Population Health and Oil and Gas Activities

A Preliminary Assessment of the Situation in North Eastern BC

A Report from the Medical Health Officer to the Board of Northern Health

northern health

PREFACE

Widespread consensus within the scientific community points to the burning of fossil fuels as the primary cause of global warming.

This study was initiated in early 2005 and was designed to identify potential health impacts on the local population from oil and gas exploration. As far as possible, the report utilizes an evidence-based approach to support recommendations promoting health and safety in a resource extraction setting. It calls for the following: a review of legislation to ensure health considerations are included when determining setback distances; an enhanced planning process for emergency response and emergency awareness zones; and research and recommendations that will address the social consequences of large influxes of workers on small communities, including health system impacts. If implemented, all these recommendations will be helpful.

This report did not, however, explicitly consider the global, as opposed to local, health impacts of increased oil and natural gas production and the urgent need to respond to climate change. This includes the recognition that the economy, an important component of a healthy community, is dependent on a healthy environment. It also recognizes that burning fossil fuels is the primary cause of climate change.

The recently-released BC Energy Plan is a strong initial response to the need to address climate change. Elimination of flaring over ten years (with a 50 percent reduction in 5 years) and CO_2 sequestration in new coal mines are significant early steps toward a sustainable non-fossil fuel energy economy.

However, the BC Energy Plan is silent on the health and safety requirements of communities being impacted by resource exploration and extraction. I hope this document will assist in bringing those considerations to the forefront.

L.M. Medd MD FRCPC
Medical Health Officer

ACKNOWLEDGEMENTS

This report was researched and written by Kelly Bush. Kelly is a graduate engineer from UBC and was a fellow in the UBC Bridge program in 2005-06. The UBC Bridge program is unique in that it brings Engineering, Public Health, and policy together.

In developing the report, Kelly and I made several trips to the North East to talk to people and to gather data. We also drew extensively on the expertise of Kelly's Bridge faculty supervisor, Dr. Mike Brauer; Dr. Ray Copes, Director of the National Collaborating Centre for the Environment and Medical Director the Environmental Health Program at BCCDC; and John Pelton, Director of Environmental Health, Calgary Regional Health Authority (retired). Many thanks to the advisors for their critical analysis, helpful suggestions, and unfailing support.

The long hours and hard work researching, analyzing the information, and developing the document were contributed by Kelly, who was indefatigable and unfailingly cheerful. The standard of excellence she brought to her task is daunting, and she distinguished herself regularly on several fronts; from sharing ideas with a range of people in the North East to researching and preparing a rigorous academic document. She brings great credit to the Bridge program.

The final document has been refined and updated through a consultation process. Any errors or omissions in the report are my responsibility.

EXECUTIVE SUMMARY

Background

A strong North American demand for natural gas has fuelled increased local petroleum exploration in north eastern British Columbia. While there is a benefit that accrues to the province as a whole, the health and safety risks to the local population as a consequence of this activity require study.

Northern Health (NH) initiated a preliminary study in March 2005 to identify potential community health and safety impacts from oil and gas activities in the northeast region of British Columbia.

Study Objectives

The intent of this study was to review the relevant scientific literature and develop an evidence-based approach that identifies population health and safety concerns in northeastern British Columbia communities. The objectives of the study were to:

- outline the potential population health impacts from oil and gas activities in northeastern BC;
- investigate the emergency response capacity related to oil and gas development activities in BC; and
- make recommendations to the Board of Northern Health and provincial authorities to assist the Health Authority with policy development that addresses public health and safety needs related to the oil and gas industry.

Methodology

The methods used to assess potential population health impacts from oil and gas activities in northeastern British Columbia were a literature review and stakeholder input. A literature review was conducted to assess potential issues related to population health and safety arising from oiland gas exploration and development. The literature review focused on published findings in both peer-reviewed and non-peer reviewed or grey literature. A number of articles were also obtained via online internet searching from relevant government agencies, non-governmental organizations, and oil and gas industrial web sites.

In conjunction with the literature review, input was documented from a range of stakeholders. Meetings were held in Fort St. John, Dawson Creek, and Fort Nelson. The consultation process included meetings with the residents of a Fort St. John subdivision, the Peace River Regional District Board of Directors, representatives of the Oil and Gas Commission, Ministry of Environment, workers employed in the oil patch, and First Nations groups.

