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Phase 2

HHRA SUMMARY REPORT

Prepared for: British Columbia Ministry of Health



SUMMARY OF HUMAN HEALTH RISK ASSESSMENT OF OIL AND GAS ACTIVITIES IN NORTHEASTERN BRITISH COLUMBIA

In late 2012, the Ministry of Health commissioned Intrinsic Environmental Sciences Inc. (Intrinsic) to complete Phase 2 of the human health risk assessment (HHRA) of oil and gas activity in northeastern British Columbia (NE BC). Intrinsic's study team was composed of specialists in toxicology, epidemiology, medicine, air quality, water quality, and emergency response planning. The project was overseen by a provincial Steering Committee and an independent three-member advisory panel. The Steering Committee was made up of executive-level staff from a number of provincial Ministries, the BC Oil and Gas Commission and Northern Health Authority. The advisory panel provided an independent perspective on the design and approach of the HHRA, and the interpretation of the results.

Following two years of extensive analysis, the study team produced six different reports as part of this project, all of which are now available at: <http://www.health.gov.bc.ca/protect/oil-gas-assessment.html>.

The key deliverables and findings of the project are summarized below.

Project Start-up and Identifying the Direction of the Phase 2 HHRA (Timeline: Fall 2012 to Spring 2013)

The study team first met with the provincial government Steering Committee in late 2012 in order to outline and discuss the initial approach to the work. Community consultation activities took place during January 2013 in Fort St. John, where some public feedback was provided.

Before additional in-depth work on the project was completed, a high-level plan as to how the Phase 2 HHRA would be completed was developed.

The study team conducted an information search/environmental scan to establish the scope and extent of oil and gas activities in NE BC. This search involved an examination of the overall nature of oil and gas operations, emission sources and chemical discharges, to determine the information available and data gaps. The search also helped identify the chemicals related to oil and gas activities to which people could potentially be exposed.

The study team also reviewed the report by the Fraser Basin Council commissioned under Phase 1, which summarizes public concerns about the potential health impacts related to oil and gas in NE BC. These concerns were considered within the HHRA to the extent possible, in keeping with the defined scope of work.

Based on direction from the Steering Committee, this study took a human health risk assessment approach with a focus on environmental exposure to chemicals on a regional scale. It was not an epidemiological or clinical health study and did not directly measure the occurrence of disease in the region. The scope of work did not include an analysis of how oil and gas activity in NE BC could influence other determinants of health (such as housing, access to community services, mental health, addictions, quality of life, etc.) or other non-chemical hazards (including noise, light, traffic accidents). Addressing these concerns will require further analysis, in collaboration with regional organizations, such as Northern Health.

A review of publicly available reports related to the potential health effects associated with oil and gas activity was conducted by the study team's epidemiologists and medical doctor, with the findings helping to guide the design of the HHRA. The review included peer-reviewed scientific literature as well as reports produced for the local health areas, the province, and other jurisdictions with oil and gas activity. Most of the studies evaluated as part of this review lacked information regarding exposure pathways, chemicals emitted from the various sources, and exposure concentrations. The review did, however, identify the potential health effects that should be considered in the HHRA, including different types of respiratory disease and cancer.

Screening Level Risk Assessment (Winter 2013 to Fall 2013)

The process of evaluating if emissions from oil and gas activities in the region were contributing to adverse health effects in the population was divided into two steps – a screening level risk assessment (SLRA) and a detailed HHRA.

The intention of the SLRA was to:

- Identify the potential oil and gas related emission sources in the region that presented the greatest potential risk to human health
- Set practical boundaries on the detailed HHRA, including the definition of a focused study area for the HHRA
- Prioritize oil and gas emission scenarios for further evaluation in the detailed HHRA
- Provide additional input into the scope of both the detailed HHRA and the review of the BC regulatory framework

In order to do this, the study team completed a comprehensive analysis of a spectrum of potential emission sources to air and water, with the aim of identifying those sources that pose the greatest potential risk to people in NE BC. This screening exercise was conducted through statistics, risk analysis and professional judgment. Particular consideration was given to potential adverse health impacts, likelihood of occurrence, scale of potential impacts, and magnitude of potential exposures in order to identify the emission sources and scenarios presenting the greatest potential risk.

