AIR EMISSIONS HUMAN HEALTH RISK ASSESSMENT

WORKPLAN

PARKLAND REFINING (B.C) LTD.

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WSP
SUITE 1000
840 HOWE STREET
VANCOUVER, BC, CANADA V6Z 2M1

T: +1 604 685-9381
F: +1 604 683-8655
WSP.COM

SIGNATURES

PREPARED BY

Theresa Repaso-Subang, B.Sc.H, DABT, ERT, QPRA
Senior Technical Lead, Toxicology & Risk Assessment

APPROVED BY

Francis Ries, B.Sc. P.Eng
Senior Air Quality Engineer, Environment

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1 INTRODUCTION

This document provides a workplan outlining the proposed approach for conducting a Human Health Risk Assessment ("HHRA") for the Burnaby Refinery ("the refinery") owned and operated by Parkland Refining (B.C.) Ltd ("Parkland"). Pursuant to a request received from Fraser Health Authority ("FHA") in December 2020, the HHRA will be conducted in support of Parkland's planned application to amend the Air Quality Management Permit ("the permit amendment") for the refinery to incorporate the results of Parkland's Refined Technology Assessment ("RTA"). Pursuant to the RTA, Parkland plans to implement non-capital operational changes to the Fluid Catalytic Cracker ("FCC") that will reduce both nitrogen dioxide ("NO_2") and sulphur dioxide ("SO_2") emissions, and further plans to install a Tail Gas Treatment Unit ("TGTU") on the Sulphur Recovery Unit ("SRU") that will reduce SO_2 emissions, and a Flue Gas Recirculation (FGR) system on the CO Boiler (COB) that will reduce NO_2 emissions. The past addition of a Third Stage Separator ("TSS") to the FCC has already produced reductions in fine particulate matter ("$PM_{2.5}$"). All of these past and planned emissions reductions will be incorporated in the Parkland's permit amendment, and the results of air quality dispersion modelling assessing the impact of these reductions will form a key input to this HHRA.

The following sections of the HHRA workplan detail the proposed scope and approach for the HHRA, which will be conducted in alignment with the *British Columbia Guidance for Prospective Human Health Risk Assessment*[1] and *Health Canada Guidance for Evaluating Human Health Impacts in Environmental Assessment: Human Health Risk Assessment*[2]. The workplan also describes Parkland's proposed approach for consulting public agencies, First Nations and stakeholder groups on the HRRA technical scope and approach, as well as communicating the results once the HHRA is complete.

2 HHRA PROBLEM FORMULATION

The HHRA will evaluate the potential health effects associated with air emissions from the Parkland refinery located at 5201 Penzance Drive, Burnaby, BC ("Area 2") and tank farm located at 355 N Willingdon Avenue, Burnaby, BC ("Area 1"). The assessment period for the HHRA will be 2018 / 2019, the most recent two-year period for which air quality monitoring data is available, and the period which contains the May 1, 2018 – April 30, 2019 period used for the Air Quality Assessment ("AQA") dispersion modelling studies conducted in support of the RTA. Development of the problem formulation for the proposed HHRA has been informed by the following previous assessments:

- *Kennedy, S.M et al. (2002) Air Emissions from the Chevron North Burnaby Refinery: Human Health Impact Assessment: Final Report*[3]
- *Fraser Health Authority & Metro Vancouver (2013) Air Quality & Health Impact Assessment Update - Chevron CAP*[4]

The results of these assessments, along with the emissions reductions that are expected to result from Parkland's permit amendment, have guided the preliminary HHRA problem formulation detailed below.

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[1] https://www2.gov.bc.ca/assets/gov/health/keeping-bc-healthy-safe/healthy-communities/bc-hhra-guidance.pdf

[2] https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-evaluating-human-health-impacts-risk-assessment.html

[3] https://open.library.ubc.ca/cIRcle/collections/facultyresearchandpublications/52383/items/1.0048215

[4] https://www.burnabyrefinery.ca/application/files/7616/0452/6990/Parkland-CAP-minutes-2013-09-18-attachment-2.pdf

2.1 CONTAMINANTS OF POTENTIAL CONCERN

The historical 2002 *Human Health Impact Assessment* performed for the Parkland refinery assessed ambient air quality data from Metro Vancouver's ("MV") monitoring stations located both near the refinery and throughout the region. It assessed a broad range of pollutants, including criteria air contaminant such as SO_2, NO_2 and PM_{10}, odorous compounds such as total reduced sulphur ("TRS") and over 100 volatile organic compounds ("VOC"). The key pollutants identified as potential risks to human health in the refinery area included SO_2, benzene and 1,3-butadiene. The 2013 *Air Quality & Health Impact Assessment Update* focused on these three pollutants and found that benzene and 1,3-butadiene levels had decreased significantly and were consistently below health-based reference concentrations established for the 2013 update. Concentrations of SO_2 also decreased, but infrequent exceedances of 1-hour (hr) and 24-hr SO_2 air quality objectives were still observed.

Since 2013, ambient concentrations of SO_2, benzene and 1,3-butadiene have continued to decline both throughout the region and near the Parkland refinery, as shown in the Figure 2, Figure 3, Figure 4 and Figure 5 presented in Appendix A. Though they were not identified as contaminants of concern in the 2002 or 2013 assessments, NO_2 and $PM_{2.5}$ have become an increasing focus of concern for air quality assessments throughout the region, as there has been significant evolution in understanding of the impacts of these pollutants, including the non-threshold nature of their associated health impact. Ambient concentrations of NO_2 and $PM_{2.5}$ show similar downward trends to other pollutants, as shown in Figure 6, Figure 7, Figure 8, and Figure 9 in Appendix A.

Parkland's past and planned operational and capital upgrades discussed in Section 1 are expected to result in significant reduction in refinery emissions of SO_2 and NO_2, with modest reduction of $PM_{2.5}$ emissions and no expected change in emissions of VOCs including benzene and 1,3-butadiene. Based on this, **SO_2**, **NO_2** and **$PM_{2.5}$** will be key Contaminants of Potential Concern (COPC) proposed in the HHRA. Though VOC emissions are not expected to change due to the past and planned operational and capital changes that will be incorporated into Parkland's planned permit amendment, and despite the fact that ambient VOC levels near the refinery and across the region have continued to decline since previous assessments, inclusion of **benzene** and **1,3-butadiene** as COPCs is proposed in order to provide continuity with the previous assessments.

