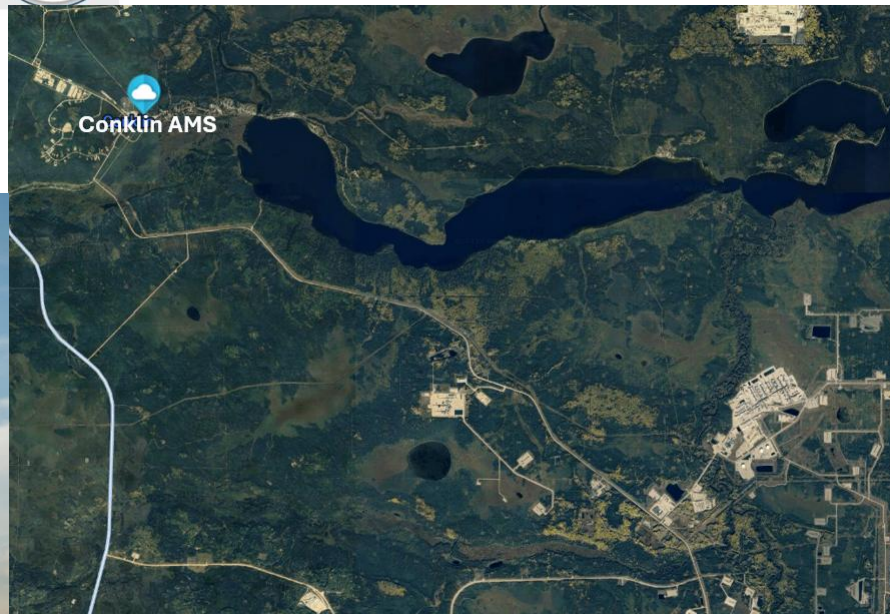
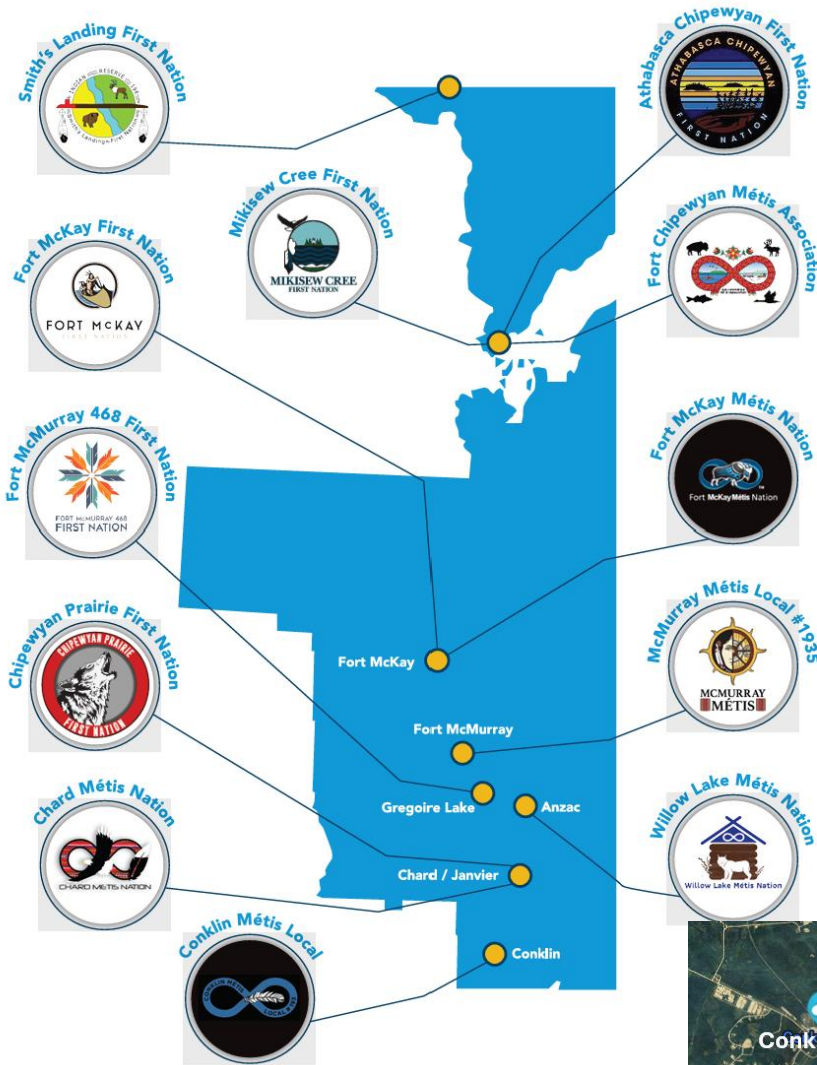


Possible Air Quality Indicators and Criteria for Indigenous Communities in the Regional Municipality of Wood Buffalo: An Assessment of Approaches using the Community of Conklin as a Demonstration Case



Prepared for the Wood Buffalo Indigenous Sub-Committee (WBISC)

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This ERRATUM corrects errors in this Final Report which focused on identifying and evaluating possible air quality indicators for Indigenous communities using air quality in Conklin as a demonstration case.

In using the Conklin air quality data analysis as template for similar air quality analysis in other communities in the RMWB, it was noted that the RPF (relative potency factor) for benzo(a)pyrene was incorrectly stated as 0.1 when it should have been 1.0 and for benzo(a)anthracene was stated as 10 when it should have been 0.1. In correcting these errors, a further review of RFPs for all the PAHs (polycyclic aromatic compounds) measured was undertaken. This resulted in some changes to some of the RFPs and to the addition of RFPs for some parameters that were not given RFPs because of lack of information.

The results of these corrections and the rework is a revised Table 1 which is now as follows:

Table 2: The Annual Average Concentration of each of the 23 PAHs Monitored by the WBEA (24-hr sample every 6 days), the Potency Factor of each PAH relative to Benzo(a)pyrene and the Individual and Summed PAH Cancer Risk

| PAHs Monitored by WBEA | Relative Potency Factor (RFP)* | Average Concentration (ng/m ³) in Noted Period | | | | | | Cancer Risk** |
|---|--------------------------------|--|---------|---------|---------|---------|-----------|-----------------|
| | | 2020 | 2021 | 2022 | 2023 | 2024 | 2020-2024 | |
| Naphthalene ¹ | 0.001 | 13.4677 | 14.9027 | 22.7171 | 29.7526 | 35.4422 | 23.5711 | 1.41E-08 |
| Acenaphthylene ¹ | 0.001 | 2.6425 | 4.1019 | 3.9724 | 3.6532 | 3.2455 | 3.6425 | 2.19E-09 |
| Acenaphthene ¹ | 0.001 | 4.9622 | 5.5145 | 4.3132 | 6.5556 | 8.1023 | 5.8548 | 3.51E-09 |
| Fluorene ¹ | 0.001 | 3.4087 | 3.8341 | 3.5808 | 4.6238 | 4.9082 | 4.0929 | 2.46E-09 |
| Phenanthrene ¹ | 0.001 | 6.1065 | 6.6685 | 5.0931 | 6.5772 | 9.8174 | 6.7510 | 4.05E-09 |
| Anthracene ¹ | 0.01 | 0.8118 | 1.0390 | 0.8324 | 1.1042 | 1.9718 | 1.1387 | 6.83E-09 |
| Acridine | Inadequate | 0.0125 | 0.0155 | 0.0081 | 0.0073 | 0.0065 | 0.0099 | NA |
| Fluoranthene ² | 0.001 | 1.0572 | 1.3126 | 1.2527 | 1.2401 | 1.1719 | 1.2265 | 7.36E-10 |
| Pyrene ¹ | 0.001 | 0.7728 | 0.9101 | 0.9421 | 0.7901 | 0.8209 | 0.8575 | 5.15E-10 |
| Benzo(c)phenanthrene ² | 0.01 | 0.0192 | | 0.0084 | 0.0068 | 0.0073 | 0.0107 | 6.40E-11 |
| Benzo(a)anthracene ² | 0.1 | 0.1042 | 0.1922 | 0.1817 | 0.2576 | 0.2046 | 0.1965 | 1.18E-08 |
| Chrysene ² | 0.01 | 0.1418 | 0.2117 | 0.2342 | 0.2700 | 0.2178 | 0.2232 | 1.34E-09 |
| 7,12-Dimethylbenz(a)anthracene ² | 10 | 0.0210 | 0.0170 | 0.0080 | 0.0073 | 0.0075 | 0.0115 | 6.89E-08 |
| Benzo(b)fluoranthene ² | 0.1 | 0.0725 | 0.1558 | 0.4354 | 0.2720 | 0.2030 | 0.2466 | 1.48E-08 |
| Benzo(k)fluoranthene ² | 0.1 | 0.0687 | 0.1582 | 0.4351 | 0.2738 | 0.2036 | 0.2472 | 1.48E-08 |
| Benzo(a)pyrene ² | 1 | 0.0561 | 0.0571 | 0.0557 | 0.0645 | 0.0299 | 0.0537 | 3.22E-08 |
| 3-Methylcholanthrene ³ | 13 | 0.0116 | 0.0111 | 0.0079 | 0.0058 | 0.0053 | 0.0082 | 6.37E-08 |
| Indeno(123-cd)pyrene ² | 0.1 | 0.0213 | 0.0247 | 0.0181 | 0.0150 | 0.0263 | 0.0207 | 1.24E-09 |
| Dibenzo(a,h)anthracene ² | 1 | 0.0089 | 0.0092 | 0.0143 | 0.0084 | 0.0123 | 0.0107 | 6.40E-09 |
| Benzo(ghi)perylene ² | 0.01 | 0.0188 | 0.0189 | 0.0159 | 0.0113 | 0.0226 | 0.0170 | 1.02E-10 |
| Dibenzo(a,l)pyrene ² | 100 | 0.0059 | 0.0063 | 0.0080 | 0.0070 | 0.0049 | 0.0067 | 4.04E-07 |
| Dibenzo(a,i)pyrene ² | 1 | 0.0025 | 0.0032 | 0.0038 | 0.0055 | 0.0055 | 0.0040 | 2.42E-09 |
| Dibenzo(a,h)pyrene ² | 1 | 0.0026 | 0.0033 | 0.0036 | 0.0050 | 0.0060 | 0.0038 | 2.31E-09 |
| Total Cancer Risk | | | | | | | | 6.59E-07 |
| *Mixtures of carcinogenic PAHs are assessed using relative potency factors (RPFs), also referred to as potency equivalence factors. An RPF is the ratio of carcinogenic potential of an individual PAH relative to benzo[a]pyrene. Inadequate means that there is insufficient information to determine if the PAH is carcinogenic. | | | | | | | | |
| **Cancer risk is based a benzo(a)pyrene unit risk factor of 0.6 mg/m ³ with the individual PAH's potency factor times the annual average concentration of each PAH used to estimate its contribution to the overall cancer risk associated with the 23 measured PAHs | | | | | | | | |
| ¹ Tomasietig, F., Tebby, C., Graillot, V., Zeman, F., Perry, R. R., & et al. (2020). Comparative genotoxic potential of 27 polycyclic aromatic hydrocarbons in three human cell lines. <i>Toxicologic Letters</i> , 99-105. | | | | | | | | |
| ² Health Canada. (2021). <i>Federal Contaminated Site Risk Assessment in Canada: Toxicological Reference Values (TRVs)</i> . Ottawa: Health Canada. | | | | | | | | |
| ³ ATSDR. (2022, April 14). <i>PAH-Guidance</i> . Retrieved from Agency for Toxic Substances and Disease Registry: https://www.atsdr.cdc.gov/pha-guidance/resources/ATSDR-PAH-Guidance-508.pdf | | | | | | | | |

The sentence following **Table 3** was: ***“The calculated total cancer risk of the 23 PAHs being measured in Conklin is 0.56 per million, which Health Canada considers as negligible (Health Canada, 2021).”*** This sentence is now: ***“The calculated total cancer risk of the 23 PAHs being measured in Conklin is 0.66 per million, which Health Canada considers as negligible (Health Canada, 2021).”***

Executive Summary

An analysis of potential Indigenous community air quality indicators and related criteria was conducted at the request of the Wood Buffalo Indigenous Sub-Committee, funded by the ICBM Indigenous Indicators and Knowledge Transfer Project.

Initially, the objective was to assess air quality in all Indigenous communities within the Regional Municipality of Wood Buffalo (RMWB) that possess continuous air monitoring stations, specifically Conklin, Janvier, Anzac, Fort McKay, and Fort Chipewyan. The assessment commenced using air quality data from Conklin. However, based on the analysis of this data, and the identification and evaluation of various possible indicators and criteria, it became evident that conducting such an assessment for all communities could not be achieved within the project's budget and timeline. Consequently, the project's focus was revised.

The assessment of Conklin's air quality was redirected to providing examples of how different air quality parameters, criteria, and assessment approaches could assist communities in identifying existing or potential future air quality issues, along with the indicators and criteria that could be used to address these concerns.

In general, the assessment approaches were used involved comparing past and current community air quality relative to air quality criteria that are based on health and environmental protection principles that may be acceptable to communities. These included: the fully health risk-based World Health Organization's 2021 Air Quality Guidelines for NO₂, SO₂, PM_{2.5} and PM₁₀; the Canadian Ambient Air Quality Standards “green” and “yellow” management levels for NO₂, SO₂ and PM_{2.5}; the Environment and Climate Change Canada (ECCC) Air Quality Health Index, which is based on ambient air quality NO₂, PM_{2.5} and O₃ levels; Alberta's Ambient Air Quality Objectives for two PAHs, benzo(a)pyrene and naphthalene, which are stringent relative to criteria in other jurisdictions; Health Canada cancer potency factors for PAHs used to estimate a cumulative PAH exposure cancer risk level; and Alberta's Ambient Air Quality Guidelines for dustfall.

The potential for odours was evaluated using THC and TRS hourly data and criteria developed by Fort McKay. These criteria link the concentrations of THC and TRS to the likelihood of odours. Acknowledging the limitations of applying these Fort McKay criteria, which are predominantly based on tailings pond odorants, alternative approaches for assessing odours were proposed if odours are, or become, a concern for the community.

Air quality was also assessed relative to estimated pre-development baseline levels which provides an indication of the magnitude of air quality changes over time. Recent ECCC air quality modelling outputs were also used to provide estimates of the impact that different emission source types e.g. oil sands emissions and all anthropogenic emissions, are having on air quality. Oil Sands facilities within a 35 km

radius of Conklin were identified and the 2022 emissions of NO_x, SO₂, PM_{2.5} and PM₁₀ from each facility summarized. On Google Earth, the concentrations of each of these four pollutants in Conklin, as a function of wind direction, were shown relative to the location of each facility. This allowed a depiction and assessment of the linkage between each facility's location and emissions and its impact on air quality in Conklin. The intent being to provide communities with information that can be used in discussions with regulators and operators on emission management needs and requirements.

(Note: After the completion of this report, it was discovered that the ECCC GEM-MACH modelling of in-situ facilities may not have included all the emission sources associated with these facilities when determining the oil sands “zero out” scenario. This occurred because, while all the industry emissions were included in the inventory, not all the oil sands emissions grid cells containing these oil sands emissions were included in the shapefiles used to designate cells with oil sands emissions. The implication of this is that the oil sands “zero out” scenario does not remove all the oil sands emission influences. Therefore, the predicted oil sands “zero out” air quality influences are underestimated and the non-industrial anthropogenic emissions are overestimated. The conclusions from the GEM-MACH model analysis, as outlined in this report, have to be considered as approximations with considerable uncertainty. The analysis needs to be updated once future modelling run outputs which include the missed oil sands emission sources are available. The GEM-MACH model analysis is therefore presented as an example of how this modelling can be used to understand the air quality impacts associated with different emission source types.)

In summary, the focus of the assessment was on providing approaches that communities can use to:

- assess the status of their air quality relative to protective criteria and baseline levels,
- determine the nature and location of emission sources, or emission source types, influencing their air quality, and
- select community relevant air quality indicators and criteria.

The assessment demonstrates the application of each approach, the type of information that it provides and how this information might inform air quality indicator and criteria selection. The following is an overview of assessment findings:

- Air quality in Conklin is generally very good relative to protective air quality criteria with an associated recommendation that the Community consider indicators and criteria that reflect a “*keeping clean areas clean*” approach to air quality management;
- Air Quality Health Index levels in Conklin are almost always in the 1 to 3 range which is another indication of generally good air quality;
- PM_{2.5} and PM₁₀ are the two air quality parameters that are close to, and occasionally exceed, the WHO health risk based annual Guideline limit and are therefore two parameters that would appear to warrant a focus in terms of tracking changes and identifying the sources influencing PM_{2.5} and PM₁₀ levels in the Community and possible management of these sources;
- Air quality levels over the 2017-2024 period relative to estimated pre-development levels provide an indication of the impact that current emissions and activities are having on the Community's air quality;
- The air quality modelling shows how modelling predictions can be used to provide information on the possible impact that local and/or regional emission influences are having on air quality in

Conklin but no conclusions from this analysis can be made due the above noted missing industrial emissions for certain facilities;

- Based on THC and TRS levels, the likelihood of frequent odour events appears low, but this needs to be validated based on community members' experience;
- Dustfall measurements taken over the November 2022 to October 2024 period would indicate potential dust issues in the Community, while PM_{2.5} and PM₁₀ data would indicate a relatively low potential for dust, therefore, community members' experiences with dust needs to be determined and additional dustfall monitoring appears desirable to better assess whether dust is a community air quality issue warranting action; and
- The review of PAH levels in the Community relative to air quality and cancer risk criteria would indicate that PAH levels are below, to well below, protective criteria levels.

There are many ways to analyze air quality data and to present the results of these analyses. The approaches used in this analysis were based on providing easily understood/interpreted depictions with the recognition that for certain types of data this is very challenging.

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1 Introduction and Project Overview

The nature and extensiveness of oil sands development results in air emissions that impact air quality throughout the Regional Municipality of Wood Buffalo (RMWB) (McLinden, et al., 2012; McLinden, et al., 2016; Horb, et al., 2021). Air pollution can have a significant impact on health and well-being (WHO, 2016). Indigenous peoples living in the oil sands regions have raised concerns regarding how air emissions from oil sands development affect their air quality. Considering that the average person takes thousands of breaths and inhales approximately 15,000 litres of air each day, air can be a substantial source of exposure to contaminants even at low pollutant concentrations (IARC, 2016; USEPA, 2011).

To understand how regional air emissions affect ambient air quality, the Wood Buffalo Environmental Association operates a network of air monitoring stations (AMS) (<https://wbea.org/data/network-map-station-data/>). Figure 1 shows aerial images of all continuous air monitoring stations in the RMWB, including those within communities. These stations, some located in Indigenous communities, provide residents with information on their air quality.

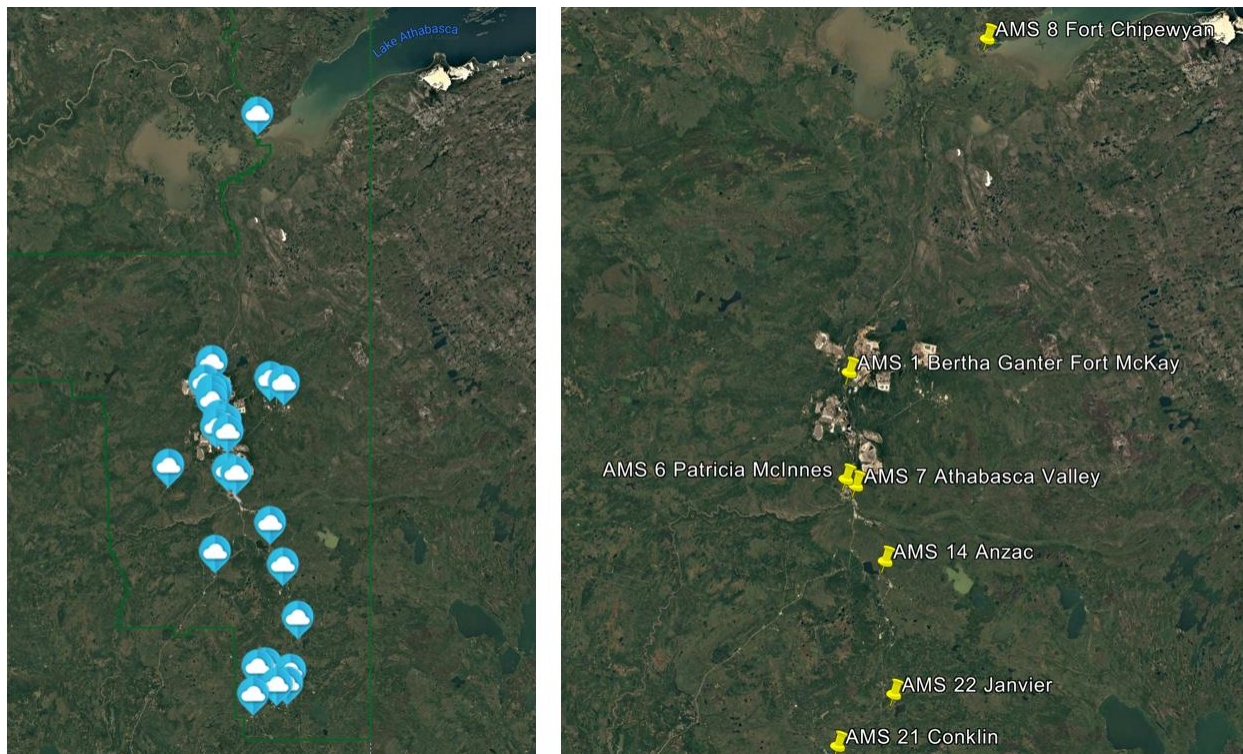


Figure 1: Aerial Images of all the Wood Buffalo Environmental Associations (WBEA) Ambient Air Monitoring Stations (AMS) (Left Image) and the Community AMSs (Right Image)

The Wood Buffalo Indigenous Sub-Caucus (WBISC), which is part of the Canada-Alberta Oil Sands Monitoring Program (OSMP), requested ideas from the authors on how existing air quality datasets could be analyzed and used to assist Indigenous communities in selecting possible Indigenous-based air quality indicators and related evaluation and management level criteria. While initially the intent was to analyze air quality from all the Indigenous Community AMSs, time, scope and budget constraints were such that it was decided focus on air quality at the air monitoring station in the community of Conklin to

demonstrate how existing air quality data could be analyzed and assessed in the context of establishing Indigenous-based air quality indicators and criteria. Preliminary results from some of the analyses were presented at the Indigenous Indicators Workshop held in Fort McMurray on February 24th and 25th 2025. Based on feedback received at this Workshop, additional air quality parameters related to health and odours were added to the air quality parameter/indicator analysis list. The analyses presented in this assessment represent a western science approach to evaluating air quality and the factors influencing air quality with a focus on possible oil sands development related impacts. An effort was made to try and assess air quality, and identify air quality criteria, in a way that would assist in bridging western science approaches to Indigenous knowledge and perspectives on what constitutes “good quality air” and the approaches that Indigenous communities use to evaluate their air quality. Feedback from Indigenous communities is a crucial part of this bridging. The incorporation of additional parameters related to health and odour, based on discussions with Indigenous Community members, is an example of the ongoing and iterative process of defining and refining indicators that are meaningful and relevant to Indigenous communities impacted by oil sands developments in the region.

1.1. Air quality parameters/indicators

The air quality parameters/indicators covered in this analysis are:

- Particulate Matter (PM) which includes fine particulate matter PM_{2.5} and coarse particulate matter (PM₁₀);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Sulphur Dioxide (SO₂);
- Nitrogen Dioxide (NO₂);
- Total Hydrocarbons (THCs) and Total Reduced Sulphur (TRS) (odour-related compounds);
- Dustfall; and
- The Air Quality Health Index (AQHI).

Appendix 1 outlines the reasoning behind the selection of each of these parameters/indicators and its relevance in the context of oil sands region (OSR) emission sources and health and/or environmental impacts.

1.2. Data and Air Quality Criteria Sources

The following are the datasets and air quality that were used in this study:

(

- **Table 4** shows when continuous air quality commenced in each community and **Table 5** outlines the monitoring method used by WBEA at Conklin for each of the air quality parameters analyzed in this study);
- **Oil Sands Monitoring Program (OSMP) Environment and Climate Change Canada (ECCC) GEM-MACH model runs** which provided air quality model predictions for the OSR for several different emissions scenarios (**as noted above, some emissions from certain in-situ facilities were not captured in this modelling**);
- **The Alberta Emission Inventory Report (AEIR)**; and
- **Four sets of air quality criteria:**
 - The Alberta Ambient Air Quality Objectives and Guidelines (AAAQO/Gs);

- The Canadian Ambient Air Quality Standards (CAAQs);
- The World Health Organization (WHO) Air Quality Guidelines (AQGs); and
- The Canadian Air Quality Health Index (AQHI).

More details on these data sources are provided in the “Analysis Approach” sections in the context of how the data was used.

Table 4: The Dates when Continuous Air Quality Monitoring commenced in Each Community

| Community | Population | Air Monitoring Start Date |
|---|------------|---------------------------|
| Conklin | 155* | April 2016 |
| Janvier I.R. 194 + Janvier South | 421* | January 2017 |
| Anzac | 506* | January 2006 |
| Fort McKay I.R.174 + Métis Community | 742** | October 1997 |
| Fort Chipewyan | 798* | July 1998 |
| *Statistics Canada (https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/index.cfm?Lang=E) 2021 Census Data | | |
| **Townfolio https://townfolio.co/ab/fort-mackay/summary | | |

Table 5: Monitoring Method Details for the Air Quality Parameters Measured at the Conklin AMS and which were used in this Study

| Parameter | Start of Monitoring | Sampling – Monitoring Method | Comment |
|---|-------------------------------|---|---|
| SO ₂ | April 1, 2016 | Thermo Environmental 43i | Continuous |
| NO ₂ | April 1, 2016 | Thermo Environmental 42i | Continuous |
| Total Hydrocarbon (THC) | April 1, 2016 | Thermo Environmental 55i | Continuous |
| Total Reduced Sulphur (TRS) | April 1, 2016 | CD Nova -101 | Continuous |
| PM _{2.5} | i) April 2016 to June 2020 | i) Thermo Scientific 5030 | Continuous |
| | ii) June 2020 to present | ii) Teledyne/API T640 | Continuous |
| PM _{2.5} | July 1, 2020 | Thermo Environmental 2000i PM _{2.5} Partisol | Two samplers Time-integrated (24-hr every 6 days) |
| | | MASS by Microbalance | |
| | | ELEMENTS by Inductively Coupled Plasma Mass Spectrometry (ICP/MS) | |
| | | IONS by Ion Chromatography (IC) | |
| PM ₁₀ | May 1, 2020 | Teledyne/API T640 | Continuous |
| PM ₁₀ | July 1, 2020 | Thermo Environmental 2000i PM ₁₀ Partisol | Two samplers Time-integrated (24-hr every 6 days) |
| | | MASS by Microbalance | |
| | | ELEMENTS by Inductively Coupled Plasma Mass Spectrometry (ICP/MS) | |
| | | IONS by Ion Chromatography (IC) | |
| PAHs | July 1, 2020 | a glass fiberfilter + PUF/XAD-2/PUF | Time-integrated (24-hr every 6 days) |
| | | Gas Chromatography/ Mass Selective Detector (GC/MSD) | |
| Dustfall | November 2022 to October 2024 | Plastic container in a mounted holder | Monthly |
| Wind Direction (WD) and Wind Speed (WS) | April 1, 2026 | Met One | Continuous |

1.3. Wildfire Influences

Wildfires frequently impact air quality in the Regional Municipality of Wood Buffalo (RMWB), complicating efforts to distinguish between wildfire influences and oil sands emission influences. Given that wildfire emissions vary from year to year and, depending on the wildfire severity and location, can significantly affect all of the parameters of interest in this study (Landis et al., 2018), an approach used in other research (Wentworth, Aklilu, Landis, & Hsu, 2018; Wnorowski, Aklilu, Harner, Schuster, & Charland, 2021) was employed to exclude wildfire influences when comparing measured air quality levels to air quality criteria. This method involves the elimination of all data hours with PM_{2.5} levels exceeding 25 µg/m³. Although this simplified approach has limitations, it is considered a reasonable and practical means to remove most wildfire influences from air quality datasets in the RMWB.

1.4. Baselines

One of the focuses of this study is to assess air quality in each community relative to an estimated pre-development baseline for each of the parameters studied. This allows the magnitude of oil sands air quality impacts to be estimated. The following are the baselines used in this analysis:

- PM_{2.5} - 1.8 micrograms per cubic metre (µg/m³) (annual average),
- PM₁₀ – 5.1 micrograms per cubic metre (µg/m³) (annual average),
- NO₂ - 0.30 parts per billion by volume (ppb) (annual average),
- SO₂ – 0.1 ppb (annual average),
- Dustfall – 20 mg/100cm²-month,
- PAHs – 0.03 ng/m³ for benzo(a)pyrene (Jasiura, Gorzel, Warchol, & Lipczynska, 2023)

Appendix 4 provides details on the basis for these baselines.

These estimated pre-development baseline air quality values for Indigenous Communities provide a general indicator of background air quality. Due to uncertainties and estimating difficulties, these estimates should be used to gauge the relative magnitude, not the specific impact, of oil sands development-related air emissions on community air quality.

1.5. Analyses Approaches

The following are the air quality parameter/indicator analysis approaches used in this study:

- **Air Quality vs. Air Quality Criteria and Approximate Baseline** - Measured pollutant levels are compared to Ambient Air Quality Criteria (NO₂, SO₂, PM_{2.5}, PM₁₀, PAHs and dustfall), and also to each parameter's approximated baseline, to help assess the acceptability of current air quality and the criteria that a community might consider or adopt as an acceptable limit of change;
- **Wind Direction and Air Quality** - NO₂, SO₂, PM_{2.5}, PM₁₀ levels in Conklin as a function of wind direction, and relative to the location of oil sands facilities within a 35 km radius of the community, are assessed to identify the oil sands facilities having the most impact on the community's air quality;
- **GEM-MACH Model Predictions** – the model predictions under different emission scenarios were used to demonstrate how such modelling can be to assess the air quality impacts that different emission sources are having which provides communities with information on sources that should possibly be a priority for additional emissions management (**as noted previously,**

because of some missing emissions, these predictions are only examples of how modelling information can be used);

- **THC and TRS** – levels of these two parameters are used as a measure of the potential for odours using Fort McKay’s THC-TRS odour potential estimating methodology; and
- **AQHI** – the AQHI levels in the community was used as a health risk indicator.

Each of these analyses is presented as separate sections in this report.

2 Air Quality in Conklin Compared to Established Air Quality Criteria that may be Relevant in Terms of Establishing Community-based Air Quality Criteria

2.1. Background

Air quality data from Conklin for SO₂, NO₂, PM₁₀, PM_{2.5}, PAHs and dustfall was evaluated against the applicable Alberta, Canadian and WHO air quality criteria. The levels of THC and TRS were compared to criteria that Fort McKay has developed to assess the likelihood of odours when THC and TRS reach certain values. AQHI levels in Conklin were compared to the index’s health risk scale levels.

When comparing air quality data to established air quality criteria, it is important to understand the basis or purpose of the criteria levels which determines how, or if, the criteria is relevant in terms of the information the comparison is intended to provide. For this study, the focus of the air quality data vs. criteria comparison is to provide information that will assist Indigenous communities in identifying priority air quality indicators and desired criteria levels for these indicators.

The Fort McKay First Nation (FMFN) recently evaluated SO₂, NO₂, PM_{2.5} and PM₁₀ levels in Fort McKay relative to Alberta (AAAQOs), Canada (CAAQS) and WHO air quality criteria. The following outlines the basis for each of the three sets of criteria and how the criteria need to be considered in the context of air quality analysis, as each set of criteria is based on different considerations.

The Alberta Government¹ notes that: “AAAQOs are developed to provide protection of human health and the environment to an extent technically and economically feasible, and reflective of Albertans’ social concerns.” It is also noted that the AAAQOs “...are used in a variety of contexts to:

- *evaluate the adequacy of facility design in regulatory applications*
- *establish approval conditions for regulated air emission sources*
- *assess beyond project boundary impacts of air pollutant sources and evaluate facility performance”*

The AAAQOs therefore have an emissions management focus and are not strictly health based as the following statement notes:

¹ Alberta Government. (2024). Alberta Ambient Air Quality Objectives and Guidelines. <https://open.alberta.ca/publications/alberta-ambient-air-quality-objectives-and-guidelines>

“As the ambient air quality objectives are in many cases not entirely protective of human health and the environment, efforts are made to improve air quality in order to stay well below ambient air quality objectives and if the circumstances warrant, to lower the ambient air quality objectives over time.”²

This also implies that the AAAQOs, while potentially relevant in the greater regulatory context, may not adequately address factors that are relevant to Indigenous communities and/or their Treaty Rights.

CAAQS were established based on a “*population improvement approach (PIA)*.” The PIA approach is based on continuously reducing the proportion of the population subject to CAAQS parameter concentrations above the standard and is therefore not based on any specific environmental and/or health-based air quality endpoint other than exposure reduction. In addition to establishing an air quality standard, the CAAQS also establish air zone management levels that are focused on continuous air quality improvement. These CAAQS management levels provide air quality benchmark levels that may be relevant in terms of establishing air quality expectations and/or goals.

The WHO AQGs are based on:

“... the lowest levels of exposure for which there is evidence of adverse health effects.”

This means that the WHO AQGs represent health-based “*near-safe*” ambient air quality levels as supported by up-to-date scientific evidence, and as such represent air quality criteria that are very relevant in terms of possible health concerns related to ambient air pollutant exposure.

Like the WHO criteria, the AQHI represents a strictly acute toxicity health risk-based air quality metric and is therefore a criterion that also warrants consideration in terms of establishing air quality expectations and/or goals air quality criteria that are relevant.

2.2. Summary of the Air Quality Criteria

Table 6 summarizes the specific air quality criteria in the AAAQO/Gs, CAAQS and WHO Guidelines.

Table 7 summarises the CAAQS levels for each CAAQS management level, i.e. “red”, “orange”, “yellow” and “green” and the air quality management actions associated with each level. **Table 8** shows the health risk scale in the AQHI and the health risk guidance associated with the scale.

As all the footnotes in Table 6 and

Table 7 indicate, the determination approaches for assessing air quality relative to the criteria are often different, which complicates criteria comparisons and requires slightly different dataset analysis depending on the criteria that the data is being evaluated against.

In this analysis, Conklin’s air quality was compared to AAAQO/G, CAAQS, WHO and AQHI criteria to provide an example of how such air quality-criteria comparisons can be used to help identify and select community-relevant air quality indicators and possible associated assessment criteria. The analysis focused on the WHO and AQHI criteria due to their health-risk basis. Additionally, unlike the previous FMFN review that emphasized the “red” and “orange” management CAAQS criteria, this analysis

² Alberta Government. (2013). Using Ambient Air Quality Objectives in Industrial Dispersion Modelling and Individual Industrial Site Monitoring. <https://open.alberta.ca/publications/9781460112922>

concentrated on the "green" and "yellow" CAAQS management levels as these levels are the most relevant to the air quality in the other four Indigenous communities, i.e. Conklin, Janvier, Anzac and Fort Chipewyan.

Table 6: A Summary of the Air Quality Criteria used in this Study

| Parameter | Averaging Period | Criteria and Limits for Noted Parameter and Averaging Period (NC- no criteria) | | |
|-------------------|---------------------|---|-----------------------------------|------------------------------------|
| | | AAAQO/G ¹ | WHO AQG ² | CAAQS ³ |
| SO ₂ | Hourly | 172 ppb | NC | ⁶ 65 ppb |
| | Daily ⁵ | 48 ppb | 15 ppb | NC |
| | Annual | 8 ppb | NC | 4 ppb |
| NO ₂ | Hourly ⁴ | 159 ppb | NC | ⁷ 42 ppb |
| | Daily ⁵ | NC | 13 ppb | NC |
| | Annual | 24 ppb | 5.2 ppb | 12 ppb |
| PM _{2.5} | Daily | 29 µg/m ³ | ⁵ 15 µg/m ³ | ⁸ 27 µg/m ³ |
| | Annual | NC | 5 µg/m ³ | ⁹ 8.8 µg/m ³ |
| PM ₁₀ | Daily | NC | ⁵ 45 µg/m ³ | NC |
| | Annual | NC | 15 µg/m ³ | NC |
| Dustfall | Monthly | 53 mg/100-cm ² /30 days | NC | NC |
| PAHs | Annual | <ul style="list-style-type: none"> • Naphthalene (3 ug/m3) • Benzo[a]pyrene (0.3 ng/m3) | NC | NC |

¹Alberta Ambient Air Quality Objectives and Guidelines

²World Health Organization Air Quality Guidelines (2021 update)

³Canadian Ambient Air Quality Standards

⁴The CAAQS value is based on the 3-year average of the annual 98th percentile of the daily-maximum 1-hour average concentrations

⁵The WHO value is based on 99th percentile of daily values in a year (i.e. 3- 4 exceedance days per year)

⁶ The CAAQS value is based on a 3-year average of the annual 99th percentile of the daily-maximum 1-hour average concentrations

⁷The CAAQS value is based on the 3-year average of the annual 98th percentile of the daily-maximum 1-hour average concentrations

⁸The CAAQS value is a 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.

⁹The CAAQS value is the 3-year average of the annual average of the daily 24-hour average concentrations.

Table 7: A Summary of the Canadian Ambient Air Quality Standards Management Levels

| Management Level | Objective/Action | Parameter | | | | | |
|---|--|---------------------|---------------------|---------------------|---------------------|-------------------------|---------------------------|
| | | SO ₂ | | NO ₂ | | PM _{2.5} | |
| | | Hourly ¹ | Annual ² | Hourly ³ | Annual ² | ⁴ Hourly | ⁵ Annual |
| Red Management Level (CAAQS Exceedance) | To reduce pollutant levels below the CAAQS through Advanced Air Management Actions | >65 ppb | >4 ppb | >42 ppb | >12 ppb | >27 µg/m ³ | >8.8 µg/m ³ |
| Orange Management Level | To improve air quality through Active Air Management and Prevent exceedance of the CAAQS | 51-65 ppb | 3.1-4.0 ppb | 32-42 ppb | 7.1-12 ppb | 20-27 µg/m ³ | 6.5-8.8 µg/m ³ |
| Yellow Management Level | To improve air quality using Early and Ongoing Actions for Continuous Improvement | 31-50 ppb | 2.1-3.0 ppb | 21-31 ppb | 2.1-7.0 ppb | 11-19 µg/m ³ | 4.1-6.4 µg/m ³ |
| Green Management Level | To maintain good air quality through Proactive Air Management Measures to Keep Clean Areas Clean | ≤30 ppb | ≤2 ppb | ≤20 ppb | ≤2 ppb | ≤10 µg/m ³ | ≤4 µg/m ³ |

¹The CAAQS values are based on a 3-year average of the annual 99th percentile of the daily-maximum 1-hour average concentrations

²The AAAQO and CAAQS values are based on the arithmetic average over a single calendar year of all 1-hour average concentrations

³The CAAQS values are based on the 3-year average of the annual 98th percentile of the daily-maximum 1-hour average concentrations

⁴The CAAQS value is a 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.

⁵The CAAQS value is the 3-year average of the annual average of the daily 24-hour average concentrations.

Table 8 shows the AQHI scale and the health messages for “at risk” individuals and the general public for each of the AQHI Health Risk Categories. “Wildfire influence removed” AQHI levels in Conklin over the 2017-2024 period were compared to these health risk criteria and levels to provide a general indication of air quality in the community relative to these health-based criteria.

Table 8: The AQHI Health Risk Levels and the Health Messaging associated with each with each Health Risk Category

| Health Risk | Air Quality Health | Health Messages | |
|-------------|--------------------|--|--|
| | | At Risk Population* | General Population |
| Low | 1-3 | Enjoy your usual outdoor activities. | Ideal air quality for outdoor activities. |
| Moderate | 4-6 | Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms. | No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation. |
| High | 7-10 | Reduce or reschedule strenuous activities outdoors. Children and the elderly should also take it easy. | Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation. |
| Very High | Above 10 | Avoid strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion. | Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation. |

* People with heart or breathing problems are at greater risk. Follow your doctor's usual advice about exercising and managing your condition.

2.3. Air Quality Criteria Comparisons

The levels of SO₂, NO₂, PM_{2.5} and PM₁₀, as measured in Conklin in the 2017-2024 period, were converted into the air quality metrics used in the Canadian Ambient Air Quality Standards (CAAQS) and in the WHO Air Quality Guidelines (WHO AQGs). When a metric involved a 3-year averaging period, only yearly numbers were determined, but this simplification has negligible relevance in terms of the comparisons made against the criteria. For the CAAQS, the measured air quality was only compared to the green and yellow management levels because these are the levels of most relevance to Conklin since Conklin’s air quality is relatively good and the “green” and “yellow” management levels provide a better and more relevant air quality management indicator. The WHO AQGs, which are strictly health risk-based, are very relevant in terms of understanding the risk levels associated with current SO₂, NO₂, PM_{2.5} and PM₁₀ levels in Conklin. The Alberta Ambient Air Quality Objectives were not used, except for PAHs, since these objectives are largely focused on fenceline-level emissions management and they are much higher than current ambient air quality levels. Therefore, the objectives are not relevant in the context of considering air quality management priorities.

Monthly dustfall levels collected by WBEA in Conklin over the November 2022 to October 2024 period were also evaluated in relation to Alberta’s Ambient Air Quality Guideline for dustfall in residential and recreational areas. The approaches used to assess odour potential and to calculate AQHI levels are noted in the two sections on these parameters (Sections 2.4 and 2.5 respectively).

