission source, particularly the smaller communities, and adjustments in the inventories were made accordingly.

Of particular note, and as explained further below, it should be emphasized that the relative contribution by Yukon Energy's facilities to total $PM_{2.5}$ emissions from all sources in each of the four communities is extremely low: < 1% in each community, and only 0.02% in Whitehorse specifically.

4.2 WHITEHORSE

4.2.1 Emissions Inventory

The City of Whitehorse contains the majority of the population within the Yukon and represents the foundation for development of the emission inventories. The airshed boundary identified for the emission inventory uses the boundaries identified in the Official Community Plan which was available from the City's web site. The following are points of interest for the inventory:

- Within the city boundary there is very little agricultural activity both for agricultural land use practices and equipment usage.
- Four point sources have been identified: the Whitehorse General Hospital, the sand and gravel supply in the southern parts of town, the local asphalt batch plant, and the concrete batch plants, in addition to the Yukon Energy generators.
- The highway traffic accounts for vehicles travelling along a 36 km stretch of the Alaska Highway.
- A population of 23,751 was estimated for the inventory year.
- A total of 27,525 flights were recorded between the two airports.
- A total of 24,600 cords of wood were estimated to have been burned during the year.

The following table summarizes the 2006 component contributions to the Whitehorse airshed for some emissions of interest.

Table 3 Summary of Select Component Contributions to Air Emissions in Whitehorse[7]

Source	Particulate Matter ($PM_{2.5}$)	Oxides of Nitrogen (NO_x)	Carbon Dioxide (CO_2)
Yukon Energy Diesel Generators	0.02%	1%	0.1%
Home Heating	84%	26%	57%
Local Vehicle Traffic	0.9%	46%	25%
All Others Sources Combined	15%	27%	18%

4.2.2 Ambient Air Quality

Environment Canada operates an air quality monitoring station in Whitehorse, located at 1091 - 1st Avenue, as part of the National Air Pollution Surveillance (NAPS) network. The most recent 5-year data record includes monitoring for CO, NO, NO_2 and $PM_{2.5}$ for the period 2000-2005. This data was used and analyzed during the air quality assessment and is presented in SENES report in Appendix B.

The data from the station indicate that the CO and NO_2 levels in Whitehorse are well below ambient air quality objectives defined by both Environment Canada (EC) and the World Health Organization (WHO). There are no criteria for NO for human health protection because NO is not considered to represent a risk to health. For particulate matter, the data for $PM_{2.5}$ during the period 2001 to 2003 were well below WHO guideline values, but forest fires in 2004 and 2005 caused maximum $PM_{2.5}$ concentrations that were 3-4 times the WHO guideline. Despite these $PM_{2.5}$ levels in Whitehorse during 2004 and 2005, $PM_{2.5}$ concentrations were still well within the Canada-Wide Standard (CWS)

[7] All figures in Table 3 are approximate.

target of 30 µg/m^3 (98th percentile of 24-hour ambient concentrations, averaged over 3 consecutive years) for 2003-2005, at 23 µg/m^3. Further, without the influence of forest fires, NO_2 concentrations in Whitehorse are well within any health-based criteria for air quality management for the period of data collection (2000-2005).

4.3 FARO

4.3.1 Emissions Inventory

The Town of Faro contains a small fraction of the population within the Yukon and its inventory utilizes scaled activity from the Whitehorse inventory in situations where local data were not available. The following are points of interest for the inventory:

- Within the inventory bounds there is very little agricultural activity both for land use activity and agricultural equipment usage.
- There were no significant point sources identified for Faro other than the Yukon Energy power plant.
- The highway traffic accounts for vehicles travelling along a 15 km stretch of the Campbell Highway.
- A population of 388 was estimated for the inventory year.
- A total of 786 flights were recorded at the local airport.
- A total of 367 cords of wood were estimated to have been burned during the year.
- Yukon Energy diesel operations contributed approximately 0.4%, 16%, and 2% of the total community emissions of $PM_{2.5}$, NO_x, and CO_2, respectively.

4.4 MAYO

4.4.1 Emissions Inventory

The Town of Mayo contains a small fraction of the population within the Yukon and its inventory also utilizes scaled activity from the Whitehorse inventory in situations where local data were not available. The following are points of interest for the inventory:

- Within the inventory bounds there is very little agricultural activity both for land use activity and agricultural equipment usage.
- There were no significant point sources identified for Mayo, other than the Yukon Energy power plant.
- The highway traffic accounts for vehicles along a 25 km stretch of Highway 11.
- A population of 409 was estimated for the inventory year.
- A total of 4,377 flights were recorded at the local airport.
- A total of 470 cords of wood were estimated to have been burned during the year.
- Yukon Energy diesel operations contributed approximately 0.1%, 4%, and 0.3% of the total community emissions of $PM_{2.5}$, NO_x, and CO_2, respectively.

4.5 DAWSON CITY

4.5.1 Emissions Inventory

Dawson City contains a small fraction of the population within the Yukon and its inventory also utilizes scaled activity from the Whitehorse inventory in situations where local data were not available. The following are points of interest for the inventory:

- Within the inventory bounds, there is very little agricultural activity both for land use activity and agricultural equipment usage.
- A single point source representing sand and gravel supply is included, in addition to the Yukon Energy power plant.
- The highway traffic accounts for vehicles travelling along a 20 km stretch of the Klondike Highway.
- A population of 1,813 was estimated for the inventory year.
- A total of 5,567 flights were recorded at the local airport, located approximately 15 km east of town and are included for comparison to the other communities.

- A total of 2,201 cords of wood were estimated to have been burned during the year.
- Yukon Energy diesel operations contributed approximately 0.3%, 15%, and 2% of the total community emissions of $PM_{2.5}$, NO_x, and CO_2, respectively.

5.0 EFFECTS ASSESSMENT

5.1 GENERAL

The air quality effects assessment carried out by SENES, and outlined in its report in Appendix B, includes a thorough and comprehensive dispersion modelling analysis to assess the potential effects within the Whitehorse airshed of four air contaminants produced from the diesel generators: carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and respirable particulate matter ($PM_{2.5}$).

The potential effect of Yukon Energy emissions of those contaminants was modelled, analyzed, and assessed based on simulations of three different hypothetical levels of operation of the Whitehorse diesel facilities, ranging from the levels of operations reasonably expected to occur during the 2009-2011 (based on actual operations during a typical year (2007)), to a very conservative, worst-case scenario, based on a hypothetical assumption of operating all seven Whitehorse diesel facilities at full capacity for 24 hours each day, 365 days of the year. Of course, the latter scenario is not a realistic operating profile for Yukon Energy's facilities, and is presented solely for the purpose of testing the potential effect of emissions at hypothetical levels of operation well above the outside range of what could be reasonably anticipated, under all potential meteorological conditions occurring throughout a full calendar year.

The effects assessment focuses principally on modelling and assessing potential effects of emissions in the Whitehorse airshed. This site was selected because of the availability of suitable meteorological data that was required to conduct the modelling, as well as suitable ambient air quality monitoring data that provides a measure of background concentrations against which to assess the potential impact of Yukon Energy operations. Equivalent data was not available for Mayo, Faro, or Dawson City; in the absence of such data, it is assumed that the results and findings for Whitehorse provide reasonably representative, conservative estimates of the outcomes that could be expected for the smaller diesel plants in the other three communities, given the likely levels of use of the units in these communities during the three-year term of the renewed Permit.

It should also be noted that by their very nature, the effects of diesel generation emissions on human health result from the cumulative interaction of emissions from Yukon Energy and all other sources of contaminants in the airshed, including community sources such as local vehicular traffic, home heating (using either fuel oil or wood stoves), and other (non-Yukon Energy) industrial activity. Those other sources, which are not within the Corporation's control, collectively produce the vast majority of contaminants in all four communities (as outlined in Section 4.0 above, and in the air quality inventories prepared by SENES and included in its report in Appendix B). Any potential effects on human health would be as a result of overall ambient air quality.

As such, the effects assessment focuses on the cumulative effect of Yukon Energy emissions combined with reasonably contemplated background concentrations of contaminants from other sources, based on actual ambient air quality data observed both:

- during a typical three-year period (2001-2003) that is assumed to be reasonably representative of the background levels of contaminants that would normally be expected to occur, and
- during an atypical period (2004-2005) that was characterized by extensive forest fires in the region, which resulted in much higher concentrations of both $PM_{2.5}$ and NO_2 than would normally be expected to occur.

5.2 GENERATION PROFILES

For the purpose of analyzing the potential effects on human health of emissions from the Whitehorse diesel facilities, SENES developed and conducted air dispersion modelling of the following three operating scenarios:

- Scenario 1: Normal Operations;
- Scenario 2: Extraordinary Operations; and
- Scenario 3: "Maximum Potential to Emit".

5.2.1 Scenario 1: Normal Operations

In Scenario 1, SENES modelled the normal level of emissions that could reasonably expected to be generated by Yukon Energy's diesel facilities in Whitehorse over the course of a typical year, by conducting a computer simulation of engine emissions, based on Yukon Energy's hour-by-hour records of actual levels of operation of the diesel units over the course of a representative year (2007).

A total of 368 MWh were generated by the Whitehorse diesel plant over the course of that year.

Yukon Energy anticipates that the levels of operation experienced during 2007 are reasonably representative of the levels of operation of the diesel facilities that can be expected to occur over the three-year term of the renewed Air Emissions Permit (2009-2011).

5.2.2 Scenario 2: Extraordinary Operations

In Scenario 2, SENES has assumed a hypothetical maximum daily operating profile for the Whitehorse diesel plant that is reflective of the highest diesel production levels that would reasonably be contemplated to occur on any given day during the term of the renewed Permit (2009-2011) in the absence of a catastrophic failure or sustained major outage of transmission or hydro generation facilities. That daily operating profile is based on the actual operations of the diesel facilities as a result of peaking demand during a very cold day (January 30, 2008) that is representative of the highest daily diesel energy production levels over the past year. In addition, the operating profile was scaled further upwards, to conservatively reflect potential increased demand in the near future (without taking into account any potential reduction in the frequency and extent of Yukon Energy's operation of the Whitehorse units in the future, as a result of Yukon Energy's possible future acquisition of the Minto diesel generators).

For the purpose of its analysis, SENES has modelled emissions in this scenario based on an assumption of the Whitehorse diesel facilities operating at the levels assumed in the hypothetical maximum daily operating profile for every day of the year. Application of this profile over a full year yields a hypothetical daily generation level of 168 MWh, and a hypothetical annual generation level of 61 GWh.

Scenario 2 does not represent a realistic operating scenario, as it is extremely unlikely that Yukon Energy would actually operate its diesel generators at levels approaching the assumed daily operating profile in this scenario for 365 days a year during 2009-2011, based on forecast demand during that period. In fact, Yukon Energy contemplates that, on most days, it will not operate the Whitehorse diesel units at all, or will operate them at a much lower level than is assumed in Scenario 2.

However, Scenario 2 is presented for the purpose of testing the potential effect of Yukon Energy diesel emissions at hypothetical levels of operation that are reflective of the highest daily diesel production levels that could reasonably be expected to occur at any time during the term of the renewed Permit (other than in an emergency situation resulting from a catastrophic failure or sustained major outage of transmission or hydro generation facilities) under all potential meteorological conditions occurring throughout a full calendar year.

5.2.3 Scenario 3: "Maximum Potential to Emit"

Scenario 3 is the most conservative, worst-case scenario, which assumes the operation of all seven Whitehorse diesel units at maximum capacity, continuously, for 24 hours a day, each day of the year.

Application of this profile over a full year yields a hypothetical daily generation level of 600 MWh, and a hypothetical annual generation level of 219 GWh

Scenario 3 is not a realistic operating profile for the Whitehorse facilities, which could ever be expected to actually occur. It is a purely hypothetical scenario that represents the theoretical maximum possible generation profile for the seven Whitehorse units.

In fact, from an operational point of view, it would not be technically possible or feasible to operate the diesel facilities at the extreme levels assumed in Scenario 3 for 365 days of the year. Also, the plant likely could only be operated up to 90% its rated capacity, as routine maintenance and other operation factors would prohibit continuous operation of all units.

Indeed, Yukon Energy does not contemplate that the actual operation of the Whitehorse units could ever approach the theoretical maximum levels assumed under Scenario 3 during the 2009-2011 period, except potentially in the event of a catastrophic failure or sustained serious outage on certain key transmission or hydro generation facilities, resulting in an emergency situation requiring extraordinarily heavy reliance on diesel generation to ensure a reliable supply of power to customers (such as occurred for a brief period in January 2006 during a major power outage on the WAF grid due to a failure on the connection to the Aishihik hydro generating facility).

Based on past experience, this type of emergency situation is a very low probability event occurring very infrequently. Further, if such an event does occur, it is contemplated that Yukon Energy would only operate the diesel facilities at levels approaching the operating profile assumed in Scenario 3 for the number of days that it might take to conduct the repairs necessary to restore the transmission or hydro generation facilities.

However, Scenario 3 is presented for the purpose of testing the potential effect of Yukon Energy diesel emissions based on the “maximum potential to emit” at a theoretical maximum level of operations that is well above the outside range of what could ever reasonably be anticipated, and under all potential meteorological conditions occurring throughout a full calendar year.

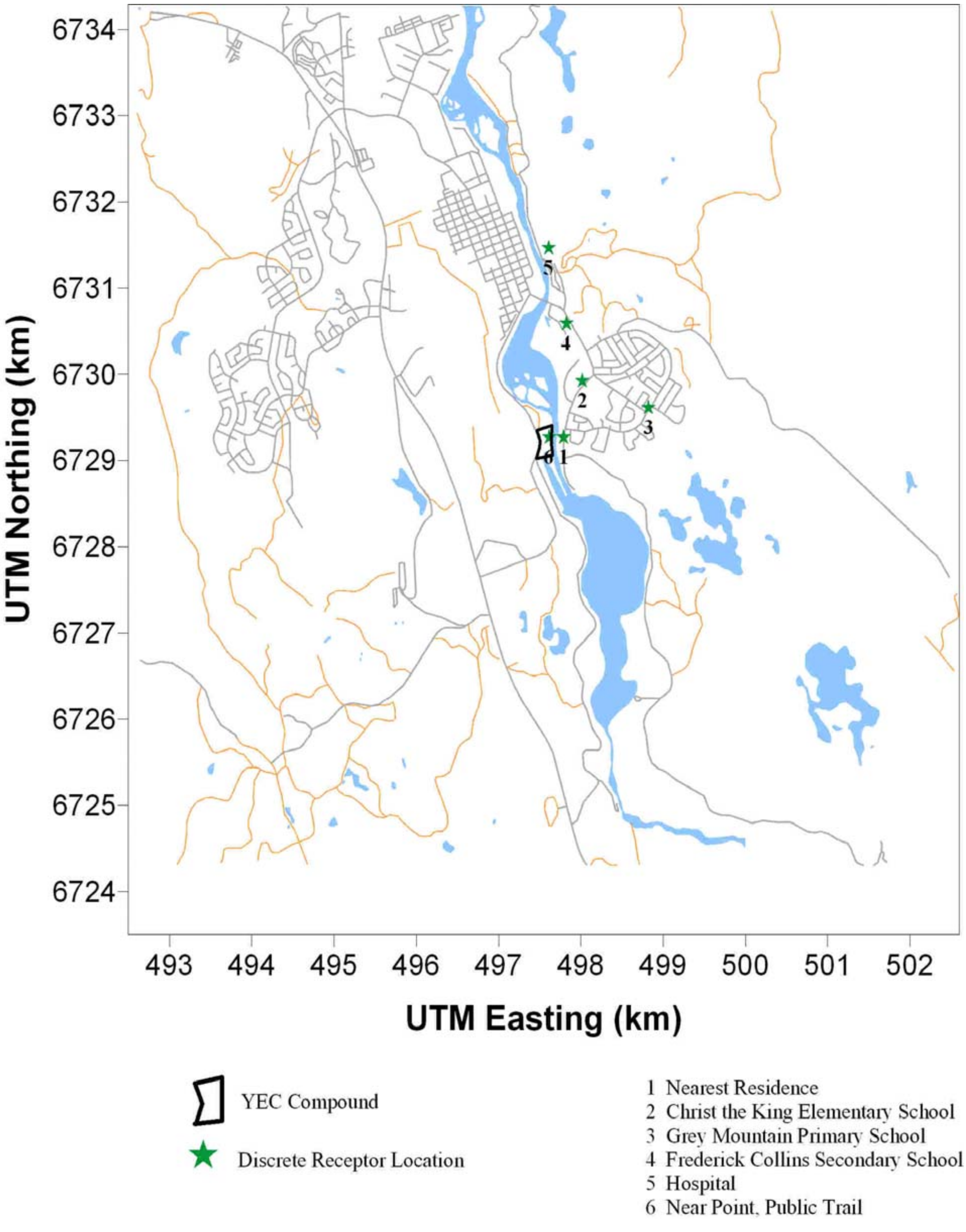
5.3 REPRESENTATIVE RECEPTOR SITES

Estimates of ambient air quality concentrations were produced on a regular grid every 20 metres within 200 metres of the diesel plant, every 50 metres between 200 metres and 500 metres from the plant and then every 200 metres for the remainder of the study area. In addition, six discrete receptor locations were used. Discrete receptors are commonly used in air quality assessments to look at the full distribution of predicted ambient concentrations at locations considered particularly sensitive to air contaminants, such as homes, schools and hospitals. The receptors in the vicinity, including four receptor sites in Riverdale, were the focus of the analysis, since concentrations of contaminants beyond 5 km from the diesel plant were generally found to be very low.

The six sensitive receptors chosen were as follows and are presented in Figure 5, below (approximate distance from the plant shown in brackets):

1. nearest residence to the power plant, located on the east side of the Yukon River (240 m);
2. Christ the King Elementary School (840 m);
3. Grey Mountain Primary School (1.3 km);
4. Frederick H. Collins Secondary School (1.4 km);
5. the Whitehorse General Hospital (2.2 km); and,
6. the plant property fence line on the western river bank at the foot bridge over the Yukon River (75 m).

Figure 5 Inner Modelling Domain and Discrete Receptor Locations



5.4 POTENTIAL HEALTH EFFECTS & APPLICABLE ENVIRONMENTAL STANDARDS

The screening-level human health risk assessment conducted by SENES and outlined in its report considers predicted concentrations of CO, SO_2, NO_2 and $PM_{2.5}$ in the actual and hypothetical operating scenarios modelled under each of Scenarios 1, 2 and 3, at each of the six selected receptor sites and at the "maximum point of impingement" (Max POI)[8], and the resulting risk (if any) to human health.

The predicted total ambient concentration of each contaminant depends on the combination of the predicted concentration arising from Yukon Energy's operation of its diesel facilities plus the expected background concentration of the contaminant arising from other sources, including other community emission sources, such as local vehicular traffic, home heating (using either fuel oil or wood stoves), and other (non-Yukon Energy) industrial activity. Background concentrations of contaminants such as NO_2 and $PM_{2.5}$ may also vary significantly as a result of natural variations in baseline conditions not within Yukon Energy's control (i.e., forest fires), causing an increased presence of those contaminants in the airshed.

In general, high ambient concentrations of CO, SO_2, and NO_2 are known to give rise to a potential risk of short-term adverse effects, generally associated with irritation of the tissues of the eyes and upper and lower respiratory systems. It must also be emphasized, however, that any such effects would be temporary and reversible once the exposure level is reduced.

That potential risk may be assessed in connection with the operation of the Whitehorse diesel units with reference to established environmental norms, as represented by guidelines/objectives which have been established by the World Health Organization (WHO) or the Canadian Council of Ministers of the Environment (CCME) and which are commonly recognized and used as exposure limits to assess potential health effects.

[8] The Max POI includes any point in the modelling domain outside the property line of the facility where the highest concentration of the contaminant is predicted to occur.

The WHO guidelines include 1-hour average exposure limits of 30 mg/m^3 for CO, 350 µg/m^3 for SO_2, and 200 µg/m^3 for NO_2, as well as an 8-hour average exposure limit of 10 mg/m3 for CO, and a 24-hour average exposure limit of 20 µg/m^3 for SO_2 (with an interim guideline of 125 µg/m^3). The CCME has also established a 24-hour average exposure limit of 200 µg/m^3 for NO_2.

The foregoing WHO and CCME guidelines are more stringent than the National Ambient Air Quality Objectives (NAAQO) established by Environment Canada in the 1970s, and reflect more up-to-date research.

Accordingly, the WHO and CCME guidelines provide an appropriate and sound standard against which to assess the "significance" of any potential adverse health effects arising from CO, SO_2, and NO_2 for the purpose of section 56(1) of *YESAA*, in conjunction with any other effect attributes that are relevant to the "significance" analysis, including the temporary and reversible nature of any potential effects arising from these contaminants, their anticipated geographic extent and duration, and the extent to which they result from causes such as other community emission sources or forest fires that are not within Yukon Energy's control.

As regards $PM_{2.5}$, there is no clearly defined exposure limit that is recognized to be 100% protective against any potential health effects. The potential for there to be any impact due to $PM_{2.5}$ is therefore evaluated in terms of whether Yukon Energy emissions could result in measurable impacts, i.e., an incremental increase in ambient $PM_{2.5}$ concentrations greater than 1 µg/m^3.

However, given the reality that the presence of some measurable background levels of ambient $PM_{2.5}$ in populated areas is simply unavoidable, the CCME also has established the Canada-Wide Standard (CWS) for $PM_{2.5}$, which sets an achievable target level of 30 µg/m^3 for 24-hour ambient $PM_{2.5}$ concentrations (based on the 98th percentile concentrations averaged over 3 consecutive years). The CWS standard was formally adopted in June 2000, and is considered to be a reasonably achievable target level for particulate matter to be achieved nationally by 2010; it is recognized to be based on sound science, while taking into consideration socio-economic factors such as effects on jobs, other economic impacts, and technical feasibility.

The WHO has also established a guideline value of 25 µg/m^3 for 24-hour average $PM_{2.5}$ concentrations (99th percentile), which is more stringent than the CWS standard. Accordingly, SENES has considered and analyzed predicted $PM_{2.5}$ concentrations in Whitehorse with reference to both the CWS standard and the WHO guideline.

Yukon Energy submits that the CWS standard represents an established and recognized environmental norm that provides an appropriate and sound basis against which to assess the potential "significance" of any potential adverse health effect arising from $PM_{2.5}$ emissions, for the purpose of section 56(1) of *YESAA*, in conjunction with any other effect attributes that are relevant to the "significance" analysis, including the very low extent to which the diesel facilities actually contribute to total concentrations of $PM_{2.5}$ relative to other community sources of $PM_{2.5}$ emissions, or natural variations in baseline conditions resulting from forest fires, which are not within the Corporation's control and against which it cannot reasonably be expected to mitigate.

5.5 EFFECTS SUMMARY

5.5.1 Beneficial Effect of Yukon Energy's Diesel Facilities

There is an obvious beneficial effect of Yukon Energy's diesel generation facilities for human health and safety, given its reliance on those facilities for back-up power generation capacity. Those facilities are essential to the Corporation's ability to provide a reliable supply of electricity to customers in emergency situations, as well as during periods of planned maintenance, or when demand otherwise outstrips hydro supply as a result of peaking demand during cold winter temperatures.

If Yukon Energy were not able to use and rely on its diesel generation facilities to provide a reliable supply of back-up power to customers in these circumstances, this would put both infrastructure and human health and safety at very serious risk, particularly during the cold winter months.

5.5.2 Potential Effects Resulting from Combustion Gas Emissions (CO, SO_2, and NO_2)

SENES's analysis clearly demonstrates that there are no potential adverse health effects from either CO or SO_2 emissions from Yukon Energy's diesel facilities.

In particular, SENES's modelling demonstrates that emissions from Yukon Energy's diesel facilities would not result in exposure limits for CO or SO_2 being exceeded anywhere in Whitehorse, even under the most extreme possible operating conditions that have assumed in Scenario 3.

With respect to NO_2, SENES's modelling and analyses demonstrate that:

- there are no potential adverse health effects from NO_2 emissions from Yukon Energy's diesel facilities under the normal operating profile assumed in Scenario 1, given that emissions from the diesel facilities would not result in the exposure limits for NO_2 being exceeded anywhere in Whitehorse in that scenario, and
- to the very limited extent that any potential adverse health effect might possibly result from the hypothetical heavier use of Yukon Energy's facilities at levels similar to those assumed in Scenarios 2 and 3, that potential effect is not significant within the meaning of section 56(1) of *YESAA*, having regard to the relevant effect attributes.

SENES's findings concerning NO_2 emissions in Scenarios 2 and 3 are summarized as follows:

- emissions from Yukon Energy's facilities would not result in the 24-hour average exposure limit for NO_2 being exceeded anywhere in Whitehorse, at any time of the year, under the very high level of operations assumed in Scenario 2;
- indeed, the Corporation's emissions would not result in the 24-hour average exposure limits being exceeded in Whitehorse, at any time of the year, even under the most extreme possible operating conditions assumed in Scenario 3, with the background levels of NO_2 anticipated to occur in years without forest fires;
- it is only with the higher background NO_2 levels anticipated to occur in years with forest fires that 24-hour average exposure limits for NO_2 would come close to being

exceeded in Scenario 3 (although predicted concentrations are still within the 24-hour exposure limit);

- with respect to 1-hour average exposure limit of NO_2, that limit could be exceeded under the very high level of operations assumed in Scenario 2 in the immediate vicinity of Yukon Energy's compound (at the Max POI and, in years with forest fires only, at receptor 6 (the nearest point on the public trail)), but would not be exceeded at any of the other sensitive receptor sites in Riverdale or at the Hospital (even in years with forest fires); and
- under the most extreme possible operating conditions assumed in Scenario 3, the 1-hour average exposure limit could be exceeded at the Max POI and receptor 6, and (in years with forest fires) could be exceeded at receptor 3 and could come close to being exceeded at receptors 1, 4 and 5, although predicted concentrations at receptors 1, 4 and 5 are still within the 1-hour exposure limit, even in this extreme scenario and the 1-hour exposure limit would not be exceeded at receptors 2 or 3.

These findings demonstrate that, to the extent there are any possible health effects arising from NO_2 emissions from Yukon Energy's facilities under the very high level of operations assumed in Scenario 2, or the most extreme possible operating conditions assumed in Scenario 3, such health effects are not significant for the purpose of section 56(1) of *YESAA*, particularly having regard to the following relevant effect attributes:

- any potential effects of NO_2 (i.e., irritation) would be temporary and reversible;
- given the fact that, on most days of the year, Yukon Energy does not operate the diesel facilities at all, or operates them at a much lower level than is contemplated in Scenario 2 or 3, any possible exceedence of the 1-hour average exposure limit can be expected to be of very low frequency;
- given the short period of time that Yukon Energy would ever be expected to operate the facilities at the high or extreme levels of operation assumed in Scenarios 2 and 3, any potential effects arising from such exceedence would also be of short-term duration;
- at the high levels of operation assumed in Scenario 2, the potential for short-term health effects would likely arise only close to the plant boundary, in areas where

members of the public are unlikely to be present except for brief periods of exposure, particularly in the winter months (when the highest levels of operation of the facilities would be most likely to occur) – any such potential effects are therefore of low probability, and of very limited geographic extent;

- the modelling does yield some pockets of higher concentrations of NO_2 in Scenario 2 several kilometers from the point of release (but not at any of the sensitive receptor sites in Riverdale or at the Hospital) due to the gradual conversion of NO to NO_2 with distance, which could possibly cause 1-hour exposure limits to be exceeded in years with high background levels of NO_2 due to forest fires; however, SENES has indicated that those higher predicted NO_2 concentrations may in fact be an artefact of the conversion rates used in the analysis, because the maximum NO_2 levels are predicted to occur in those areas as a result of meteorological conditions (i.e., inversion) that would ordinarily occur during cold weather in winter or early spring, and in the evening hours, at which times the conversion rates are actually likely to be lower than the rates that were assumed in the model;
- it should also be noted that the high background levels of NO_2 due to forest fires would not be present in the winter months, and therefore would be unlikely to coincide with the meteorological conditions that could give rise to high NO_2 concentrations at a distance from the Yukon Energy compound;
- with respect to potential effects under the most extreme possible operating conditions assumed in Scenario 3, during the 2009-2011 period, it is not anticipated that Yukon Energy would operate the diesel facilities at levels approaching the theoretical maximum operating profile assumed in Scenario 3, except potentially in an emergency situation resulting from a catastrophic failure or sustained serious outage on Yukon Energy's transmission or hydro generation facilities, which is a low probability and low frequency occurrence;
- if such an emergency event does occur, high levels of operation of the Whitehorse diesel facilities are expected to be of short duration, only for as long as it takes to restore transmission/hydro generation; and
- it should also be emphasized that the highest 1-hour concentrations of NO_2 are predicted to occur when there is an atmospheric "inversion", under meteorological

conditions that are generally cold (in the winter or early spring, and in the evening), with a stable atmosphere and low mixing height (indicating poor dispersion), and with low to moderate winds from the north, causing air to be "trapped" in the valley; so, even under the extreme operating conditions assumed in Scenario 3, the potential for there to be any health impacts is further dependent on whether those extreme operating conditions happen to coincide with the particular meteorological conditions which could give rise to higher NO_2 concentrations (which can be expected to further reduce the likelihood and frequency of any potential health effects).

5.5.3 Potential Effects Resulting from Particulate Matter Emissions ($PM_{2.5}$)

SENES's modelling and analyses also demonstrate that:

- there are no potential adverse health effects resulting from $PM_{2.5}$ emissions from Yukon Energy's diesel facilities under the normal operating profile assumed in Scenario 1; and
- to the very limited extent that any potential adverse health effect might possibly result from the hypothetical heavier use of Yukon Energy's facilities at levels similar to those assumed in Scenarios 2 and 3, that effect is not significant within the meaning of section 56(1) of *YESAA*, having regard to the relevant effect attributes.

As noted previously, there is no clearly defined exposure limit for $PM_{2.5}$ that is recognized to be 100% protective against any possible health effects, so the potential for there to be any impact due to $PM_{2.5}$ must first be evaluated in terms of whether Yukon Energy emissions could result in measurable impacts, as represented by an incremental increase in ambient $PM_{2.5}$ concentrations greater than 1 $\mu g/m^3$ (i.e., an increase in ambient concentrations of less than 1 $\mu g/m^3$ would not be measurable).

In that regard, SENES's modelling and analysis demonstrate that Yukon Energy emissions under the normal operating profile assumed in Scenario 1 do not result in any measurable increase in ambient $PM_{2.5}$ concentrations at any of the sensitive receptor sites in Riverdale or at the Hospital. Accordingly, Yukon Energy makes no discernable or measurable contribution to background concentrations of $PM_{2.5}$ at any of those locations under normal operating conditions.

Even in the immediate vicinity of the Yukon Energy compound, SENES's modelling for Scenario 1 yields contributions to $PM_{2.5}$ concentrations of only 1.1 µg/m^3 at receptor 6 (on the walking trail at the point where it crosses the Yukon River on a foot bridge, 75 m from the diesel plant) and 1.6 µg/m^3 at the Max POI. Although those concentrations would be barely measurable, they are still very low relative to background concentrations of $PM_{2.5}$, and are only predicted to occur one day per year; on all other days Yukon Energy's contribution to $PM_{2.5}$ would not be discernable or measurable anywhere in Whitehorse (even at the Max POI). It is also unlikely that members of the public would be present at those locations except for brief periods of exposure.

Overall, SENES has determined that, at the normal levels of operation assumed for Scenario 1, the relative contribution of Yukon Energy plant emissions to annual average concentrations of $PM_{2.5}$ in Whitehorse from all sources is insignificant (i.e., 0.01 µg/m^3 from Yukon Energy emissions compared to the total annual average background concentration of 2.0 µg/m^3).

In these circumstances, SENES has concluded that no measurable health effects are likely to result from $PM_{2.5}$ emissions under the normal operating profile represented by Scenario 1.

Even at the very high level of operations assumed in Scenario 2, SENES's modelling indicates that measurable contributions to $PM_{2.5}$ concentrations could only occur for a few days per year at the nearest neighbour location (receptor 1) and for one day per year at the F.H. Collins Secondary School (receptor 4), but not at any of the other sensitive receptor sites in Riverdale or at the Hospital. It should also be noted that:

- the predicted incremental impact would be measurable only < 2% of the time, or roughly < 7 days per year, on the (unrealistic) assumption that Yukon Energy would operate its facilities at the very high levels contemplated in Scenario 2 for every day of the year;

- given the fact that, on most days of the year, Yukon Energy does not operate the diesel facilities at all, or operates them at a much lower level than is contemplated in Scenario 2, the frequency with which Yukon Energy emissions could result in any measurable incremental increase in background $PM_{2.5}$ concentrations is actually expected to be significantly lower than the outcome of the Scenario 2 model;
- Yukon Energy's contribution to $PM_{2.5}$ would also still be low relative to background concentrations of $PM_{2.5}$ resulting from other community sources, such as local vehicular traffic, home heating (using either fuel oil or wood stoves), and other (non-Yukon Energy) industrial activity, which are not within Yukon Energy's control, and collectively result in the vast majority of $PM_{2.5}$ emissions within the Whitehorse airshed;
- taking into account the cumulative effect of Yukon Energy emissions combined with the expected background concentrations of $PM_{2.5}$ in years without major forest fires, the WHO guideline value of 25 µg/m^3 (which is considerably more stringent than the CWS standard) would not be exceeded anywhere in Whitehorse (except at the Max POI, in the immediate vicinity of the Yukon Energy compound, where members of the public are not likely to be present except for brief periods of exposure), and the CWS standard would not be exceeded anywhere in the modelling domain; and
- although there may be a potential for the WHO guideline value to be exceeded in Whitehorse in years with high background levels of $PM_{2.5}$ due to forest fires, Yukon Energy's operations would not have any material effect on that outcome, which would be caused by smoke from the forest fires alone, regardless of the level of operation of Yukon Energy's facilities.

At the most extreme possible levels of operation of the diesel unit that are assumed in Scenario 3, the frequency with which Yukon Energy's diesel emissions could have a measurable impact on $PM_{2.5}$ concentrations in Whitehorse is greater than under Scenario 2. However, it must be emphasized that the modelling of Scenario 3 is based on the unrealistic assumption of operating all seven diesel units at their maximum capacity for 24 hours a day, every day of the year. In fact, as noted previously:

- during the 2009-2011 period, it is not anticipated that Yukon Energy would operate the diesel facilities at levels approaching the theoretical maximum operating profile assumed in Scenario 3, except potentially in an emergency situation resulting from a catastrophic failure or sustained serious outage on Yukon Energy's transmission or hydro generation facilities, which is a low probability and low frequency occurrence; and

- when such an emergency event does occur, high levels of operation of the Whitehorse diesel facilities are expected to be of short duration, only for as long as it takes to restore transmission/hydro generation.

It should also be noted that, even under the extreme, unrealistic assumptions of Scenario 3, SENES has concluded that neither the CWS parameter value, nor the more stringent WHO standard for $PM_{2.5}$, would be exceeded at any of the five sensitive receptor sites in Riverdale or at the Hospital (with the background $PM_{2.5}$ levels expected to occur in years without major forest fires). Even at receptor 6, on the trail immediately adjacent to the Yukon Energy compound, the CWS standard still would not be exceeded under the extreme of Scenario 3 (in non-forest fire years).

SENES has also specifically concluded that, unless the Whitehorse plant were to operate in emergency mode for the entire year, it is unlikely that the CWS parameter would be exceeded anywhere in the modelling domain (even at the Max POI).

Overall, SENES has concluded that:

- given the low frequency with which Yukon Energy could reasonably be expected to operate the diesel units at the levels contemplated in either Scenario 2 or 3, predicted $PM_{2.5}$ levels would not result in statistically significant short-term, adverse health outcomes; and,
- Yukon Energy emissions of $PM_{2.5}$ simply are not relevant to chronic (long-term) health effects, because no measurable adverse health effects would be expected from chronic exposure to $PM_{2.5}$ emissions from Yukon Energy operations at the levels assumed for Scenario 1, and because the very high hypothetical levels of operation assumed for Scenarios 2 and 3 would only be expected to occur for a few days per year.

5.6 SIGNIFICANCE CONCLUSIONS

Having regard to the foregoing review of the potential effects of Yukon Energy's diesel generation facilities on human health and safety, it must be concluded that no significant adverse effects to human health and safety within the meaning of section 56(1) of *YESAA* are reasonably anticipated to result from Yukon Energy's continuing operation of the diesel units under a renewed Permit, during the 2009-2011 period.

Accordingly, Yukon Energy requests that the Designated Office issue a recommendation to the Yukon Government under section 56(1)(a) of *YESAA* to allow the renewal of Yukon Energy's Air Emissions Permit to proceed, on the basis that Yukon Energy's continuing operation of the diesel units during the 2009-2011 term of the renewed Permit, in compliance with the terms of the renewed Permit and the requirements of the *Environment Act* and *Air Emissions Regulations*, will not have significant adverse environmental or socio-economic effects in or outside the Yukon.

6.0 ACKNOWLEDGEMENT AND CERTIFICATION

The information submitted in this Project Proposal is required for the purpose of conducting an evaluation under the *Yukon Environmental and Socio-economic Assessment Act.*

I acknowledge that, pursuant to sections 119 and 120 of the *Act*, a copy of this Project Proposal will be placed on a public register and be available to any member of the public to review. I understand that misrepresenting or omitting information required for the evaluation may cause delays in the evaluation or render the recommendations invalid.

I certify that the information provided is true and correct to the best of my knowledge and belief.

September 24, 2008

Travis Ritchie, P.Biol. CCEP
Manager, Environment
Yukon Energy Corporation

Date

Air Emissions Permit (No. 4201-60-010)
Renewal Application Supporting Document

Appendix A

Application for Air Emissions Permit

YUKON ENERGY

Yukon Energy Corporation
P.O. Box 5920
Whitehorse
Yukon Y1A 6S7
Ph: (867) 393-5300
Fax: (867) 393-5322

September 24, 2008

Janine Kostelnik, Environmental Protection Analyst
Department of Environment, Standards & Approvals Section
Yukon Government
Box 2703
Whitehorse, Yukon Y1A 2C6

(Via email)

Dear Ms. Kostelnik,

RE: APPLICATION FOR RENEWAL OF AIR EMISSIONS PERMIT NO. 4201-60-010

Yukon Energy is pleased to submit for your consideration an application for the renewal of the Corporation's existing Air Emissions Permit. The supporting document attached to this letter contains the requisite application form in Appendix A.

This submission has also been provided electronically via the YESAB Online Registry for the purposes of YESAA evaluation at the Designated Office Level.

Please do not hesitate to contact me at 867.393.5350 or by email: travis.ritchie@yec.yk.ca should there be any questions, comments, or concerns regarding the proposal.

Thank you for your time and consideration in this matter.

Yours Sincerely,

Travis Ritchie, P.Biol., CCEP
Manager, Environment

Attachment

Yukon
Environment

Air Emissions Regulation
APPLICATION FOR AN AIR EMISSIONS PERMIT
PART I – GENERAL

- Applicants should ensure that they:
  - are familiar with the *Air Emissions Regulation* (Environment Act).
  - complete all applicable sections, legibly printing or typing all information.
  - initial each completed page in the space provided.
  - complete the signature block at the end of the form.
  - submit all required attachments, including the permit fee and all applicable activity-specific form(s).
- A **fee of $100** is payable to the **Government of Yukon** on submission of this application. There is no fee for the renewal or amendment of an active permit.
- A pre-permit inspection may be conducted prior to the issuance of any permit.
- An assessment of the activity you are undertaking may be required under the Yukon Environmental and Socio-Economic Assessment Act (YESAA).
- Additional information may be required upon receipt of this application.

The original completed and signed application form should be mailed or delivered to your local government office or:

Environment Programs Branch (V-8)
Department of Environment
Government of Yukon (located at 10 Burns Road, Whitehorse)
Box 2703
Whitehorse, Yukon Y1A 2C6

For additional information:
Phone: (867) 667-5683 or 1-800-661-0408 ext. 5683 Fax: (867) 393-6205
web: http://environmentyukon.gov.yk.ca/monitoringenvironment/regulations.php
email: envprot@gov.yk.ca

PLEASE READ CAREFULLY AND FILL OUT ALL SECTIONS

❖ PART 1 – CONTACT AND SITE INFORMATION

A. Name and address of applicant

Travis Ritchie - Manager, Environment — 393.5350
Contact name and position title — Phone #

Yukon Energy Corporation — 393.5322
Business name or government agency/branch/department — Fax #

P.O. Box 5920, Whitehorse, YT — Y1A 6S7
Mailing Address — Postal Code

travis.ritchie@yec.yk.ca
Email Address

Yukon Energy Corporation
Name (person or business) to appear on permit

B. Who is directly responsible for the activity requiring an Air Emissions Permit?
☐ **same as (1) above, or:** *(For multiple site locations, list on a separate sheet).*

Leo Poile - Director of Operations — 393.5399
Contact name and position title — Phone #

Yukon Energy Corporation — 393.5322
Business name or government agency/branch/department — Fax #

leo.poile@yec.yk.ca
Email Address

C. Where will the source of the air emissions be located?
☐ **same as (1) above, or:** *(For multiple site locations, list on a separate sheet).*

Mayo, Dawson City, Whse, and Faro. See Support Document S.3.0.
Mailing Address — Postal Code

Street and/or Legal Address

D. Who owns the land on which the source of air emissions will be located?
☑ **same as (1) above, or:** *(For multiple site locations, list on a separate sheet).*

*Applicants not owning the land on which the source is to be located **must include** with this application a letter from the landowner authorizing the intended activity on their property.*

Applicant's initials TR

E. Is the land leased? If so, by whom?
No.

❖ PART 2 – ACTIVITIES REQUIRING AN AIR EMISSIONS PERMIT

Check off the activity(ies) that apply to your operation and complete the applicable site-specific information form(s).

