



BAYTEX RENO FIELD
Ambient Air Study – Summary Report

Baytex Reno Field Ambient Air Study Overview

Baytex Energy Ltd. (“Baytex”) engaged Chemistry Matters Inc. (“Chemistry Matters”), an independent firm providing environmental and chemistry consulting services, to investigate local resident complaints regarding odours and claims of health issues in the vicinity of heavy oil production facilities in the Reno field, near Peace River, Alberta.

Chemistry Matters developed an air sampling program to:

- Measure volatile organic compounds (“VOCs”) and reduced sulphur compounds (“RSCs”) on selected heavy oil production leases
- Measure polycyclic aromatic hydrocarbons (“PAHs”) at the heavy oil leases
- Assess potential human health effects using appropriate regulatory guidelines

Air samples were collected between February 26 and March 6, 2013 at nine leases in the Reno field. A total of 73 samples were analyzed for VOCs, RSCs or PAHs. The results were as follows:

- Only one detected concentration of VOCs that was above odour-based Alberta Ambient Air Quality Objectives (“AAAQO” or “Alberta Air Objectives”) or the Texas Commission on Environmental Quality’s Effects Screening Levels. It was determined post-sampling that the location where the VOC exceedance was measured was in an “upset condition”. This well was immediately shut-in and the condition remedied.
- Only one compound was ‘detected’ in the RSCs samples above Alberta Air Objectives at an on-lease location
- No PAHs concentrations found to be above guidelines

Overall, from a human health perspective, the study’s sampling program found that no health-based objectives or screening levels were exceeded in this study.

This document is a detailed summary of Chemistry Matter’s Ambient Air Study. It highlights the program, regulatory guidelines, procedures, results and key findings and conclusions.

INTRODUCTION

Baytex Energy Ltd. engaged Chemistry Matters Inc., an independent firm providing environmental and chemistry consulting services, to investigate resident complaints regarding odours and claims of health issues in the vicinity of heavy oil production facilities in the Reno field, near Peace River, Alberta (see Schedule A for a map of the Reno field). Chemistry Matters designed an air sampling program to measure levels of compounds in the air at nine Baytex leases in the Reno field.

The goals of the air sampling program were to:

- Measure volatile organic compounds and reduced sulphur compounds both upwind and downwind of the tanks on selected heavy oil production leases;
- Measure polycyclic aromatic hydrocarbons at the heavy oil leases; and
- Assess potential human health effects using appropriate regulatory guidelines.

The compounds referred to above were included in the study to address the compounds that are likely to be linked to odours. These compounds are also believed to be most likely connected with potential human health effects.

More information about these groups of compounds can be found in Schedule B.

KEY FINDINGS AND CONCLUSIONS

Air samples were collected from February 26 to March 6, 2013 at nine leases in the Reno field. A total of 73 samples were analyzed for RSCs, VOCs or PAHs.

The laboratory reported only one ‘detected’ compound at very low concentration in the RSCs samples. Hydrogen sulphide was measured at 16 parts-per-billion (ppb). This concentration is above the 10 ppb 1 hour average Alberta Air Objective based on odour perception. Human health effects are only observed at higher concentrations and a single detection of this nature is not considered a health risk. It should be noted that this single hydrogen sulphide detection was for a sample collected on-lease (Lease 05-32), and in the upwind location where tank emissions are not anticipated. Other sources may have contributed to the hydrogen sulphide detection. The presence of the 16 ppb hydrogen sulphide concentration in the vicinity of Lease 05-32 suggested that odours may be originating from onsite activities at Lease 05-32. All other RSCs were below their laboratory detection limits, which are all below the applicable Alberta Air Objectives). These results do not necessarily indicate that other RSCs do not contribute to odours potentially emitted from the production facilities. This is because odour perception for certain chemicals may be more sensitive than laboratory analytical methods. Also, commercial analytical methods may not detect the whole range of odour-causing chemicals, as these methods typically only include a small subset of all possible odour-causing chemicals.

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Overall, from a human health perspective, the study found that no health-based objectives or screening levels were exceeded.

With one exception, air samples for analysis of VOCs reported no concentrations that were above the Alberta Air Objectives or the Texas Commission on Environmental Quality's Effects Screening Levels (the "Texas ESL"). A single result at Lease 09-21-1 for carbon disulphide (20 ppb) was above the 1-hour average Alberta Air Objective of 10 ppb (based on odour threshold). This carbon disulphide exceedance in the vicinity of Lease 09-21-1 suggested that odours may be originating from onsite activities at Lease 09-21-1. No other measured levels of VOCs were above the Alberta Air Objectives or the Texas ESL. Concentrations of VOCs were usually lower at 150 metres ("m") than at 50 m downwind of the tanks. As found in a previous Alberta Environment study, wind patterns at the local scale introduced variability to sampling of air contaminants. It was determined post-sampling that the location where the one VOC exceedance was measured was in an "upset condition" with an excessive gas-oil ratio that was likely responsible for the high carbon disulphide reading. This well was immediately shut-in and the condition remedied.

PAHs, including benzo[a]pyrene ("B[a]P"), were detected and compared with the Alberta Air Objectives and the Texas ESL. No concentrations were found to be above these guidelines. The potential cancer risks from exposure to PAHs by inhalation were estimated to be at least 1,000 times below Health Canada's acceptable cancer risk level. The downwind samples had the highest total PAHs concentrations.