2.3.1 Ambient Air Quality NO₂ Levels in Conklin Relative to NO₂ Air Quality Criteria

NO₂ is a parameter with several potential health and environmental impacts. Both the WHO and the CAAQS have annual and daily NO₂ criteria. NO₂ data for the 2017-2024 period at Conklin was compared to these daily and annual criteria, with the results of the analysis shown in **Figure 2**, **Figure 3** and **Figure 4**.

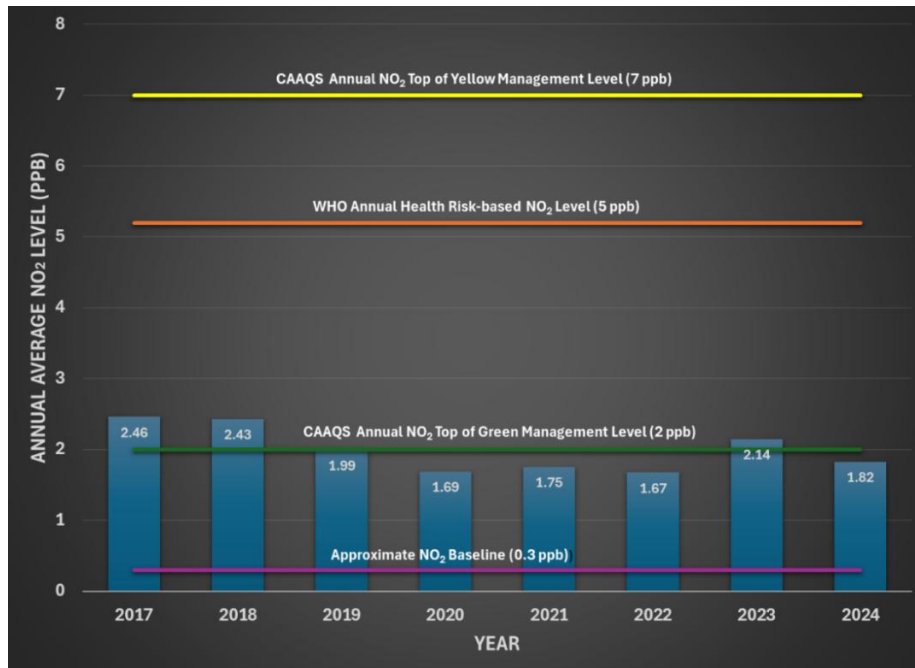


Figure 2: Annual Average NO₂ Levels in Conklin compared to the Top of the CAAQS Green and Yellow Management Levels and compared to the WHO Health-based Criteria (2017-2024 period)

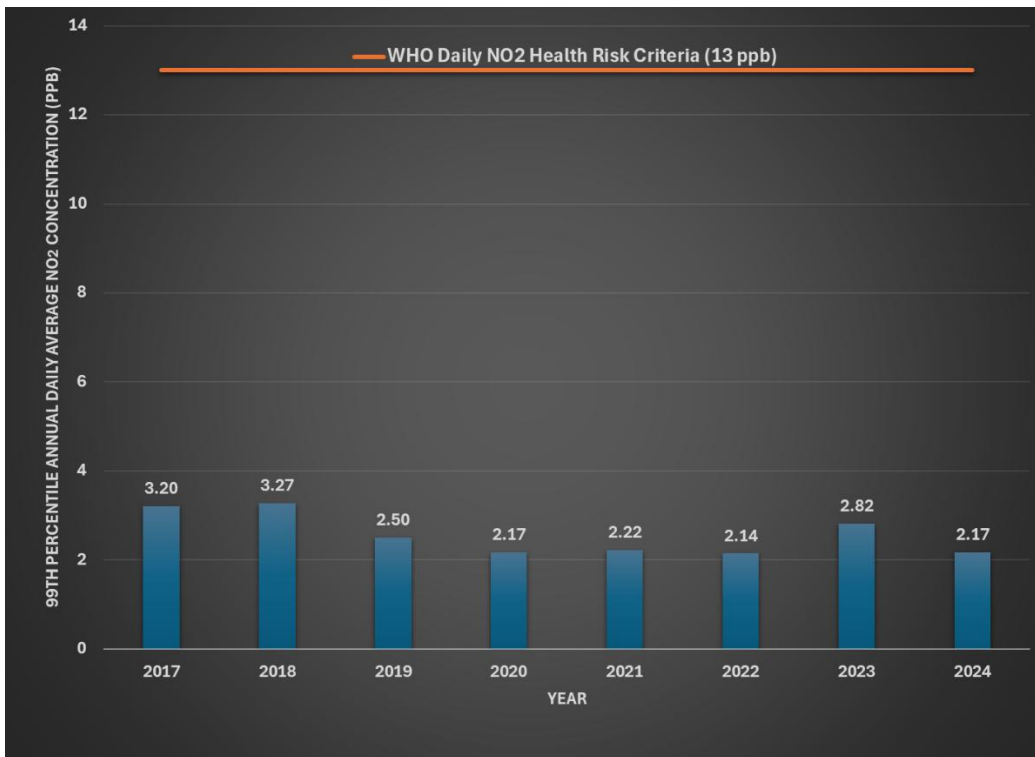


Figure 3: Daily WHO Metric NO₂ Levels in Conklin compared to the Daily WHO Health-based Criteria (2017-2024 period)

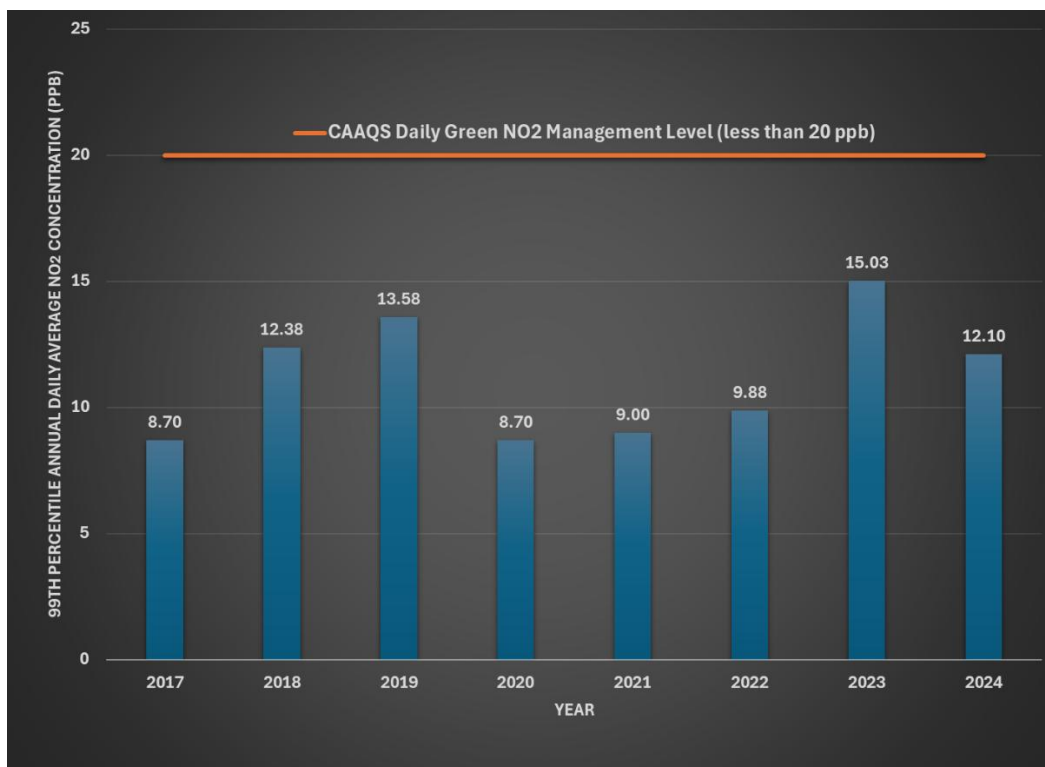


Figure 4: Daily CAAQS Metric NO₂ Levels in Conklin compared to the top of the CAAQS Daily Metric Green Management Level (2017-2024 period)

The comparisons in *Error! Reference source not found.*, **Figure 3** and **Figure 4** indicate that the current annual and daily NO₂ levels in Conklin are well below the WHO health risk-based air quality criteria, and are in the green management level for daily NO₂ levels and fluctuate just above, or just below, the CAAQS annual green management level. This would indicate that, consistent with the CAAQS, the air quality management goal in Conklin should be “to maintain good air quality through proactive air management to Keep Clean Areas Clean” (See

Table 7). As **Figure 2** shows, the current annual average NO₂ levels are well above the estimated annual background NO₂ level of 0.3 ppb. This reflects the relative significance and contribution of the NO_x emission sources associated with human, non-industry related activities to ambient NO₂ levels in Conklin.

2.3.2 Ambient Air Quality SO₂ Levels in Conklin Relative to SO₂ Air Quality Criteria

SO₂ can impact both human health and the environment, with environmental effects being more relevant at lower concentrations. Sources of SO₂ emissions are predominantly anthropogenic (i.e. there are few natural SO₂ sources), therefore ambient SO₂ levels usually indicate specific source influences, including oil sands operations as noted in **Table 12**. The WHO sets daily SO₂ criteria, and the CAAQS have annual and daily criteria. **Figure 5**, **Figure 6** and **Figure 7** present the analysis of SO₂ data from Conklin (2017-2024) compared to these criteria. These figures indicate that, while ambient SO₂ levels in Conklin are far below the CAAQS green management levels (for both the annual and daily metrics), and far below the WHO AQG, the ambient annual SO₂ average is approximately triple that of the baseline level since the baseline for SO₂ is very low.



Figure 5: Annual Average SO₂ Levels in Conklin compared to the Top of the CAAQS Green and Yellow Management Levels (2017-2024 period)

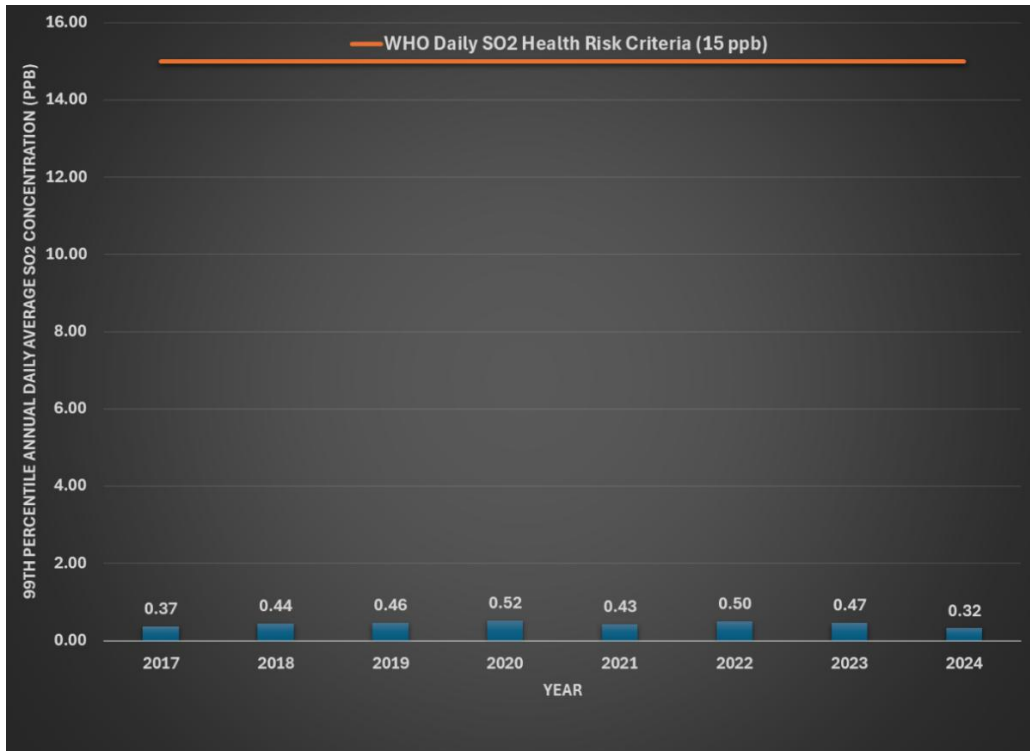


Figure 6: Daily WHO Metric SO₂ Levels in Conklin compared to the WHO Health-based Criteria (2017-2024 period)

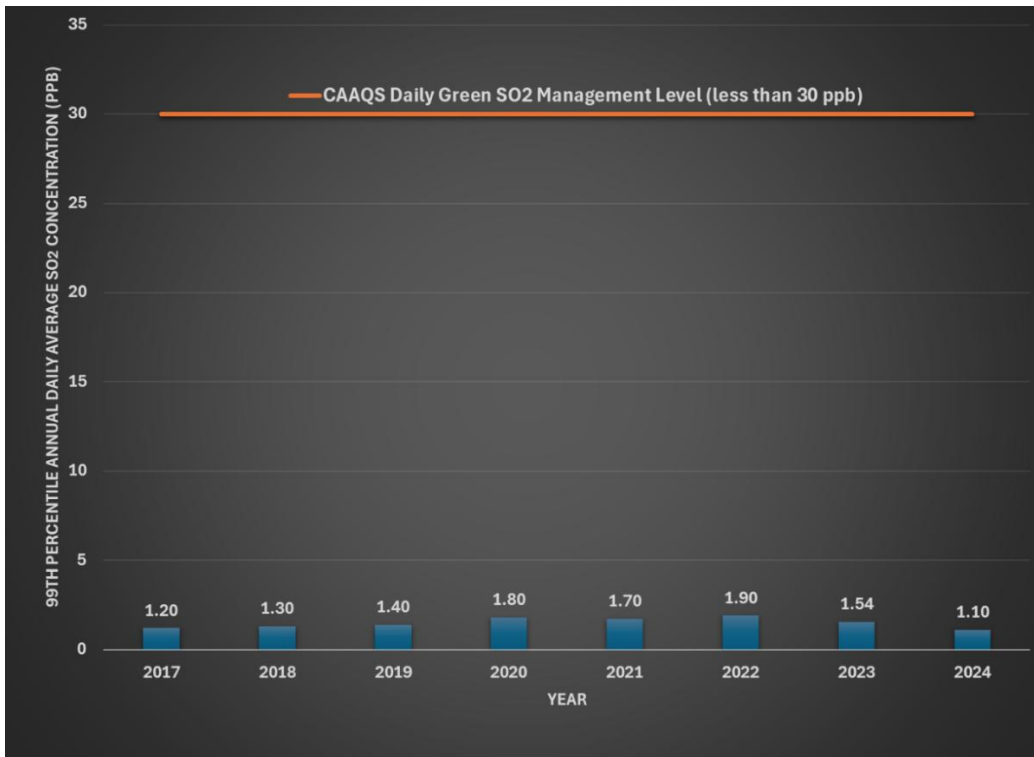


Figure 7: Daily CAAQS Metric SO₂ Levels in Conklin compared to the top of the CAAQS Daily Metric Green Management Level (2017-2024 period)

2.3.3 Ambient Air Quality PM_{2.5} Levels in Conklin Relative to PM_{2.5} Air Quality Criteria

PM_{2.5} is a parameter with several potential health impacts. Both the WHO and the CAAQS have annual and daily PM_{2.5} criteria. Ambient PM_{2.5} levels can also be significantly affected by wildfire influences. Therefore, when comparing measured ambient PM_{2.5} levels against criteria, the common approach is to remove the wildfire influences. This allows the impact of local and regional PM_{2.5} sources to be assessed, since these are the PM_{2.5} source influences that may be reduced through specific emission source management actions. PM_{2.5} data for the 2017-2024 period at Conklin was compared to these daily and annual criteria with the results of the analysis shown in **Figure 8**, **Figure 9** and **Figure 10**. The approach used to remove wildfire influences was to remove all hourly PM_{2.5} readings above 25 µg/m³ (see Section 1.3). A general review of the 2017-2024 PM_{2.5} dataset for Conklin indicated that there may be wildfire influences associated with PM_{2.5} levels of less than 25 µg/m³, and therefore the non-wildfire influenced PM_{2.5} levels may be slightly lower than the values shown in **Figure 8**, **Figure 9** and **Figure 10**.

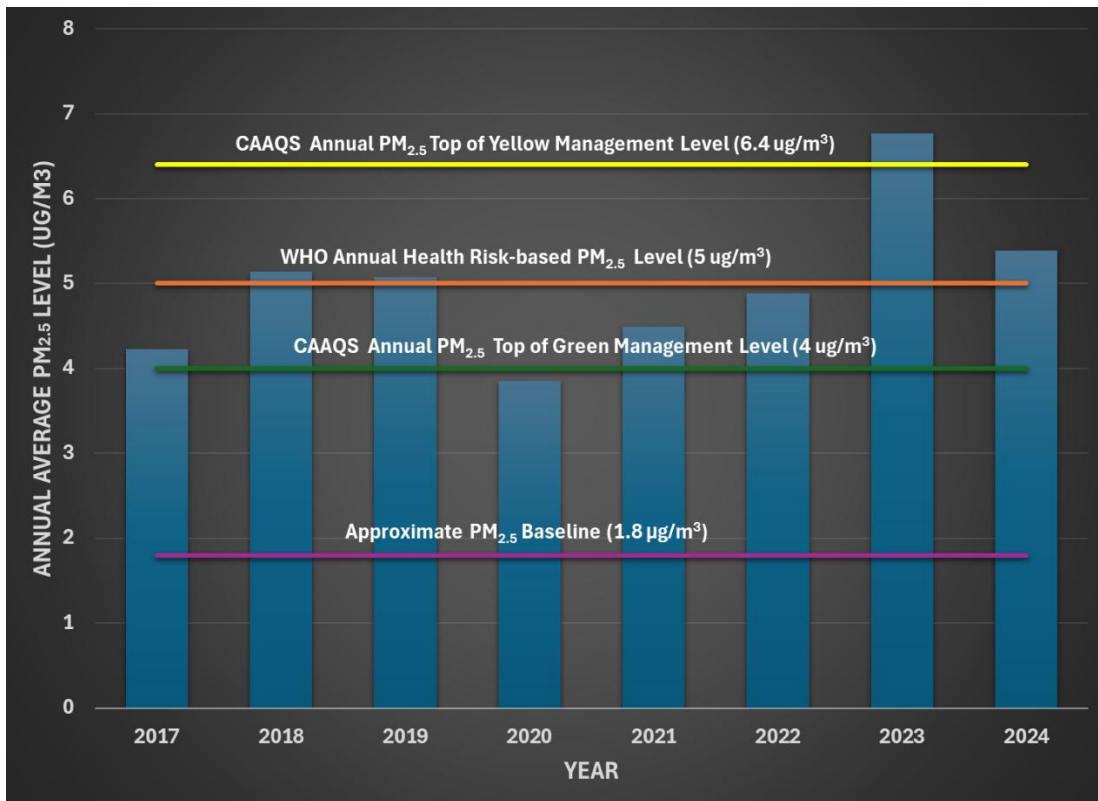


Figure 8: Annual Average PM_{2.5} Levels in Conklin compared to the Top of the CAAQS Green and Yellow Management Levels and the WHO Annual PM_{2.5} Criteria (2017-2024 period) (Wildfire Influences Removed)

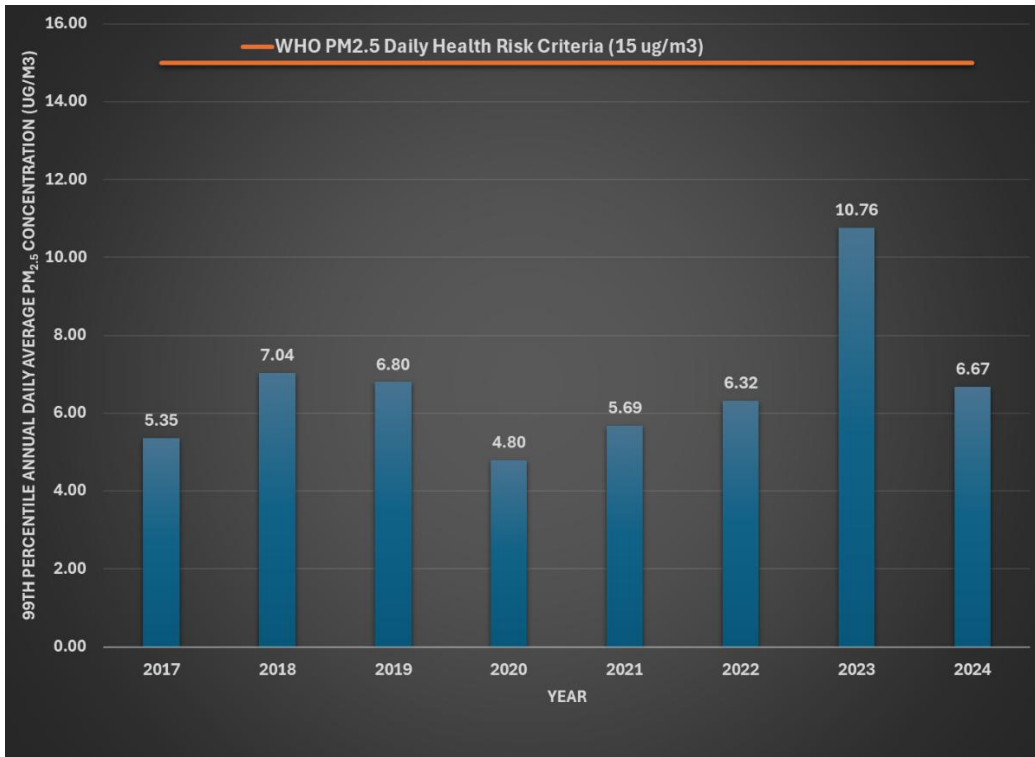


Figure 9: Daily WHO Metric PM_{2.5} Levels in Conklin compared to the WHO Health-based Criteria (2017-2024 period) (Wildfire Influences Removed)

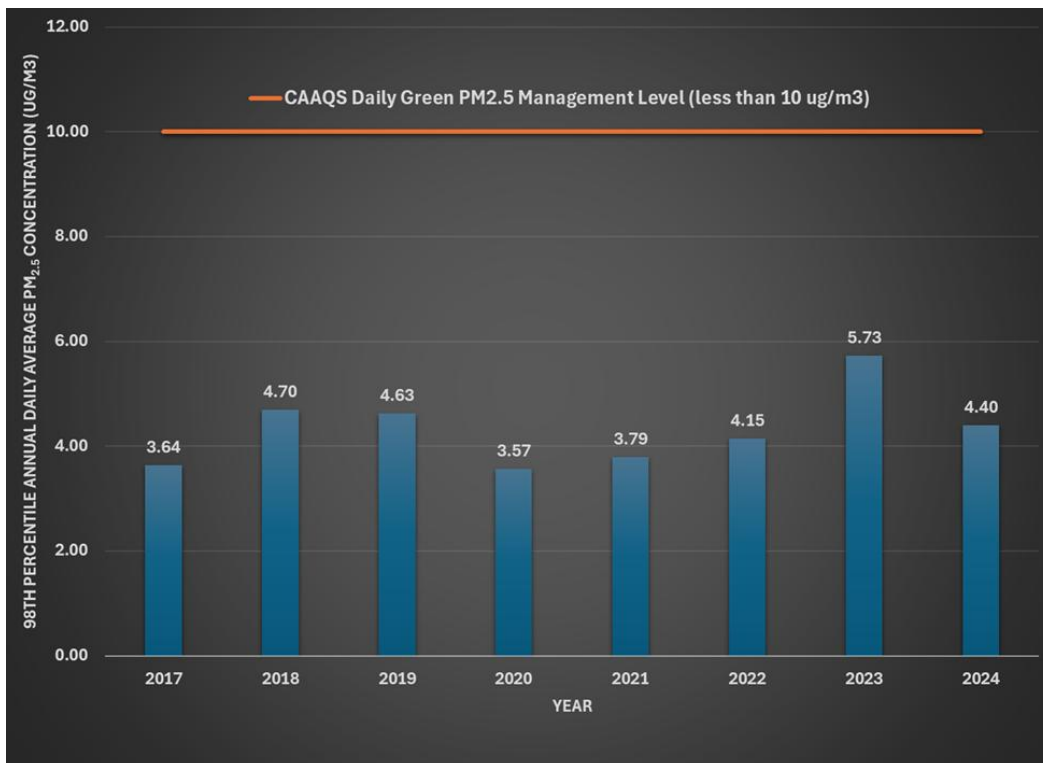


Figure 10: Daily CAAQS Metric PM_{2.5} Levels in Conklin compared to the top of the CAAQS Daily Metric Green Management Level (2017-2024 period) (Wildfire Influences Removed)

The comparisons in **Figure 8**, **Figure 9** and **Figure 10**, indicate that the current daily $PM_{2.5}$ levels in Conklin are well below the WHO health risk-based air quality criteria and are in the CAAQS green management level for daily $PM_{2.5}$. However, the annual $PM_{2.5}$ levels are often above the CAAQS green management level and often above the WHO health risk-based annual criteria. This may, in part, be due to the limitations of the wildfire influence screening approach. The results would indicate, however, that in terms of air quality in Conklin, $PM_{2.5}$ influences warrant further investigation. In this regard, the focus should be to manage annual $PM_{2.5}$ levels “to maintain good air quality through proactive air management to Keep Clean Areas Clean” (See

Table 7). As **Figure 8** shows, the current annual average $PM_{2.5}$ levels are approximately two to three times higher than the estimated $PM_{2.5}$ baseline of $1.5 \mu\text{g}/\text{m}^3$. This reflects the likely influence of both industrial and normal human activity-related emissions.

2.3.4 Ambient Air Quality PM_{10} Levels in Conklin Relative to PM_{10} Air Quality Criteria

PM_{10} is a parameter that has potential health impacts, although not to the same extent as $PM_{2.5}$, and is a parameter often associated with dust. The WHO has established annual and daily PM_{10} criteria based on health risks. Dust associated with PM_{10} and larger particulate matter sizes, is addressed through the dustfall criteria. PM_{10} includes $PM_{2.5}$, and both can be significantly impacted by wildfire influences. The same method used to remove wildfire influences from $PM_{2.5}$ was applied to PM_{10} , with PM_{10} values excluded from the dataset when hourly $PM_{2.5}$ levels were above $25 \mu\text{g}/\text{m}^3$. This approach allows the impact of local and regional PM_{10} sources to be assessed since these influences may be reducible through source management. PM_{10} monitoring commenced in Conklin in July 2020, therefore PM_{10} for most of 2020-2024 period in Conklin was compared to the WHO's daily and annual criteria, with the analysis results shown in **Figure 11** and **Figure 12**.

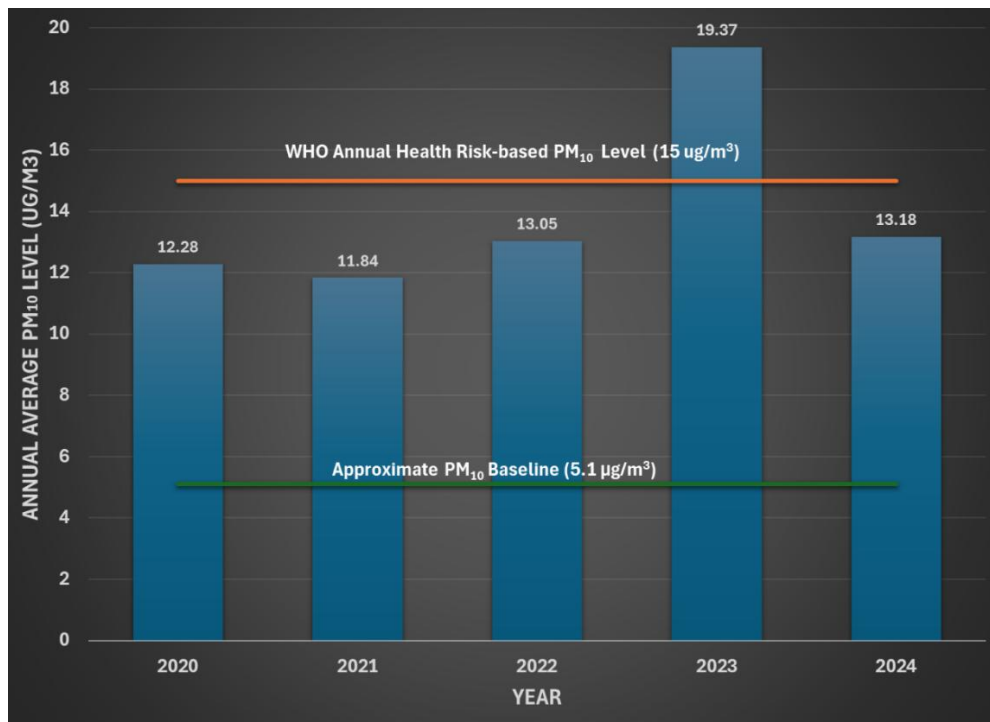


Figure 11: Annual Average PM_{10} Levels in Conklin compared to the WHO Annual PM_{10} Criteria (July 2020 to December 2024 period) (Wildfire Influences Removed)

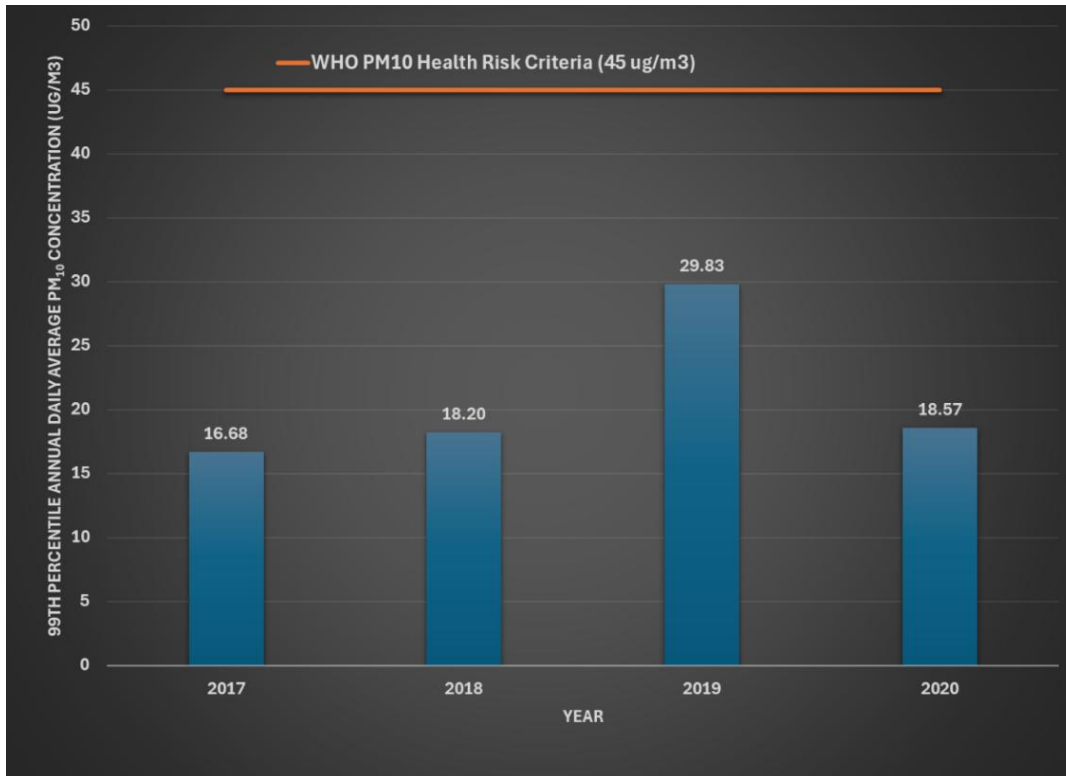


Figure 12: Daily WHO Metric PM₁₀ Levels in Conklin compared to the WHO Health-based Criteria (July 2020 to December 2024 period) (Wildfire Influences Removed)

The comparisons in **Figure 11** and **Figure 12** indicate that the current daily PM₁₀ levels in Conklin are, in general, below the WHO health risk-based air quality criteria. However, the annual PM₁₀ levels are close to, and in 2023, were above the WHO health risk-based annual criteria. This may, in part, be due to the limitations of the wildfire influence screening approach and the significant wildfire PM influences in 2023. However, it does indicate that, in terms of air quality in Conklin, and like PM_{2.5}, the influences on PM₁₀ warrant further investigation. In this regard, the focus should be on managing annual PM₁₀ levels to remain below the WHO criteria. As **Figure 11** shows, the current annual average PM₁₀ levels are approximately two to three times higher than the estimated PM₁₀ baseline of 5.1 µg/m³. As was the case for the PM_{2.5} levels, this likely reflects the influence of both industrial and normal human activity-related emissions and further highlights the possible need to investigate the sources of the PM₁₀ influences on air quality in the community.

2.3.5 Ambient Air Quality Polycyclic Aromatic Hydrocarbons (PAHs) Levels in Conklin Relative to PAH Air Quality Criteria

Alberta has Ambient Air Quality Objectives for two PAHs, naphthalene and benzo(a)pyrene. These objectives are more stringent than the recent Health Canada (2021) toxicity reference values and carcinogenic unit risk levels. Therefore, these AAAQOs were used in this comparison of measured PAH levels to PAH air quality criteria. An overall PAH carcinogenic risk estimate was also calculated using the carcinogenic unit risk factor for benzo(a)pyrene and the available relative potency factors for other PAHs

from Health Canada (2021), the California Office of Environmental Health Hazard Assessment³ and (Colins, Brown, Alexeeff, & Salmon, 1998). The measurement versus criteria analysis for PAHs was done for both the entire PAH dataset and for a dataset with wildfire influences removed, which was based on removing all days from the dataset that had a daily average PM_{2.5} level of 20 µg/m³. A daily screening threshold of 20 µg/m³ was used rather than the hourly threshold of 25 µg/m³ used for PM_{2.5} and PM₁₀ screening in the previous sections. This was done because the PAH data is based on 24-hr averages and a daily average of 25 µg/m³ PM_{2.5} will include some hourly PM_{2.5} levels above 25 µg/m³. This approach was used to estimate the impact that wildfires had on ambient naphthalene and benzo(a)pyrene levels by comparing the “wildfire influence removed” and the “with wildfire” naphthalene and benzo(a)pyrene levels. For the total PAH carcinogenic risk estimate, wildfire influences were not removed to give a total (wildfire and non-wildfire) and a non-wildfire, PAH cancer risk estimate.

Figure 13 and **Figure 14** show the annual averages of naphthalene and benzo(a)pyrene, respectively, with and without wildfire influences and the annual levels relative to the AAAQOs for these two PAHs.

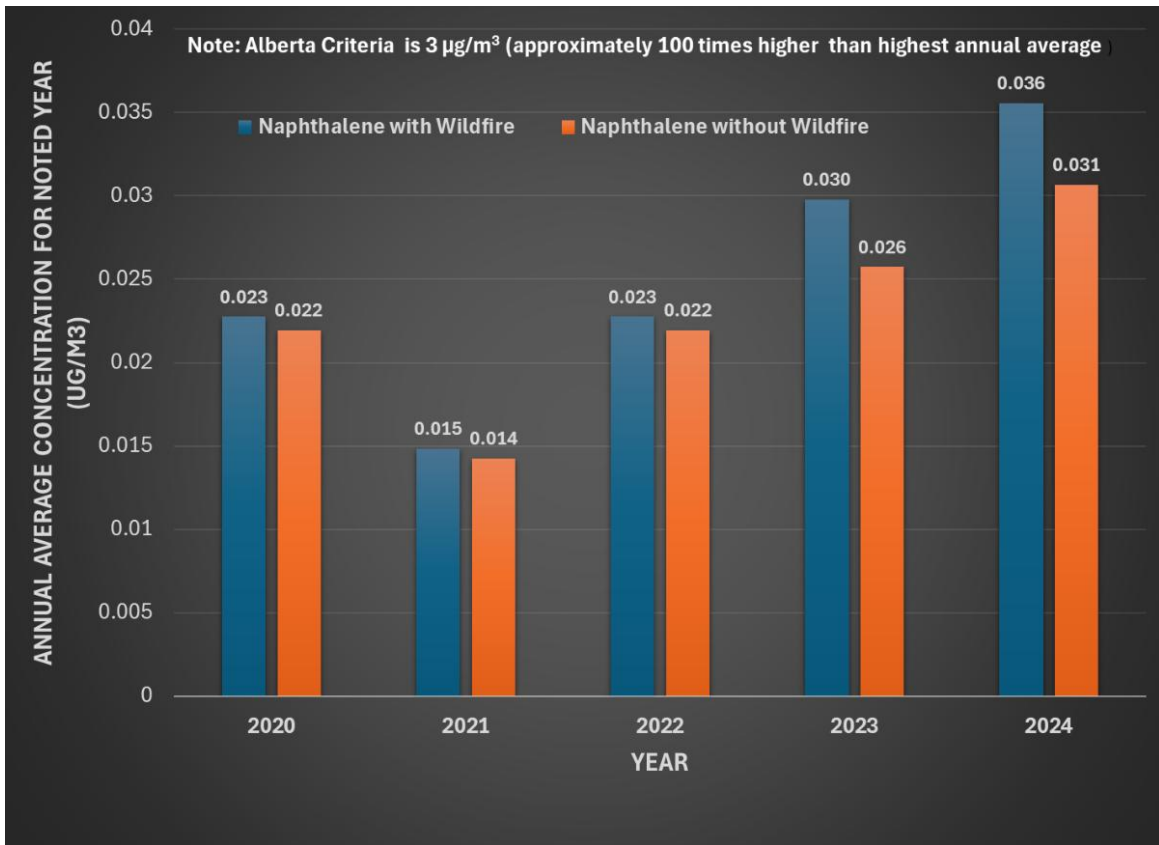


Figure 13: Wildfire and Non-Wildfire Influenced Annual Naphthalene Levels (ng/m³) in Conklin for the 2020-2024 Period

³ Guidance Manual for Preparation of Health Risk Assessments, Appendices G-J, [California PAH potency factors 2015gmappendicesgj.pdf](#)



Figure 14: Wildfire and Non-Wildfire Influenced Annual Benzo(a)pyrene Levels (ng/m³) Compared to the AAAQO for the 2020-2024 Period

The plots for benzo(a)pyrene levels in Conklin from 2020 to 2024 show that only in 2023 was there a significant difference between the wildfire included and wildfire excluded benzo(a)pyrene levels. In 2023, wildfire effects resulted in one day being above the annual limit. This indicates that, while wildfires influence benzo(a)pyrene levels, these influences are limited.

Figure 15 and **Figure 16** are box and whisker plots that illustrate, respectively, the intra-annual variability in naphthalene and benzo(a)pyrene levels in Conklin over the 2020-2024 period, both with and without wildfire influences. Notably, only in 2023 and 2024 was there a significant difference between naphthalene levels affected by wildfires, and wildfire influences removed levels, and those differences were not large. The maximum average annual naphthalene levels were approximately one hundred times lower than the annual naphthalene criteria, indicating that current naphthalene levels in Conklin should not pose a health risk concern.

Figure 14 and **Figure 16** indicate that the current annual average benzo(a)pyrene levels are similar to, or slightly above, the estimated annual background benzo(a)pyrene level of 0.03 ng/m³. This would indicate that there appear to be some, but relatively minimal, industrial and/or non-industrial influences on benzo(a)pyrene levels in Conklin.