- ☐ Manufacturing asphalt
- ☐ Production/ Exploration of Oil and Natural Gas resulting in release of combustion products from flaring or burning
- ☐ Quarrying, crushing and screening of stone, clay, shale, coal or minerals in an active excavation area covering an area greater than 4 hectares
- ☐ Processing or handling of coal at a rate of greater than 5 million BTU per hour
- ☐ Operation of equipment capable of generating, burning or using, according to the manufacturer's specifications, heat energy equivalent to or greater than 5,000,000 BTU/hr
- ☐ Burning of waste by:
  - ☐ Incinerating:
    - ☐ Operation of incinerators capable of burning, according to the manufacturer's specifications, more than 5kg of solid waste per day
    - ☐ Incinerating special waste, as defined in the *Special Waste Regulations*
    - ☐ Incinerating contaminated soil containing any contaminant in excess of the generic numerical soil standard or the matrix numerical soil standard as defined in Schedules 1 or 2 of the *Contaminates Sites Regulation* and having less than 3% hydrocarbons and or levels greater than those specified in Part 2, Appendix 4 of the *Federal Transportation of Dangerous Goods Regulation*
  - ☐ Open burning of more than 5 kg/day of solid waste

Note:

Incinerating *means combustion in an incinerator, which is equipment used for the burning of waste or contaminated soil where the air intake and combustion temperatures may be controlled.*
Open burning *refers to the combustion of material without control of the combustion air and without a stack or chimney to vent the emitted products of combustion to the atmosphere.*

- ☑ Operation of electricity generating facilities with a maximum nameplate capacity equal to or more than 1.0 Megavolt ampere (at unity power factor equivalent to 1.0 megawatt).
- ☐ Use of fuel with sulphur content in excess of 1.1% for:
  - ☐ Heating
  - ☐ Generating steam or electricity
  - ☐ Combustion in industrial process
- ☐ Storage or handling of solid, liquid or gaseous materials or substances in a manner that causes or may cause an adverse effect.
- ☐ This application been required by the Minister for any of the following reasons:
  - ☐ Opacity of emissions exceeds 40%
  - ☐ Release of a contaminant to the air that may cause or is likely to cause irreparable damage to the natural environment
  - ☐ In the opinion of a health officer, the release of a contaminant to the air that may cause actual or imminent harm to public health or safety

PART 3 – OTHER PERMITS/APPROVALS

A. Have you applied for another permit(s) under Yukon's Environment Act regulations:

- ☐ Solid Waste Regulations
  - ☐ operation of a solid waste disposal site
  - ☐ operation of a commercial dump
  - ☐ other:
- ☐ Special Waste Regulations
  - ☐ disposal of special waste
  - ☐ other:
- ☐ Other Regulation:

B. Is your project subject to review under the Yukon Environmental & Socio-economic Assessment Act (YESAA)?

- ☑ yes: YESAA Project Number: Project numbers not yet assigned.
- ☐ no

❖ PART 4 – EMISSIONS AND SOURCE INFORMATION

A. Please provide a description of the type and quantity of the contaminants that may be released into the air. If available, provide (as an attachment) results of any stack tests that have been conducted on the emissions at source.

Please see attached permit renewal supporting document.

B. Provide (as an attachment) a set of plans/drawings of the facility clearly showing the layout of the following as they apply:

- The location of relevant process equipment,
- The point or points of discharge to the atmosphere,
- Building dimensions,
- Stack heights,
- The north and prevailing wind directions, and
- The scale or approximate scale of the drawing.

C. Provide (as an attachment) a map or aerial photograph, on a scale of 1:50,000 detailing the location of the facility, homes, buildings, roads and other adjacent facilities within a five kilometre radius of the source(s).

D. Provide a description of any measures to be taken to reduce the amount of air emissions released from the facility and/or the concentrations of contaminants in the air emissions.

Please see attached permit renewal supporting document.

E. Provide a description of any measures to be taken to measure and/or mitigate the effects of the release of air contaminants on the surrounding environment.

Please see attached permit renewal supporting document.

F. Provide a description of any equipment or devices the applicant intends to use to monitor the release of contaminants into the air at the point(s) of release. Include information on contaminants monitored, monitoring frequency, action levels and responses, and any other relevant information.

Please see attached permit renewal supporting document.

G. List staff certified to observe opacity:

Name of Staff	Training Institution	Date Last Trained
Ron Gee	YTG	2005

I, TRAVIS RITCHIE [print name clearly], am the authorized representative of YUKON ENERGY CORPORATION [business/person responsible for source or activity], and I certify that the information provided on this application form is correct and complete to the best of my knowledge.

All attachments and site-specific information forms comprise part of this application.

[signature]
Signature of applicant

Sept. 18/2008
Date

Number of attachments: 1

This information is being collected under the authority of Section 11 of the *Air Emissions Regulation.* For further information, contact the Environmental Programs Branch at (867) 667-5683 or toll free at 1-800-661-0408 extension 5683.

Applicant's initials [initials]

YUKON ENERGY

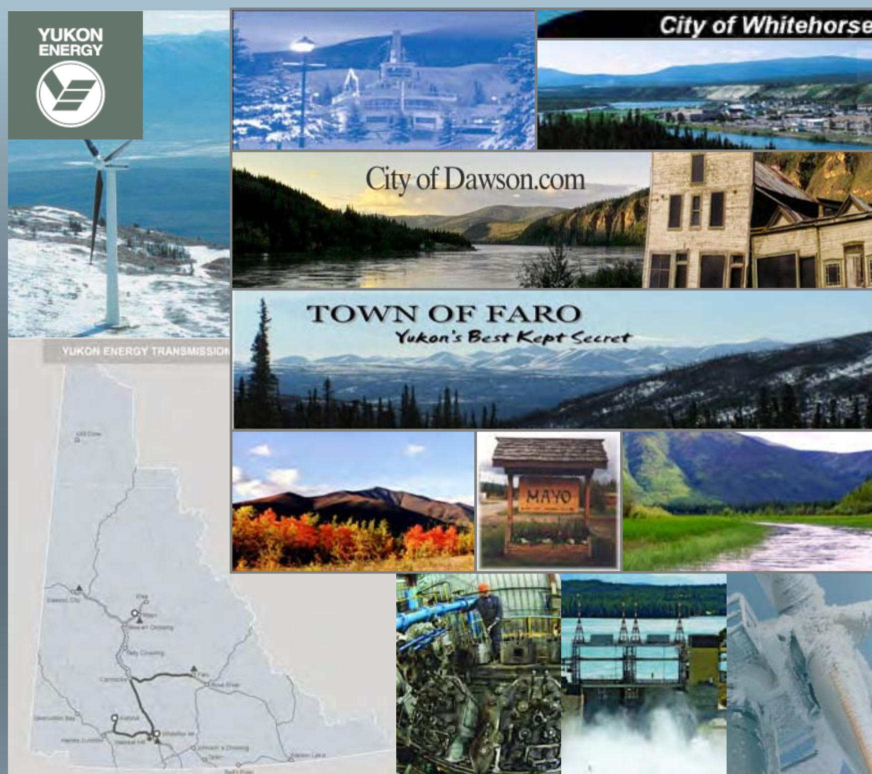
Air Emissions Permit (No. 4201-60-010)
Renewal Application Supporting Document

Appendix B

Report of Air Quality Assessment
for Yukon Energy Diesel Generator Operations
Prepared by SENES Consultants Ltd.

Final Report:

Air Quality Assessment For Yukon Energy Corporation Diesel Generator Operations



Prepared For:

Yukon Energy Corporation
#2 Miles Canyon Road
Whitehorse, Yukon Y1A 6S7

Prepared By:

SENES Consultants Limited

September 18, 2008

Air Quality Assessment
For Yukon Energy Corporation
Diesel Generator Operations

Prepared for:

Yukon Energy Corporation
#2 Miles Canyon Road
Whitehorse, Yukon Y1A 6S7

Prepared by:

SENES Consultants Limited
1338 West Broadway, Suite 303
Vancouver, B.C. V6H 1H2

18 September 2008

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EXECUTIVE SUMMARY

An air quality assessment was completed in support of the air emissions permit renewal application by the Yukon Energy Corporation (YEC) for diesel-powered generators in Whitehorse, Dawson City, Faro and Mayo. The components of the assessment included:

- emission inventories for the four communities in 2007 for the following contaminants:
  - Common Air Contaminants (CAC)
    - nitrogen oxides (NO_x)
    - carbon monoxide (CO)
    - volatile organic compounds (VOC)
    - sulphur oxides (SO_x)
    - inhalable particulate matter (PM_{10})
    - respirable particulate matter ($PM_{2.5}$)
    - ammonia (NH_4)
  - Greenhouse Gases (GHG)
    - carbon dioxide (CO_2)
    - methane (CH_4)
    - nitrous oxide (N_2O)
- air dispersion modelling of emissions from the YEC plant in Whitehorse based on three operational scenarios:
  - Scenario 1 - actual operations in 2007;
  - Scenario 2 - a hypothetical operating scenario assuming maximum daily operation expected over the next few years; and,
  - Scenario 3 - emergency operations with all seven stationary diesel generators running simultaneously;
- a summary of air quality monitoring data for Whitehorse during the period 2000-2005 based on the monitoring station in downtown Whitehorse operated by Environment Canada as part of the National Air Pollution Surveillance (NAPS) network; and,
- a screening-level human health risk assessment of the CAC emissions in Whitehorse for the three YEC power generation scenarios.

It should be noted that both Scenarios 2 and 3 represent short-term operations whose duration would last for only a few days at a time. However, in order to test the impact of such operations under all potential meteorological conditions that might prevail when such operational levels occur, the dispersion modelling analysis was run assuming the emission levels occur on every day of the year. As such, Scenarios 2 and 3 should not be construed as indicating a higher level of operation than would actually be expected to occur.

The community emission inventories compiled for this assessment indicate that YEC operations in all four communities generally contribute relatively small-to-insignificant amounts of emissions for both the CAC and GHG constituents. Most emissions in these communities are dominated by mobile sources and heating using either fuel oil or wood stoves. Table ES.1 summarizes the relative contribution of YEC emissions to total emissions in each community. With the exception of NO_x emissions, the contribution of YEC operations in 2007 to total community CAC emissions was less than 1%. For GHG emissions, YEC operations in Dawson City and Faro accounted for slightly over 2% of CO_2 and N_2O emissions, but less than 1% in Whitehorse and Mayo.

Table ES.1
YEC Emissions as a Percentage of Total Community Emissions in 2007

Contaminant	YEC Emissions / Total Community Emissions (%)			
	Whitehorse	Dawson City	Faro	Mayo
NO_x	1.02	15.16	16.46	3.68
CO	0.02	0.30	0.33	0.05
VOC	<0.01	0.27	0.24	0.05
SO_2	0.04	0.82	0.80	0.21
PM_{10}	0.01	0.23	0.29	0.06
$PM_{2.5}$	0.02	0.49	0.55	0.11
NH_3	0.00	0.00	0.00	0.00
CO_2	0.11	2.30	2.33	0.33
CH_4	0.00	0.07	0.00	0.00
N_2O	0.00	2.32	2.17	0.00

The available NAPS monitoring data in Whitehorse indicate that CO and NO_2 levels are well below the National Ambient Air Quality Objectives (NAAQO) defined by Environment Canada (EC) and the ambient air quality guidelines defined by the World Health Organization (WHO). SO_2 levels are not monitored in Whitehorse and are presumed to be low. For the available record of $PM_{2.5}$ monitoring data, ambient concentrations in three of the five years (2001-2003) were low and well within both the Canada-Wide Standard (CWS) and the WHO guideline. However, forest fires in the region in 2004 and 2005 resulted in much higher concentrations of both $PM_{2.5}$ and NO_2. Although both pollutants remained within the acceptable limits for the NO_2 NAAQO and the $PM_{2.5}$ CWS, the more stringent WHO guideline for $PM_{2.5}$ was exceeded in both years due to smoke from the forest fires.

Dispersion modelling was only completed for Whitehorse, where there was suitable meteorological data to conduct the modelling and ambient monitoring data to provide some measure of background concentrations to compare against the predicted impacts from YEC operations. The analysis shows that the highest air quality impacts for most contaminants are confined to the immediate vicinity of the power plant (i.e., <100 m from the property line) and channelled along the north/south axis of the Yukon River valley, in the direction of prevailing winds. The exception is NO_2 because this pollutant is formed in the atmosphere from the conversion of NO to NO_2 as the emission plume is transported downwind from the source. The highest predicted NO_2 concentrations in this analysis may in fact be an artefact of the conversion rates used in the analysis because the maxima are predicted to occur during cold weather in winter or early spring, and in the evening hours, when the conversion rates are likely to be lower than has been assumed in this analysis.

The dispersion analysis indicates that, when combined with background contaminant concentrations from other sources, the emissions from YEC in Whitehorse would not be expected to exceed the NAAQO for either SO_2 or CO, or to cause the non-attainment of the $PM_{2.5}$ CWS. Although the analysis does show that the NAAQO for NO_2 may be exceeded, particularly during periods of high background NO_2 such as during years with forest fires in the region, the predicted exceedences of the NAAQO may not be real (i.e., an artefact of the assumed NO to NO_2 conversion rate) and would require further analysis to verify.

In order to evaluate the potential impact of YEC emissions on the health of the general public, a screening-level risk assessment was conducted using the modelling analysis for Whitehorse which considered the predicted concentrations at six discrete receptor locations. Discrete receptors are commonly used in air quality assessments to look at the full distribution of predicted ambient concentrations at locations considered particularly sensitive to air contaminants, such as homes, schools and hospitals. The six sensitive receptors chosen for this assessment were as follows (approximate distance from YEC stacks shown in brackets):

1. nearest residence to the power plant located on the east side of the Yukon River (240 m);
2. Christ the King Elementary School (840 m);
3. Grey Mountain Primary School (1.3 km);
4. Frederick Collins Secondary School (1.4 km);
5. the Whitehorse General Hospital (2.2 km); and,
6. located at the plant property fenceline on the western river bank at the foot bridge over the Yukon River (75 m).

The screening-level human health risk assessment considered the predicted concentrations of CO, NO_2, SO_2 and $PM_{2.5}$ at these six locations, as well as at the location of the maximum point of impingement (Max POI). The Max POI includes any point in the modelling domain outside the property line of the YEC facility where the highest concentration is predicted to occur. The total ambient concentrations of CO, NO_2 and SO_2 (i.e., maximum predicted concentration from

YEC emissions plus background concentrations) were compared against health-based exposure limits. Since epidemiological studies of exposure to $PM_{2.5}$ have not identified a level below which no adverse health effects can be expected to occur, the potential adverse effects due to $PM_{2.5}$ were evaluated in terms of whether the YEC emissions could result in measurable impacts (i.e., incremental increases in ambient $PM_{2.5}$ concentrations greater than 1 $\mu g/m^3$). For measurable $PM_{2.5}$ concentrations, potential adverse health effects would be commensurate with exposure-response relationships established for exposure to $PM_{2.5}$ in epidemiological studies. (Note that measurable $PM_{2.5}$ concentrations do not necessarily mean that related health effects in the community would be statistically significant in terms of measurable health outcomes.)

For contaminants in diesel-fired generator combustion gases, some short-term adverse effects are generally associated with irritation of the tissues of the eyes, and upper and lower respiratory systems, all of which would be temporary and reversible effects once the exposure level is reduced. Therefore, the toxicity is dependent on the chemical concentration in the air rather than the total internal dose received by multiple exposure pathways. For CAC in combustion gases, exposure limits are represented by air quality guidelines/objectives and are used as exposure limits to assess potential health effects.

The results of the human health risk assessment are as follows:

- None of the short-term, health-based exposure limits would have been exceeded for CO, NO_2 and SO_2 for actual operations in 2007. Therefore, no short-term adverse health effects would be expected for these three CAC from operations of the diesel generators in that year.

- For the hypothetical operational Scenario 2, the short-term exposure limits for CO and SO_2 would have been met at all locations, as would the 24-hour average NO_2 exposure limit. However, the 1-hour average NO_2 exposure limit could be exceeded at the maximum POI in years with or without forest fires in the region, at receptor 6 in years with forest fires, but not at any of the other sensitive receptor locations under any circumstances. The degree to which the exposure limit would be exceeded, if at all, at the maximum POI may be overestimated based on the assumed rate of conversion of NO to NO_2 at this location.

- For the emergency operating Scenario 3, the short-term exposure limits for CO and SO_2 would also have been met at all locations. For NO_2 concentrations, the degree to which the NO_2 exposure limits may be exceeded depends to some degree on when emergency operations are likely to occur in years with and without forest fires in the region, namely:

- o the exposure limit for 24-hour average NO_2 concentrations would be met in all areas of Whitehorse in non-forest fire years (e.g., 2001-2003);
- o the maximum predicted 24-hour average NO_2 concentrations at the maximum POI, in conjunction with the highest background NO_2 during forest fire years, could come close to exceeding the exposure limit;
- o the exposure limit for 1-hour average NO_2 concentrations would be met at receptors 1-5 during non-forest fire years (e.g., 2001-2003), but not at receptor 6 or at the maximum POI;
- o in years with forest fires in the region, the 1-hour average NO_2 exposure limit could be exceeded at the maximum POI, at receptors 3 and 6, and could come close to being exceeded at receptors 1, 4 and 5 during periods of high background NO_2 concentrations;
- o the exceedence of the exposure limit for 1-hour average NO_2 concentrations at the maximum POI may be an artefact of the assumed conversion rate for NO to NO_2 with distance from the source used in the modelling analysis, and may overestimate the magnitude by which the exposure limit would be exceeded because the highest NO_2 concentrations are predicted to occur at a time of year when atmospheric conversion rates would be lower than has been assumed in this analysis. Furthermore, the exposure limit may not be exceeded at all if the need for emergency operations coincides with meteorological conditions that are favourable to good dispersion of emitted contaminants.

- No measurable short-term adverse health effects due to incremental short-term $PM_{2.5}$ exposure would be expected for YEC plant operations in 2007 at any location in Whitehorse (Scenario 1).

- A conservative, hypothetical estimate of the potential for short-term adverse health effects arising from exposure to $PM_{2.5}$ concentrations assuming daily operation of the generators at the maximum daily level in the foreseeable future (Scenario 2) could result in measurable concentrations at the nearest neighbour location only for a few days per year and at receptor 4 only for one day per year, but not anywhere else in Whitehorse. However, if Scenario 2 operations coincide with favourable meteorological conditions, then no measurable adverse effects due to exposure to $PM_{2.5}$ concentrations would be expected to occur at these locations. Furthermore, the WHO guideline value of 25 $\mu g/m^3$, which is more stringent than the CWS, would not be exceeded anywhere in Whitehorse in years without forest fires in the region. When forest fires were present in 2004 and 2005, the WHO guideline value was exceeded for 15 days in 2004 and 4 days in 2005 due to smoke from the fires alone. Except at the maximum POI, which is immediately adjacent to the YEC compound, neither the WHO guideline value nor the CWS parameter would be exceeded in non-forest fire years for Scenario 2 operations.

- Potential short-term adverse health effects due to $PM_{2.5}$ emissions from YEC operations could occur for emergency operations at the YEC plant (Scenario 3) when all seven engines are running simultaneously for a year. Measurable $PM_{2.5}$ concentrations could occur at several of the sensitive receptor locations, and the WHO guideline value could be exceeded at the maximum POI, and potentially at receptor 6. The magnitude of the potential $PM_{2.5}$ concentrations at these locations would depend on the meteorological conditions that prevail at the time that such operations occur. However, unless the YEC plant were to operate in emergency mode for the entire year, it is unlikely that the CWS parameter would be exceeded anywhere in the modelling domain.

In summary, no measurable short-term adverse health effects would be expected to occur as a result of emissions from actual YEC operations for the power generation rates experienced in 2007. There is a potential for the 1-hour average NO_2 exposure limit to be exceeded close to the power plant for the maximum expected daily power generation scenario in the future, but this would only occur at locations in the immediate vicinity of the plant, but not at any of the other sensitive receptor locations. Such future power generation levels could result in measurable levels of $PM_{2.5}$ at the nearest residence to the plant for a few days per year if the plant were to operate at that level of power generation every day of the year. More realistically, the plant would only operate at this level of power generation for a few days per year, and thus the potential for measurable levels of $PM_{2.5}$ would be reduced accordingly. The highest potential for emissions from the YEC operations to exceeded NO_2 exposure limits or to result in measurable $PM_{2.5}$ concentrations at sensitive receptor locations is related to operation of all seven stationary diesel generators simultaneously. Such operation would only be required in emergency situations, and only for a few days per year when the need arises.

While there exists the potential for short-term adverse health effects from YEC operations in specific circumstances of higher power generation rates for maximum daily operations or emergency generation situations, the potential for such effects to occur would depend to some extent on the background concentrations of NO_2 and the meteorological conditions that prevail at the time of the operations Such operations could result in measurable $PM_{2.5}$ concentrations at some of the sensitive receptor locations. However, because such operations would typically be restricted to only a few days of operation, the predicted $PM_{2.5}$ levels would not result in statistically significant short-term, adverse health outcomes.

The analysis indicates that no adverse health effects would be expected to occur from chronic exposure to YEC plant emissions from actual operations at the levels assumed for Scenario 1, and the relative contribution of $PM_{2.5}$ concentrations to annual average levels in Whitehorse is insignificant (i.e., 0.01 $\mu g/m^3$ from YEC emissions compared to the total annual average background concentration of 2.0 $\mu g/m^3$) even in years without forest fires. As such, no measurable adverse health effects would be expected for chronic exposure to $PM_{2.5}$ emissions from YEC operations at the levels assumed for Scenario 1. Emissions of both gaseous and particulate matter contaminants for Scenarios 2 and 3 are not relevant to chronic health effects because these levels of operation would only occur for a few days per year.

It should be noted that the air quality impact analysis presented in this report has not been considered within the context of the meaning of the term 'significant adverse effects' under the Yukon Environmental and Socio-economic Assessment Act (YESAA), Sections 56 (1). Any effects discussed in this report are only considered within the context of whether the predicted concentrations would be of a magnitude that could be measured and/or would result in statistically significant health effects.

1.0 INTRODUCTION

SENES Consultants Limited (SENES) was retained by the Yukon Energy Corporation (YEC) to prepare an air quality assessment in support of YEC's upcoming air emissions permit renewal application. The components of the study include the following:

- emission inventories for the communities of Whitehorse, Dawson City, Faro and Mayo including:
    - Common Air Contaminants (CAC)
        - nitrogen oxides (NO_x)
        - carbon monoxide (CO)
        - volatile organic compounds (VOC)
        - sulphur oxides (SO_x)
        - inhalable particulate matter (PM_{10})
        - respirable particulate matter ($PM_{2.5}$)
        - ammonia (NH_4)
    - Greenhouse Gases (GHG)
        - carbon dioxide (CO_2)
        - methane (CH_4)
        - nitrous oxide (N_2O)
- air dispersion modelling of emissions from the YEC plant in Whitehorse based on three operational scenarios:
    - actual operations in 2007;
    - a hypothetical operating scenario assuming maximum daily operation expected over the next few years; and,
    - emergency operations with all seven stationary diesel generators running simultaneously;
- a summary of air quality monitoring data for Whitehorse during the period 2000-2005 based on the monitoring station in downtown Whitehorse operated by Environment Canada as part of the National Air Pollution Surveillance (NAPS) network; and,
- a screening level human health risk assessment of the CAC emissions for the three YEC power generation scenarios.

It should be noted that neither Scenario 2 nor Scenario 3 represents an actual operating scenario as presented in this analysis. The dispersion modelling analysis was run assuming a constant rate of emissions in Scenarios 2 and 3 corresponding to maximum rates of power generation. Although YEC may run the generators in these two modes for a few days at a time, these two scenarios do not represent realistic operating scenarios in the sense that it is not in YEC's reasonable expectation that the Whitehorse diesel facilities would actually be operated at the levels contemplated in Scenario 2 or Scenario 3 every day for the entire year. Rather, Scenarios 2 and 3 have been examined by SENES on a hypothetical basis, in order to test the effect of YEC's operations under all potential meteorological conditions occurring throughout a full calendar year. This should not be interpreted to mean that YEC actually expects that either of these scenarios could realistically be expected to occur during the 2009-2011 period.

The results of the emission inventories for the four communities are summarized in Section 2, with more detailed information in Appendix A. The air dispersion modelling analysis is presented in Section 3. The ambient air quality data for Whitehorse is summarized in Section 4. Section 5 provides a discussion of the potential implications of YEC emissions in Whitehorse for human health based on screening level risk assessment methods. A discussion of sources of uncertainty in the dispersion modelling analysis is presented in Section 6. The results of this assessment are summarized in Section 7.

1.1 YEC Thermal Power Generation

YEC operates a total of 19 diesel-powered generators in the four communities:

- eight in Whitehorse (including one mobile unit);
- six in Dawson City (including one mobile unit);
- three in Faro; and,
- two in Mayo.

Figure 1.1 shows the total amount of thermal power generated by YEC units over the period 1996-2007. The total thermal power generation over this period has declined from a peak of 118,111 megawatt hours (MWh) in 1996 to 580 MWh in 2005. Major decreases in thermal power generation occurred after 1997 and 2003. The reduction in operations in 1997 was due to the closure of the Faro Mine, while the reduction in 2003 occurred after the installation of transmission lines between Dawson City and Mayo, which allowed the transmission of hydro power to Mayo, and resulted in the reduced need for power generation using diesel generators in Mayo. Total production for 2007, the year for which the emission inventory was calculated in this report (Section 2.0), saw total thermal power generation of 1,220 MWh.

Figure 1.2 shows the proportion of thermal power generated in each of the four communities in 2007. On an annual basis, 60% of the thermal power was generated in Dawson City, while another 30% was generated in Whitehorse. Only 8.7% of the thermal power was generated in Faro, and less than 2% was generated in Mayo. The peak period of generation was in the summer months of July through September at both Dawson City and Whitehorse. The lowest period of generation was in the April to June time frame.

Figure 1.3 shows the thermal power generation rates at the four communities on a monthly basis. The data indicate a high degree of month-to-month variability in generation for all four generating sites, but especially at Whitehorse and Dawson City due to the much higher rates of power generation at these two facilities. This variability was incorporated into the emission inventory presented in Section 2.0 of this report, as well as into operating Scenario 1 for Whitehorse presented in Section 3.0.

Figure 1.1:
Historical Trend in YEC Thermal Power Generation

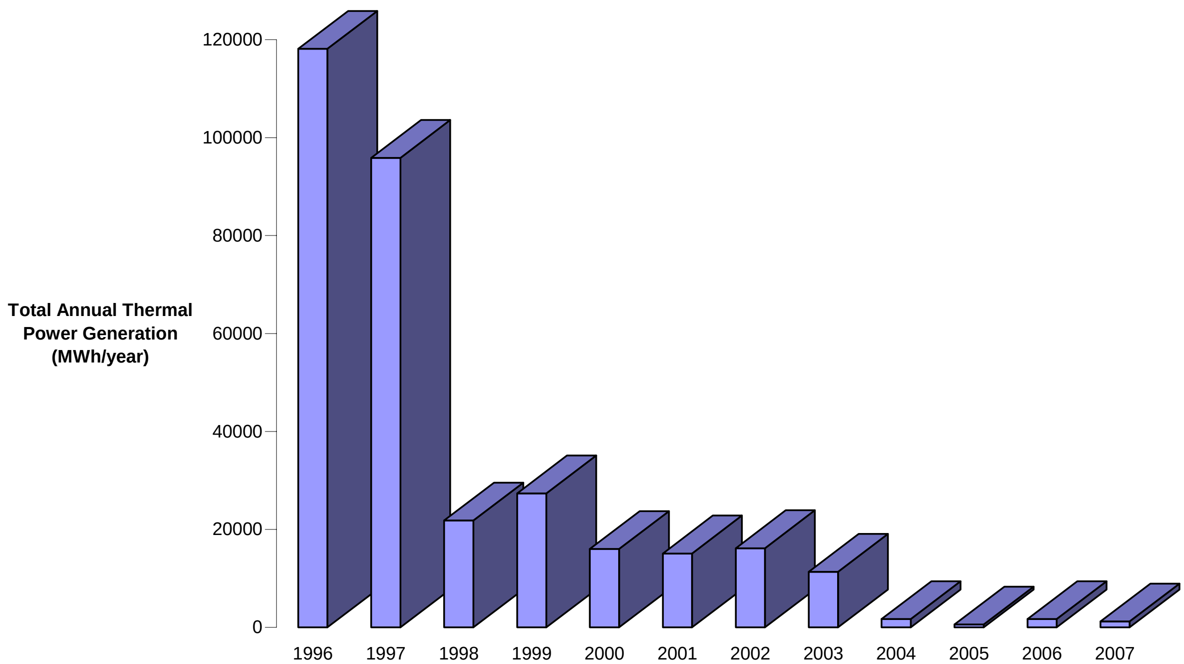


Figure 1.2: Seasonal Thermal Power Generation Rates in 2007

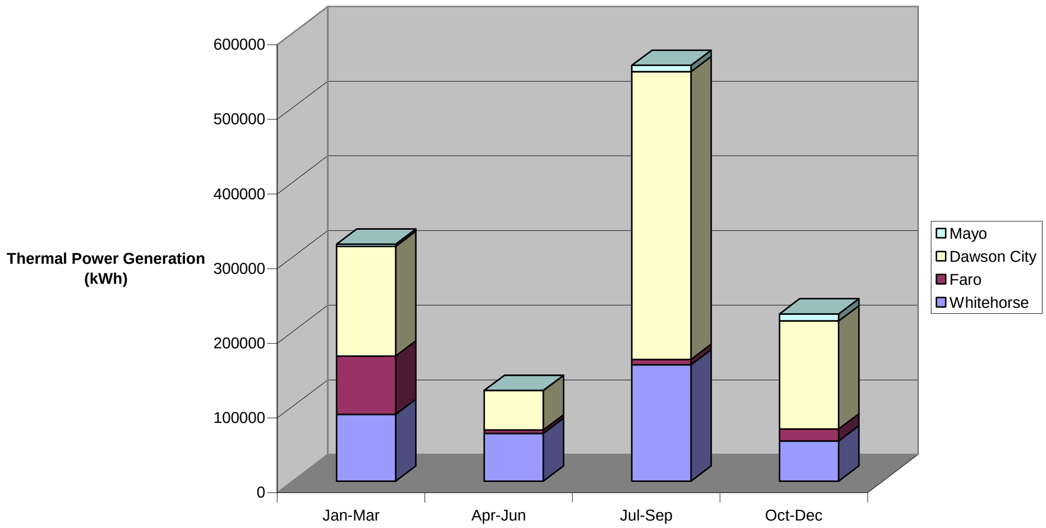
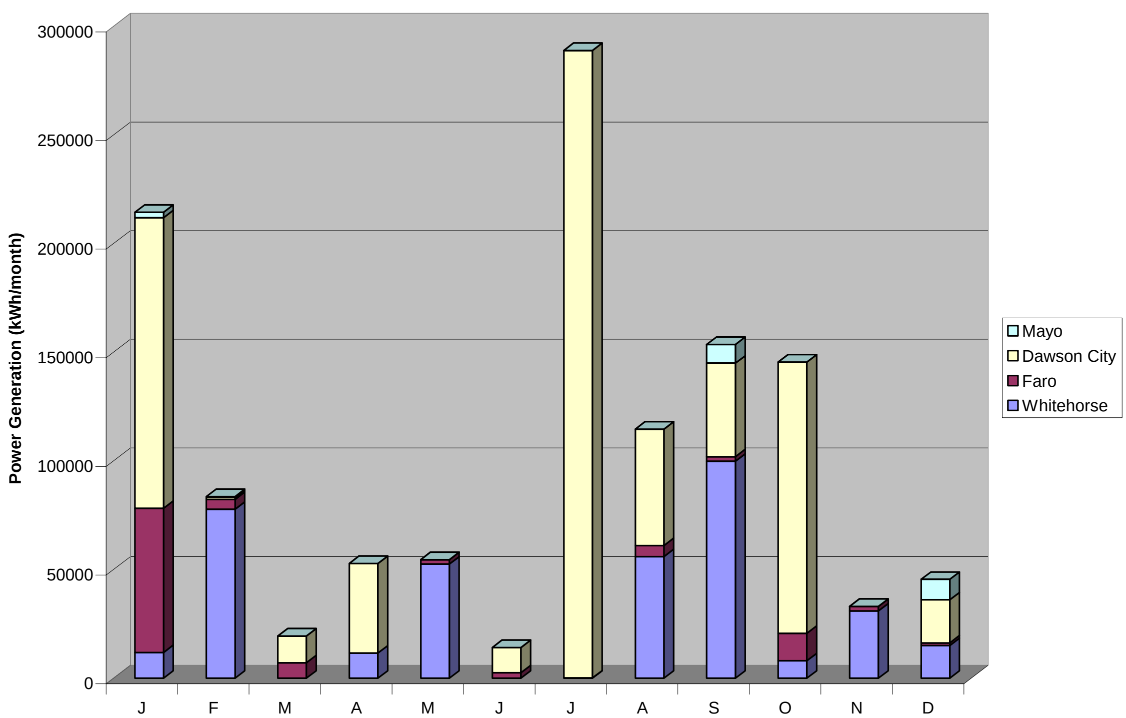


Figure 1.3: Monthly Thermal Power Generation Rates in 2007



2.0 EMISSION INVENTORY

Community air emission inventories have been developed for the City of Whitehorse, Dawson City, the Town of Faro and the Town of Mayo. These inventories provide a backdrop for understanding the role and relationship of individual emission sources within the communities. The inventories presented in this report represent an activity based emission inventory for the year of 2006, which was chosen as a sample year due to the availability of data. The overall emissions from the activity within the communities would not significantly differ for 2005 or 2007.

The annual emission tables within this section summarize approximately 120 unique sources (listed in Table 2.1) for each community for a series of Common Air Contaminants (CAC) and Greenhouse Gas (GHG) Emissions. Not every community has every emission source, particularly the smaller communities, and adjustments in the inventories were done accordingly. Using the standard practice of grouping the emission sources into area, mobile and point sources, the contributions from each source grouping can be easily viewed. Appendix A contains the specific details on methodology, sources of data, and complete table of emission factors for Whitehorse.

One slight deviation from standard emission inventory practices is that the electrical energy supplied to the community is generally attributed as an area source evenly disbursed through the community. Because YEC maintains specifics on the emissions from the diesel generators, these emissions have been attributed within the inventory as a point source (stack emissions). The rest of electrical power comes from hydro or wind production, and thus effectively does not contribute any air emission. Figure 2.1 reports electrical power generation by YEC from the diesel generators providing an indication of variability from year to year. The developed emission inventories represent community activities for 2006 and diesel energy production for 2007 which supports the more detailed modelling later in this report. A discussion of year-to-year variability in operations and its significance is provided at the end of this section.

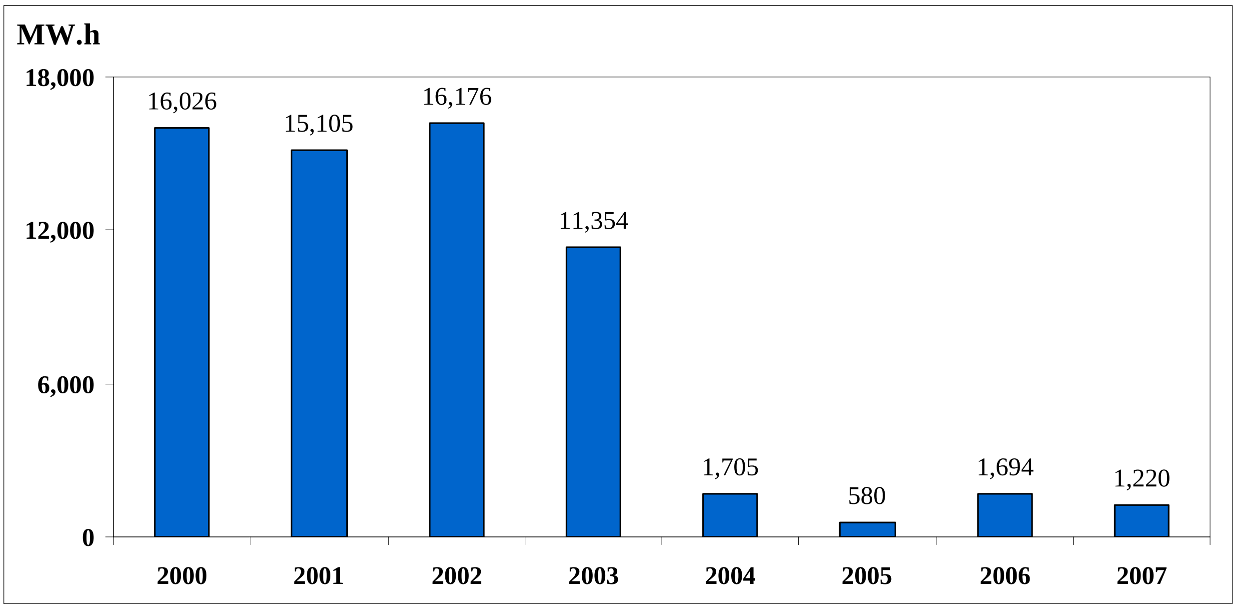
The summary tables of the emission inventories presented within this report are generated from a database tool, also provided to YEC as part of the project, and should be referenced for additional details on community activity and emission factors. Compiling the inventory data within a single dynamic tool provides the user additional features beyond basic reporting, specifically:

- Seasonal allocation of the emissions throughout the year; Winter (Jan-Mar), Spring (Apr-Jun), Summer (Jul-Sep), and Fall (Oct-Dec).
- Dynamic tools for graphing and extracting specific details of the emissions inventory for additional insight.

- Option to change the activity levels in the future as additional knowledge is gained about the community or to assess different policy scenarios.
- Management of uncertainty propagation for activity levels and emission factors providing additional context for emissions to aid in understanding the inventory implications for the community.
- Transparency of inventory development methods and ease of sharing information.

Figure 2.1

Yukon Energy Thermal (diesel) Electrical Production (2000-2007)



Note: The reduction in emissions after 2003 resulted from the completion of a transmission line between Dawson City and Mayo, which reduced the need for diesel-powered generation in Dawson City because the power can now be supplied from hydro generation sources.

In general, two significant sources of emission are present within the Yukon communities; the use of wood as a primary heating fuel and the significant influx of travellers both by automobile and air travel. These sources fluctuate seasonally and are presented in the last part of this section providing some additional insight into the impacts of community activities on air quality. Historically, the Yukon has consumed a significant amount of wood for heating both residential and commercial buildings and wood-burning appliances are represented within the Area Category of Heating Sources. The large influx of travellers through the Yukon during the spring and summer months is represented within the mobile category of Highway Traffic and Airport sources.

Table 2.1: Community Emission Sources

	Category	Source
AREA	**Agricultural**	Land Clearing
		Land Fertilizer
		Land Manure
		Land Pesticide
		Land Soil Erosion
		Land Tillage
	Heating	Fuel Oil-Diesel
		Fuel Oil-Light
		Kerosene
		Wood Advanced
		Wood Conventional
		Wood Fireplace
		Wood Furnace
	Miscellaneous	Landfill
		Architectural Coatings
		Auto Refinishing
		Bakeries
		Consumer Products
		Cooking Meat
		Dry Cleaning
		Fuel Market
		Glues General
		Industrial Coatings
		Metal Degreasing
		Perspiration-cat
		Perspiration-dog
		Perspiration-human
		Printing Inks
	Fugitive Dust	Alaska Highway
		Local Paved Road
		Local Unpaved Road

	Category	Source
MOBILE	**Agricultural**	Baler
		Combine
		Irrigation Equip
		Mower
		Sprayer
		Swather
		Tiller
		Tractor
	Construction	Loader
		Excavator
		Bull Dozer
		Truck – Off-road
		Backhoe
		Forklift
		Loader Skid
		Roller
		Grader
		Trencher
		Paver
		Bore Drill
		Saw
		Crusher
		Signal Board
		Mixer
		Surface Equip
		Compactor
		Tamper
		Dump Truck
	Residential	Mower
		Snow Blower
		Mower- Ride
		Trimmer
		Tiller
		Leaf Blower
		Chain Saw
	Recreational	Snow Machine
		ATV
		Golf Cart
		General
		Dirt Bike

	Category	Source
MOBILE	**Industrial**	Refrigeration Unit
		Sweeper
		Material Handling
		Aerial Lift
		Forklift
		Truck - Large
	Commercial	Generator
		Welder
		Compressor Air
		Pressure Washer
		Pump
		Chipper
		Turf Equip
		Mower
		Leaf Blower
		Tractor L/G
		Tiller
		Chain Saw
		Trimmer
		Snow Blower
		Hydraulic Power
		Shedder
		Compressor Gas
		Mower - Ride
	Mobile Traffic	Truck Light
		Passenger Car
		Truck Heavy
		Truck Medium
		Bus
		Motorcycle
	Airport	General Aviation
		Commercial Aviation
		Helicopter
		Ground Support
POINT	**Industrial Facilities**	Asphalt Batch Plant
		Concrete Batch Plant
		Hospital
		Sand & Gravel Supply
	Energy Production	Yukon Energy Diesel Generators

2.1 CITY OF WHITEHORSE

The City of Whitehorse contains the majority of the population within the Yukon and represents the foundation for development of the emission inventories. The airshed boundary identified for the emission inventory uses the boundaries identified in the Official Community Plan which was available from the city web site. The following are points of interest for the inventory:

- Within the city boundary. there is very little agricultural activity both for agricultural practices and equipment usage.
- Four point sources have been identified: the General Hospital, the Sand & Gravel supply north of town, the local Asphalt Batch Plant, and the Concrete Batch plant, in addition to the YEC generators.
- The highway traffic accounts for vehicles travelling along a 36 km stretch of the Alaskan Highway.
- A population of 23,751 was estimated for the inventory year.
- A total of 27,525 flights were recorded between the two airports.
- A total of 24,600 cords of wood were estimated to have been burned during the year.