Overall, from a human health perspective, the study found that no health-based objectives or screening levels were exceeded.

Of the 73 samples analyzed, only two detected a compound above odour-based objectives: Lease 05-32 (hydrogen sulphide) and Lease 09-21-1 (carbon disulphide).

PREVIOUS INVESTIGATIONS IN THE RENO FIELD

Prior to this study, there has not been a full assessment of VOCs, RSCs or PAHs in ambient air in the Reno field. Spot samples (also known as grab samples) have been collected irregularly in response to resident complaints.

There have been other similar studies conducted in different regions of Alberta to address odour related complaints as well as concerns about potential releases of PAHs from oil production operations. The Reno field study was designed to be similar to these studies, which are described in Schedule C.

CONCURRENT STUDIES

Two additional studies were conducted in the Reno field at the same time as the Chemistry Matters Inc. ambient air study.

Clearstone Engineering Limited ("Clearstone") conducted an infrastructure emissions inventory, and RWDI Air Limited ("RWDI") examined the offsite odours and completed predictive modeling of offsite levels. Each of these studies is complementary to the other and involved particular aspects of the overall assessment of odours and emissions concerns in the Reno area.

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Clearstone Engineering Limited

Clearstone completed field studies at the Baytex Reno field from February 26 to March 6, 2013. The purpose of its work was to characterize emissions and to complete an emissions inventory for the operation. Clearstone conducted flow measurements of produced fluids and solution gas vented to the atmosphere or directed to flare. It also collected flue gas samples from casing gas, solution gas, and combustion device flue gas. Samples were submitted to a laboratory for detailed analysis.

RWDI Air Limited

RWDI began a study with Baytex in September 2012 to address resident complaints about odours and potential health impacts. The study objectives were to: i) evaluate the existing and proposed Baytex Reno facilities in accordance with applicable regulatory requirements under the Alberta Environmental Protection and Enhancement Act and applicable directives of the Energy Resources Conservation Board (now the Alberta Energy Regulator), such as D56 and D60, ii) where needed, suggest mitigation analysis and provide direction to Baytex with respect to pads in need of emissions reduction and action ranking, and iii) provide a summary of predictive modeling results.

ENGAGEMENT OF RESIDENTS

Residents within the Baytex Reno field were invited to take part in the ambient air study. An RWDI representative met with residents before the study began to gather comments and concerns. Residents were notified when the study was to be completed.

During the course of the study, a representative of Chemistry Matters met or talked with ten residents to discuss their concerns and the nature of the study being undertaken as well as to ask permission to access their lands in order to conduct the monitoring. Residents were encouraged to call Chemistry Matters if they noticed bad odour incidents so that samples could be collected as part of the ambient air study. None of the residents called Chemistry Matters while the study was being completed to complain about odours; therefore, no samples were collected at the request of residents during the study.

Air samples were collected using sample containers (Summa canisters) for RSCs and VOCs, and high-volume samplers for PAHs.

AIR SAMPLING PROGRAM

Air samples were collected from February 26 to March 6, 2013 at nine leases in the Reno field (as noted on Schedule A). The nine sites were chosen based on the following:

- Proximity to residences in the area;
- Production on the lease based on the number of wells and tanks;
- Presence of a flare stack on the lease; and
- To provide a fair representation of all Reno area leases.

At each lease, air samples were collected at both upwind (50 m from tanks) and downwind (50 and 150 m from tanks) locations. The upwind samples were collected to compare background compound concentrations and patterns with those from production emissions. The 50 m downwind sample should allow for reasonable detection downwind of the production facilities. The 150 m downwind sample may provide data on dilution further away from the sources and be at a distance that is relevant for maximum likely public exposure scenarios. A distance of 150 m downwind from the tanks or compressors is also a reasonable distance for roads or private property. Standard operating procedures were followed during all field activities.

It should be noted that during the sampling program, “hydrocarbon-like” odours were perceived by field staff at downwind on-lease locations, demonstrating that the samples collected during the sampling program are representative of potential odour ‘episodes’. In fact, two spot ambient air samples were collected (on lease close to the tanks) and analyzed when field staff noted especially intense odours during the sampling program. These spot samples formed part of the 73 samples that were analyzed for RSCs, VOCs and PAHs.