The 2002 health impact assessment assessed the risks associated with refinery-area exposure to VOCs other than benzene and 1,3-butadiene to be negligible, and similar to the ambient data shown for benzene and 1,3-butadiene, concentrations of all VOCs measured have declined significantly since 2002 (see Figure 4 and Figure 5). The recently adopted federal regulation titled: *"Reduction in the Release of Volatile Organic Compounds Regulations (Petroleum Sector)"* [5] requires the implementation of fenceline VOC monitoring at refineries across Canada, including Parkland. Fenceline monitoring will start in January 2022, and once measurement results are available, they will provide a large additional data source that could support a reassessment of VOC air quality / health risks very near the refinery fenceline. Based on the significant reduction in VOC emissions since the 2002 assessment, the lack of VOC emissions changes associated with Parkland's planned permit amendment, and the forthcoming availability of the new fenceline VOC monitoring dataset, the inclusion of VOCs beyond benzene and 1,3-butadiene as COPCs is not proposed within the scope of the current HHRA.

2.2 RECEPTORS OF POTENTIAL CONCERN

The purpose of the HHRA will be to assess potential health risks, if any, associated with ambient concentrations of identified COPCs that may be influenced by emissions from the refinery. To achieve this objective, WSP will evaluate the source-pathway-receptor linkage based on possible interactions with human receptors within a 10 km x 10 km box centered on the Facility, as detailed in Figure 1 below. This box encompasses the high density (250 m) receptor grid employed in the AQA dispersion modelling, and encompasses all receptors predicted by the AQA to experience exceedances of current MV NO_2 and SO_2 air quality objectives under the "Current Permit Maximum" dispersion modelling scenario (see Section 3 below).

[5] https://pollution-waste.canada.ca/environmental-protection-registry/regulations/view?Id=147

Figure 1also includes MV air quality monitoring stations in or near the proposal HHRA spatial extent. The use of data from these stations is further discussed in the Exposure Assessment section below.

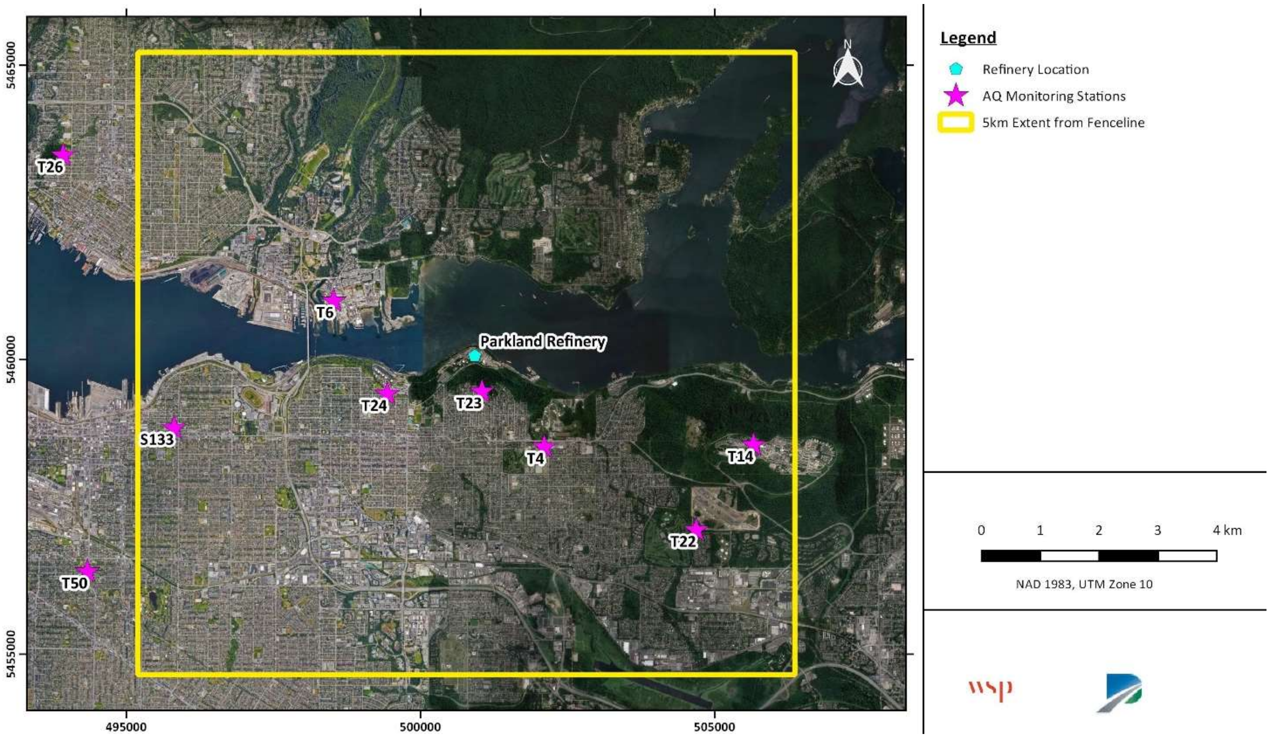

Figure 1 - Spatial extent of HHRA, and MV ambient air monitoring stations in or near this extent.

The human receptors that are typically evaluated in an HHRA are identified based on a defined study area and current/future land use(s) within the study area. This approach is based on an accepted standard of HHRA practice. For the Parkland HHRA, WSP defined the spatial extent of the study area as discussed above and identified land uses that may be present within the study area. The identified human receptors associated with the identified land uses are intended to be inclusive of human populations including sensitive subpopulations such as First Nations community members, asthmatics, children and elderly. Within the identified spatial extent, WSP proposes that the HHRA will consider the following human receptors:

- Childcare facilities – toddlers and young children who are at a daycare facility for a typical eight-hour day, five days per week for 50 weeks;
- Schools – children who are attending an elementary school for a typical six-hour day, five days per week, for 10 months (i.e., school year);
- Hospital facilities – patients who are at hospitals whose health is already compromised;
- Seniors' facilities – elderly who reside in retirement facilities;
- Workers –individuals who work near the Facility for a typical eight-hour work shift, five days per week, for 50 weeks (assuming 2-weeks of vacation);
- Highschool Students –full-time students who attend classes and are potentially present for a maximum of eight hours per day, five days per week, for fall and winter semesters (i.e., 8 months);
- Visitors –individuals who use the waterfront areas within the assessment area for recreational purposes (i.e., 2 hours);

- Residential Community –individuals who live in the residential communities near the Facility.;
- First Nations residential communities – individuals who live in the First Nations residential communities near the Facility, and;
- First Nations cultural use locations – individuals who make use of First Nations lands near the facility for outdoor cultural practices.