Table 2.2: Annual Emissions (tonnes) in Whitehorse

Emission Sources		NO_X	CO	VOC	SO_X	PM_{10}	$PM_{2.5}$	NH_3	CO_2	CH_4	N_2O
Area	Agricultural	0.00	0.0	0.0	0.0	0.0	0.00	0.00	0	0.0	0.00
	Heating	142.57	2,299.7	647.7	255.7	424.2	422.67	12.62	131,040	302.8	5.54
	Miscellaneous	0.00	0.0	377.3	0.0	2.1	2.14	20.33	15,321	5,583.9	0.00
	Fugitive Dust (T) *	-	-	-	-	197.5	43.91	-	-	-	-
	Fugitive Dust (S) *	-	-	-	-	295.3	0.00	-	-	-	-
	Total	142.57	2,299.7	1,025.1	255.7	919.1	468.72	32.95	146,361	5,886.7	5.54
Mobile	Agricultural Equip	0.12	0.8	0.0	0.0	0.0	0.01	0.00	10	0.0	0.00
	Commercial Equip	10.94	674.6	29.9	0.9	1.5	1.43	0.03	1,711	1.5	0.20
	Construction Equip	85.29	157.4	14.2	11.8	7.7	7.45	0.14	8,639	0.7	3.39
	Industrial Equip	1.30	3.9	0.2	0.2	0.1	0.11	0.00	136	0.0	0.05
	Residential Equip	0.76	119.5	15.9	0.0	0.4	0.34	0.00	236	0.3	0.01
	Recreational Equip	1.30	246.0	69.3	0.2	1.8	1.69	0.02	995	1.1	0.02
	Highway Traffic	29.58	284.8	21.4	0.3	0.7	0.49	0.83	5,729	1.2	1.30
	Local Traffic	251.02	2,280.0	158.8	2.9	6.4	4.58	8.87	56,611	9.0	13.29
	Airport	2.28	166.7	0.0	0.3	3.8	3.62	0.10	9,821	8.3	2.77
	Total	382.61	3,933.6	309.9	16.6	22.5	19.74	9.98	83,888	22.2	21.04
Point	Energy Production	5.54	1.3	0.1	0.0	0.1	0.10	0.00	258	0.0	0.04
	Industrial Facilities	9.40	18.8	7.8	6.3	32.4	14.73	0.00	0	0.0	0.00
	Total	14.94	20.1	8.0	6.3	32.5	14.83	0.00	258	0.0	0.04
	Grand Total	**540.12**	**6,253.3**	**1,342.9**	**278.6**	**974.0**	**503.29**	**42.93**	**230,508**	**5,908.9**	**26.62**

* (S) and (T) distinguish between Suspendable and Transportable particulate matter from fugitive dust

2.2 DAWSON CITY

Dawson City contains a small fraction of the population within the Yukon and its inventory utilizes scaled activity from the Whitehorse inventory in situations where local data were not available. The following are points of interest for the inventory:

- Within the inventory bounds, there is very little agricultural activity both for land use activity and agricultural equipment usage.
- A single point source representing Sand & Gravel supply is included, in addition to the YEC power plant.
- The highway traffic accounts for vehicles travelling along a 20 km stretch of the Klondike Highway.
- A population of 1,813 was estimated for the inventory year.
- total of 5,567 flights were recorded at the local airport, located approximately 15 km east of town and are included for comparison to the other communities.
- A total of 2,201 cords of wood were estimated to have been burned during the year.

Table 2.3: Annual Emissions (tonnes) in Dawson City

Emission Sources		NO_X	CO	VOC	SO_X	PM_{10}	$PM_{2.5}$	NH_3	CO_2	CH_4	N_2O
Area	Agricultural	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0	0.00	0.00
	Heating	11.75	205.48	57.88	20.50	37.87	37.75	1.084	10,484	27.00	0.49
	Miscellaneous	0.00	0.00	10.48	0.00	0.16	0.16	1.289	0	0.00	0.00
	Fugitive Dust (T) *	-	-	-	-	22.14	4.32	-	-	-	-
	Fugitive Dust (S) *	-	-	-	-	33.09	0.00	-	-	-	-
	Total	11.75	205.48	68.36	20.50	93.26	42.23	2.373	10,484	27.00	0.49
Mobile	Agricultural Equip	0.05	0.32	0.02	0.00	0.00	0.00	0.000	4	0.00	0.00
	Commercial Equip	0.82	47.88	2.18	0.06	0.12	0.11	0.002	125	0.11	0.02
	Construction Equip	5.45	9.97	0.93	0.76	0.51	0.50	0.009	556	0.04	0.22
	Industrial Equip	0.13	0.39	0.02	0.02	0.01	0.01	0.000	14	0.00	0.01
	Residential Equip	0.06	8.93	1.19	0.00	0.03	0.03	0.000	18	0.02	0.00
	Recreational Equip	0.10	18.42	5.48	0.02	0.14	0.13	0.001	78	0.09	0.00
	Highway Traffic	23.08	222.19	16.69	0.24	0.54	0.39	0.645	4,470	0.96	1.01
	Local Traffic	19.53	181.59	12.64	0.22	0.50	0.35	0.707	4,424	0.72	1.06
	Airport	0.33	28.00	0.02	0.03	0.46	0.42	0.024	1,543	1.67	0.56
	Total	49.54	517.68	39.17	1.35	2.31	1.93	1.389	11,231	3.62	2.88
Point	Energy Production	10.95	2.92	0.29	0.02	0.18	0.18	0.000	511	0.02	0.08
	Industrial Facilities	0.00	0.00	0.00	0.00	15.48	9.06	0.000	0	0.00	0.00
	Total	10.95	2.92	0.29	0.02	15.66	9.24	0.000	511	0.02	0.08
	Grand Total	**72.24**	**726.08**	**107.83**	**21.88**	**111.23**	**53.41**	**3.762**	**22,227**	**30.64**	**3.45**

* (S) and (T) distinguish between Suspendable and Transportable particulate matter from fugitive dust

2.3 TOWN OF FARO

The Town of Faro contains a small fraction of the population within the Yukon and its inventory utilizes scaled activity from the Whitehorse inventory in situations where local data were not available. The following are points of interest for the inventory:

- Within the inventory bounds there is very little agricultural activity both for land use activity and agricultural equipment usage.
- There was no significant point source identified for Faro other than the YEC power plant.
- The highway traffic accounts for vehicles travelling along a 15 km stretch of the Campbell Highway.
- A population of 388 was estimated for the inventory year.
- A total of 786 flights were recorded at the local airport.
- A total of 367 cords of wood were estimated to have been burned during the year.

Table 2.4: Annual Emissions (tonnes) in Faro

Emission Sources		NO_X	CO	VOC	SO_X	PM_{10}	$PM_{2.5}$	NH_3	CO_2	CH_4	N_2O
Area	Agricultural	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.0	0.000	0.000
	Heating	1.96	34.26	9.66	3.42	6.32	6.30	0.181	1,746.1	4.501	0.082
	Miscellaneous	0.00	0.00	2.24	0.00	0.03	0.03	0.336	0.0	0.000	0.000
	Fugitive Dust (T) *	-	-	-	-	2.80	0.60	-	-	-	-
	Fugitive Dust (S) *	-	-	-	-	4.18	0.00	-	-	-	-
	Total	1.96	34.26	11.90	3.42	13.33	6.94	0.517	1,746.1	4.501	0.082
Mobile	Agricultural Equip	0.02	0.16	0.01	0.00	0.00	0.00	0.000	2.0	0.001	0.001
	Commercial Equip	0.25	11.98	0.56	0.02	0.03	0.03	0.000	34.9	0.029	0.005
	Construction Equip	1.46	2.60	0.24	0.20	0.14	0.13	0.002	148.8	0.011	0.058
	Industrial Equip	0.08	0.05	0.01	0.01	0.01	0.01	0.000	9.3	0.001	0.004
	Residential Equip	0.01	1.84	0.25	0.00	0.01	0.01	0.000	3.6	0.004	0.000
	Recreational Equip	0.02	3.10	1.15	0.00	0.03	0.03	0.000	15.2	0.017	0.000
	Highway Traffic	0.98	9.46	0.71	0.01	0.02	0.02	0.028	190.4	0.041	0.043
	Local Traffic	3.21	30.18	2.10	0.04	0.08	0.06	0.117	730.0	0.120	0.176
	Airport	0.08	4.02	0.01	0.01	0.07	0.06	0.003	221.0	0.236	0.081
	Total	6.12	63.40	5.03	0.30	0.39	0.34	0.150	1,355.2	0.459	0.367
Point	Energy Production	1.59	0.42	0.04	0.00	0.03	0.03	0.000	74.0	0.004	0.011
	Industrial Facilities	-	-	-	-	-	-	-	-	-	-
	Total	1.59	0.42	0.04	0.00	0.03	0.03	0.000	74.0	0.004	0.011
	Grand Total	**9.66**	**98.08**	**16.97**	**3.72**	**13.74**	**7.30**	**0.667**	**3,175.3**	**4.964**	**0.461**

* (S) and (T) distinguish between Suspendable and Transportable particulate matter from fugitive dust

2.4 VILLAGE OF MAYO

The Village of Mayo contains a small fraction of the population within the Yukon and its inventory utilizes scaled activity from the Whitehorse inventory in situations where local data were not available. The following are points of interest for the inventory:

- Within the inventory bounds there is very little agricultural activity both for land use activity and agricultural equipment usage.
- There were no significant point sources identified for Mayo, other than the YEC power plant.
- The highway traffic accounts for vehicles along a 25 km stretch of Highway 11.
- A population of 409 was estimated for the inventory year.
- A total of 4,377 flights were recorded at the local airport.
- A total of 470 cords of wood were estimated to have been burned during the year.

Table 2.5: Annual Emissions (tonnes) in Mayo

Emission Sources		NO_X	CO	VOC	SO_X	PM_{10}	$PM_{2.5}$	NH_3	CO_2	CH_4	N_2O
Area	Agricultural	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.0	0.000	0.000
	Heating	2.52	43.88	12.37	4.39	8.09	8.07	0.232	2,246.1	5.765	0.105
	Miscellaneous	0.00	0.00	2.36	0.00	0.04	0.04	0.342	0.0	0.000	0.000
	Fugitive Dust (T) *	-	-	-	-	2.75	0.60	-	-	-	-
	Fugitive Dust (S) *	-	-	-	-	4.11	0.00	-	-	-	-
	Total	2.52	43.88	14.73	4.39	14.98	8.70	0.574	2,246.1	5.765	0.105
Mobile	Agricultural Equip	0.02	0.16	0.01	0.00	0.00	0.00	0.000	2.0	0.001	0.001
	Commercial Equip	0.24	11.81	0.55	0.02	0.03	0.03	0.000	34.5	0.028	0.005
	Construction Equip	1.27	2.30	0.21	0.17	0.12	0.12	0.002	128.1	0.010	0.050
	Industrial Equip	0.08	0.05	0.01	0.01	0.01	0.01	0.000	9.3	0.001	0.004
	Residential Equip	0.01	1.84	0.25	0.00	0.01	0.01	0.000	3.6	0.004	0.000
	Recreational Equip	0.02	3.10	1.15	0.00	0.03	0.03	0.000	15.2	0.017	0.000
	Highway Traffic	0.82	7.89	0.59	0.01	0.02	0.01	0.023	158.7	0.034	0.036
	Local Traffic	3.21	30.18	2.10	0.04	0.08	0.06	0.117	730.0	0.120	0.176
	Airport	0.19	23.01	0.01	0.02	0.36	0.32	0.019	1,205.6	1.314	0.440
	Total	5.87	80.34	4.88	0.27	0.65	0.58	0.161	2,287.0	1.528	0.712
Point	Energy Production	0.32	0.08	0.01	0.00	0.01	0.01	0.000	14.7	0.001	0.002
	Industrial Facilities	-	-	-	-	-	-	-	-	-	-
	Total	0.32	0.08	0.01	0.00	0.01	0.01	0.000	14.7	0.001	0.002
	Grand Total	**8.70**	**124.30**	**19.62**	**4.67**	**15.64**	**9.29**	**0.735**	**4,547.8**	**7.294**	**0.819**

* (S) and (T) distinguish between Suspendable and Transportable particulate matter from fugitive dust

2.5 SIGNIFICANT EMISSIONS

For the purposes of examining the relationship between the emissions from certain sectors during the course of the year, a select set of sources have been extracted from the database tool for the City of Whitehorse across the four seasons. The common air contaminants of NO_x and VOC have been selected for Table 2.6 because these contaminants are important to the formation of ground-level ozone, while NO_x, SO_x and $PM_{2.5}$ are important contaminants derived from heating (fuel oil and wood) and the seasonal transportation activities. $PM_{2.5}$ and SO_x emissions are presented in Table 2.7. Of note within Tables 2.6 and 2.7 are the significant VOC and $PM_{2.5}$ emissions from conventional wood stoves. Only the transportable fugitive dust has been included for this comparison as it is the more relevant fraction of dust emissions since it can be carried a significant distance from the source.

Tables 2.6 and 2.7 indicate that the contribution of YEC diesel generator emissions to total emissions of these four contaminants in Whitehorse is relatively small-to-insignificant in all seasons. Emissions are dominated by wood stoves, mobile sources and heating using diesel, light oil and kerosene.

Table 2.6

Seasonal Emissions (VOC, NO_X), Specific Sources

Emission Sources			VOC (tonnes)				NO_X (tonnes)			
Category		Source	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Area	Heating (fuels)	Fuel oil – Diesel	1.11	0.38	0.21	0.66	28.62	9.74	5.48	17.05
		Fuel oil – Light	0.30	0.10	0.06	0.18	7.77	2.65	1.49	4.63
		Kerosene	0.45	0.13	0.13	0.45	11.09	3.13	3.13	11.09
	Heating (wood)	Advanced Stove	20.71	7.05	3.97	12.34	4.14	1.41	0.79	2.47
		Conventional Stove	205.64	70.01	39.38	122.51	8.11	2.76	1.55	4.83
		Fireplace	15.75	5.36	3.02	9.38	1.04	0.35	0.20	0.62
		Furnace	60.38	20.56	11.56	35.97	3.97	1.35	0.76	2.36
	Fugitive Dust (T) *	Alaska Highway	-	-	-	-	-	-	-	-
		Local Paved	-	-	-	-	-	-	-	-
		Local Unpaved	-	-	-	-	-	-	-	-
Mobile		Recreational Vehicles	33.45	13.48	13.65	8.69	0.38	0.35	0.36	0.22
		Airport Landing and Takeoffs	0.01	0.02	0.01	0.01	0.27	1.01	0.75	0.24
		Highway Traffic	2.93	8.60	7.14	2.72	4.12	11.85	9.79	3.82
		Local Traffic	39.21	40.11	40.30	39.21	58.73	66.72	66.84	58.73
Point	Energy	YEC-Genset	0.04	0.03	0.06	0.02	1.38	1.00	2.23	0.83

* (S) and (T) distinguish between Suspendable and Transportable particulate matter from fugitive dust

Table 2.7

Seasonal Emissions ($PM_{2.5}$, SO_X), Specific Sources

Emission Sources			$PM_{2.5}$ (tonnes)				SO_X (tonnes)			
Category		Source	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Area	Heating (fuels)	Fuel oil – Diesel	1.31	0.45	0.25	0.78	67.74	23.06	12.97	40.35
		Fuel oil – Light	0.36	0.12	0.07	0.21	18.39	6.26	3.52	10.95
		Kerosene	0.53	0.15	0.15	0.53	26.19	7.39	7.39	26.19
	Heating (wood)	Advanced Stove	14.20	4.83	2.72	8.46	0.59	0.20	0.11	0.35
		Conventional Stove	134.39	45.75	25.73	80.06	1.16	0.39	0.22	0.69
		Fireplace	10.06	3.42	1.93	5.99	0.15	0.05	0.03	0.09
		Furnace	37.70	12.83	7.22	22.46	0.57	0.19	0.11	0.34
	Fugitive Dust (T) *	Alaska Highway	0.16	0.46	0.38	0.15	-	-	-	-
		Local Paved	0.00	5.31	5.31	0.00	-	-	-	-
		Local Unpaved	0.00	16.07	16.07	0.00	-	-	-	-
Mobile		Recreational Vehicles	0.72	0.36	0.40	0.22	0.11	0.04	0.03	0.03
		Airport Landing and Takeoffs	0.62	1.41	1.05	0.54	0.04	0.15	0.11	0.04
		Highway Traffic	0.07	0.20	0.16	0.06	0.04	0.12	0.10	0.04
		Local Traffic	1.02	1.27	1.27	1.02	0.64	0.79	0.79	0.64
Point	Energy	YEC-Genset	0.03	0.02	0.04	0.02	0.00	0.00	0.00	0.00

* (S) and (T) distinguish between Suspendable and Transportable particulate matter from fugitive dust

Examining the variability of year-to-year electrical diesel generation for 2005, 2006 and 2007 provides additional context to the overall impact for the communities over the longer term. As was stated earlier, the community activity is based upon the 2006 calendar year and would reasonably represent the 2005 and 2007 inventory years, as well. Table 2.8 lists the total emissions from the YEC diesel generators throughout the Yukon and shows that the selected 2007 activity for the generators is representative of emissions from operations in recent years.

Table 2.8
Annual Year-to-Year Generator Emissions for the Yukon

Emissions (Tonnes)		NO_X	CO	VOC	SO_X	PM_{10}	$PM_{2.5}$	NH_3	CO_2	CH_4	N_2O
All Four Communities Combined	2005	8.70	2.32	0.23	0.01	0.14	0.14	0.00	406	0.02	0.06
	2006	25.41	6.78	0.68	0.04	0.42	0.42	0.00	1,186	0.06	0.17
	2007	18.30	4.88	0.49	0.03	0.30	0.30	0.00	854	0.04	0.13

2.6 SUMMARY

The community emission inventories compiled for this assessment indicate that YEC operations in all four communities contribute relatively small amounts of emissions for both the CAC and GHG constituents. Most emissions in these communities are dominated by mobile sources and heating using either fuel oil or wood stoves. It should be noted, however, that the actual fuel oil and wood usage in each community is uncertain. Fuel oil usage is known for the Yukon as a whole, and the proportion assumed to be used in each of the four communities was allocated evenly on a per capita basis. Similarly, the proportion of households that use wood for heating was assumed to be the same in each community. In the absence of actual data on fuel usage for heating, this was the most reasonable assumption to make, but it may not reflect reality in all cases. Any detailed emission inventory assessment conducted for one of the communities in the future should re-assess the fuel usage amounts presented in this report, if possible.

2.6.1 City of Whitehorse

The emission inventory compiled for Whitehorse indicates that the operations of the YEC diesel generators contribute relatively little to the overall emissions in the city (i.e., 1% for NO_x and much less for all other CAC and GHG considered in this inventory).

Mobile sources are the dominant sources of NO_x and CO emissions. SO_x and combustion-related $PM_{2.5}$ are primarily derived from heating using fuel oil or wood stoves. Approximately 93% of the CO_2 emissions are also derived from heating and mobile sources combined, while 94% of the CH_4 emissions are derived from the municipal landfill.

2.6.2 Dawson City

Approximately 15% of the NO_x emissions in Dawson are derived from the YEC diesel generator operations. The remainder of the NO_x is emitted by on-road vehicles, construction equipment and fuel oil used for heating. The YEC operations also contribute about 2% of the CO_2 emissions in the city, but all other pollutant emissions are less than 1% of total emissions from all sources.

Over 70% of the CO emissions are attributed to mobile sources, while 93% of the SO_x emissions and 70% of the $PM_{2.5}$ emissions are derived from fuel oil or wood used for heating. Almost all of the CO_2 emissions are attributed to heating and mobile sources, while 88% of the CH_4 is derived from heating alone.

2.6.3 Town of Faro

Similar to Dawson City, the YEC operations in Faro contribute about 16% of the total NO_x emissions and 2% of the CO_2 emissions. The YEC contribution for all other contaminant emissions is less than 1%.

Virtually all of the CO, CO_2 and CH_4 emissions in Faro are derived from mobile sources and heating using fuel oil, while 84% of the NO_x emissions are also attributed to these two sources. 95% of the $PM_{2.5}$ emissions are also derived from heating.

2.6.4 Village of Mayo

YEC operations in Mayo contribute less than 4% of the total NO_x emissions in the community, and insignificant amounts of emissions for all other contaminants considered in this inventory.

Mobile sources and fuel oil use for heating accounts for virtually all of the NO_x, CO, CO_2 and CH_4 emissions in Mayo. In addition, heating accounts for 94% of the SO_x emissions and 87% of the $PM_{2.5}$ emissions.

3.0 DISPERSION MODELLING ANALYSIS FOR WHITEHORSE

A diesel generator can be defined as a diesel engine linked to an electrical generator for the purposes of generating electricity. Diesel generators can be used to provide emergency power, or to supplement power for a utility grid that normally relies on alternate sources of energy. The seven stationary YEC generators in Whitehorse serve both functions and are used on an as-needed basis. For the majority of the time, the diesel generators do not operate.

The impact that the YEC diesel generators may have on community air quality in Whitehorse was assessed by simulating the engine emissions for the 2007 year (based on actual operations), a high usage scenario (whereby the maximum daily production from the diesel plant expected over the next several years is assumed for each day of the year) and a maximum worst-case scenario (whereby all engines are considered to operate at maximum levels, for all hours of the year). These simulations are referred to as Scenario 1, Scenario 2 and Scenario 3.

Whereas Scenario 1 represents actual operations in 2007, Scenario 2 assumes a daily operating profile that is representative of the highest diesel production levels that could reasonably be contemplated to occur on any given day of the year (in the absence of a catastrophic failure of transmission or hydro generation facilities), as determined based on actual operations during a very cold day in the winter of 2007/08 (January 30, 2008), scaled upward to reflect expected power generation requirements in the near future. Therefore, while Scenario 2 reflects the actual maximum level of operations that would be expected to occur on any given day in future operations, on most days during the 2009-2011 period, YEC will not operate the diesel facilities at all, or will operate them at a much lower level than is assumed under the modelled Scenario 2. In the dispersion modelling analysis, this level of operation has been assumed for every day of the year in order to ensure that the analysis considers potential air quality impacts under all meteorological conditions that might occur during the year.

Similarly, Scenario 3 assumes a daily operating profile that represents a worst-case scenario, based on an assumption of YEC operating all seven stationary diesel generators in Whitehorse. In the modelling analysis of Scenario 3, emissions have been represented as occurring at this level of operation on a continuous basis for 24 hours a day, on every day of the year in order to ensure that the analysis considers potential air quality impacts under all meteorological conditions that might occur during the year. However, it is not in YEC's reasonable expectation that the operation of the Whitehorse diesel facilities would ever approach the levels assumed under Scenario 3 during the 2009-2011 period, except potentially in the event of a catastrophic failure of transmission or hydro generation facilities resulting in an emergency situation, requiring unusually heavy reliance on YEC's diesel facilities to ensure a reliable supply of power to customers (such as occurred in January 2006 during a major power outage on the WAF grid due to a failure on the connection to the Aishihik generation facility). Based on YEC's past experience, this is a low probability event, and, even if such an event does occur, it is contemplated that YEC would only ever have to operate the diesel facilities at levels approaching the operating profile that is assumed in Scenario 3 for the number of days that it might take to repair the failure of transmission or hydro generation facilities. Thus, Scenario 3 modelling should be considered to be indicative of emergency situations only (i.e., if a persistent, major upset occurs at a YEC hydro facility).

Four air contaminants that are produced from the diesel generators were assessed: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO) and respirable particulate matter ($PM_{2.5}$). $PM_{2.5}$ is the smallest size fraction of suspended particulate matter (2.5 microns or less in diameter). These four air contaminants were chosen based on concerns expressed in other Canadian communities and not necessarily from an expectation that the YEC engine emissions would be problematic. Emissions of additional air contaminants from the YEC engines were accounted for in the community emission inventories but were not simulated in the model.

3.1 Diesel Engine Emissions

The YEC diesel generators can be characterized by use of activity-based emission rates. These emission rates require consideration of engine properties (age, type of engine), fuel specifications (in particular, sulphur content of diesel) and operating data (kWh produced over a defined period of time). The U.S. Environmental Protection Agency (EPA) maintains a compilation of emission factors called 'AP-42' that provides a general characterization of a multitude of emission sources commonly found in communities[1]. However, in many cases specific emission testing programs can provide emission factors that better represent a particular source.

SENES was provided with the diesel engine characteristics for the seven stationary engines in the Whitehorse diesel generating plant by YEC. These are listed in Table 3.1.

The engines listed in Table 3.1 are 'uncontrolled', meaning that there are no devices that treat the exhaust before being vented to the atmosphere. In terms of EPA emission standards (that are commonly referenced in Canada), the engines can be further classified as 'pre-Tier'. In general, engines manufactured before 2000 would be considered pre-Tier since they were not subject to the EPA emissions standards. Emission standards for Tiers 1 – 4 have been established since 2000.

[1] See http://www.epa.gov/oms/ap42.htm.

Table 3.1: YEC Diesel Engine Characteristics

UNIT NO.	PRIME MOVER TYPE	PRIME MOVER MANUF.	PRIME MOVER MODEL	NAME PLATE CAPACITY	MCR RATING (kW)	RPM	IN-SERVICE DATE
WD1	diesel	Mirrlees	KV12	3,920	4,000	514	1968
WD2	diesel	Mirrlees	KV16	5,150	5,000	514	1968
WD3	diesel	Mirrlees	KV16	5,150	5,000	514	1970
WD4	diesel	EMD	20C	2,500	2,500	900	1975
WD5	diesel	EMD	20C	2,500	2,500	900	1975
WD6	diesel	EMD	20C	2,500	2,700	900	1990
WD7	diesel	Caterpillar	3612	3,300	3,300	900	1991

SENES conducted an investigation of published emission factors that could be used to represent the YEC engines. Table 3.2 provides emission factors for nitrogen oxides (NO_x), CO, total particulate matter (TPM), particulate matter of diameter 10 microns or less (PM_{10}) and $PM_{2.5}$. NO_x emissions are made up of both nitrogen oxide (NO) and NO_2 (majority NO). Over time, some of the emitted NO oxidizes to NO_2 in the atmosphere as the emission plume is transported downwind.

In some cases, engine emission tests do not express particulate matter in the smaller size fractions and assumptions have to be applied. For diesel engine exhaust, total particulate is commonly considered to be made up of 80 – 100% $PM_{2.5}$. SO_2 emission factors are not included in Table 3.2, since emissions of this air contaminant depend directly on the amount of sulphur in the diesel fuel used. The average sulphur content of diesel used in the Whitehorse diesel plant in 2007 was 50 parts per million (ppm). This level is lower than the current Environment Canada sulphur-in-fuel regulation for diesel sold in Canada for 'off-road' purposes[2].

In addition to the AP-42 emission factors, emission factors used for auxiliary marine diesel engines recently summarized for Transport Canada[3] and emission factors determined for locomotive engines in tests conducted by the Southwest Research Institute (SwRI)[4] are included. The diesel engines used for the generation of auxiliary power on ships are from similar stock to those used by utilities for backup power requirements. Both systems tend to use 'medium speed' diesel engines (operating engine rpm approximately 400 – 1,800) with power ratings of 1 to 3 MW.

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[2] See http://www.ec.gc.ca/cleanair-airpur/Pollution_Sources/Fossil_Fuels/.
[3] Weir Engineering and SENES Consulting Ltd., 2008. 2007 Marine Emissions Inventory and Forecast Study, FINAL DRAFT. Prepared for Transportation Development Centre, Transport Canada.
[4] Fritz, S.G., 2000. *Diesel Fuel Effects on Locomotive Exhaust Emissions*. Prepared for the California Air Resources Board, Stationary Source Division. SwRI Project No. 0802062.

Locomotive diesel engines are also similar to the YEC diesel engine stock. The SwRI engine tests included three 3,300 kW EMD medium speed diesel engines at varying engine loads. These engines are very similar to the three YEC EMD engines noted in Table 3.1. During a site visit to the YEC Whitehorse diesel plant, SENES confirmed that the YEC EMD engines are 2-stroke, as are the EMD engines tested by SwRI. The other YEC engines are 4-stroke. The SwRI engine tests were considered particularly relevant, since they assessed four different qualities of diesel fuel. The SwRI emission factors in Table 3.2 correspond to diesel of sulphur content 330 parts per million (ppm) which is reasonably close to (but slightly higher than) the diesel fuel used by YEC in 2007.

Table 3.2: Diesel Engine Emission Factors*

	Air Contaminant Emission Factors (g/kWh)				
Source of Emission Factors	**NOx**	**CO**	**TPM**	**PM10**	**PM25**
EPA Large Stationary Diesel Engines (uncontrolled) AP-42 Ch. 3.4	14.59	3.34	0.43	0.35	n/a
Transport Canada Auxilliary Marine Diesel Engines (4-stroke)	13.90	1.10	0.25	0.24	0.22
SwRI 2-stroke locomotive tests (pre-Tier)	15.34	2.56	0.40	n/a	n/a
SwRI 4-stroke locomotive tests (pre-Tier)	16.62	4.05	0.17	n/a	n/a

*The SwRI factors correspond to diesel fuel with sulphur content of 330 ppm and engine loading of 40 – 100%.

The SwRI 4-stroke engines tested were three 3,300 kW General Electric (GE) medium speed diesels. Consistent with the SwRI results, other emission studies have found that particulate matter (PM) emission rates tend to be higher from 2-stroke diesel engines than 4-stroke engines, with use of similar quality diesel fuel. In addition, the effect of diesel quality (sulphur content) on PM emission rates has received considerable attention recently. The SwRI locomotive study indicates that PM emissions are approximately 20% lower with use of low sulphur diesel fuel compared to higher sulphur (off-road) diesel fuel. An investigation of PM emissions from marine diesel engines conducted by the California Air Resources Board (CARB) found considerable variation in PM emission rates determined from previous studies[5]. CARB suggested that a PM emission factor for marine diesel engines using distillate fuel should be 0.3 g/kWh. The distillate fuel considered in that study was equivalent to off-road diesel of approximately 2,500 ppm sulphur.

3.2 YEC ENGINE EMISSION RATES FOR MODELLING

The seven YEC diesel engines listed in Table 3.1 are used in the following firing order: 7,6,5,4,1,2,3. This yields a maximum power level available from the diesel engines of approximately 25 MW. When used, the YEC Whitehorse diesel plant rarely operates the older WD1 –WD3 units and more commonly operates WD4 – WD7. For this reason, the emission factors used for air quality modelling must represent both 4-stroke and 2-stroke diesel engines. The emission factors representative of the YEC engines in Whitehorse are shown in Table 3.3. The SO_2 emission factor assumes diesel of 50 ppm sulphur, 100% conversion of S to SO_2 and a fuel consumption rate of 220 g/kWh (representative of YEC fuel consumption records). The emission factors in Table 3.3 were based on the discussion provided in Section 3.1 and are representative of the Whitehorse diesel engine stock in general. However, it should be noted that the emissions from one particular diesel engine at the diesel plant could significantly differ from these averaged rates (either higher or lower).

Table 3.3: Emission Factors for YEC Diesel Engines

		Air Contaminant Emission Factors (g/kWh)			
Engine Type	**Sulphur content (ppm)**	**NOx**	**SO2**	**CO**	**PM25**
YEC 4-stroke engines	50	15.00	2.46E-02	4.00	0.25
YEC 2-stroke engines	50	15.00	2.46E-02	2.50	0.35

3.2.1 Engine Emissions During Start-up

YEC requested SENES to conduct additional analysis to highlight engine emission rates during atypical operations. The engine emission rates presented in Table 3.3 and used for both the community inventories and the dispersion modelling relate to normal operations, commonly referred to as ‘steady state’.

[5] CARB, 2007. A Critical Review of Ocean-Going Vessel Particulate Matter Emission Factors. Todd Sax and Andrew Alexis, California Air Resources Board, Sacramento CA. Available from the CARB website.

The emission factors presented in Table 3.3 assume that the engines are operating under normal and essentially stabilized working conditions. For almost all the time that the YEC diesel generators operate, this is a reasonable assumption. One of the more visible operating conditions outside the normal scope of generating power, that operators and members of the public notice, is the short period of start-up as the diesel engines are warmed and ramped up to load conditions. It is important to qualify the impacts of start-up emissions and relative amounts to normal operation. Start-up emissions are particularly relevant to the functioning of the diesel engines within the YEC electrical operations. In Whitehorse, the diesel engines are used as the last power source option, responding to peak load that may only last a few hours, and thus the engines may start/stop quite often in relation to an electrical plant that provides continuous power. The start-up operation is a special state and is briefly reviewed in this report in order to establish a more complete picture of the potential community impacts from the diesel engines.

The start-up of a large diesel engine has three phases that influence the exhaust emissions:

1. The initial cranking and first 90 cycles driven by combustion stability and fuel injector pressure stabilization[6];
2. The first 300 seconds of running condition as the concentration of exhaust components stabilize[7]; and
3. The warm up time for the coolant and exhaust stack, driven by the exhaust temperature profile.

It is important to note that the power levels, and thus fuel consumption, during start-up are significantly lower than during full load operation. For the purposes of the YEC engine emissions assessment and dispersion modelling, the context of total hourly emissions must be addressed. What affect do start-up conditions potentially have on the total hourly emissions from the YEC diesel engines?

The total start-up emissions from one YEC diesel engine would be equivalent to approximately 8-10 minutes of idle operation[8]. However, the idle emissions, when compared to emissions with engine under load, are relatively low. If the total start-up emissions are compared to engine emissions while under load (e.g., in normal operating conditions, used to generate electricity), these emissions would be equivalent to approximately one minute of normal operation.

[6] Peng, H. Cui, Y. Deng, K. Shi, L. Li.; *Combustion and Emissions of a Direct-Injection Diesel Engine During Cold Start Under Different Exhaust Valve Closing Timing Conditions*; Proc. IMechE 2008 Vol. 222 Part D: J. Automotive Engineering

[7] Piaseczny, L. Zadrag, R.; *Investigations of Exhaust Toxicity Decreasing from Ship's Engines During the Start Up*; Technical Institute of Ship Maintenance; Journal of Kones. Combustion Engines, Vol 8, No 1-2, 2001

[8] Weaver, C.; *Start-up and Idling Emissions From Two Locomotives*; South Coast Air Quality Management District; January 16, 2006, Final Report

One of the potential concerns during start-up is that emissions are clearly visible at the exhaust stack during all three phases, such as smoke and condensed water vapour. While the total emissions during this time may be quite low compared to emissions during load conditions, it is important to understand the cause of the emission changes.

During Phase One (i.e., the initial cranking and fuel injector pressure stabilization), the engine experiences significant change in the combustion chamber and creates a broad range of emissions. The engine may experience a series of misfires, lean-fires, overly rich conditions and uneven gas mixing which cause the exhaust concentrations to significantly alter during this phase. At times when no combustion occurs, very little pollutants exit the exhaust stack as the unburned fuel condenses in the exhaust system. At other times, the fuel delivery rate is too extreme or timed incorrectly causing unnecessarily high peaks in cylinder pressure which drives the NO_X emissions relatively high. In part due to the large variations in fuel injector pressure and in turn spray pattern within the combustion chamber, the formation of particulate emissions (PM) can be significant.

During Phase Two (i.e., combustion stabilization), the combustion kernel experiences stable in-cylinder conditions and generates exhaust emissions in a predictable manner. Over the initial 300 seconds of start-up, both the NO_X and CO emissions rise and then stabilize at idle emission rates.

During Phase Three (i.e., warm up) the emissions can vary based on how the engine was operated previous to the start-up and the current weather conditions. Any residue, either fuel or moisture from rain or condensation, will start to cook off as the exhaust system increases in temperature. Many times, these ‘cook off’ emissions can be clearly seen from the exhaust stack during this phase, and while they are of concern, their relative significance to the overall emissions from the engine operations is small, and their contribution to ambient air concentrations is equivalently low. It should also be noted that the increased moisture in the exhaust plume gives the appearance of greater overall emissions. The duration of the third phase is influenced by the outside temperature and the ramp up rate of the engine speed and load.

While it is true that diesel engine emission rates during engine start-up can be greater than during running conditions, the contributions from the start-up period are expected to be quite small in the context of total hourly emissions for the YEC engines. As previously indicated, this is due to the fact that normal operation of the engines involves usage under load, with a much higher rate of fuel consumption when compared to idling. The emission rates used for the emission inventory, and the dispersion modelling, assume the engines are loaded at all times. Improvements in engine controls, combustion design and start-up procedures can reduce some of the start-up emissions. However, these changes most likely occur during normal upgrades and equipment replacement.

The formal inclusion of start-up emission rates in the dispersion modelling analysis would not change the overall estimates of predicted CAC concentrations in the ambient air.

3.3 SCENARIO EMISSION LEVELS

Hour-by-hour engine emission estimates in grams of pollutant per second (g/s) were calculated by using YEC Whitehorse generation records for 2007 (Scenario 1) and by assuming a maximum usage daily production profile applied to every day of the year (Scenario 2). The Scenario 2 daily profile was determined from operations during a very cold day (January 30, 2008), representative of the highest diesel production levels over the past year. In addition, the profile was scaled up a small amount to account for the expected increase in average demand over the next few years. Scenario 3 simply assumes that all seven stationary diesels in Whitehorse are operated at maximum load, all of the time.

A total of 368 MWh were generated by the YEC Whitehorse diesel plant in 2007. SENES was provided with the hour-by-hour power production records for the year, which showed that one or more of the diesel engines were operating during 126 hours of the year, with a maximum generation rate of 20.22 MW produced during one hour in September. The maximum energy generated in a full day was 78 MWh, developed over a continuous nine hour period in February.
The Scenario 2 emissions were determined by using the maximum daily production profile shown in Table 3.4. Application of this profile over a full year yields a daily generation level of 168 MWh and an annual generation level of 61 GWh. Comparing this annual generation level to those provided in Figure 2.1 clearly shows that Scenario 2 represents a much higher level of generation than any that has actually occurred in the period 2000-2007.

Table 3.4: Maximum Daily Usage Profile: Whitehorse Diesels Scenario 2

Hour	Diesel Required (MW)
1:00	5.24
2:00	5.19
3:00	5.18
4:00	5.18
5:00	5.18
6:00	5.26
7:00	5.43
8:00	8.30
9:00	12.04
10:00	10.68
11:00	9.97
12:00	9.97
13:00	10.11
14:00	8.54
15:00	6.28
16:00	9.73
17:00	5.66
18:00	5.76
19:00	5.82
20:00	5.80
21:00	5.75
22:00	5.66
23:00	5.52
0:00	5.37

Scenario 3 emission assumptions yield a daily generation level of 600 MWh and an annual level of 219 GWh.

To serve as an example, the estimated $PM_{2.5}$ emissions from the Whitehorse diesel engines when producing 3MW of power would be calculated as follows:

$$Emissions = 3.0MW x 1000 \frac{kW}{MW} x 0.25 \frac{g}{kWh} x 1 hour = 750 g$$

An estimated $PM_{2.5}$ emission rate of 0.75 kg/hour or 0.208 g/s is produced.

The engine firing order noted previously was used to determine engine emissions during power production greater than 3 MW (equivalent to the capacity of the first engine). This approach utilizes both the 2-stroke and 4-stroke emission factors, applied as a particular engine is brought on line.

3.4 COMPUTER MODELLING

Emissions from the YEC diesel generators at Whitehorse were modeled with a refined dispersion model called the California Puff Model (CALPUFF)[9]. CALPUFF is a recommended model in the B.C. Dispersion Modelling Guidelines[10] and the modelling guidelines for other Canadian provinces for situations involving complex circulation patterns that can influence the advection and dispersion of air pollutants. Due to the fact that Whitehorse is situated in a valley and experiences stagnant conditions each year that can inhibit the movement of air, the CALPUFF model was considered appropriate to determine the effect of YEC emissions on community air quality.

3.4.1 Meteorology

The CALPUFF modelling system includes a meteorological processor called CALMET. CALMET is used to produce a three-dimensional simulation of the atmosphere, based on available meteorological monitoring data, and/or output from a larger scale weather model. The resultant CALMET fields govern the advection and dispersion of emissions in the CALPUFF dispersion model itself.

The following meteorological inputs were used to drive CALMET: Whitehorse surface observations at the airport (Environment Canada station YXY, Surface) and Whitehorse upper air observations at the airport (Environment Canada station YXY, Upper Air). A windrose diagram of the Environment Canada (EC) YXY surface winds is shown in Figure 3.1. A windrose diagram shows the distribution of winds by direction (direction *from* which the wind blows) and speed class. Figure 3.1 shows that the wind in Whitehorse is commonly from the South, following the orientation of the valley. Also noteworthy, calm conditions (zero or near-zero wind speeds) are experienced over 15% of the time.

The YXY surface wind data is expressed with wind direction in increments of 10 degrees. This is not ideal for dispersion modelling, since it leads to plume travel along specific radial lines (i.e., the plume often travels in direction 180^o but never 185^o. To correct for this limitation in the data, all wind directions were randomized within the appropriate 10 degree sectors (for example, a 180^o direction in the original data would be randomized within the range 175^o – 184^o). A revised windrose diagram for the corrected station data (as used in the CALMET model) is shown in Figure 3.1a.