The emission scenarios that were selected for further analysis in the detailed (quantitative) HHRA include continuous emissions from gas processing plants, and continuous emissions from oil and gas production facilities (including batteries, storage tanks, compressors, dehydrators, *etc.*). The assessment of these emission sources was focused on a smaller study area of approximately 175 kilometres (north/south) by 150 kilometres (east/west). This area, centred on Fort St. John, and also including Dawson Creek, Pouce Coupe, Hudson's Hope and Taylor, the Blueberry and Doig River First Nations, and the northern boundary of Tumbler Ridge, represents the most densely populated area in the region under study, as well as the area with the highest density of continuous emission sources. The characterization of health risks inside the defined study area also ensured that worst-case conditions were captured in the HHRA. As such, the results for the study area can be applied across the entire region.

The SLRA identified a number of water emission sources that could not be assessed on a regional scale. For example, scenarios relating to historical and current fluid management practices are associated with a relatively low consequence to human health, however, the potential likelihood of occurrence is reasonably high due to the number of historical and active

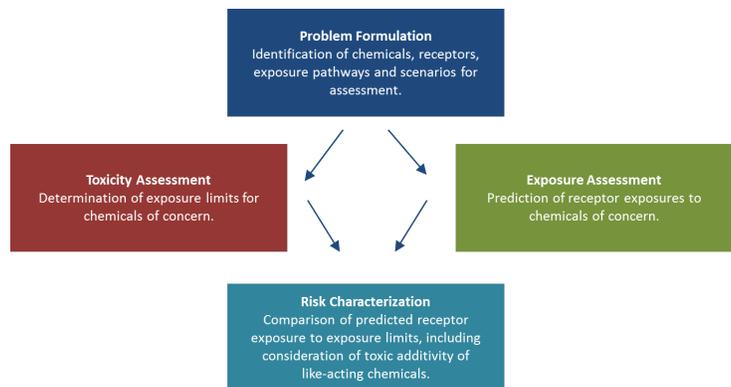
wells. However, the health risks associated with these site-specific issues can only be assessed on a case-by-case basis using measured, site-specific data. While the regional distribution of air emissions can be predicted more readily, the spread of chemicals in water and the vulnerability of water resources depends on several site-specific factors. Such factors could include the nature of contamination at a particular site, the specific soil conditions at a site, the depth to contamination, and the proximity to nearby waterbodies, etc. There are a number of data gaps in publicly available information regarding groundwater and surface water resources in NE BC that influence the ability to complete site-specific assessments. The HHRA could not assess specific sites individually. As a result, these scenarios could not be carried forward into the detailed HHRA, which was intended to have a regional focus.

Another example is a pipeline rupture scenario, which is associated with a relatively low likelihood of occurrence, but a much higher potential consequence to human health in the event of a release. While these types of release events cannot be assessed on a regional scale, they can be mitigated through emergency planning and response practices, communication, and site-specific activities (such as evacuation or closure of drinking water intakes) to reduce the potential for human exposure. As a result, such scenarios were excluded from quantitative analysis in the quantitative HHRA.

A number of the exposure scenarios evaluated in the SLRA, like those described for historical and current fluid management and pipeline releases, were evaluated further in the Review of the Regulatory Framework.

**Detailed Human Health Risk Assessment
(Fall 2013 to Summer 2014)**

The detailed HHRA was conducted using widely accepted methods that have been endorsed by regulatory organizations worldwide, including Health Canada, the US Environmental Protection Agency, the World Health Organization and other leading health agencies.



A step-wise risk assessment process (shown in the figure) was followed in the collection and review of information, and in the estimation of potential risks.

The two air scenarios identified in the SLRA and the numerous associated emission sources within each of these scenario categories were considered together to represent continuous emissions from oil and gas activity within this detailed HHRA. By combining the emissions from the gas processing plants and production facilities into a single emission scenario representing oil and gas activities, the potential influence on air quality (and consequently human health) was addressed on a cumulative basis. In addition, information regarding emissions from regional sources from other non-oil and gas activities was incorporated into the detailed HHRA.