Specific locations for each receptor group will be identified and mapped to determine the locations of each type that are likely to experience the maximum impacts associated with ambient concentrations of identified COPCs that may be influenced by emissions from the refinery.

2.3 EXPOSURE PATHWAYS OF CONCERN

The HHRA will evaluate potential health effects associated with acute (short-term) and chronic (long-term) inhalation exposures to ambient concentrations of identified COPCs that may be influenced by emissions from the refinery. Additionally, the HHRA will include a screening assessment of particulate deposition at sensitive receptor locations to determine if exposure pathways such as ingestion or dermal contact should be included in the full assessment. Wet and dry particulate deposition will be predicted for the Dispersion Modelling - Current Permit Maximum scenario (see Section 3 below), as this scenario represents the highest particulate emissions rate from the refinery. The screening assessment will evaluate changes in soil quality resulting from predicted deposition of refinery particulate emissions by screening against background soil concentrations and health-based soil standards. COPC for this assessment will include metals and polycyclic aromatic hydrocarbons (PAH) that would be expected to occur in particulate emitted from petroleum refineries. Should the screening assessment determine that significant accumulation of particulates and associated COPC are likely to occur at any sensitive receptor locations, additional exposure pathways including ingestion or dermal contact will be considered for inclusion in the full HHRA.

2.4 UNCERTAINTY ANALYSIS

The HHRA will include a discussion of major sources of uncertainties incorporated into the assessment including exposure estimates applied for each receptor groups, exposure and modelling assumptions.

3 EXPOSURE ASSESSMENT

The Exposure Assessment step will be conducted for each COPC-pathway-receptor combination identified in the Problem Formulation to estimate the amount of COPCs that human receptors are potentially exposed to. Exposure estimates will be calculated from estimated near ground level maximum concentrations of each identified COPC, the amount of time an individual spends in the area and receptor-specific parameters such as body weight, inhalation rates, exposure frequency and durations. In this assessment step, conservative assumptions will be applied to ensure that it is protective of health including sensitive subpopulations (i.e. children, elderly, asthmatics).

Assessment of COPC exposure concentrations will be performed for 4 scenarios: one using ambient air quality monitoring data from 2018/2019 to determine COPC exposure concentrations for all pollutants for all receptors, and three using COPC concentrations predicted by air dispersion modelling of refinery emissions. The following table provides full details of the proposed scenarios.

Table 1 – HHRA Exposure Assessment Scenarios

	#1 - Current Ambient Monitoring	#2 - Dispersion Modelling - Current Permit Maximum	#3 - Dispersion Modelling - Amended Permit Maximum	#4 - Dispersion Modelling - Amended Permit Normal
Proposed Exposure Data Source	Ambient monitoring from MV network stations located within a 10 km x 10km box around the Parkland refinery. The most recent 2 years of validated ambient data will be used to develop exposure concentrations.	Dispersion modelling results for "current permit" emissions at maximum permitted levels for all refinery sources of SO_2, NO_2, $PM_{2.5}$, for a 10 km x 10km box around the Parkland refinery. Based on MVRD permit GVA0117 dated January 27, 2021.	Dispersion modelling results for "amended permit" / FCC Non-Capital Solutions + TGTU + COB FGR emissions at proposed maximum permitted levels for all refinery sources of SO_2, NO_2, $PM_{2.5}$, for a 10 km x 10km box around the Parkland refinery. Based on proposed emissions limits in Parkland's permit application to be submitted prior to the current permit expiry date of July 31, 2022.	Dispersion modelling results for "amended permit" / FCC Non-Capital Solutions + TGTU + COB FGR emissions at expected future normal operating levels for all refinery sources of SO_2, NO_2, $PM_{2.5}$, for a 10 km x 10km box around the Parkland refinery. Based on normal operating conditions associated with Parkland's permit application to be submitted prior to the current permit expiry date of July 31, 2022.
Proposed Pollutants Included	SO_2, NO_2, $PM_{2.5}$, benzene, and 1,3-butadiene	SO_2, NO_2, $PM_{2.5}$	SO_2, NO_2, $PM_{2.5}$	SO_2, NO_2, $PM_{2.5}$
Proposed Monitoring Stations Used	T4: SO_2, NO_2, $PM_{2.5}$ T9: SO_2, NO_2, $PM_{2.5}$, benzene, 1,3-butadiene T23: SO_2 T24: SO_2, benzene, 1,3-butadiene T26: SO_2, NO_2, $PM_{2.5}$ S113: SO_2 ** see note below	Model baseline concentrations: T4: SO_2, NO_2, $PM_{2.5}$ T9: SO_2, NO_2, $PM_{2.5}$ T24: SO_2 T26: SO_2, NO_2, $PM_{2.5}$	Model baseline concentrations: T4: SO_2, NO_2, $PM_{2.5}$ T9: SO_2, NO_2, $PM_{2.5}$ T24: SO_2 T26: SO_2, NO_2, $PM_{2.5}$	Model baseline concentrations: T4: SO_2, NO_2, $PM_{2.5}$ T9: SO_2, NO_2, $PM_{2.5}$ T24: SO_2 T26: SO_2, NO_2, $PM_{2.5}$
** MVRD station T6 (North Vancouver Second Narrows) has been excluded from the proposed station list due to the influence of 2019 Greater Vancouver Water District construction activities occurring immediately beside the monitoring station. These activities resulted in high NO_2 and $PM_{2.5}$ levels that were not characteristic of broader air contaminant levels in the Burrard Inlet area.				