[9] http://www.src.com/calpuff/calpuff1.htm
[10] http://www.env.gov.bc.ca/air/airquality/pdfs/air_disp_model_08.pdf

Figure 3.1: Windrose Diagram, EC YXY Surface Station

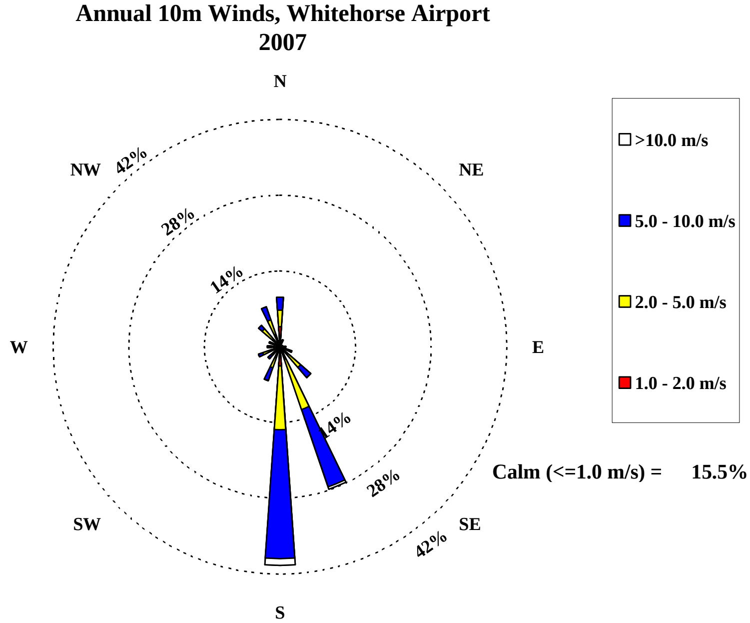
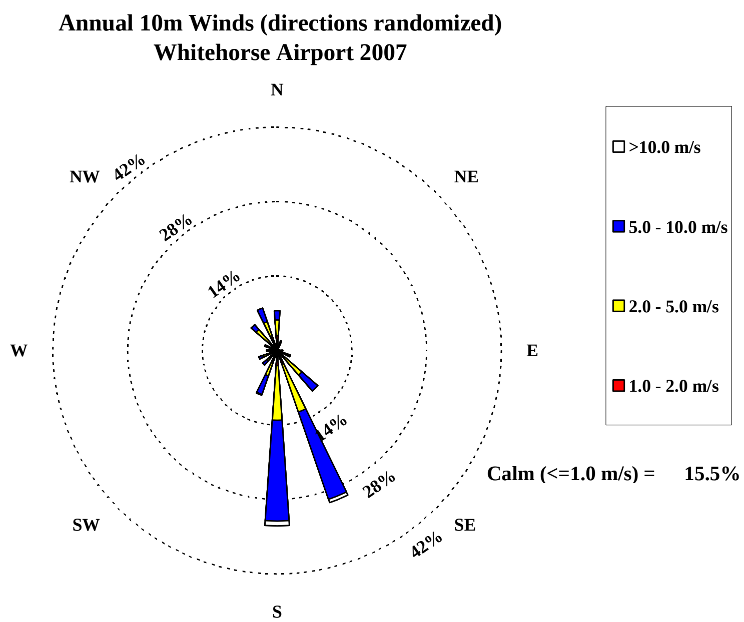


Figure 3.1a: Windrose Diagram, EC YXY Surface Station with directions randomized



In addition to meteorological data, CALMET requires a number of settings and additional datasets to configure the modelling domain (shown in Table 3.5).

Table 3.5: CALMET Configuration

Size of Modelling Domain	30 km by 30 km, centered on YEC diesel plant
Grid Horizontal Resolution	200 m by 200 m
Grid Vertical Resolution	12 levels (0 to 3300 m)
Input Terrain (elevation)	30 m DEM from Geomatics Canada
Input Vegetation (land use)	Whitehorse Municipal Planning Maps
Input Precipitation Levels	EC YXY daily precipitation records
Wind Field Model	On, with model defaults
Wind Interpolation	RMAX1,2 = 5,10km
Terrain Influence on winds	TERRAD = 5 km

Hourly precipitation records could not be acquired for Whitehorse (only daily total amounts were available from EC). However, hourly precipitation *indicators* were available in the station records. These indicators show whether or not precipitation occurred in a particular hour and the relative magnitude (low, medium or high). For each day, SENES matched the daily total precipitation amounts (and types) with the hourly indicators to achieve estimates for hourly precipitation levels in a linear fashion. This approach is not ideal, but was necessary given the availability of data. However, due to the relatively low precipitation levels in Whitehorse, this methodology likely does not have a significant impact on the dispersion model outcomes. This issue is further discussed in Section 3.4.2.

Surface energy fluxes and wind flow are influenced by local terrain and vegetation. Figure 3.2 and Figure 3.3 show a visualization of terrain and landuse characterization at the modelling resolution of 200m. The terrain was categorized by 30m digital elevation model (DEM) files from Geomatics Canada and landuse category was configured by extracting information from the Whitehorse Official Community Plan 'Area Landuse Designations' map, available from the city website.[11]

[11] http://ww3.whitehorse.ca/Features/OCP/OCP-TableofContents.pdf

Figure 3.2: CALMET Terrain Heights

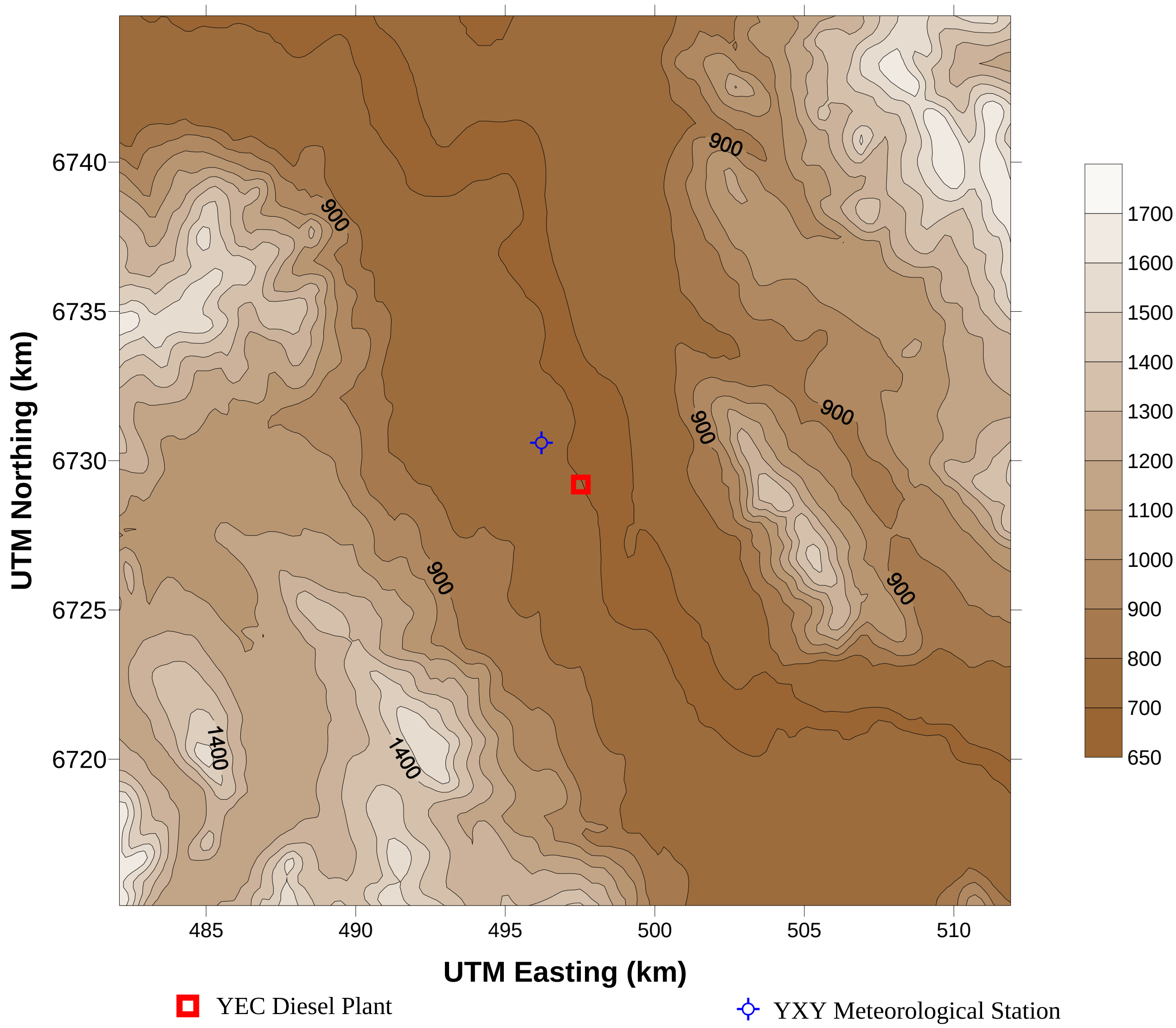
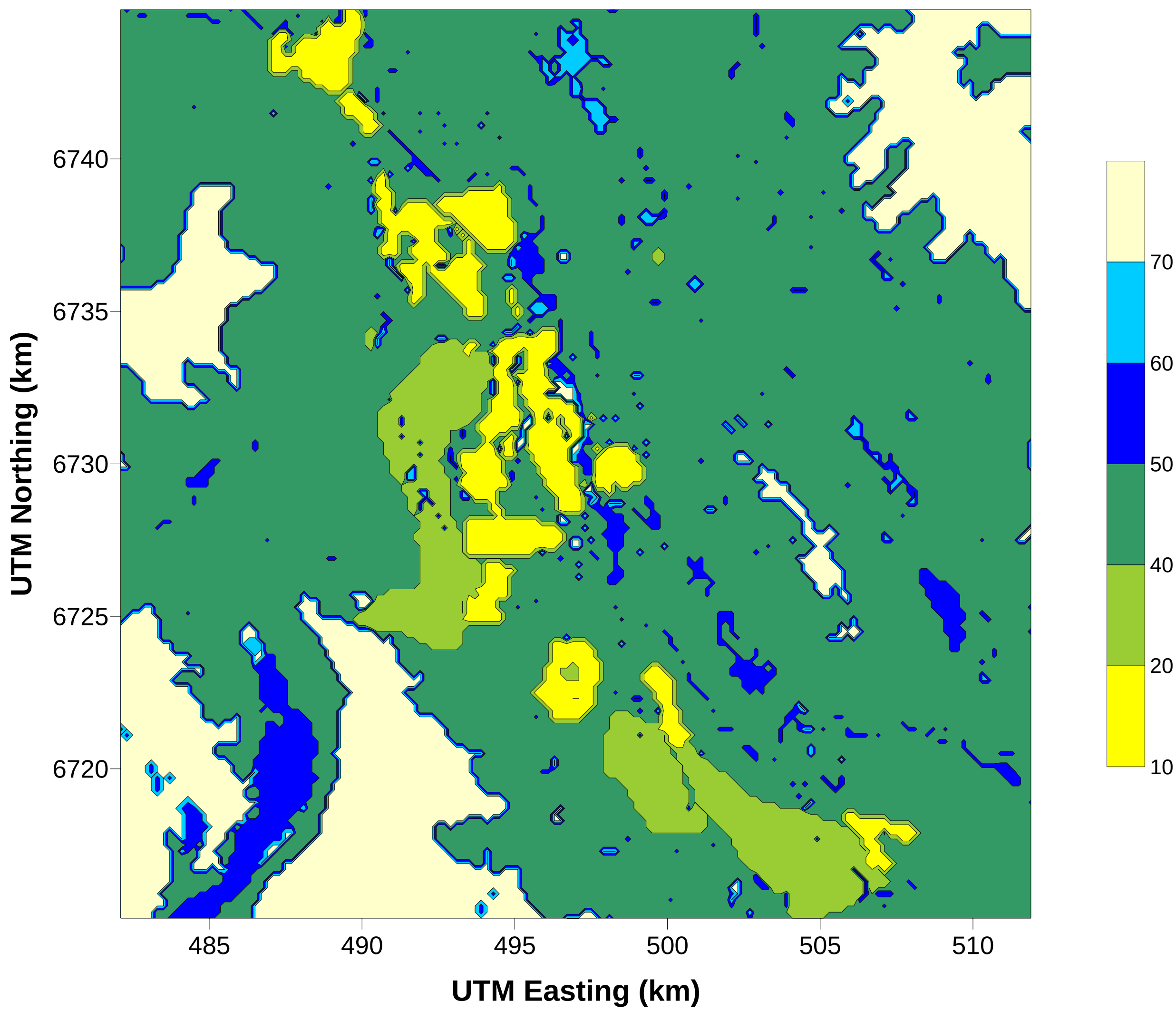


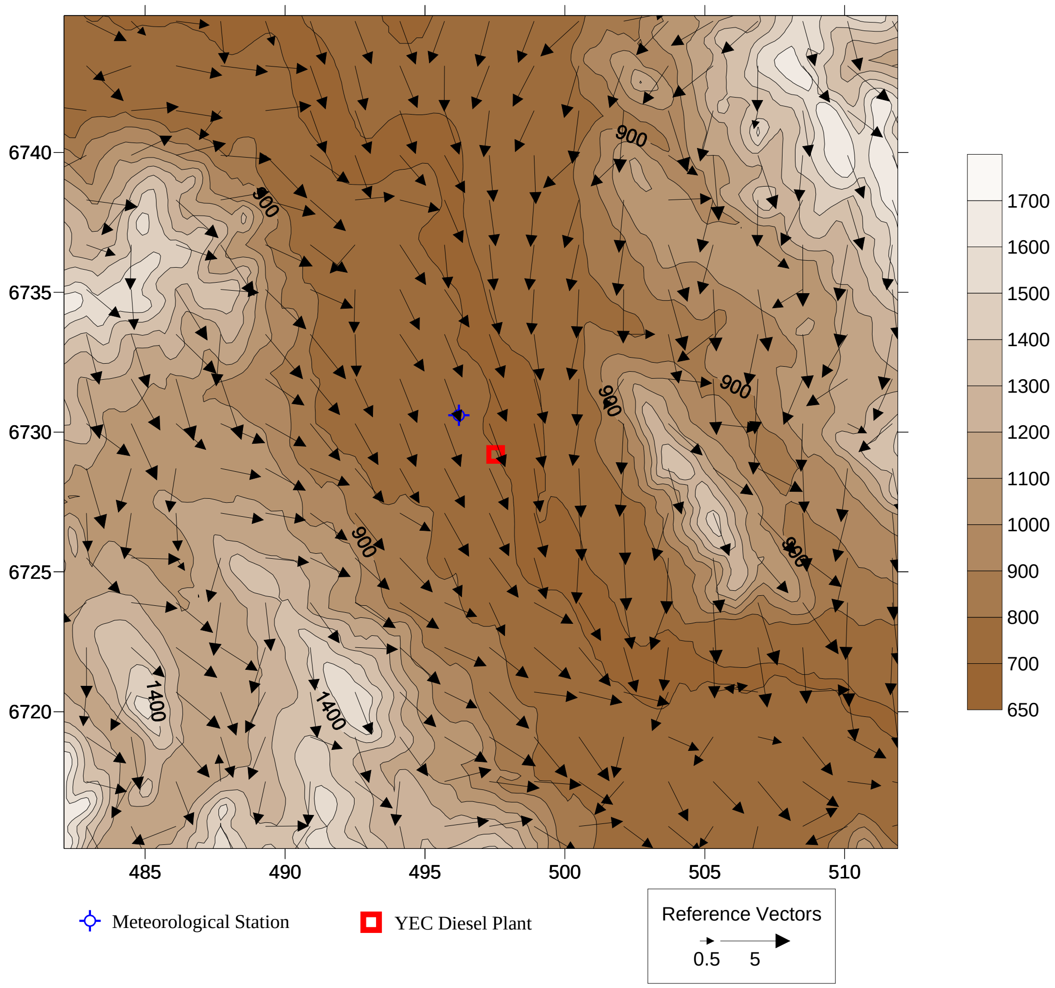
Figure 3.3: CALMET Landuse Categorization



10 = urban, 20 = agricultural, 40 = forest, 50 = water, 60 = wetland, 70 = barren

Figure 3.4 provides an example of the surface winds on January 5 in the late afternoon (5 pm). The plot illustrates the meteorological modelling approach reasonably well: the surface station winds were given broad influence over wind flow in the valley (e.g., through most of the city) and the model algorithms account for the expected terrain steering at higher elevation and at a distance from the city core. This particular example should not be interpreted to be representative of the 'normal' surface wind flow in Whitehorse (winds from the south would occur far more often). However, the surface winds are almost always flowing either up the valley or down the valley and this pattern largely dictates the general advection of pollutants when the YEC diesels are operating.

Figure 3.4: CALMET Surface Winds, January 5, 17:00



3.4.2 Dispersion

Emissions from the seven YEC engines were modelled as individual point sources with the characteristics defined in Table 3.6. The exhaust exit velocity and temperature were conservatively based on past engine emission assessments. It is possible that both parameters are, in reality, moderately higher, which would tend to increase dispersion and lower ground level concentrations. As previously described, the engines were turned 'on' in the model based on the rate of power generation for each hour. An emissions input file was constructed for each of the three scenarios, which the CALPUFF model read in during each hour of the simulations.

Table 3.6: YEC Emission Configuration for CALPUFF

YEC Engine	UTM Northing (km)	UTM Easting (km)	Stack Height (m)	Stack Diameter (m)	Exhaust Exit Velocity (m/s)	Exhaust Temperature (^oC)
WD1	497.551	6729.204	12.0	0.7	20	300
WD2	497.553	6729.207	12.0	0.7	20	300
WD3	497.555	6729.210	12.0	0.7	20	300
WD4	497.560	6729.217	12.0	0.7	20	300
WD5	497.564	6729.223	12.0	0.7	20	300
WD6	497.568	6729.229	12.0	0.7	20	300
WD7	497.571	6729.234	12.0	0.7	20	300

Several Canadian provinces publish dispersion modelling guidelines that are used to indicate the level of assessment that should be applied to an air quality simulation of industrial or commercial emission sources. The guidance may indicate appropriate model configuration, degree of spatial resolution for model predictions, or both. SENES consulted the BC Dispersion Modelling Guidelines[12] for supported CALPUFF configuration and receptor spacing. Receptor spacing denotes the specific spacing at which the model is set to estimate ground level concentrations.

The CALPUFF modelling configuration chosen for the YEC simulations is consistent with the BC guidelines, which in general follow the default EPA choices (which are clearly indicated in the model guidance support). Chemical transformation of pollutants was not modelled since very little transformation of the primary contaminants released from the engines is expected within the city confines (exception NO_x/NO_2).

To determine ambient NO_2 concentration estimates, concentrations of nitrogen oxides (NO_x) from the CALPUFF simulations were converted to NO_2 using an external method. This general approach is consistent with the BC Modelling Guidelines (and guidelines from other Canadian jurisdictions), which reflects the issue that current air quality models such as CALPUFF cannot yield realistic estimates of NO_2 based on NO_x emission levels. External methods involve applying conversion rates (portion of emitted NO that forms NO_2) based on the ratio of NO_x and NO_2 in the ambient air, or distance from source (greater distance implies more conversion). Janssen (1988) developed NO_x/NO_2 ratios based on direct measurements in stack plumes from

[12] BC MoE, 2008. *Guidelines for Air Quality Dispersion Modelling in British Columbia, March 2008*. Available from the Ministry webpage.

Dutch power plants between 1975 and 1985[13]. The ratios were determined through 60 measurement flights conducted under varying atmospheric conditions. Practical application of the ratios to estimate NO_2 concentrations from ambient NO_x concentrations can be referred to as the *Janssen Method*, which requires determination of the distance of a particular point (receptor) from the emission source. The method has been practically applied and tested in another study[14]. This external conversion method was chosen for Whitehorse; the conversion ratios applied to the modelled NO_x concentrations are shown in Table 3.7.

Table 3.7: NO_2/NOx Ratios Assumed for Modelling

Distance from Source (km)	NO_2/NO_x Ratio
0 – 1	0.05
1 – 2	0.14
2 – 3	0.19
3 – 4	0.25
4 – 5	0.29
5 – 6	0.33
6 – 7	0.37

In reality, the actual conversion ratios depend on time of day, temperature, wind speed and amount of solar radiation. The ratios in Table 3.7 used for the modelling assessment are representative of daytime conditions in warmer months (late spring, summer). During cooler months, or evening hours, these ratios would likely be very conservative. The *Janssen Method* additionally indicates wintertime ratios that should be considered in more refined assessments. This issue is further discussed in Section 3.5.3, where relatively high NO_2 concentrations are indicated.

CALPUFF was additionally configured to represent wet removal of pollutants due to precipitation and building downwash. The latter mechanism is significant to represent, since the engine stacks at the YEC diesel plant are not high enough to escape building wake effects in the wind flow. The physical dimensions of the stacks and the building were used to determine

[13] Janssen et al. 1988. A classification of NO oxidation rates in power plant plumes based on atmospheric conditions. *Atmospheric Environment, 22*(1), 43-53.
[14] De Oliveira and Simonsen. 2003. Utilization of a method to estimate NO_2 concentrations from a NO_x simulation for thermal power plants. *Air & Waste Management Association Conference and Exhibition* (96th : 2003: San Diego, California).

downwash parameters for the model[15], which are internally accessed depending on the characteristics of the wind flow on any particular hour.

3.5 AIR QUALITY PREDICTIONS

Estimates of ambient air quality concentrations were produced on a regular grid every 20m within 200m of the YEC diesel plant, every 50m between 200 and 500m from the plant and then every 200m for the remainder of the domain. This approach surpasses the expectations in the BC guidelines, which calls for 20m spacing at the fenceline only. A number of discrete receptor locations were additionally used. Discrete receptors are commonly used in air quality assessments to look at the full distribution of predicted ambient concentrations at locations considered particularly sensitive to air contaminants, such as homes, schools and hospitals. The six sensitive receptors chosen were as follows (approximate distance from YEC stacks shown in brackets):

1) nearest residence to the power plant located on the east side of the Yukon River (240 m);
2) Christ the King Elementary School (840 m);
3) Grey Mountain Primary School (1.3 km);
4) Frederick Collins Secondary School (1.4 km);
5) the Whitehorse General Hospital (2.2 km); and,
6) located at the plant property fenceline on the western river bank at the foot bridge over the Yukon River (75 m).

Figure 3.5 shows the locations of the six discrete receptors chosen for the modelling, superimposed on a 10km by 10km map referred to as the inner domain. The inner domain was defined to display the predicted air concentrations since concentrations beyond 5 km from the YEC diesel plant were found to be very low. Figure 3.6 provides a visualization of the regular receptor grid. This grid is used to determine the maximum ambient off-site concentrations from the model.

[15] These parameters were determined using the EPA *Building Profile Input Program* (BPIP) model.

Figure 3.5

Inner Modelling Domain and Discrete Receptor Locations

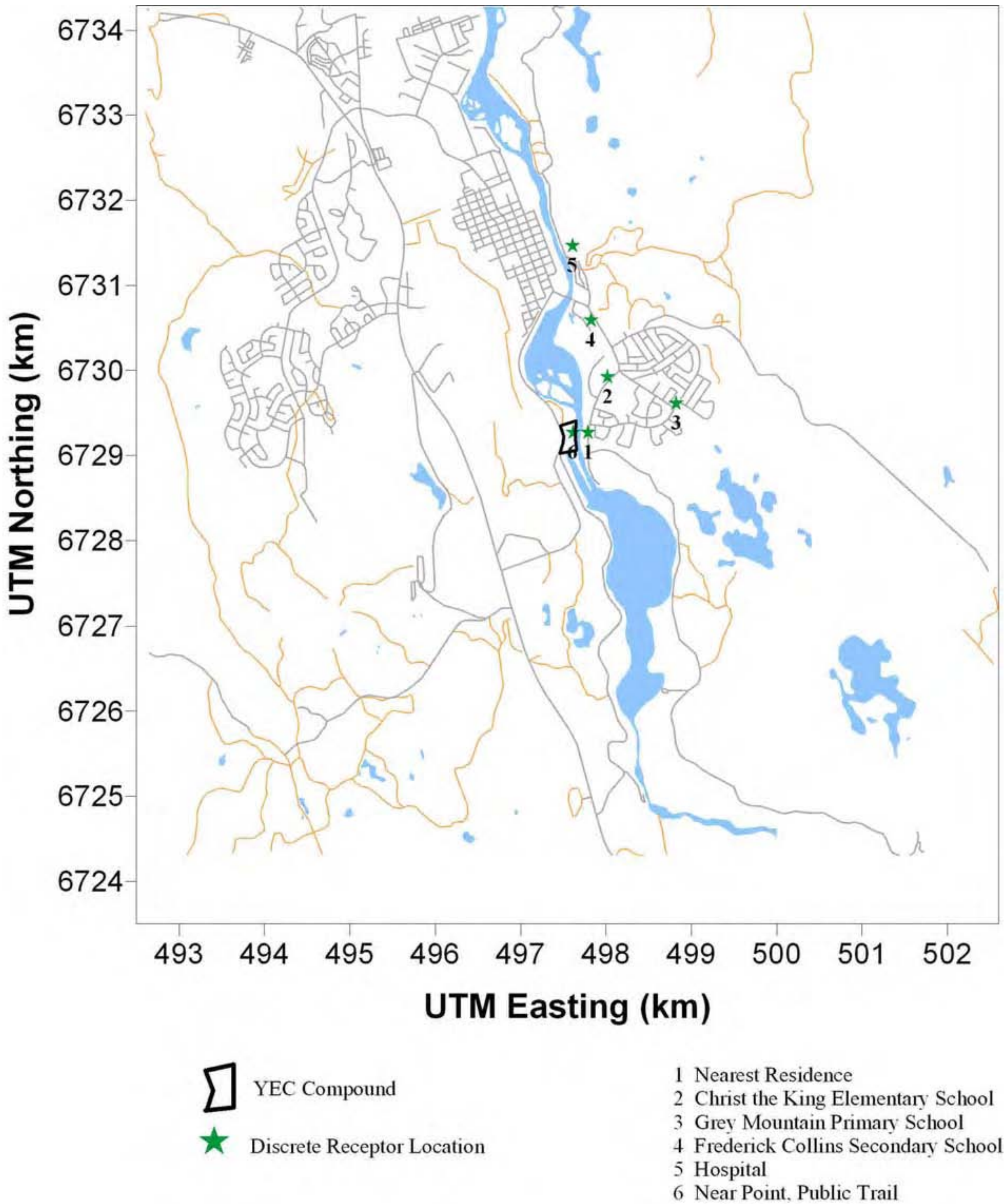
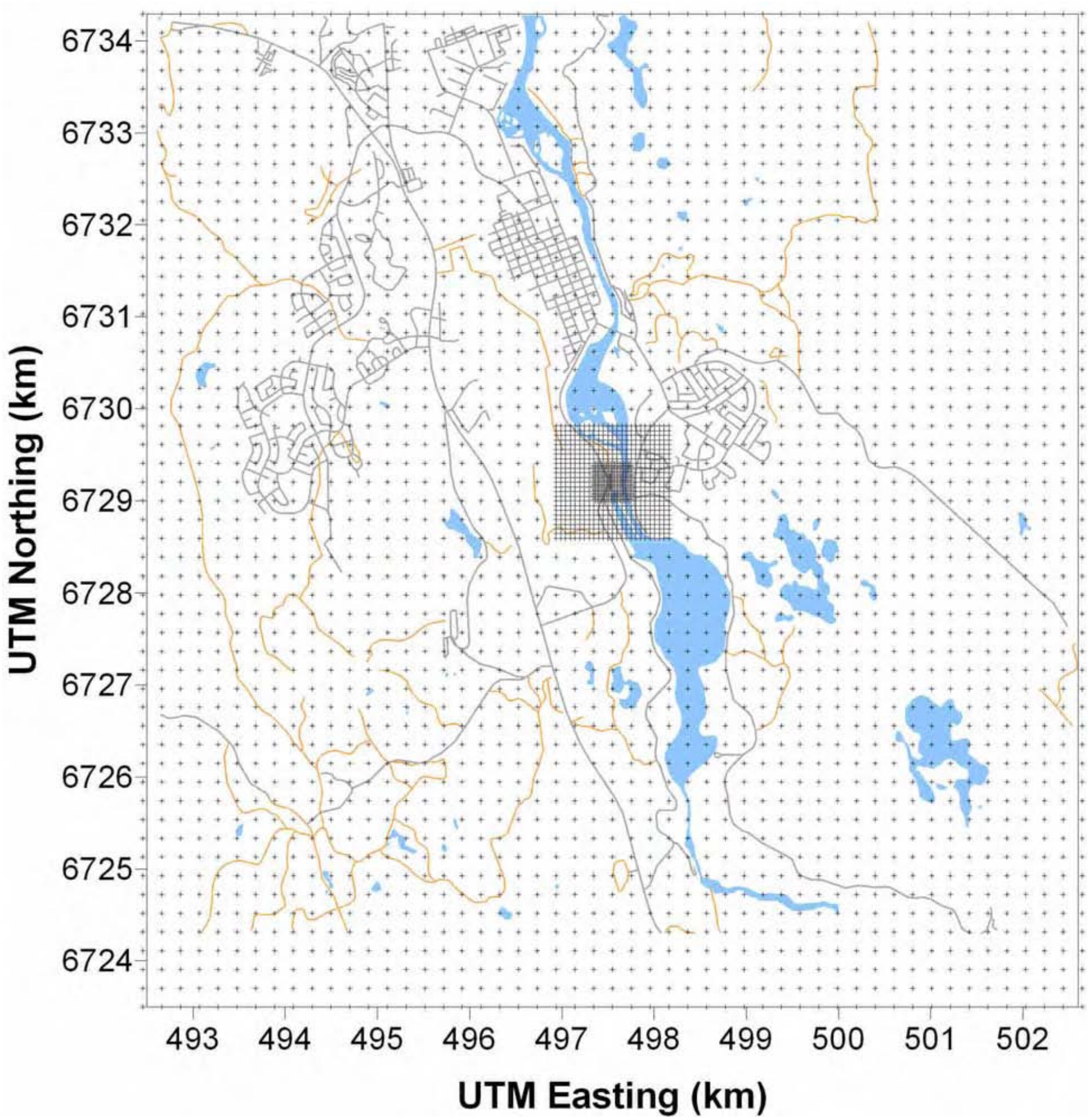


Figure 3.6

Regular Grid for CALPUFF Modelling



For Scenario 1, ambient air quality estimates are provided in tabular form for maximum 1-hour, 24-hour and annual average concentrations in the domain, for each air contaminant modelled. In addition, a number of example plots are also provided. For Scenarios 2 and 3, only the maximum 1-hour and 24-hour concentrations are assessed, since longer term averaging would not be representative of reality (these profiles would not persist over any extended time period).

3.5.1 Scenario 1 (Actual Engine Usage in 2007)

The highest predicted ambient concentrations of NO_2, SO_2, CO and $PM_{2.5}$ are shown in Table 3.8, for 1-hour, 8-hour, 24-hour and annual averaging periods. These values represent the highest predicted concentrations at any off-site location in Whitehorse, over the full calendar year. The 8-hour average concentration estimates are only relevant to CO levels, since ambient objectives for this pollutant are specified for 8-hour (and not 24-hour) periods.

Table 3.8
Maximum Predicted Ambient Concentrations - Scenario 1

Averaging Period	**Maximum Ambient Concentrations** (µg/m³)			
	NO_2	SO_2	CO	$PM_{2.5}$
1-hour	69.0	2.3	292.5	28.0
8-hour	n/a	n/a	76.5	n/a
24-hour	4.8	0.2	n/a	1.6
Annual	0.04	0.001	0.2	0.01

A plot of maximum estimated 1-hour NO_2 concentrations is shown in Figure 3.7. The maximum concentrations are those predicted by the model over the year and each concentration value could occur on any given hour. In other words, the plot is not a snapshot in time, but instead represents the greatest potential impact over the entire year. The prevalence of the north-south wind flow in Whitehorse is obvious, as locations to the east and west of the diesel plant do not experience maximum concentrations over 20 µg/m³.

A plot of 1-hour average $PM_{2.5}$ concentrations is shown in 3.8. The plot shows a similar pattern to that of 1-hour NO_2 concentrations and higher maximum concentrations are found to the north and south of the diesel plant.

No plots are shown for maximum 24-hour or annual average concentrations, since the community levels are very low for all air contaminants modelled.

Figure 3.7

Maximum Predicted 1-hour NO_2 Concentrations - Scenario 1

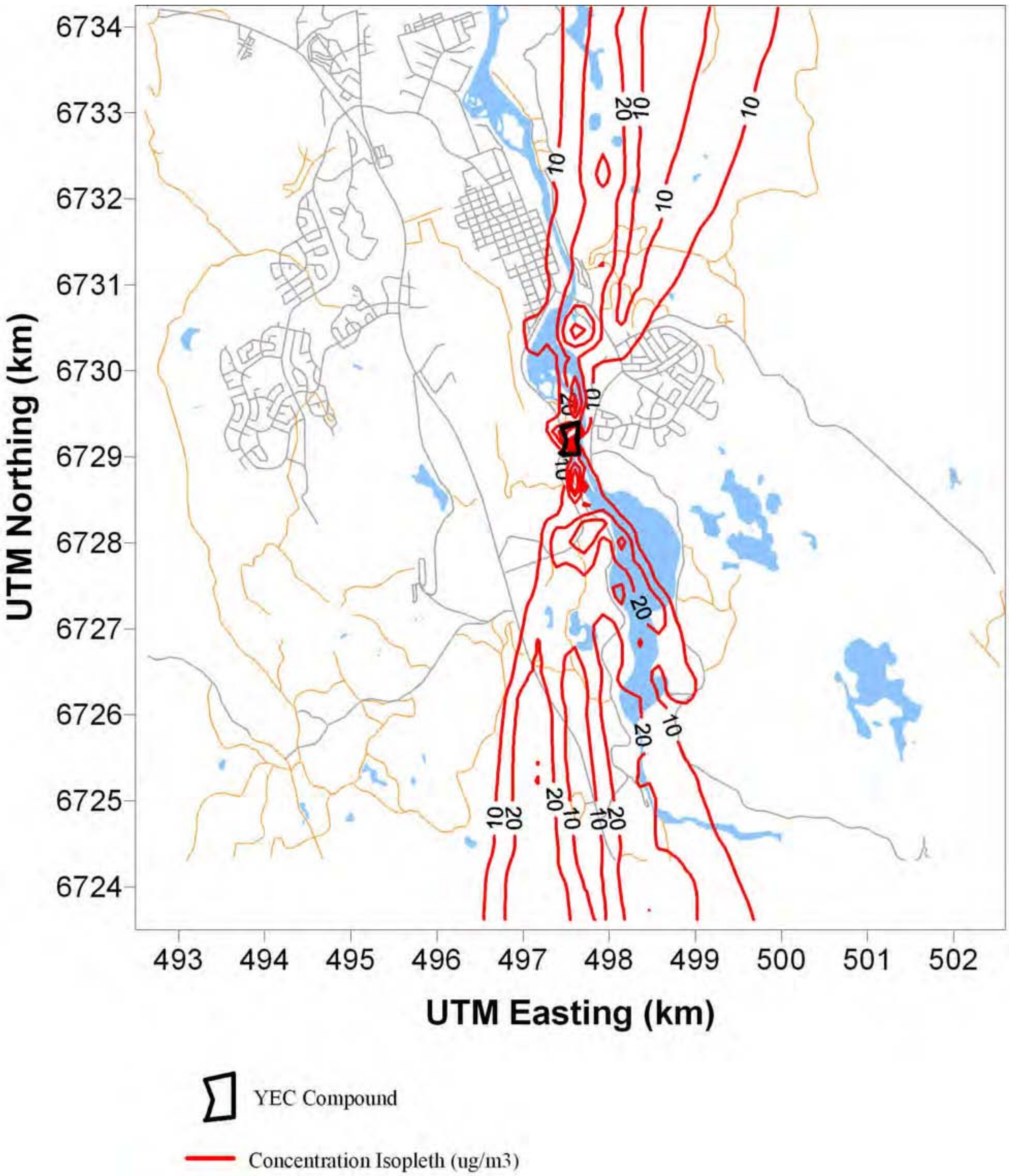
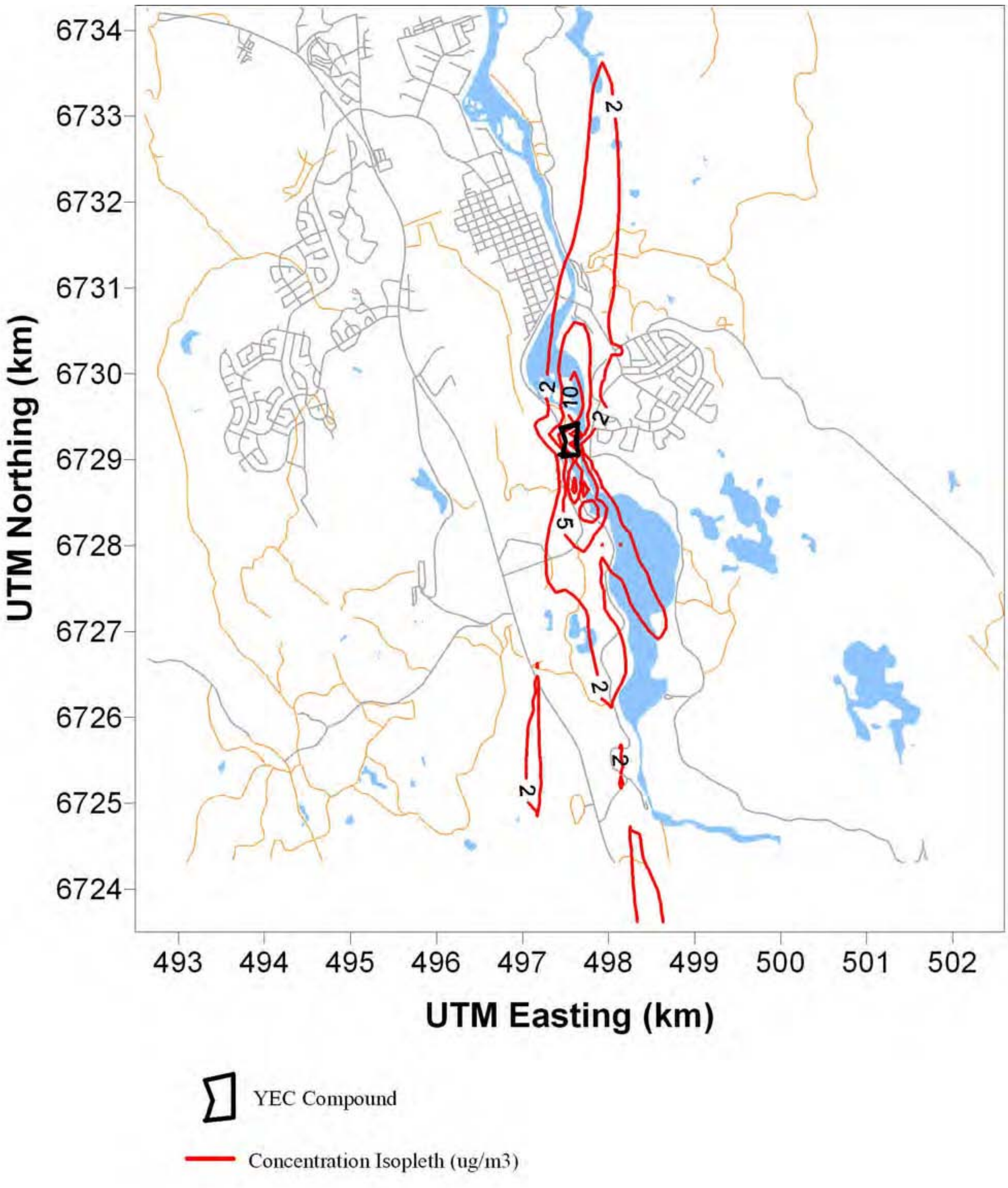


Figure 3.8

Maximum Predicted 1-hour $PM_{2.5}$ Concentrations - Scenario 1



3.5.2 Scenario 2 (Maximum Daily Production)

The highest predicted 1-hour, 8-hour and 24-hour average concentrations from the model are shown in Table 3.9. Annual average concentrations were not determined for Scenario 2, since this level of production would not occur over any extended time period.

Table 3.9: Maximum Predicted Ambient Concentrations - Scenario 2

Averaging Period	**Maximum Ambient Concentrations** (µg/m³)			
	NO_2	SO_2	CO	$PM_{2.5}$
1-hour	255.0	8.2	1022.5	107.5
8-hour	n/a	n/a	331.3	n/a
24-hour	42.1	1.4	n/a	17.4
Annual	n/a	n/a	n/a	n/a

The maximum ambient concentrations predicted for Scenario 2 are considerably higher than those estimated for Scenario 1. This is a result of both higher assumed emissions and emissions occurring during stagnant conditions where the dispersion of air contaminants is hindered.

Plots of 1-hour and 24-hour maximum NO_2 concentrations are shown in Figure 3.9 and Figure 3.10, respectively. Plots for $PM_{2.5}$ are shown in Figure 3.11 and Figure 3.12.

The highest predicted 1-hour NO_2 concentration is shown to occur immediately adjacent to the YEC compound. Due to a gradual conversion of NO to NO_2 with distance, several pockets of NO_2 concentration between 100 and 150 µg/m³ are predicted to occur several kilometres from the point of release. The highest maximum 24-hour NO_2 concentration is also predicted to occur adjacent to the YEC compound. Predicted 24-hour concentrations in the community are low.

Similarly, elevated 1-hour average $PM_{2.5}$ concentrations are predicted to occur very near the diesel plant, but in this case predicted concentrations further from the plant are low. The maximum 24-hour averaged $PM_{2.5}$ concentrations are less than 2 µg/m³ in almost all areas of the community.