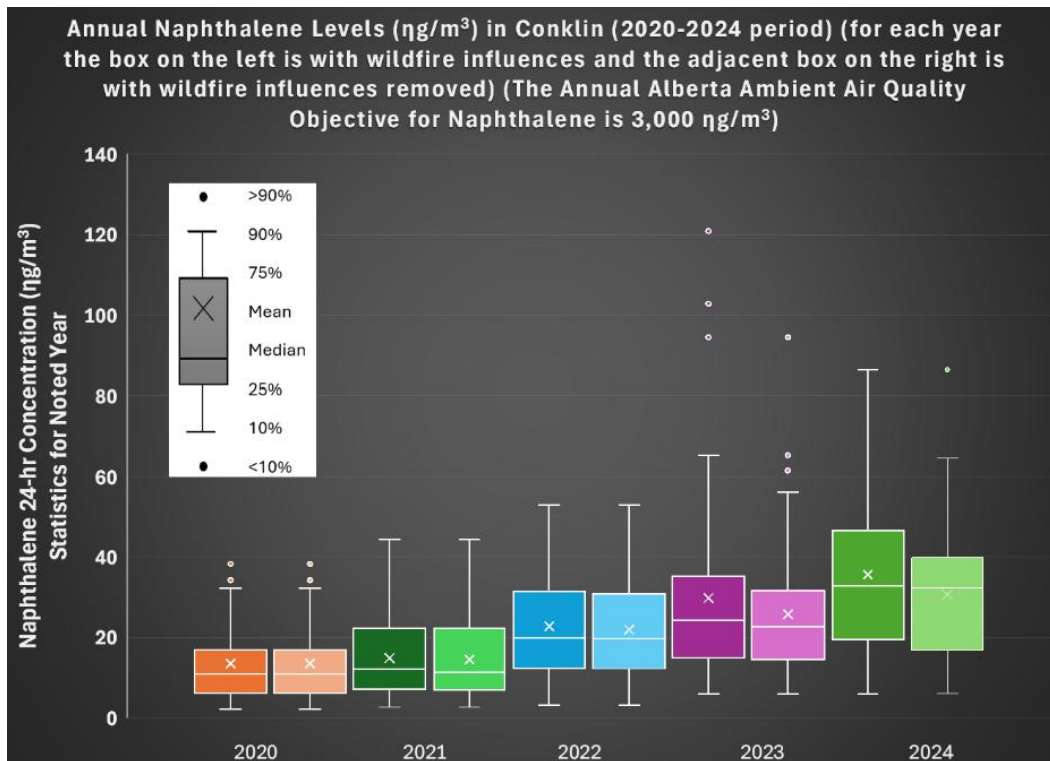


Figure 15: Box and Whisker Plots of Annual Wildfire and Non-Wildfire Influenced Annual Naphthalene Levels (ng/m^3) for the 2020-2024 Period

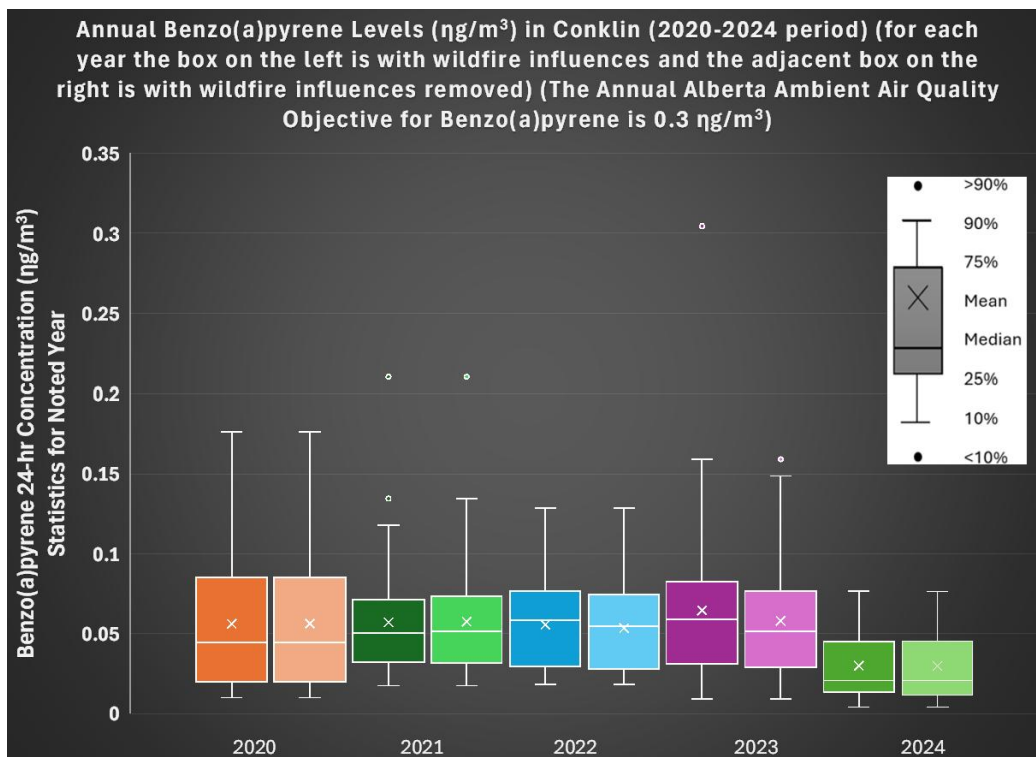


Figure 16: Box and Whisker Plot of Annual Wildfire and Non-Wildfire Influenced Annual Benzo(a)pyrene Levels (ng/m^3) for the 2020-2024 Period

Benzo(a)pyrene, and several other Polycyclic Aromatic Hydrocarbons (PAHs), are known or suspected carcinogens; therefore, minimizing PAH exposure is desirable. An assessment of the cancer risk associated with the PAHs measured in Conklin during the 2020-2024 period was conducted. The results of this assessment are summarized in **Table 9**.

Table 9: The Annual Average Concentration of each of the 23 PAHs Monitored by the WBEA (24-hr sample every 6 days), the Potency Factor of each PAH relative to Benzo(a)pyrene and the Individual and Summed PAH Cancer Risk

| PAHs Monitored by WBEA | Relative Potency Factor (RFP)* | Average Concentration (ng/m ³) in Noted Period | | | | | | Cancer Risk** |
|---|--------------------------------|--|---------|---------|---------|---------|-----------|-----------------|
| | | 2020 | 2021 | 2022 | 2023 | 2024 | 2020-2024 | |
| Naphthalene | Inadequate | 13.4677 | 14.9027 | 22.7171 | 29.7526 | 35.4422 | 23.5711 | NA |
| Acenaphthylene | Inadequate | 2.6425 | 4.1019 | 3.9724 | 3.6532 | 3.2455 | 3.6425 | NA |
| Acenaphthene | 0.001 | 4.9622 | 5.5145 | 4.3132 | 6.5556 | 8.1023 | 5.8548 | 3.51E-09 |
| Fluorene | Inadequate | 3.4087 | 3.8341 | 3.5808 | 4.6238 | 4.9082 | 4.0929 | NA |
| Phenanthrene | Inadequate | 6.1065 | 6.6685 | 5.0931 | 6.5772 | 9.8174 | 6.7510 | NA |
| Anthracene | 0.001 | 0.8118 | 1.0390 | 0.8324 | 1.1042 | 1.9718 | 1.1387 | 6.83E-10 |
| Acridine | Inadequate | 0.0125 | 0.0155 | 0.0081 | 0.0073 | 0.0065 | 0.0099 | NA |
| Fluoranthene | 0.01 | 1.0572 | 1.3126 | 1.2527 | 1.2401 | 1.1719 | 1.2265 | 7.36E-09 |
| Pyrene | 0.1 | 0.7728 | 0.9101 | 0.9421 | 0.7901 | 0.8209 | 0.8575 | 5.15E-08 |
| Benzo(c)phenanthrene | 0.01 | 0.0192 | | 0.0084 | 0.0068 | 0.0073 | 0.0107 | 6.40E-11 |
| Benz(a)anthracene | 10 | 0.1042 | 0.1922 | 0.1817 | 0.2576 | 0.2046 | 0.1965 | 1.18E-06 |
| Chrysene | 0.1 | 0.1418 | 0.2117 | 0.2342 | 0.2700 | 0.2178 | 0.2232 | 1.34E-08 |
| 7,12-Dimethylbenz(a)anthracene | 0.1 | 0.0210 | 0.0170 | 0.0080 | 0.0073 | 0.0075 | 0.0115 | 6.89E-10 |
| Benzo(b)fluoranthene | 1 | 0.0725 | 0.1558 | 0.4354 | 0.2720 | 0.2030 | 0.2466 | 1.48E-07 |
| Benzo(k)fluoranthene | 0.1 | 0.0687 | 0.1582 | 0.4351 | 0.2738 | 0.2036 | 0.2472 | 1.48E-08 |
| Benzo(a)pyrene | 0.1 | 0.0561 | 0.0571 | 0.0557 | 0.0645 | 0.0299 | 0.0537 | 3.22E-09 |
| 3-Methylcholanthrene | 1 | 0.0116 | 0.0111 | 0.0079 | 0.0058 | 0.0053 | 0.0082 | 4.90E-09 |
| Indeno(123-cd)pyrene | 0.01 | 0.0213 | 0.0247 | 0.0181 | 0.0150 | 0.0263 | 0.0207 | 1.24E-10 |
| Dibenz(a,h)anthracene | 100 | 0.0089 | 0.0092 | 0.0143 | 0.0084 | 0.0123 | 0.0107 | 6.40E-07 |
| Benzo(ghi)perylene | 1 | 0.0188 | 0.0189 | 0.0159 | 0.0113 | 0.0226 | 0.0170 | 1.02E-08 |
| Dibenzo(a,i)pyrene | 1 | 0.0059 | 0.0063 | 0.0080 | 0.0070 | 0.0049 | 0.0067 | 4.04E-09 |
| Dibenzo(a,i)pyrene | 1 | 0.0025 | 0.0032 | 0.0038 | 0.0055 | 0.0055 | 0.0040 | 2.42E-09 |
| Dibenzo(a,h)pyrene | 1 | 0.0026 | 0.0033 | 0.0036 | 0.0050 | 0.0060 | 0.0038 | 2.31E-09 |
| Total Cancer Risk | | | | | | | | 2.09E-06 |
| *Mixtures of carcinogenic PAHs are assessed using relative potency factors (RPFs), also referred to as potency equivalence factors. An RPF is the ratio of carcinogenic potential of an individual PAH relative to benzo(a)pyrene. Inadequate means that there is insufficient information to determine if the PAH is carcinogenic. | | | | | | | | |
| **Cancer risk is based a benzo(a)pyrene unit risk factor of 0.6 mg/m ³ with the individual PAH's potency factor times its concentration used to estimate its contribution to the the cancer risk associated with the total PAH exposure | | | | | | | | |

The calculated total cancer risk of the 23 PAHs being measured in Conklin is 0.56 per million, which Health Canada considers as negligible (Health Canada, 2021). However, these 23 PAHs only represent a fraction of the total polycyclic aromatic hydrocarbons and compounds that are expected to be present. This analysis indicates that naphthalene and benzo(a)pyrene are below the provincial air quality criteria and that current cumulative PAH levels do not represent a concern in terms of cancer risk levels. However, as more years of PAH data becomes available, a more comprehensive assessment of total PAC levels, cumulative exposure, and the associated health risks will be possible.

2.3.6 Dustfall Levels in Conklin Relative to Dustfall Criteria

Alberta has Ambient Air Quality Guidelines for dustfall levels in residential/recreational areas and for commercial/industrial areas (see **Table 6**). Over a two-year period (November 2022 to October 2024),

WBEA conducted dustfall monitoring at all its community stations except Fort Chipewyan. Dustfall consists of both soluble and insoluble fractions, which are combined to give total dustfall.

Figure 17 presents the results of the dustfall monitoring in Conklin, showing the fractions of total dustfall that are soluble and insoluble. There were two months, September 2023 and August 2024, when dustfall exceeded the Guideline of 53mg/100cm²-month. High PM_{2.5} and PM₁₀ levels influenced by wildfires were observed in the community during these months, which may, in part, explain the elevated dustfall levels. The estimated baseline dustfall rate of 20 mg/100cm²-month as shown in **Figure 17** is rough approximation, as background dust levels vary by environment, location, and season. The measured values in relation to this baseline show a seasonal trend with values higher in the warm weather period. The higher dustfall levels in the warm weather periods may be associated with local fugitive dust sources which also appear to be contributing to the higher PM₁₀ levels as discussed in Section 2.3.4.

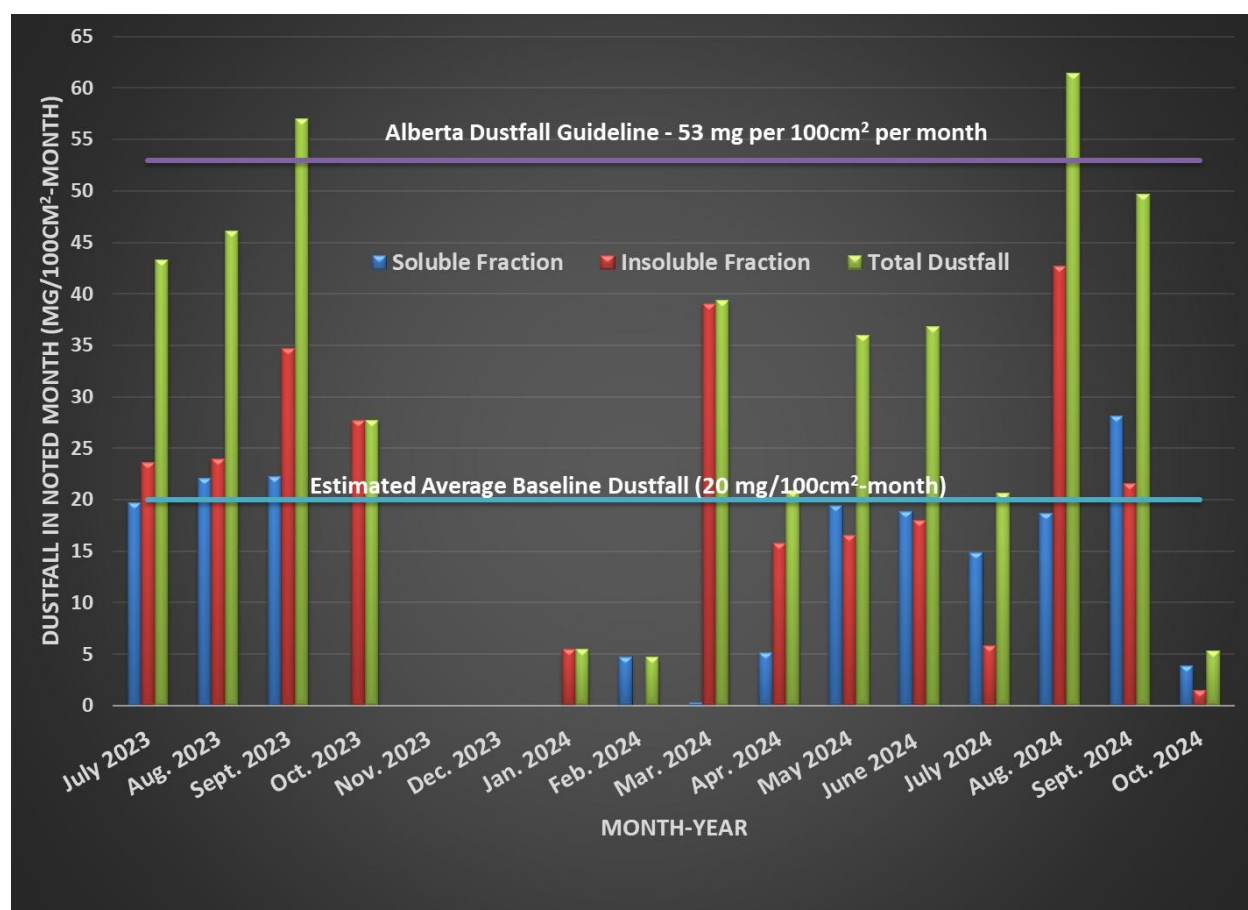


Figure 17: Monthly Dustfall Levels (mg/100cm²-month) in Conklin (November 2022 to October 2024 Period)

Figure 18 is a plot of the distribution of PM_{2.5}/PM₁₀ ratios with wildfire event PM data removed. PM_{2.5}/PM₁₀ ratios are used to provide an indication of the level of dust in the PM₁₀ particle size range. Low PM_{2.5}/PM₁₀ ratios indicate higher levels of dust, i.e. a higher fraction of PM_{2.5-10} particles that are termed “coarse” particles and which are generally associated with dust sources. **Figure 18** has an inset that is based on a study in China (Fan, Zhao, Yang, & Yang, 2021) that developed a particulate

classification system based on $PM_{2.5}/PM_{10}$ ratios. Based on this classification system, $PM_{2.5}$ and PM_{10} levels in Conklin would be classified as “atypical anthropogenic” with the peak of the histogram at $PM_{2.5}/PM_{10}$ ratio of ~ 0.75 . This indicates that particulate levels in Conklin are principally impacted by combustion-related sources which would include traffic, industrial processes/activities and residential heating. These sources are associated with greater $PM_{2.5}$ emissions thereby resulting in higher ambient $PM_{2.5}/PM_{10}$ concentration ratios. The frequent occurrence of $PM_{2.5}/PM_{10}$ ratios below 0.4 would, however, indicate some fugitive dust influence periods when the $PM_{2.5-10}$ fraction dominates the PM_{10} fraction.

The relatively large soluble fraction in the total dustfall measurement during certain months indicates possible dust sources such as road salt or limestone-based road construction materials, which imply traffic-related dust sources. The dustfall analysis suggests that, while dustfall levels in Conklin are not generally elevated, there are certain dust influences that may require further investigation.

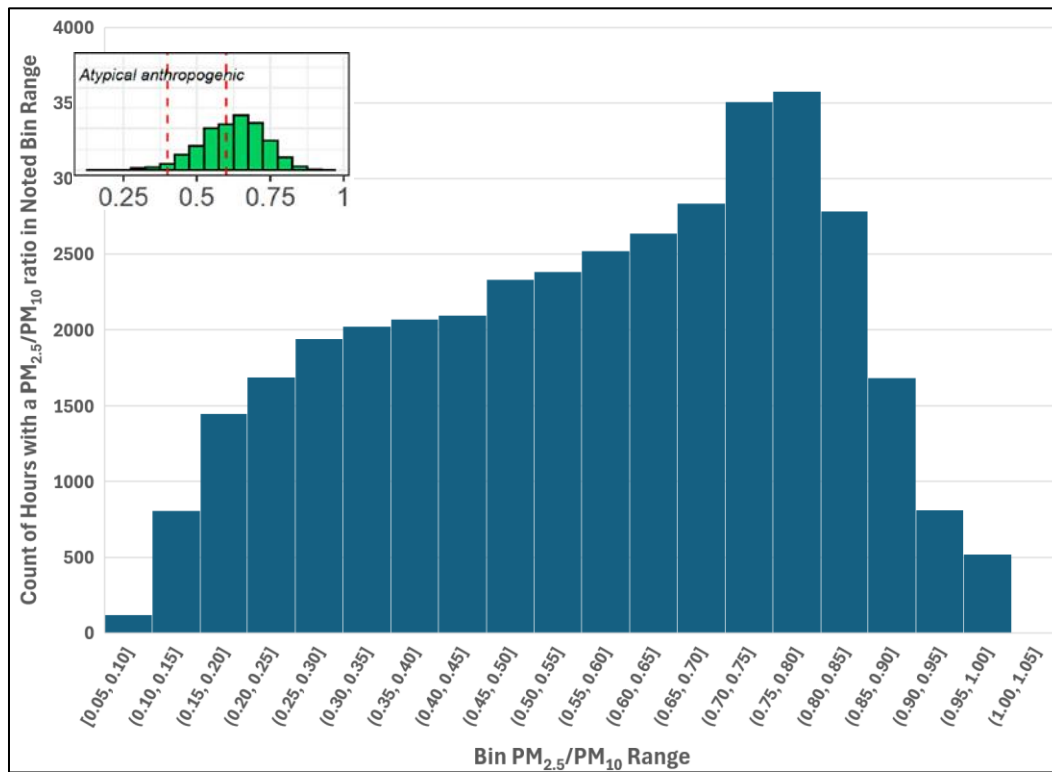


Figure 18: A Plot showing the Count of Hours when the $PM_{2.5}/PM_{10}$ Ratios in Conklin were within the Noted Bin Ranges (Wildfire Influences Removed).

2.4. Total Hydrocarbon (THC) and Total Reduced Sulphur (TRS) Levels in Conklin Relative to Fort McKay’s THC and TRS Potential/Likely Odour Criteria

THC and TRS levels in Conklin were analyzed because these two air quality measures can be used as an indicator of the potential for odours and, through the type of wind direction analysis conducted in Section 3, used to identify the possible sources of odours.

A challenge in determining the influence of industrial emissions on ambient air quality levels of THC and TRS levels is that there are natural sources of these compounds and significant global background concentrations that need to be considered when interpreting measured THC and/or TRS levels at a given location. For example, THC measurements also include methane, which has a current global background concentration of approximately 1.93 ppm (Lan, Thoning, & Dlugokencky, 2025) . Similarly, TRS measurements include some natural background carbonyl sulphide and carbon disulphide (McQuaker, Ragala, & Pengilly, 1986; Rinsland, et al., 2002; Montzka, et al., 2007).

Based on the authors’ analysis of THC and TRS levels in Fort McKay as part of a baseline development project, background levels of TRS in Fort McKay were estimated to be in the 0.3-0.4 ppb range and for THC in the 1.9 to 2.0 ppm range.

To understand the levels of TRS and THC relative to approximate background levels, hourly TRS and THC levels in Conklin over the 2017-2024 period were analyzed. **Table 10** is a statistical summary of the findings from this analysis.

Table 10: Summary statistics for the Hourly TRS and THC Measurements in Conklin for the 2017-2024 Period (Percentile values indicate the percent of total hourly values that are below the noted concentration)

| Parameter | Year | Percentile | | | | | Maximum | Mean/Average | Std Dev. |
|-----------------------------------|------|------------|------|------|------|------|---------|--------------|----------|
| | | 25th | 50th | 75th | 90th | 95th | | | |
| Total Reduced Sulphur (TRS) (ppb) | 2017 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.8 | 0.34 | 0.062 |
| | 2018 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.8 | 0.34 | 0.065 |
| | 2019 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 1.1 | 0.33 | 0.071 |
| | 2020 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 1.2 | 0.35 | 0.066 |
| | 2021 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 1 | 0.38 | 0.077 |
| | 2022 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.8 | 0.38 | 0.070 |
| | 2023 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 4.1 | 0.39 | 0.081 |
| | 2024 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 1.3 | 0.29 | 0.136 |
| Total Hydrocarbon (THC) (ppm) | 2017 | 1.9 | 1.9 | 2 | 2.1 | 2.2 | 3.7 | 1.96 | 0.137 |
| | 2018 | 2 | 2 | 2.1 | 2.1 | 2.2 | 3.1 | 2.02 | 0.114 |
| | 2019 | 1.9 | 2 | 2.1 | 2.2 | 2.2 | 4.1 | 2.02 | 0.136 |
| | 2020 | 2 | 2 | 2.1 | 2.2 | 2.2 | 3.5 | 2.06 | 0.117 |
| | 2021 | 2 | 2 | 2.1 | 2.2 | 2.3 | 3.3 | 2.05 | 0.125 |
| | 2022 | 2 | 2.1 | 2.1 | 2.2 | 2.3 | 3.9 | 2.11 | 0.140 |
| | 2023 | 2 | 2.1 | 2.1 | 2.2 | 2.3 | 4.3 | 2.11 | 0.130 |
| | 2024 | 2 | 2 | 2.1 | 2.2 | 2.3 | 2.9 | 2.05 | 0.136 |

Histograms of the hourly TRS (**Figure 19**) and THC (**Figure 20**) levels were also generated to give graphical depiction of the frequency-distribution of hourly TRS and THC levels in Conklin over the 2017-2024 period. Using Fort McKay’s TRS and THC odour potential criteria (see Appendix 2) and the data in **Table 10**, and in **Figure 19** and **Figure 20**, odours in Conklin would be expected to occur infrequently and, when they do occur, not be particularly intense. However, since TRS and THC measurements do not provide information on the specific compounds being measured, and since the odour thresholds for individual compounds within the THC and TRS groups vary significantly, the results from the above analysis only provide a general indication of odour potential.

If odours are an air quality issue and/or concern, there are several approaches that can be used to understand the nature and type of sources contributing to odours at a location. The Fort McKay Metis Nation is currently undertaking an ICBM Odour project in Fort McKay. The Fort McKay First Nation has

been conducting odour-related monitoring and analysis (see Appendix 2) for approximately 20 years so there is considerable Indigenous experience with oil sands-related odour issues that other Indigenous communities can use in terms of establishing an odour-based air quality indicator. As noted previously, odour-based air quality indicators require being able to link measured air quality parameters to community members' experience. In this regard, the WBEA Community Odour Monitoring Program (COMP) has an app for mobile devices that makes odour observation reporting very simple and quick. This type of sensory-based observation data, combined with continuous ambient air quality measurements allows for the possible identification of linkages between ambient air quality data and odour events. This type of indicator requires community feedback and reporting of odour episodes. Since submission through the COMP app is voluntary, inconsistent usership and reporting can significantly limit the size of the dataset available. In this regard, the Fort McKay Métis Nation-led an ICBM Odour project that has successfully collected a sizeable odour-related dataset since its initiation in August 2022. The project has dedicated odour monitors that are assigned to conduct routine monitoring in the community. Other Indigenous communities can consider routine monitoring if odour is an air quality indicator of interest and/or frequent odor issues are experienced in the community.

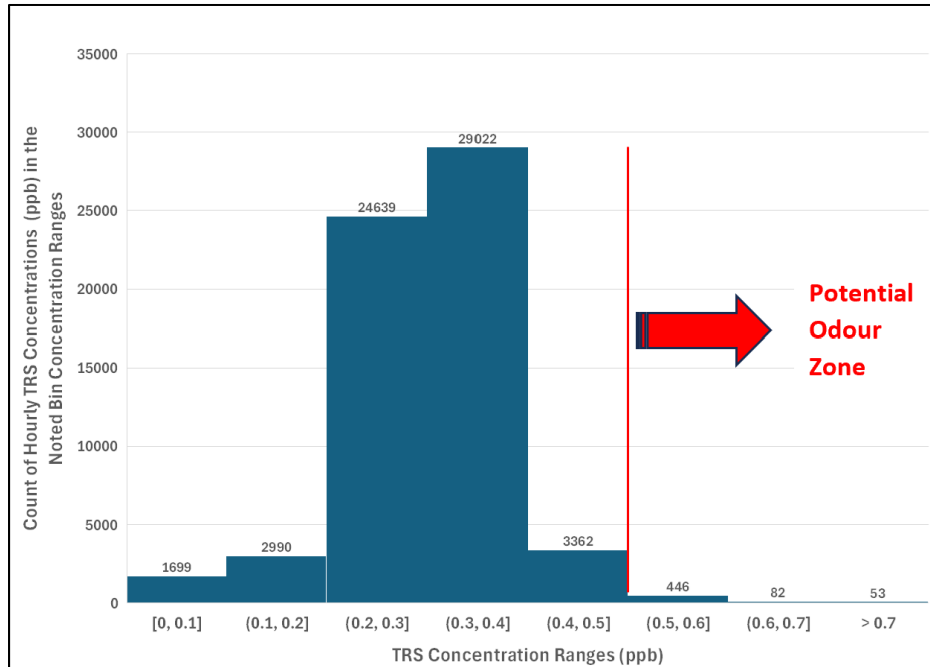


Figure 19: The Count of Hourly Total Reduced Sulphur (TRS) Concentrations (ppb) in Conklin in the 2017-2024 Period within each of the Noted Bin Width Concentration Ranges (Note: The “RED” line shows the TRS levels that might start to result in detectable odours based on studies in Fort McKay)

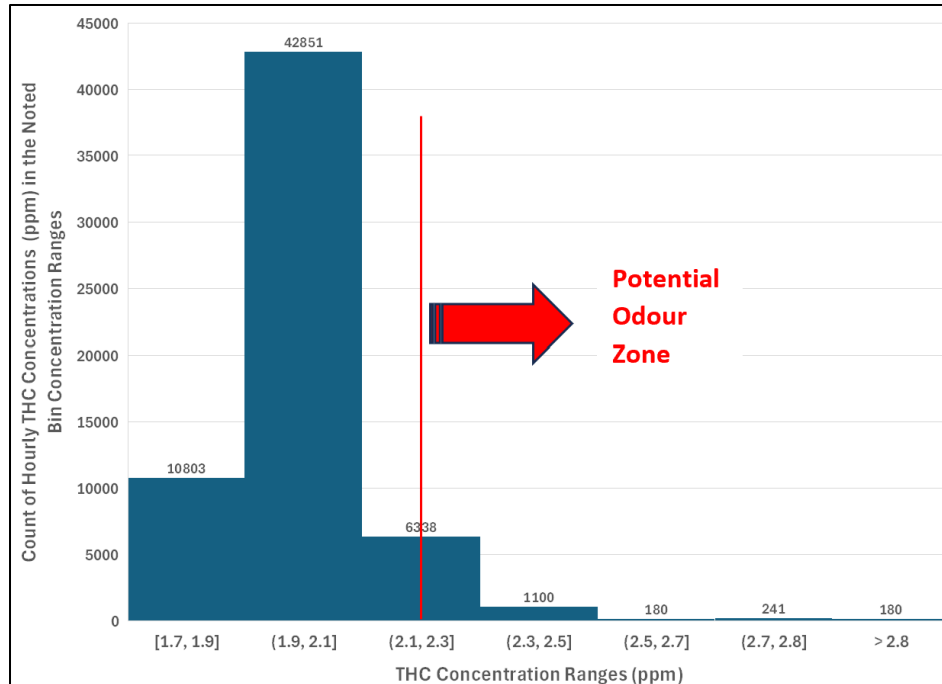


Figure 20: The Count of Hourly Total Hydrocarbon (THC) Concentrations (ppm) in Conklin in the 2017-2024 Period within each of the Noted Bin Width Concentration Ranges (Note: The “RED” line shows the THC levels that might start to result in detectable odours based on studies in Fort McKay)

2.5. Air Quality and Health – The Air Quality Health Index (AQHI)

As noted in Section 1, the potential health implications associated with oil sands development air emissions are an inherent and understandable air pollution concern to Indigenous communities.

While health-based air quality criteria can be used to assess air quality-related impacts on a parameter-by-parameter basis, the cumulative effect of exposure to many different air pollutants, with different effects, is very difficult to determine or assess. For some groups of air quality parameters, an attempt has been made to estimate the risk associated with the cumulative parameter exposures. The cancer risk associated with air-borne PAH exposures in Conklin, as outlined in Section 2.3.5, is an example of a multi-pollutant air pollutant risk assessment.

The Air Quality Health Index (AQHI) (Stieb, Doiron, Blagden, & Burnett, 2005) is a health-based metric which considers the short-term cumulative health impacts of ambient air quality levels of PM_{2.5}, NO₂, and O₃. These are three common air pollutants, each with potentially significant health impacts, and which are relevant in terms of oil sands development emissions and impacts. A study examining emergency department (ED) visits in Edmonton in relation to AQHI levels concluded that: “Our finding that ED visits for stroke were significantly associated with the AQHI suggests that the AQHI may be a valid communication tool for air pollution morbidity effects related to stroke.” (Chen, Villeneuve, Rowe, Liu, & Stieb, 2014).

In terms of assessing the short-term air pollution health risk for pollutants that are always present in ambient air at some level, and which are relevant in terms of oil sands influences, the AQHI is an excellent health-risk indicator.

To understand the AQHI levels in Conklin, hourly NO₂, O₃ and PM_{2.5} were converted to AQHI values. Although AQHI values are based on three-hour rolling averages of NO₂, O₃ and PM_{2.5} values, the hour-by-hour method gives a very close approximation of the three-hour AQHI levels and facilitates AQHI determination. A statistical summary of the year-by-year analysis of the 1-hr calculated AQHI values is shown in **Table 11**.

Table 11: Summary Statistics for the Hourly AQHI Levels in Conklin for the 2017-2024 Period (Percentile values indicate the percent of total hourly values that are below the noted concentration)

| Parameter | Year | Percentile | | | | | Maximum | Mean/Average | Std Dev. |
|---------------------------------|------|------------|------|------|------|------|---------|--------------|----------|
| | | 25th | 50th | 75th | 90th | 95th | | | |
| Air Quality Health Index (AQHI) | 2017 | 1.70 | 2.09 | 2.42 | 2.74 | 2.95 | 4.75 | 2.05 | 0.579 |
| | 2018 | 1.51 | 1.95 | 2.41 | 2.91 | 3.20 | 4.78 | 1.98 | 0.699 |
| | 2019 | 1.49 | 1.92 | 2.30 | 2.65 | 2.88 | 4.35 | 1.90 | 0.610 |
| | 2020 | 1.42 | 1.81 | 2.20 | 2.56 | 2.76 | 3.73 | 1.81 | 0.579 |
| | 2021 | 1.52 | 1.88 | 2.23 | 2.58 | 2.80 | 4.25 | 1.87 | 0.568 |
| | 2022 | 1.45 | 1.83 | 2.12 | 2.41 | 2.63 | 3.37 | 1.78 | 0.532 |
| | 2023 | 1.59 | 1.96 | 2.39 | 2.87 | 3.12 | 4.72 | 2.01 | 0.636 |
| | 2024 | 1.44 | 1.84 | 2.22 | 2.57 | 2.83 | 4.18 | 1.84 | 0.589 |

Figure 21 is a histogram of the hourly AQHI values to give graphical depiction of the frequency-distribution of the non-wildfire influenced hourly AQHI levels in Conklin over the 2017-2024 period. Collectively, the data in **Table 11** and **Figure 21**, indicate that air quality in Conklin is very good in terms of the potential short-term health risks associated PM_{2.5}, NO₂ and O₃ during non-wildfire influenced periods.

Pollution rose plots of AQHI were generated to provide an indication of how the wind directions influence AQHI levels (**Figure 22**). **Figure 23** shows the dominant wind directions when the AQHI is above 3 (note: an AQI value of 4 is reported when the AQHI value is above 3.5).

This type of analysis clearly indicates that higher AQHI values in Conklin are associated with SSE to SW wind directions. A Google Earth overlay of AQHI values of greater than 3.5 was generated (**Figure 24**) to provide an indication of what, if any, oil sands operations might be contributing to these somewhat higher than normal AQHI levels.

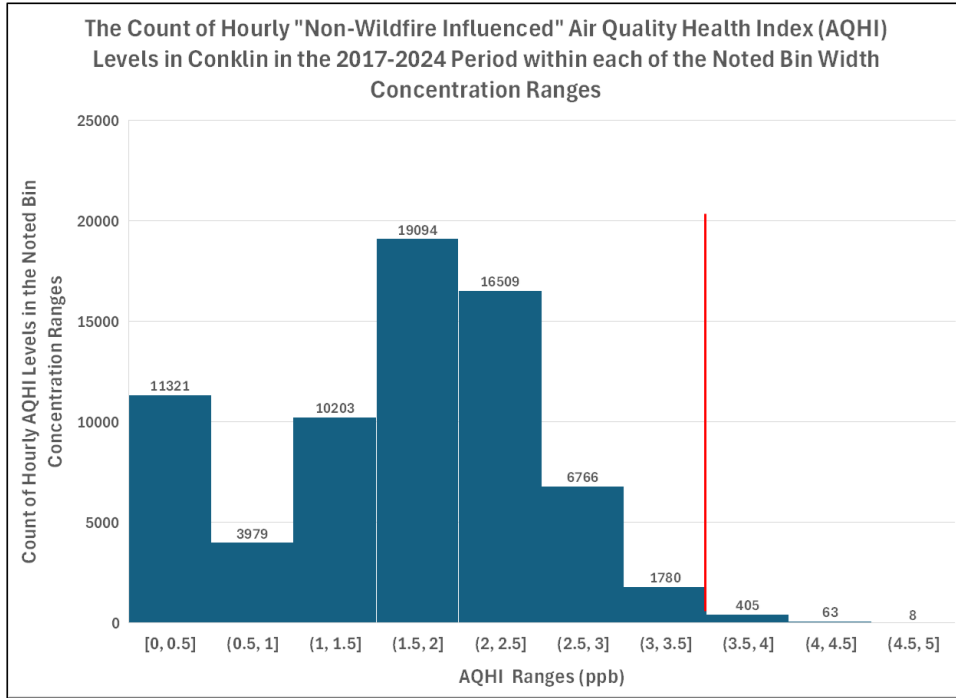


Figure 21: The Count of "Non-Wildfire Influenced" Hourly AQHI Levels in Conklin in the 2017-2024 Period within each of the Noted Bin Width Concentration Ranges (Note: The "RED" line shows the AQHI levels above which there are potential risk implications to "at risk" individuals)

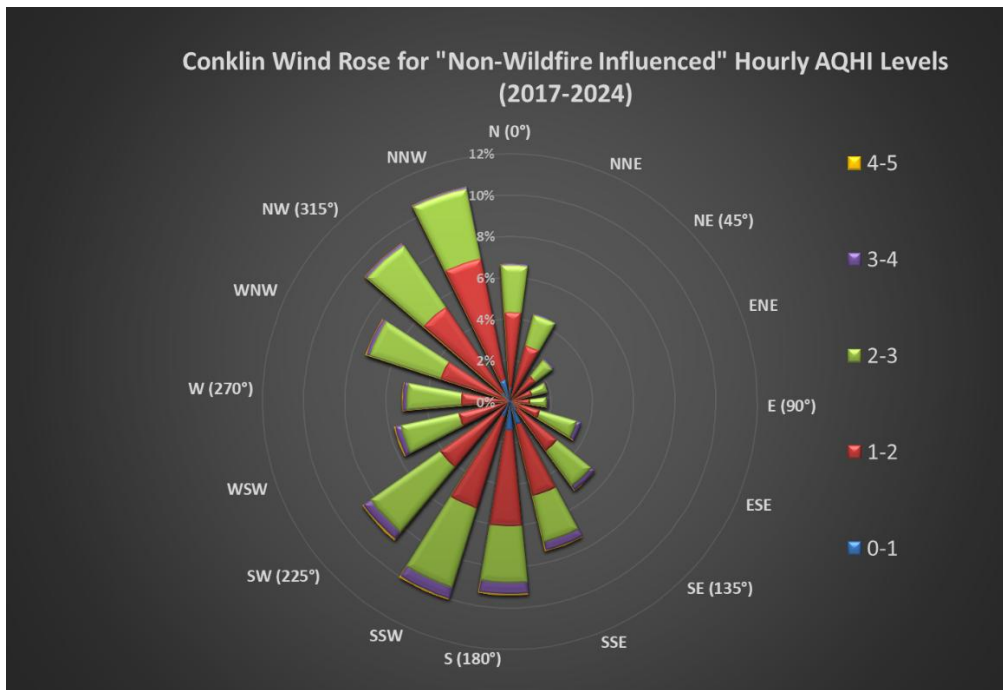


Figure 22: Pollution "Non-Wildfire Influenced" Hourly AQHI Wind Rose for Conklin for the 2017-2024 Period (Note: the % values shown on this plot reflect the % of time the wind is from the noted wind direction)

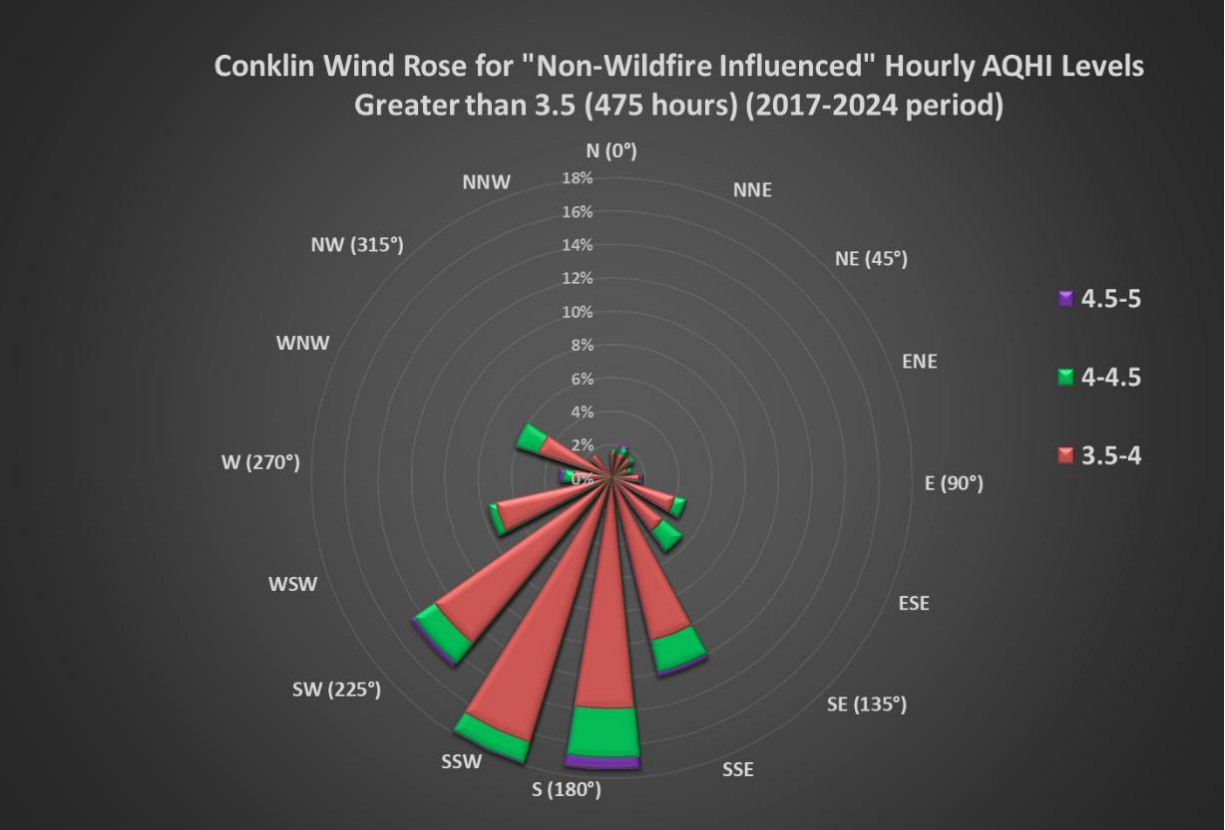


Figure 23: Pollution "Non-Wildfire Influenced" Hourly AQHI Wind Rose for Conklin for the 2017-2024 Period (Note: the % values shown on this plot reflect the % of time the wind is from the noted wind direction when only considering AQHI values above 3.5)

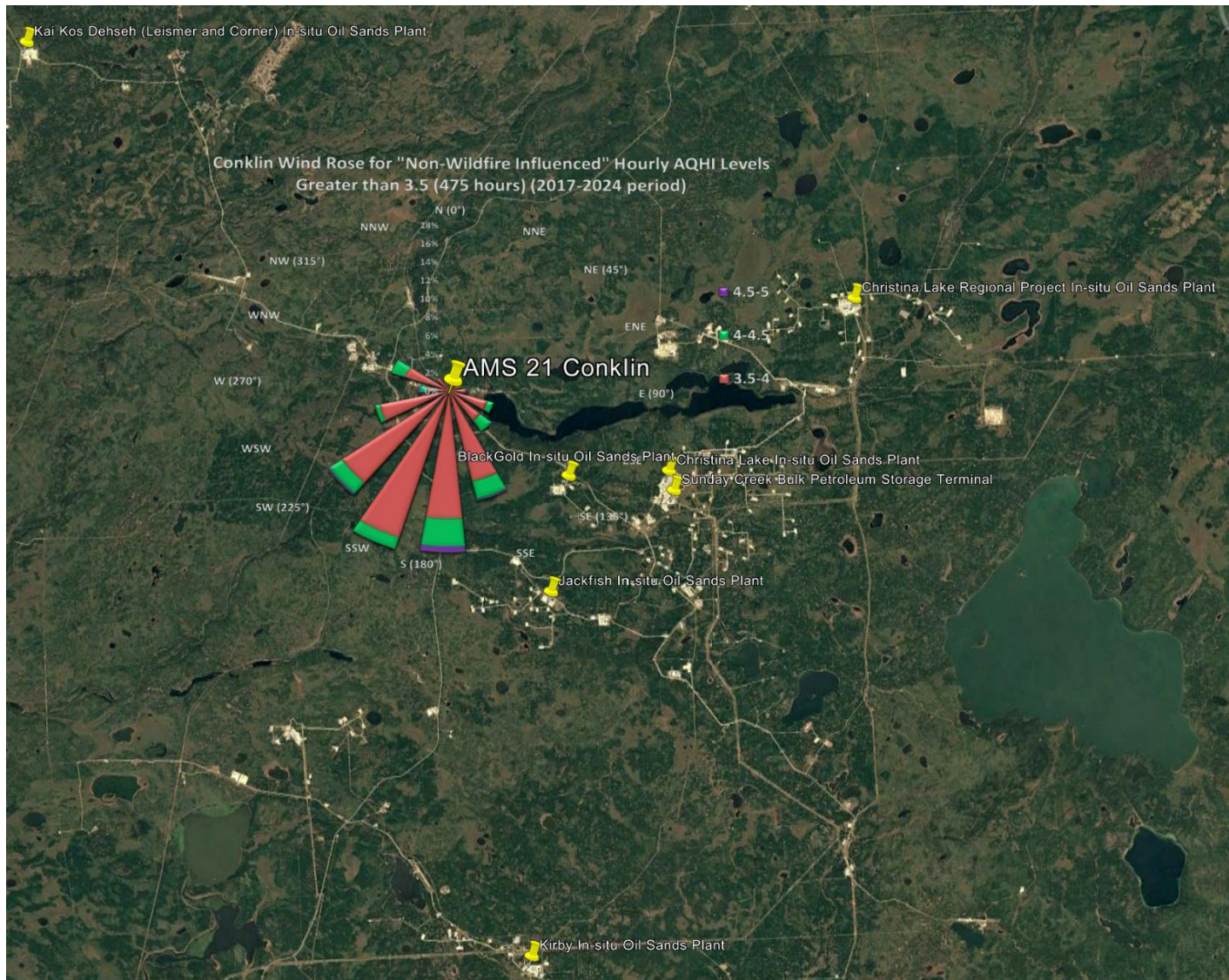


Figure 24: A Google Map Overlay of the Pollution Rose for Hourly SO₂ Levels above 3 ppb in Conklin in the 2017-2024 Period depicted in Figure 23

2.6. Established Air Quality Criteria Analysis Summary

The analysis of air quality in Conklin for SO₂, NO₂, PM₁₀, PM_{2.5}, PAHs, dustfall, TRS/THC and AQHI relative to different air quality criteria would indicate that:

- In general, air quality in Conklin is very good relative to health risk and “clean air” criteria and therefore air quality criteria and management goals for the Community should be based on maintaining this good air quality;
- Established and defensible air quality criteria exist that the Community can use to establish “keeping clean area clean” and low “health risk” air quality criteria;
- PM_{2.5} and PM₁₀ are two air quality parameters that appear to warrant further analysis in terms of source management, including both oil sands related or possibly local emissions;
- The significance of odour and dustfall as potential issues that require indicators/criteria could not be determined based on existing data and further discussion with the community and work on these issues appears warranted; and
- In terms of health risks associated with current air quality in Conklin, the AQHI data, air quality relative to WHO health risk-based air quality criteria for SO₂, NO₂, PM₁₀, PM_{2.5} and the relatively low levels of the 23 PAHs considered, collectively would indicate that the current health risk associated with air quality appears to be very low. However, as noted above, PM_{2.5} and PM₁₀ sources and levels warrant additional analysis and possibly source management. A more comprehensive assessment to confirm the cumulative exposure and health risks associated with all PAHs and PACs will be possible as more monitoring data becomes available.