This 4-scenario approach has been selected for four reasons:

1) Dispersion modelling in support of the RTA AQA focused only on pollutants which are expected to change as a result of the RTA emission reduction measures: SO_2, NO_2, $PM_{2.5}$. As such, no predicted ambient benzene and 1,3-butadiene concentrations are available from the dispersion model output, so health risk associated with exposure to these two COPCs can only be determined from the ambient monitoring data.
2) The dispersion model predicted concentrations of SO_2, NO_2, and $PM_{2.5}$ provide a high level of spatial detail in exposure concentrations, but are by their nature very conservative, and may not align with measured ambient concentrations at MV monitoring stations. By estimating the health risks for both ambient monitoring concentrations and dispersion modelled concentrations, "worst case" and "average" health risks across receptor groups can be better explored.
3) The use of "current permit" maximum and "amended permit" maximum and normal dispersion modelling scenarios allows for identification of the potential change in health risks due to the emissions reductions associated with the amendment.
4) The use of the "amended permit" normal scenario will provide the most representative characterization of the expected future "average" health risks for receptors, while the "amended permit" maximum scenario will best characterize "worst case" acute health risks what are likely to occur infrequently.

4 HAZARD ASSESSMENT

The Hazard Assessment step will provide the basis for evaluating what is an acceptable exposure and what level of exposure may be harmful to human health. This step will involve identification of potentially harmful effects associated with each COPC and determining the dose that a receptor can be exposed to without experiencing unacceptable effects. This value is called the toxicity reference value (TRV).

4.1 TOXICOLOGY REVIEW OF AVAILABLE JURISDICTIONAL AMBIENT AIR QUALITY OBJECTIVES

As part of the Hazard Assessment step, WSP proposes to complete a toxicology review of available jurisdictional ambient air quality objectives (AAQO) for benzene, 1,3-budiene, NO_2, SO_2 and $PM_{2.5}$, including the 2025 Canadian Ambient Air Quality Standards (CAAQS) for NO_2 and SO_2.

The HHRA will take the jurisdictional review of available AAQO a step further by conducting a comprehensive review of the available short-term (acute) and long-term (chronic) numerical limits that will include the following:

- For the available acute and chronic AAQO, assess the technical, specifically toxicological basis, of the numerical limits;
- Assess if these limits are health based and if so, identify the health endpoints they are protective of, determine if the toxicological study upon which the numerical limits are based on human or animal data including uncertainties inherent in the studies;
- Assess the scientific rigour in the derivation of the numerical limits;
- Regulatory key considerations in the standard derivation process; and

- Of the jurisdictional limits available for acute and chronic exposure durations, for each COPC, identify which jurisdictional AAQO is health-protective for application in the HHRA.

WSP will summarize the findings of the jurisdictional review of available AAQOs for acute and chronic exposure and their toxicological basis. Should the screening assessment of particulate deposition detailed in Section 2.3 identify additional exposure pathways of concern, a toxicology review of ingestion and dermal contact reference values will also be conducted.

4.2 TOXICOLOGY REVIEW

WSP also proposes to complete a toxicology review of associated health effects following inhalation exposures to the identified COPCs. WSP will review and summarize the following:

- The health outcomes related to inhalation exposures to identified COPCs following short- and long-term exposures; and,
- The available human (or epidemiological) toxicological data rather than animal studies.

The findings of the toxicology review of available jurisdictional AAQO and associated health effects following inhalation exposures to the identified COPCs will be integrated in the Hazard Assessment step. Should the screening assessment of particulate deposition detailed in Section 2.3 identify additional exposure pathways of concern, a toxicology review of ingestion and dermal contact reference values will also be conducted.

5 RISK CHARACTERIZATION

The HHRA Risk Characterization step will involve comparing the estimated exposure to the TRV. The Risk Characterization will be conducted for the air inhalation exposure pathway, which will be characterized using the emissions -> atmospheric dispersion & chemical transformation -> ground-level inhalation pathway. Depending on the results of the screening assessment described in Section 2.3, additional multi-media fate and transport modelling may be considered including incidental ingestion of soil by sensitive receptors, dermal contact with soil by sensitive receptors, root uptake of chemicals in soil by plants and consumption of plants by people.

Exposure Ratio (ER) values for identified COPCs, will be calculated as the ratio of the estimated exposure (based on the Exposure Assessment) to the TRV (based on the effects assessment). WSP will describe key uncertainties that influence results, including data gaps that drive risks. This information will guide additional fate and transport modelling to refine exposure assumptions and support a more detailed evaluation.

The risk characterization step of the HHRA will evaluate the following:

- The contribution to overall risk from each source-receptor-pathway;
- The controls, mitigation measures or monitoring programs that can be implemented to prevent or address potential effects; and,
- The residual impacts to human health (if any) with the implementation of these mitigation measures.

6 PROPOSED REPORTING

The HHRA reporting will be completed based on the above noted approach and methodology. WSP has prepared a draft table of contents for the HHRA report, which is detailed in an attachment at the end of the Workplan.

7 CONSULTATIONS

Parkland and WSP will submit this workplan for review by MV, FHA and First Nations Health Authority (FNHA) and will incorporate comments received into a second draft workplan. Pending approval from MV, FHA, and FNHA, Parkland and WSP will then initiate consultations with other governments and key stakeholders in summer 2021, with results to be shared in early 2022 in conjunction with Parkland's air permit application.

Parkland will lead these consultations, with support from the WSP project team. The second draft workplan will form the basis for consultations with Tsleil-Waututh Nation, Vancouver Coastal Health, City of Burnaby, and Parkland's Community Advisory Panel. Parkland and WSP will also engage and inform the local community.

The intent of the workplan consultations is to inform and receive feedback on the planned scope and approach for the conduct of the HHRA. Where possible, feedback may be used to update the workplan to its final version, which will be submitted to MV, FHA and FNHA. WSP will compile all feedback received through consultations, and the HHRA reporting will provide a compilation of feedback along with an indication of how is was addressed in the HHRA. Following completion of the HHRA report, WSP and Parkland will return to each group to review the results.

APPENDIX B

SUPPORTING AMBIENT AIR QUALITY DATA

APPENDIX B

A.1 SUPPORTING AMBIENT AIR QUALITY DATA NOTES

The following figures for SO_2, 1,3-butadiene, benzene, NO_2 and $PM_{2.5}$ are provided simply to illustrate temporal trends in levels of the proposed COPC for the HHRA. The following notes apply to the figures:

SO_2

- SO_2 data shown in Figure 2 and Figure 3 have been summarized using the statistical forms of the Canadian Ambient Air Quality Standards (CAAQS). MV's 1-hr AAQO for SO_2 follows a more stringent statistical form (absolute maximum, or "not to be exceeded"), while MV's annual AAQO is equivalent to the annual CAAQS. Regarding of the difference in 1-hr statistical form, the CAAQS data provide a good representation of the temporal trends in 1-hr and annual SO_2 levels.