A comprehensive emission inventory of the continuously emitting oil and gas facilities was compiled for the study area. This inventory incorporated several thousand individual emission sources. In addition, to further characterize air quality on a cumulative basis and in order to

compare air quality associated with oil and gas activities with those associated with non-oil and gas emission sources, two scenarios were considered in the HHRA:

1. **Oil and Gas Scenario:** includes all on-going emissions from gas processing plants and various production facilities within the HHRA study area. These sources include, but are not limited to significant emitters such as, sweet and sour gas plants, compressor stations, and fugitive emissions from tank storage.
2. **Cumulative Scenario:** includes the oil and gas sources from the oil and gas scenario, as well as emissions from background sources such as other industries (for example, forestry and mining), transportation, and community activities (such as wood burning to heat homes).

Community locations were evaluated within the HHRA, along with the maximum predicted ground-level concentrations of each chemical of potential concern for the entire study area.

Results were presented and described for inhalation on a short-term and long-term basis, and for all possible routes of exposure on a long term basis. A brief summary of the results is as follows:

- In general, the predicted short-term air concentrations were less than the health-based guidelines. As well, the potential combined risks of the assessed chemicals were not predicted to result in negative health effects in people living or visiting the study area. However, the predicted exposures at some locations were found to exceed guidelines for some chemicals (acrolein, formaldehyde, nitrogen dioxide (NO₂), sulphur dioxide (SO₂), fine particulate matter (PM_{2.5})) and their corresponding “common health endpoint” groups (including the eye, nasal and respiratory irritants). The “exceedances” for formaldehyde, NO₂ and SO₂ appear to be due to oil and gas facilities, with some contributions from other sources in the area. Due to the rare nature and/or remote location of these exceedances and the margin of safety built into the HHRA, these exposures are not expected to result in health impacts.
- Overall, estimated long-term inhalation exposures to the chemicals are associated with a low potential for health effects. For PM_{2.5}, exceedances of the BC Ambient Air Quality Objective were predicted for only the Cumulative Scenario at two remote locations where people are unlikely to be regularly exposed. For formaldehyde, potential cancer risks were predicted for a remote location in close proximity to an oil and gas site. However, further analysis of this exceedance indicating that the probability for people to be exposed to formaldehyde concentrations at the predicted level over a lifetime was very low. When the potential combined effects of the chemicals were evaluated, nasal and respiratory irritant mixtures were predicted to have elevated risk estimates. However, given the locations of where the maximum concentrations for these chemicals were expected to occur, and the degree of conservatism incorporated into the HHRA, the potential mixture risks were determined to have a low potential for health effects.
- The potential changes in environmental media other than air were addressed in the HHRA through the assumed deposition of chemicals onto soil, water and plants. In the assessment of potential exposures that people in the area might receive over the long term through eating locally-grown foods, drinking water, *etc.*, it was determined that the potential for adverse human health effects is low.

The overall findings of the detailed HHRA of oil and gas activity in NE BC suggest that, while there is some possibility for elevated air concentrations to occur at some locations, there is a

low probability that health impacts would occur in association with these exposures. The elevated air concentrations were rare or occurred in remote locations, and given the margin of safety built into the HHRA, are not expected to result in negative health effects.

Review of BC's Regulatory Framework and Recommendations Report (Winter 2013 to Summer 2014)

In addition to the detailed HHRA, a review of existing regulatory and policy frameworks related to oil and gas activity in place in BC was completed. The review placed particular emphasis on those scenarios which were not evaluated in the detailed HHRA, but that still were of interest to public health in the region.

The purpose of the regulatory review was to determine to what degree the protection of human health is captured within the existing provincial regulatory framework (as it relates to oil and gas activity), with a view to identifying potential improvements.

The existing regulatory framework in BC was compared with what exists in other oil and gas producing jurisdictions, and industry best practices. The review did not critically evaluate the enforcement of the existing regulations in either BC or in the other jurisdictions.

Overall, the review found that the existing regulatory framework in BC is both extensive and protective of human health, although there are some areas that warrant further consideration, including: emergency planning; flaring, venting and fugitive emissions management; hydraulic fracturing; information management; and, environmental monitoring.