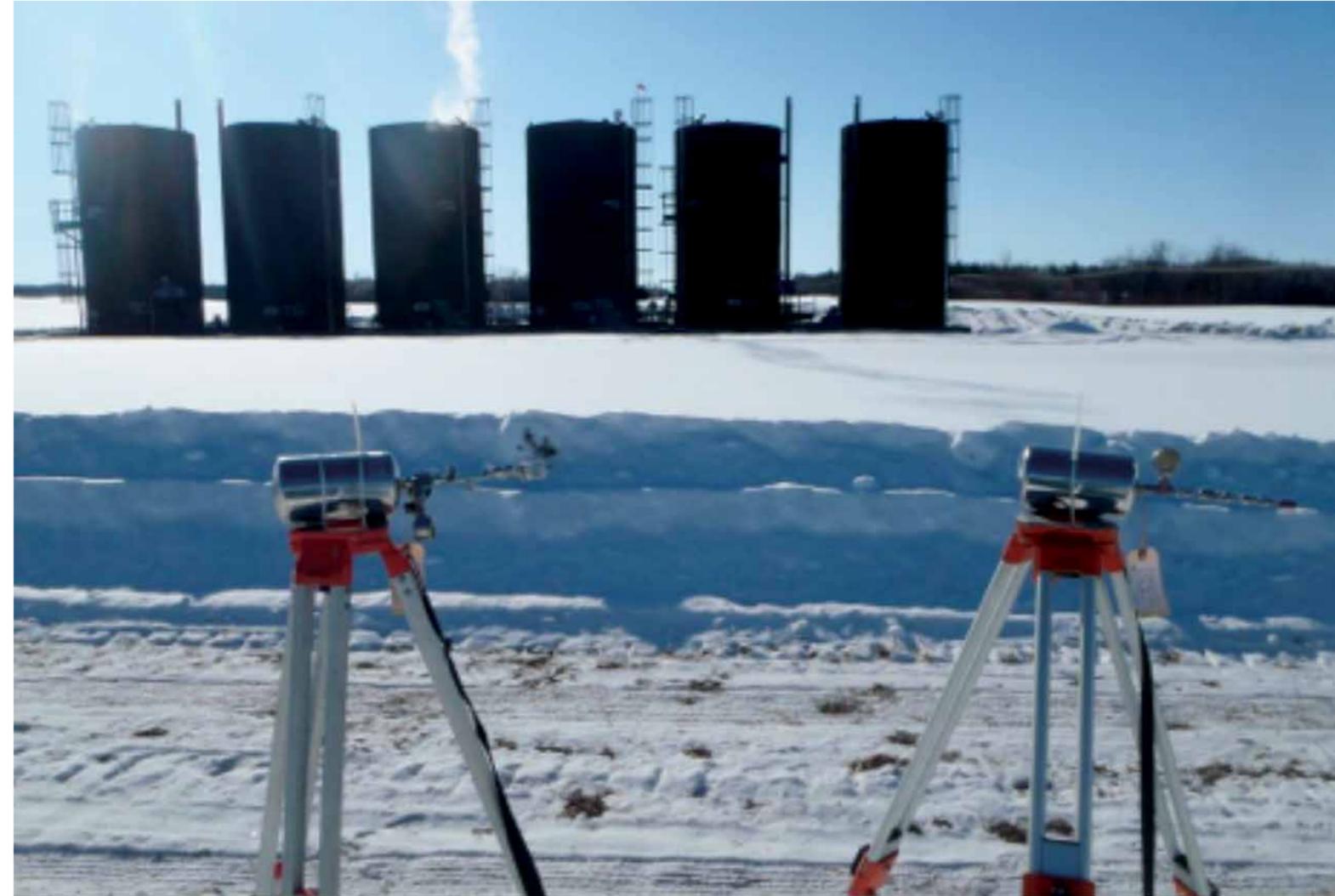


Figure 1 - View south of VOC samples 50 m downwind of tanks on pad 5-32 (1 one-hour sample, 1 four-hour sample).



Figure 2 - View south of VOC samples 150 m downwind of tanks on pad 5-32 (1 one-hour sample).

APPROPRIATE REGULATORY GUIDELINES

For the current study, all air sampling results were compared with the Alberta Air Objectives. The Alberta Air Objectives are based on the potential for human health effects, aesthetic effects (for example, odour perception), or adverse impacts to vegetation. In situations where an Alberta Air Objective was not available for comparison with a chosen compound, the Texas ESL were used. The Texas ESL are compound-specific air concentrations set to protect human health and welfare. Short-term ESLs are based on data concerning acute health effects, the potential for odours to be a nuisance, and effects on vegetation. Long-term ESLs are based on data concerning chronic health and vegetation effects. Welfare-based ESLs (odour and vegetation) are set based on effect threshold concentrations.

If predicted or measured airborne levels of a compound do not exceed an Alberta Air Objective or Texas ESL, adverse health or welfare effects are not expected. If predicted or measured ambient levels of compound in air exceed an Alberta Air Objective or Texas ESL, it does not necessarily indicate a problem but triggers a more in depth review.

AMBIENT AIR SAMPLING PROCEDURE

The field procedures followed while collecting the VOCs, RSCs and PAHs samples during the Baytex Reno field program were standardized and replicated for all of the samples collected. A detailed description of the field air sampling procedures is contained in Schedule D.

AMBIENT AIR SAMPLING RESULTS

Reduced Sulphur Compounds

Air samples for analysis of RSCs were collected upwind (50 m) and downwind (50 m) from five leases in the Reno field (as noted on Schedule A). The laboratory reported only one 'detected' compound in the RSCs samples. Hydrogen sulphide was measured at 16 parts-per-billion (ppb). This concentration is above the 10 ppb 1-hour average Alberta Air Objective. All other RSCs were below the laboratory detection limits (which are all below the applicable Alberta Air Objectives). It should be noted that the single hydrogen sulphide detection was for a sample collected on-lease and in the upwind location (pad 05-32).



Figure 3 - View west of RSC sample on pad 08-29.



Figure 4 - View south of triplicate RSC samples 50 m downwind of tanks on pad 08-21.