3 The Influence of Wind Direction on Air Pollutant Levels in Conklin

3.1. Introduction

It is important to understand the factors affecting air quality at a given location or in an area. Understanding the nature and magnitude of air emission sources in an area is necessary to ensure appropriate air quality monitoring is in place to assess the impacts of these emission sources. This understanding also helps identify the emission sources that are having, or may have, the greatest impact on air quality at the location of interest and which are therefore a priority for air emission management. Some of this information can be obtained by relating air quality levels to wind direction and information and data on emission source locations and their emission rates. In the context of Conklin, and the location of related oil sands developments, the analysis in this section is intended to demonstrate how an assessment of the location, magnitude and nature of emissions in conjunction with wind direction data can be used to show how different oil sands developments might be impacting the community's air quality.

In this analysis, the levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Conklin were assessed as function of wind direction using a 16-wind direction compass. This was done using “radar” plots that show pollutant levels (in various percentiles) as a function of wind direction. For example, the 60thile plot indicates that when the wind is from the noted direction, 60% of the SO₂ levels are below that value and 40% of the levels are above the shown value. These types of plots are useful in identifying the wind direction(s) that are having the most influence on the pollutant level at the monitoring station location and therefore the possible sources contributing to these influences. In this regard, the 70+iles are of most

interest because they highlight the possible location of the source(s) having the greatest influence on the ambient concentration of that pollutant in the Community. An alternate approach to “radar” plots is “pollution roses” which provide similar information and an example of the use of “pollution roses” is included in this analysis, but the focus was on “radar” plots. **Figure 21, Figure 22 and Figure 23** in Section 2.5 relate to AQHI levels in Conklin as a function of wind direction are an example of the use of pollution roses.

3.2. Industrial Emission Sources in the Vicinity of Conklin

Using Alberta’s Emission Inventory Reporting (AEIR) system⁴, all industrial facilities reporting to the AEIR that were within a 35 km radius of the Conklin AMS were identified and are shown in **Figure 25**. These facilities all have an Environmental Protection and Enhancement Act (EPEA) Approval and therefore report their air emissions to the Alberta Emission Inventory Report (AEIR) system.

The 2022 NO_x, SO₂, PM_{2.5} and PM₁₀ emissions associated with each of the eight facilities within a 35 km radius were obtained from the AEIR and are shown in **Table 12**. Emission data for 2022 was used as it represents the most recent emission inventory data that is publicly available. The emissions presented are the total estimated annual emission, which includes emissions associated with normal operating conditions and upset conditions. It needs to be noted that emissions can vary significantly from year to year, which was observed when 2021 emissions were compared to 2022 emissions. **Table 12** also shows the distance and location from the Conklin AMS to each facility. The two nearest in-situ oil sands facilities to Conklin are the Cenovus Christina Lake Project 12.5 km to the ESE and the CNRL Jackfish project 13 km to the SSE.

(Note: In the executive summary, and introduction, it was noted that emissions modelling may not have included all the emissions associated with a facility. This was the result of the modelling defining areas (termed “polygons”) from which industrial emissions were being released and, in the case of in-situ operations, some of the polygons used did not cover the entire area from which facility emissions were occurring. The analysis in this section captures/uses all a facility’s reported emissions and “missing emissions” is therefore not an issue in the analysis and findings presented in this Section.)

This type of location and emission inventory information provides an indication of which emission sources (i.e. industrial facilities), and air pollutants, would be expected to be measured at the Conklin AMS. In this analysis, the emission data in **Table 12** was used to relate emission source location and specific parameter emission rates to the “radar” plot depictions of measured ambient concentrations. Standalone radar plots are presented for each parameter, and these plots were also overlaid onto a map similar to **Figure 25**.

As noted in the Section 3.1, higher percentile levels reflect the periods when air pollutant levels are elevated relative to normal levels and it is these periods that generally are of most interest in terms of source emission impacts and identifying these sources.

⁴ AERI Emission Rates [AEIR Air Emission Rates - Open Government](#)

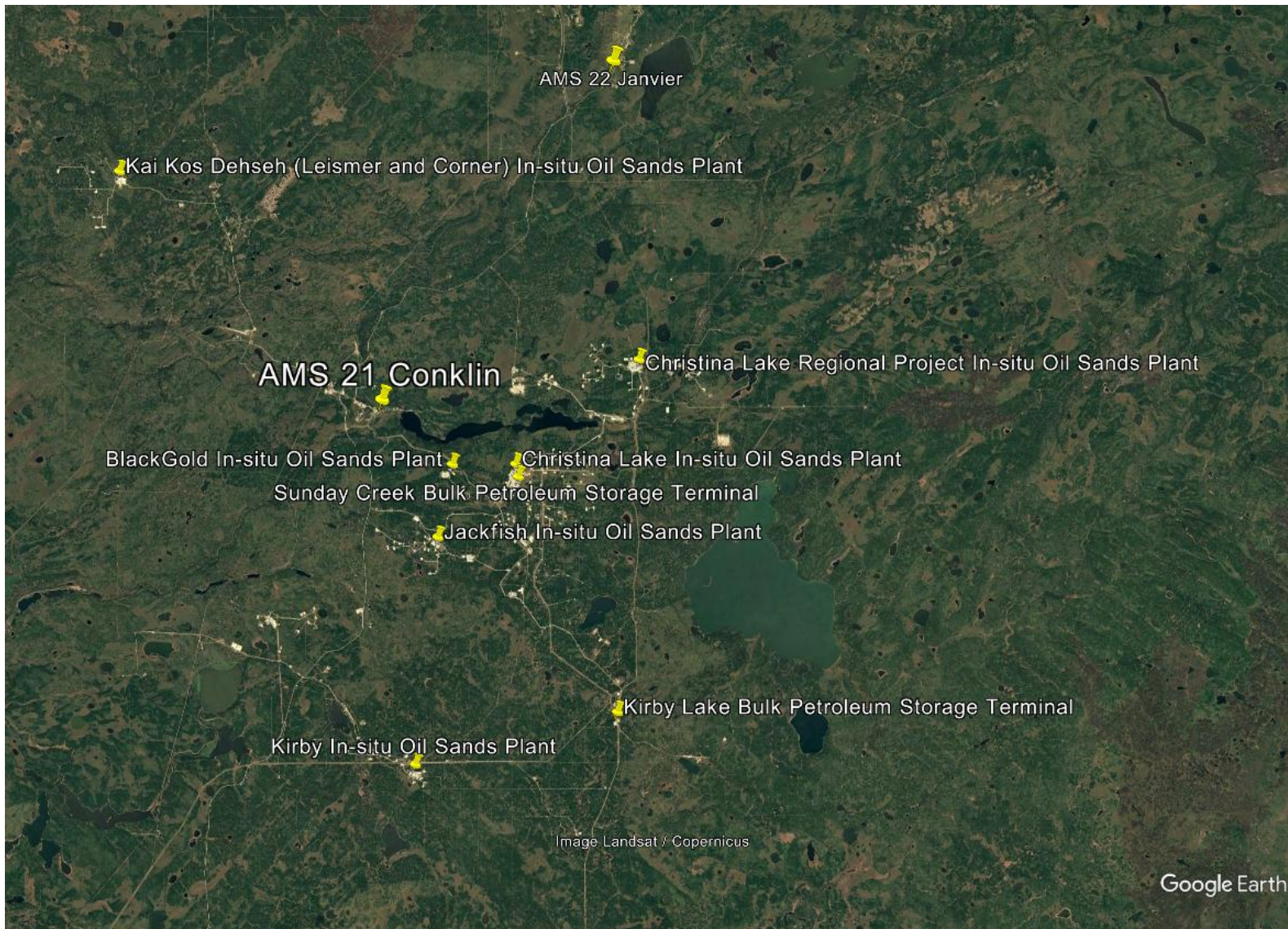


Figure 25: The Location of Facilities within 35 km of Conklin that have an Environmental and Protection Act Approval and which Reported Air Emissions to the Alberta Emission Inventory Report for the 2022 Year.

Table 12: The Location of the Industrial Facilities within a 35 Kilometer Radius of the Conklin Air Monitoring Station Monitoring and the Point and Non-point SO₂, NO₂, PM_{2.5} and PM₁₀ Reported Emissions from Each Facility (2022 AEIR data)

| Approval Holder | Facility Name | Facility Latitude (°N) | Facility Longitude (°E) | Distance and Direction from Conklin AMS | Annual Emissions (tonnes/year) of Noted Parameter (PS – point source emission and NPS – non-point source emission) | | | | | | | |
|-------------------------------------|---|------------------------|-------------------------|---|--|-----------------------|----------------------|-----------------------|------------------------|-------------------------|-----------------------|------------------------|
| | | | | | SO ₂ (PS) | SO ₂ (NPS) | NO _x (PS) | NO _x (NPS) | PM _{2.5} (PS) | PM _{2.5} (NPS) | PM ₁₀ (PS) | PM ₁₀ (NPS) |
| Enbridge Pipelines (Athabasca) Inc. | Kirby Lake Bulk Petroleum Storage Terminal | 55.38436 | -110.74629 | ~35 km to the SE | 0.004 | 0.047 | 0.057 | 0.715 | 0.001 | 0.115 | 0.001 | 0.702 |
| MEG Energy | Christina Lake Regional Project In-situ Oil Sands Plant | 55.66640 | -110.71400 | ~23 km to the ENE | 545 | 0.2 | 989 | 171.9 | 36.2 | 4.1 | 36 | 11.7 |
| Canadian Natural Resources Limited | Jackfish In-situ Oil Sands Plant | 55.52447 | -110.99889 | ~13 km to the SSE | 1396 | 0.439 | 1045 | 11.3 | 48.100 | 0.477 | 48 | 7.131 |
| Canadian Natural Resources Limited | Kirby In-situ Oil Sands Plant | 55.34267 | -111.03059 | ~31 km to the S | 1850 | 0.878 | 600 | 22.5 | 31.009 | 1.402 | 31 | 5.21 |
| Athabasca Oil Corporation | Kai Kos Dehseh (Leismer and Corner) In-situ Oil Sands Plant | 55.81650 | -111.45280 | ~30 km to the NW | 517 | 3.965 | 314 | 83.0 | 1.333 | 6.305 | 1.33 | 24.3 |
| Harvest Operations Corp. | BlackGold In-situ Oil Sands Plant | 55.58263 | -110.97820 | ~8 km to the SE | 161 | 0.73 | 165 | 11.1 | 3.40 | 0.890 | 3.40 | 1.84 |
| Enbridge Pipelines (Athabasca) Inc. | Sunday Creek Bulk Petroleum Storage Terminal | 55.57278 | -110.88528 | ~13.5 km to the ESE | 0.003 | 0.016 | 0.121 | 0.110 | 0.004 | 0.078 | 0.004 | 0.63 |
| Cenovus Energy Inc. | Christina Lake In-situ Oil Sands Plant | 55.58275 | -110.88885 | ~12.5 km to the ESE | 2354 | 0.067 | 1223 | 6.04 | 66.2 | 16.3 | 66.2 | 151 |
| Totals | | | | | 6823 | 6.30 | 4336 | 307 | 186 | 30 | 186 | 202 |

3.3. Sulphur Dioxide (SO₂)

The emission data in **Table 12** indicates that SO₂ is the major pollutant emission type associated with oil sands facilities and that almost all these SO₂ emissions are associated with point sources. **Figure 26** is a radar plot showing the 25thile, 50thile, 70thile, 80thile, 90thile and 95thile SO₂ concentration by wind direction. The radar plot at each %ile level provides (points to) the wind direction(s) from which SO₂ influences are greatest.

This radar plot for the 70thile, 80thile, 90thile and 95thile concentrations was superimposed on Google Earth image showing the location of the facilities within a 35 km radius of Conklin (**Figure 27**). This plot indicates a strong source influence from the ESE. This is the direction in which the Cenovus Christina Lake In-situ facility is located which also has relatively high SO₂ emissions i.e. ~2,354 t/yr (2022 AEIR data - see **Table 12**). **Figure 27** also indicates an influence from the S and SSE where the CNRL Jackfish and Kirby In-situ facilities are located and have a combined SO₂ emissions of ~3,246 tonnes per year (2022 AEIR data - see **Error! Reference source not found.**). An influence from the NW can also be seen, which is the direction to the Kai Kos Dehseh (Leismer and Corner) in-situ facility with annual SO₂ emissions of

~517 tonnes/yr. There are also some SO₂ influences from the NNE, SSW and NNW wind directions which may indicate some unreported SO₂ sources in the area and/or influences from the large SO₂ emission stacks at the Suncor Base Plant, at Syncrude Mildred Lake and at CNRL Horizon.

When interpreting this type of data analysis and the associated plots, it needs to be noted that local topography can influence wind flow patterns and therefore WD as measured at Conklin may not exactly reflect the WD being experienced at the source. It also needs to be noted that even the higher %ile SO₂ levels are relatively low and don't indicate a large SO₂ emission influence or SO₂ levels of concern from a health or general air quality standpoint (see Section 2.3.2).

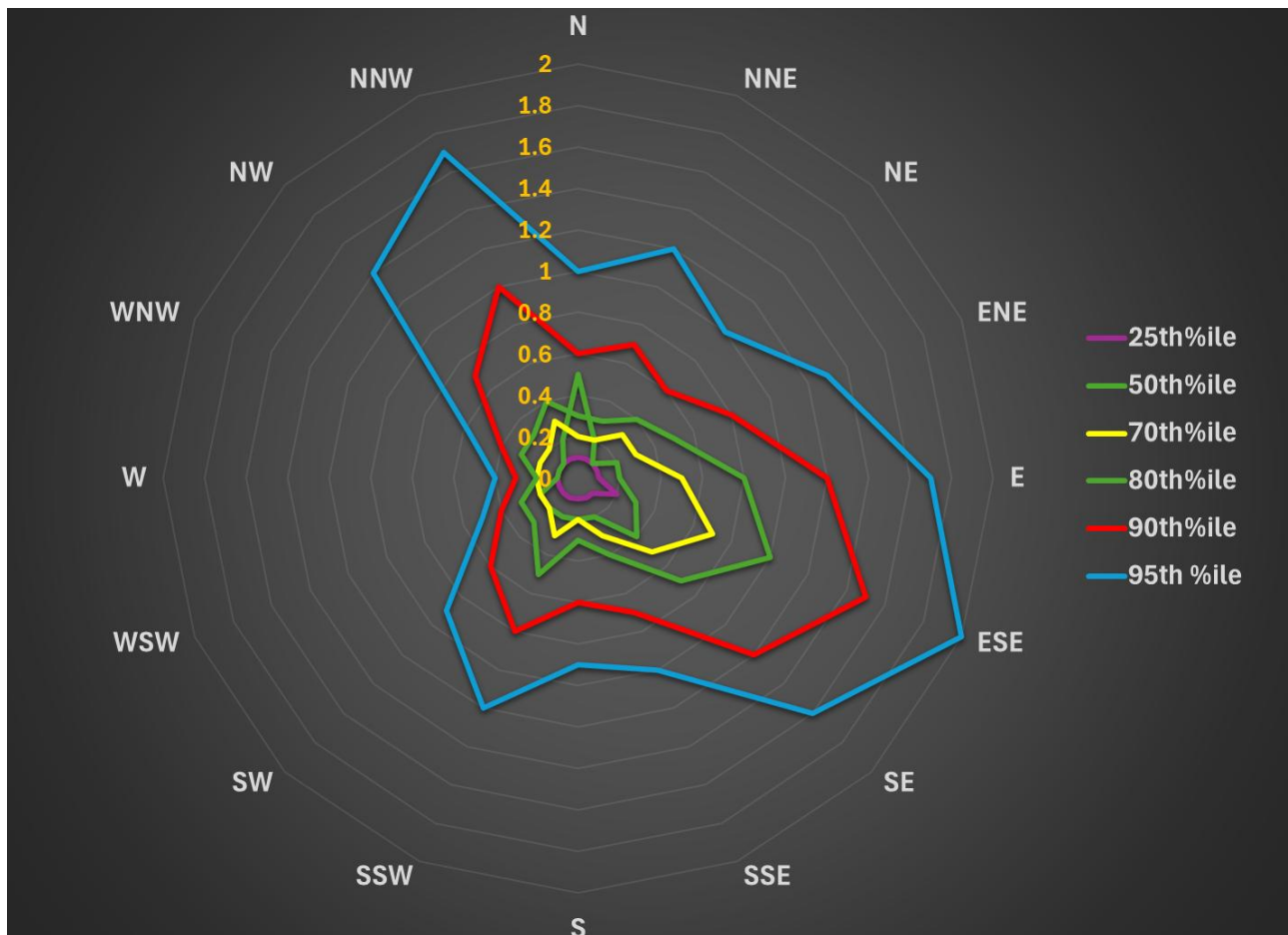


Figure 26: A Plot of the Noted Percentile Concentrations (orange-coloured values on the vertical axis line) of SO₂ (ppb) at Conklin (2017-2024 period) for a 16 Wind Direction Compass.

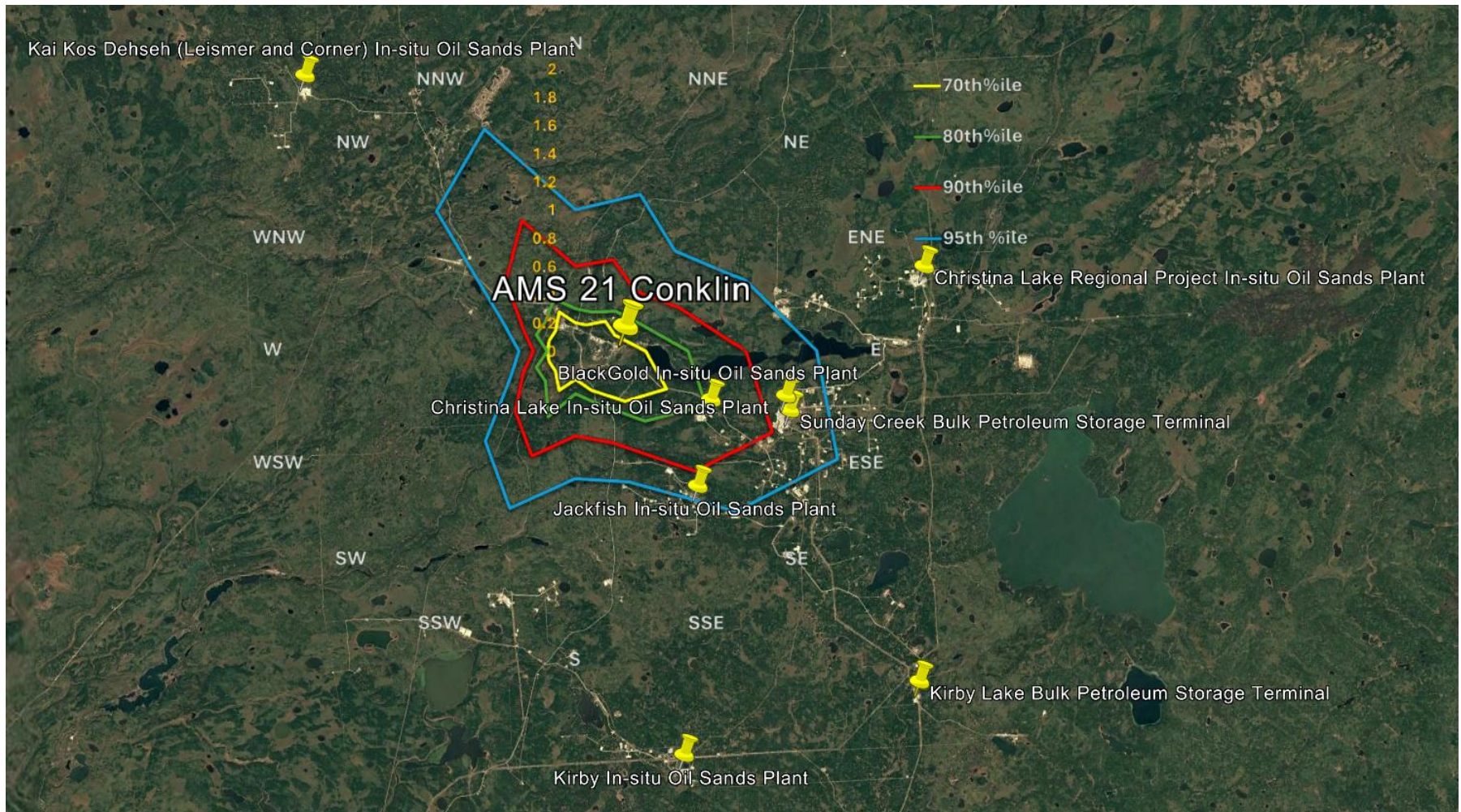


Figure 27: A Google Map Overlay of the 70thile, 80thile, 90thile and 95thile Concentration of SO₂ (ppb) at Conklin (2017-2024 period) based on a 16 Wind Direction Compass (the percentile concentrations of SO₂ (ppb) are the orange-coloured values on the vertical axis line).

As noted in Section 3.1, another similar approach to linking emission sources to air quality impacts is to use “pollution roses”. **Figure 28** is a pollution rose for hourly SO₂ levels in Conklin. The length of each wind direction rose reflects the percent of time the wind is from that direction, and different colours in each of the 16 roses indicate the relative frequency of different SO₂ levels (as shown in the legend) when the wind is from that wind rose direction. The advantage of pollution rose plots is that, unlike radar plots which show the magnitude of wind direction influences, pollution rose plots show both the magnitude and frequency that a wind direction has on the ambient level of a pollutant. In the case of SO₂, **Figure 28** indicates that the greatest influence on SO₂ levels in Conklin is when the wind is from the NNW and this influence is likely due to both upwind emission sources in the NNW wind direction and the frequency of winds from that direction. By doing pollution rose plots of only the highest SO₂ level hours, the wind directions associated with this subset of data can be highlighted. **Figure 29** is such a plot and highlights that the NNW wind direction is the significant wind direction in terms of influences on SO₂ levels in Conklin. The SO₂ sources in this wind direction are therefore of the most relevance in terms of reducing the emission source impacts on the Community. **Figure 30** is a Google Earth overlay of **Figure 29** to show the pollution rose of elevated SO₂ levels relative to the oil sands facilities within a 35 km radius of Conklin.

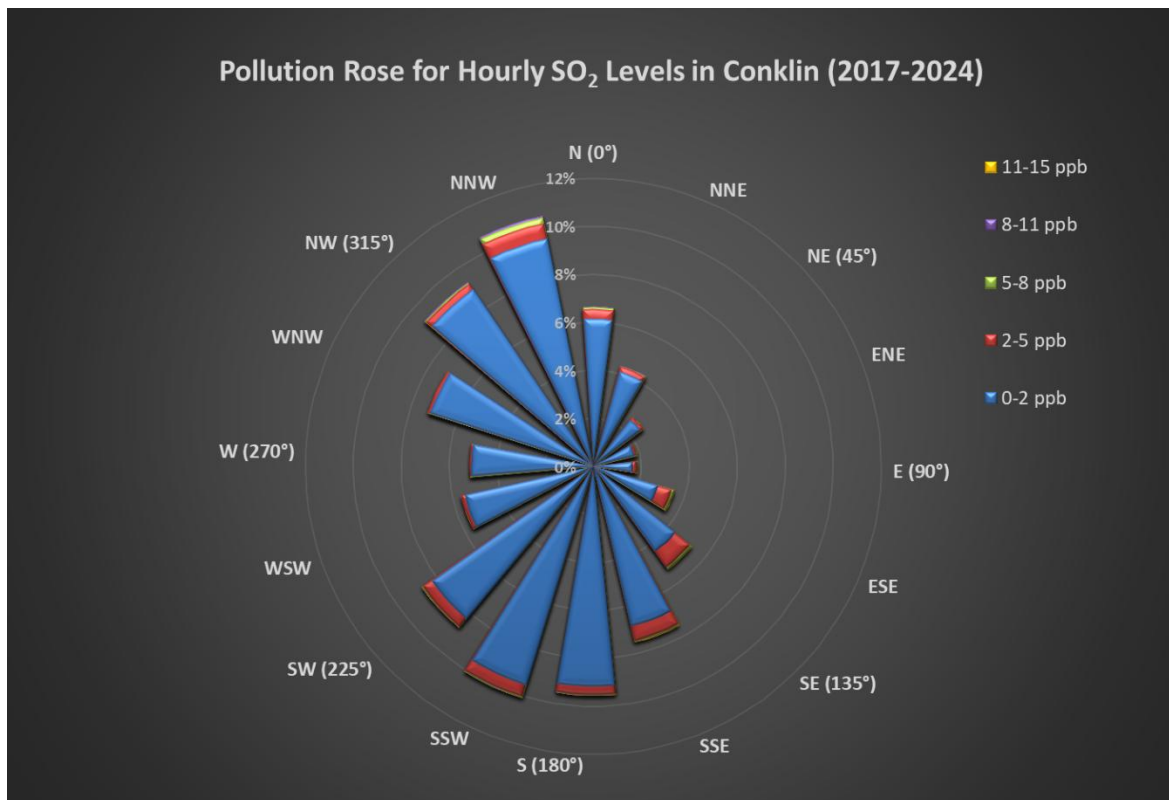


Figure 28: A Pollution Rose of Hourly SO₂ Levels (ppb) in Conklin in the 2017-2024 Period with the Percent Frequency of the Noted SO₂ Ranges (see legend) Associated with Each of the Noted 16 Wind Compass Directions

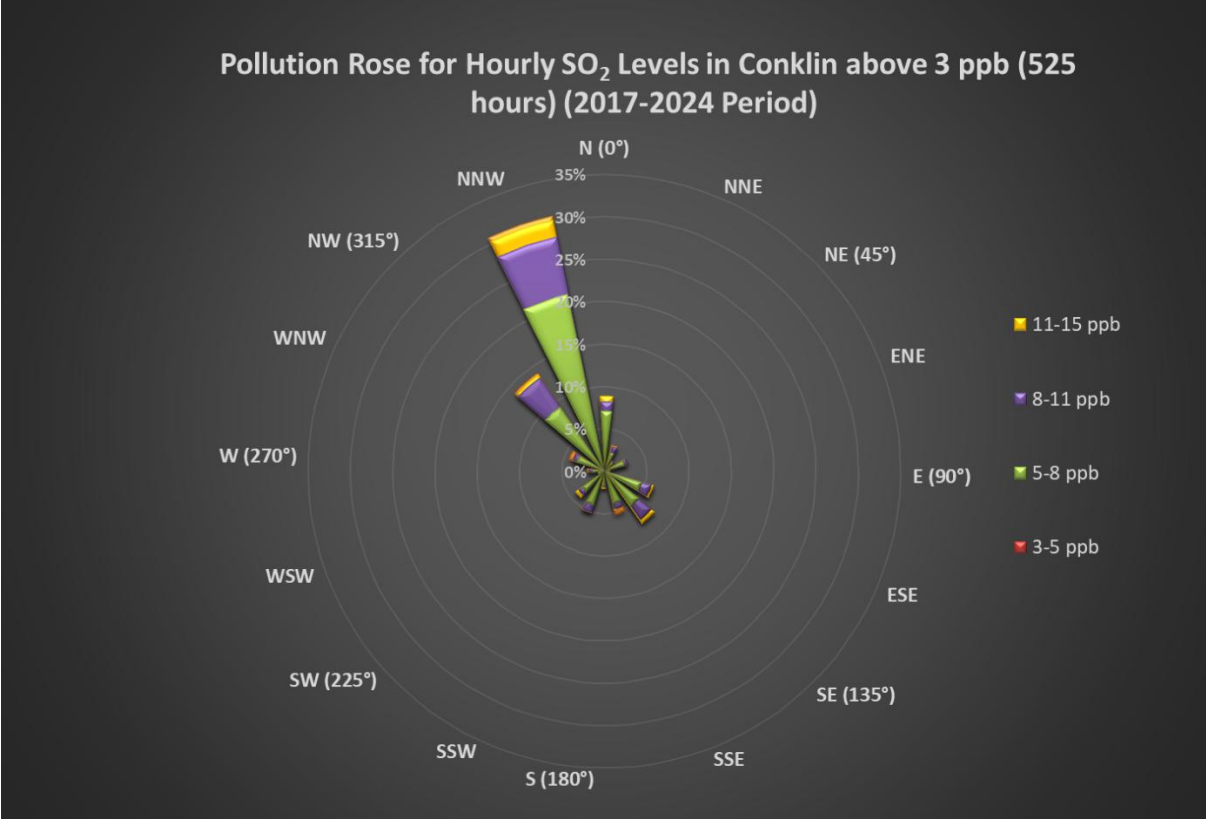


Figure 29: A Pollution Rose of Hourly SO₂ Levels above 3 ppb in Conklin in the 2017-2024 Period with the Percent Frequency of the Noted SO₂ Ranges (see legend) Associated with Each of the Noted 16 Wind Compass Directions

Time did not allow these types of pollution roses to be generated for NO₂, PM_{2.5} and PM₁₀ but this SO₂ example demonstrates how this data analysis approach, in conjunction with radar plots, can be used to identify and prioritize source types and/or locations for possible additional emission management. The pollutant rose in **Figure 30** points to the Kai Kos Dehseh facility to the NNW as having (relatively) the most significant influence on SO₂ levels in Conklin. This is not immediately apparent according to **Table 12**, as this facility is neither the closest to Conklin nor is it the facility contributing to the most SO₂ the emissions within a 35 km radius. As noted previously, it is possible that large SO₂ stack emissions in the oil sands mining area could also be contributing to SO₂ levels in Conklin since some of these stack sources are in an NNW direction from Conklin.

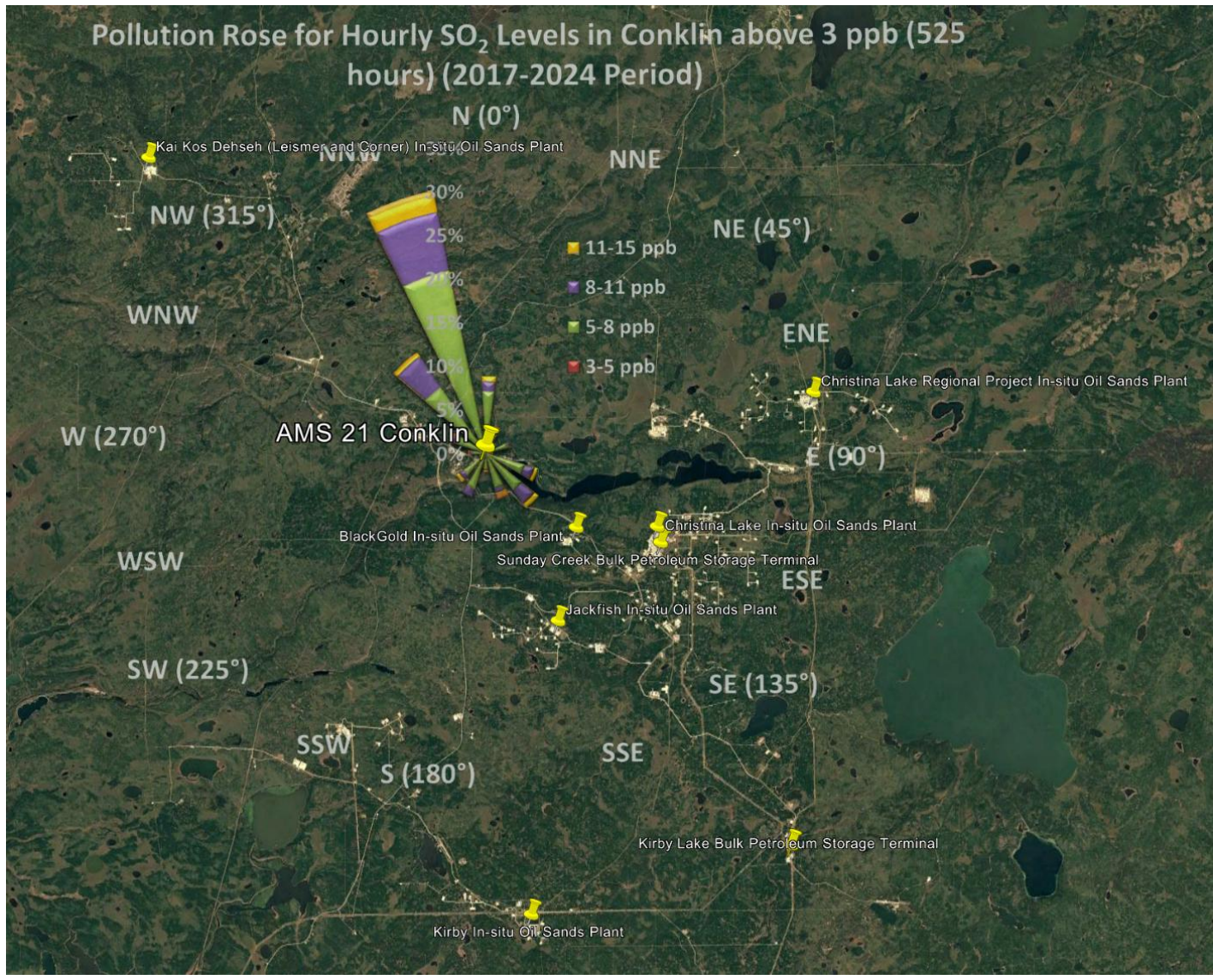


Figure 30: A Google Map Overlay of the Pollution Rose for Hourly SO₂ Levels above 3 ppb in Conklin in the 2017-2024 Period depicted in Figure 29

3.4. Nitrogen Oxides (NOx)

NOx emissions are the other major pollutant emitted by the industrial facilities in the Conklin region as shown in **Table 12**. Through oxidation in the atmosphere, NOx emissions result in NO₂ formation which is a common air pollutant for which there are both health and environment-related air quality criteria.

Like SO₂, oil sands NOx emissions in the Conklin region are largely associated with point sources but approximately 7% of the total NOx emissions are from non-point sources (see **Table 12**).

Figure 31 is a radar plot showing the 25thile, 50thile, 70thile, 80thile, 90thile and 95thile NO₂ concentration by wind direction. The radar plots at each %ile level provide (point to) the directions from which NO₂ influences are greatest.

This radar plot for the 70thile, 80thile, 90thile and 95thile NO₂ concentrations was superimposed on Google Earth image showing the location of the facilities within a 35 km radius of Conklin (**Figure 32**). This plot does not show sharp %ile directional NO₂ influences but does show that the greatest influences on NO₂ levels are from the SE to SW WD quadrant. There is also a NO₂ influence from the NNW. Based on NOx emission rates and location, the CNRL Jackfish and Kirby In-situ facilities and the Harvest Operations Corp. BlackGold In-situ facility are the likely contributors to these higher NO₂ levels, with the two CNRL facilities likely the largest contributors based on their NOx emissions (see **Table 12**). The higher concentrations from the NNW direction could be related to oil sands NOx emissions from North of Fort McMurray and NOx emissions from the Fort McMurray urban centre. Like SO₂, it needs to be noted that even the higher %ile NO₂ levels are relatively low and don't indicate a large NO₂ emission influence or levels of concern from a health or general air quality standpoint.