Intrinsic's final recommendations report is based on information provided in the Fraser Basin Council Phase 1 report, input from the technical advisory panel, and the findings of the SLRA, HHRA and Review of the Regulatory Framework. The 14 recommendations fall under a number of common themes or broad categories, including:

- Public Safety (Recommendations 1 and 2)
- Flaring, venting and fugitive emissions management (Recommendation 3)
- Hydraulic fracturing (Recommendations 4 and 5)
- Legacy sites (Recommendation 6)
- Information management (Recommendation 7)
- Environmental monitoring (Recommendations 8 to 12)
- Health surveillance (Recommendation 13)
- Standards development (Recommendation 14)

The recommendations put forward to the Province include:

- **Recommendation 1** The tools applied to the calculation of emergency planning zones representing the range of hazards associated with oil and gas infrastructure and activities should be updated using a more up-to-date approach.
- **Recommendation 2** The Province should consider implementing reciprocal setback provisions between the oil and gas industry and BC's municipalities.
- **Recommendation 3** BC's Ambient Air Quality Objectives should guide the development of regulations, directives and policies pertaining to venting, fugitive emissions, flaring limits, flaring notification and reporting, and flaring performance

requirements. This should be done in a transparent manner that demonstrates how the objectives are considered.

- **Recommendation 4** BC should consider implementing baseline, pre-drilling ground water testing requirements for oil and gas activity in the Province. Whenever possible, the process for collecting the information should be transparent, and the results publicly available, and reviewed on a regular basis. To facilitate the interpretation of results, it may also be beneficial to encourage the collection and reporting of well information in addition to sample data.
- **Recommendation 5** The Province should consider refining its fracturing fluid disclosure process so that designated authorities and health professionals can gain access to needed information about fluid ingredients, without compromising confidential business information.
- **Recommendation 6** When possible, the site classification tool and the existing framework for the management of contaminated sites should be used together in the assessment and management of environmental risks at legacy sites in NE BC.
- **Recommendation 7** The overall objectives and efficient use of the various databases that manage permits, facility information, wells and flare data should be reviewed, with the aim of identifying means to make the systems more accessible and user-friendly.
- **Recommendation 8** The Province's on-going air monitoring program in NE BC should continue to follow the principles outlined in BC MoE's *Framework for the British Columbia Air Monitoring Network*. Consideration should be given to the air quality contour maps provided in the detailed HHRA in the placement of future air quality monitors. As well, the identification of specific air contaminants for inclusion in the air monitoring program should consider the findings of the detailed HHRA.
- **Recommendation 9** Once additional data for the NE BC region are available from new monitoring stations or are made available from regulatory submissions, the air quality predictions and human health risk estimates from the detailed HHRA should be revisited.
- **Recommendation 10** While some groundwater mapping has been completed in NE BC, it is recommended that the existing groundwater mapping (and vulnerability mapping) be expanded for the NE BC region to help enhance the protection of groundwater resources in relation to oil and gas development. This information would aid in regional and site-specific assessments of potential risks to groundwater. As one of the limitations with the current aquifer mapping relates to an overall absence of subsurface data, it is suggested that surficial geology mapping (on an appropriate scale) for the region be completed as well.
- **Recommendation 11** Additional study of groundwater and surface water interactions within shallow aquifers and local ground water flow conditions in the NE BC region should be completed. This information could contribute to a better understanding of potential contaminant fate and migration. As well, studies could be carried out to investigate the location and sources of groundwater recharges.
- **Recommendation 12** Consideration should be given to the overall goals of the existing environmental monitoring programs for soil, water, and biota, along with the presentation and quality of these data within the existing databases, specifically as these relate to the value that these data could provide with respect to human and environmental health.
- **Recommendation 13** The Province should explore tailoring their health surveillance to determine whether or not there are any differences in disease rates in those areas

identified in the HHRA with the highest predicted air concentrations. If possible, such future health surveillance would help verify the conclusions of the HHRA.

- **Recommendation 14** The BC air quality objectives should be reviewed and updated based on the existing provincial framework for developing air quality objectives.