Volatile Organic Compounds

Air samples for analysis of VOCs were collected upwind (50 m) and downwind (50 and 150 m) of the tanks on nine leases in the Reno field (as noted on Schedule A). In addition to pre-determined sampling times and locations, spot samples were also collected during the study if intense odours were noted at a particular lease. Two spot samples were collected as part of the study. With one exception, VOC concentrations were not above the Alberta Air Objectives or the Texas ESL. A single result at Lease 09-21-1 for carbon disulphide (20 ppb) was above the 1-hour average Alberta Air Objective of 10 ppb (based on odour threshold). It was later determined through results provided by Clearstone that the location where the one VOC exceedance was measured was in an "upset condition" (i.e., experiencing an excessive gas-oil ratio).

The upset condition was likely responsible for the high carbon disulphide reading. This well was immediately shut-in and the condition remedied.



Figure 5 - View northeast of triplicate VOC samples 50 m downwind of tanks on pad 02-01.



Figure 6 – View of spot sample taken on pad 08-29 downwind of tanks. Spot sample was collected during a time of noticeable odours.

EXHIBIT 1: BAYTEX RENO

Maximum VOCs concentrations in ambient air Feb 26 to Mar 6, 2013

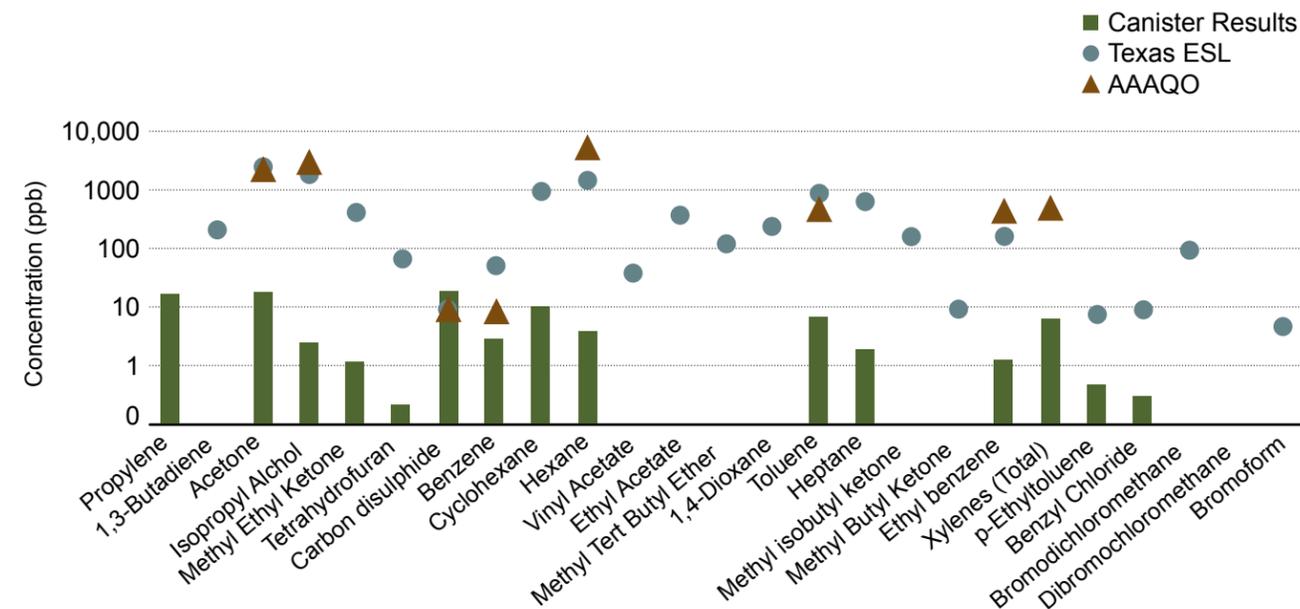


Exhibit 1 – Maximum VOC concentrations from nine leases in the Baytex Reno field compared with Alberta Air Objectives and Texas ESLs. Note that the scale of the graph is logarithmic.

Exhibit 1 compares the highest VOC concentrations measured in air samples collected from across the Reno field to the Alberta Air Objectives and the Texas ESL. Note the one carbon disulphide exceedance that was related to an upset condition. All other VOC concentrations were below guidelines.

Polycyclic Aromatic Hydrocarbons

PAHs were measured in air samples collected from 50 m upwind, downwind, and both crosswind locations at four leases in the Reno field (as noted on Schedule A). These locations were based on wind direction at the start of sampling. These samples were collected over a 24-hour period which included all vehicular traffic near lease, vehicular traffic on lease and potential tank emissions. Trail cameras were used to document vehicle traffic on site (see Figure 7). PAHs, including B[a]P, were detected and compared with the Alberta Air Objectives and the Texas ESL. No concentrations were found to be above these guidelines.



Figure 7 – Picture taken by Trail Camera of a truck leaving pad 13-14.



Figure 8 – Components of high volume sampler used to collect PAH samples.



Figure 9 – Inside view of high volume sampler.