Figure 3.9

Maximum Predicted 1-hour NO_2 Concentrations - Scenario 2

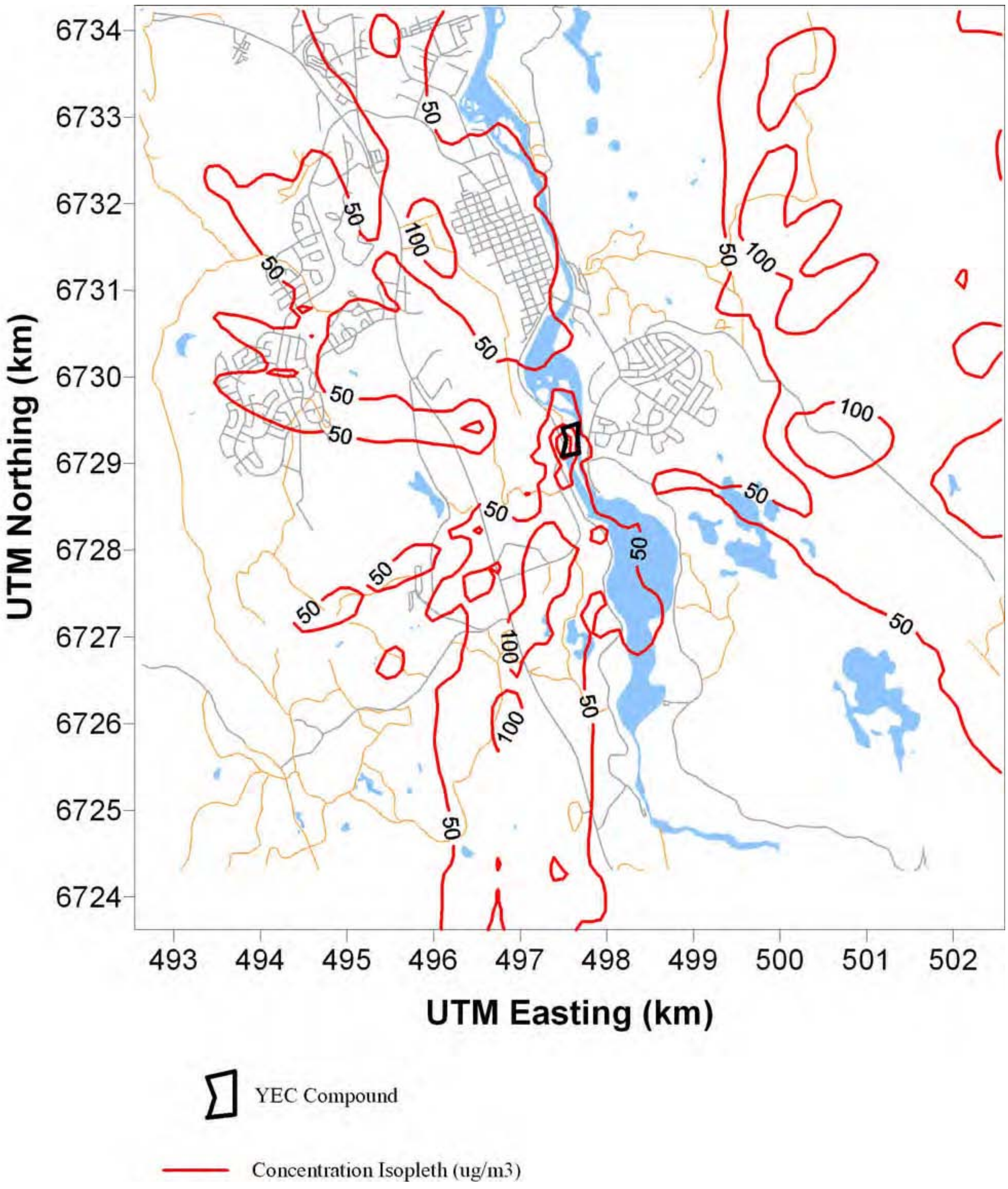


Figure 3.10

Maximum Predicted 24-hour NO_2 Concentrations - Scenario 2

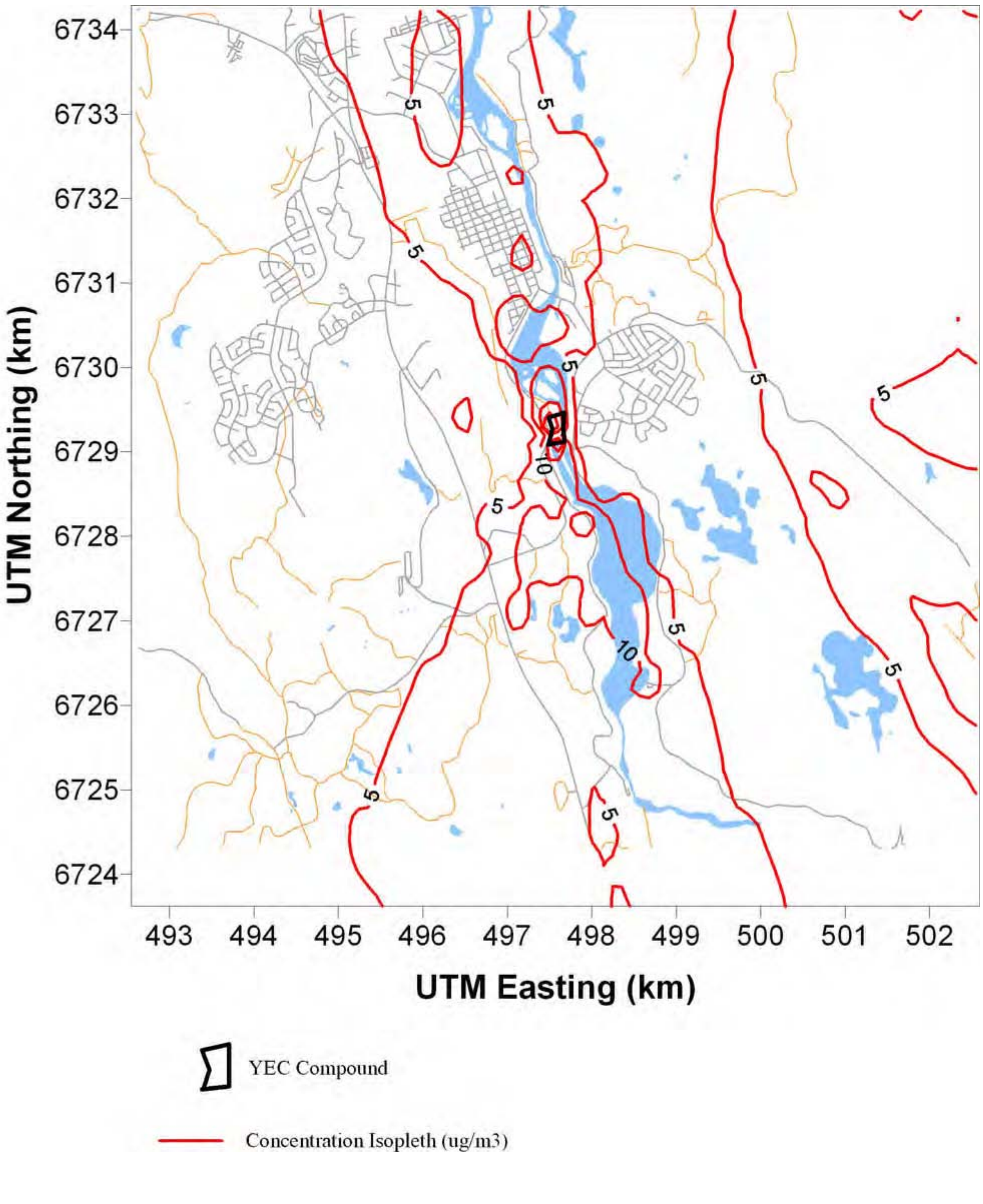


Figure 3.11

Maximum Predicted 1-hour $PM_{2.5}$ Concentrations - Scenario 2

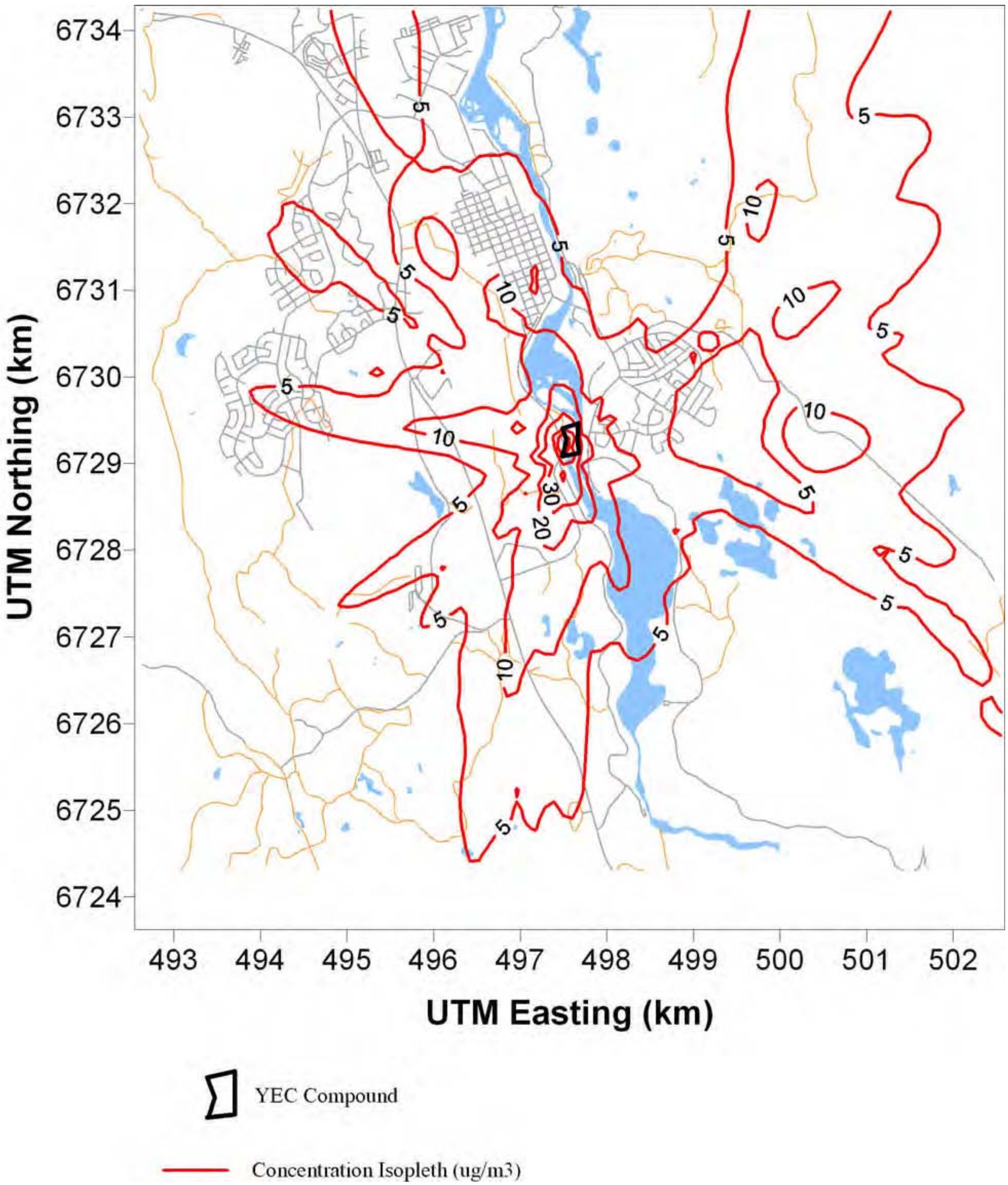
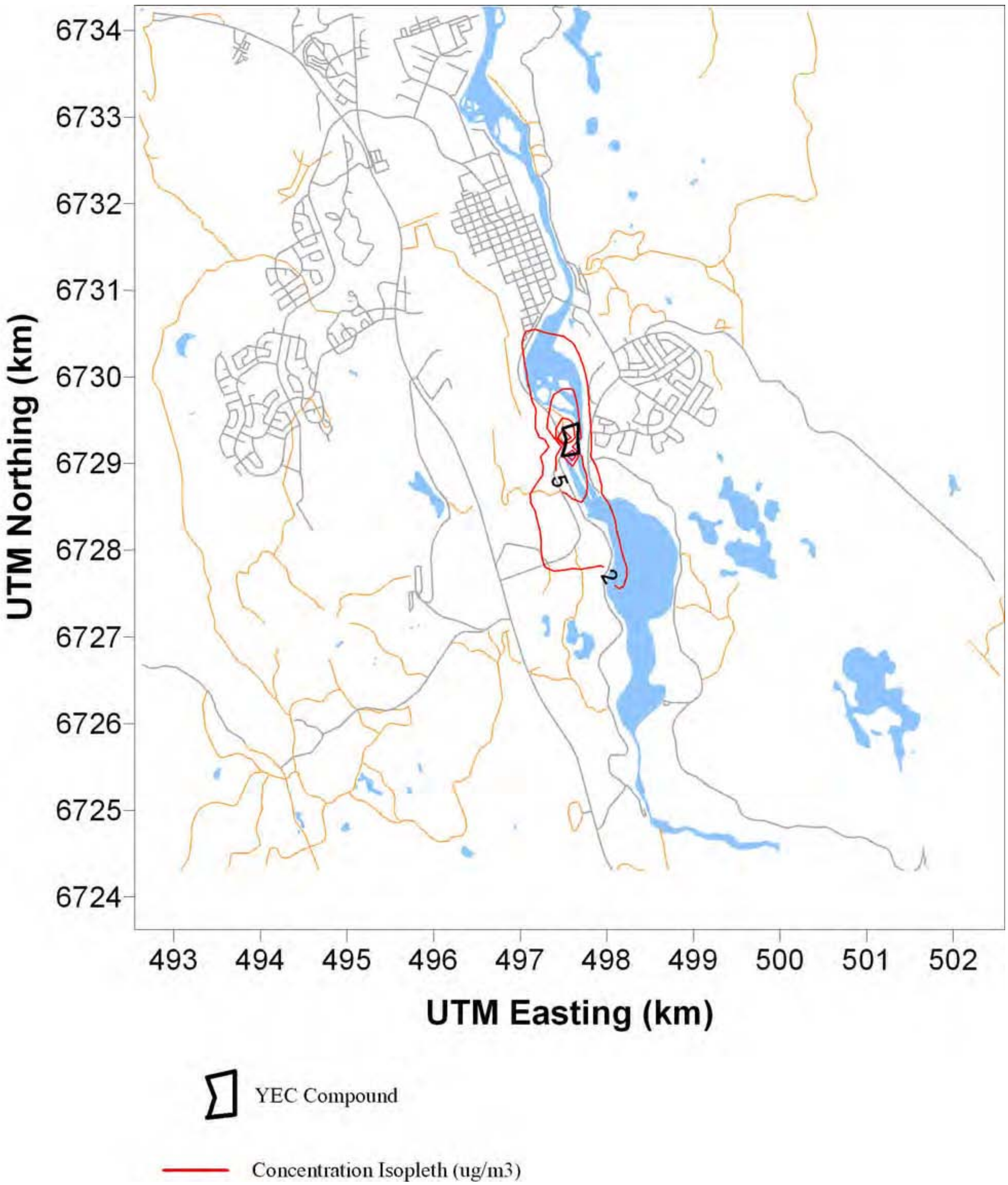


Figure 3.12

Maximum Predicted 24-hour $PM_{2.5}$ Concentrations: Scenario 2



3.5.3 Scenario 3 (Emergency Operations - Maximum Engine Use)

The highest predicted 1-hour, 8-hour and 24-hour average concentrations from the model are shown in Table 3.10. Annual average concentrations were not determined for Scenario 3 (similar to Scenario 2), since maximum engine use would only occur in emergency type of situations that would not be expected to persist over any extended time period.

Table 3.10: Maximum Predicted Ambient Concentrations - Scenario 3

Averaging Period	**Maximum Ambient Concentrations** (µg/m³)			
	NO_2	SO_2	CO	$PM_{2.5}$
1-hour	522.2	16.0	2340.0	181.7
8-hour	n/a	n/a	960.9	n/a
24-hour	147.4	4.8	n/a	54.3
Annual	n/a	n/a	n/a	n/a

Plots of maximum predicted 1-hour and 24-hour concentrations of NO_2 and $PM_{2.5}$ are shown in Figures 3.13 to 3.16. In contrast to Scenario 1 and 2, the highest predicted 1-hour NO_2 concentration occurs at a distance from the YEC diesel plant. The highest 1-hour concentration of 522.2 µg/m³ occurs approximately 1 km (south) of the facility. Another relative maximum (over 400 µg/m³) occurs approximately 2 km northwest of the facility. In the first case, the Janssen NO_x to NO_2 conversion method assumes a 14% conversion rate and in the second case, a 19% conversion rate. However, in reality there is some variation that should be expected in the NOx to NO_2 conversion rates, depending on the time of year (winter conditions experience lower conversion rates).

This issue of NO to NO_2 conversion rates is discussed further in Section 6 with respect to the uncertainty in predicted NO_2 concentrations. As indicated in Section 3.6, the highest NO_2 concentrations are predicted to occur on cold days in winter or early spring, and in the evening hours, when the rate of NO to NO_2 conversion would be much lower than has been assumed in this analysis. The *Janssen* measurements show that the conversion rates during winter are approximately half of those assumed in this assessment[16]. Given that the relatively high NO_2 concentrations were additionally found to occur during evening hours, the highest model-

[16] Janssen et al. 1988. A classification of NO oxidation rates in power plant plumes based on atmospheric conditions. *Atmospheric Environment, 22*(1), 43-53.

predicted NO_2 concentrations should be considered an artefact of the assumed rate of conversion in this analysis rather than actual high concentrations.

The highest predicted maximum 24-hour NO_2 concentration occurs adjacent to the YEC facility, which is also the case for both the highest 1-hour and 24-hour maximum $PM_{2.5}$ concentrations.

Figure 3.13
Maximum Predicted 1-hour NO_2 Concentrations: Scenario 3

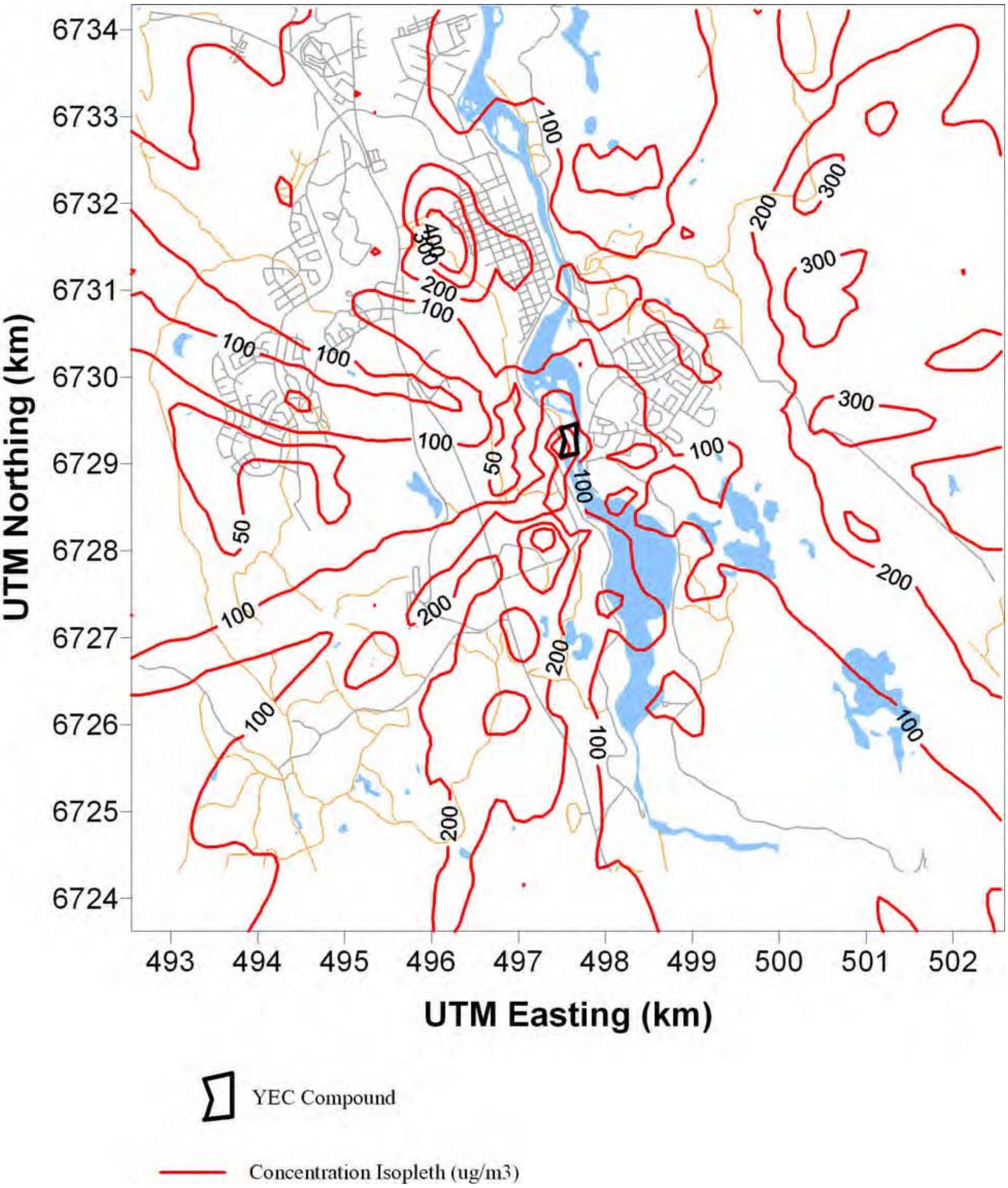


Figure 3.14
Maximum Predicted 24-hour NO_2 Concentrations: Scenario 3

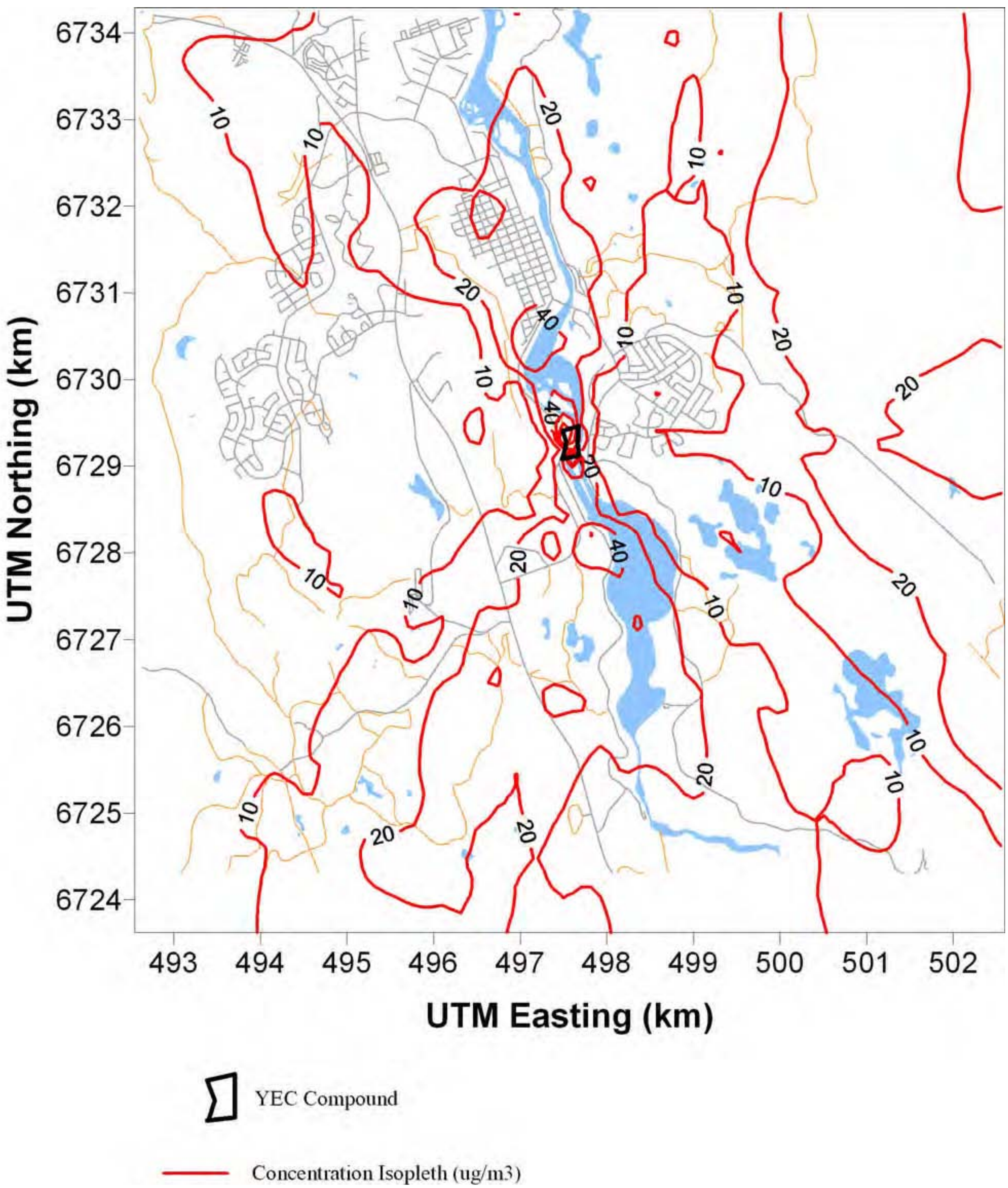


Figure 3.15
Maximum Predicted 1-hour $PM_{2.5}$ Concentrations: Scenario 3

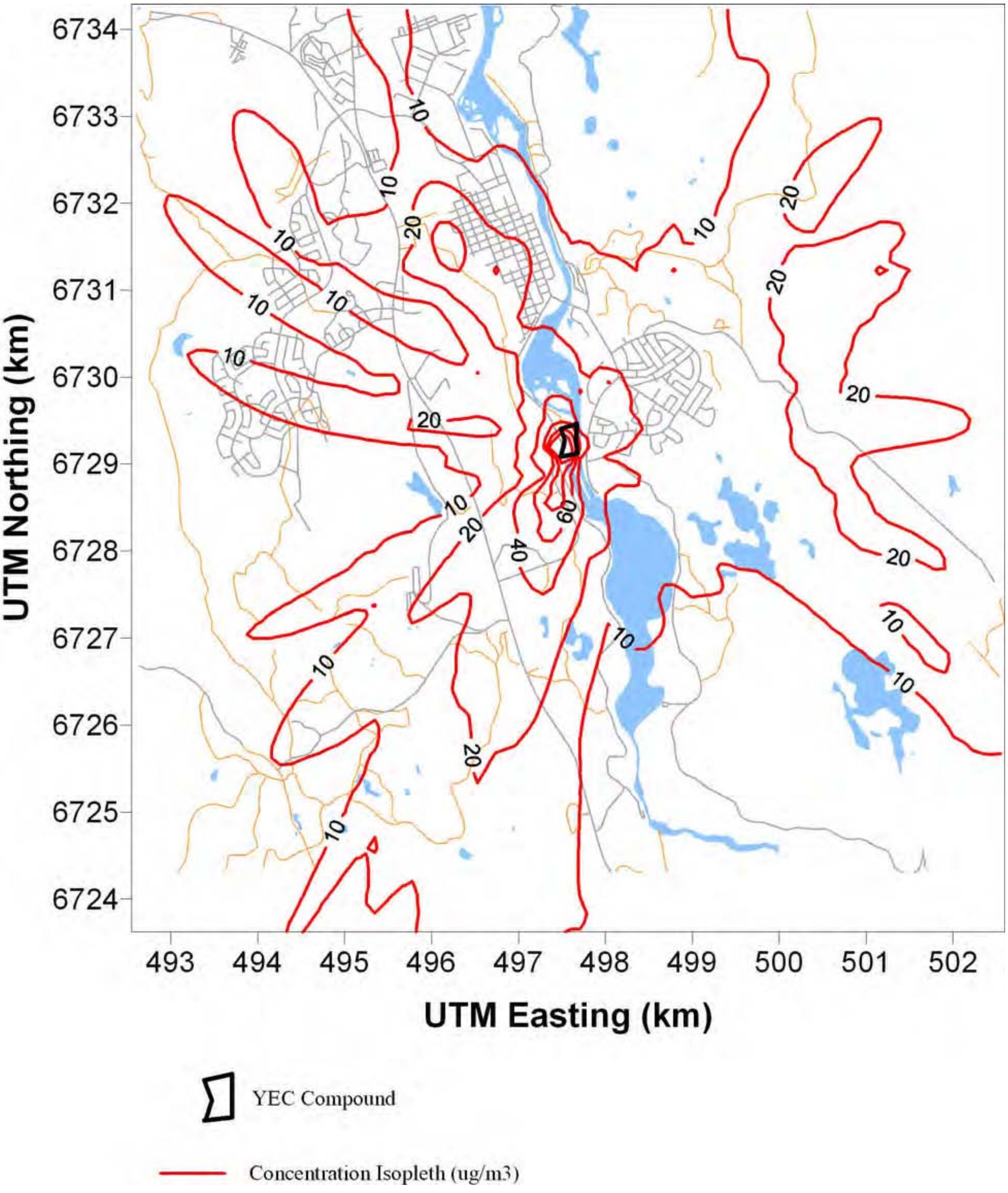
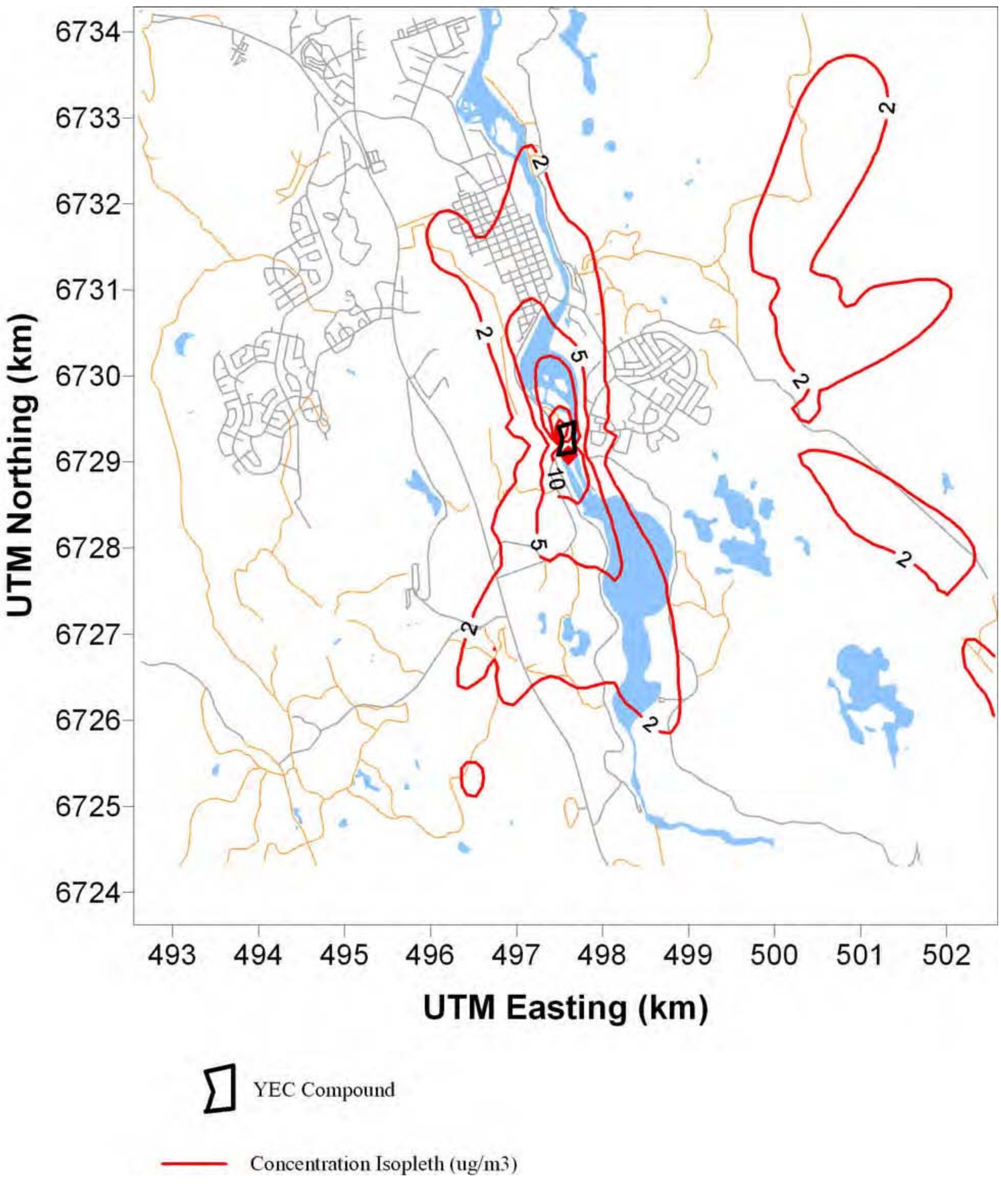


Figure 3.16
Maximum Predicted 24-hour $PM_{2.5}$ Concentrations: Scenario 3



3.6 METEOROLOGICAL CONDITIONS ASSOCIATED WITH RELATIVELY HIGH PREDICTED CONCENTRATIONS

The CALMET meteorological model determines the atmospheric dispersion conditions for each hour of the simulated year (2007) based on the surface and upper air station data that are input to the model. The general transport of air contaminants released from the YEC diesel plant is governed by the wind flow (wind speed, wind direction). Two additional model parameters that are internally calculated each hour are also useful to consider because they are intuitive and can help explain why the 'plume' of emitted contaminants may or may not disperse when released to the atmosphere. These two additional parameters are the Pasquill-Gifford Stability Class (PG Class) and the Mixing Height.

The PG Class is indicated on a scale of 1 to 6, with 6 representing a stable atmosphere and 1 representing extreme instability. The measures relate to the layer of air near the earth's surface (called the boundary layer) and the degree to which vertical mixing is either suppressed (Class 6) or enhanced (Class 1). Class 6 generally can only occur with low winds in the evening, and Class 1 with sunshine in the daytime (i.e., sunshine leads to surface heating and vigorous vertical mixing most of the time). The atmosphere is classified as either Class 4 or Class 3 most of the time, representing a 'neutrally' buoyant atmosphere. In a neutral atmosphere, a pocket of air will remain neutrally buoyant at ambient temperature, but will rise if warmed. The Mixing Height denotes the height of the layer of air above the surface within which pollutants are mixed effectively. In practice, the Mixing Height varies from a low of 50m or so, to several thousand metres. An atmospheric 'inversion' would be associated with a very low Mixing Height. Both PG Class and Mixing Height are calculated primarily from observed wind speed, cloud cover and temperature (including temperature variation with height).

A brief analysis of the meteorological conditions associated with the highest Scenario 3 model-predicted concentrations is shown here. Scenario 3 is particularly useful to assess, since the assumed emission rates do not change hour-to-hour. For this reason, a relatively high predicted concentration would be related to atmospheric conditions rather than changes to YEC operations. Tables 3.11 and 3.12 show the date, the predicted concentration, wind speed, wind direction, PG Class and Mixing Height for NO_2 and $PM_{2.5}$, that are associated with the five highest predicted 1-hour concentrations at the point of maximum impingement. For NO_2, this point is approximately 1 km south of the YEC diesel plant. For $PM_{2.5}$, this point is at the facility boundary, just west of the diesel plant (on or near the South Access Road).

Table 3.11
Meteorological Conditions at Highest Predicted 1-hour NO_2 Concentrations
Maximum Point of Impingement (Scenario 3)

Date	Concentration (µg/m³)	Wind Speed (m/s)	Wind Direction (deg)	PG Class (1 – 6)	Mixing Height (m)
0600 Feb 24	522	2.5	9	5	215
2200 Jan 9	436	3.1	8	6	273
2100 Jan 9	400	3.1	8	6	287
2300 Feb 28	377	2.5	8	6	174
0000 Mar 13	316	2.5	8	6	187

The five highest predicted 1-hour NO_2 concentrations are shown to occur under the following meteorological conditions:

- generally cold (winter or early spring, in the evening hours);
- a stable atmosphere and low Mixing Height, indicating poor dispersion; and,
- low to moderate winds from the north.

Table 3.12
Meteorological Conditions at Highest Predicted 1-hour $PM_{2.5}$ Concentrations
Maximum Point of Impingement (Scenario 3)

Date	Concentration (µg/m³)	Wind Speed (m/s)	Wind Direction (deg)	PG Class (1 – 6)	Mixing Height (m)
1800 Jun 27	182	5.3	82	4	1245
1500 Aug 16	143	4.7	83	3	1289
1700 Jul 8	125	2.5	105	4	961
1500 Apr 16	121	4.2	62	3	1141
1100 Jun 21	117	3.1	90	3	673

The five highest predicted 1-hour average $PM_{2.5}$ concentrations are shown to occur under the following meteorological conditions:

- generally warm (late spring or summer, mid to late afternoon);
- a neutral atmosphere and moderate to high Mixing Height, indicating reasonably good dispersion conditions; and,
- moderate winds from the east.

Tables 3.11 and 3.12 show that high NO_2 and high $PM_{2.5}$ concentrations are predicted to occur under very different atmospheric conditions. Relatively high NO_2 concentrations occur during cold weather when the air in the valley is somewhat trapped. Conversely, high $PM_{2.5}$ concentrations occur when the winds are moderate and vertical mixing occurs.

In the case of $PM_{2.5}$, the features noted above indicate that building downwash is responsible for the relatively high 1-hour average concentrations. The moderate winds from the east cause the emitted plume to be caught in the downstream wake of the YEC diesel plant, and brought down to ground level. This explanation is consistent with the 1-hour maximum $PM_{2.5}$ plots for both Scenario 2 and Scenario 3 (Figure 3.11 and 3.15), which show the highest concentrations occur immediately around the building housing the YEC engines.

4.0 OBSERVED AIR QUALITY IN WHITEHORSE

Table 4.1 provides a summary of the available air quality monitoring data for Whitehorse. The monitoring station in Whitehorse, located at 1091 - 1st Avenue, is part of the National Air Pollution Surveillance (NAPS) network operated by Environment Canada. The most recent 5-year data record includes monitoring for CO, NO, NO_2 and $PM_{2.5}$ for the period 2000-2005.

Table 4.1
Air Quality Monitoring Data Summary for Whitehorse

CAC	Ave. Period	Criteria		Maximum Concentrations (µg/m^3)						
		EC	WHO	2000	2001	2002	2003	2004	2005	2003-2005
CO	1-h	35,000	30,000	3,132	1,276	4,408	4,408	2,552	2088	
	8-h	15,000	10,000	2,204	928	1,972	1,856	1,392	1508	
	24-h	-	-	1,508	696	1,276	812	1,392	1044	
	annual	-	-	-	-	464	232	232	348	
NO_2	1-h	400	200	-	5.7	19.1	24.8	84.0	74.5	
	24-h	200	-	-	3.8	11.5	9.6	32.5	45.8	
	annual	60	40	-	-	1.9	0.0	-	7.6	
NO	1-h	-	-	-	257.5	125.0	143.8	131.3	90.0	
	24-h	-	-	-	53.8	31.3	33.8	21.3	30.0	
	annual	-	n/a	-	-	3.8	2.5	-	1.3	
$PM_{2.5}$	24-h	-	25[2]	n/a	12	11	14	101	80	
	CWS	30[1]								23
	annual	-	10	-	-	2	2	5	3	

n/a – not available
[1] Canada-Wide Standard (CWS): 24-h average, 98th percentile averaged of 3 consecutive years
[2] 99th percentile

Currently, there are no established ambient air quality criteria for the combustion gases in the Yukon, although a resolution was passed on March 19, 2007 by the Association of Yukon Communities requesting the Government of Yukon to *"develop and bring forward air quality legislation, including air quality standards."*

The data in Table 4.1 indicate that the CO and NO_2 levels in Whitehorse are well below ambient air quality objectives defined by both Environment Canada (EC) and the World Health Organization (WHO). There are no criteria for NO for human health protection because NO is not considered to represent a risk to health. For particulate matter, the data for $PM_{2.5}$ during the period 2001 to 2003 were well below the WHO guideline value of 25 µg/m^3, but forest fires in 2004 and 2005 caused maximum $PM_{2.5}$ concentrations that were 3-4 times the recommended WHO guideline. Nevertheless, the highest annual average $PM_{2.5}$ concentration in 2004 of 5 µg/m^3 was still less than half the WHO guideline value. Furthermore, despite the fact that $PM_{2.5}$ levels in Whitehorse during 2004 and 2005 were significantly higher than in the period 2000-2003 due to forest fires, the Canada-Wide Standard (CWS) of 30 µg/m^3 (98th percentile averaged over 3 consecutive years) for 2003-2005 was 23 µg/m^3, still well within the CWS value.

The effect of the forest fires in 2004 and 2005 on air quality in Whitehorse can be seen in the frequency distributions for 1-hour average NO_2 and 24-hour average $PM_{2.5}$ concentrations in 2004-2005 as compared with 2001-2003. Figure 4.1 shows that NO_2 concentrations in 2004-2005 were higher than in the preceding 3 years even at the lowest percentiles and were significantly higher even at the 80th percentile. Nevertheless, the maximum concentrations recorded in 2004/2005 were still less than half of the WHO guideline value of 200 µg/m^3, and only about 20% of the NAAQO value of 400 µg/m^3. Without the influence of forest fires, NO_2 concentrations in Whitehorse are well below any health-based criteria for air quality management.