1,3-BUTADIENE

- Data for the MV monitoring station nearest to the Parkland refinery (T24) is highlighted in Figure 4
- The US EPA risk-specific concentration for 1,3-butadiene from the 2013 *Air Quality & Health Impact Assessment Update* has been provided for comparison to the measured ambient levels.

BENZENE

- Data for the MV monitoring station nearest to the Parkland refinery (T24) is highlighted in Figure 5.
- The US EPA Cancer risk specific concentration Upper Range for benzene from the 2013 *Air Quality & Health Impact Assessment Update* has been provided for comparison to the measure ambient levels.

NO_2

- NO_2 shown in Figure 6 and Figure 7 have been summarized using the statistical forms of the CAAQS. MV's 1-hr and annual AAQOs for NO_2 are equivalent to the CAAQS.
- NO2 data presented here have been cleaned to remove the impact of summer-time wildfire smoke events that impacted regional air quality.

$PM_{2.5}$

- $PM_{2.5}$ data shown in Figure 8 and Figure 9 have been summarized using the statistical forms of the CAAQS. MV's 24-hr and annual AAQO for $PM_{2.5}$ follow a more stringent statistical form (absolute maximum, or "not to be exceeded" over a single year). Despite this difference, the CAAQS data provide a good representation of the temporal trends in 24-hr and annual $PM_{2.5}$ levels.
- $PM_{2.5}$ data shown include a discontinuity caused by MV's shift from the previous monitoring technology (TEOM or tapered element oscillating microbalance) to the current monitoring technology (SHARP or Synchronized Hybrid Ambient Real-time Particulate). This shift does not represent a change in $PM_{2.5}$ trends, but rather an improvement in the capture of semi-volatile particulate levels, which leads to an apparent increase in $PM_{2.5}$ levels for more recent years.
- $PM_{2.5}$ data presented here have been cleaned to remove the impact of summer-time wildfire smoke events that impacted regional air quality.

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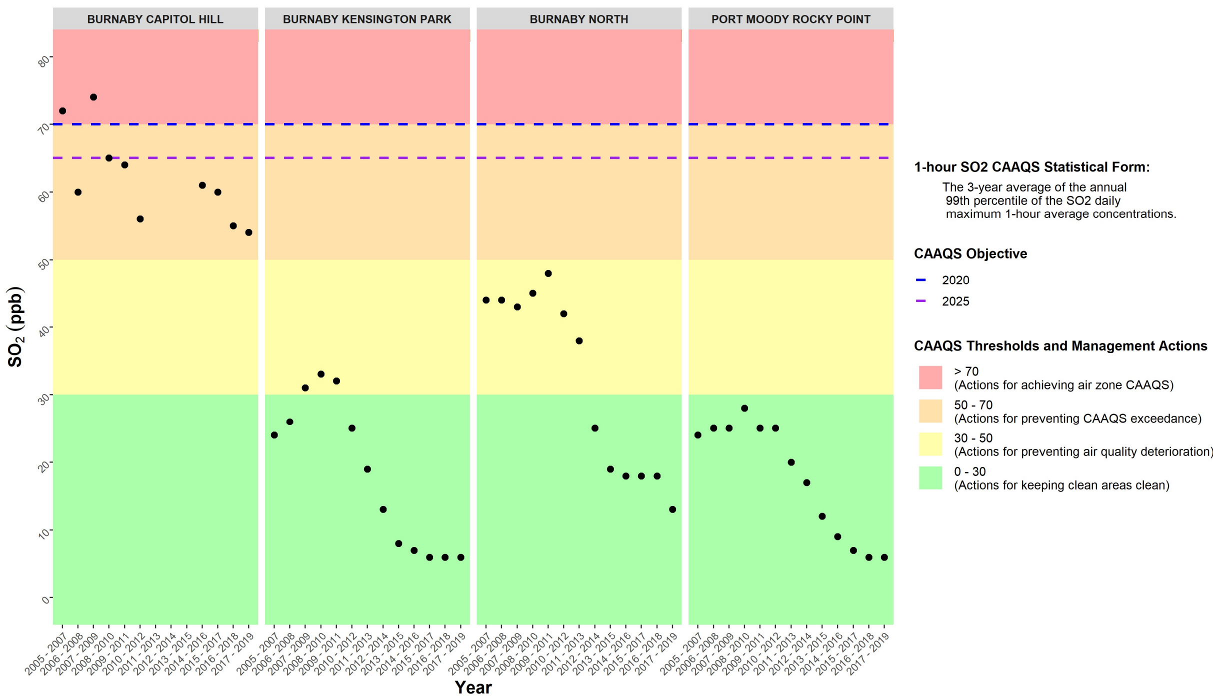

Figure 2 – CAAQS 1hr SO_2 concentrations for monitoring stations nearest to Parkland refinery