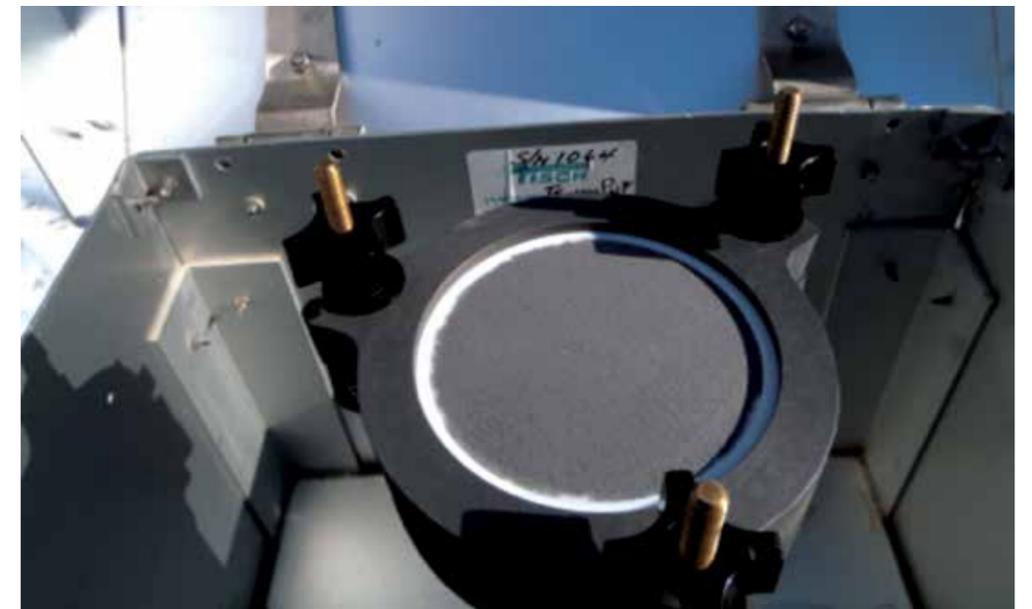


Figure 10 – View of quartz filter with gray particulates after 24-hour sample time for high volume sampler.



Figure 11 - View east of high volume sampler on pad 08-21.

A number of PAHs are known, or suspected of being, cancer-causing to humans. The potential cancer risks associated with PAHs in air samples collected from the Reno field were calculated using the concentration and potency (relative to B[a]P) of 17 individual PAHs. The potential cancer risks from exposure to PAHs by inhalation were estimated to be at least 1,000 times below Health Canada's acceptable cancer risk level (see Exhibit 2). This risk level is based on exposure for lifetime to the concentrations present 50 m away from the tanks.