Figure 4.1
Frequency Distributions of 1-Hour Average NO_2 Concentrations
Whitehorse 2001-2005

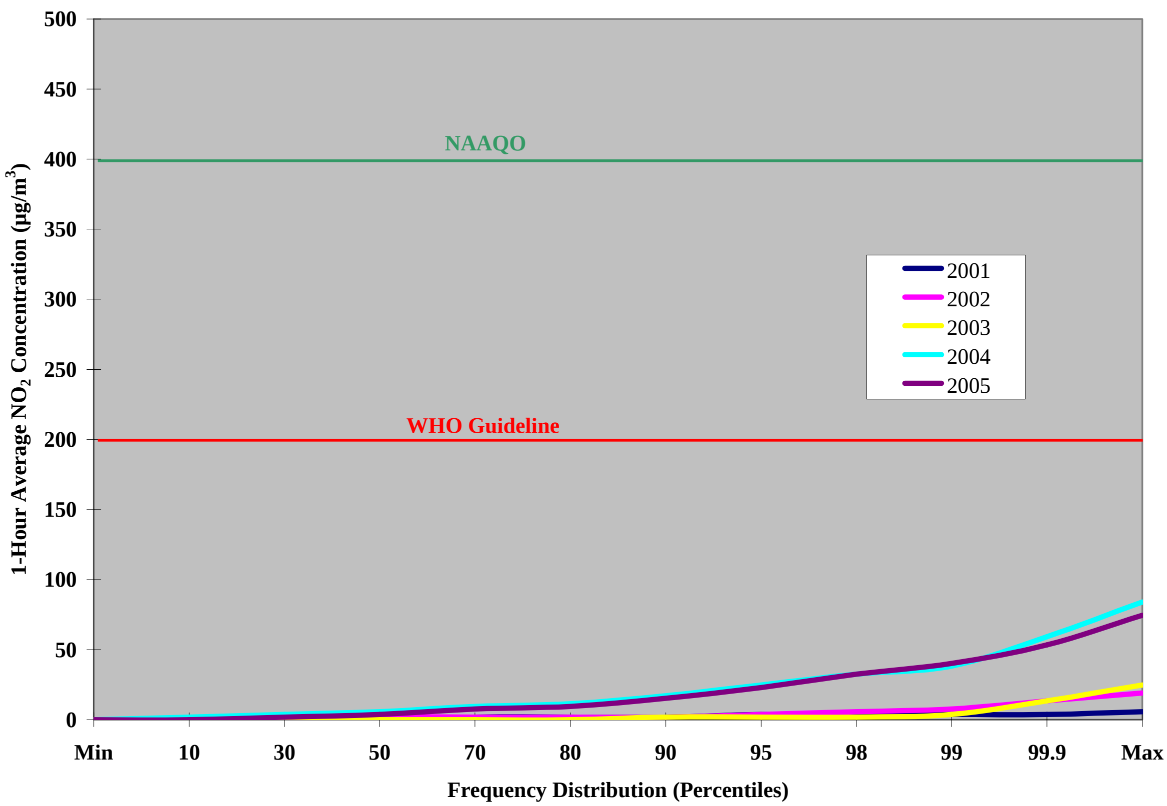
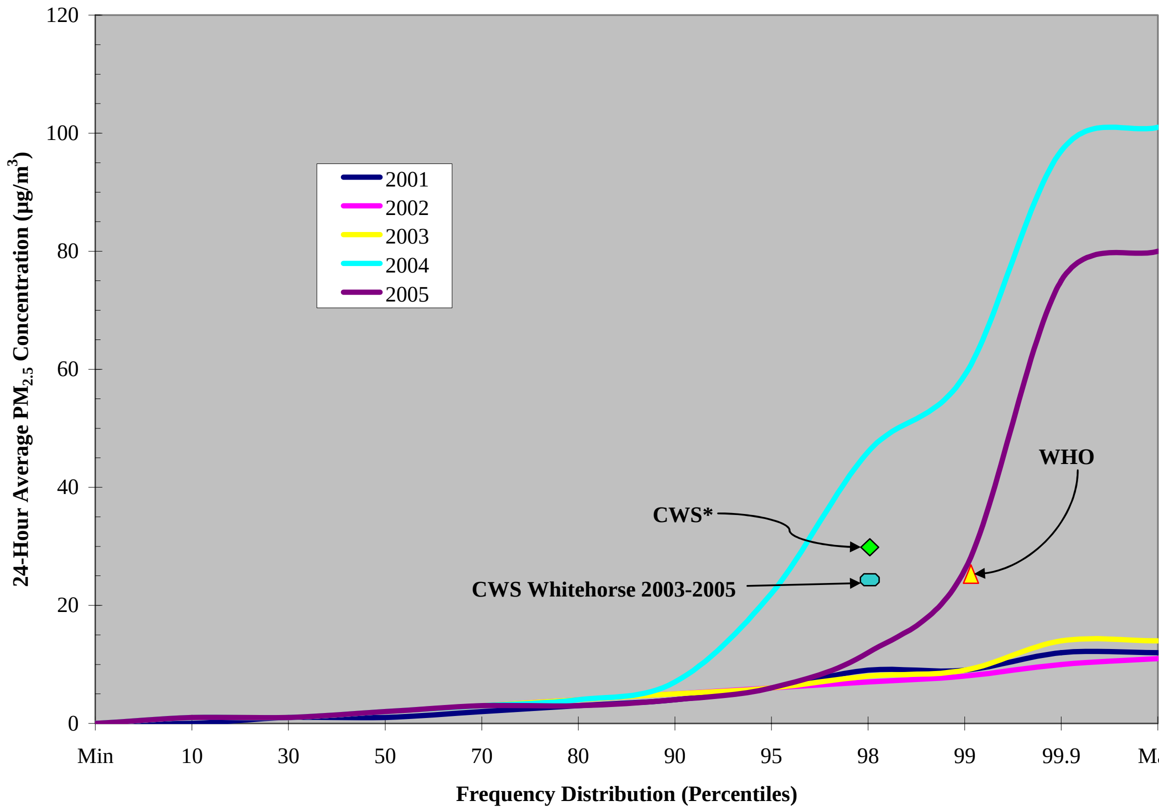


Figure 4.2 shows a similar pattern for $PM_{2.5}$ concentrations to that of NO_2 concentrations over the 2001-2005 period. Concentrations of fine particulate matter in 2004 were higher than was typical in 2001-2003 at the 90th percentile level, and exceeded the WHO guideline value of 25 µg/m^3 (99th percentile) ~4% of the time (i.e., approximately 15 days of the year) in 2004. In 2005, $PM_{2.5}$ concentrations were higher than in 2001-2003 at the 98th percentile level, and exceeded the WHO guideline value 1% of the time, or on about 3-4 days of the year. As noted above, despite the higher-than-normal $PM_{2.5}$ levels in 2004 and 2005, the CWS for the period 2003-2005 was not exceeded.

Figure 4.2
Frequency Distributions for 24-Hour Average $PM_{2.5}$ Concentrations
Whitehorse 2001-2005



* CWS – 98th percentile, averaged over 3 consecutive years

4.1 BACKGROUND AIR QUALITY

For regulatory air quality analyses, there is no consistency in the way that regulatory agencies apply air quality monitoring data to define background air quality. Some jurisdictions use the maximum observed concentrations, while others (e.g., in British Columbia) commonly use the

98th percentile value. For the observations of NO_2 and $PM_{2.5}$, the interpretation of background air quality is complicated by the fact that, as indicated in Figures 4.1 and 4.2, two of the five years of record are quite different from the other three due to forest fires.

The maximum NO_2 concentrations in 2001-2003 were only 24.8 µg/m^3 (1-hour average) and 11.5 µg/m^3 (24-hour average), compared with 84 µg/m^3 and 45.8 µg/m^3 respectively in 2004/2005. Similarly, the 98th percentiles for NO_2 concentrations were just 3.8 µg/m^3 for both the 1-hour and 24-hour averaging periods during the 3 non-forest fire years, and 32.5 µg/m^3 and 23.9 µg/m^3 respectively for 2004/2005.

For particulate matter, the maximum 24-hour average $PM_{2.5}$ concentration for the period 2001-2003 was 14 µg/m^3, compared with 101 µg/m^3 in 2004. The average 98th percentile concentration for 2001-2003 was just 8 µg/m^3, compared with 46 µg/m^3 in 2004 and 12 µg/m^3 in 2005.

Consequently, it is difficult to determine which values should be used to define the 'normal' background levels of either of these pollutants. As discussed below, both the Canada-Wide Standard for $PM_{2.5}$ and the World Health Organization guideline value are based on a percentile of the observed values rather than the maximum concentration. Therefore, in the discussion of the potential implications of the predicted $PM_{2.5}$ concentrations, the background concentration has been defined as the 98th percentile value. On the other hand, the background NO_2 (and CO) levels have been considered in terms of maximum concentrations in either the non-forest fire years or the higher values recorded in 2004 and 2005.

4.2 APPLICATION OF CWS AND WHO CRITERIA

It is important to recognize that the CWS for $PM_{2.5}$ is only a target level based on a balance of both health and socio-economic factors that were considered by the Canadian Council of Ministers of the Environment (CCME) during the CWS development process. The CWS are intended to be achievable targets that are based on sound science, but which take into consideration factors such as social aspects (e.g., the effect on jobs), economic impacts (e.g., costs associated with solving the problem), and technical feasibility. As such, achievement of the CWS for $PM_{2.5}$ is not intended to imply that health effects do not occur below the CWS value. Annex A of the CWS Agreement sets out a requirement for jurisdictions to take preventative action by developing air quality management strategies for Continuous Improvement and Keeping Clean Areas Clean (CI/KCAC). Air quality management agencies are encouraged to make additional efforts to reduce emissions of fine particles, even in areas where the CWS has been achieved.

Similarly, the update to the WHO air quality guidelines in 2005[17] noted that *"current scientific evidence indicates that guidelines cannot be proposed that will lead to complete protection against adverse health effects for particulate matter, as thresholds have not been identified"*. Consequently, a decision was made by the WHO to define $PM_{2.5}$ concentration guideline values that, if achieved, would be expected to result in significantly reduced rates of adverse health effects. Furthermore, in recognition of the fact that not all countries may be able to immediately achieve the proposed guideline values, the WHO also proposed interim target values which countries can use to set standards according to country-specific approaches to balancing risks to health, technological feasibility, economic considerations, and other political and social factors. Table 4.2 summarizes the updated WHO air quality guidelines (AQG) for $PM_{2.5}$ and the interim target (IT) values.

Table 4.2
WHO Air Quality Guidelines and Interim Targets for $PM_{2.5}$

Interim Target /Guideline	Averaging Period	Value ($\mu g/m^3$)	Basis for the selected level
IT-1	24-hour	75	Based on published risk coefficients from multi-centre studies and meta-analyses (about 5% increase of short-term mortality over AQG)
	annual	35	These levels are estimated to be associated with about 15% higher long-term mortality than at AQG
IT-2	24-hour	50	Based on published risk coefficients from multi-centre studies and meta-analyses (about 2.5% increase of short term mortality over AQG)
	annual	25	In addition to other health benefits, these levels lower risk of premature mortality by approximately 6% (2-11% compared to WHO IT-1)
IT-3	24-hour	37.5	Based on published risk coefficients from multi-centre studies and meta-analyses (about 1.2% increase of short term mortality over AQG)
	annual	15	In addition to other health benefits, these levels lower risk of premature mortality by approximately 6% (2-11% compared to WHO IT-2)
AQG	24-hour	**25**	Based on relationship between 24-hour and annual PM levels
	annual	**10**	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to $PM_{2.5}$ in the American Cancer Society study.

However, as indicated in Table 4.3, there is currently no consensus among regulatory agencies in North America, Europe, Australia or New Zealand as to the level at which medium or long-term goals for $PM_{2.5}$ should be set. Furthermore, none of the levels listed in Table 4.3 would be considered completely protective of human health because statistically significant health

[17] World Health Organization (2005). WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. Global update 2005. Summary of Risk Assessment. WHO Press, Geneva, Switzerland.

outcomes have been reported at levels as low as 15 µg/m^3 in epidemiological studies for large urban areas.

Table 4.3: Summary of Existing Control Levels for Particulate Matter (PM)

(Source: NRTEE 2008[18]; BC Lung Association 2005[19])

Country	Jurisdiction	PM Concentration (µg/m^3)				
		$PM_{2.5}$			PM_{10}	
		1-hour	24-hour	annual	24-hour	annual
Canada	CWS		30[1]			
	BC		25[2]		50	
	BC/GVRD		25	12		
	BC/CRD		25[3]			
	BC/Quesnel		18[4]			
	AB	80	30[5]			
	MB		30[5]			
	QC		30[6]			
	QC/Montreal	35[6]	25[6]			
	SK		30[5]			
	NB		30[5]			
	NL		25			
USA	Federal		35[7]	15[8]		
Europe	EU			25[9]	50	
Australia	Federal		25[10]	8[10]		
New Zealand	Federal		25[11]			
Global	WHO		25[12]	10[13]	50[14]	20[15]

[1] 3-year average of the 98th percentile of the 24-hour average achieved by 2010
[2] Proposed for province-wide adoption for permitting purposes
[3] Guideline value only; not use for permitting
[4] target value - 3-year average of the 98th percentile of the 24-hour average achieved by 2010
[5] Use for permitting purposes
[6] Used for air quality index
[7] 3-year average of the 98th percentile of the 24-hour average achieved by 2010
[8] Averaged over 3 consecutive years
[9] Target of 20% reduction in ambient $PM_{2.5}$ levels over the period 2010-2020
[10] Advisory reporting standard only
[11] Interim guideline
[12] 99th percentile; interim targets of 75, 50 and 37.5 µg/m^3 for areas of poorer air quality
[13] Interim targets of 35, 20 and 15 µg/m^3 for areas of poorer air quality
[14] Interim targets of 150, 100 and 75 µg/m^3 for areas of poorer air quality
[15] Interim targets of 70, 50 and 30 µg/m^3 for areas of poorer air quality

[18] National Round Table on the Environment and the Economy 2008. Developing Ambient Air Quality Objectives for Canada. Advice to the Minister of the Environment, Ottawa, Ontario.
[19] British Columbia Lung Association 2005. Development of Options for a New Provincial $PM_{2.5}$ Air Quality Objective. Prepared by SENES Consultants Limited, Vancouver, British Columbia.

5.0 INTERPRETATION OF PREDICTED AIR QUALITY IMPACTS

5.1 HAZARD ASSESSMENT

For contaminants in diesel-fired generator combustion gases, some adverse effects related to short-term exposure are generally associated with irritation of the tissues of the eyes, and upper and lower respiratory systems. Therefore, the toxicity is dependent on the chemical concentration in the air rather than the total internal dose received by multiple exposure pathways. For CAC in combustion gases, exposure limits are represented by air quality guidelines/objectives and are used as exposure limits to assess potential health effects. It is noted that some of the exposure limits are not necessarily health-based (e.g., the SO_2 value from WHO as it incorporates other considerations); however in lieu of other information the use of these values are appropriate. A summary of the exposure limits for combustion gases are presented in Table 5.1.

Note that the WHO guidelines are more stringent than the NAAQO established by Environment Canada. The latter were defined in the 1970s, and have not been updated with more up-to-date research as is the case for the WHO guidelines. This is especially true with regard to NO_2 and SO_2 exposure limits. The NAAQO are simply provided for comparison purposes.

Table 5.1: Exposure Limits/Air Quality Guidelines and Objectives for Combustion Gases

Combustion Gas		**Exposure Limits/Guidelines Used for Hazard Assessment**		**National Ambient Air Quality Objectives ($\mu g/m^3$)**	
		Concentration ($\mu g/m^3$)	**Jurisdiction**	Maximum Desirable	Maximum Acceptable
CO	1-hr	30,000	WHO (2000)	15,000	35,000
	8-hr	10,000	WHO (2000)	6,000	15,000
	Annual	2,400[a]		-	-
NO_2	1-hr	200	WHO (2005)	-	400
	24-hr	200	CCME (2005)	-	200
	Annual	40	WHO (2005)	60	100
SO_2	1-hr	350	WHO (2005)	450	900
	24-hr	125[b]	WHO (2000, 2005)	150	300
	24-hr	20	WHO (2005)	-	-
	Annual	n/a	WHO (2005)	30	60

Note: n/a – not available
[a] The 1-hr WHO guideline was divided by a factor of 12.5 to obtain an annual average value (U.S. EPA 1992)[20]
[b] Interim guideline

[20] United States Environmental Protection Agency (U.S. EPA) 1992. *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised*. Office of Air and Radiation, Office of Air Quality Planning and Standards. EPA/454/R-92-019. Research Triangle Park, North Carolina.

Currently, there is no WHO 24-hr guideline for NO_2; therefore, the NAAQO currently used by the Canadian Council of Ministers of the Environment (CCME) was used for the exposure limit. As shown in Table 5.1, the 24-hour guideline for SO_2 has been updated in 2005 – the new guideline is about six times lower than the guideline set in 2000 and is based on epidemiological studies. The WHO realizes that this new guideline may be quite difficult to achieve in the short term, and has suggested a stepped approach using the interim value of 125 $\mu g/m^3$ shown in Table 5.1. It should be noted that these recommended guideline values for sulphur dioxide are not linked with guidelines for particles. WHO further noted in their *Air Quality Guidelines Global Update* (2005) that an annual guideline for SO_2 is not necessary because compliance with the 24-hour level will assure low levels for the annual average.

5.2 HUMAN HEALTH RISK ASSESSMENT

The final step in the risk assessment process is the characterization of health risks or potential for adverse effects. In this step the predicted exposures are compared to the exposure limits for a given chemical in order to determine the risks associated with the various chemicals of concern.

For the current assessment, potential adverse effects and risks are calculated using deterministic (point estimate) risk estimates or concentration ratios. Concentration ratio values for short-term or long-term exposure to combustion gases are calculated by dividing the predicted concentration at the location of the maximum point of impingement (Max POI)[21] by the appropriate reference concentration as shown in the following equation:

$$Concentration\,Ratio = \frac{Predicted\ Air\,Concentration\left(\mu g / m^3\right)}{Exposure\ Limit\left(\mu g / m^3\right)}$$

A concentration ratio value based on the total air concentration (i.e., background levels from other sources plus incremental impacts from YEC emissions) of below 1 implies that the health effects associated with the combustion gas are not significant.

5.3 POTENTIAL HEALTH EFFECTS ARISING FROM COMBUSTION GASES

As discussed previously, the health effects associated with CAC combustion gases occur at the site of contact with the sensitive tissues of the eyes and respiratory system. Any such health

[21] The maximum point of impingement is defined as any point on the ground or on a receptor, such as nearby buildings, located outside the company's property boundaries at which the highest concentration of a contaminant emitted from a facility is expected to occur. The location of the Max POI will differ for different averaging periods.

effects are short-lived and reversible once exposure levels are reduced to levels below the exposure limits.

CAC combustion gases are assessed using concentration ratio values. Potential adverse health effects from short-term exposures are determined by using 1-hour, 8-hour or 24-hour ground level air concentrations at the maximum point of impingement. Similarly, chronic health risks associated with the combustion gases are estimated using annual average air concentrations predicted at the maximum point of impingement for residential receptors.

Concentration ratio values less than 1 indicate that the predicted air concentrations are less than the reference concentrations, and as such it is not expected that any adverse health effects would occur. A concentration ratio value above 1 would indicate that the reference concentration is exceeded and that there is a possibility that an adverse health effect, namely irritation, may occur.

5.3.1 Potential Short-Term Human Health Risks Associated with Exposure to CAC Combustion Gases

The results of the assessment for short-term health effects associated with estimated exposure to the combustion gases produced by the operation of the diesel-powered generators in Whitehorse are presented in Tables 5.2, 5.3 and 5.4 for Scenarios 1, 2 and 3, respectively. The assessment was based on predicted incremental concentrations at the six sensitive receptor sites, without including background concentrations from all other sources.

The maximum predicted concentrations for all three pollutants occur at the maximum point of impingement (Max POI). For CO, SO_2 and $PM_{2.5}$ emissions, the Max POI occurs close to the stack, and results from building downwash of the emission plumes from the short emission stacks on the generators. However, for NO_2 concentrations, the Max POI occurs at some distance from the YEC plant as the NO emissions are transformed into NO_2 in the atmosphere.

The potential significance of these ambient concentrations is determined in Tables 5.2, 5.3 and 5.4 as the ratio of the total ambient concentrations (i.e., maximum predicted concentrations from YEC generator operations plus background concentration) for two operating scenarios against the exposure limits listed in Table 5.1. The NAAQO values are also listed for comparison purposes.

Table 5.2: Potential Concentration Ratios for Combustion Gases – Scenario 1

Location	Emission Scenarios	Maximum Concentrations (µg/m³)					
		CO		NO_2		SO_2	
		1-hour	8-hour	1-hour	24-hour	1-hour	24-hour
Max. Predicted Concentration due to YEC Emissions	Receptor 1	27.8	3.9	5.2	0.2	0.17	0.01
	Receptor 2	18.8	2.3	4.3	0.2	0.14	0.01
	Receptor 3	1.7	0.3	0.9	0.1	0.01	0.0
	Receptor 4	42.7	8.4	29.5	1.7	0.35	0.02
	Receptor 5	25.2	4.3	20.9	1.2	0.18	0.01
	Receptor 6	194.7	24.3	47.0	2.9	1.6	0.1
	Max POI	292.5	76.5	69.0	4.8	0.23	0.2
Max. Background	2000-2003	4408	2204	24.8	9.6	n/a	n/a
	2004 - 2005	2552	1508	84.0	45.8	n/a	n/a
Max. Ambient Concentration (2001-2003 Background)	Receptor 1	4435.8	2207.9	30.0	9.8	1.6	0.2
	Receptor 2	4426.8	2206.3	29.1	9.8	0.6	0.1
	Receptor 3	4409.7	2204.3	25.7	9.7	0.4	0.0
	Receptor 4	4450.7	2212.4	54.3	11.3	0.4	0.1
	Receptor 5	4433.2	2208.3	45.7	10.8	0.3	0.1
	Receptor 6	4602.7	2228.3	71.8	12.5	4.1	0.7
	Max POI	4700.5	2280.5	93.8	14.4	8.2	1.4
Max. Ambient Concentration (2004-2005 Background)	Receptor 1	2579.8	1511.9	89.2	46.0	1.6	0.2
	Receptor 2	2570.8	1510.3	88.3	46.0	0.6	0.1
	Receptor 3	2553.7	1508.3	84.9	45.9	0.4	0.0
	Receptor 4	2594.7	1516.4	113.5	47.5	0.4	0.1
	Receptor 5	2577.2	1512.3	104.9	47.0	0.3	0.1
	Receptor 6	2746.7	1532.3	131.0	48.7	4.1	0.7
	Max POI	2844.5	1584.5	153.0	50.6	8.2	1.4
NAAQO	Max. Acceptable	35,000	15,000	400	200	900	300
	Max. Desirable	15,000	6000	-	-	450	150
Exposure Limits/Guidelines		30,000	10,000	200	200	350	20
Ratio Max. Ambient /Exposure Limits (2001-2003 Background)	Receptor 1	0.15	0.22	0.15	0.05	0.0005	0.0005
	Receptor 2	0.15	0.22	0.15	0.05	0.0004	0.0005
	Receptor 3	0.15	0.22	0.13	0.05	0.00003	0
	Receptor 4	0.15	0.22	0.27	0.06	0.001	0.001
	Receptor 5	0.15	0.22	0.23	0.05	0.0005	0.0005
	Receptor 6	0.15	0.22	0.36	0.06	0.005	0.005
	Max POI	0.16	0.23	0.47	0.07	0.0007	0.01
Ratio Max. Ambient /Exposure Limits (2004-2005 Background)	Receptor 1	0.09	0.15	0.45	0.23	0.0005	0.0005
	Receptor 2	0.09	0.15	0.44	0.23	0.0004	0.0005
	Receptor 3	0.09	0.15	0.42	0.23	0.00003	0
	Receptor 4	0.09	0.15	0.57	0.24	0.001	0.001
	Receptor 5	0.09	0.15	0.52	0.24	0.0005	0.0005
	Receptor 6	0.09	0.15	0.66	0.24	0.005	0.005
	Max POI	0.09	0.16	0.77	0.25	0.0007	0.01

Value exceeding exposure limits are shown in bold

Table 5.3: Potential Concentration Ratios for Combustion Gases – Scenario 2

Location	Emission Scenarios	Maximum Concentrations (µg/m³)					
		CO		NO_2		SO_2	
		1-hour	8-hour	1-hour	24-hour	1-hour	24-hour
Max. Predicted Concentration due to YEC Emissions	Receptor 1	205.4	55.1	50.2	5.5	1.6	0.2
	Receptor 2	81.3	15.0	19.9	1.9	0.6	0.1
	Receptor 3	47.3	11.5	32.0	2.8	0.4	0.0
	Receptor 4	47.8	20.4	33.4	7.3	0.4	0.1
	Receptor 5	38.3	12.8	36.9	7.5	0.3	0.1
	Receptor 6	497.0	209.3	126.5	21.2	4.1	0.7
	Max POI	1,022.5	303.1	255.0	42.1	8.2	1.4
Max. Background	2000-2003	4408	2204	24.8	9.6	n/a	n/a
	2004 - 2005	2552	1508	84.0	45.8	n/a	n/a
Max. Ambient Concentration (2001-2003 Background)	Receptor 1	4613.4	2259.1	75.0	15.1	3.6	0.4
	Receptor 2	4489.3	2219.0	44.7	11.5	1.7	0.2
	Receptor 3	4455.3	2215.5	56.8	12.4	1.5	0.1
	Receptor 4	4455.8	2224.4	58.2	16.9	1.2	0.3
	Receptor 5	4446.3	2216.8	61.7	17.1	0.9	0.2
	Receptor 6	4903.0	2413.3	151.7	30.8	7.5	1.4
	Max POI	5430.5	2507.1	279.8	51.7	16.0	4.8
Max. Ambient Concentration (2004-2005 Background)	Receptor 1	2757.4	1563.1	134.2	51.3	3.6	0.4
	Receptor 2	2633.3	1523.0	103.9	47.7	1.7	0.2
	Receptor 3	2599.3	1519.5	116.0	48.6	1.5	0.1
	Receptor 4	2599.8	1528.4	117.4	53.1	1.2	0.3
	Receptor 5	2590.3	1520.8	120.9	53.3	0.9	0.2
	Receptor 6	3049.0	1717.3	210.5	67.0	7.5	1.4
	Max POI	3574.5	1811.1	339.0	87.9	16.0	4.8
NAAQO	Max. Acceptable	35,000	15,000	400	200	900	300
	Max. Desirable	15,000	6000	-	-	450	150
Exposure Limits/Guidelines		30,000	10,000	200	200	350	20
Ratio Max. Ambient /Exposure Limits (2001-2003 Background)	Receptor 1	0.15	0.23	0.38	0.08	0.005	0.01
	Receptor 2	0.15	0.22	0.22	0.06	0.002	0.005
	Receptor 3	0.15	0.22	0.28	0.06	0.001	0
	Receptor 4	0.15	0.22	0.29	0.08	0.001	0.005
	Receptor 5	0.15	0.22	0.31	0.09	0.0009	0.005
	Receptor 6	0.16	0.24	0.76	0.15	0.01	0.035
	Max POI	0.18	0.25	**1.40**	0.26	0.004	0.07
Ratio Max. Ambient /Exposure Limits (2004-2005 Background)	Receptor 1	0.09	0.16	0.67	0.26	0.005	0.01
	Receptor 2	0.09	0.15	0.52	0.24	0.002	0.005
	Receptor 3	0.09	0.15	0.58	0.24	0.001	0
	Receptor 4	0.09	0.15	0.59	0.27	0.001	0.005
	Receptor 5	0.09	0.15	0.60	0.27	0.0009	0.005
	Receptor 6	0.10	0.17	**1.05**	0.34	0.01	0.035
	Max POI	0.12	0.18	**1.70**	0.44	0.004	0.07

Value exceeding exposure limits are shown in bold

Table 5.4: Potential Concentration Ratios for Combustion Gases – Scenario 3

	Location	**Maximum Concentrations** (µg/m³)					
		CO		**NO_2**		**SO_2**	
		1-hour	8-hour	1-hour	24-hour	1-hour	24-hour
Max. Predicted Concentration due to YEC Emissions	Receptor 1	519.0	150.7	109.3	13.6	3.6	0.4
	Receptor 2	244.7	58.7	51.6	5.5	1.7	0.2
	Receptor 3	220.0	39.2	130.3	7.7	1.5	0.1
	Receptor 4	175.9	61.9	104.1	23.7	1.2	0.3
	Receptor 5	126.3	50.3	100.9	24.1	0.9	0.2
	Receptor 6	1107.3	480.8	230.1	44.2	7.5	1.4
	Max POI	2,340.0	960.9	522.2	147.4	16.0	4.8
Max. Background	2000-2003	4408	2204	24.8	9.6	n/a	n/a
	2004 - 2005	2552	1508	84.0	45.8	n/a	n/a
Max. Ambient Concentration (2001-2003 Background)	Receptor 1	4927.0	2354.7	134.1	23.2	3.6	0.4
	Receptor 2	4652.7	2262.7	76.4	15.1	1.7	0.2
	Receptor 3	4628.0	2243.2	155.1	17.3	1.5	0.1
	Receptor 4	4583.9	2265.9	128.9	33.3	1.2	0.3
	Receptor 5	4534.3	2254.3	125.7	33.7	0.9	0.2
	Receptor 6	5515.3	2684.8	254.9	52.8	7.5	1.4
	Max POI	6748.0	3164.9	547.0	157.0	16.0	4.8
Max. Ambient Concentration (2004-2005 Background)	Receptor 1	3071.0	1658.7	193.3	59.4	3.6	0.4
	Receptor 2	2796.7	1566.7	135.6	51.3	1.7	0.2
	Receptor 3	2772.0	1547.2	214.3	53.5	1.5	0.1
	Receptor 4	2727.9	1569.9	188.1	69.5	1.2	0.3
	Receptor 5	2678.3	1558.3	184.9	69.9	0.9	0.2
	Receptor 6	3659.3	1988.8	314.1	90.0	7.5	1.4
	Max POI	4892.0	2468.9	606.2	193.2	16.0	4.8
NAAQO	Max. Acceptable	35,000	15,000	400	200	900	300
	Max. Desirable	15,000	6000	-	-	450	150
Exposure Limits/Guidelines		30,000	10,000	200	200	350	20
Ratio Max. Ambient /Exposure Limits (2001-2003 Background)	Receptor 1	0.16	0.24	0.67	0.12	0.01	0.02
	Receptor 2	0.16	0.23	0.38	0.08	0.005	0.01
	Receptor 3	0.15	0.22	0.78	0.09	0.004	0.005
	Receptor 4	0.15	0.23	0.64	0.17	0.003	0.015
	Receptor 5	0.15	0.23	0.63	0.17	0.003	0.01
	Receptor 6	0.18	0.27	**1.27**	0.27	0.02	0.07
	Max POI	0.22	0.32	**2.74**	0.79	0.05	0.24
Ratio Max. Ambient /Exposure Limits (2004-2005 Background)	Receptor 1	0.10	0.17	0.97	0.30	0.01	0.02
	Receptor 2	0.09	0.16	0.68	0.27	0.005	0.01
	Receptor 3	0.09	0.15	**1.07**	0.27	0.004	0.005
	Receptor 4	0.09	0.16	0.94	0.35	0.003	0.015
	Receptor 5	0.09	0.16	0.92	0.35	0.003	0.01
	Receptor 6	0.12	0.20	**1.57**	0.45	0.02	0.07
	Max POI	0.16	0.25	**3.03**	0.97	0.05	0.24

Value exceeding exposure limits are shown in bold

Scenario 1 – Actual Operations in 2007

The ratios of predicted concentrations to exposure limits for Scenario 1 in Table 5.2 are low for both CO and SO_2, but can exceed 75% of the exposure limit for the 1-hour averaging period for NO_2 at the Max POI for years with high background concentrations (e.g., 2004-2005). The maximum measured baseline 1-hour average NO_2 concentrations in Whitehorse during 2001-2003 (i.e., years without forest fire impacts) were less than 25 µg/m^3. Therefore, the exposure limits would not have been exceeded in 2007 even if the background concentration at the Max POI were as high as in downtown Whitehorse during those years for operating Scenario 1. Similarly, the combination of the maximum predicted 24-hour average NO_2 concentration of 4.8 µg/m^3 and the maximum observed baseline 24-hour average of 45.8 µg/m^3 in 2005 would not exceed the exposure limit of 200 µg/m^3 for Scenario 1.

Scenario 2 – Hypothetical Operations at Maximum Daily Engine Usage

For the hypothetical operating Scenario 2 (Sc 2), which assumes that the YEC plant operates at the maximum daily level of power generation expected in the foreseeable future every day of the year, the ratios of predicted ambient concentrations plus maximum background levels to exposure limits remain below 1.0 for both CO and SO_2. The ratios for SO_2 may be higher than indicated in Table 5.3 because the background SO_2 level in Whitehorse is unknown (i.e., no NAPS monitoring data).

Table 5.3 also indicates that 1-hour average NO_2 concentrations could exceed the WHO guideline value for human health protection at the Max POI even without the additional contribution to background levels from other sources (but not at the 6 sensitive receptor sites). The WHO guideline could be significantly exceeded (i.e., 67.4% over the guideline value) at the Max POI for the combination of emission levels in Scenario 2 and high background NO_2 levels such as occurred in 2004. The exposure limit could be exceeded at the Max POI for about 18 hours per year (i.e., at the 99.8^{th} percentile level) in years with high background NO_2 concentrations, but only for about 4 hours per year in years with low background levels. It should be noted, however that the highest predicted 1-hour average NO_2 concentration at the Max POI may be overestimated by about a factor of 2 due to the fact that the highest predicted concentrations occur in the winter when NO to NO_2 conversion rates could be 50% lower than has been assumed in the modelling analysis. In that case, the NO_2 concentrations at the Max POI could be on the order of 127 µg/m^3, instead of 255 µg/m^3 as listed in Table 5.2. In that case, the exposure limit would not be exceeded because background levels would likely be lower in winter as well.

At the sensitive receptors located within 1 km of the YEC plant (i.e., receptors 1, 2, 3, 4 and 6), there is less uncertainty about the NO to NO_2 conversion rates. The 1-hour average exposure limit would also be exceeded at receptor #6 (i.e., 126.5 µg/m^3 from YEC plus 84 µg/m^3

compared with the exposure limit of 200 µg/m^3) for about 4 hours per year (i.e., at the 99.95th percentile level) in years with high background NO_2, but not at all in years with low background levels.

It must be emphasized that this exceedence of the exposure limit would not occur at any of the five sensitive receptor sites such as schools in Riverdale or the general hospital, or at other residential areas of Whitehorse. The exceedence of the guideline value would only occur close to the plant boundary. Furthermore, none of the predicted air quality levels anywhere in the modelling domain would exceed the NAAQO values as defined by Environment Canada.

Scenario 3 – Emergency Operations – Maximum Potential to Emit

The maximum predicted concentrations of CO and SO_2 in Table 5.4 remain well below the exposure limits for Scenario 3, and are thus of no particular concern for human health effects. On the other hand, interpretation of the maximum predicted 1-hour average NO_2 concentrations must be considered in the context of background NO_2 levels in non-forest fire years versus maximum levels during forest fire years.

- In non-forest fire years, the exposure limits for 1-hour average NO_2 concentrations would not be exceeded at sensitive receptors 1-5 under any circumstances, but could be exceeded at receptor 6 and at the Max POI for emissions from the YEC plant alone (i.e., even without the additional contribution from background NO_2). The level at the Max POI is predicted at more than 2.5 times the exposure limit. However, as noted previously, the highest concentrations at the Max POI occur at a time of year when the NO to NO_2 conversion rate would be about half the rate assumed in the dispersion modelling analysis. Therefore, the maximum predicted NO_2 concentration of 522 µg/m^3 at the Max POI could more reasonably be expected to be as low as 260 µg/m^3. Such a level would still exceed the exposure limit for health effects regardless of the magnitude of background concentrations. However, the 24-hour average exposure limit would not be exceeded at any of the locations in the modelling domain.

- During forest fire years when the background NO_2 levels could be higher than normal, the 1-hour average NO_2 exposure limit could be exceeded at the Max POI, as well as at receptor 6 located at the footbridge on the east side of the Yukon River, at receptor 3 at the Grey Mountain Primary School, and could also approach within >90% of the exposure limit at receptor 1 (the nearest residence), at receptor 4 (F.H. Collins Secondary School) and receptor 5 (the Whitehorse General Hospital). Although no one would be expected to be present at receptor 6 for long periods of exposure, a person could be present at this location for a 1-hour period. People would certainly be present at the other sensitive receptor locations for periods of one hour or more. Furthermore, even the 24-

hour average NO_2 concentration at the maximum POI is just under the Maximum Acceptable NAAQO value when combined with the higher background levels of NO_2 experienced during 2005. No one would be expected to remain at receptor 6 for a full 24-hour period, however, and the exposure limit for 24-hour averages would not be exceeded at any of the other sensitive receptor locations.

Summary
None of the health-based exposure limits would have been exceeded for CO, NO_2 and SO_2 for actual operations in 2007. Therefore, no adverse health effects would be expected for these three CAC from operations of the diesel generators in that year.

For the hypothetical operational Scenario 2, the exposure limits for CO and SO_2 would have been met at all locations, as would the 24-hour average NO_2 exposure limit. However, the 1-hour average NO_2 exposure limit could be exceeded at the maximum POI and at receptor 6.

For the emergency operating Scenario 3, the exposure limits for CO and SO_2 would also have been met at all locations. The 24-hour average NO_2 exposure limit would not have been exceeded. In non-forest fire years, the exposure limits for 1-hour average NO_2 concentrations would not be exceeded at sensitive receptors 1-5 under any circumstances, but could be exceeded at receptor 6 and at the Max POI for emissions from the YEC plant alone (i.e., even without the additional contribution from background NO_2). On the other hand, with higher background NO_2 levels during forest fire years, the 1-hour average NO_2 exposure limit could be exceeded at the maximum POI, at receptors 3 and 6, and could come close to being exceeded at receptors 1, 4 and 5. Therefore, the degree to which the NO_2 exposure limits may be exceeded depends to some degree on when emergency operations are likely to occur.

5.3.2 Potential Long-Term Human Health Risks Associated with Exposure to CAC Combustion Gases

The results of the assessment for chronic health effects associated with estimated exposure to the combustion gases produced by YEC operations in 2007 are presented in Table 5.5. The results shown in Table 5.5 are based on Scenario 1 only because neither Scenario 2 nor 3 would see operations continue at those levels of emissions for only a few days per year.

As seen from Table 5.5, long-term concentration ratio values for CO and NO_2, including background levels measured in Whitehorse, are below the acceptable value of one. These long-term concentrations are based on the maximum predicted annual average concentrations (at the maximum point of impingement) for Scenario 1. The operation of the YEC plant contributed insignificant levels of CO, NO_2 and SO_2 to average annual ambient concentrations in Whitehorse.

Table 5.5
Potential Chronic Concentration Ratios for the Combustion Gases at the Maximum Point of Impingement (Including Background)

Contaminant	Exposure Limit (μg/m^3)	Maximum Predicted Annual Average Concentration (μg/m^3)	Average Background Concentration (μg/m^3)	Concentration Ratio [(Max POI + Background)/Exposure Limit]
CO	2,400	0.2	319	0.13
NO_2	40	0.04	3.2	0.08
SO_2	n/a	0.001	n/a	n/a

Note: n/a – not available

It should be noted that the exposure limits used to generate these ratios were derived by regulatory agencies to protect the most sensitive individuals within a population. In their recent guideline for SO_2, the WHO (2005) indicated that an annual value for SO_2 is not necessary since compliance with the 24-hour guideline will assume low annual values. The predicted 24-hour SO_2 concentrations are below the most stringent SO_2 guidelines which suggests that there should be no long-term adverse health effects from exposure to SO_2. Therefore, no measurable adverse health effects would occur from long-term exposure to the combustion gases emitted from the YEC operations in Whitehorse at the power generation rates that occurred in 2007.

5.4 POTENTIAL HEALTH EFFECTS OF PARTICULATE MATTER

5.4.1 Potential Short-term Health Effects of $PM_{2.5}$

Particulate matter describes all airborne solid and liquid particles of microscopic size, with the exception of pure water. The suspended portion of particulate matter generally consists of particles less than 40 to 50 microns (µm) in diameter. These particles include a broad range of chemical species, such as elemental and organic carbon compounds, sulphates, nitrates and trace metals.

Many studies over the past 15 years have indicated that particulate matter (PM) in the air is associated with various adverse health effects in people who already have compromised respiratory systems such as asthma, chronic pneumonia and cardiovascular problems. The World Health Organization (WHO) in 2004 provided a summary of the effects relating to particulate matter. The WHO Working Group stated that in the absence of clearly defined thresholds in exposure-response relationships for both long-term and short-term health effects, and the fact that these exposure-response relationships had been established at currently observed particulate matter exposure ranges, it can be concluded that adverse health effects from particulate matter exposure are occurring at the levels of exposure currently experienced in urban areas in Europe. Since the conclusions were based on multi-city studies in the U.S., Canada and Europe, it suggests that health impacts also occur at particulate matter levels commonly observed in Canada. Table 5.6 provides a summary of the health effects associated with particulate matter.

Table 5.6
Important Health Effects Associated with Exposure to Particulate Matter

Effects Related to Short-term Exposure	Effects Related to Long-term Exposure
Lung inflammatory reactions	Increase in lower respiratory symptoms
Respiratory symptoms	Reduction in lung function in children
Adverse effects on the cardiovascular system	Increase in chronic obstructive pulmonary disease
Increase in medication usage	Reduction in lung function in adults
Increase in hospital admissions	Reduction in life expectancy, owing mainly to cardiopulmonary mortality and probably to lung cancer
Increase in mortality	

Source: WHO (2004)

The United States Environmental Protection Agency in 2004 also completed a comprehensive review of epidemiological studies on the human health effects associated with particulate matter inhalation. The document, *Air Quality Criteria for Particulate Matter* (U.S. EPA 2004), provides a synthesis of the available information summarizing epidemiological and toxicological studies prior to 2004 and combines it with the previous reviews conducted by the U.S. EPA (1996). Some of the relevant conclusions include:

- A large majority of relevant mortality studies show a statistically positive correlation with concentration of PM_{10}. Based on several multi-city studies in the U.S., Canada and Europe, statistically significant associations have been developed for cardiovascular and respiratory mortality with effect estimates ranging from 1.0 to 3.5 % (per 50 µg/m^3 PM_{10} increment);
- A growing body of epidemiologic evidence that confirms short - and long - term exposure to $PM_{2.5}$ is associated with various mortality or morbidity endpoints effects. Cardiovascular and respiratory mortality risks show positive correlations; however, the respiratory risks are not statistically significant. For multi-city studies, there is a 1 to 3.5 % increased risk of mortality per 25 µg/m^3 $PM_{2.5}$ increment;
- There are positive statistical associations with hospitalization for cardiovascular and respiratory diseases with exposure to both PM_{10} and $PM_{2.5}$; and

- Evidence suggests that not only $PM_{2.5}$ but coarse thoracic particles (e.g., $PM_{10-2.5}$) may contribute in exacerbating various respiratory conditions (e.g., asthma). Furthermore, there is new evidence suggesting a likely increase in the occurrence of chronic bronchitis associated with particulate matter exposure, especially long-term particulate matter exposure.