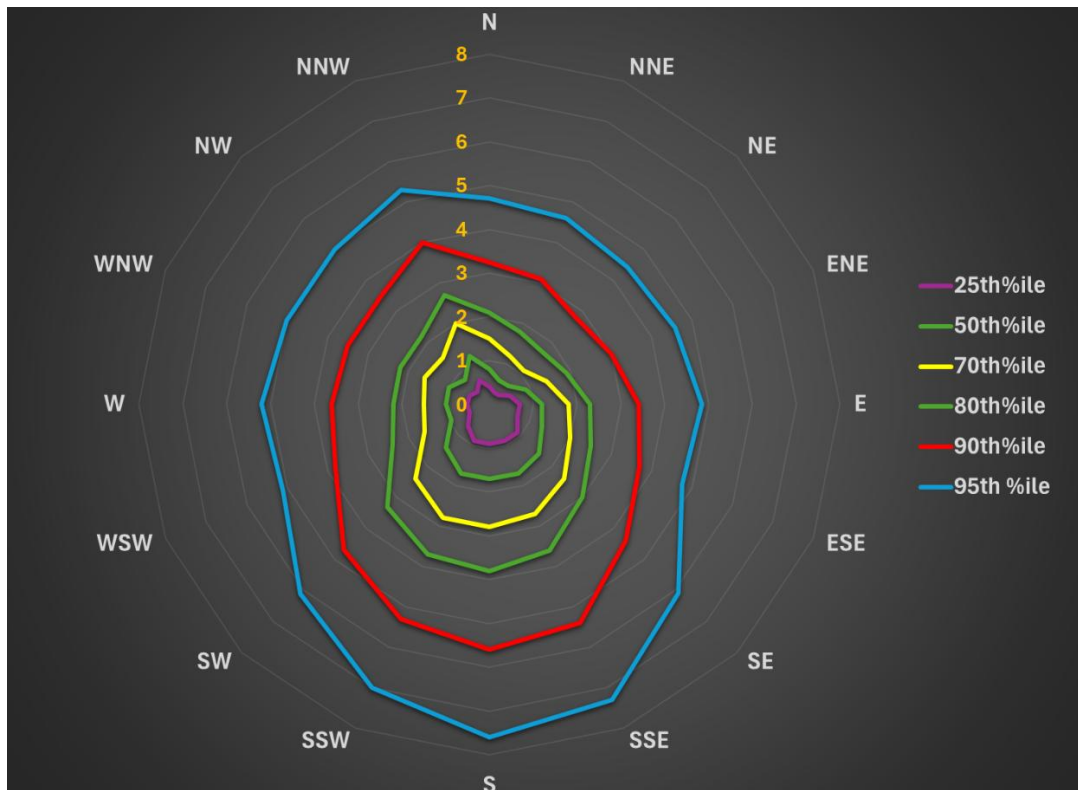


Figure 31: A Plot of the Noted Percentile Concentrations (orange-coloured values on the vertical axis line) of NO₂ (ppb) at Conklin (2017-2024 period) for a 16 Wind Direction Compass

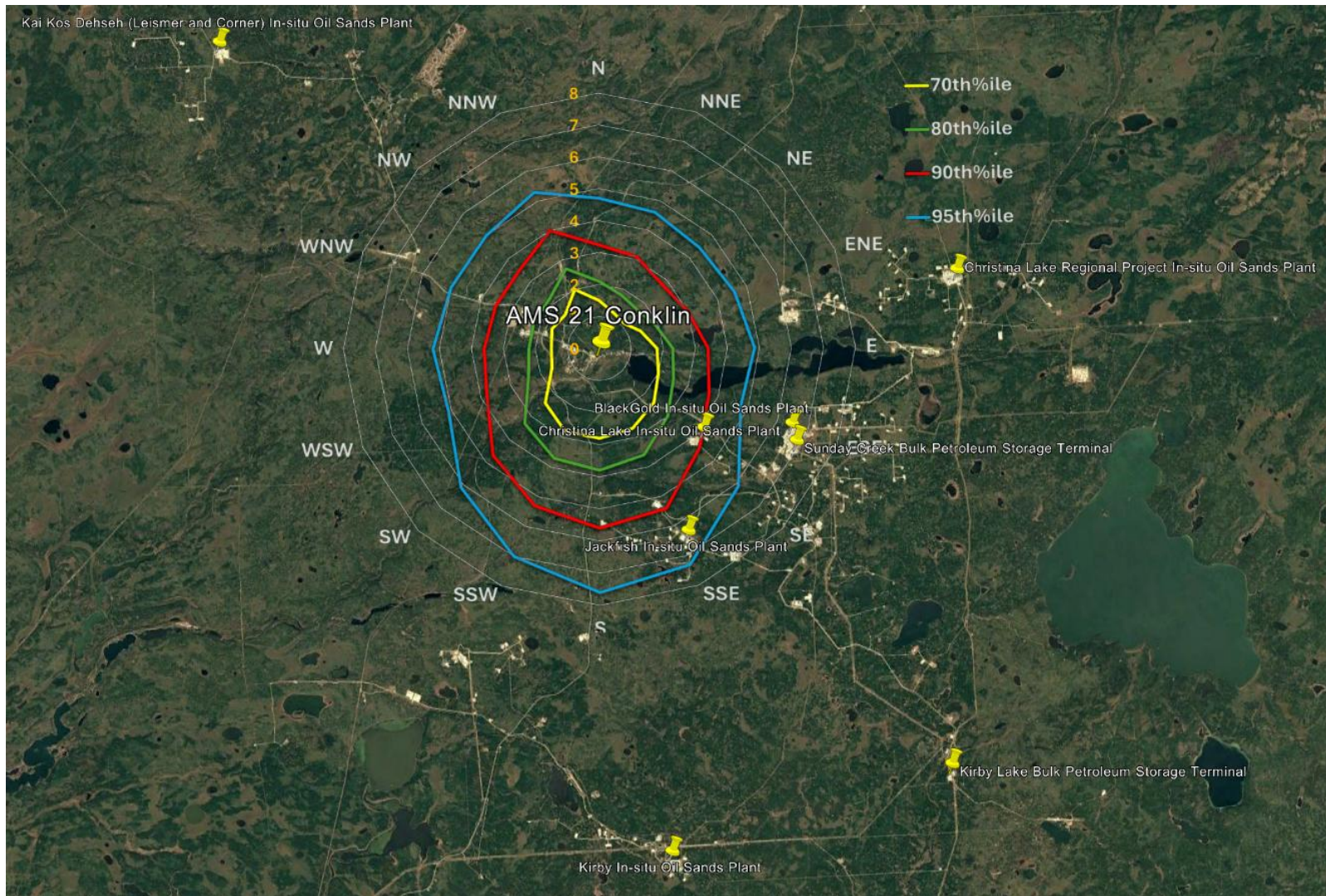


Figure 32: A Google Map Overlay of the 70thile, 80thile, 90thile and 95thile Concentration of NO₂ (ppb) at Conklin (2017-2024 period) based on a 16 Wind Direction Compass (the percentile concentrations of NO₂ (ppb) are the orange-coloured values on the vertical axis line)

3.5. Particulate Matter <2.5 µm (PM_{2.5})

PM_{2.5} emissions from the eight oil sands-related facilities within 35 km of Conklin are not large (**Table 12**) and there are other sources of PM_{2.5} which include both natural and long-range transport sources. Wildfires can be a very large source of PM_{2.5} and its impact on air quality varies from year to year depending on the severity and location of wildfire activity. Wildfire influences were not removed from the **Figure 33** radar plot which shows the 25thile, 50thile, 70thile, 80thile, 90thile and 95thile PM_{2.5} concentrations (µg/m³) by wind direction. The radar plots at each %ile level provide (point to) the directions from which PM_{2.5} source influences are greatest. The 95thile and to a lesser extent the 90thile PM_{2.5} plots show a clear wildfire influence i.e. much higher %ile concentrations than the 85thile and lower %ile concentrations.

A radar plot for the 70thile, 80thile and 85thile PM_{2.5} concentrations was superimposed on Google Earth image showing the location of the facilities within a 35 km radius of Conklin (**Figure 34**). These percentile levels were selected to try and show the WDs with the highest non-wildfire influenced PM_{2.5} levels. This plot does not show any sharp %ile directional influences but clearly shows a PM_{2.5} influence when the wind is from the S and SSE. The CNRL Jackfish and Kirby In-situ facilities are PM_{2.5} sources that are in these WDs and are therefore likely contributors to these higher PM_{2.5} levels, although local traffic and other local sources, e.g. exposed ground, may also be sources as the GEM-MACH modelling results presented in the Section 4 indicate. As for SO₂ and NO₂, it needs to be noted that even the higher %ile PM_{2.5} levels are relatively low and don't indicate large PM_{2.5} emission source influences or levels.

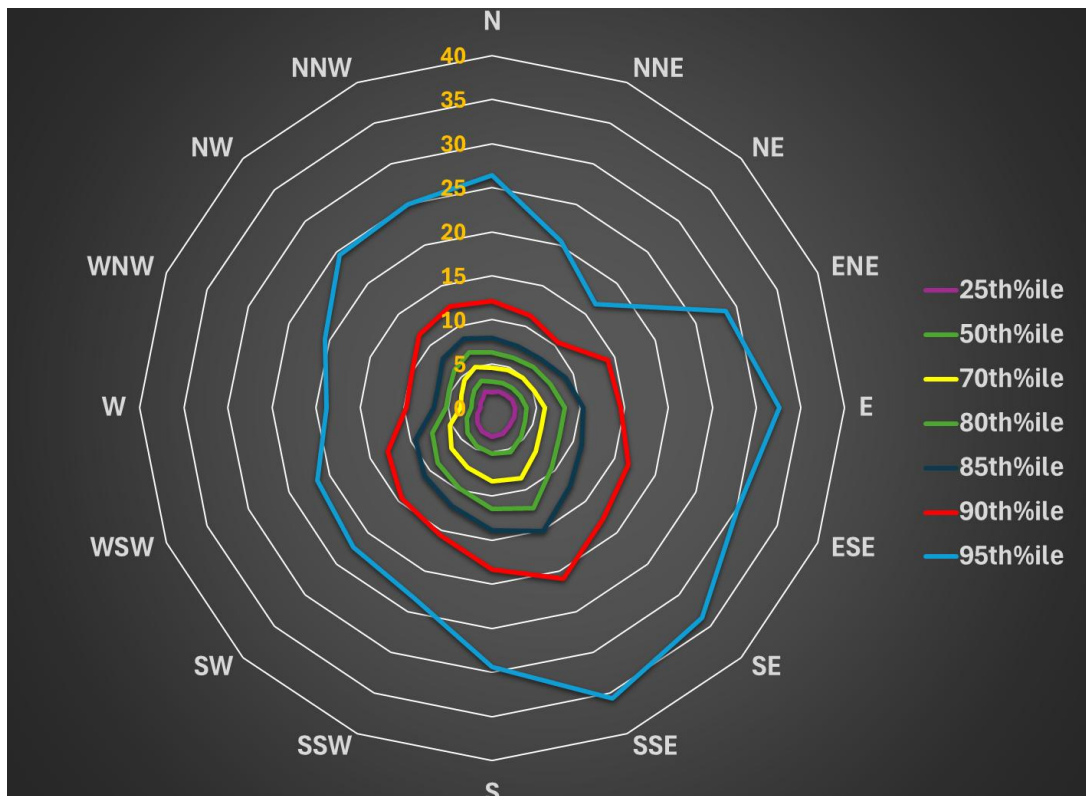


Figure 33: A Plot of the Noted Percentile Concentrations (orange-coloured values on the vertical axis line) of PM_{2.5} (µg/m³) at Conklin (2017-2024 period) for a 16 Wind Direction Compass

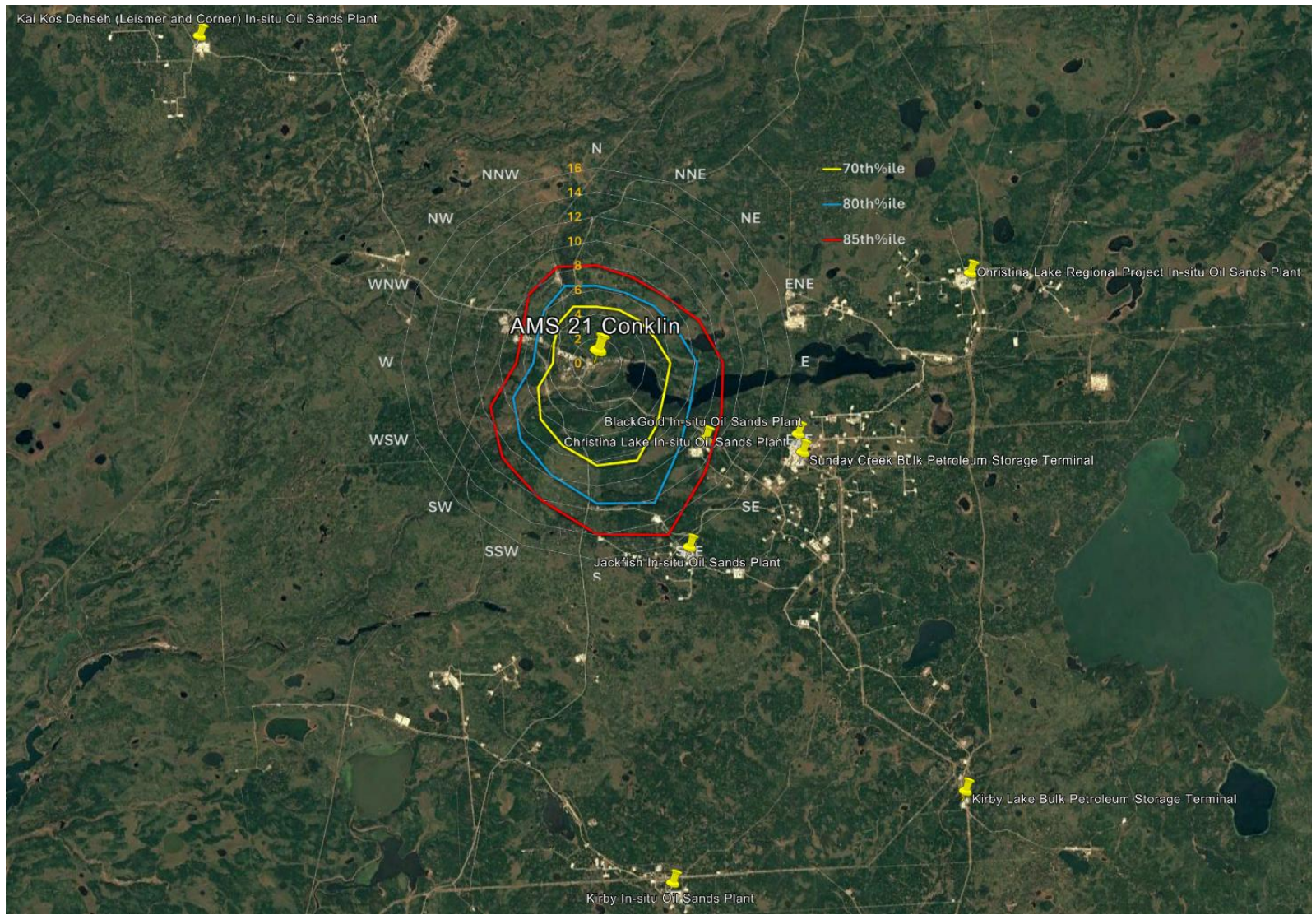


Figure 34: A Google Map Overlay of the 70thile, 80thile and 85thile Concentrations of PM_{2.5} ($\mu\text{g}/\text{m}^3$) at Conklin (2017-2024 period) based on a 16 Wind Direction Compass (the percentile concentrations of PM_{2.5} ($\mu\text{g}/\text{m}^3$) are the orange-coloured values on the vertical axis line)

3.6. Particulate Matter <10 µm (PM₁₀)

The PM₁₀ emissions from the eight oil sands-related facilities within 35 km of Conklin are not large. For point sources, the reported emission rates for PM₁₀ are similar to the reported rates for PM_{2.5}. Since PM₁₀ includes PM_{2.5}, the emissions of PM_{10-2.5} from point sources are small. The non-point source emissions of PM₁₀ are almost exclusively particles in the PM_{10-2.5} size range and are largely associated with non-point or fugitive sources such as road dust (Table 12). Other sources of PM₁₀ include both natural and long-range transport influences of PM_{2.5}, which, as noted above, are part of the PM₁₀ fraction. Like PM_{2.5}, wildfires are a very large source of PM₁₀. Wildfire influences were not removed from the Figure 35 radar plot. This plot shows the 25thile, 50thile, 70thile, 80thile, 90thile and 95thile PM₁₀ concentrations (µg/m³) by wind direction. The radar plots at each %ile level provide (point to) the directions from which PM₁₀ source influences are greatest. The 95thile, and to a lesser extent the 90thile, PM₁₀ plots show a clear wildfire influence i.e. much higher %ile concentrations than the 85thile and lower %ile concentrations.

The radar plot for the 70thile, 80thile and 85thile PM₁₀ concentrations was superimposed on Google Earth image showing the location of the facilities within a 35 km radius of Conklin (Figure 36). These percentile levels were selected to try and show the WDs with the highest non-wildfire influenced PM₁₀ levels. This plot does not show any very sharp %ile directional influences but clearly shows a PM₁₀ influence when the wind is from the SSE and the WSW. The CNRL Jackfish and Kirby In-situ facilities are PM₁₀ sources that fall in these WDs and are therefore likely contributors to these higher PM₁₀ levels but local traffic and other local sources e.g. exposed ground, may also be sources as the as the GEM-MACH modelling results presented in the next session indicate. As for SO₂ and NO₂, it needs to be noted that even the higher %ile PM₁₀ levels are relatively low and don't indicate a large PM₁₀ emission influence or levels of large concern from a health or general air quality standpoint. However, since there does not appear to be a safe level of PM exposure (WHO, 2013) it is desirable to maintain low ambient PM levels (see Section 3.5).

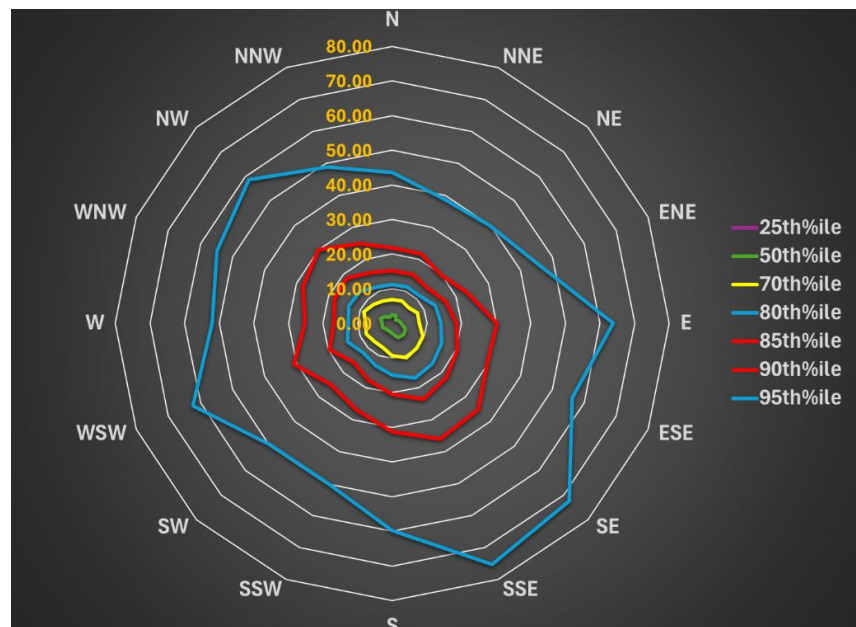


Figure 35: A Plot of the Noted Percentile Concentrations (orange-coloured values on the vertical axis line) of PM₁₀ (µg/m³) at Conklin (2017-2024 period) for a 16 Wind Direction Compass

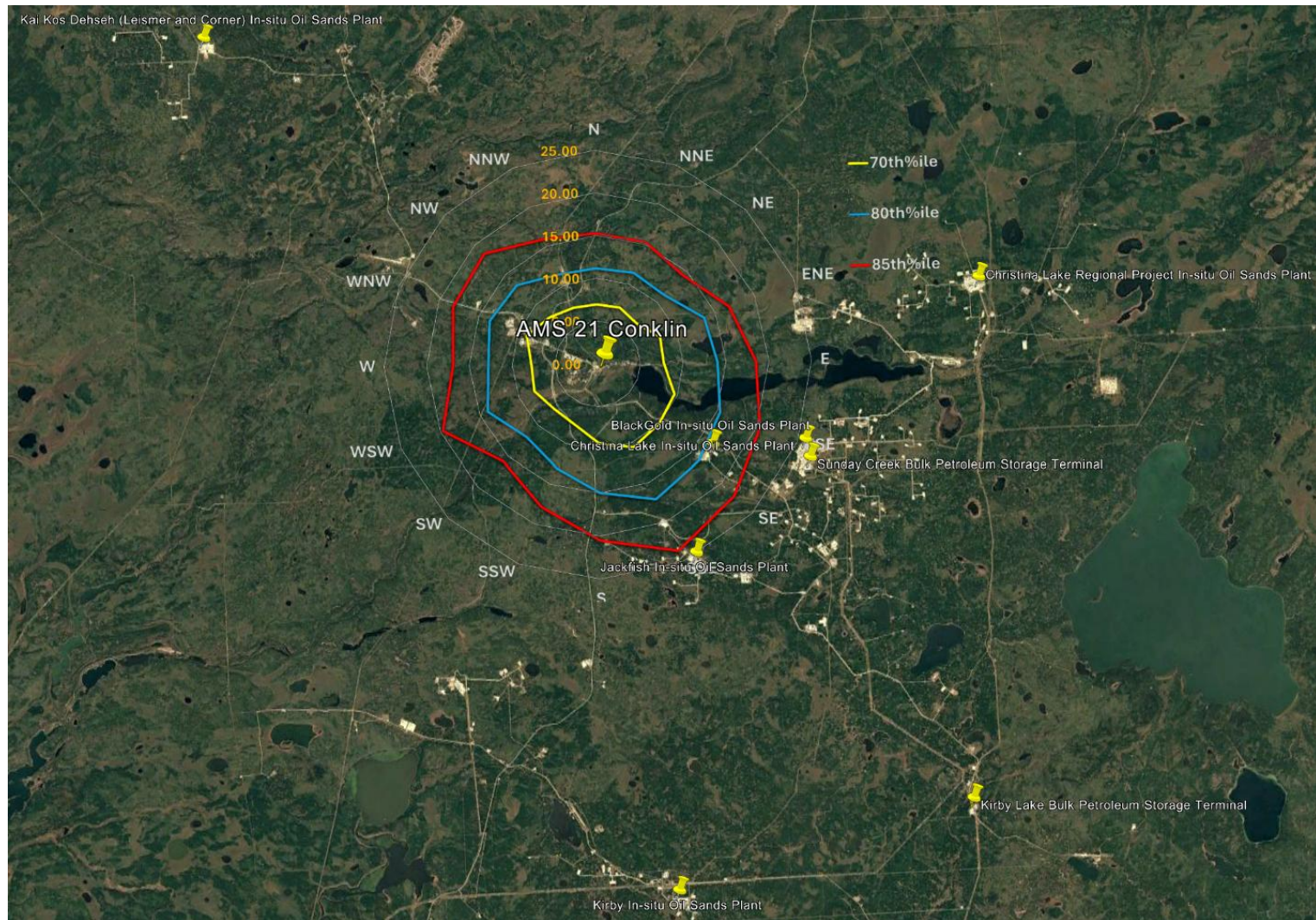


Figure 36: A Google Map Overlay of the 70thile, 80thile and 85thile Concentrations of PM₁₀ (µg/m³) at Conklin (2017-2024 period) based on a 16 Wind Direction Compass (the percentile concentrations of SO₂ (ppb) are the orange-coloured values on the vertical axis line)

3.7. Wind Direction and Air Quality Analysis Summary

The analysis of wind direction related air quality in Conklin for SO₂, NO₂, PM_{2.5} and PM₁₀, relative to reported emissions of these parameters for oil sands related facilities within a 35 km radius of the Community, would indicate that:

- the influence of certain oil sands facilities emission sources on air quality is evident, particularly for SO₂ and NO₂, with the magnitude of the influence related to emission rates, but these influences are generally small;
- there are air quality influences from wind directions with no oil sands facilities within the 35 km radius studied, which indicates there may be unaccounted for local emission sources and/or these influences are due to longer range transport of pollutants;
- no strong directional influences were noted for PM_{2.5} and PM₁₀ levels, however, levels are generally higher when the winds are from the south; overall, the PM_{2.5} and PM₁₀ influences from industrial facilities appear to be relatively small; and
- industrial SO₂ and NO₂ emissions are largely associated with stack sources, with a large fraction of PM_{2.5} emissions also associated with point sources; PM₁₀ emissions are largely non-point sources.

The analysis would indicate that radar plots can be a useful method of relating emission sources to air quality influences. Based on the example use of pollution roses for SO₂, it is recommended that both analysis approaches be used when conducting wind direction-air quality analyses.

4 Measured Air Quality and GEM-MACH Model Predicted Air Quality Impact Scenarios

4.1. Introduction

The Oil Sands Monitoring Program (OSMP) Environment and Climate Change Canada (ECCC) have been using, and advancing, an air dispersion and deposition model called the Global Environmental Multi-scale-Modelling Air Quality and Chemistry (GEM-MACH) model for use in the OSR. The model uses emission inventories that have been developed, and continue to be updated, for all significant air emission sources in the OSR. Information on the GEM-MACH model and the results from the recent model runs that were analyzed as part of this study are available (Makar, Fathi, S., Netcheva, & Wu, 2024). The recent “Run 4” and “Run 5” model results provided air quality model predictions for the OSR for the following modelling scenarios:

- Air quality estimates based on a **2017/2018 (Run 4 and Run 5) total modelling domain emissions** (termed the base case),
- Air quality estimates with **all oil sands emissions removed** which provides an estimate of the impact that oil sands emissions have on air quality inside and outside the OSR,
- Air quality estimates with **all anthropogenic emissions removed** which provides an estimate of the impact that the oil sands, other industrial emission e.g. quarries, forestry activities, etc. and urban related emissions e.g. home heating, vehicle traffic, etc. have on air quality),

- Air quality estimates with ***all oil sands stack emissions removed*** which provides an indication of the air quality impacts just associated with oil sands' stack and flare emissions, and
- Air quality estimates with ***all oil sands mine fleet emissions removed*** which provides an indication of the air quality impacts just associated with oil sands' mine fleet emissions.

These types of model runs can be used to estimate how different emission sources are impacting air quality at a location. In this study, the above GEM-MACH model run outputs were used to estimate how different emission sources impact air quality in all the Indigenous Communities. The model covers a very wide range of air quality parameters. In this study, SO₂, NO₂, PM_{2.5} and PM₁₀ model predictions were analyzed.

Since the Run 4 GEM-MACH modelling⁵ output published in July 2024 was based on 2017/2018 regional emissions, in this study the GEM-MACH model predictions were compared to 2018 air quality in Conklin. Since PM₁₀ monitoring only commenced in Conklin in 2020, the model predictions for PM₁₀ were compared to the PM₁₀ levels in Conklin in 2021 which was the first full year of PM₁₀ monitoring in the community. The model's total hydrocarbon concentration (THC) predictions could not be compared to the THC measurements at Conklin because the hydrocarbon emissions used in the modelling are different than the hydrocarbons measured by the THC instrument at the Conklin AMS⁶. Hydrogen sulphide (H₂S) emissions were also modelled, but total reduced sulphur (TRS) is the reduced sulphur parameter measured at AMS 21. Therefore, H₂S/TRS was not considered in the GEM-MACH prediction-measurement analysis comparison.

During the analysis of Run 4 GEM-MACH model outputs, Run 5 model output data became available in March 2025. There was insufficient time for detailed analysis of the Run 5 output for inclusion in this report, but Run 5 SO₂ and NO₂ predictions were pictorially analyzed with this limited analysis outlined in **Section 4.3**. Future emission year model runs are planned by ECCC. Therefore, when conducting the type of model output analysis in this study, the latest available model runs should be used since emissions sources and locations are continually changing, and emission inventories are improving. The ECCC also makes ongoing improvements to GEM-MACH and documents the model's performance in the latest version of its evaluation report⁵.

When using and interpreting model outputs, it needs to be noted that there are uncertainties associated with atmospheric modelling. One uncertainty is related to the accuracy of the emission estimates which are a key modelling input. Certain area emission sources e.g. tailings ponds, mine faces, roads, material stockpiles, etc. are difficult to quantify and/or highly variable both spatially and temporally, and mobile sources e.g. mine fleets, are also difficult to quantify and the location of these types of sources is constantly changing. Considerable work has been done, and is ongoing, trying to improve regional emission source inventories. When using model predictions, these limitations need to be recognized, with certain inventories quite reliable, e.g. SO₂ emission inventories, and other inventories e.g. PM₁₀

⁵ See - <https://data-donnees.az.ec.gc.ca/data/air/monitor/ambient-air-quality-oil-sands-region/modelled-concentration-deposition-fluxes-and-deposition-velocities-database-global-environmental-multiscale-modelling-air-quality-and-chemistry-model-oil-sands-region?lang=en>

⁶ Personal communication w/Paul Makar, Environment and Climate Change Canada, January 27, 2025

emissions inventories, not very reliable. These uncertainties are discussed in the Joint Oil Sands Monitoring Program emissions inventory compilation report (2016) and by Zhang, et al. (2018).

NOTE: As previously indicated, in analyzing GEM-MACH Run 4 and 5 Alberta Environment and Protected Areas (AEPA) noted some of the same anomalies in model predictions versus measured and/or expected findings that this report found. AEPA in conjunction with ECCC found that the defined areas (termed “polygons”) from which industrial emissions were assumed to occur did not cover the entire area from which certain in-situ facility emissions were occurring. The analysis in this section of GEM-MACH outputs therefore only provides an example of how modelling outputs can be used to understand the impacts of different emissions source types impact air quality at a location. A future modelling run (Run 6) using the 2017/18 emission, but with the appropriate industrial releases polygons, will allow a determination of the significance of oil sands emissions on predicted industrial emissions air quality impacts in Conklin.

4.2. GEM-MACH Model Predictions (Run 4/2018 Emissions) in relation to Measured Air Quality

In this analysis, GEM-MACH model predictions are used in the following ways:

- The **base case** model predictions for NO₂, SO₂, PM_{2.5} and PM₁₀ for 2018 are compared to the measured concentrations of these parameters in Conklin in 2028 to give an indication of the reliability of model predictions for that parameter (not to be confused with the baseline ambient air concentrations discussed in Section 2.3 which represents air quality without the influence of oil sands-related emissions) (Note: the oil sands emissions that were not allocated to oil sands facilities do not impact the outputs of this model run since those emissions are part of the total emissions used in the modelling);
- The **no oil sands emissions** model results provide an indication of the magnitude of the air quality impacts in Conklin associated with industrial emission sources but as noted there are oil sands emissions missing so these predictions cannot be used and the results are only presented to show how such data can be analyzed and used);
- The **no anthropogenic (human) emissions** model results provide an indication of the magnitude of the air quality in Conklin associated with all oil sands and other significant human-related emission sources such as municipal sources (note: small human-related impacts associated with sources like local traffic, parking lots, small open burning, non-urban residential dwellings etc. which are not in the inventory will have local air quality impacts and these predictions are not impacted by the missing oil sands emissions);
- The **no oil sands emission model predictions can be subtracted from the no anthropogenic sources predictions** to give an indication of the influence that non-oil sands emission sources are having on air quality which provides information on the relative significance of industrial vs. non-industrial sources in terms of air quality impacts (note: the missing oil sands emissions affect this calculation and therefore are presented only as an example of how these predictions can be used to estimate non-oil sands anthropogenic emission influences; and
- The **no stack sources**, and **no mine fleet sources** model outputs provide an indication of the type of industrial source that is having the greatest air quality impact. Stack emissions travel greater distances and are therefore more likely to have longer range impacts making them possibly a more relevant consideration for Conklin as opposed to ground-level sources like mine fleets.

Figure 37 shows measured and GEM-MACH model predicted, NO₂, SO₂, PM_{2.5} and PM₁₀ air quality in Conklin for 2018. The GEM-MACH model scenarios shown are intended to provide a general indication of how different emission source types are influencing the concentrations of these four pollutants in the community. The “Model Prediction” category represents the base case predictions that should, theoretically, align with the measured concentrations (based on 2018 monitoring data collected in Conklin). The “No Industry” and “No Anthropogenic” categories are GEM-MACH model predictions corresponding to the scenarios described above. Since some of the oil sands emissions are in the non-oil sands emission category not the missing allocation of emissions oil sands **Figure 37** is just an example of how the model estimates can be compared.

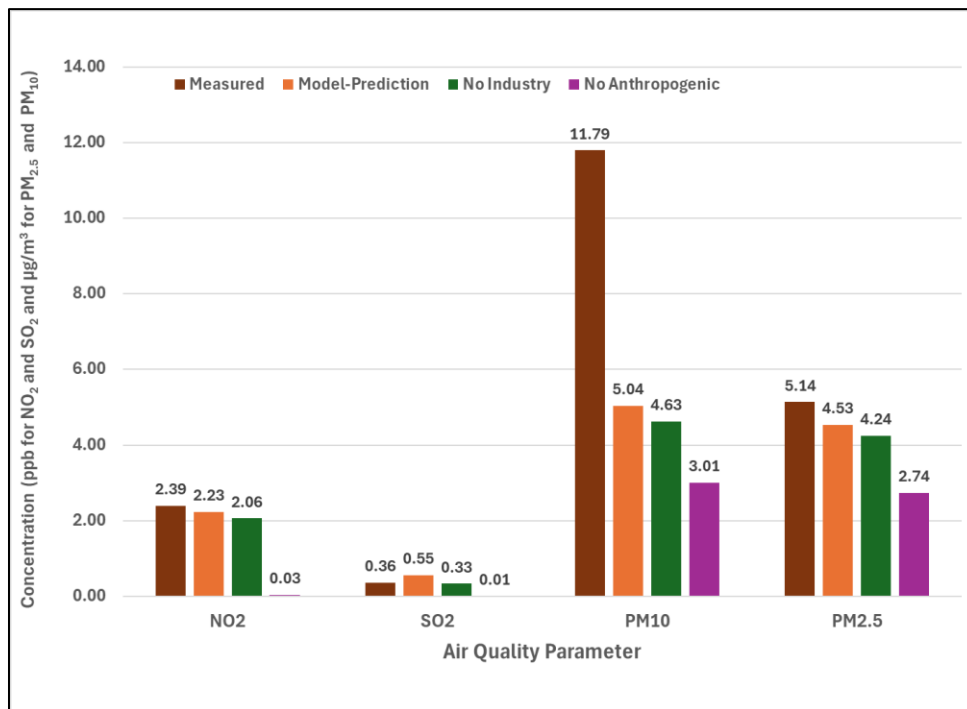


Figure 37: Measured and GEM-MACH model Predicted Concentration of NO₂, SO₂, PM_{2.5} and PM₁₀ in Conklin in 2018 and the Air Quality Influences of Industry and total Anthropogenic Emissions Sources

The type of data in **Figure 37** can be used to provide an indication of the influences that industrial and total anthropogenic emissions can have at a location.

Since an air quality question frequently asked by the Community is: “*how are oil sands emissions impacting our air quality?*” Several ways of presenting the GEM-MACH prediction were explored to see if there were better ways to present the information in **Figure 37** to make it easier to see the model-predicted impact of different emission source types.

The following are two examples of the alternate model prediction data presentation approaches considered.

Figure 38 depicts the **Figure 37** findings but in a different pictorial way. **Figure 38** shows the predicted concentrations of each of NO₂, SO₂, PM_{2.5} and PM₁₀ in Conklin when different emission source types are removed. The following outlines how the data can be analyzed recognizing the numbers in this example are not accurate based on the emission mis-allocation issue. This Figure needs to be analyzed from left to right for each parameter. The changes in the numeric values indicate the relevance of that emission source. For example, looking at NO₂ (the second row from the front), the model predicted annual average concentration of NO₂ in Conklin in 2018 was 2.23 ppb (2nd row and 2nd column from the right). This compares with the measured 2018 annual average of 2.39 ppb (2nd row 1st column on the right). There is a good measurement vs. model prediction agreement in this case. The model estimates that if there were no oil sands emissions, the NO₂ level in Conklin would be 2.06 ppb (2nd row 1st column on the left) and the model estimates that with oil sands emissions, but no other regional NO_x emissions, the concentration of NO₂ in Conklin would be 0.20 ppb (4th column from the left and 2nd row).

Figure 39 depicts the **Figure 38** and **Figure 37** data but rather than showing predicted concentration under different emission scenarios, it shows the percentage contribution of each source type to the all emission sources predicted concentrations of SO₂, NO₂, PM_{2.5} and PM₁₀. Higher percentile values indicate that the source type has a significant influence on the concentration of that parameter in the Community.

Since these GEM-MACH model outputs are relatively new, and of relevance to all Communities, **Figure 38** and **Figure 39** type model output plots were prepared for each community and presented in Appendix 3. The model output plots in Appendix 3 were not analysed in any detail, and cannot be considered fully representative of oil sands emission impacts because of the emission mis-allocation issue, they clearly show what would be expected i.e. that stack emissions of SO₂ are estimated to be a significant contributor to ambient air quality SO₂ levels in all the communities - i.e. 40% in Conklin, 52% in Janvier, 74% in Anzac, 86% in Fort McKay and 57% in Fort Chipewyan. A more detailed analysis of the Appendix 3 plots and similar plots using the recent GEM-MACH Run 6 predictions would be informative and provide information on the emission source types of most relevance in terms of impacting each community's air quality.

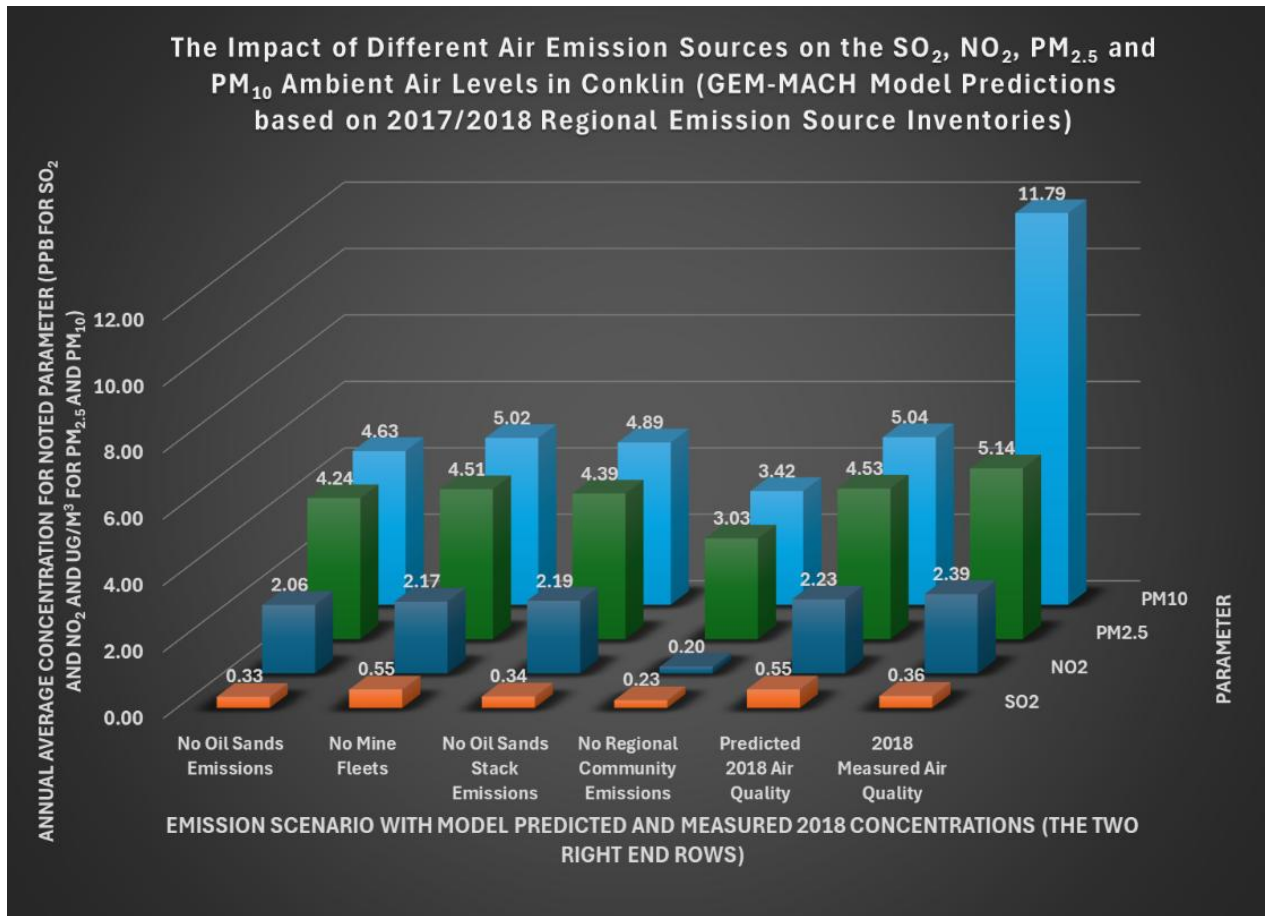


Figure 38: GEM-MACH Model Predictions of Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Conklin when Certain Emission Source Types are Removed with the Model Predicted and Measured Concentrations of each Parameter noted on the Right-side of the Plot

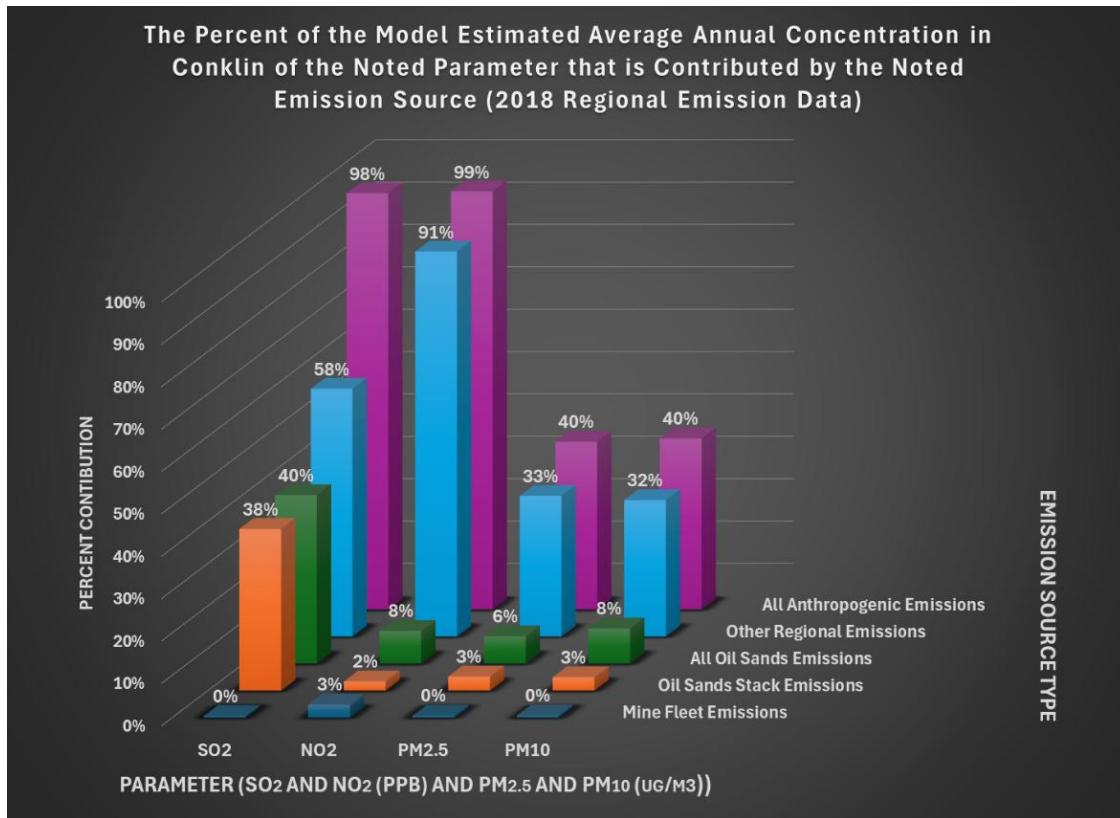


Figure 39: GEM-MACH Model Predictions used to Calculate the Percentage Contribution made by Different Emission Source Types to the Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Conklin

4.3. GEM-MAC Model Predictions (Run 5/2018 Emissions) Relative to CAAQS and WHO Criteria

To give an example of a pictorial representation of GEM-MACH model predictions relative to CAAQS and WHO Air Quality criteria, colour-coded maps were generated for:

- GEM-MACH Run 5 (i.e. based on the 2018 emission inventory) SO₂ and NO₂ predictions for:
 - The **Base Case** i.e. model predictions based on all industrial and other e.g. city/town, related air emissions in the region that were captured in the 2018 regional municipal emissions inventory,
 - The **Oil Sands Zero-out (OS Zero) Case** i.e. predicted air quality without any regional oil sands industrial emissions, and
 - The **Anthropogenic Zero-out (AnthZero) Case** i.e. no to very minimal human activity of any kind, related emissions included in the model run.