Exhibit 2: Inhalation Incremental Lifetime Cancer Risk

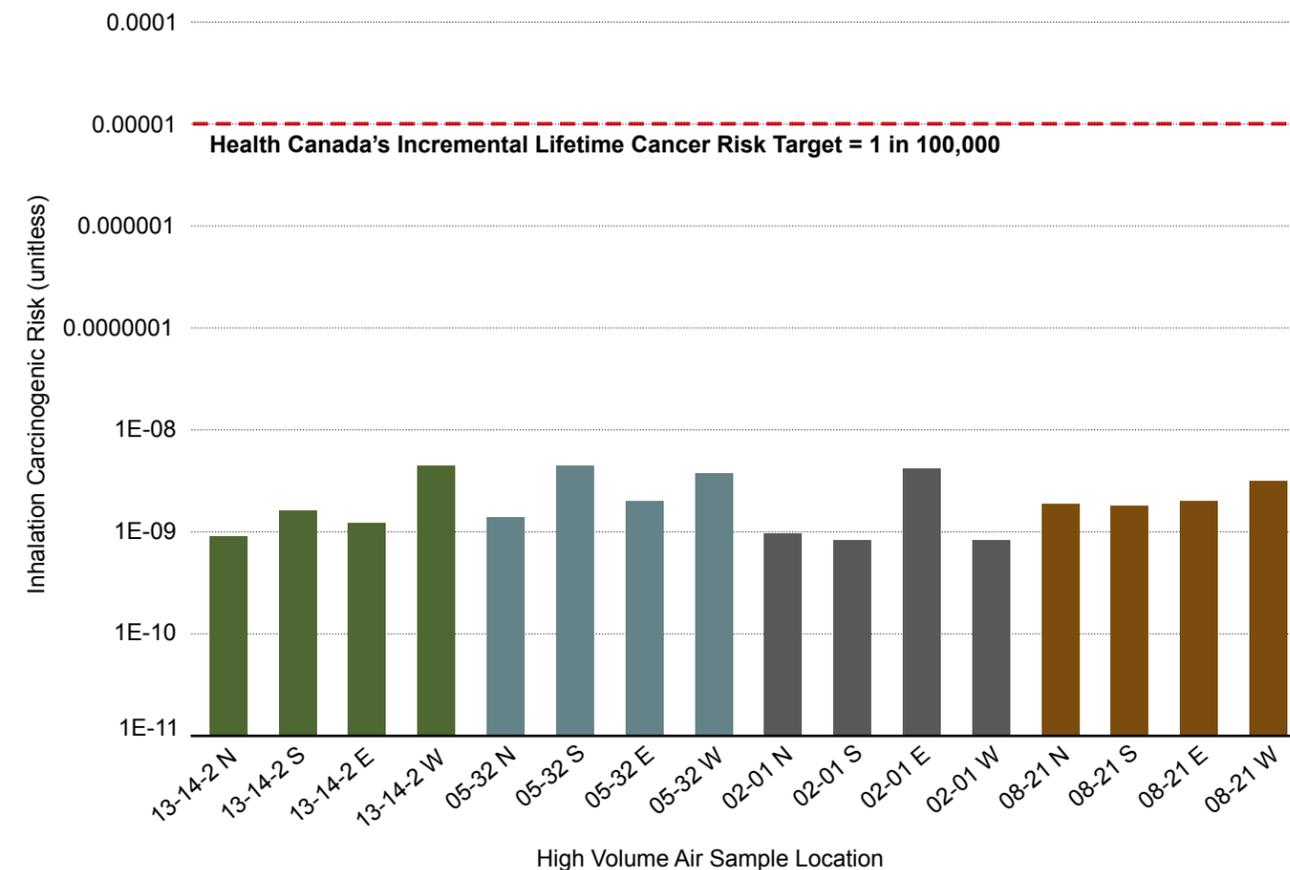
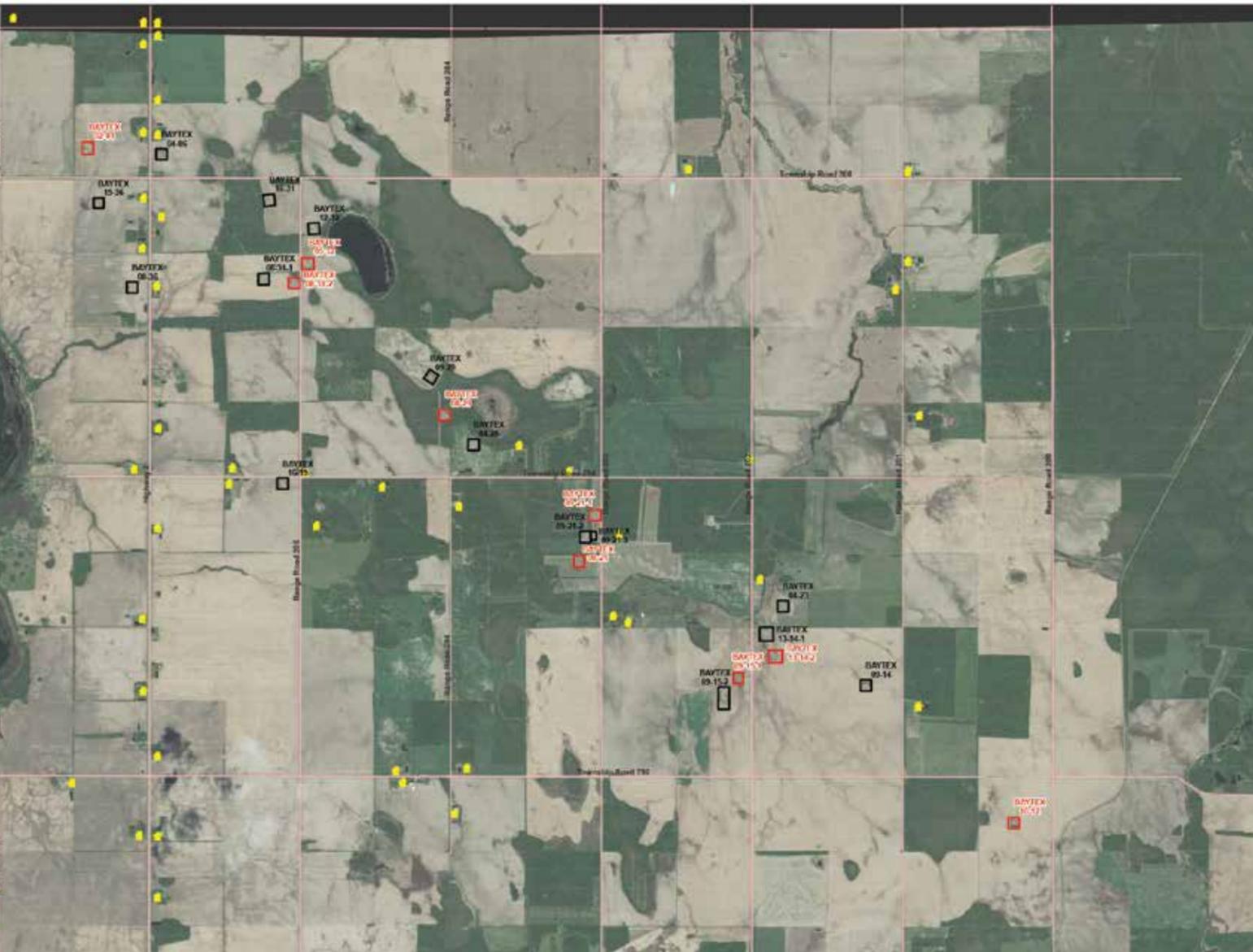


Exhibit 2 - Estimated incremental lifetime cancer risks (ILCRs). Calculated from B[a]P Total Potency Equivalents and Health Canada's inhalation unit risk for B[a]P. Note the log scale of the graph. Each horizontal line represents a 10-fold change in lifetime cancer risk: at 4E-09, the inhalation ILCR is >1,000 times lower than Health Canada's target of 1 in 100,000.