The current national regulatory limits for particulate matter in Canada are as follows:

- Canada-Wide Standard (CWS) target level for 24-hour concentrations of $PM_{2.5}$ of 30 $\mu g/m^3$ by the year 2010. The Canadian Environmental Protection Act/Federal Provincial Advisory Committee Working Group on Air Quality Objectives and Guidelines (CEPA/FPAC WGAQOG) recommends a 24-hour average $PM_{2.5}$ health reference level of 15 $\mu g/m^3$, which was derived statistically from several studies, and below which statistically significant health effects cannot be determined.

The CWS of 30 $\mu g/m^3$ for $PM_{2.5}$, which was formally adopted in June 2000, is considered to be a reasonably achievable target level for particulate matter to be achieved nationally by 2010.

In order to evaluate the potential significance of the emissions from the YEC diesel-powered generators in Whitehorse, it is necessary to consider the relative magnitude of those effects in relation to the ability to monitor and detect adverse effects. The accuracy of $PM_{2.5}$ monitoring equipment is such that an increase in $PM_{2.5}$ concentrations of less than 1 $\mu g/m^3$ on a 24-hour average basis would be undetectable (i.e., it would fall within the noise level of the monitoring equipment). Table 5.7 lists the predicted $PM_{2.5}$ concentrations at the 6 sensitive receptor locations near the YEC facility.

The highest $PM_{2.5}$ concentrations at the nearest residence (receptor 1) are predicted to occur under two specific meteorological conditions:

1. Persistent winds of about 5-6 m/s towards receptor 1, neutral atmospheric stability and high mixing heights. Under such conditions, the elevated concentrations would result from building downwash of the plumes from the short stacks on the generators.
2. Persistent calm conditions through the night time hours, and low mixing heights followed by rapid rise of the mixed layer after sunrise on the following day. Under such conditions, plume fumigation with the increase in the mixed layer could cause rapid mixing of the contaminants in the plume towards the surface, leading to elevated overall concentrations.

In both of these situations, the elevated $PM_{2.5}$ concentrations may only persist for a few hours.

Table 5.7
Predicted 24-Hour Average $PM_{2.5}$ Concentrations at Sensitive Receptor Locations in Whitehorse

Scenario	Frequency of Occurrence	Concentrations (µg/m³) at Discrete Receptor Locations						
		Max POI	1	2	3	4	5	6
Sc 1	Maximum	1.6	0.1	0.1	0.0	0.2	0.1	1.1
Sc 2	Maximum	17.3	2.3	0.8	0.4	1.1	0.8	9.0
	99th percentile	14.8	1.5	0.5	0.4	0.8	0.7	6.4
	98th percentile	13.4	1.2	0.4	0.3	0.6	0.6	4.7
	95th percentile	11.1	0.8	0.4	0.2	0.5	0.5	2.8
	90th percentile	9.1	0.5	0.3	0.1	0.4	0.4	1.4
Sc 3	Maximum	54.3	5.1	2.0	1.0	3.2	2.4	16.6
	99th percentile	34.2	4.0	1.4	0.8	2.2	1.8	10.3
	98th percentile	26.5	2.9	1.3	0.7	1.9	1.8	8.4
	95th percentile	14.9	2.1	1.0	0.4	1.6	1.6	5.2
	90th percentile	9.1	1.5	0.8	0.2	1.3	1.3	3.0
Background	Maximum 2001-2003 2004-2005	14 101						
	98th percentile 2001-2003 2004 / 2005	8 12 / 46						

Sc 1 – Scenario 1: Actual engine usage in 2007

Sc 2 – Scenario 2: Hypothetical operations - Maximum daily engine usage expected in the foreseeable future applied every day of the year

Sc 3 – Scenario 3: Emergency operations - maximum potential to emit based on all seven engines operating every day of the year

Note: PM_{10} impacts are assumed to be identical to $PM_{2.5}$ impacts

It should be emphasized that the percentiles listed in Table 5.7 for Scenarios 2 and 3 would only apply if the YEC operations were to be sustained at the levels modelled for the entire year. Because the operations for Scenarios 2 and 3 are actually only likely to be sustained for a few days at most, the frequency distributions for predicted $PM_{2.5}$ concentrations listed in Table 5.7 would not actually occur. Thus, if the YEC plant were to operate for a few days of the year in Scenario 3, the actual concentration of $PM_{2.5}$ at receptor 1 could potentially be as high as 5 µg/m³, if the operation coincides with the right meteorological conditions. Alternatively, depending on the meteorological conditions at the time of operation, the actual $PM_{2.5}$ concentrations could equally be as low as 1.5 µg/m³, or even lower than 1 µg/m³. The level of actual air quality impacts depends on the joint coincidence of operations in Scenario 3 mode coupled with meteorological conditions that produce strong building downwash of the emission plume towards receptor 1. The probability of such occurrence is relatively low, but not zero.

Scenario 1 – Actual Operations in 2007

The data in Table 5.7 indicate that, for operating Scenario 1 (Sc 1), the maximum predicted incremental 24-hour average $PM_{2.5}$ concentration anywhere in Whitehorse is 1.6 µg/m^3. This level occurs very close to the plant in an area where it is unlikely that anyone would be exposed to this level for a full 24 hours. The predicted concentrations at all sensitive receptor locations except receptor #6 are below 1 µg/m^3. These concentrations are very much lower than background and will not be able to be discernable from background concentrations. Receptor #6, on the western shore of the Yukon River where the walking trail crosses the Yukon River on a foot bridge, is located 75 m from the power plant. It is unlikely that anyone would be exposed to emissions from the plant on this trail for a full 24-hour period, and there are no residences in the immediate vicinity of this location. Furthermore, even at this location, the predicted $PM_{2.5}$ level would be greater than 1 µg/m^3 on only 1 day per year assuming that the plant was running at the actual operating scenario for 2007. At all other times, the $PM_{2.5}$ levels at these locations would be indistinguishable from background levels with or without the plant's emissions. On that basis, it is concluded that no measurable health effects are likely to result from particulate matter emissions from the YEC diesel generators for operations in 2007.

Scenario 2 – Hypothetical Operations at Maximum Daily Engine Usage

Table 5.7 also indicates that $PM_{2.5}$ emissions from the YEC generators could result in maximum incremental ambient concentrations that exceed 1 µg/m^3 at three of the six sensitive receptor sites at least one day per year assuming that the plant was running at the maximum daily power generation rate expected in the foreseeable future on every day of the year (i.e., Scenario 2). At the Max POI, the predicted 24-hour average is 17.3 µg/m^3. With the addition of maximum observed background levels of 11-14 µg/m^3 recorded in 2001-2003, the WHO guideline value of 25 µg/m^3 (99th percentile) could potentially be exceeded for up to 18 days per year at the maximum POI.

The highest predicted concentration at the sensitive receptor locations occurs at receptor #6 where it is unlikely that anyone would be present on a 24-hour basis. The predicted levels are above the 1 µg/m^3 level of instrument accuracy at least 10% of the time, meaning that the emissions from the YEC plant would be measurable at this location on up to 36 days per year if the plant were to run at the hypothetical level of operations assumed for Scenario 2 every day of the year.

At receptor #4 (i.e., the F.H. Collins Secondary School in Riverdale), the predicted concentrations would be less than 1 µg/m^3 on 364 days of the year, even for the conservative level of operations assumed for Scenario 2. Only at receptor #1, the nearest residence on the east side of the Yukon River would the predicted $PM_{2.5}$ levels exceed 1 µg/m^3 for more than one day per year. If the YEC generators were to operate at the levels assumed for Scenario 2 on every day of the year, the predicted incremental impact of emissions from the plant would be measurable <2% of the time, or roughly <7 days per year. Given the observed maximum $PM_{2.5}$ levels of 11-14 µg/m^3 in Whitehorse during 2001-2003, the maximum predicted incremental contribution of 2.3 µg/m^3 represents a potential maximum increase in ambient concentrations at receptor #1 of about 20% over background levels in years without major forest fires. However, operations under Scenario 2 would not result in any exceedence of the WHO guideline value except at the maximum POI, and the CWS parameter would not be exceeded at any location in non-forest fire years.

Scenario 3 – Emergency Operations – Maximum Potential to Emit

For the emergency operations scenario (Sc 3), Table 5.7 indicates that the WHO guideline value would be exceeded on 7 days per year at the maximum POI, even without any additional contributions from background concentrations. With a background concentration of around 7-9 µg/m^3 (98th percentile) in non-forest fire years, the WHO guideline value would be exceeded at the maximum POI on approximately 15 days per year. The CWS parameter would also be exceeded at this location. However, it is important to note that the maximum POI does not occur in the vicinity of a residence where anyone is likely to be present 24 hours a day.

For the six sensitive receptor locations, the largest predicted $PM_{2.5}$ concentrations occur at receptor 6, on the west side of the foot bridge across the Yukon River. At this location, the maximum predicted concentration for emissions from YEC engines is 16.6 µg/m^3. Therefore, with a background $PM_{2.5}$ level of 9 µg/m^3, the WHO guideline value could be exceeded at this location in some years, but the CWS parameter would not be exceeded.

The maximum predicted concentration at the nearest residence (receptor 1) is 5.1 µg/m^3, and the predicted concentrations would be measurable (i.e., >1 at the Grey Mountain Primary School (Receptor 3) on at least 36 days per year, if, and only if, the YEC plant were to operate at the level assumed for Scenario 3 on every day of the year. Therefore, for Scenario 3 operations, it is possible that measurable health impacts could occur at the nearest residential property. However, neither the WHO guideline value nor the CWS parameter value would be exceeded in non-forest fire years.

At receptors 2, 4 and 5 (i.e., Christ the King Elementary School, Frederick H. Collins Secondary School and the Whitehorse General Hospital, respectively), the predicted $PM_{2.5}$ concentrations would be measurable on at least 18 days per year for Scenario 3 operations, if, and only if, the YEC plant were to operate at the level assumed for Scenario 3 on every day of the year. However, neither the WHO guideline value nor the CWS parameter value would be exceeded in non-forest fire years at any of these locations. Furthermore, the predicted concentrations due to YEC operations would not be measurable at the Grey Mountain Primary School (Receptor 3).

Note, however, that the potential for predicted adverse health effects would only hold true if the operations assumed for Scenario 3 were to apply for the entire year. That is to say, all seven engines would have to be running all day, every day, all year long. Because emergency operations would only be expected to continue for a short period of time, the frequency with which predicted $PM_{2.5}$ concentrations would be greater than 1 µg/m^3 would depend on the meteorological conditions at the time of the emergency operations, and the duration of those operations. For example, it is unlikely that the predicted $PM_{2.5}$ levels would be greater than 1 µg/m^3 for 36 days per year as discussed above. Nevertheless, the Scenario 3 analysis shows that a potential for adverse health effects in sensitive individuals due to exposure to measurable impacts on $PM_{2.5}$ concentrations can occur at the nearest residence if all seven engines are operated simultaneously and in conjunction with suitable adverse meteorological conditions.

Summary

In summary, no measurable adverse health effects would be expected for YEC plant operations in 2007 at any location in Whitehorse (Scenario 1).

A conservative, hypothetical estimate of the potential for adverse health effects arising from exposure to $PM_{2.5}$ concentrations assuming daily operation of the generators at the maximum daily level reported in the foreseeable future (Scenario 2) could result in measurable concentrations at the nearest neighbour location for a few days per year and at the F.H. Collins Secondary School for one day per year, but not anywhere else in Whitehorse. Furthermore, the WHO guideline value of 25 µg/m^3 would not be exceeded anywhere in Whitehorse in years without forest fires in the region. When forest fires were present in 2004 and 2005, the WHO guideline value was exceeded for 15 days in 2004 and 4 days in 2005 due to smoke from the fires. Except at the maximum POI, neither the WHO guideline value nor the CWS parameter would be exceeded in non-forest fire years.

The largest potential adverse health effects due to $PM_{2.5}$ emissions from YEC operations are predicted to occur for emergency operations at the YEC plant (Scenario 3) when all seven engines are running simultaneously for a year. Measurable $PM_{2.5}$ concentrations could occur at several of the sensitive receptor locations, and the WHO guideline value could be exceeded at the maximum POI and potentially at receptor 6. However, unless the YEC plant were to operate in emergency mode for the entire year, it is unlikely that the CWS parameter would be exceeded anywhere in the modelling domain.

5.4.2 Potential Long-term Health Effects of $PM_{2.5}$

Table 4.1 (Section 4.0) indicates that average annual $PM_{2.5}$ concentrations in Whitehorse are about 2 µg/m^3 in non-forest fire years, and 3-5 µg/m^3 during years with forest fires. For Scenario 1, Table 3.8 (Section 3.5.1) of this report indicates that the average annual contribution to levels of $PM_{2.5}$ at the maximum POI due to emissions from YEC operations in 2007 was only 0.01 µg/m^3. Therefore, the contribution of YEC emissions to total ambient levels of $PM_{2.5}$ is insignificant (0.5%) even in non-forest fire years. As such, no measurable adverse health effects are likely to be associated with YEC operations at the power generation levels that occurred in 2007.

6.0 SOURCES OF UNCERTAINTY

While the air quality assessment has been prepared following standard practices for regulatory impact assessments, it is recognized that there remain a number of sources of uncertainty which could affect the absolute accuracy of the analysis. Specifically, these include:

- variability in source emission factors;
- background air quality;
- NO to NO_2 conversion rates;
- meteorological uncertainty; and,
- modelling uncertainty.

The emission factors used for the YEC diesel generators are considered to be reasonably representative of these types of units. However, it is recognized that emission rates between units may vary, even for the same type of unit (i.e., same age and manufacturer). This variability relates to how the units have been operated in the past, how they were maintained, etc. There is insufficient information available for emission testing of stationary diesel engines to determine the degree of variability that might be expected. Therefore, while the air quality assessment presented in this report provides a reasonably accurate estimate of emissions from the YEC generators in the four communities, absolute estimates of their emissions cannot be determined without stack testing of emissions from each unit. Actual emissions may be higher, lower or similar to those presented in this report.

Air quality is monitored in one location in Whitehorse, at a distance from the YEC power plant at which the emissions from the plant are minor contributors to overall observed concentrations. As such, the monitoring data provides a reasonable estimate of the contributions from other sources in Whitehorse to ambient air quality. However, the actual background air quality in the vicinity of the YEC power plant is unknown, and may be different from that which has been estimated based on the monitoring data in downtown Whitehorse.

Approximately 95% of the NO_x emitted from combustion sources is emitted as nitric oxide (NO) rather than NO_2. All or part of the NO eventually reacts in the atmosphere to form NO_2 but the rate at which this conversion takes place depends on time of plume travel from the emission source, whether the emission occurs during the daytime or at night, the season in which it is released, the air temperature and availability of bright sunshine, as well as the presence of free radicals in the atmosphere to promote the chemical reactions. NO to NO_2 conversion rates at night may be an order of magnitude lower than during the daytime, and similarly lower in the winter than during the summer. At present, it is not possible to vary NO to NO_2 conversion rates continuously on an hour-by-hour basis in a model such as CALPUFF. For the purposes of this assessment, SENES has used empirically-derived estimates of conversion rates based on plume sampling of power plant plumes. The conversion rates used provide reasonably accurate conversion rates for daytime conditions in the summer, but overestimate conversion rates at night or during the colder months of the year. For example, the highest predicted NO_2 concentrations in the dispersion modelling analysis for Whitehorse occur in the winter, and thus may have been significantly overestimated. Furthermore, the estimated conversion rates are based on a step-function approach for plume travel distance from the source. For example, the rate of conversion within 1 km of the source is assumed to be 5%, but this rate increases to 14% at 1-2 km from the source and to 19% at distances greater than 2 km from the source. Consequently, the estimated NO_2 concentration at a receptor located 1.1 km from the YEC power plant may be estimated to have a 1-hour average NO_2 concentration that is almost 3 times higher than a receptor located at 0.9 km from the power plant. This difference is an artefact of the assumed rate of NO to NO_2 conversion rather than a real difference in NO_2 concentrations.

The *Janssen* plume measurements during winter months indicate an NO to NO_2 conversion rate of 0.05 to 0.11 at a distance of 2 km (depending on the amount of ozone in the air), which is approximately ½ of the assumed rate of conversion in the modelling analysis. Therefore, a more realistic analysis of predicted NO_2 concentrations due to the YEC engines would require the accounting of ambient atmospheric conditions during the periods of maximum predicted concentrations.

Finally, the empirically derived method for NO to NO_2 conversion assumes that the plume is being transported downwind, so that conversion rates are proportional with distance from the source. The method does not, however, provide estimates of NO to NO_2 conversion rates for stagnant atmospheric conditions wherein significant rates of conversion to NO_2 may occur at shorter distances from the source.

The meteorological uncertainty stems from the use of only one year of meteorological data for the dispersion modelling analysis. Year-to-year variability in atmospheric conditions can lead to slightly different results in predicted concentrations; either increases or decreases in the location and magnitude of maximum predicted concentrations. For regulatory applications, a minimum of one year of meteorological data is a standard requirement. Where available, up to 5 years of meteorological data may be required. The analysis presented in this report meets the standard minimum requirement for an air quality assessment. It should be noted that there are data gaps present in the available station data at Whitehorse for the years 2003-2007. Therefore, a five year assessment would have been challenging to complete.

The dispersion modelling analysis has been conducted using a model (CALPUFF) that has been accepted/recommended for regulatory permit applications modelling across Canada and the

United States, as well as in various countries overseas. Nevertheless, it is recognized that no dispersion model is capable of achieving 100% accuracy in predicting the precise location, magnitude and timing of ground-level contaminant concentrations. Models such as CALPUFF have undergone thorough model evaluations and the modelling results are considered to be reasonably accurate, provided that appropriate inputs to the models are used.

In the case of the CALPUFF model, one validation study[22] completed by SENES using a trace compound in Idaho showed that almost 60% of the predicted 1-hour average concentrations at distances up to 50 km from the source were within a factor of 2 of the observed concentrations. In general, the accuracy of dispersion models such as CALPUFF is greater for longer averaging periods (e.g., 24-hour averages) than for shorter averaging periods (e.g., 1-hour averages) because the over and under predictions at a location tend to average out closer to the mean over longer time frames. In the tracer study example noted above, the mean predicted concentrations were on average 25-30% higher than observed levels, indicating that the CALPUFF model predictions were somewhat conservative for longer averaging periods.

In regulatory model applications in support of permits, model results are accepted as given without further qualification as to modelling uncertainty if:

- the model used was suitable to the type of sources modelled and the physical setting in which the emissions are dispersed;
- the source emission data are valid and reasonably accurate; and,
- the meteorological data used are representative of the atmospheric conditions in the location where the emissions are released.

In the air quality assessment for the YEC operations in Whitehorse, each of these three conditions has been met to the extent possible. Therefore, the modelling analysis can be considered to provide a reasonable estimate of the air quality impacts from YEC diesel generator operations.

[22] Radonjic, Z. Stager, R. and A.I. Apostoaei 2005. An Analysis of the Atmospheric Dispersion of Radionuclides Released from the Idaho Chemical Processing Plant (ICPP) (1957-1959). Prepared for the Centers for Disease Control and Prevention, Atlanta Georgia, by SENES Consultants Limited and SENES Oak Ridge, Inc. Contract No. 200-2002-00367, Task Order No. 1, Subtask 5.

Appendix A – General Source Description and Methods

Appendix A is provided as a supplement to the Community Emission Inventory development presented within the main body of the report. The intent of this section is to describe how the emission for the individual sources throughout the community where estimated. As a very brief background, emissions are calculated using a general methodology that can be represented as:

[Activity] X [Emission Factor] = Total Emissions for Source

The emissions from each source are added together to represent the entire community. A database tool has been developed to capture all the activities and related emission factors for each of the communities. The database tool should be considered as the final version of both activity levels and emission estimates; extractions from the tool were produced for this report. The database tool provides some additional functionality not directly addressed within this appendix:

- Seasonal allocation of the emissions throughout the year (Winter, Spring, Summer, Fall).
- Management of uncertainty propagation for activity levels and emission factors, using an Intergovernmental Panel on Climate Change (IPCC) standard procedure; thus providing additional context for emissions to aid in understanding the inventory implications for the community.
- Dynamic tools for graphing and extracting specific details of the emissions inventory for additional insight.
- Option to change the activity levels in the future as additional knowledge is gained about the community or to assess different policy scenarios.

The following tables and sections define the basis for the activity and emission factors used for each source within the emissions inventory. Each table represents a general category as described in the results tables and provides the background on how the emissions for the particular sources have been entered into the database tool.

Area Sources

Area sources account for activities that are distributed throughout the community.

Table A-1: Agricultural Area Sources

Category	Source	Activity Basis (Area)	Emission Factor (Area)
Agricultural (Area)	Land Clearing	Yukon Agriculture State of Industry, Land Use Maps of Whitehorse from OCP.	Factors developed for the Greater Vancouver Regional District on a Hectare managed per year basis.
	Land Fertilizer		
	Land Manure		
	Land Pesticide		
	Land Soil Erosion		
	Land Tillage		

Heating sources account for both residential and commercial buildings within the city. SENES believes that some propane may be used in the Yukon, but the amounts are not reported within Yukon Statistics, implying that they contribute a very small portion to the total community energy use; thus, propane consumption is not captured in the inventory currently. In addition, natural gas is not used within the community as a heating source, due to the availability and use of fuel oil and wood.

Table A-2: Heating Area Sources

Category	Source	Activity Basis (Area)	Emission Factor (Area)
Heating (Area)	Fuel Oil-Diesel	The use of fuel oil and kerosene are from the Statistics Yukon and allocated on a per capita basis.	Emission Factors for fuel oil and kerosene are from US EPA AP42 Factors.
	Fuel Oil-Light		
	Kerosene		
	Wood Advanced	The wood usage assumes that 60 percent of households burn wood and an average of 4.0 cords of wood is used per year. The type of wood (species) is sourced from the Yukon Management Forestry Plan. The species determines the weight of wood which is needed to convert cords of wood to tonnes of wood used in the emission factors. The distribution of appliance types is estimated, based on the MoE *Residential Wood Burning* study (northern communities).	Wood appliance factors are sourced from *Residential Wood Burning Emissions in British Columbia* (MoE, 2005).
	Wood Conventional		
	Wood Fireplace		
	Wood Furnace		

Miscellaneous sources account for activities that are present in all North American communities, that tend to be generally characterized on a per-capita basis (due to lack of direct information) . The VOC emissions are generally the primary concern with miscellaneous sources, as emissions of other air contaminants tend to be relatively low.

Table A-3: Miscellaneous Area Sources

Category	Source	Activity Basis (Area)	Emission Factor (Area)
Miscellaneous (Area)	Landfill	Statistics Yukon and Yukon State of the Environment Reports provide the amount of waste sent to the Landfill in Whitehorse. The changes in 2000 in waste management / diversion are captured in the LandGEM model.	EPA LandGEM Model
	Fuel Market	Total fuel sales from Statistics Yukon allocated on a per capita basis	Factors developed for the Greater Vancouver Regional District.
	Architectural Coatings	Emission on a per capita basis	
	Auto Refinishing		
	Dry Cleaning		
	Metal Degreasing		
	Glues General		
	Printing Inks		
	Industrial Coatings		
	Bakeries		
	Consumer Products		
	Cooking Meat		
	Perspiration-cat		
	Perspiration-dog		
	Perspiration-human		
	Auto Refinishing		
	Dry Cleaning		
	Metal Degreasing		

Fugitive dust emissions within the Yukon communities relate to the dust generated by the vehicular traffic on both local roads and highways. An important distinction for fugitive dust emission estimates is that some of the generated dust should be considered suspendable and some transportable (to areas beyond the immediate vicinities of roadways). The suspendable portion of dust emissions will generally not travel more than 10 – 20m beyond the roadway and thus remains localized. The transportable portion of the generated dust is of smaller particle sizes that can remain airborne for longer periods of time. For the inventories developed for the Yukon, the amount of dust that is transportable and suspendable have been distinguished with separate emission factors marked with an (S) or (T). It should be noted that estimating road dust is challenging and that there is significant uncertainly in the emissions factors.

Table A-4: Fugitive Dust Area Sources

<table>
<tr><th>Category</th><th>Source</th><th>Activity Basis (Area)</th><th>Emission Factor (Area)</th></tr>
<tr><td rowspan="3">Fugitive Dust (Area)</td><td>Highway Traffic Road Dust</td><td>The highway activity for dust is based on the same analysis used for the mobile activity in table A-6. The total kilometres travelled and vehicle weight distribution are needed for estimation.</td><td rowspan="3">US EPA AP42 Emission Factors
The Transportable fraction of dust has been allocated as 25% of TSP, 40% of PM10 and 100% of PM2.5. Emissions are calculated on a g/VKT basis.</td></tr>
<tr><td>Local Paved Road Dust</td><td rowspan="2">The local activity for dust is based on the same analysis used for the mobile activity in table A-6 in order to determine kilometres travelled. Assumed that only 10% of local traffic travels on the unpaved roads within the city limits. Due to snow on the ground and other precipitation only Summer and Spring are assumed to generate significant dust.</td></tr>
<tr><td>Local Unpaved Road Dust</td></tr>
</table>

Mobile Sources

Mobile sources capture the emissions from engines that operate throughout the community. The general categories are nonroad engines, vehicles and aviation sources. Data are available for vehicle (passenger cars, trucks, etc) and aviation activity for the Yukon from Statistics Yukon and Statistics Canada providing specifics by individual communities. Local activity estimates for nonroad populations required consideration of activity levels in U.S. communities defined in the EPA NONROAD model. Statistics for population, general weather, heating degree days, number of wholesale/commercial establishments, recreational parks, family homes, farm cropland and golf courses provided the metrics available to choose an appropriate U.S. county to represent the City of Whitehorse. The county of Summit Colorado matched the profile of Whitehorse in several key areas and was used as the basis for determining nonroad equipment populations. For the other three communities, a reasonable scaling was conducted to determine equipment populations. SENES has applied this approach to other Canadian communities in the past; this approach is necessary due to lack of appropriate Canadian studies to refer to.

Table A-5: Nonroad Mobile Sources

Category	Source	Activity Basis (Mobile)	Emission Factor (Mobile)
Nonroad Equipment (Mobile)	Agricultural	Amount of cropland managed. Within the boundary of the communities very little active cropland is farmed resulting in very few pieces of equipment identified.	US EPA NONROAD Model Default hours and age distributions.
	Commercial	Equipment populations based on the surrogate county of Summit, Colorado.	
	Construction		
	Industrial		
	Residential		
	Recreational		

Table A-6: Vehicle Mobile Sources

Category	Source	Activity Basis (Mobile)	Emission Factor (Mobile)
Highway Traffic (Mobile)	Passenger Car	Vehicle registrations from Statistics Canada providing the overall mix of vehicles. Some additional weighting was allocated to Buses and Medium Trucks to represent peak RV traffic. Yukon Highway Department for traffic counts.	US EPA MOBILE Model. Higher average speed Age distribution from Statistics Canada
	Motorcycle		
	Bus		
	Light Truck		
	Medium Truck		
	Heavy Truck		
Local Traffic (Mobile)	Passenger Car	Vehicle registrations from Statistics Yukon The allocation for vehicles from the territory level is on a per capita basis. City of Whitehorse provided local traffic counts. Statistics Canada provided an indication of vehicle miles travelled per year by different vehicles.	US EPA MOBILE Model Mixed speed travel Age distribution from Statistics Canada
	Motorcycle		
	Bus		
	Light Truck		
	Medium Truck		
	Heavy Truck		

Table A-7: Aviation Mobile Sources

Category	Source	Activity Basis (Mobile)	Emission Factor (Mobile)
Aviation Landing and Takeoff cycle (Mobile)	General Aircraft	Yukon Statistics provided numbers of flights to the four communities on a monthly basis. Aircraft Movements Statistics Canada Report provided general distribution of aircraft types. (In general at the smaller airports a 85%/15% split was assumed for General Aviation/Helicopter traffic.)	Alaska Aviation Emission Inventory provided data for both Winter and Summer which is indicated in the inventory with W for winter and S for summer.
	Commercial Aircraft		
	Helicopters		
	Ground Support Equipment	Equipment population based on general observations of NONROAD model allocations.	US EPA NONROAD Model Scaled hours based on aircraft activity and default age distribution.

Point Sources

Point sources capture emissions from permit applications where the source of emissions are tracked by a government organization or from internal corporate data. Access to the permit data from the identified point sources was not available and surrogate emissions where extracted from the National Emissions Inventory database maintained by the US EPA.

Table A-8: Point Sources

Category	Source	Activity Basis (Point)	Emission Factor (Mobile)
Energy	Yukon Energy Diesel Generators	Yukon Energy Statistics	Developed for this assessment and details within the report body
Industrial Point Sources	Concrete Batch Plant	US NEI database. Similar size facility. [Colorado Lien Co, Buena Vista, CO]	
	Sand and Gravel Supply	US NEI database. Similar size facility [ACA Products Inc, Buena Vista, CO]	
	Hospital	US NEI database, Similar size facility [Union Hospital, Lynn, MA]	
	Asphalt Batch Plant	US NEI database, Similar size facility. [Schmidt Const Co, Castle Rock, CO]	

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Appendix B: Whitehorse Inventory Activity and Emission Factors

The table provided in this appendix represents the activity and emission factors for the Town of Whitehorse. Each individual source has been listed along with its general type and category.
The Activity is presented as a base quantity and then modifiers to that quantity to ensure that the units are in the same form as the stated emission factors.
The seasonal distribution allocates the emissions to each season and generally add up to 1, unless there are separate emission factors for the different seasons (in particular aviation).

General	Category	Source	Activity: Quantity/Indicator		Modifier 1		Modifier 2		Unit Per Quantity		Emission Factors: CO	NOx	SOx	VOC	TSP	NH3	PM10	PM25	CO2	CH4	N2O	Seasonal Distribution: Winter	Spring	Summer	Fall
Area	Agricultural	Land Clearing	-						kg	ha	42.	3.	.5	15.	8.	.32	8.	8.	.	6.5	16.	0.25	0.25	0.25	0.25
		Land Fertilizer	-						kg	ha	.	.	.	.	2.23	136.	1.09	.31	.	.	19.6	0.25	0.25	0.25	0.25
		Land Manure	-						kg	ha	.	.	.	.	.	.	.	.	.	.	31.4	0.25	0.25	0.25	0.25
		Land Pesticide	-						kg	ha	.	.	.	.	1.67	.	.82	.23	.	.	.	0.25	0.25	0.25	0.25
		Land Soil Erosion	-						kg	ha	.	.	.	.	15.	.	3.1	.7	.	.	.	0.25	0.25	0.25	0.25
		Land Tillage	-						kg	ha	.	.	.	.	15.8	.	3.3	.7	.	.	.	0.25	0.25	0.25	0.25
	Heating	Fuel Oil-Diesel	28232	m3					kg	m3	.599	2.157	5.105	.084	.2	.096	.129	.099	2672.	.213	.006	0.47	0.16	0.09	0.28
		Fuel Oil-Light	7664	m3					kg	m3	.599	2.157	5.105	.084	.2	.096	.129	.099	2672.	.213	.006	0.47	0.16	0.09	0.28
		Kerosene	13636	m3					kg	m3	.575	2.085	4.925	.084	.2	.096	.129	.099	2576.	.213	.006	0.39	0.11	0.11	0.39
		Wood Advanced	24600	cords	0.24	dist	1.066	Tonne/ cord	kg	tonne	70.4	1.4	.2	7.	5.1	.3	4.8	4.8	.	6.8	.2	0.47	0.16	0.09	0.28
		Wood Conventional	24600	cords	0.47	dist	1.066	tonne/ cord	kg	tonne	100.	1.4	.2	35.5	24.6	.3	23.2	23.2	.	15.	.2	0.47	0.16	0.09	0.28
		Wood Fireplace	24600	cords	0.06	dist	1.066	tonne/ cord	kg	tonne	115.4	1.4	.2	21.3	14.4	.3	13.6	13.6	.	15.	.2	0.47	0.16	0.09	0.28
		Wood Furnace	24600	cords	0.23	dist	1.066	tonne/ cord	kg	tonne	68.5	1.4	.2	21.3	14.1	.3	13.3	13.3	.	6.8	.2	0.47	0.16	0.09	0.28
	Miscellaneous	Architectural Coatings	23751	pop					kg	capita	.	.	.	.97	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Auto Refinishing	23751	pop					kg	capita	.	.	.	.62	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Bakeries	23751	pop					kg	capita	.	.	.	.03	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Consumer Products	23751	pop					kg	capita	.	.	.	2.8	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Cooking Meat	23751	pop					kg	capita	.	.	.	.	.09	.	.09	.09	.	.	.	0.25	0.25	0.25	0.25
		Dry Cleaning	23751	pop					kg	capita	.	.	.	.06	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Fuel Market	96857	m3					g	m3	.	.	.	.288	.	.	.	.	.	.	.	0.2	0.25	0.35	0.2
		Glues General	23751	pop					kg	capita	.	.	.	.12	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Industrial Coatings	23751	pop					kg	capita	.	.	.	.64	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Landfill	1	unit					tonnes	unit(1)	.	.	.	240.01	.	.	.	.	15320.92	5583.905	.	0.25	0.25	0.25	0.25
		Metal Degreasing	23751	pop					kg	capita	.	.	.	.22	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
		Perspiration-cat	4000	pop					kg	capita	.	.	.	.	.	.8	.	.	.	.	.	0.25	0.25	0.25	0.25
		Perspiration-dog	4000	pop					kg	capita	.	.	.	.	.	2.5	.	.	.	.	.	0.25	0.25	0.25	0.25
		Perspiration-human	23751	pop					kg	capita	.	.	.	.	.	.3	.	.	.	.	.	0.25	0.25	0.25	0.25
		Printing Inks	23751	pop					kg	capita	.	.	.	.32	.	.	.	.	.	.	.	0.25	0.25	0.25	0.25
	Fugitive Dust Suspendable	Alaska Highway	457710	counts			36	km	g	km	.	.	.	.	6.05	.	.82	.	.	.	.	0.14	0.4	0.33	0.13
		Local Paved Road	168661500	km	0.9	dist			g	km	.	.	.	.	8.07	.	1.13	.	.	.	.	0	0.25	0.25	0
		Local Unpaved Road	168661500	km	0.1	dist			g	km	.	.	.	.	151.1	.	23.25	.	.	.	.	0	0.25	0.25	0
	Fugitive Dust Transportable	Alaska Highway	457710	counts	36	km			g	km	.	.	.	.	2.02	.	.55	.07	.	.	.	0.14	0.4	0.33	0.13
		Local Paved Road	168661500	km	0.9	dist			g	km	.	.	.	.	2.69	.	.76	.14	.	.	.	0	0.25	0.25	0
		Local Unpaved Road	168661500	km	0.1	dist			g	km	.	.	.	.	50.37	.	15.5	3.81	.	.	.	0	0.25	0.25	0
		Baler	-						g	hours	3413.205	270.224	12.74	251.743	12.057	.403	12.057	11.625	23884.47	20.167	3.007	0.25	0.25	0.25	0.25
		Combine	-						g	hours	301.403	796.393	84.155	70.398	90.418	.965	90.418	87.706	60130.40	3.092	24.225	0.25	0.25	0.25	0.25

General	Category	Source	Activity						Unit Per Quantity		Emission Factors											Seasonal Distribution			
			Quantity/Indicator		Modifier 1		Modifier 2				CO	NOx	SOx	VOC	TSP	NH3	PM10	PM25	CO2	CH4	N2O	Winter	Spring	Summer	Fall
Mobile	NonRoad Agricultural	Irrigation Equip	-						g	hours	876.205	275.306	30.058	57.331	21.08	.41	21.08	20.431	25295.34	11.41	8.519	0.25	0.25	0.25	0.25
		Mower	-						g	hours	3422.284	31.724	2.505	75.449	2.318	.114	2.318	2.216	6680.71	6.61	.503	0.25	0.25	0.25	0.25
		Other	1	pop			260	hours	g	hours	3202.357	471.215	44.001	159.055	45.128	.659	45.128	43.728	40301.34	13.837	12.278	0	0.4	0.5	0.1
		Sprayer	-						g	hours	2324.863	149.223	15.609	137.147	17.043	.254	17.043	16.418	15495.58	6.359	4.3	0.25	0.25	0.25	0.25
		Swather	-						g	hours	1424.084	387.953	37.742	113.147	44.18	.528	44.18	42.829	32452.35	8.695	10.62	0.25	0.25	0.25	0.25
		Tiller	-						g	hours	3364.572	18.656	1.351	121.517	.587	.112	.587	.54	6545.95	7.486	.14	0.25	0.25	0.25	0.25
		Tractor	-						g	hours	285.613	490.263	59.618	53.241	52.391	.684	52.391	50.819	42639.55	2.245	17.16	0.25	0.25	0.25	0.25
	NonRoad Airport	Commercial Aviation-Summer	27525	flights	0.19	dist			kg	LTO	14.107	.286	.054	.	.	.	.381	.381	700.	.3	.1	0	0.39	0.29	0
		Commercial Aviation-Winter	27525	flights	0.19	dist			kg	LTO	6.795	.154	.032	.	.	.	.381	.381	700.	.3	.1	0.17	0	0	0.15
		General Aviation -Summer	27525	flights	0.69	dist			kg	LTO	6.573	.023	.001	.	.	.005	.027	.018	300.	.3	.1	0	0.39	0.29	0
		General Aviation -Winter	27525	flights	0.69	dist			kg	LTO	2.98	.009	.001	.	.	.005	.027	.018	300.	.3	.1	0.17	0	0	0.15
		Ground Support	1	pop			725	hours/ yr	g	hours	666.938	557.327	73.638	59.009	41.088	.886	41.088	39.852	54531.46	4.355	21.165	0.17	0.39	0.29	0.15
		Helicopter -Summer	27525	flights	0.12	dist			kg	LTO	.572	.082	.009	.	.	.	.381	.381	128.	.3	.1	0	0.39	0.29	0
		Helicopter -Winter	27525	flights	0.12	dist			kg	LTO	.386	.068	.005	.	.	.	.381	.381	128.	.3	.1	0.17	0	0	0.15
	NonRoad Commercial	Chain Saw	50	pop			303	hours/ yr	g	hours	897.904	2.99	.38	247.724	23.414	.032	23.414	21.541	1861.11	2.129	.039	0.25	0.25	0.25	0.25
		Chipper	7	pop			470	hours/ yr	g	hours	2794.403	327.569	33.266	82.246	23.671	.513	23.671	22.939	30300.85	8.056	9.395	0.15	0.35	0.35	0.15
		Compressor Air	23	pop			615	hours/ yr	g	hours	2016.542	117.57	12.11	75.766	8.492	.221	8.492	8.213	12834.5	5.702	3.358	0.25	0.25	0.25	0.25
		Compressor Gas	0	pop					g	hours	4668.78	350.205	.934	6.786	6.091	.672	6.091	6.091	42345.82	492.914	1.344	0.25	0.25	0.25	0.25
		Generator	448	pop			144	hours/ yr	g	hours	3815.161	57.549	3.538	119.15	2.953	.159	2.953	2.816	8934.79	9.841	.79	0.25	0.25	0.25	0.25
		Hydraulic Power	3	pop			514	hours/ yr	g	hours	3337.506	49.329	5.104	84.605	3.913	.137	3.913	3.744	8080.63	5.972	1.279	0.25	0.25	0.25	0.25
		Leaf Blower	73	pop			160	hours/ yr	g	hours	2338.469	17.961	.919	152.319	10.81	.077	10.81	9.945	4464.68	5.107	.095	0	0.1	0.2	0.7
		Mower	26	pop			316	hours/ yr	g	hours	2348.554	59.981	6.863	71.069	5.54	.14	5.54	5.35	8424.34	4.943	1.819	0	0.4	0.5	0.1
		Mower - Ride	0	pop					g	hours	2829.25	14.671	.881	46.379	.478	.073	.478	.439	4277.72	4.894	.091	0.25	0.25	0.25	0.25
		Other	48	pop			60	hours/ yr	g	hours	1951.826	13.618	.763	111.597	.646	.063	.646	.595	3652.78	4.168	.081	0.25	0.25	0.25	0.25
		Pressure Washer	180	pop			115	hours/ yr	g	hours	4163.704	28.845	1.823	160.878	1.439	.123	1.439	1.339	7161.98	7.866	.264	0.1	0.4	0.4	0.1
		Pump	115	pop			238	hours/ yr	g	hours	1885.973	33.887	2.414	100.24	5.235	.089	5.235	4.892	5075.76	4.396	.567	0.25	0.25	0.25	0.25
		Shedder	20	pop			50	hours/ yr	g	hours	2116.892	14.904	.815	167.057	.913	.068	.913	.84	3966.61	4.538	.084	0.25	0.25	0.25	0.25
		Snow Blower	50	pop			136	hours/ yr	g	hours	1456.876	7.41	.595	203.677	6.109	.043	6.109	5.623	2528.89	2.823	.078	0.7	0	0	0.3
		Tiller	38	pop			450	hours/ yr	g	hours	1071.382	7.331	.42	94.549	1.479	.035	1.479	1.36	2044.15	2.339	.043	0	0.4	0.5	0.1
		Tractor L/G	25	pop			300	hours/ yr	g	hours	3767.074	28.054	2.302	59.952	1.56	.111	1.56	1.481	6511.95	6.57	.445	0	0.4	0.5	0.1
		Trimmer	128	pop			137	hours/ yr	g	hours	488.391	2.142	.299	118.221	10.862	.025	10.862	9.993	1460.62	1.671	.031	0	0.4	0.5	0.1
		Turf Equip	30	pop			300	hours/ yr	g	hours	4698.315	30.2	1.757	101.886	1.088	.134	1.088	1.006	7791.43	8.774	.214	0	0.4	0.4	0.2