Comparisons between the AnthZero, OS Zero, and Base Case provide an estimate of the relative impact of oil sands-related emissions and other anthropogenic emissions on ambient air quality and deposition, as well as an estimate of air quality in the absence of human activity emissions. These comparisons are valuable when considering limits-of-change in air quality. The following heat-map style graphics are therefore just presented as examples how GEM-MACH model predictions might be used to give a visual

depiction of predicted air quality in and around a community. In the examples shown, a 70km-by-70km area centered on Conklin was used.

Although this type of analysis is based on predicted air quality which has inherent uncertainties associated with both the model input (i.e. emission estimates) and the model itself, the advantage is that it provides some information on how far air quality influences can extend based on emission source types and characteristics. This can be valuable for Indigenous communities with Traditional Territory or land-use areas of specific interests that do not have ambient air quality and/or deposition monitoring.

4.3.1 GEM-MACH Predictions (2018 Emissions) for SO₂

The following Figures are colour-coded depictions of GEM-MACH Model predicted annual average hourly SO₂ concentrations (ppb) under the different SO₂ emission scenarios, i.e. all regional emissions in the model emission inventory (Base Case), no regional industrial emissions (OS Zero Case) and no regional human activity related emissions (AnthZero Case) and, since there are issues with these predictions, they are shown as examples of how the data from different emission scenarios can be plotted and used.

4.3.1.1 GEM-MACH Model Predictions (2018 Emissions) for Annual Average Hourly SO₂ Levels with No Oil Sands or other Human Activity Emissions Influences (the AnthZero Scenario)

AnthZero SO₂ (ppb) - GEM-MACH -OS Run5

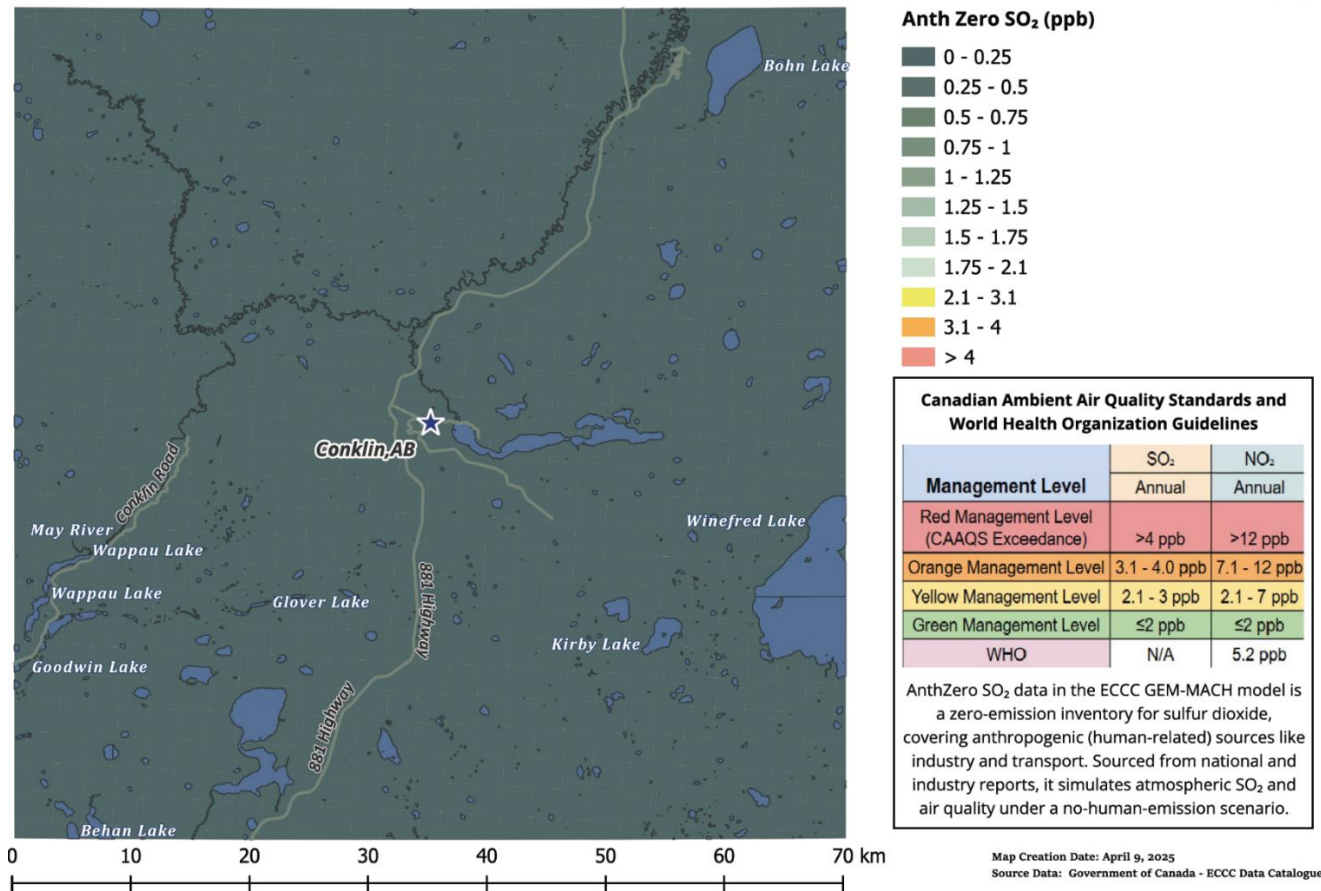
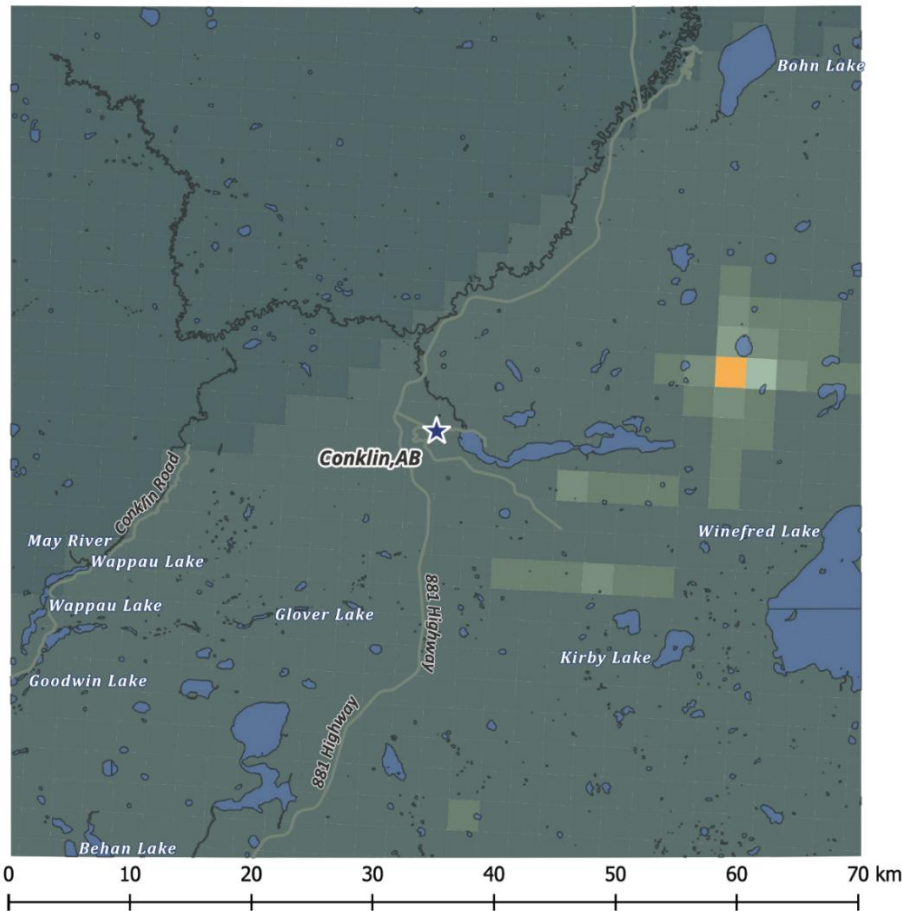


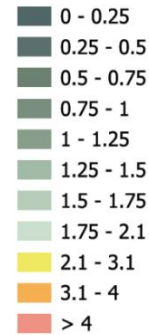
Figure 40: Colour Coded Depiction of GEM-MACH “No Anthropogenic Emissions” Annual Average Hourly SO₂ Concentrations in a 70km-by-70km area centred on Conklin (2018 Emission Inventory)

4.3.1.2 GEM-MACH Model Predictions (2018 Emissions) for Annual Average Hourly SO₂ Levels with No Industrial (Oil Sands) Emission Influences (the OSZero Scenario)

OS Zero SO₂ (ppb) - GEM-MACH -OS Run5



OS Zero SO₂ (ppb)



Canadian Ambient Air Quality Standards and World Health Organization Guidelines

| Management Level | SO ₂ | NO ₂ |
|---|-----------------|-----------------|
| | Annual | Annual |
| Red Management Level (CAAQS Exceedance) | >4 ppb | >12 ppb |
| Orange Management Level | 3.1 - 4.0 ppb | 7.1 - 12 ppb |
| Yellow Management Level | 2.1 - 3 ppb | 2.1 - 7 ppb |
| Green Management Level | ≤2 ppb | ≤2 ppb |
| WHO | N/A | 5.2 ppb |

OS Zero SO₂ data in the ECCC GEM-MACH model is a zero-emission Oil Sands scenario from national and industry sources, used to simulate atmospheric SO₂ and air quality.

Map Creation Date: April 9, 2025
Source Data: Government of Canada - ECCC Data Catalogue

Figure 41: Colour Coded Depiction of GEM-MACH “No Industrial Emissions” Annual Average Hourly SO₂ Concentrations in a 70km-by-70km area centred on Conklin (2018 Emission Inventory)

4.3.1.3 GEM-MACH Model Predictions (2018 Emissions) for Annual Average Hourly SO₂ Levels with All Oil and Other Human Activity Emission Influences (the BaseCase Scenario)

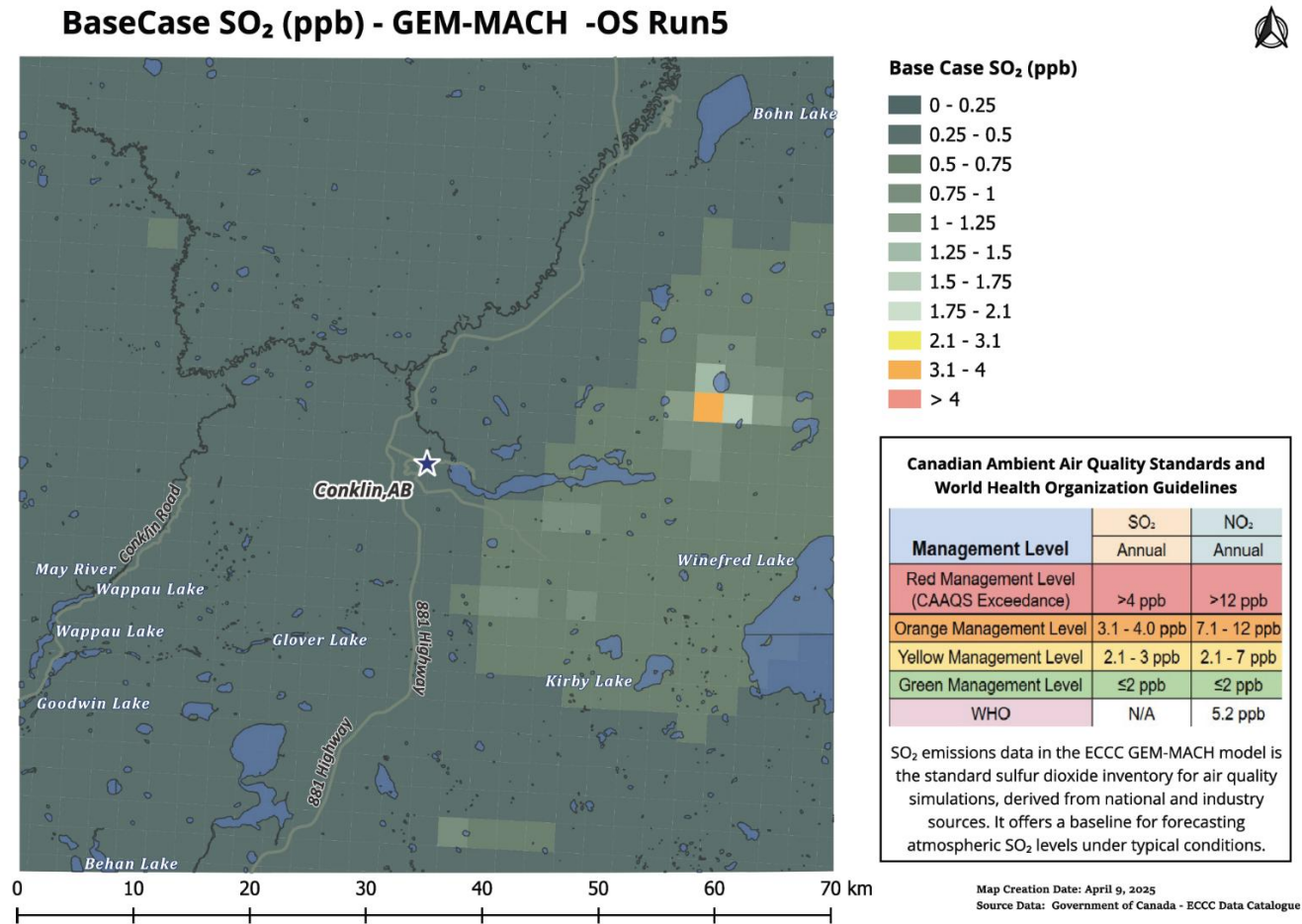


Figure 42: Colour Coded Depiction of GEM-MACH “All Emissions” Annual Average Hourly SO₂ Concentrations in a 70km-by-70km area centred on Conklin (2018 Emission Inventory)

In comparing the differences in concentrations shown in **Figure 40, Figure 41** and **Error! Reference source not found.**, it is difficult to distinguish some of the concentration changes associated with removing industrial emissions and all human activity emissions. **Figure 43** shows all the depictions together to allow an easier comparison of the concentration changes and the spatial extent of changes associated with removing the two emission source types compared to the predicted background, i.e. no human activity emission influences.

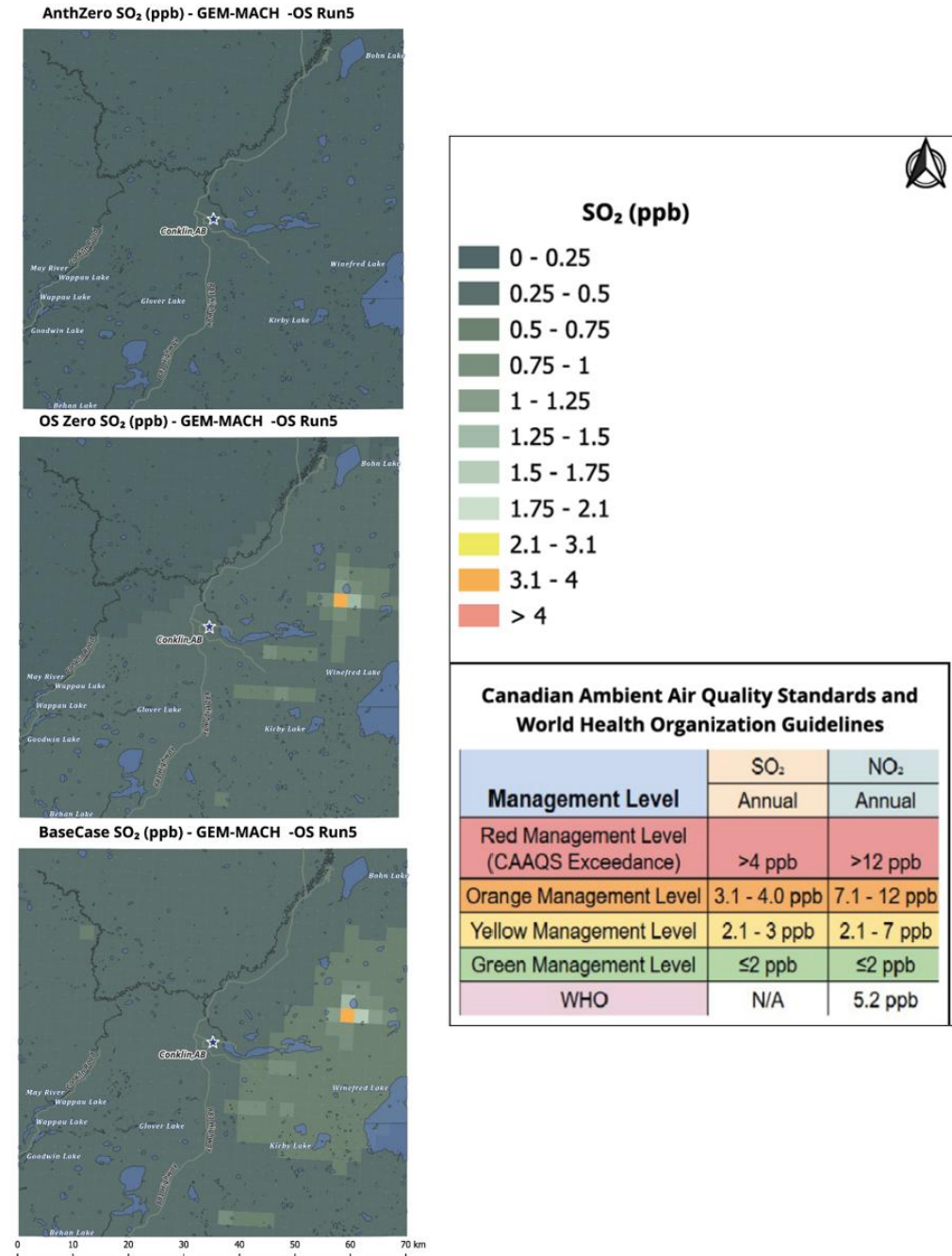


Figure 43: Model Predicted SO₂ Concentration Comparisons for the "No Anthropogenic Emissions" (top), "No Industrial Emissions" (middle) and "All Emissions" (bottom) Scenarios (2018 Emissions)

The top plate in **Figure 43** shows the SO₂ concentrations under the “No Anthropogenic Emissions” scenario with the entire 70-by-70km area a darker green, which indicates that SO₂ concentrations are in the 0.00-0.25 ppb range. The middle plate in **Figure 43** shows the SO₂ concentrations under the “No Industrial Emissions” scenario, i.e. only non-industry human activity-related SO₂ emissions. The bottom plate in **Figure 43** shows the SO₂ concentrations under the “All Emissions” scenario, i.e. the impact of all industry and non-industry human activities on SO₂ levels in the Conklin area. This clearly shows, as would be expected, that there is an impact on SO₂ in the Conklin area from SO₂ emissions. These impacts are greatest to the East to South area where the major oil sands industrial activities are located. These impacts are reflected in the lighter coloured cells in this area. As noted previously, while there are impacts, the annual levels of SO₂ are still at CAAQS “keeping clean areas clean” levels, except for the one grid cell at the Christiana Lake In-situ facility.

4.3.2 GEM-MACH NO₂ Predictions

The following Figures are colour-coded depictions of GEM-MACH Model predicted annual average hourly NO₂ concentrations (ppb) under the three different emission scenarios i.e. all regional emissions in the model emission inventory (Base Case), no regional industrial emissions (OS Zero Case) and no regional human activity related emissions (AnthZero Case). Since there are issues with these predictions, they are shown as examples of how the data from different emission scenarios can be plotted and used.

In comparing the differences in concentrations shown in **Figure 44**, **Figure 45** and **Figure 46** an indication of the difference in the significance of the different sources types can be determined recognizing that these Figures are not based on accurate emission allocations.

Figure 47 shows all the depictions together to allow an easier comparison of the concentration changes and the spatial extent of changes associated with removing the two emission source types compared to the predicted background i.e. no human activity emission.

4.3.2.1 GEM-MACH Model Predictions (2018 Emissions) for Annual Average Hourly NO₂ Levels with No Oil Sands or other Human Activity Emissions Influences (the AnthZero Scenario)

AnthZero NO₂ (ppb) - GEM-MACH -OS Run5

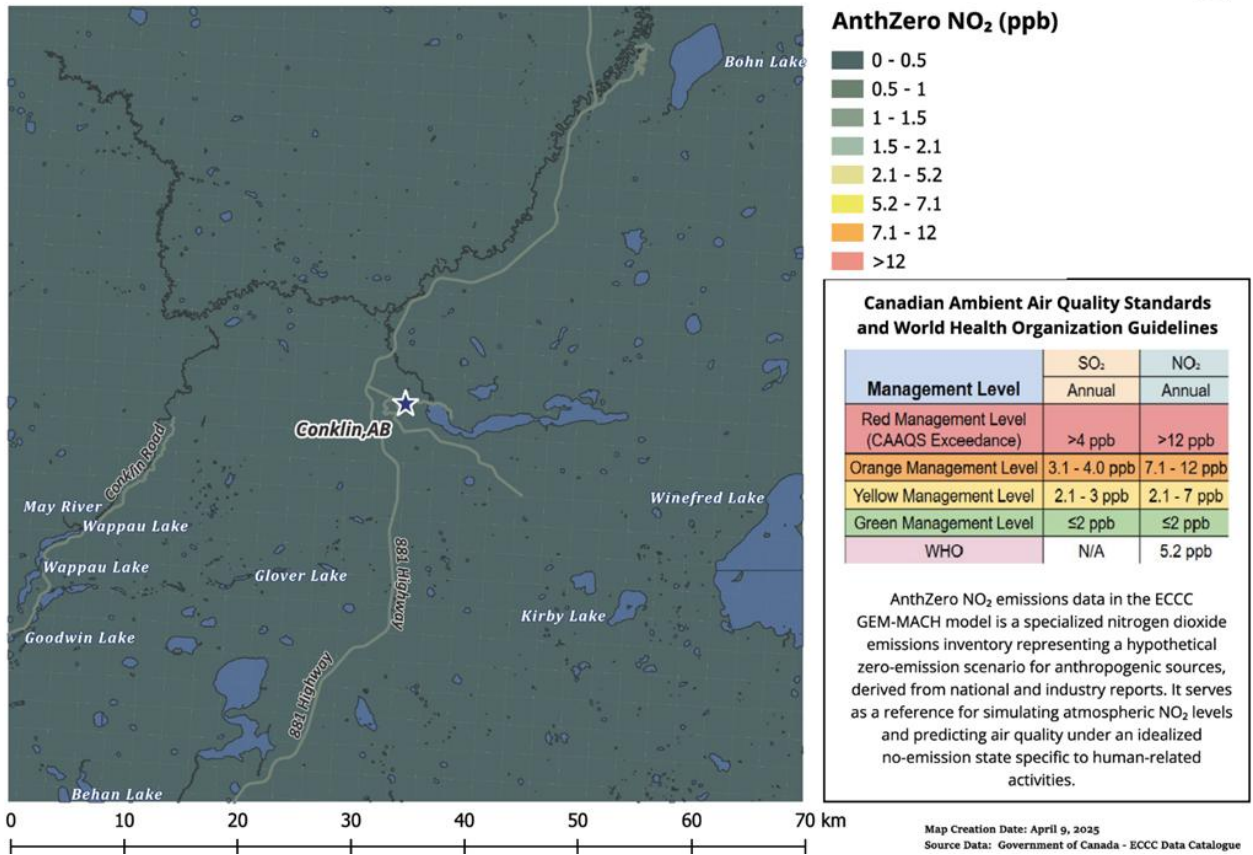


Figure 44: Colour Coded Depiction of GEM-MACH “No Anthropogenic Emissions” Annual Average Hourly NO₂ Concentrations in a 70km-by-70km area centred on Conklin (2018 Emission Inventory)

4.3.2.2 GEM-MACH Model Predictions (2018 Emissions) for Annual Average Hourly NO₂ Levels with No Industrial (Oil Sands) Emission Influences (the OSZero Scenario)

OSZero NO₂ (ppb) - GEM-MACH -OS Run5

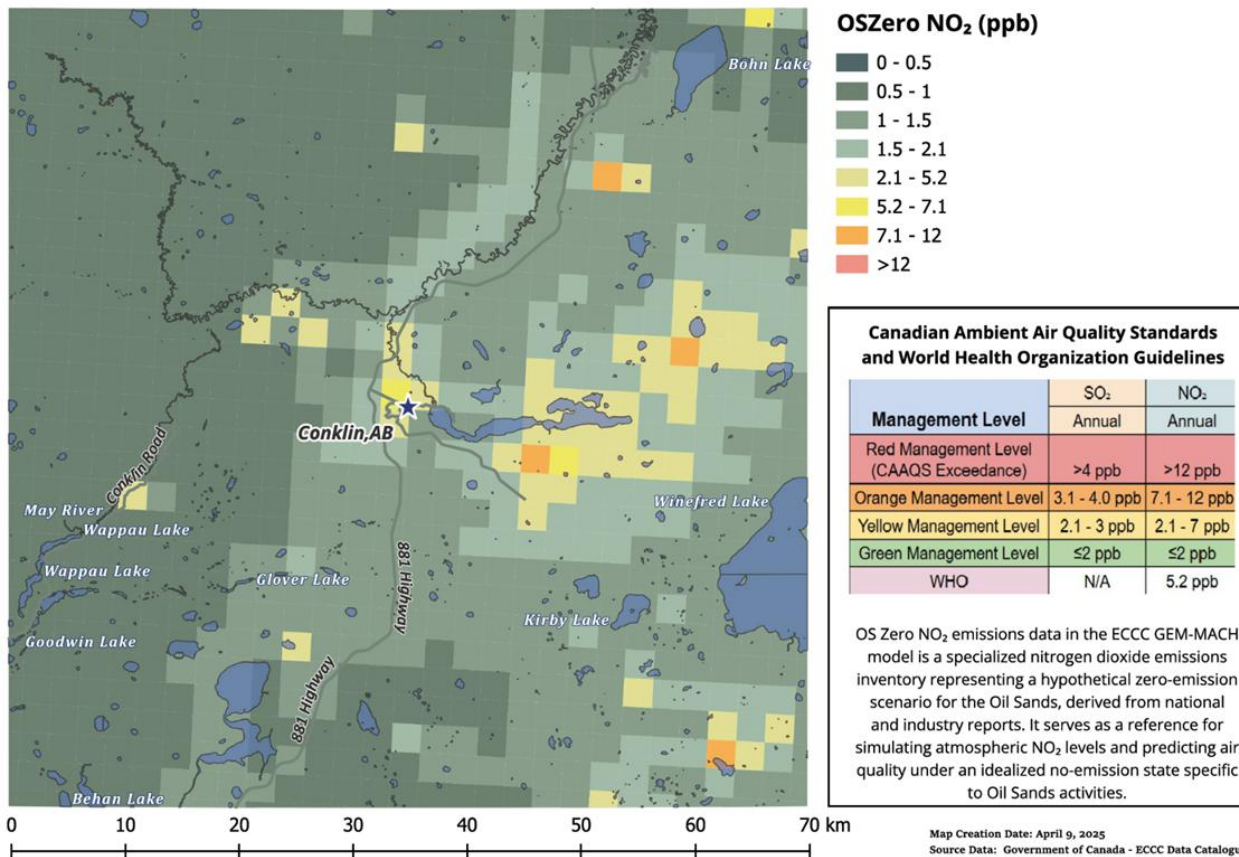


Figure 45: Colour Coded Depiction of GEM-MACH “No Industrial Emissions” Annual Average Hourly NO₂ Concentrations in a 70km-by-70km area centred on Conklin (2018 Emission Inventory)

4.3.2.3 GEM-MACH Model Predictions (2018 Emissions) for Annual Average Hourly NO₂ Levels with All Oil and Other Human Activity Emission Influences (the BaseCase Scenario)

BaseCase NO₂ (ppb) - GEM-MACH -OS Run5

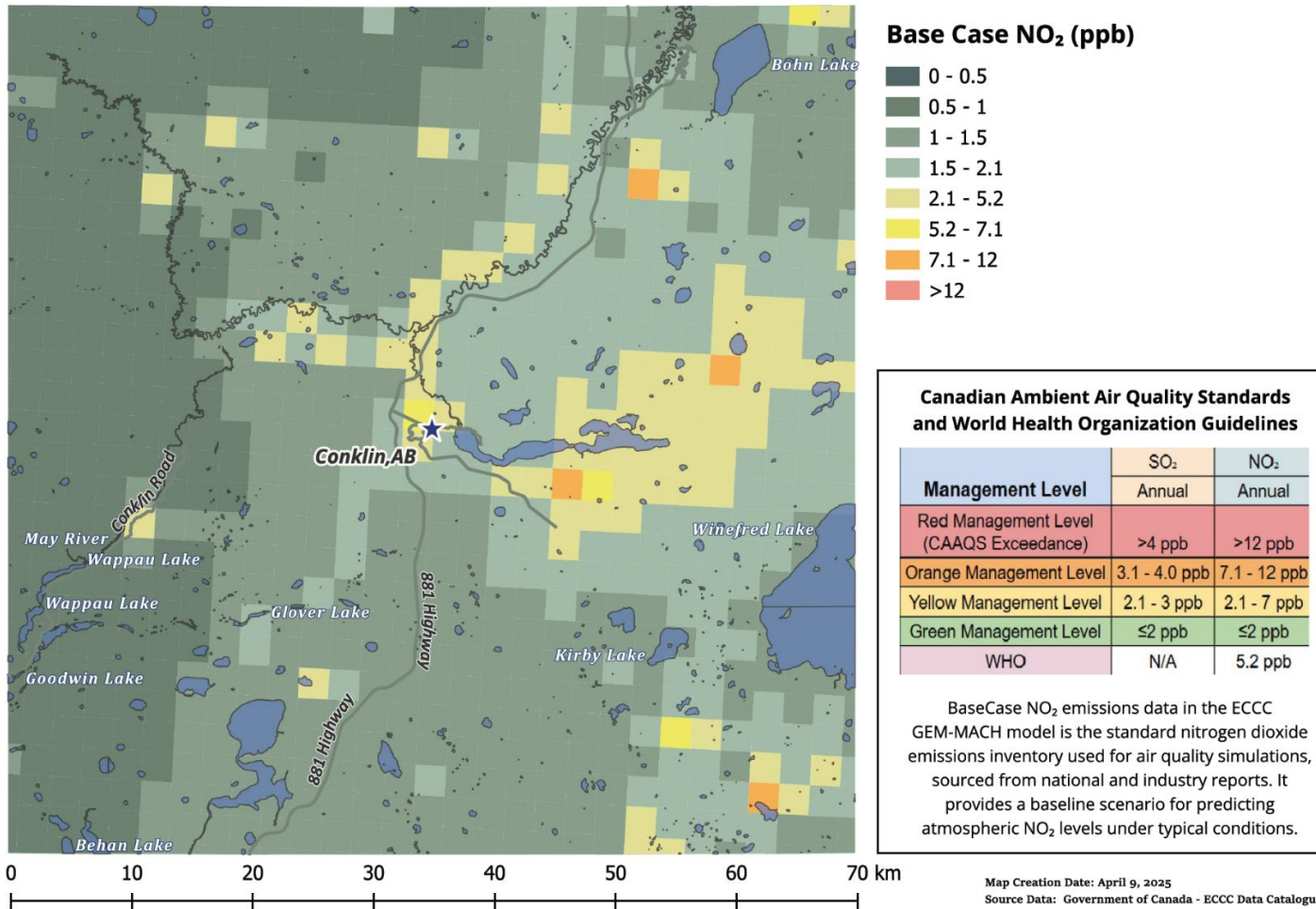
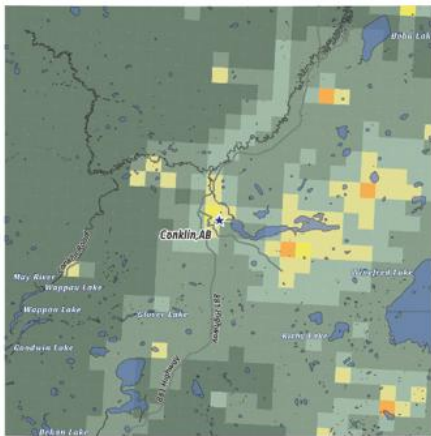


Figure 46: Colour Coded Depiction of GEM-MACH “All Emissions” Annual Average Hourly NO₂ Concentrations in a 70km-by-70km area centred on Conklin (2018 Emission Inventory)

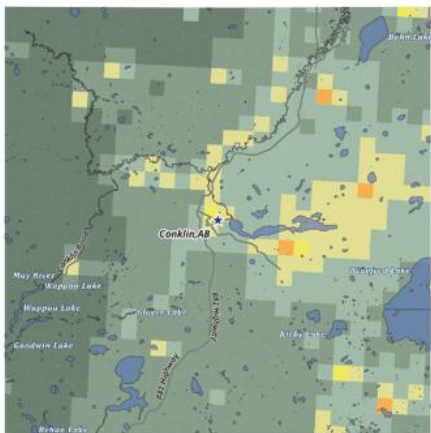
AnthZero NO₂ (ppb) - GEM-MACH -OS Run5



OSZero NO₂ (ppb) - GEM-MACH -OS Run5



BaseCase NO₂ (ppb) - GEM-MACH -OS Run5



0 10 20 30 40 50 60 70 km

NO₂ (ppb)



Canadian Ambient Air Quality Standards and World Health Organization Guidelines

| Management Level | SO ₂ | NO ₂ |
|--|-----------------|-----------------|
| | Annual | Annual |
| Red Management Level (CAAQS Exceedance) | >4 ppb | >12 ppb |
| Orange Management Level | 3.1 - 4.0 ppb | 7.1 - 12 ppb |
| Yellow Management Level | 2.1 - 3 ppb | 2.1 - 7 ppb |
| Green Management Level | ≤2 ppb | ≤2 ppb |
| WHO | N/A | 5.2 ppb |

Figure 47: Model Predicted NO₂ Concentration Comparisons for the “No Anthropogenic Emissions” (top), “No Industrial Emissions” (middle) and “All Emissions” (bottom) Scenarios

The top plate in **Figure 47** shows the NO₂ concentrations under the “No Anthropogenic Emissions” scenario with the entire 70-by-70km area in a darker green. This indicates that NO₂ concentrations are in the 0.00-0.5 ppb range, which is consistent with Fort McKay’s estimated regional background NO₂ level of approximately 0.45 ppb.

The middle plate in **Figure 43** shows the NO₂ concentrations under the “No Industrial Emissions” scenario i.e. only non-industry human activity related NO₂ emissions. This shows that there are a large number of “non-oil sands” related NO_x emissions that are influencing NO₂ levels in the Conklin area.

The bottom plate in **Figure 43** shows the NO₂ concentrations under the “All Emissions” scenario i.e. the impact of all industry and non-industry human activities on NO₂ levels in the Conklin area. This clearly shows, as would be expected, that there is an impact on NO₂ in the Conklin area from NO_x emissions. As with SO₂, these impacts are greatest in the East to South area where the major oil sands industrial activities are located. These impacts are reflected in the greater number of grid cells that are yellow.

In general, the model predictions relative to the CAAQS NO₂ management criteria and the WHO health risk-based annual NO₂ criteria would indicate that, except at the in-situ plant sites, the levels in the area are in the green or yellow levels and near or below the WHO health criteria.

For both the SO₂ and NO₂, GEM-MACH model predictions outlined above, it again needs to be noted that these are model predictions which are based on air emissions inventories that have a level of uncertainty. There are also other uncertainties associated with atmospheric modeling. However, despite these uncertainties, the model predictions provide a good general indication of the relative impact on air quality of different emission source types.

4.4. GEM-MACH Model Prediction Summary

The analysis of the GEM-MACH 2018 emission inventory-based model predictions under different emissions scenarios can provide insights into the influence that different regional emission source types have on air quality. While it is unfortunate that the Run 4 model predictions did not allocate all oil sands emissions to oil sands, overall, the GEM-MACH multi-scenario model predictions are very helpful in understanding the air quality influences associated with different emission source types and, in conjunction with wind direction analysis, can help communities better understand what is influencing its air quality and the magnitude of the different influences.

5 Study Summary

The study used air quality data from the air monitoring station in Conklin covering the period 2017-2024 to trial and assess different air quality analysis approaches. This station, and the other similar monitoring stations located in Indigenous communities in the Athabasca Oil Sands Region, are operated by WBEA (except in Fort Chipewyan where the community is a co-operator) provide comprehensive air quality data which facilitates the type of analyses undertaken in this study.

The intent of the study was to provide air quality analysis examples that would assist Indigenous communities in identifying air quality indicators and associated air quality criteria relevant to their concerns and interests.

The air quality parameters selected for analyses were: PM_{2.5}, PM₁₀, SO₂, NO₂, PAHs, THC, TRS, dustfall and the AQHI.

Five general air quality analysis approaches were used. Namely:

- Comparing air quality in Conklin for the above parameters against established air quality criteria to provide information on how current air quality in Conklin compares to different criteria and to identify possible air quality criteria the community might wish to adopt;
- Comparing THC and TRS measurements in Conklin against estimated odour potential levels, which are based on Fort McKay's extensive work on addressing odours in the community;
- Using the AQHI, which is determined based on hourly PM_{2.5}, NO₂, and O₃ concentrations, as a general real-time health risk indicator;
- Showing how air quality varied as a function of wind direction and in relation to the location of oil sands developments within a 35 km radius of Conklin to identify the emission sources that have a measurable impact on the Community's air quality; and
- Using recent Oil Sands Monitoring Program air dispersion and deposition modelling outputs to demonstrate how modelling different emission source types i.e. oil sands, oil sands stack sources, oil sands mine fleet, and anthropogenic sources, can provide additional information on the emission source influences having the greatest impact on the community's air quality.

Pre-oil sands development air quality baselines were estimated for all the pollutants analyzed. These baselines were presented relative to the measured levels and certain air quality criteria to provide a general indication of air quality changes associated with development in the region. It was noted that pollutants such as PM_{2.5}, PM₁₀, NO₂, PAHs and dust are associated with both natural and normal everyday human activities, and also long-range transport from outside the region. Therefore, it would be expected that measured values of these pollutants would be above a true background level.

The current air quality to criteria analyses shows that, in general, air quality in Conklin is good, with a few exceptions. NO₂ and SO₂ daily and annual levels in the community are in the CAAQS green management level and well below current health risk levels. Therefore, it is recommended that Conklin consider adopting the CAAQS "keeping clean areas clean" air quality criteria for SO₂ and NO₂.

The analyses found that at times annual PM_{2.5} and PM₁₀ levels in Conklin are near or above the WHO fully health risk-based criteria. Therefore, PM is an air quality issue that warrants further investigation as there may be local sources of these pollutants that could be reduced. A complication with PM_{2.5} and PM₁₀ analysis is the influence that wildfires have on the levels of these pollutants. While efforts were made in this analysis to remove wildfire influences, some wildfire influences may be contributing to the high annual PM_{2.5} and PM₁₀ findings.

Dust levels in the community fluctuate from month to month and can be elevated at times. Dustfall is related to PM₁₀ levels and associated larger-sized particle, and the analysis indicates that there may be local and/or near-region sources of dust contributing to dustfall levels. Therefore, it is recommended that, in any examination of possible sources contributing to the higher levels of PM_{2.5} and PM₁₀ in the community, possible dust sources be also examined.

PAH levels in the community were assessed against AAQOs and cancer risk criteria. The analysis found the levels of naphthalene and benzo(a)pyrene are well below current air quality objectives even when wildfire influences are included. The cumulative lifetime cancer risk associated with all the PAHs measured in the community by WBEA are much less than 1 per 100,000, which is considered a negligible

health risk by Health Canada. In terms of cancer risk, minimizing the risk is desirable and therefore efforts should continue to be made to minimize the levels and exposure to PAHs.

THC and TRS levels were compared to odour criteria established based on Fort McKay's experience in addressing odours in the community. Based on the use of THC and TRS concentrations as general indicators, the potential for odours in Conklin appears low.

AQHI values derived based on ambient PM_{2.5}, NO₂, and O₃ levels would indicate that air quality in Conklin is generally good to very good, with the AQHI almost always below 3 during non-wildfire influence periods which is considered low risk.

The GEM-MACH model output analyses could not be used to quantitatively assess the influence of different emission source types on air quality due to an emission allocation issue. Examples of how future model predictions could be analyzed and used would indicate that GEM-MACH modelling has the potential to provide significant insights into the impact that different emission source types have on air quality at a given location.

The study would indicate that collectively the five analyses approaches used can provide air quality level and influence information that can assist Indigenous communities in establishing community-based air quality indicators and associated criteria that addresses each Community's needs and interests.

6 Integration with Indigenous Knowledge/ Perspective and Application of Analysis Approach to Other Communities

The analyses undertaken in this study were conducted primarily based on a western-science perspective. Prior to expanding the analyses to other communities (Fort Chipewyan, Fort McKay, Janvier, and Anzac), the study findings summarized in Section 5 should be presented to community representatives for feedback. Some conclusions, such as the general location of sources have the greatest influence on certain air quality parameters in Conklin are objective and evidence-based, whereas others like the potential for odour (based on TRS and THC measurements), require verification based on the community's lived experience.