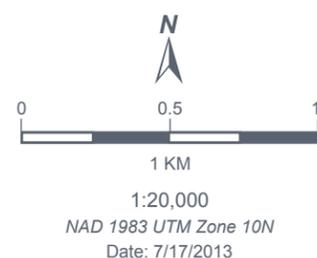
Schedule A

MAP OF RENO FIELD AND SAMPLING LOCATIONS



LEGEND

-  Homestead
-  Lease sites to be sampled
-  Other lease sites
-  Roads



Schedule B

DESCRIPTION OF RSCs, VOCs, AND PAHs

Reduced Sulphur Compounds

RSCs are a complex family of compounds that contain sulphur. RSCs are a concern as they are a major cause of unpleasant odours. This is because of their low odour thresholds. RSCs may also cause health effects at higher levels in the air. The common descriptions of odours related to RSCs are rotten egg and rotten vegetation. They are naturally present in sour gas and many crude oils. Pulp mills and other industrial facilities also release RSCs.

Volatile Organic Compounds

VOCs are compounds that have a tendency for molecules to leave the liquid form and enter the air. VOCs are a concern because of their potential to add to odours and to cause health effects at high levels measured in the air.

The VOCs chosen for this study are a subset of those analyzed using the United States Environmental Protection Agency ("US-EPA") Method TO-15. Many of the compounds commonly measured with Method TO-15 are halogenated solvents that are related to other types of industries and others are volatile refrigerants (Freons). These types of VOCs are not relevant to heavy oil production. There were no documented uses of these compounds noted in the material safety data sheets used by Baytex. Therefore, samples collected in the Reno field were measured for a shortened TO-15 list of compounds. This method focuses on petroleum related VOCs. BTEX (benzene, toluene, ethylbenzene, and xylenes) compounds were also measured because these are commonly found in crude oils.

Polycyclic Aromatic Hydrocarbons

PAHs consist of a group of hundreds of related organic compounds. They are of concern mostly due to their potential health effects at high measured levels. PAHs are formed in most combustion processes in which organic material is burned (for example, coal, fossil fuels, wood, municipal waste, tobacco, and so on). They also are present in crude oils and tars. In all of these sources, PAHs are present as complex mixtures. When released to the air, they can be present in the gas phase or be adsorbed to air particulates.

Health effects from being exposed to PAHs have been studied extensively. A group of 16 PAHs are monitored in regulatory guidance and environmental and human health assessments. These 16 PAHs are classified as 'priority pollutants' by the US-EPA based on their toxicity and common occurrence in the environment.

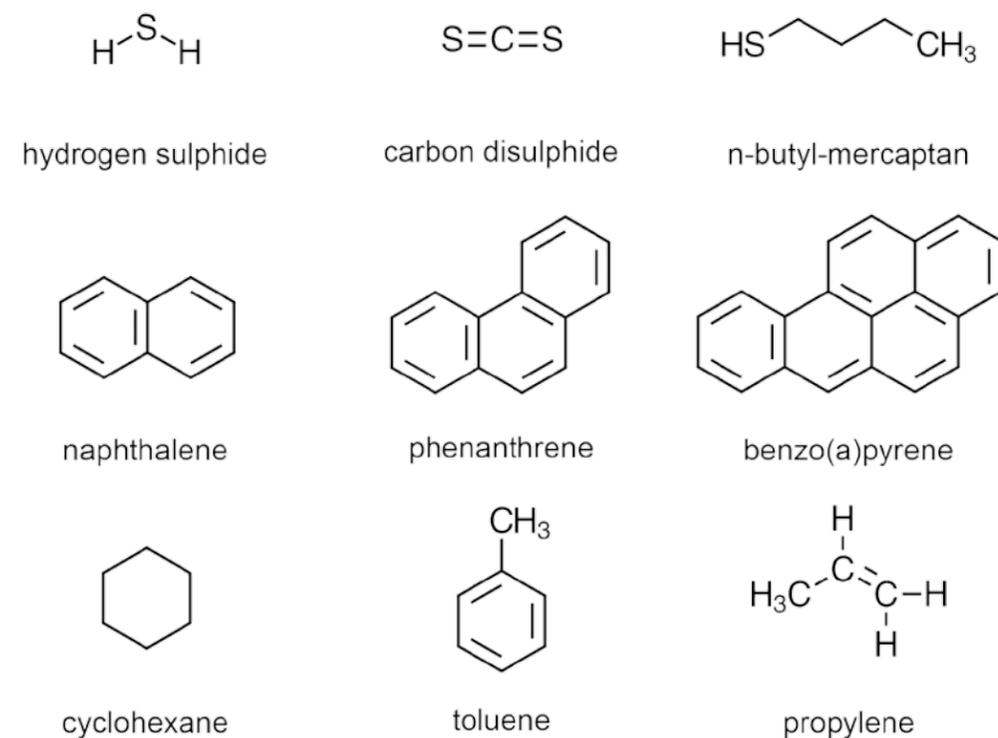


Figure 12 – Examples of those compounds monitored as part of the ambient air sampling program; reduced sulphur compounds (shown in top row), polycyclic aromatic hydrocarbons (shown in middle row) and volatile organic compounds (shown in bottom row).

Schedule C

OTHER SIMILAR STUDIES

Three Creeks Area

In response to odour complaints in the Three Creeks area of Alberta, Alberta Environment and local industry operators initiated an air monitoring study in 2010. Ambient air samples were collected from within the community of Three Creeks (for example, beside residential properties or in agricultural areas). Air samples were collected by various means: continuous monitoring stations, canisters, and the Alberta Environment Mobile Air Monitoring Laboratory. The samples were analyzed for a variety of compounds including total hydrocarbons, sulphur dioxide, total RSCs, VOCs, and PAHs. The data showed the presence of a variety of hydrocarbons in the air in the Three Creeks area. At times, these hydrocarbons were detected in elevated concentrations as compared to background locations; however, the Alberta Air Objectives were not exceeded for any of the samples collected. Higher concentrations were associated with calm conditions (that is, not windy), prevailing winds from the east, and night time.