General	Category	Source	Activity: Quantity/Indicator		Activity: Modifier 1		Activity: Modifier 2		Unit Per Quantity		Emission Factors: CO	NOx	SOx	VOC	TSP	NH3	PM10	PM25	CO2	CH4	N2O	Seasonal Distribution: Winter	Spring	Summer	Fall
Mobile		Welder	40	pop			500	hours/ yr	g	hours	3624.61	69.448	5.549	79.58	7.451	.171	7.451	7.198	9655.68	6.962	1.392	0.25	0.25	0.25	0.25
	NonRoad Construction	Backhoe	40	pop			1129	hours/ yr	g	hours	266.236	142.007	17.819	33.324	21.991	.207	21.991	21.33	12911.01	.883	5.123	0.2	0.3	0.3	0.2
		Bore Drill	26	pop			216	hours/ yr	g	hours	1121.11	184.664	17.752	80.76	12.731	.245	12.731	12.329	14867.29	3.173	5.036	0.2	0.3	0.3	0.2
		BullDozer	19	pop			936	hours/ yr	g	hours	330.546	820.038	115.618	58.88	58.032	1.325	58.032	56.291	82599.87	4.236	33.282	0.2	0.3	0.3	0.2
		Compactor	24	pop			222	hours/ yr	g	hours	1514.869	13.524	1.003	77.802	1.713	.05	1.713	1.601	2937.58	2.996	.19	0.1	0.4	0.4	0.1
		Crusher	3	pop			637	hours/ yr	g	hours	2047.226	237.956	28.372	70.958	16.345	.379	16.345	15.788	23201.06	4.7	8.051	0.1	0.4	0.4	0.1
		Dump Truck	6	pop			186	hours/ yr	g	hours	2146.438	22.025	1.683	78.346	1.886	.076	1.886	1.805	4491.52	4.444	.338	0.25	0.25	0.25	0.25
		Excavator	25	pop			1092	hours/ yr	g	hours	178.183	491.843	76.444	37.108	36.746	.876	36.746	35.644	54613.51	2.801	22.005	0.2	0.3	0.3	0.2
		Forklift	23	pop			658	hours/ yr	g	hours	261.031	317.334	44.737	36.8	34.73	.523	34.73	33.687	32397.34	2.001	12.872	0.25	0.25	0.25	0.25
		Grader	6	pop			962	hours/ yr	g	hours	190.065	588.21	90.597	44.121	42.128	1.038	42.128	40.864	64724.25	3.319	26.079	0.2	0.3	0.3	0.2
		Loader	28	pop			756	hours/ yr	g	hours	426.383	799.526	105.78	63.742	58.654	1.228	58.654	56.893	76253.10	4.439	30.44	0.25	0.25	0.25	0.25
		Loader Skid	60	pop			806	hours/ yr	g	hours	214.106	87.642	10.887	29.294	16.945	.132	16.945	16.436	8131.67	.741	3.126	0.25	0.25	0.25	0.25
		Mixer	45	pop			96	hours/ yr	g	hours	2648.068	24.026	1.63	107.556	1.25	.088	1.25	1.178	5181.49	5.412	.29	0.1	0.4	0.4	0.1
		Paver	6	pop			705	hours/ yr	g	hours	1529.34	292.312	41.599	51.541	24.126	.524	24.126	23.39	32179.68	4.372	11.89	0	0.3	0.5	0.2
		Roller	18	pop			746	hours/ yr	g	hours	701.886	264.173	38.274	33.706	24.995	.456	24.995	24.24	28270.21	2.482	10.986	0	0.3	0.5	0.2
		Saw	20	pop			608	hours/ yr	g	hours	2777.661	26.231	2.413	190.909	19.67	.099	19.67	18.166	5693.67	5.139	.532	0.25	0.25	0.25	0.25
		Signal Board	13	pop			531	hours/ yr	g	hours	104.032	63.133	8.306	12.865	7.002	.097	7.002	6.791	6021.82	.421	2.387	0.25	0.25	0.25	0.25
		Surface Equip	4	pop			500	hours/ yr	g	hours	2773.24	81.909	8.992	75.014	7.038	.166	7.038	6.797	10001.72	5.006	2.434	0.25	0.25	0.25	0.25
		Tamper	28	pop			165	hours/ yr	g	hours	764.596	3.059	.373	223.448	18.767	.027	18.767	17.267	1561.59	1.736	.051	0.2	0.3	0.3	0.2
		Trencher	17	pop			529	hours/ yr	g	hours	1602.443	186.375	24.542	60.08	20.361	.331	20.361	19.734	20160.40	3.938	6.975	0.2	0.3	0.3	0.2
		Truck - Offroad	3	pop			1641	hours/ yr	g	hours	854.599	2523.976	346.471	149.358	144.365	3.971	144.365	140.034	247525.2	12.694	99.735	0.25	0.25	0.25	0.25
	NonRoad Industrial	Aerial Lift	1	pop			375	hours/ yr	g	hours	1247.53	126.965	6.649	58.512	9.453	.203	9.453	9.164	10298.60	4.624	1.844	0.25	0.25	0.25	0.25
		Forklift	0	pop					g	hours	956.985	193.011	4.067	48.779	3.336	.354	3.336	3.266	14577.71	11.291	1.314	0.25	0.25	0.25	0.25
		Material Handling Equip	1	pop			412	hours/ yr	g	hours	1170.811	224.415	18.103	66.17	21.503	.299	21.503	20.851	17060.62	4.185	5.144	0.25	0.25	0.25	0.25
		Other	1	pop			791	hours/ yr	g	hours	1393.52	155.442	18.61	68.349	10.413	.255	10.413	10.081	15479.89	3.328	5.281	0.25	0.25	0.25	0.25
		Refrigeration Unit	10	pop			800	hours/ yr	g	hours	66.98	106.025	16.238	11.031	10.231	.187	10.231	9.924	11630.77	.727	4.674	0.1	0.3	0.45	0.15
		Sweeper	1	pop			976	hours/ yr	g	hours	1326.922	196.521	21.536	51.489	11.188	.357	11.188	10.834	20336.18	5.124	6.126	0.25	0.25	0.25	0.25
		Truck - Large	0	pop					g	hours	598.531	449.933	67.634	51.211	32.352	.861	32.352	31.381	52027.96	6.512	19.438	0.25	0.25	0.25	0.25
	NonRoad Recreational	ATV	1098	pop			1608	km	g	km	32.784	.265	.027	10.857	.325	.002	.325	.299	130.634	.149	.003	0.2	0.3	0.35	0.15
		Dirt Bike	271	pop			1600	km	g	km	34.857	.169	.026	26.658	.949	.002	.949	.873	128.921	.147	.003	0	0.3	0.55	0.15

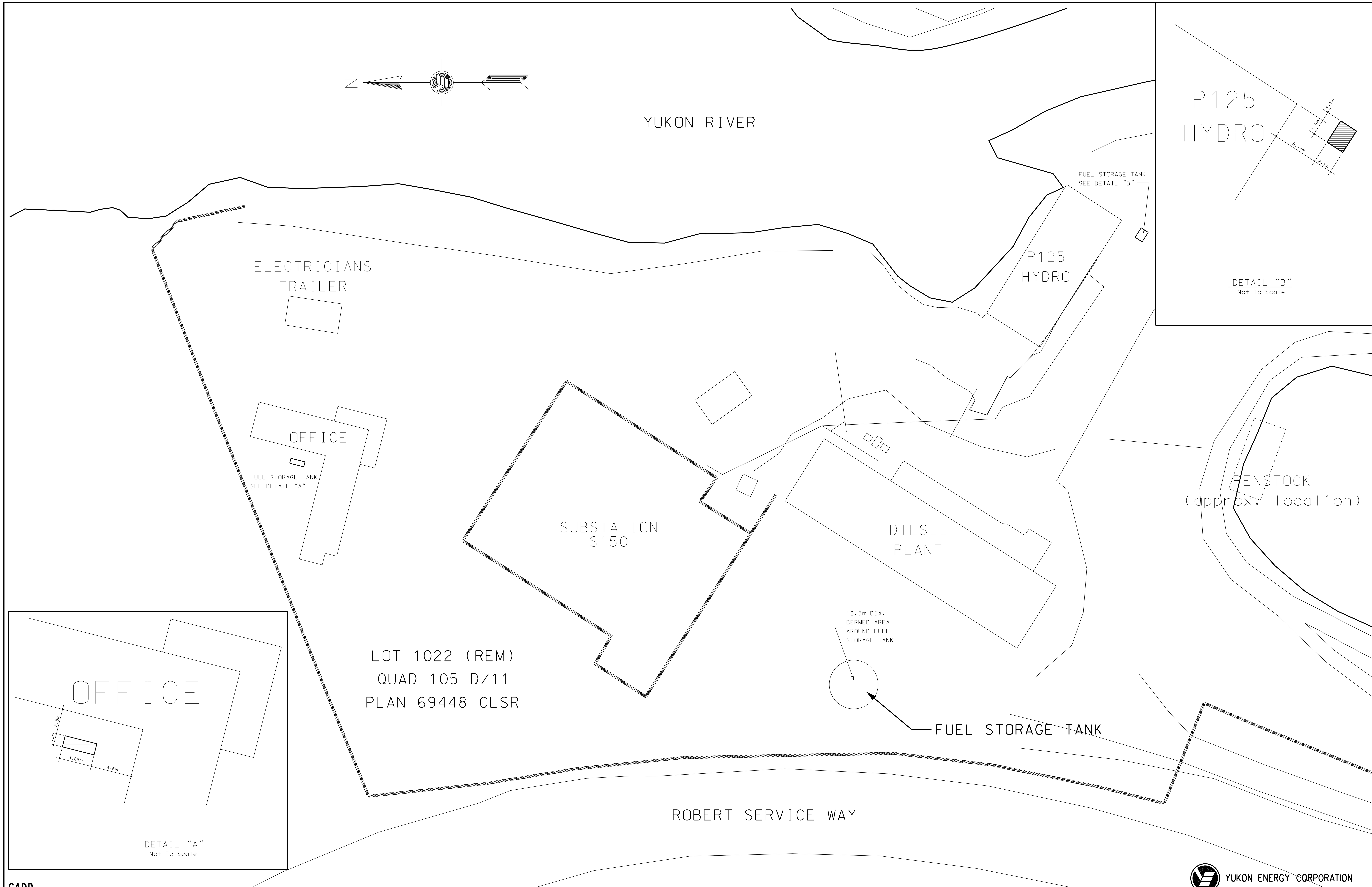
General	Category	Source	Activity: Quantity/Indicator		Modifier 1		Modifier 2		Unit Per Quantity		Emission Factors: CO	NOx	SOx	VOC	TSP	NH3	PM10	PM25	CO2	CH4	N2O	Seasonal Distribution: Winter	Spring	Summer	Fall
Mobile		Golf Cart	16	pop			1080	hours/ yr	g	hours	3291.331	14.593	.904	52.093	.529	.075	.529	.487	4389.846	5.022	.093	0	0.4	0.4	0.2
		Snow Machine	300	pop			57	hours/ yr	g	hours	5298.26	17.105	6.905	2148.356	48.751	.578	48.751	44.851	33686.62	38.54	.714	0.8	0.1	0	0.1
		Vehicle General	70	pop			94	hours/ yr	g	hours	3874.129	33.137	2.4	137.022	1.926	.149	1.926	1.827	8577.47	9.009	.398	0.25	0.25	0.25	0.25
	NonRoad Residential	Chain Saw	533	pop			13	hours/ yr	g	hours	507.928	1.659	.314	211.731	11.804	.026	11.804	10.859	1540.10	1.762	.033	0.25	0.25	0.25	0.25
		Leaf Blower	751	pop			10	hours/ yr	g	hours	516.572	2.086	.298	182.072	9.837	.025	9.837	9.05	1456.01	1.666	.031	0	0.25	0.35	0.4
		Mower	3340	pop			25	hours/ yr	g	hours	838.331	5.964	.329	83.609	.373	.027	.373	.343	1600.09	1.831	.034	0	0.3	0.5	0.2
		Mower- Ride	100	pop			36	hours/ yr	g	hours	2660.776	16.24	.907	98.06	.491	.076	.491	.452	4400.86	5.035	.093	0	0.3	0.4	0.3
		Other	60	pop			61	hours/ yr	g	hours	1951.576	13.345	.747	111.668	.634	.062	.634	.583	3632.24	4.156	.077	0.25	0.25	0.25	0.25
		Snow Blower	1200	pop			8	hours/ yr	g	hours	1458.032	6.635	.505	275.472	6.061	.042	6.061	5.576	2466.68	2.822	.052	0.85	0	0	0.15
		Tiller	341	pop			17	hours/ yr	g	hours	1063.883	7.413	.429	124.404	1.521	.036	1.521	1.399	2089.11	2.39	.044	0	0.4	0.3	0.3
		Trimmer	1429	pop			9	hours/ yr	g	hours	401.932	1.486	.245	155.716	9.012	.021	9.012	8.291	1199.99	1.373	.025	0	0.3	0.5	0.2
	Traffic Highway	Bus	9154	counts			36	km	g	km	12.388	5.962	.095	.988	.175	.021	.175	.147	1097.00	.056	.029	0.14	0.4	0.33	0.13
		Motorcycle	4577	counts			36	km	g	km	10.706	1.01	.002	2.897	.023	.007	.023	.013	110.23	.084	.002	0	0.5	0.5	0
		Passenger Car	215124	counts			36	km	g	km	16.411	1.07	.005	1.15	.017	.058	.017	.009	230.12	.072	.056	0.14	0.4	0.33	0.13
		Truck Heavy	32040	counts			36	km	g	km	1.889	6.816	.119	.341	.24	.017	.24	.202	1006.93	.015	.03	0.14	0.4	0.33	0.13
		Truck Light	178507	counts			36	km	g	km	22.881	1.432	.009	1.712	.022	.052	.022	.013	300.89	.094	.115	0.14	0.4	0.33	0.13
		Truck Medium	18308	counts			36	km	g	km	4.008	3.191	.06	.427	.11	.021	.11	.092	716.34	.024	.118	0.14	0.4	0.33	0.13
	Traffic Local	Bus	224	pop			17500	km/ year	g	km	8.578	6.117	.112	.754	.191	.02	.191	.164	1141.27	.041	.032	0.25	0.25	0.25	0.25
		Motorcycle	489	pop			1500	km/ year	g	km	7.915	.81	.002	1.251	.023	.007	.023	.013	110.23	.08	.002	0	0.4	0.6	0
		Passenger Car	10294	pop			7988	km/ year	g	km	16.138	1.087	.005	1.16	.017	.058	.017	.009	230.16	.066	.056	0.25	0.25	0.25	0.25
		Truck Heavy	936	pop			8798	km/ year	g	km	1.941	6.959	.119	.345	.244	.017	.244	.206	1006.96	.015	.03	0.2	0.3	0.3	0.2
		Truck Light	8423	pop			7988	km/ year	g	km	13.032	.885	.009	.806	.021	.056	.021	.012	302.02	.047	.116	0.25	0.25	0.25	0.25
		Truck Medium	1248	pop			5012	km/ year	g	km	3.309	3.232	.071	.403	.128	.019	.128	.108	722.08	.021	.08	0.2	0.3	0.3	0.2
Point	Energy	YEC-Gen-4stroke	369097	kwh/ year	0.71	Dist			g	kWh	4.	15.	.0246	.4	.43	.	.25	.25	700.	.034	.103	0.25	0.18	0.42	0.15
		YEC-Gen-2stroke	369097	Kwh/ year	0.29	Dist			g	KWh	2.5	15.	.0246	.4	.43	.	.35	.35	700.	.034	.103	0.25	0.18	0.42	0.15
	Industrial	Asphalt Batch Plant	1	unit					tonnes	unit(1)	16.75	2.4	.31	3.75	12.98	.	4.38	1.31	.	.	.	0	0.4	0.5	0.1
		Concrete Batch Plant	1	unit					tonnes	unit(1)	.	.	.	.	28.38	.	12.23	4.28	.	.	.	0.25	0.25	0.25	0.25
		Hospital	1	unit					tonnes	unit(1)	2.	7.	6.	4.06	.5	.	.27	.08	.	.	.	0.25	0.25	0.25	0.25
		Sand and Gravel Supply	1	unit					tonnes	unit(1)	.	.	.	.	33.69	.	15.48	9.06	.	.	.	0.25	0.25	0.25	0.25

YUKON ENERGY

Air Emissions Permit (No. 4201-60-010)
Renewal Application Supporting Document

Appendix C

Diesel Plant Drawings



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YUKON ENERGY CORPORATION

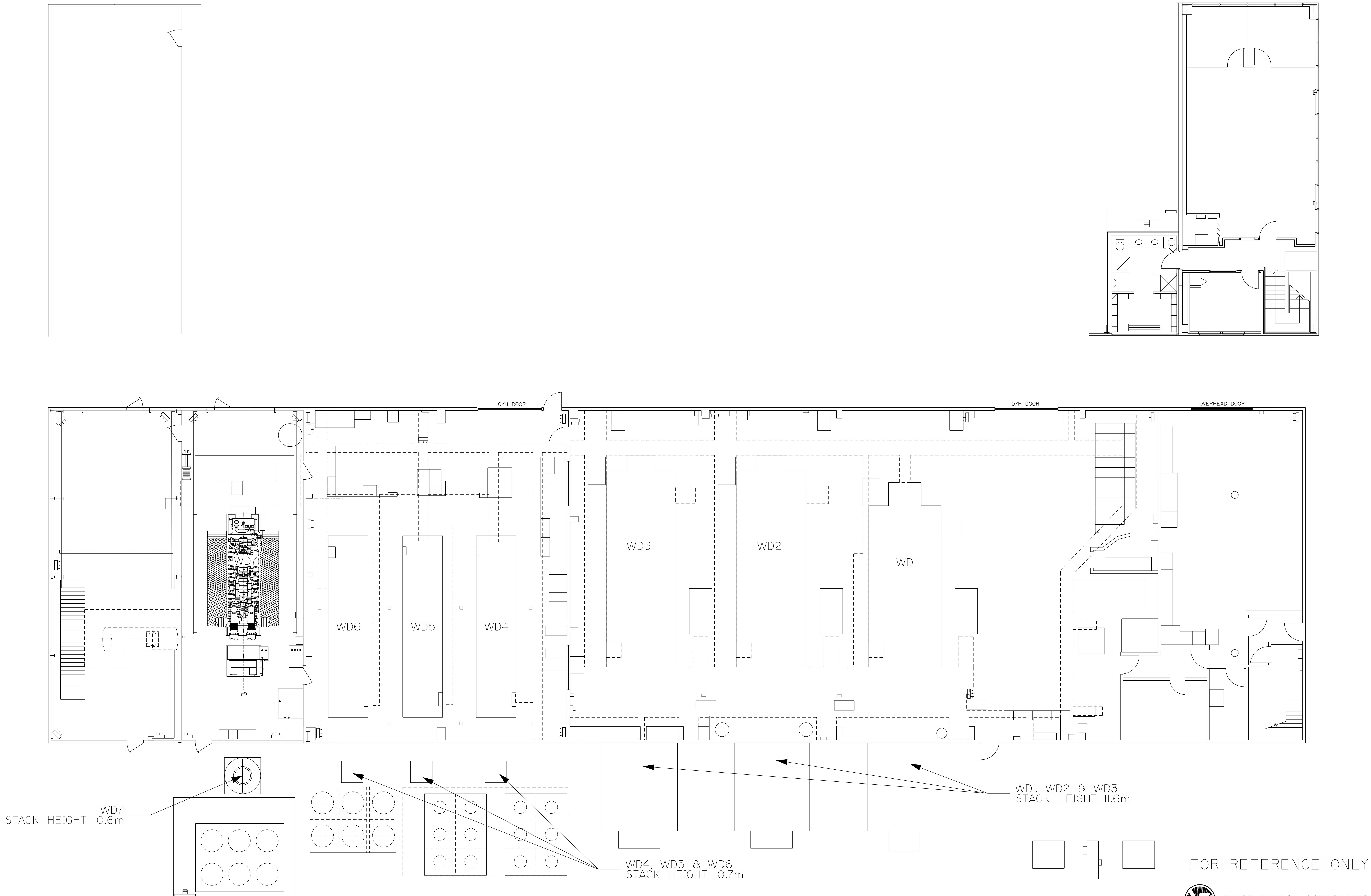
NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN
0	SEPT19/08	2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION	CM								

REF. DWG. NO.	REF. DWG. TITLE	APPROVALS		DATE	APPROVALS		DATE
		PROTECTION			MECHANICAL		
		STANDARD			CIVIL		
		PROJECT ENG.			DESIGN		
		ENG. MANAGER			ELECTRICAL		
							6-JUN-03

2008 AIR EMISSIONS PERMIT RENEWAL
APPLICATION SUPPORTING DOCUMENTATION
WHITEHORSE HYDRO/DIESEL PLANT
SITE PLAN

DRAWN TARA | DESIGN BY | SCALE NTS

A1 | DWG. NO. WHITEHORSESITE.DGN



FOR REFERENCE ONLY

CADD

YUKON ENERGY CORPORATION

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION SUPPORTING DOCUMENTATION

WHITEHORSE DIESEL PLANT LAYOUT

NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN
1	SEPT16/08	2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION	CM								

NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN	REF. DWG. NO.	REF. DWG. TITLE

APPROVALS		DATE	APPROVALS		DATE
PROTECTION			MECHANICAL		
STANDARD			CIVIL		
PROJECT ENG.			DESIGN		
ENG. MANAGER			ELECTRICAL		

DRAWN CM | DESIGN BY | SCALE: 1:100

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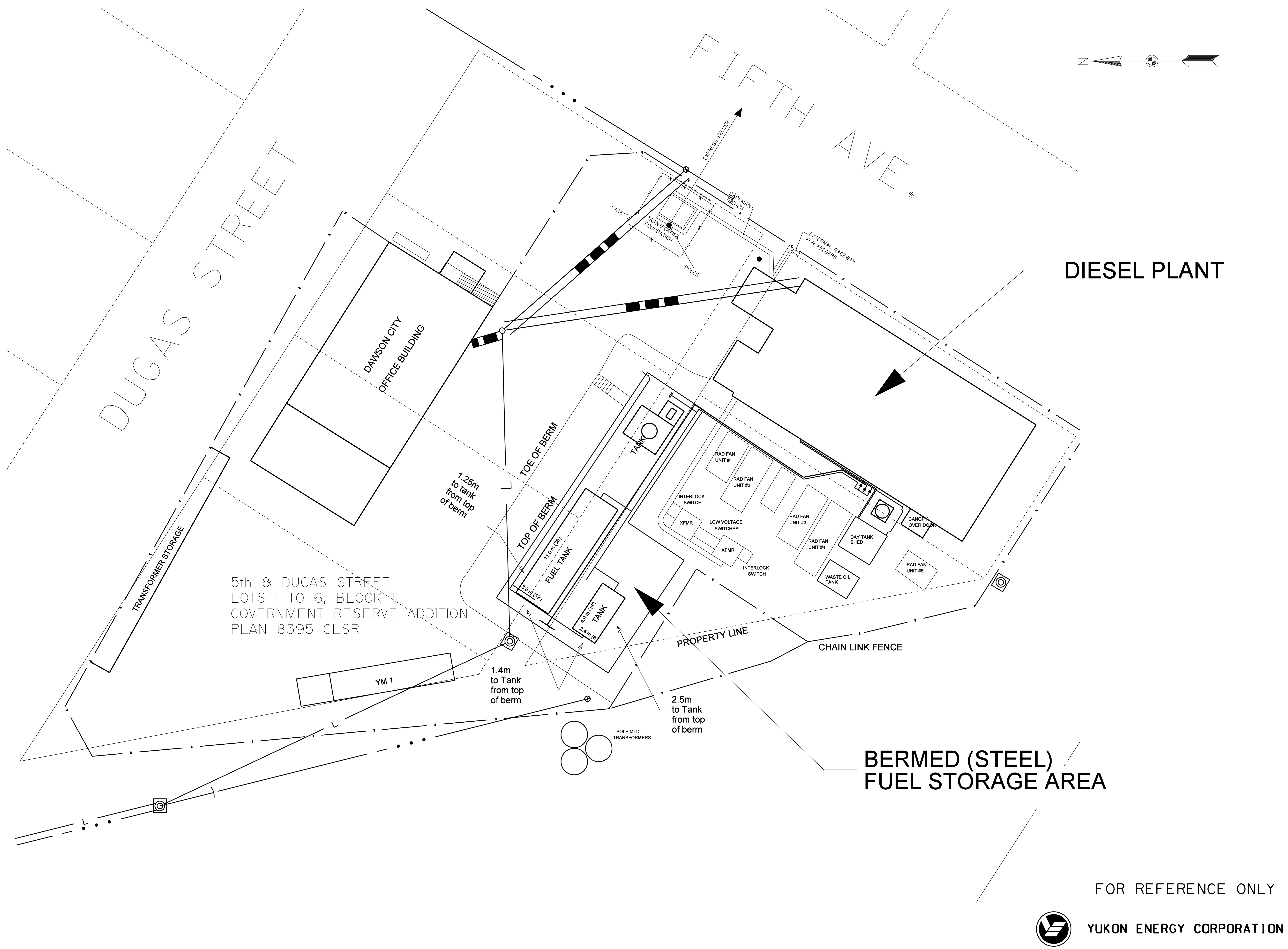

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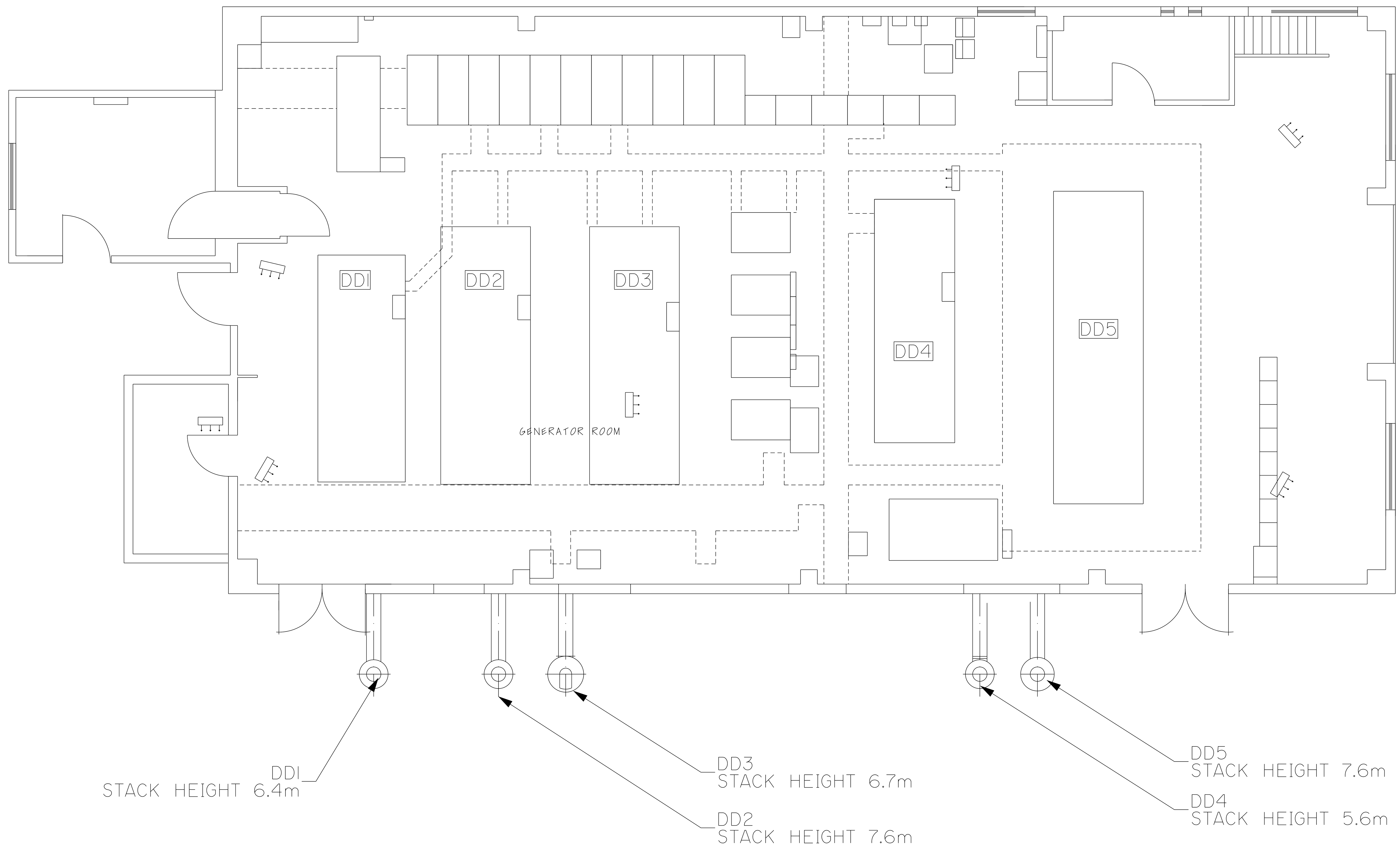
NO.	DATE	REVISIONS	BY
0	SEPT19/08	2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION	CM

APPROVALS: MECHANICAL / CIVIL / DESIGN / ELECTRICAL — DATE: 99-08-04

SKETCH SHOWING:
2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
SUPPORTING DOCUMENTATION
DAWSON CITY DIESEL PLANT & OFFICE
SITE PLAN

DRAWN: B.POWER | DESIGN BY: | SCALE: NTS

A1 | DWG NO. dawsonsite.dgn



FOR REFERENCE ONLY

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YUKON ENERGY CORPORATION

NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN
0	SEPT 19/08	2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION	CM								

NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN

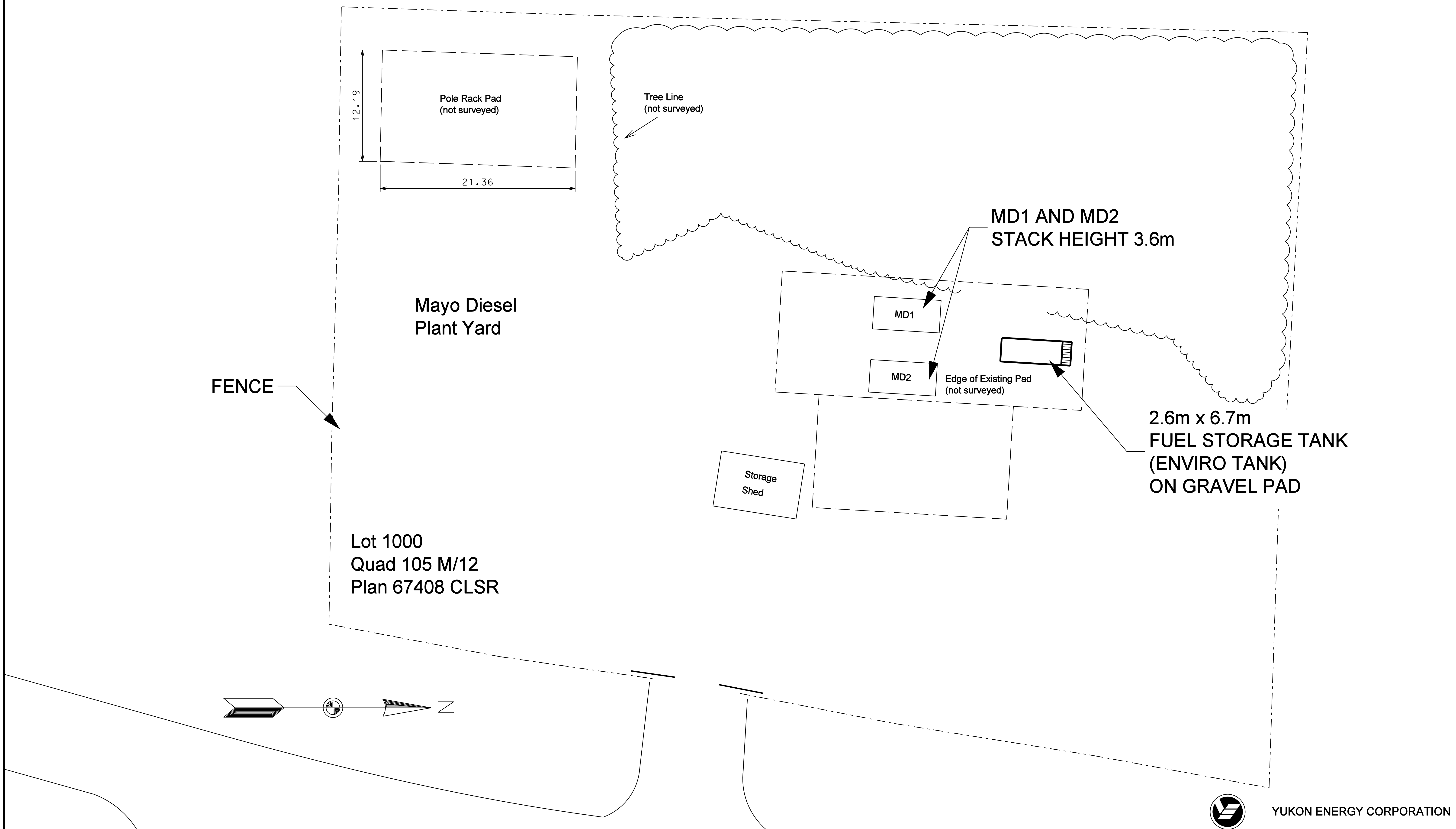
REF. DWG. NO.	REF. DWG. TITLE

APPROVALS		DATE	APPROVALS		DATE
PROTECTION			MECHANICAL		
STANDARD			CIVIL		
PROJECT ENG.			DESIGN		
ENG. MANAGER			ELECTRICAL		

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
SUPPORTING DOCUMENTATION

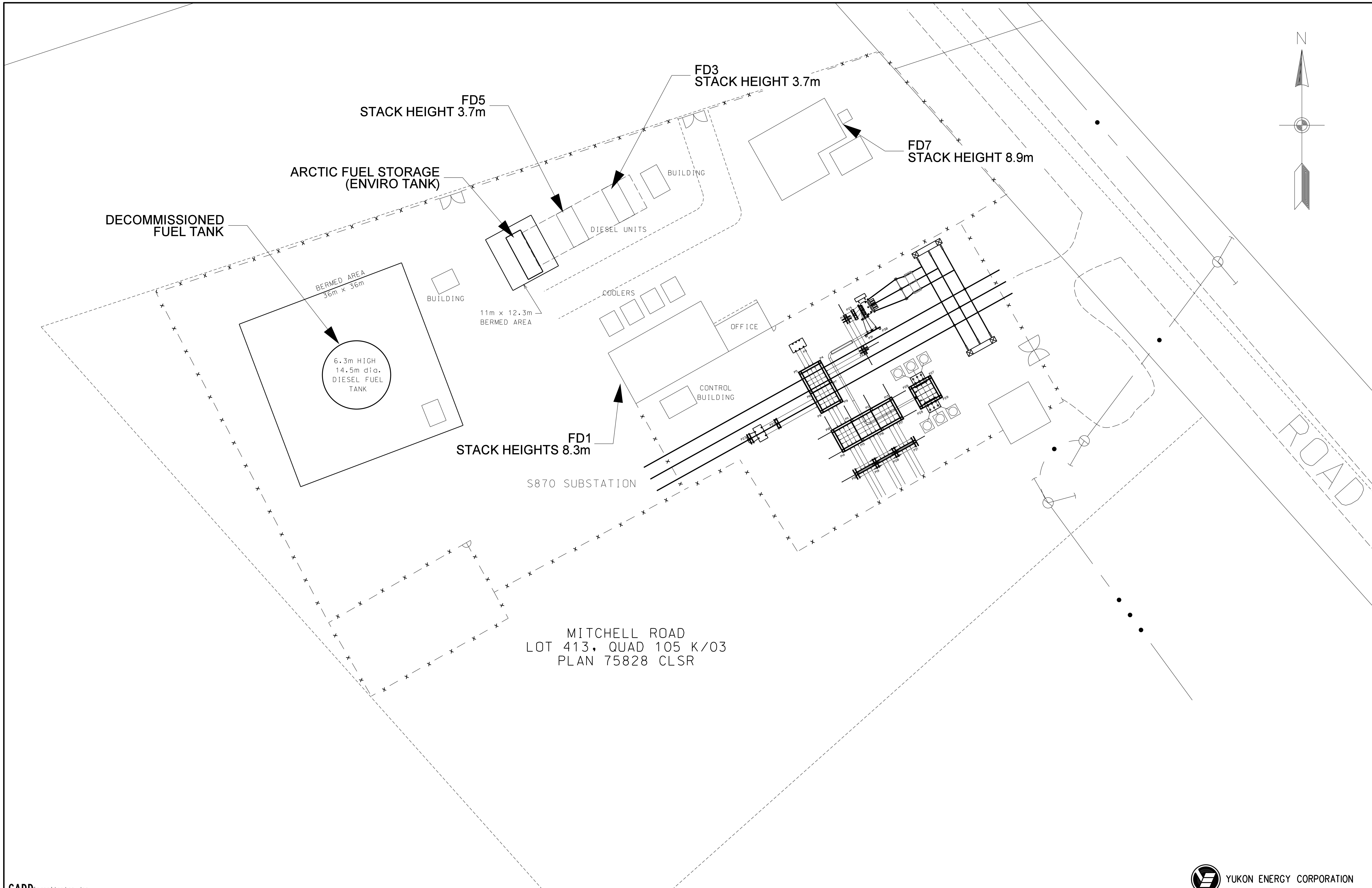
DAWSON DIESEL PLANT LAYOUT

DRAWN CM	DESIGN BY	SCALE 1:50
A1	DWG. NO. DAWSONPLANT.DGN	



YUKON ENERGY CORPORATION

REV.	DATE:dd/mo/yr	DESCRIPTION:	WO	DRAWN/ DESIGN	SKETCH SHOWING:
					2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION SUPPORTING DOCUMENTATION MAYO DIESEL PLANT SITE PLAN
0	SEPT 19/08	2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION		CM/TR	SCALE: NTS DRWG. # mayodieselplant.dgn REV. 0



CADD farositeplan.dgn

YUKON ENERGY CORPORATION

NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN	NO.	DATE	REVISIONS	BY	CIVIL	DESIGN	ELEC	MECH	PROT	STND	P.ENG	E.MAN	REF. DWG. NO.	REF. DWG. TITLE
0	SEPT 19/08	2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION	CM																						

APPROVALS	DATE	APPROVALS	DATE
PROTECTION		MECHANICAL	
STANDARD		CIVIL	
PROJECT ENG.		DESIGN	
ENG. MANAGER		ELECTRICAL	

2008 AIR EMISSIONS PERMIT RENEWAL APPLICATION
SUPPORTING DOCUMENTATION

FARO DIESEL & SUBSTATION
SITE PLAN

DRAWN TARA | DESIGN BY | SCALE NTS

A1 DWG. NO. FAROSITE.DGN Rev. 0

YUKON ENERGY

Air Emissions Permit (No. 4201-60-010)
Renewal Application Supporting Document

Appendix D

Yukon Energy's Existing Air Emissions Permit

Yukon
Environment

Permit No: 4201-60-010

AIR EMISSIONS PERMIT

Issued Pursuant to Parts 6 & 9 of the *Environment Act* and the *Air Emissions Regulations*

Permittee:	Yukon Energy Corporation
Address:	Box 5920 Whitehorse, Yukon Y1A 6S7
Facility Locations: **(Diesel Generating Plants)**	Dawson Faro Mayo Whitehorse
Phone / Fax:	867-633-7000 / 867-393-5357

In accordance with your application, the **Yukon Energy Corporation**, represented by yourself, is hereby authorized to:

- **operate electricity generating facilities with a maximum nameplate capacity equal to or more than 1.0 Megawatt ampere,**

hereinafter referred to as the source, subject to the conditions listed below.

PART 1. GENERAL CONDITIONS

1. The permittee shall comply with any applicable requirements in all federal, territorial and municipal legislation, including the *Environment Act* and the *Air Emissions Regulations*.

2. All associated personnel (employees, contractors or volunteers) shall be knowledgeable of the conditions and requirements specified in this permit, and a copy of this permit shall be kept at each site.

3. The permittee shall allow an environmental protection officer, at any reasonable time, to enter any place or premise under the permittee's ownership or occupation, other than a private dwelling, and inspect any activity which is subject to this permit.

4. The permittee shall provide notice in writing to the Environmental Programs Branch (Branch) prior to any significant change of circumstances at a permitted operation, site or business, including without limitation:
   a) closure of the facility;
   b) ownership of the facility;
   c) addition of new equipment; or
   d) release of air contaminants other than as authorized by this permit.

5. The permittee shall not release or allow the release of any air contaminant to such extent or degree as may:
   a) cause or be likely to cause irreparable damage to the natural environment; or
   b) in the opinion of a health officer, cause actual or imminent harm to public health or safety.

PART 2. RELEASE OF CONTAMINANTS

1. The permittee shall maintain and operate, in accordance with the manufacturer's procedures, fuel burning equipment, process equipment, emission control devices, testing and monitoring equipment as necessary to provide optimum control of air contaminant emissions during all operating periods.

2. The visible emissions from the source shall not exceed an opacity of 40% as measured by:
   a) an observer determining the opacity; or
   b) another method of determining the opacity as prescribed by the Branch.

3. The permittee shall not burn fuel with a sulphur content greater than 1.1% by weight without prior written authorization from the Branch.

PART 3. MONITORING, REPORTING AND RECORD KEEPING

1. The permittee must contact either an environmental protection officer, or the 24-hour Yukon Spill Report Centre (867-667-7244) as soon as possible under the circumstances in the event of an unauthorized release or emission.

2. The permittee shall ensure that emergency procedures are posted and that all associated personnel are familiar with those procedures.

3. The permittee shall keep all records for a minimum of three years and make them available upon request for inspection by an environmental protection officer.

This permit replaces permit #4201-60-010, issued on December 15th, 2004, and shall expire on December 31, 2008.

For Deputy Minister
Environmental Programs Branch
Department of Environment

Nov 28 '05
Date

I, Hector Campbell (*print name clearly*), authorized representative of **Yukon Energy Corporation**, have read and understood the terms and conditions of this permit.

Authorized Representative
Yukon Energy Corporation

2005/11/29
Date