Likewise, the recommendations on the relevant air quality indicators and criteria to adopt require further discussions with, and feedback from, the communities, recognizing that each community may have a different perspective on what constitutes good air quality, particularly given the complexity of bio-physical, health, and socio-economic influences that oil sands developments have on each community. Indigenous knowledge and each community's perspective are essential components of such a study.

Upon consulting with Conklin and other Indigenous communities on the air quality indicator analysis approaches and findings presented, further analyses can occur with the same, or a tailored approach for each community. In terms of formalizing air quality indicators and air quality criteria, communities with the ability to pass bylaws may consider the approach taken by Fort McKay First Nation which involved developing community ambient air quality permissible levels and incorporating these into a bylaw.

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Appendices

Appendix 1 Information relevant to the selection of PM, PAHs, SO₂, NO₂, THC/TRS, Dustfall and AQHI as Air Quality Parameters/Indicators of Interest in the Context of Air Quality in Indigenous Communities in the RMWB

Appendix 1.1. Particulate Matter (PM)

Particulate matter (PM) is a wide-spread air pollutant consisting of both solid and liquid particles and is an air pollutant that can have significant health and/or environmental impacts (WHO, 2013; Manisalidis, Stavropoulou, Stavropoulou, & Berzirtzoulou, 2020). PM can be emitted directly into the atmosphere (primary PM) or can be formed in the atmosphere through gas-to-particle conversion (secondary PM) with the PM's chemical composition dependent on the characteristics and nature of its sources (Zhang, et al., 2015). Oil sands developments are a major source of both direct PM emissions and PM precursors, e.g. VOC, SO₂, NO_x and ammonia (ECCC and AEP, 2016; Zhang, et al., 2018; Whaley, et al., 2018).

Particulate matter (PM) is generally classified based on a standardized aerodynamic diameter which has units of micrometer (µm). The commonly used concentration size ranges are: ultra-fine PM (<0.1 µm); fine PM (<2.5 µm); coarse PM (<10 µm), coarse fraction PM (2.5-10 µm), total suspended particulate (TSP) (all sizes) and ultra-coarse PM (>10 µm) (Wilson & Suh, 1997; Kwon, Ryu, & Carlsten, 2020).

The health and environmental impacts of PM are related to both its composition and particle size. Particle size is important because it determines how deeply into the lung the particle can penetrate and particle composition determines the nature and magnitude of any associated health impact (Brown, Gordon, Price, & Asgharian, 2013; Thomson, et al., 2015; Thomson, et al., 2016). In addition to being a dust nuisance factor, PM associated with fugitive dust can be a concern from the health and environment perspective. The spatial distribution and potential environmental impacts associated with PM deposition have been studied in the OSR using tracer elements or compounds such as metals, metalloids and PAHs all of which are associated with industrial processes, mining activities and tailings ponds (Zhang, et al., 2016; Shotyk, et al., 2016; Shotyk, 2020; Dennett, et al., 2023) with emission source profiles used to relate measured deposition to likely or possible oil sands emission sources and/or types.

There are many air quality impacts associated with PM and both Alberta and Canada have PM air quality criteria. Alberta has ambient air quality objectives (AAAQOs) for PM_{2.5} (daily average) and TSP and ambient air quality guidelines (AAAQGs) for dustfall and PM_{2.5} (hourly) ([Alberta Ambient Air Quality Objectives and Guidelines | Alberta.ca](https://www.alberta.ca/amb-air-quality-objectives-and-guidelines.aspx)). Canada has Ambient Air Quality Standards (CAAQS) for PM_{2.5} (<https://ccme.ca/en/air-quality-report>). The World Health Organization recently updated its Air Quality Guidelines (WHO AQGs) with the new guidelines solely based on health risk (WHO, 2021). Ambient PM levels can be compared to these different air quality criteria to provide an indication of the potential significance of the PM level being measured.

PM is therefore a parameter of interest in terms of its potential health and environmental impacts. In the context of this study, PM was selected for analysis because the size fraction of PM provides insights into the source of the PM particles with PM<0.1 and PM_{2.5} generally associated with combustion and other anthropogenic sources and coarse particles (PM_{>2.5}) which are generally associated with crustal

material and often referred to as dust (Celo, Yassine, & Dabek-Zlotorzynska, 2021; Kwon, Ryu, & Carlsten, 2020; Abuelgasim & Farahat, 2020; WHO, 2021). PM size fractions can therefore be used as an indicator of the nature of the sources influencing PM levels at a location, and that is how PM data will be used in this study. How this is done is outlined in the report Section 2.3.6.

The size, concentration, and composition of particulate matter at a specific location and time are influenced by numerous factors, including wind speed, wind direction, temperature, and the proximity and characteristics of local and regional emission sources, as well as dust sources. Wildfires can be significant contributors to PM levels; however, when the focus of an air quality analysis is on the impacts related to oil sands development, it is necessary to exclude wildfire-related PM from datasets. The ratio of PM_{2.5} to PM₁₀ concentrations at a given location and time can offer valuable insights into the nature of the sources affecting PM levels.

All five WBEA indigenous community AMSs in the RMWB continuously monitor PM_{2.5} and PM₁₀ and conduct time-integrated (24-hour every six days) sampling for these particulates. This study analyzed data from this PM sampling at Conklin.

Appendix 1.2. Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of carbon compounds consisting of two or more benzene rings with smaller PAHs e.g. 2-rings, existing largely in the gas phase, larger PAHs e.g. 5 or more rings existing in particulate form, and 3 and 4 ringed PAHs existing in either the gas or particle phase depending on a number of concentration and atmospheric factors (Finlayson-Pitts & Pitts, Jr., 2000). PAHs are a subset of a larger group of compounds referred to as polycyclic organic matter (POM) which also includes a group of compounds referred to as polycyclic aromatic compounds (PACs) (Finlayson-Pitts & Pitts, Jr., 2000). A subset of PAHs has been the focus of air quality measurement and study based on their designation by the U.S. Environmental Protection Agency (USEPA) as “priority PAH pollutants” (Andersson & Achten, 2015a). It is now recognized that PACs need to be considered when studying air quality related issues associated with POMs (Andersson & Achten, 2015b).

There are both natural e.g. wildfire, and anthropogenic e.g. vehicle emissions, sources of PAHs and PACs with incomplete combustion and petroleum product handling and processing all sources of PAH emissions (Baek, et al., 1991; Patel, Shaikh, Jain, Desal, & Madamwar, 2020) which are PAH emission sources relevant to the oil sands. Many PAHs have toxic properties with PAHs considered to be one of toxic constituents in PM (Yang, et al., 2021; U.S. ATSDR., 1995; WHO, 2021; Wallace & Hobbs, 2006).

Specific oil sands related PAH/PAC emissions sources include: oil sands related dust sources (Wang, et al., 2015; Landis, et al., 2019); mine fleet exhaust and bitumen processing stack sources (Watson, et al., 2011; Watson, Chow, Wang, Kohl, & Sodeman, 2010; Landis, et al., 2019); bitumen exposed areas and bitumen products e.g. coke piles (Landis, et al., 2019); and tailings ponds (Galarneau, Hollebhone, Yang, & Schuster, 2014; Moradi, et al., 2021). The magnitude of PAH/PAC emissions from different emission source types in the OSR was estimated by (Qui, et al., 2018).

A number of PAH/PAC pollutant deposition studies involving different receptor and deposition measurement techniques i.e. snowpack, precipitation, lichens, moss, lake sediment and passive dry deposition samplers, the results of which are summarized by Harner, et al., (2018) and indicate that oil sands operations are a significant contributor to PAH/PAC deposition in the oil sands region (OSR). In terms of the analysis being conducted as part of this study, of particular relevance is the study

conducted by Hsu, Harner, Li, & Fellin (2015) which examined the ambient air concentration of PAHs in four community stations in the OSR for 2013 and 2014 and which used co-pollutant concentration data to link to OS emissions to measured PAH/PAC concentration. To the authors' knowledge, no similar subsequent analysis of community PAH/PAC data has been conducted, and this study attempts to address this gap. In addition to assessing PAH levels in Indigenous Communities in the RMWB relative to PAH air quality criteria, analyzing PAH levels in communities relative to other air quality parameters e.g. PM, SO₂ and NO₂, can provide insights to the nature of the sources contributing to PAH levels in these communities (Wnorowski, Characterization of the ambient air content of parent polycyclic aromatic hydrocarbons in the Fort McKay region (Canada), 2017).

Alberta ([Alberta Ambient Air Quality Objectives and Guidelines | Alberta.ca](https://www.alberta.ca/Alberta-Ambient-Air-Quality-Objectives-and-Guidelines.aspx)), Canada (https://publications.gc.ca/collections/collection_2021/sc-hc/H129-108-2021-eng.pdf) and the European Union (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202402881) all have health related air quality criteria that can be used to assess the possible health significance of PAH levels being measured at a location.

At all five WBEA indigenous community AMSs, WBEA performs time-integrated (24-hour every six days) sampling for PAHs, and the PAH data for Conklin from this sampling was analyzed as part of this study.

Appendix 1.3. Sulphur Dioxide (SO₂)

Ambient SO₂ levels are almost exclusively anthropogenic/industrial activity related and therefore the ambient levels of SO₂ emission in OSR can be directly related to oil sands emissions with minimal to no community related influences. SO₂ emissions in the OSR are almost exclusively from stack sources associated with bitumen upgrading, burning of fuels containing sulphur, e.g. produced gas at steam assisted gravity drainage (SAGD) facilities and coke at oil sands upgraders, and gas flaring (ECCC and AEP, 2016; Zhang, et al., 2018).

Satellite imagery shows OS emissions influence ambient air SO₂ levels over a large spatial area with the levels generally relatively low (McLinden, et al., 2012; McLinden, et al., 2016). SO₂ emissions in the OSR have been declining as a result of emission reduction and fuel switching, however, the impacts of these emission reduction measures on ambient air quality SO₂ levels does not appear to be as great as was expected (McLinden C. A., et al., 2021).

A major environmental concern related to regional SO₂ emissions is the potential for resultant acid deposition levels that exceed critical loads and it was this concern that lead to the WBEA Forest Health Monitoring Program(FHMP) (Foster, Davidson, Tanna, & Spink, 2019). Based on the FHMP, SO₂ emissions remain a potential acid deposition impact issue, but nitrogen deposition and associated eutrophication/fertilization impacts resulting from regional NO_x emissions may be a greater impact issue (Davidson, Foster, & Tanna, 2020).

Alberta and Canada both have SO₂ ambient air quality criteria. Alberta has 1-hr, 24-hr, monthly and annual ambient air quality objectives (AAQOs) for SO₂ ([Alberta Ambient Air Quality Objectives and Guidelines | Alberta.ca](https://www.alberta.ca/Alberta-Ambient-Air-Quality-Objectives-and-Guidelines.aspx)). Canada has hourly and annual Ambient Air Quality Standards (CAAQS) for SO₂ (<https://ccme.ca/en/air-quality-report>). The World Health Organization recently updated its Air Quality Guidelines (WHO AQGs) for SO₂ with the new guidelines solely based on health risk (WHO, 2021). Ambient SO₂ levels can be compared to these different air quality criteria to provide an indication of the potential significance of the SO₂ level being measured. Ambient SO₂ levels can also be compared to

baseline levels, if available, to provide an indication of the impact that emission sources are having on ambient SO₂ levels.

In this study SO₂, is also used as a marker of industrial source influences and when appropriate used as a source indicator for other parameters.

Continuous monitoring of SO₂ is conducted by all five indigenous community air monitoring stations (AMSS) within the Wood Buffalo Environmental Association (WBEA). The data collected for Conklin through this SO₂ monitoring was analyzed as part of this study.

Appendix 1.4. Nitrogen Dioxide (NO₂)

Ambient NO₂ levels are influenced by both natural e.g. lightning, soil emissions and wildfires, and anthropogenic sources with oil sands operations having large NO_x emissions from both stack sources and mine fleets (ECCC and AEP, 2016). NO_x (NO+NO₂) emissions contribute directly to ambient NO₂ levels, or through NO reactions in the atmospheric, which occur quickly, and result in the formation of NO₂ (Colls, 2002). NO₂ has both health (Health Canada, 2016; Health Canada, 2021) and environmental impacts (USEPA, 2020). In terms of environmental impacts in the OSR, NO_x emissions influence acid deposition levels and nitrogen fertilization deposition levels (Foster, Davidson, Tanna, & Spink, 2019; Davidson, Foster, & Tanna, 2020; Cho, et al., 2017) and also ozone formation (Vijayaraghavan, et al., 2016; Cho, et al., 2012).

Similar to SO₂, satellite imagery shows that OS NO_x emissions influence ambient air NO₂ levels over a large spatial area (McLinden, et al., 2012; McLinden, et al., 2016). There are numerous NO_x emission sources in the OSR with NO_x emissions resulting in NO₂ formation. The primary NO_x sources include oil sands development activities such as mine fleets, boilers, and co-generation units. NO₂ is a significant air quality parameter due to its health and environmental impacts.

Alberta and Canada both have NO₂ ambient air quality criteria. Alberta has 1-hr, 24-hr, monthly and annual ambient air quality objectives (AAQOs) for NO₂ ([Alberta Ambient Air Quality Objectives and Guidelines | Alberta.ca](#)). Canada has hourly and annual Ambient Air Quality Standards (CAAQS) for NO₂ (<https://ccme.ca/en/air-quality-report>). The World Health Organization recently updated its Air Quality Guidelines (WHO AQGs) for NO₂ with the new guidelines solely based on health risk (WHO, 2021). Ambient NO₂ levels can be compared to these different air quality criteria to provide an indication of the potential significance of the NO₂ level being measured. Ambient NO₂ levels can also be compared to baseline levels, if available, to provide an indication of the impact that emission sources are having on ambient NO₂ levels.

There are established ambient air quality criteria for NO₂ and nitrogen critical load criteria for soils based on both acidifying and eutrophying effects. NO₂ is continuously monitored at all five WBEA indigenous community AMSS. The data from this NO₂ sampling for Conklin was analyzed as part of this study.

Appendix 1.5. Odours/Total Hydrocarbons (THCs)/Total Reduced Sulphur (TRS)

Odours are an air quality impact issue associated with oil sands development. Odours are a challenging and complicated issue to address from an air quality management standpoint because of the wide range of compounds that can contribute to odours and the difficulty in directly linking the concentrations of

individual substances to odour responses (Schiffman & Williams, 2005; Horb, et al., 2021; Gossel, et al., 2010). Both volatile organic compounds (VOCs) and reduced sulphur compounds (RSC) have been linked to odours (Bhandari, et al., 2024) and oil sands operations are a source of both VOC and RSC emissions (O'Brien, Percy, & Legge, 2012; O'Brien, 2014; Small, Cho, Hashisho, & Ulrich, 2015; ECCC and AEP, 2016; Alberta Energy Regulator and Alberta Health, 2016; Horb, et al., 2021). The challenge in developing indicators and criteria for odours is linking air quality measurements to odour occurrence likelihood.

The community of Fort McKay, which has experienced significant odour issues since oil sands development commenced, has developed criteria related to assessing and linking air quality to odours (Dennis, Spink, Abel, & Stuckless, 2015). As part of its efforts to address odour issues, Fort McKay developed a Fort McKay Air Quality Index (FMAQI) that translates ambient air quality measurements into a “likelihood of odour” scale. The basis for, and calculation of, the current FMAQI is presented in Appendix 2. The FMAQI uses continuous total hydrocarbon (THC) and continuous total reduced sulphur (TRS) levels to estimate the likelihood of odours being present. Both THC and TRS are measured continuously at all the Indigenous community monitoring stations and the possible application of a Fort McKay like approach for assessing odour potential in Conklin was included in this analysis.

Appendix 1.6. Dustfall

Dustfall refers to the mass of airborne particles that settle onto surfaces, with larger particles being the primary contributors. Measurement of dustfall in the region commenced in November 2022. Except for Fort McKay, data collection was paused in October 2024 to evaluate the two years of collected data. During this period, monthly dustfall samples were gathered at Conklin, Janvier, Anzac, and Fort McKay, which serve as the basis for the analysis of potential odour issues in Conklin. Based on a Fort McKay ICBM Dust Project, the authors have been using $PM_{2.5}/PM_{10}$ ratios as an indicator of dust potential. Since both $PM_{2.5}$ and PM_{10} are continuously monitored in all communities, $PM_{2.5}/PM_{10}$ ratios, in Conklin were analyzed in the context dust potential.

Appendix 1.7. Health Risks as Related to Air Quality

How oil sands air emissions may be impacting health is a common question, and concern, of Indigenous Communities. The effects of air pollution on health depends on several factors which include (Health Canada, 2019; WHO, 2014):

- the specific air contaminant(s) present;
- the background (normal) levels of the air contaminant(s)
- the specific health effects associated with the contaminant(s);
- the exposure pathways and level, duration and frequency of the exposure to the contaminant(s); and
- the susceptibility of the individual or population to effects of the air contaminant(s).

Attempting to assess the potential health effects of air quality on Indigenous Communities is well beyond both the scope of these analyses and the expertise of the authors. However, the Air Quality Health Index (AQHI), which is a multi-pollutant health related air quality measure, can, in near real-time, provide relevant air quality and health information to Community members.

The WBEA has been calculating and reporting the AQHI for over 10 years and started reporting the AQHI for Conklin when continuous monitoring started in the community in 2016. The WBEA website⁷ notes that:

“Each individual reacts differently to air pollution. If you are part of the at-risk population, use the AQHI to assess the immediate risk air pollution poses to your health and take steps to lessen that risk. Even if you are relatively healthy, fit, and active, you can consult the AQHI to decide when and how much activity to undertake outdoors.”

Real-time AQHI data is available from the WBEA website and from portable devices through the WeatherCAN app⁸.

The use of the AQHI as a health-based and relevant air quality indicator would therefore appear relevant for Indigenous communities which are also familiar with the AQHI through the health advisories associated with wildfire events.

An analysis of AQHI values in Conklin was undertaken to provide information on the typical levels in the community and any possible changes over the last 8 years.

⁷ <https://wbea.org/monitoring-programs/ambient-air-monitoring/rmwb-air-quality-monitoring/#aqhiccontent>

⁸ <https://www.canada.ca/en/environment-climate-change/services/weather-general-tools-resources/weathercan.html#toc1can>

Appendix 2 Fort McKay's Air Quality Index (FMAQI)

(Updated by David Spink, February 2020)

Introduction: Fort McKay's air quality is impacted by industrial emissions in the region. The current and previous air quality indexes used by Alberta Environment and Parks often report(ed) good air quality in Fort McKay when the sensory perception of air quality by community members e.g. odours and nasal, throat and/or eye irritation, clearly indicated that the air quality was not good. Many community members are very concerned about the quality of the air and often ask their scientists and the Fort McKay Sustainability Department the question: "*what is the real quality of our air?*" To try and answer this question Fort McKay's air and health scientists developed a "*community-specific*" Fort McKay air quality index (FMAQI). This index attempts to provide a general but representative indication and measure of the air quality in the Community. It is based on the continuous measurements of several common air contaminants, the potential health effects of certain of these contaminants and empirically determined relationships between the concentration of some of these air contaminants and community members' sensory perception of air quality. The contaminants used in the index are: sulphur dioxide (SO₂); fine particulate matter (PM_{2.5}); nitrogen dioxide (NO₂); ozone (O₃); total reduced sulphur (TRS); and total hydrocarbon (THC). All these contaminants are continuously measured at the Wood Buffalo Environmental Association (WBEA) Air Monitoring Station #1 (Bertha Ganter) located at the North end of the community. The measurements at this location are considered by Fort McKay's scientists to be generally representative of average air quality in the community.

The Approach used to develop the Fort McKay AQI (FMAQI): The goal in developing a "*community specific*" AQI was to have an index:

- based on health and general air quality considerations that considered and reflected air quality in the context of Fort McKay's location and its air quality expectations;
- covering the major air quality parameters that are most relevant to air quality in Fort McKay;
- reflecting air quality limits and criteria that represent a reasonable and defensible measure of air quality; and
- accepted by community members as a reliable indicator, and reasonable representation, of their sensory-based assessment of air quality.

In developing the FMAQI past existing provincial and/or federal AQIs were evaluated.

Health Canada has an Air Quality Health Index (AQHI). The Health Canada AQHI covers three parameters (NO₂, PM_{2.5} and O₃) that are combined using weighting factors for each contaminant and are reported as a three-hour running average. The AQHI is based solely on health. It is considered a good health-based index and therefore was incorporated into the FMAQI. However, this index only covers some of the air quality parameters of interest and relevance to Fort McKay and therefore additional parameters needed to be used to give an AQI relevant to Fort McKay.

In 2012 Alberta Environment and Sustainable Resource Development adopted the Health Canada AQHI with a modification that involves also comparing SO₂, PM_{2.5}, NO₂, O₃ and carbon monoxide (CO) to Alberta's Ambient Air Quality Objectives (AAQOs). If hourly air pollutant concentrations are higher than Alberta's AAQOs, then the AQHI value is replaced with the appropriate "*High*" or "*Very High*" risk value. There is also an odour-related message when hydrogen sulphide (H₂S) or TRS odour-based

concentrations exceed specified thresholds. Modifications to the odour-related criteria are currently being considered.

AAAQOs are not strictly health-based, and do not necessarily reflect good air quality. The current AAAQO for H₂S/TRS is also well above odour detection and nuisance levels. Therefore, the Provincial modified AQHI was not considered an appropriate air quality index for Fort McKay. However, the general approach used by the Provincial, i.e. to modify the AQHI, was the concept used in the development of the FMAQI.

Parameters Covered by Fort McKay's AQI: The FMAQI covers the following parameters:

- **Sulphur dioxide (SO₂)** – SO₂ levels in Fort McKay are largely associated with emissions related to coking, coke burning and/or coker gas clean-up from Suncor, Syncrude and CNRL, and are generally low but at times can reach elevated levels.
- **Nitrogen dioxide (NO₂)** – NO₂ levels in Fort McKay have been steadily increasing as all industrial operators have NO_x emissions and at times NO₂ levels in the community reach elevated levels.
- **Particulate Matter less than 2.5 microns in size (PM_{2.5})** – PM_{2.5} levels in Fort McKay are influenced by natural sources such as forest fires, and by industrial emissions, including dust emissions, from all companies, but principally from Suncor and Syncrude.
- **Ozone (O₃)** – O₃ occurs naturally but the emissions of NO_x and volatile organic compounds (VOCs) (from for example tailings ponds) can result in elevated levels of ground-level ozone and this sometimes occurs in Fort McKay in the summer. Ozone levels also increase during forest fire events.
- **Total Hydrocarbons (THC)** – THC is a single measure of the total amount hydrocarbon compounds found in the air. Some of these hydrocarbons are naturally occurring e.g. emitted by vegetation, and others are associated with human activity e.g. transportation and industrial emissions. In Fort McKay, increased THC levels are largely associated with tailings pond emissions and some stack emissions from Suncor and Syncrude. Elevated i.e. above background, THC levels frequently occur in Fort McKay and are often associated with odour episodes.
- **Total Reduced Sulphur (TRS)** – TRS is a single measure for all the reduced sulphur compounds (RSCs) present in the air. RSCs compounds are noted for their strong odours even at very low concentration i.e. less than parts per billion (ppb) levels. Some RSCs are naturally occurring e.g. carbonyl sulphide, but most are related to human activity e.g. waste and wastewater treatment, confined livestock operations and industrial activities. While there are many RSC emissions associated with oil sands facilities, it appears that tailings ponds and flares are likely responsible for most of the odour episodes in Fort McKay. While TRS levels can be an indicator of odours, particularly when measured TRS levels exceed a certain threshold, at low TRS levels odours can still occur. This happens when the reduced sulphur compounds present have very low odour thresholds and therefore small concentration increases, which are not detectable by the TRS measurement technique, result in odours. For this reason, the Fort McKay Sustainability Department started the community odour-event based canister sampling program in 2010. The sampling and analysis methodology used in this program was able to detect low concentrations of individual reduced sulphur compounds and provided some

insights into the RSCs likely contributing to odours in Fort McKay and at what concentrations. This information informed the AQI values used in the FMAQI. The approach used for TRS in the FMAQI is based on trying to set a scale where “fair” air quality would indicate when some community members might detect a slight odour and where “poor/very poor” would reflect TRS levels that would result in many community members experiencing strong odours. Since TRS is a very general and non-specific measure of reduced sulphur compounds, there may be times when there are strong odours in the community and the FMAQI is showing “good” air quality and there may be times when the FMAQI is reporting “poor/very poor” air quality when odours are not present. The experience to date is that the FMAQI is a good indicator of odour potential.

(Note: **Carbon monoxide** (CO) was not included in the “community specific” AQI because it is never found at levels that are considered to represent an air quality issue in Fort McKay.)

Limitations and Caveats: The FMAQI is based on short term air quality and possible related health implications and the **FMAQI DOES NOT ADDRESS POSSIBLE LONG-TERM HEALTH AND AIR QUALITY ISSUES.**

While TRS levels can be an indicator of odours, particularly when measured TRS levels exceed a certain threshold, at low TRS levels odours can still occur. This happens when the reduced sulphur compounds present have very low odour thresholds and therefore small concentration increases, which are not detectable by the TRS measurement technique, result in odours. For this reason, the Fort McKay Sustainability Department started the community odour-event based canister sampling program in 2010. The sampling and analysis methodology used in this program was able to detect low concentrations of individual reduced sulphur compounds and provided some insights into the RSCs likely contributing to odours in Fort McKay and at what concentrations. This information informed the AQI values used in the FMAQI. The approach used for TRS in the FMAQI is based on trying to set a scale where “fair” air quality would indicate when some community members might detect a slight odour and where “poor/very poor” would reflect TRS levels that would result in many community members experiencing strong odours. Since TRS is a very general and non-specific measure of reduced sulphur compounds, there may be times when there are strong odours in the community and the FMAQI is showing “good” air quality and there may be times when the FMAQI is reporting “poor/very poor” air quality when odours are not present. The experience to date is that the FMAQI is a good indicator of odour potential and odour **THE INDEX DOES NOT FULLY ADDRESS ODOURS AND EVEN THOUGH THE FMAQI INDICATES A “GOOD” AIR QUALITY ODOURS MAY BE PRESENT.**

How the AQI is calculated: The FMAQI is calculated as follows:

1. Level 1 air quality for Fort McKay (AMS#1) is downloaded for the WBEA website (<http://wbea.org>) for the period of interest;
2. The data is entered into an EXCEL spreadsheet that has been developed to automatically calculate and plot the FMAQI;

3. **NO₂, O₃, and PM_{2.5}** - The Health Canada AQHI is calculated for NO₂, O₃, and PM_{2.5} and this becomes the AQI for these three parameters;

4. **TRS** - The hourly TRS value is put into a logarithmic equation i.e. natural log (Ln) of TRS reading in ppb times 4 plus 5 to give a TRS AQI value i.e. $TRS\ AQI = 4 * LN (TRS\ reading) + 5$ (see Figure 1 for a plot of this function). Since TRS levels are related to odours, the use of a logarithmic relation is considered appropriate as it is, in general, the way in which the human nose responds to odours i.e. at concentrations just above detection levels, odours increase in intensity (strength) as the concentration of the odorant(s) increases but above a certain level there is only a small increase in the intensity of the odour even though concentrations increase significantly. The coefficients used in the equation reflect the observed relationship between TRS levels and community odour complaints/observations with odours frequently being reported when TRS levels get above 0.6-0.7 ppb. The maximum TRS AQI value is limited to ten which occurs at TRS values greater than approximately 4.2 ppb. The Fort McKay hourly criteria level for TRS is 4.2 ppb which is based on the one-half hour World Health Organization guideline for hydrogen sulphide of 5 ppb (note: atmospheric background TRS is approximately 0.3-0.5 ppb which consists mostly of carbonyl sulphide and a small amount of carbon disulphide). The current (2014) uncorrected TRS readings at AMS1 used for the index are based on an assumed background TRS value of 0.35-0.4 which are the general AMS1 TRS readings when the wind is from the North and there are no or minimal industrial emission influences on air quality in the community;

5. **THC** - the hourly THC value minus 1.9 is divided by 0.25 and 2 is added to this value (i.e. $(2 + (THC\ reading - 1.9) / 0.25)$) which results in the relationship $THC\ AQI = 4 * THC - 5.6$ (see Figure 2 for a plot of this function). The maximum value is limited to ten which occurs at THC values greater than 3.8 ppm. A THC level of 3.8 ppm is considered to be well above background levels and to represent significantly deteriorated air quality i.e. approximately double background levels (note: the background THC at Fort McKay as measured in real time at AMS1 is in the 1.8-1.9 ppm range most of which consists of methane);

6. **SO₂**:
 - a. if the SO₂ level is less than 20ppb the AQI is calculated by multiplying the actual SO₂ value by 3 and dividing by 20,
 - b. If the SO₂ value is greater than 20 ppb, then 20 is subtracted from the measured value, which is then divided by 13.4 and 3 is added,
 - c. The maximum value is limited to 10,
 (see Figure 3 for a plot of these functions).

7. **FMAQI** - The maximum of the values from 3, 4, 5 and 6 above become the FMAQI. The following Excel spreadsheet is an example of the FMAQI calculation methodology which was

done for an odour event day in Fort McKay to compare the FMAQI to the AQHI.



Example of FMAQI
Calculation Sheet Feb

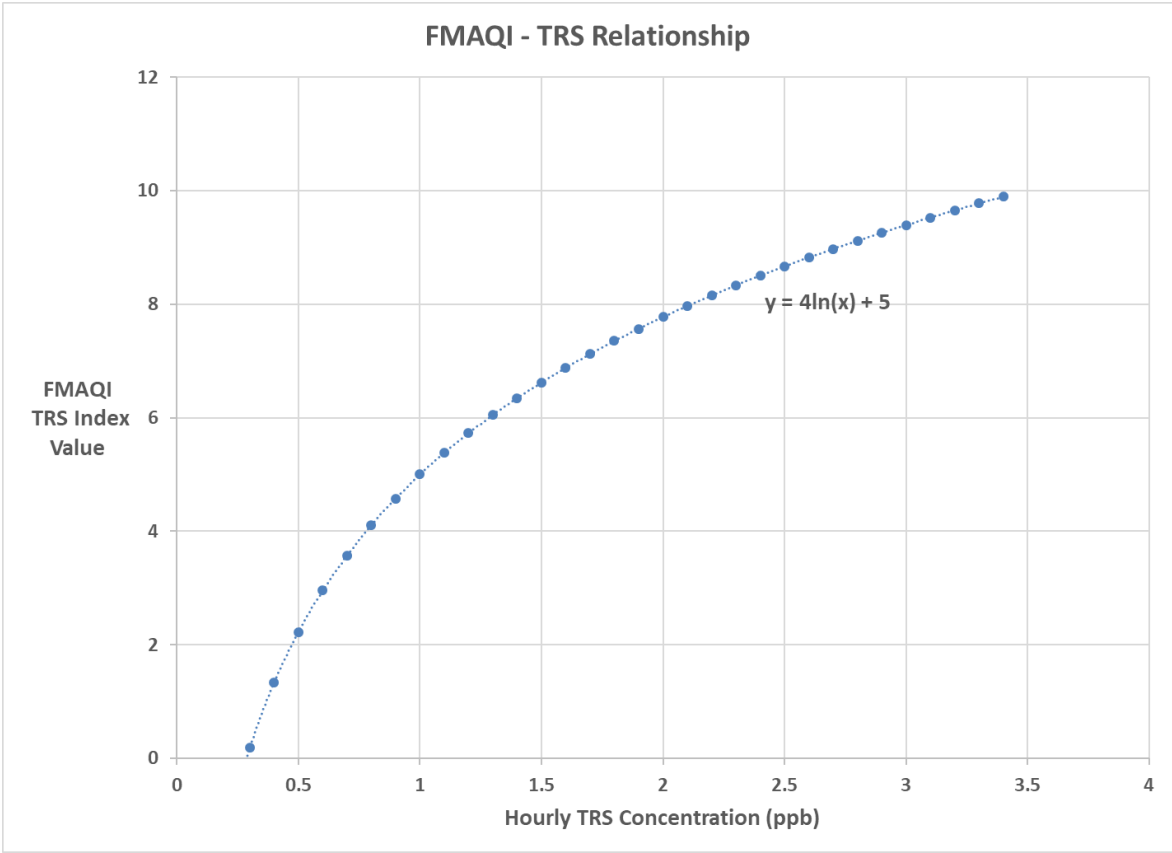


Figure 1: The Relationship for Determining the FMAQI TRS Component Index Value

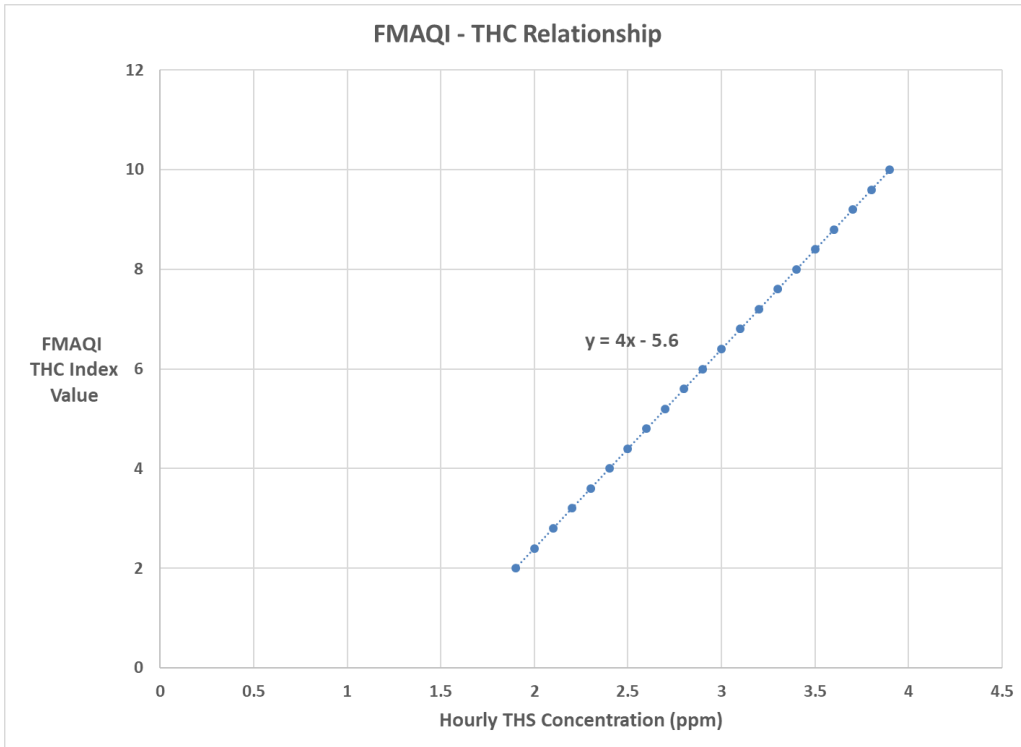


Figure 2: The Relationship for Determining the FMAQI THC Component Index Value

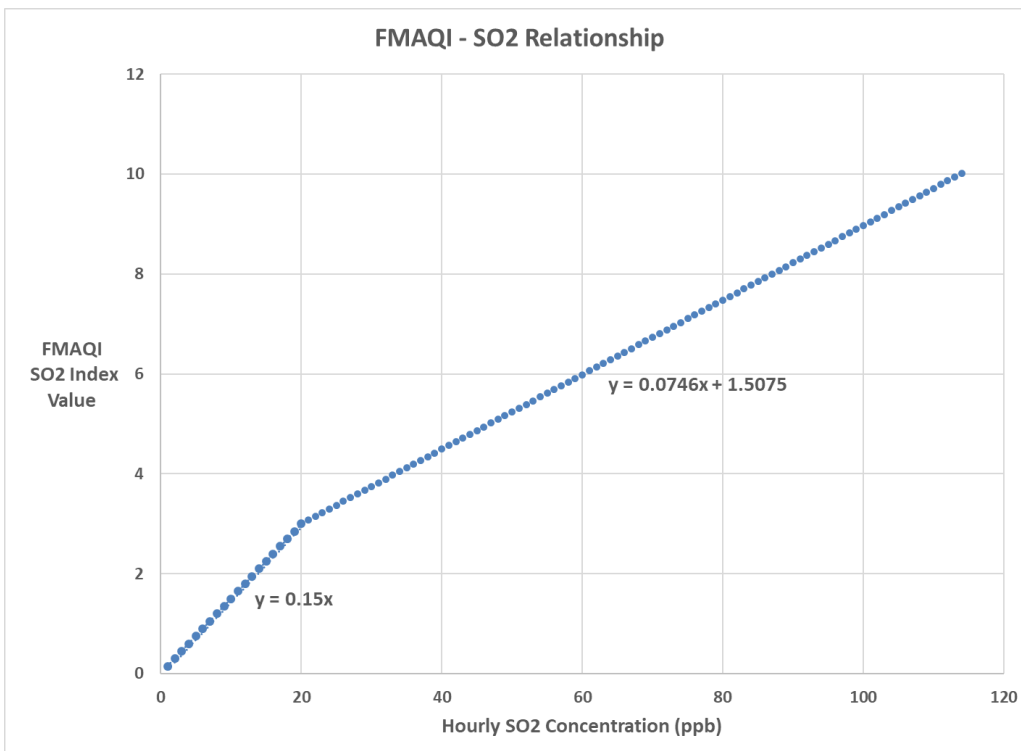
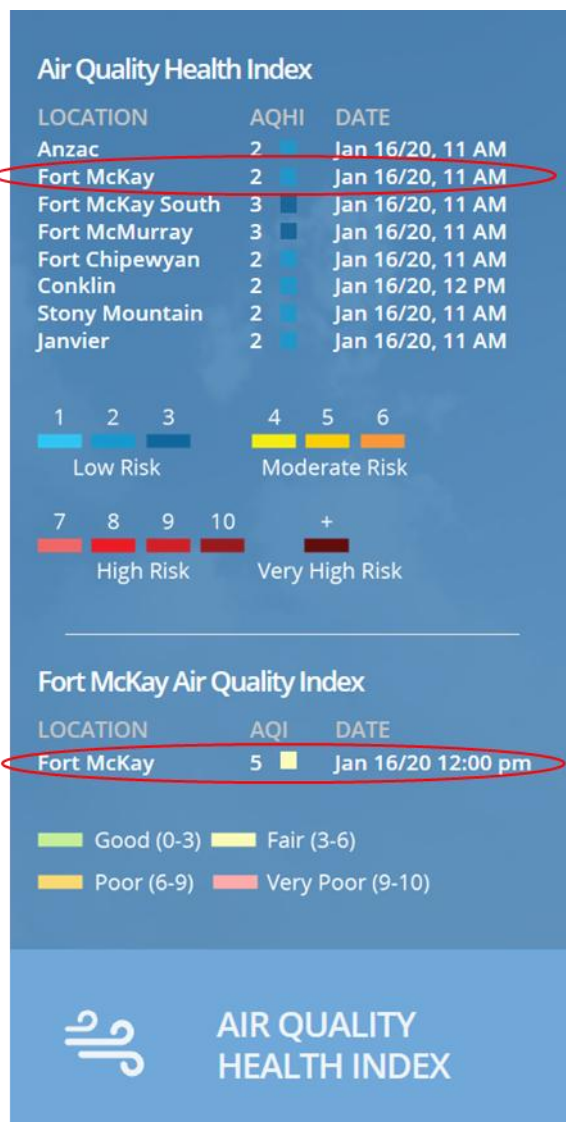
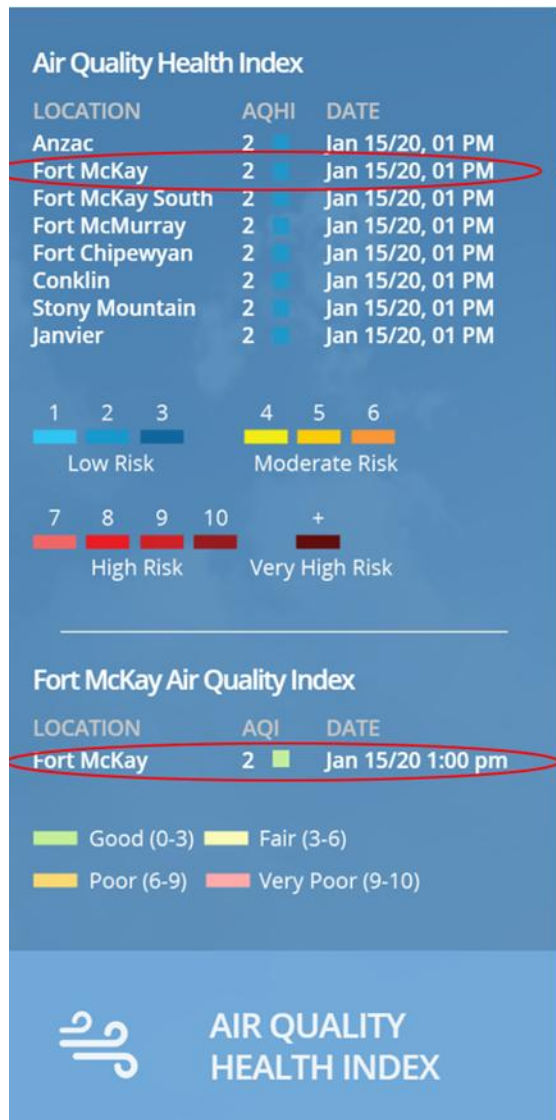


Figure 3: The Relationship for Determining the FMAQI SO2 Component Index Value

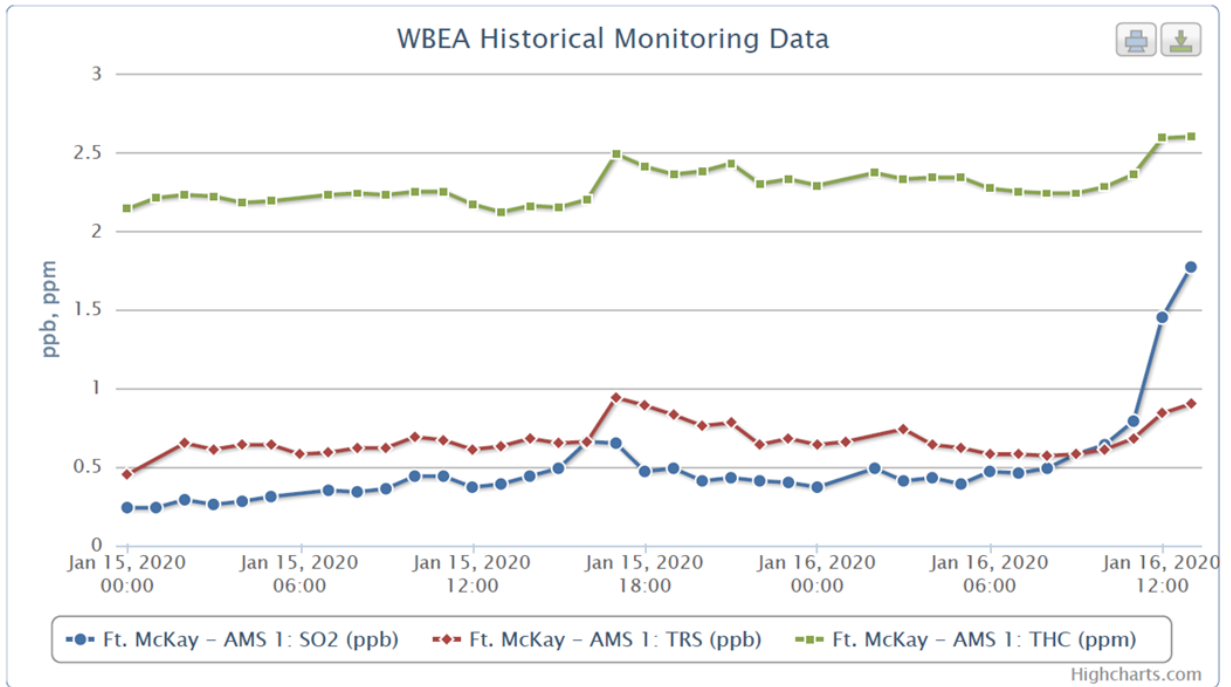
AQI Ratings: AQI values of:

1. 3 or less are considered to represent "GOOD" air quality
2. 3-6 are considered to represent "FAIR" air quality
3. 6-9 are considered to represent "POOR" air quality
4. 9-10 is considered to represent "VERY POOR" air quality

Reporting of the FMAQI: The WBEA reports the FMAQI hourly on its home page along with the AQHI. The following two screen shots give examples of when the FMAQI and AQHI are the same and when they differed significantly. The hourly air quality data in Fort McKay for the period when the two indexes had different values is also shown and demonstrates that it was the elevated levels in THC and TRS that resulted in the higher FMAQI value.