Bonnyville

Alberta Environment conducted two air sampling studies (fall 2007 and spring 2008) in the vicinity of heavy oil cold flow tanks near Bonnyville, Alberta. The studies were initiated following public complaints about odours and potential health impacts. The main objective of the studies was to examine hydrocarbon concentrations on properties located adjacent to cold flow tank platforms. Air samplers were placed at various distances downwind from the platforms (ranging from roughly 50 to 150 m from the tanks). In addition, upwind samplers were setup to simultaneously collect reference/control samples. Samples were collected using canisters for VOCs and hi-volume samplers for PAHs. At times, VOCs and PAHs concentrations measured at the downwind sites were found to be substantially higher than the reference upwind site. This suggested that the sampling sites were most likely impacted by emissions from the cold flow tanks. Air samples collected simultaneously at the downwind sites showed highly variable VOCs and PAHs concentrations within the small sampling area.

These results indicated that close to the source (tanks) there is limited mixing of the emitted substance in the air, resulting in a heterogeneous air mass and sample.

PAHs concentrations were largely composed of naphthalene and other smaller PAHs typically found in the gas phase. Short chain hydrocarbons, which are typically found in the gas phase, were the most abundant VOCs.

Although at times elevated, measured VOCs concentrations were orders of magnitude lower than Alberta Air Objectives. VOCs concentrations were also substantially lower than available odour thresholds.

Alberta Oil Sands

With the international attention on the oil sands development in Northern Alberta, there is an air monitoring study being led by scientists from the province and at Environment Canada. The PAH measurements for the Baytex study were fashioned to be similar to the Environment Canada study through discussions with the lead scientists of the Environment Canada study.

Schedule D

AMBIENT AIR SAMPLING PROCEDURE

Reduced Sulphur Compounds and Volatile Organic Compounds

The field procedures followed while collecting the VOCs and RSCs samples during the Baytex Reno field program were standardized and replicated for all of the samples collected.

At each sampling site, field workers parked their truck at the site entrance to reduce possible impacts on the samples. Field workers then established wind direction by the windsock located on the top of each tank nest. Other important field observations were also recorded. Once the wind direction was known, a range finder was used to measure the 'distance to the tank nest'. This provided the 50 m upwind and downwind sampling locations, as well as the 150 m downwind location for the VOCs sample.

Field staff then labeled the sampling canisters with the client name, site location, sample identification, and date. Photographs were taken of the sample labels. Canister and air flow regulator serial numbers were recorded in the field notes. Silonite-lined Summa canisters were used for collection of the RSCs samples.

Before samples were collected, the canisters were attached to tripods using zip-ties and then placed approximately 135 cm above the ground or snow cover. The location was then marked with a handheld global positioning system ("GPS") and photographed. To reduce impacts to the 4-hour sampler located 50 m downwind of the tanks, the neighbouring 1-hour sampler was placed slightly downwind during sample collection.

The samplers were run for their fixed time (1-hour or 4-hours). Once sampling was done, the samplers were gathered by approaching from a downwind direction. The end time was recorded in the field notes and on the canister label.

Samples along with their chain-of-custody forms were stored and shipped in coolers that were sealed with masking tape over the opening. The tape on the coolers was signed and dated then finally sealed with clear packing tape.

Polycyclic Aromatic Hydrocarbons

High volume air samplers (Tisch TE-1000) were calibrated before the first Baytex Reno field sampling event and after the program was finished. All samplers were within acceptable limits during both calibration events. The field procedures followed while collecting the PAHs samples during the field program were standardized and repeated as much as possible for all of the samples collected.

At each sampling site, field staff established wind direction by using the windsock located on the top of each tank nest, and by other field observations. Once the wind direction was known, the Tisch samplers were placed at 50 m downwind, upwind, and crosswind locations (four locations in total) with the use of a range finder. Next, generators and extension cords were placed in locations that reduced potential impacts during the sampling event (downwind). Generators were then prepared for start-up. Both Tisch samplers and generator locations were recorded with a handheld GPS.

Field trucks were parked at the site entrance to reduce potential impacts on the samples. Then both generators and Tisch samplers were started and warmed to troubleshoot any problems before the sampling event. A surveillance camera was placed near the site entrance to record traffic on the lease during the 24-hour sampling event.

To operate the Tisch samplers, field staff started the generators and loaded the sampling materials (PUF cartridge and filter paper) while wearing new, clean nitrile gloves. The sample number of the PUF was recorded before loading the Tisch sampler with the filter paper. The Tisch samplers were then turned-on, and start time, pressure, hour meter reading, and serial number of the Tisch were recorded.

The generators were refueled as needed during the 24-hour sampling period so that sampling was continuous.

After the sampling period was finished, the Tisch samplers were turned-off followed by the generators. The completion time, hours of operation, and pressure of each Tisch were recorded. The sample cartridges and filter papers were removed from Tisch samplers then wrapped and sealed for shipment to the laboratory. Samples were then stored in a cooler with cold packs to ensure a cool consistent temperature during storage and shipping.

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