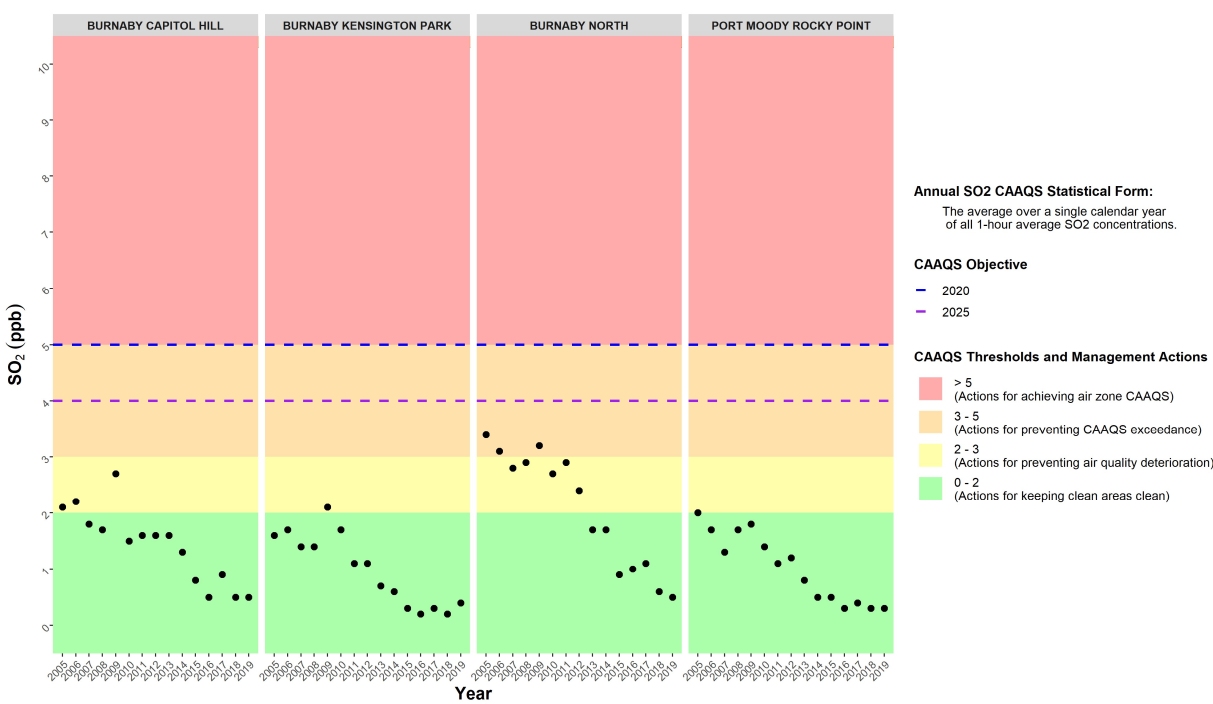

Figure 3 - CAAQS Annual SO_2 concentrations for monitoring stations nearest to Parkland refinery

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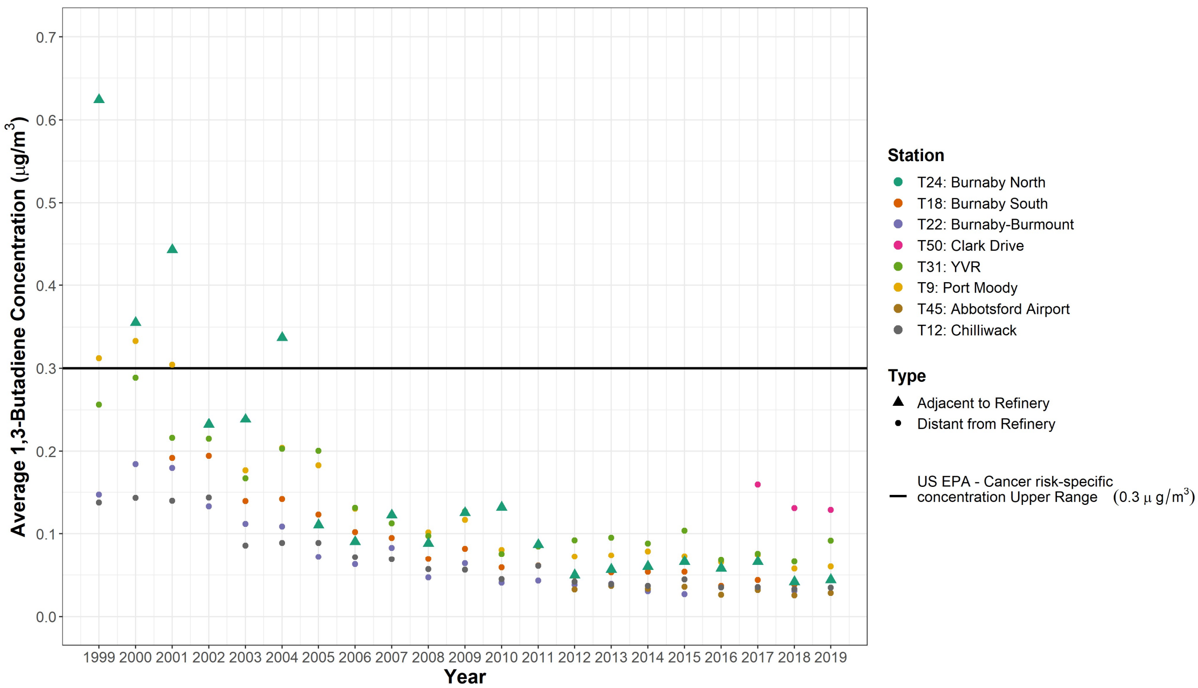

Figure 4 – Annual average 1,3-butadiene concentrations for monitoring stations throughout BC Lower Mainland

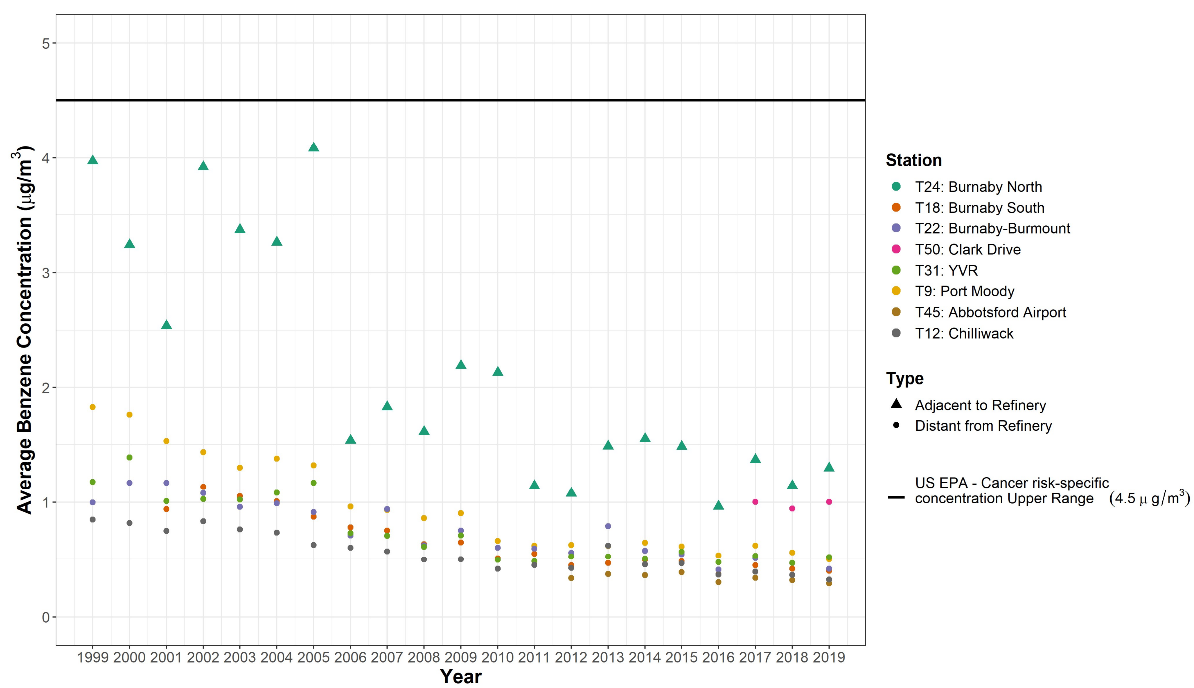

Figure 5 - Annual average benzene concentrations for monitoring stations throughout BC Lower Mainland