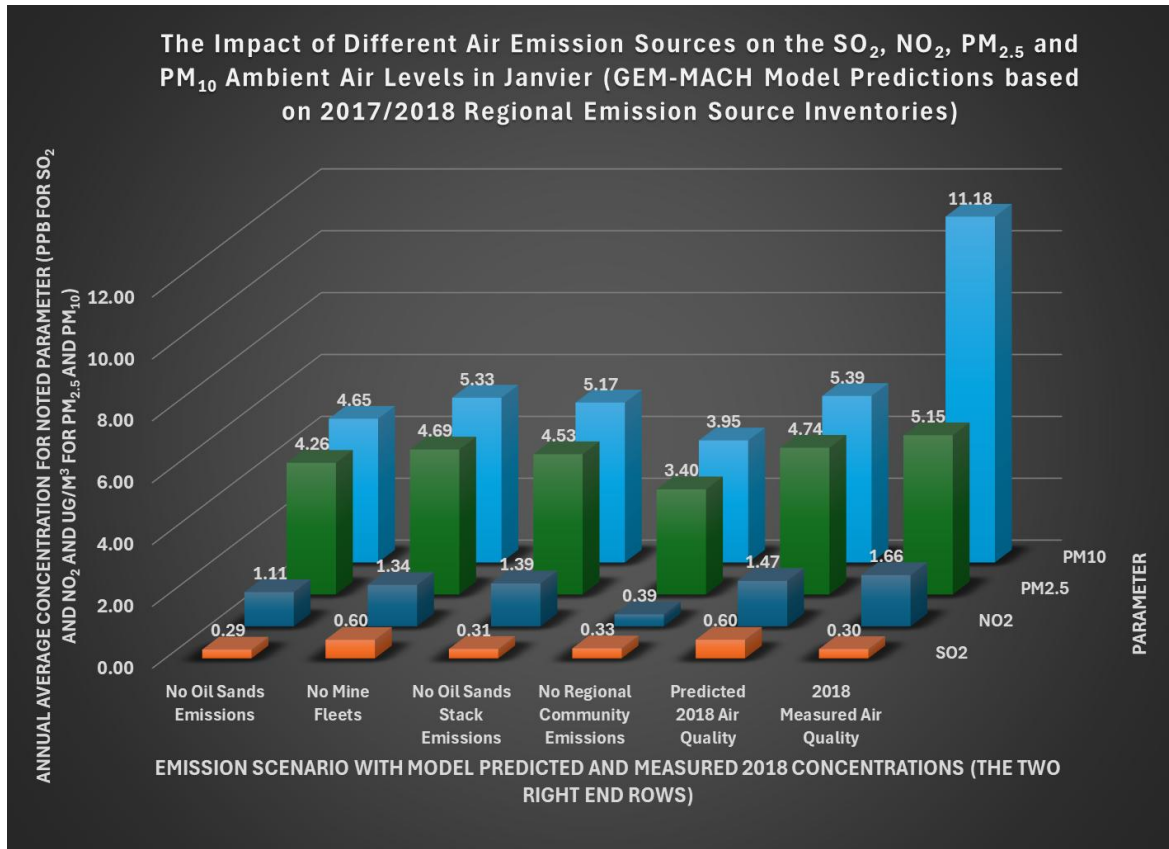


View Historical Station Data



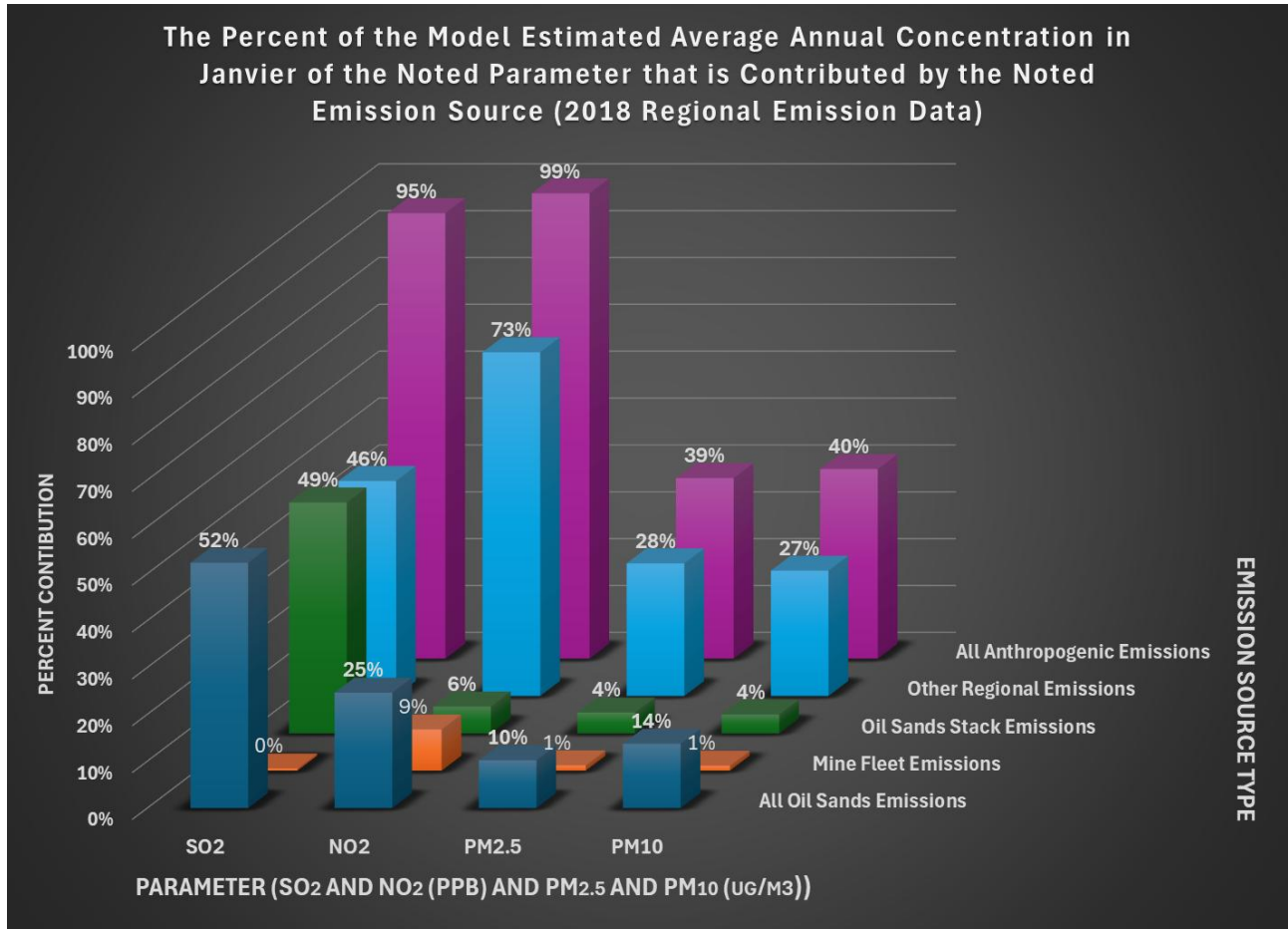
Appendix 3 Plots of ECCC GEM-MACH Model Run 4 Output Plots Janvier, Anzac, Fort McKay and Fort Chipewyan

Janvier – Model Concentration Predictions



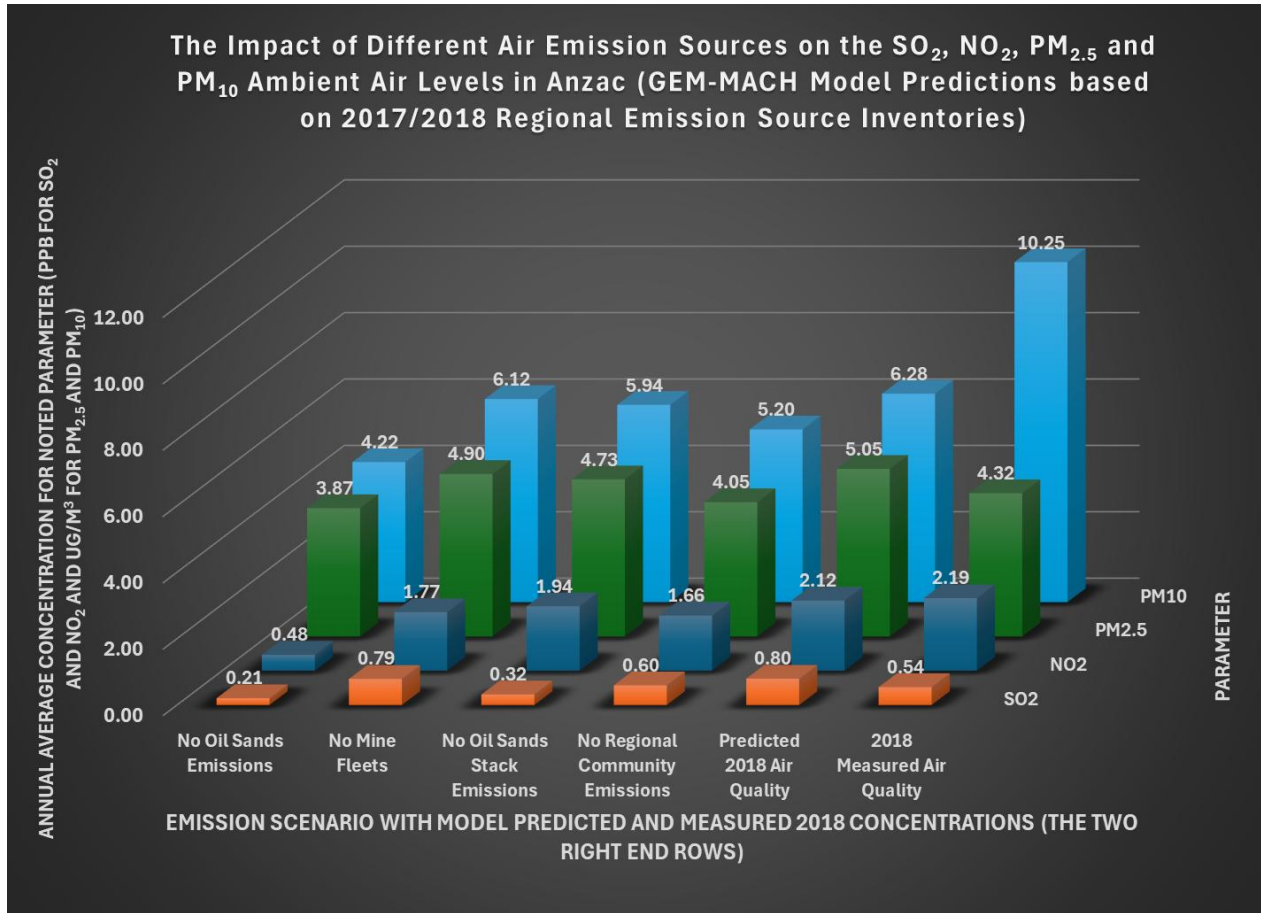
GEM-MACH Model Predictions of Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Janvier when Certain Emission Source Types are Removed with the Model Predicted and Measured Concentrations of each Parameter noted on the Right-side of the Plot

Janvier – Model Predictions Converted to Percent Contribution



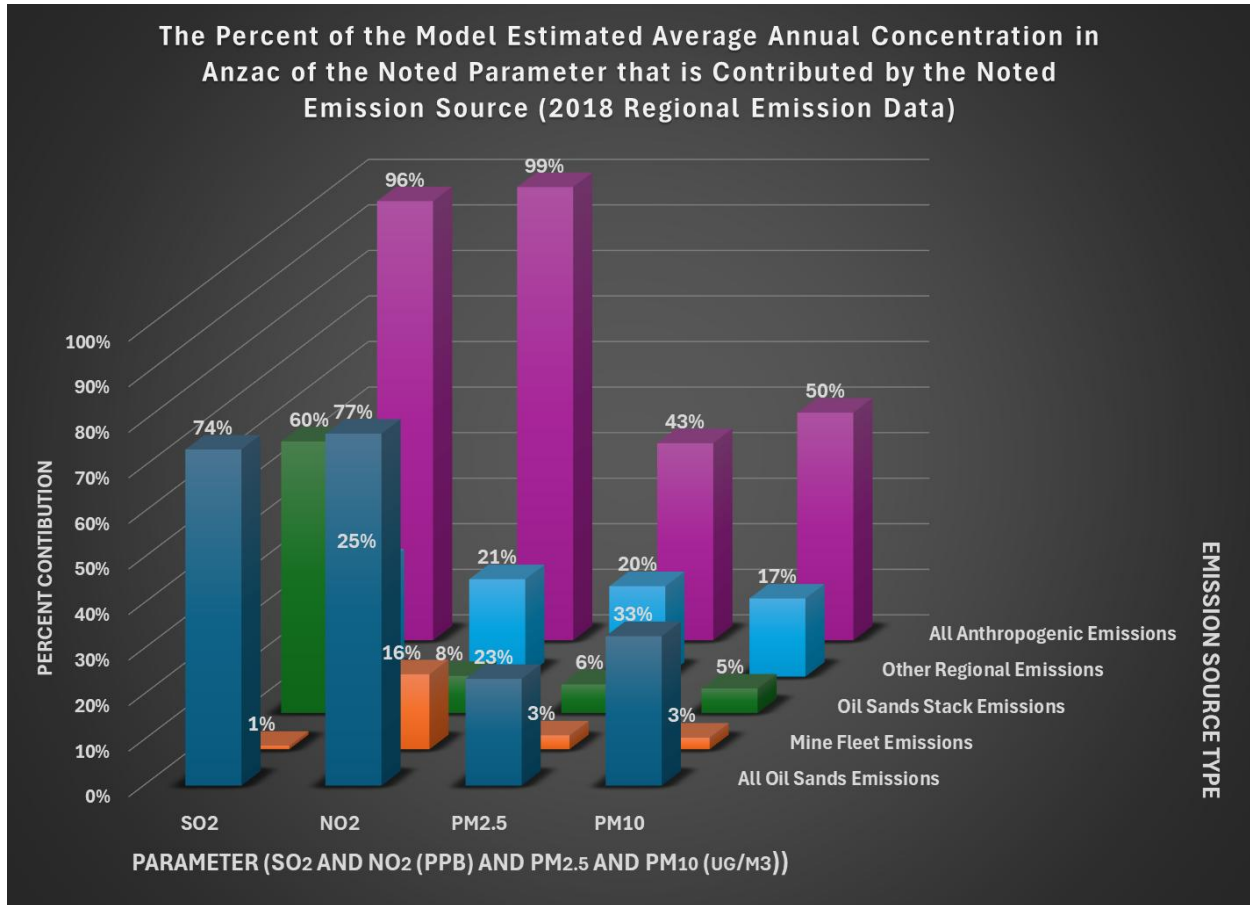
GEM-MACH Model Predictions used to Calculate the Percentage Contribution made by Different Emission Source Types to the Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Janvier

Anzac – Model Concentration Predictions



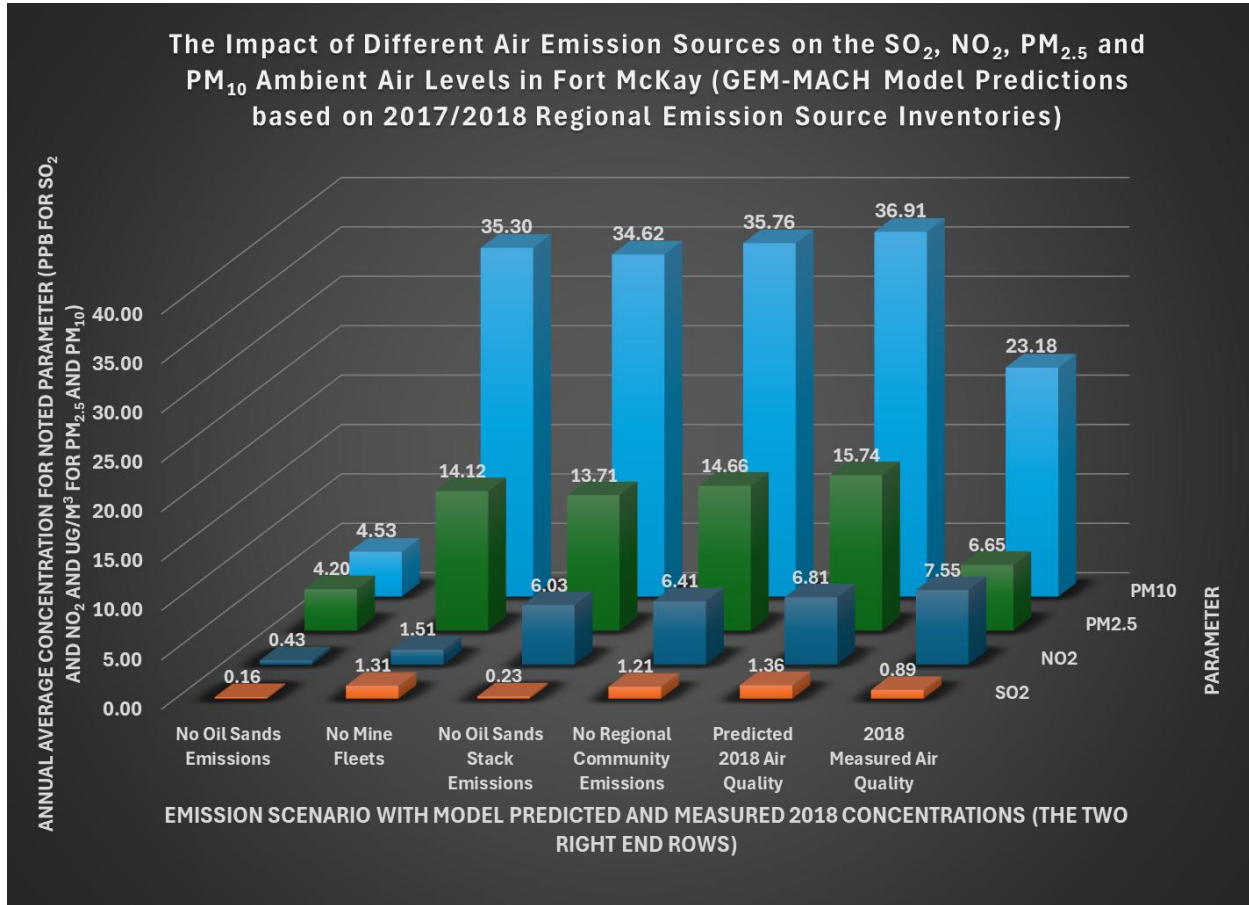
GEM-MACH Model Predictions of Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Anzac when Certain Emission Source Types are Removed with the Model Predicted and Measured Concentrations of each Parameter noted on the Right-side of the Plot

Anzac – Model Predictions Converted to Percent Contribution



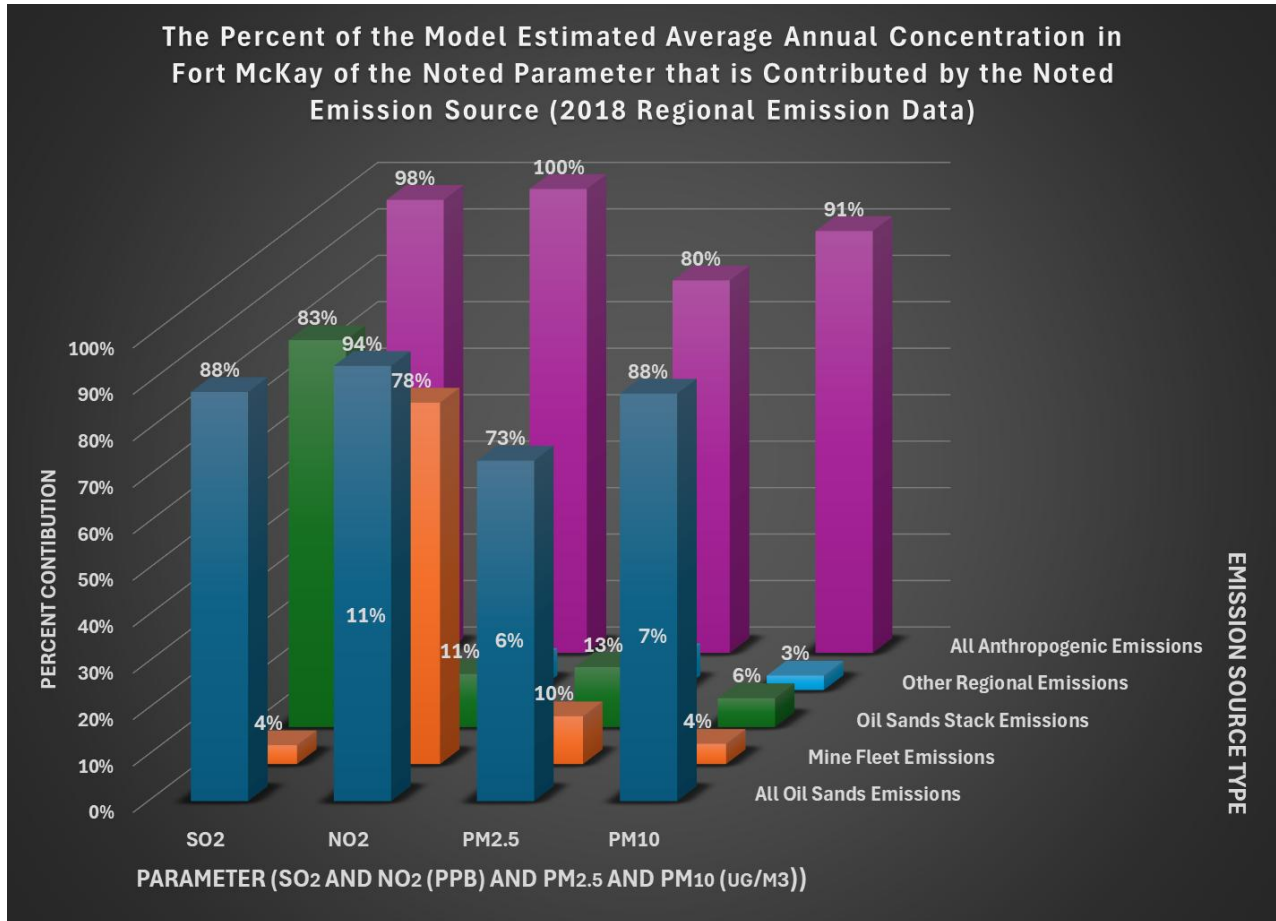
GEM-MACH Model Predictions used to Calculate the Percentage Contribution made by Different Emission Source Types to the Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Anzac

Fort McKay – Model Concentration Predictions



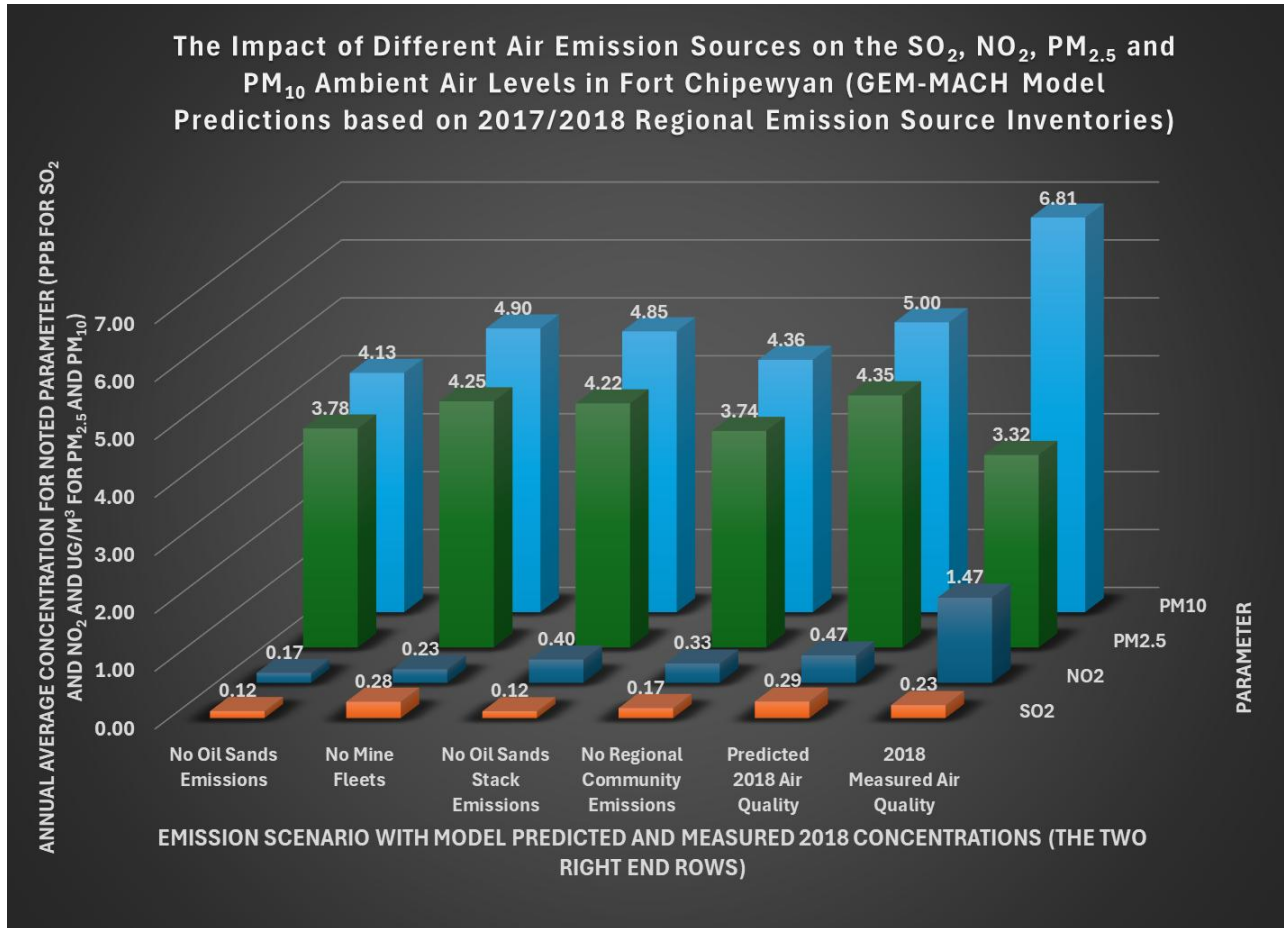
GEM-MACH Model Predictions of Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Fort McKay when Certain Emission Source Types are Removed with the Model Predicted and Measured Concentrations of each Parameter noted on the Right-side of the Plot

Fort McKay – Model Predictions Converted to Percent Contribution



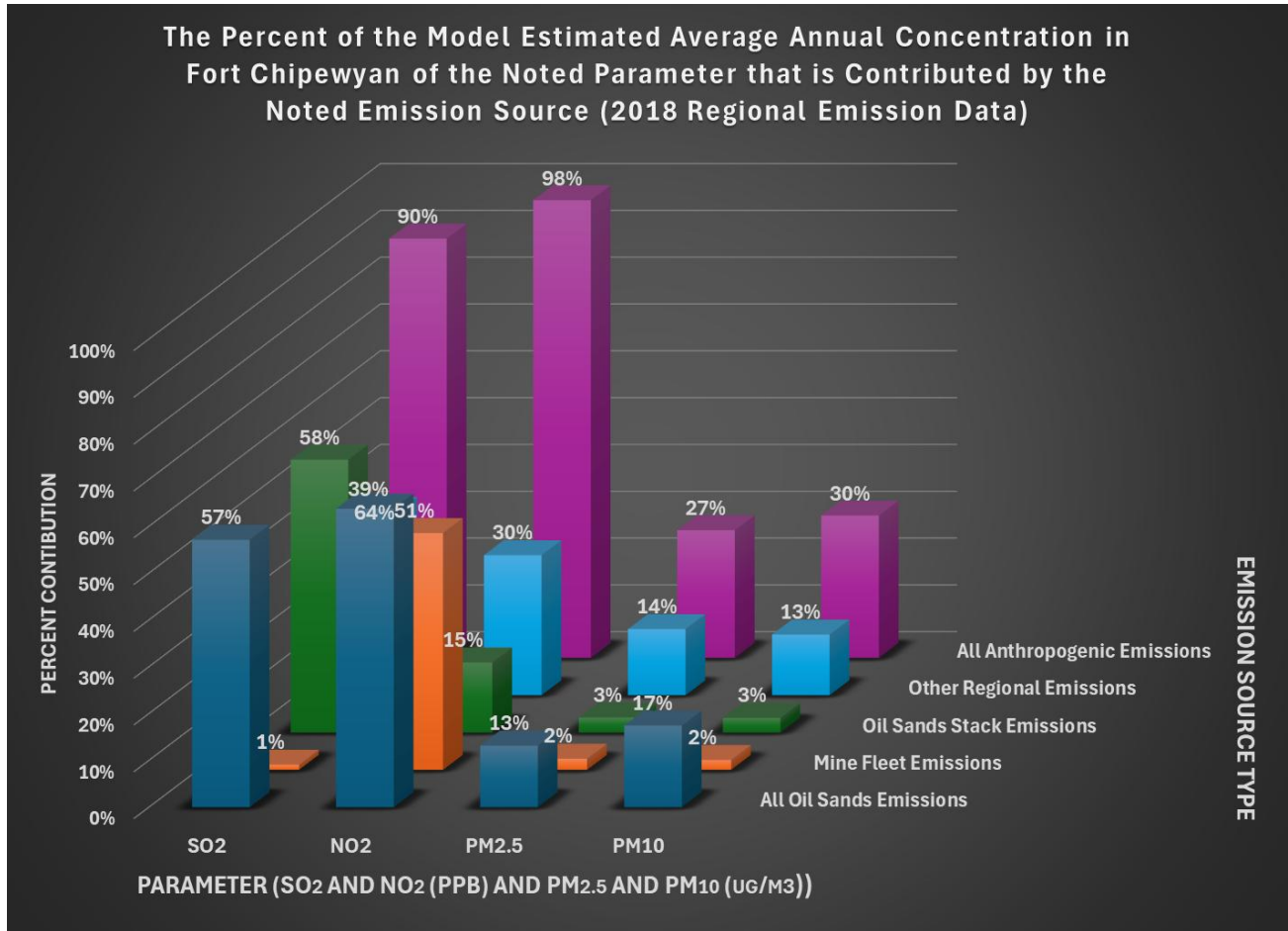
GEM-MACH Model Predictions used to Calculate the Percentage Contribution made by Different Emission Source Types to the Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Fort McKay

Fort Chipewyan – Model Concentration Predictions



GEM-MACH Model Predictions of Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Fort Chipewyan when Certain Emission Source Types are Removed with the Model Predicted and Measured Concentrations of each Parameter noted on the Right-side of the Plot

Fort Chipewyan – Model Predictions Converted to Percent Contribution



GEM-MACH Model Predictions used to Calculate the Percentage Contribution made by Different Emission Source Types to the Air Quality Levels of SO₂, NO₂, PM_{2.5} and PM₁₀ in Fort Chipewyan

Appendix 4 Ambient Air Quality Baseline Values

Appendix 4.1. Baseline value for PM_{2.5} in the literature

The residence time of PM_{2.5} in the atmospheric boundary layer is hours to days and in the free troposphere in the order of days to weeks which means that long range PM transport can influence background PM_{2.5} concentrations i.e. non-local/region emission influences (UNECE, 2010). Non-local/regional PM_{2.5} emission influences can include long range natural dust and wildfire smoke influences and primary and secondary PM_{2.5} anthropogenic sources (US EPA, 2019).

Estimated background PM_{2.5} levels from modelling and/or measurement studies range from approximately 1 µg/m³ (US EPA, 2009) to approximately 4.8 ± 2.4 µg/m³ (UNECE, 2010). Measured rural background PM_{2.5} concentrations in Norway, Sweden and Finland ranged from 1 to 4 µg/m³ (EEA, 2019), in the Western United State were ~3 µg/m³ (US EPA, 2019), in British Columbia were estimated to be 2 µg/m³ with a seasonal range from 1-4 µg/m³ (McKendry, 2006) and for Canada were estimated to be approximately 1.8 µg/m³ (annual average) based on many years of rural and remote measurement data (Health Canada, 2021).

A background PM_{2.5} level in a boreal forest environment would therefore be expected at the lower end of the range of these literature reported background PM_{2.5} levels.

Appendix 4.2. Baseline value for PM₁₀ in the Literature

There is limited recent information on background levels of PM₁₀ which is likely to be, in part, related to the current focus on PM_{2.5} monitoring and the reduced level of routine PM₁₀ monitoring. The literature found that had measured or estimated background PM₁₀ level that might be relevant to PM₁₀ background levels in the OSR where: Trijonis et al. (1990) (US based estimate of 4.5-5.8 µg/m³); Health Canada and Environment Canada (1999) (Canada based estimate 4-11 µg/m³); and Vingarzan (2007) (mean measured 10%ile PM_{2.5} at Western Canadian air quality stations between 1996-2001 – 4.3 µg/m³).

PM₁₀ data for Fort McKay and Conklin for the period 2020-2024, with wildfire influences removed had 10%ile PM₁₀ concentrations of 5.9 µg/m³ at Fort McKay and 3.4 µg/m³ at Conklin. Background ambient PM₁₀ levels can be expected to, and do, vary from location to location. The estimated PM₁₀ background of 5.1 µg/m³ used in this analysis is the 20th%ile hourly PM₁₀ level in Conklin for the 2020-2024 period with wildfire influences removed.

Appendix 4.3. Baseline value for NO₂ in the Literature

There is limited information in the literature on natural background NO₂ levels based upon the scan conducted for this assessment. One reference noted that the lifetime of NO₂ in the troposphere is a few days and remote locations are reported to have background NO₂ levels in the approximate range of 0.02-0.3 ppb (Crutzen, 1979). Another reference (Cox, 1977) reported a geometric mean of the daily average NO₂ concentrations at a remote maritime site in Ireland of 0.34 ppb. A study on the spatial and temporal variability of NO₂ concentration in the U.K found that remote locations in Scotland had minimum hourly NO₂ concentrations in the approximate range of 0.2-0.7 ppb (Atkins & Lee, 1995). ECCC, in estimating baseline NO₂ concentrations in the context of setting an NO₂ CAAQS level, estimated a baseline annual NO₂ level in Fort Chipewyan of 0.54 ppb.

To set background air quality levels for the purpose of assessing air pollutant health impacts, Health Canada (2021) used a NO₂ concentration of 0.15 ppb by volume for annual average. Their rationale for this value was stated to be:

“Background concentrations of PM_{2.5}, NO₂ and ozone were estimated in collaboration with Environment and Climate Change Canada (Judek et al. 2004). This complex initiative involved a combination of qualitative (i.e. expert judgment) and quantitative (i.e. data-driven) approaches to evaluate concentration measurements at rural and remote monitoring sites.”

Thus, it is clear that background or baseline NO₂ is very low, which is consistent with its short atmospheric lifetime.

Appendix 4.4. Baseline value for SO₂ in the Literature

In Canada, ECCC estimated that in 2011 natural sources of SO₂ (forest fires) emitted approximately 100 tonnes of SO₂ whereas the estimated anthropogenic emissions of SO₂ were 100 million tonnes and therefore overall background SO₂ levels would be expected to be very low.

The residence time of SO₂ in the atmospheric boundary layer is days and in the free troposphere in the order of days to weeks (UNECE, 2010) and remote location are reported to have background SO₂ levels in the approximate range of 0.03-0.16 ppb (Hidy & Blanchard, 2016). Maroulis, Torres, Goldberg, and Bandy (1980) reported SO₂ levels in the Northern Hemisphere troposphere boundary layer of 0.089 ± 0.069 ppb. Background SO₂ concentrations are estimated to be ~0.03 ppb (US EPA, 2017). ECCC, in estimating baseline SO₂ concentrations in the context of setting an SO₂ CAAQS level, estimated a baseline annual SO₂ level in Fort Chipewyan of 0.10 ppb and an annual median baseline level of 0.09 ppb based on data from 12 remote NAPS stations in Canada.

A source of SO₂ is the oxidation of carbonyl sulphide (COS) by the hydroxyl radical (OH) (Kettle, Kuhn, von Hobe, Kesselmeier, & Andreae, 2002; Maroulis et al., 1980). The global background of COS is approximately 0.5 ppb (Khalil & Rasmussen, 1984; Rinsland et al., 2002) and using the Maroulis et al. (1980) estimate of a COS to SO₂ ratio of 9 would give a natural SO₂ “background” of ~0.05 ppb. In the AOR an SO₂ background in the range of ~0.05-0.10 ppb would therefore be expected.

Appendix 4.5. Baseline value for Dustfall in the Literature

A literature review was recently conducted by the authors on behalf of Fort McKay First Nation under the OSMP Community-Based Dustfall Monitoring program. The review compiled dustfall criteria across local and international jurisdictions. New Zealand and Australia’s dustfall criteria are the most stringent and comprehensive as they consider an absolute maximum limit as well as a maximum incremental increase from an assumed background level. The maximum allowable dustfall rate is 4 g/m²/day or up to 2 g/m²/day increase from the background, thereby making the assumed background level 2 g/m²/day.

Dustfall determination is typically done through exposure monitoring. Data quality from such monitoring is subject to influence by factors such as sampler design, wind speed, and the particle size in question with the level of uncertainty decreasing with increasing particle size. Dustfall criteria should be considered alongside the monitoring method specified in the associated air quality regulation they are captured under.

Appendix 4.6. Baseline value for PAHs 0.03 ng/m³ for benzo(a)pyrene

It was difficult to find relevant literature on background levels of benzo(a)pyrene (BaP). Since almost all combustion sources including wood burning and gas and diesel vehicles, are a source of BaP, low levels of BaP would be expected to be found in ambient air at all locations. Van Jaarsveld, et al. (1997) estimated a natural background air concentration of BaP of 0.001 ng/m³ and calculated average BaP level ranging from 0.034 to 0.042 ng/m³ for Finland, Norway and Sweden. Jasiura et al. (2023) reported that mean concentrations of BaP in two locations in Norway of 0.002 ng/m³ and a lowest measured mean BaP concentration of 0.03 ng/m³ occurring at a location in Sweden. Maliszewska-Kordybach (1999) gives examples of measured BaP with one site in the Czech Republic having a concentration of 0.04 ng/m³ and a concentration for the Great lakes area in the range of ~0.02 to 0.04 ng/m³. The lowest level of BaP in Conklin in the 2020-2024 period was 0.004 ng/m³ and the 30%ile value was 0.03 ng/m³. The selection of background level of BaP of 0.03 ng/m³ as applicable to Conklin will require additional analysis should this BaP an air quality of interest to the Community.