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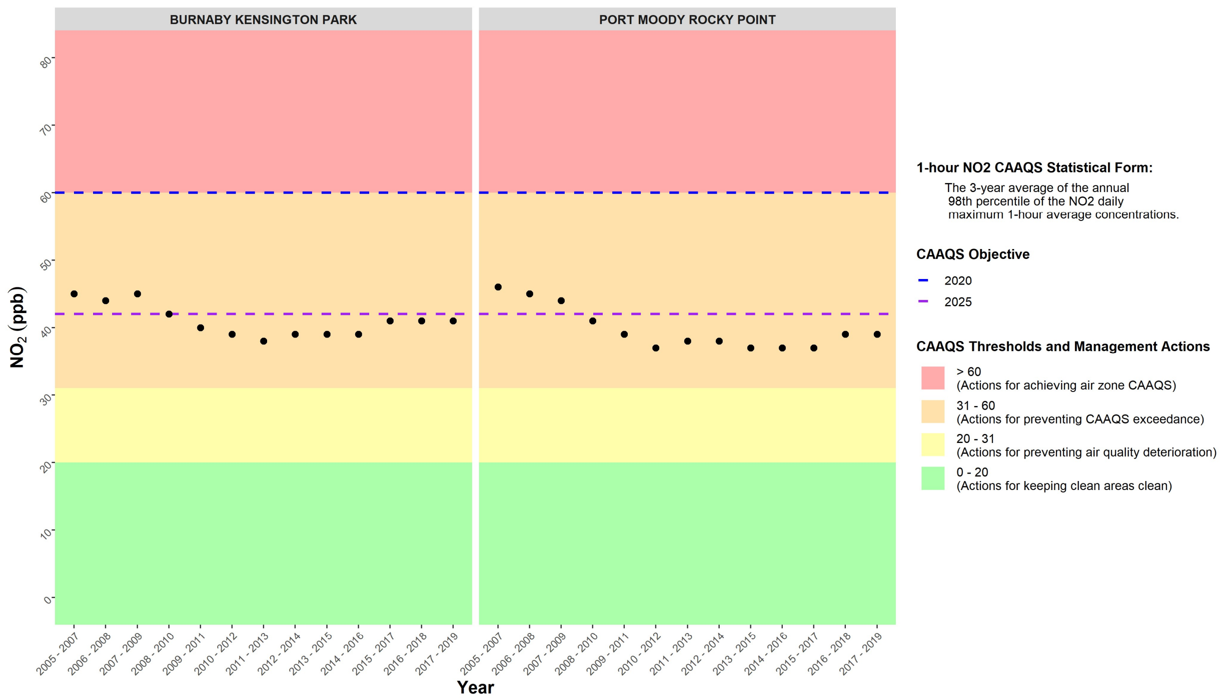

Figure 6 - CAAQS 1hr NO_2 concentrations for monitoring stations nearest to Parkland refinery

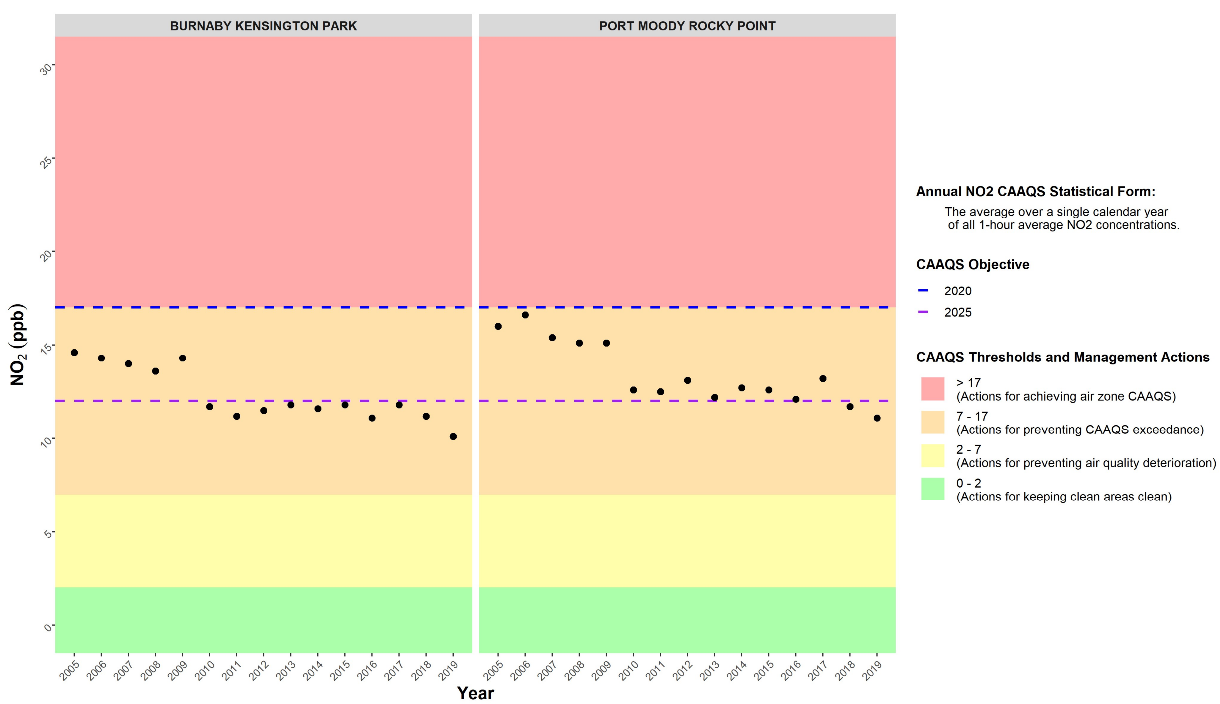

Figure 7 - CAAQS Annual NO_2 concentrations for monitoring stations nearest to Parkland refinery

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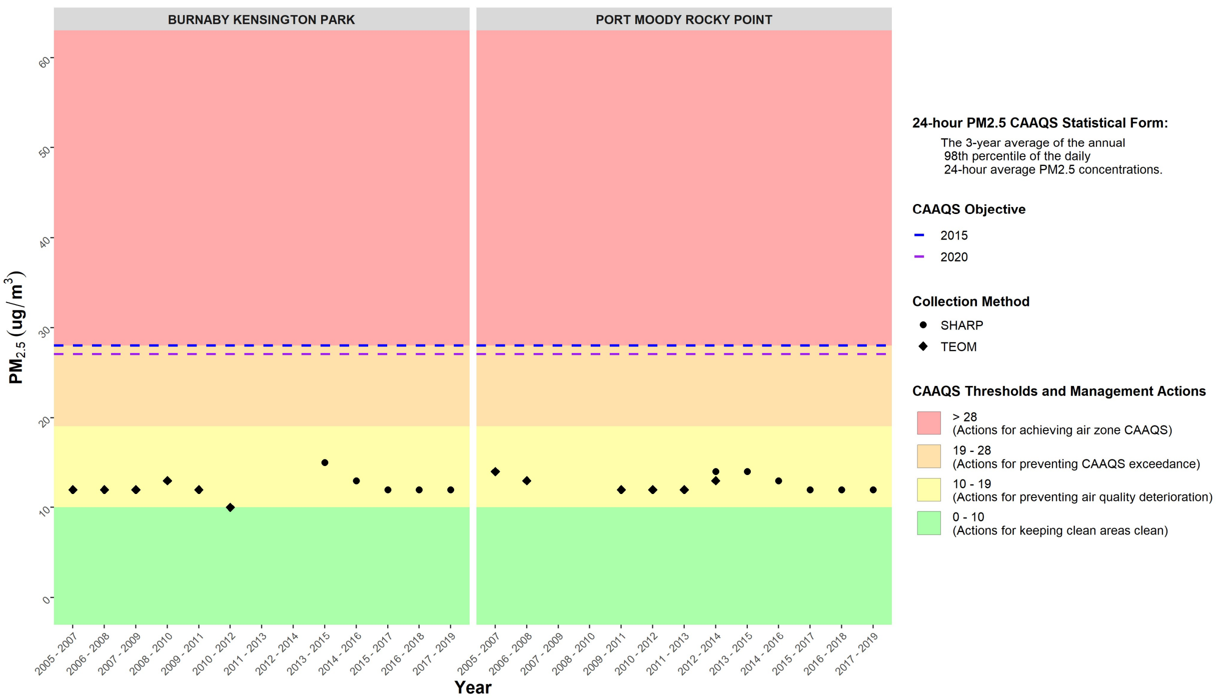

Figure 8 - CAAQS 24hr $PM_{2.5}$ concentrations for monitoring stations nearest to Parkland refinery

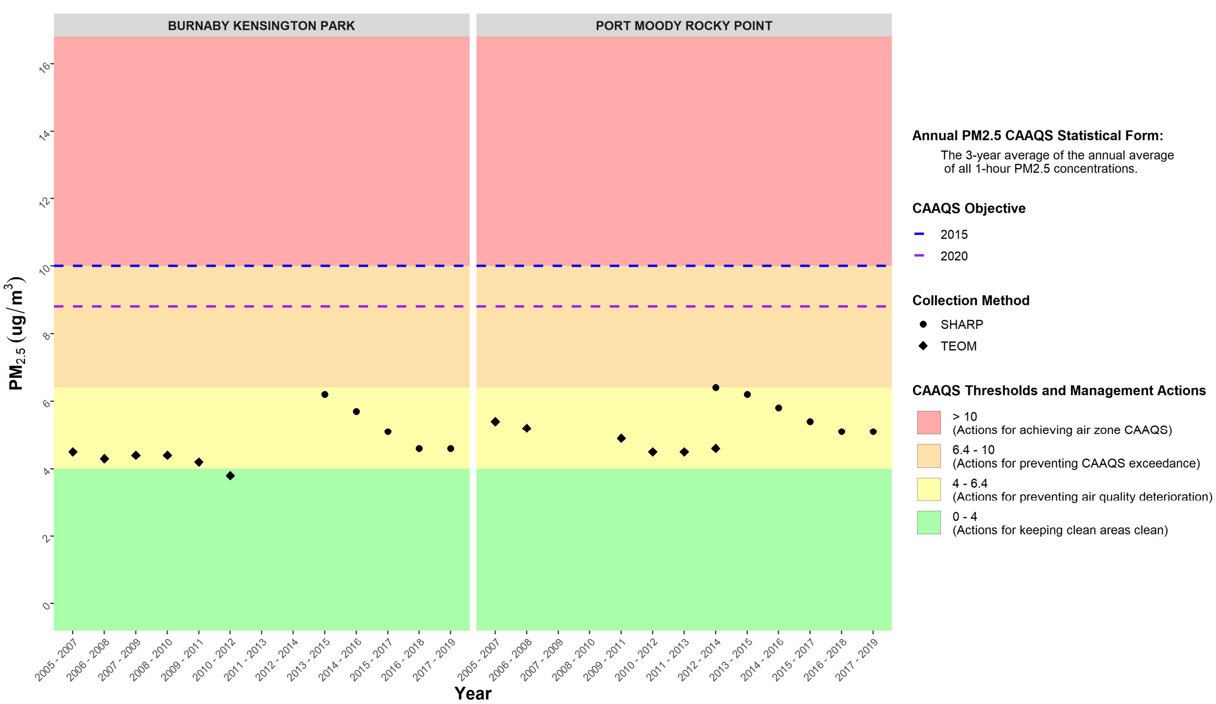

Figure 9 - CAAQS Annual $PM_{2.5}$ concentrations for monitoring stations nearest to Parkland refinery

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HHRA REPORT

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