Public Health and Safety Issues

The main themes identified by stakeholders were as follows:

- public health and safety, particularly emergency response planning, emergency response, establishment of emergency response zones and setback distances from residences and public buildings, such as schools;
- social impacts, including impacts on community residents and workers in the industry;
- First Nations community and ecosystem health, specifically any links between environmental quality, wildlife health, and human health;
- the role of the public in the decision-making process;
- potential health effects from acute and chronic low level exposures to hydrogen sulphide and other compounds related to oil and gas activities, including industry flaring activities, cumulative effects from compound releases from other industries, and emissions from increased transportation including particulate matter;
- concern for animal health including potential impacts on livestock and pets;

- reduced enjoyment of life via impacts from odours, ongoing health concerns, potential re-location from current residence, noise and light from flaring, and mental anguish;
- impacts on the environment from oil and gas activities such as water, air, and soil quality; agricultural activities; and wildlife.

Based on guidance provided by stakeholder input, the key concerns flagged for investigation in this study were:

- potential social/ health impacts on communities;
- setbacks;
- emergency response planning process; and
- a literature review of population health studies and chronic low-level exposures from sour gas (H_2S) activities.

Social/Health Impacts on Communities

There is limited published information on social impacts of resource development, specifically oil and gas developments, in northern British Columbia communities, This review has identified evidence of both positive and negative socially-mediated impacts in other resource-based communities. A number of studies of resource-based communities suggest there are impacts on the social health of communities from increased industrial activity and subsequent population growth. Social /health impacts have been identified in frontier resource communities, characterized typically by large influxes of a predominantly male workforce. Impacts identified from other resource-based industries include increases in sexually transmitted disease, drug and alcohol abuse, prostitution, crime, and violence. It was beyond the scope of this study to conduct a social impact assessment. However, these issues have the potential to impact health and health service utilization within these regions.

A preliminary overview of potential social/health impacts to northern BC communities from influxes in workers was conducted. This assessment used a qualitative approach and included a review of published literature and consultations with public health officials in northeastern British Columbia communities. The available literature and anecdotal evidence suggested that social and community health impacts are occurring as a result of increased oil and gas development. An assessment of health services utilization data for northeastern communities indicated that utilization, particularly unscheduled emergency room visits, increased during peak oil and gas activity periods from October to March annually (2000–2005). Issues that warrant further study include the observed shift in the rates of emergency room visits for occupational, alcohol, drug, and violence-related injuries in these communities during peak oil and gas exploration and drilling activities. There are also concerns about evictions of vulnerable clients when accommodations are insufficient to meet demand.
Setbacks and Emergency Response Planning in Oil and Gas Development
Regulations in place within British Columbia and Alberta were designed to protect the public during stages of oil and gas development activities. These methods include setback distances and emergency response planning. In British Columbia, the Oil and Gas Commission (OGC) is responsible for overseeing the compliance with well setbacks and for the approval of Emergency Response Plans (ERPs).

The ERPs for oil and gas activities in the province are based on best available practices and are consistent with guidelines put forth by the Alberta Energy Utilities Board (EUB), which governs oil and gas activities within Alberta. ERP development requires involvement of local governments at various stages, including members of the public within and adjacent to the emergency planning zone, local municipal authorities, (such as the Provincial Emergency Program), the medical health officer and/or the director of environmental health services of affected regional health authorities and/or environmental health officers for First Nations and Inuit Health Branch Health Canada.

Emergency Planning Zones (EPZs) are established using mathematical models based on the maximum potential H2S release rate or "worst case" release scenario. Discussions are ongoing regarding the use of an appropriate endpoint or value upon which to base the establishment of an EPZ. There is currently debate surrounding the establishment of appropriate health endpoints on which EPZs are established.

The recommended minimum setback distance for well development in BC is 80 m for sweet wells and 100 m for sour gas wells. However, to date, it has not been possible to identify health-based (as distinct from safety) indicators with which to benchmark setback distances. There are some key knowledge gaps in the rationale for the development of setbacks and EPZs with respect to public health and safety. Further research will be needed to refine the parameters. Research is ongoing in Alberta to further examine this issue. It is our understanding that the Ministry of Energy, Mines and Petroleum Resources will review the findings of EUB's work as part of the development of a sour gas plan for British Columbia.

With respect to the planning process, it has been observed that there could be a more highly coordinated effort with various stakeholders (provincial ministries, OGC, Health Authorities, the public, and the oil and gas industry) in the development of setbacks, and in the planning, organizing, and coordinating emergency response plans. Stronger cooperative links among the stakeholders will be required with the anticipated expansion in oil and gas development in BC. Enhanced coordination will further ensure public health and safety, and enhance efficient and appropriate responses in the event of an emergency.

Review of Population Health Studies and Chronic Low-Level Exposures from Air Emissions

The published literature available for population health impacts of chronic, low-level exposures to sour gas activities is limited. The main study conducted to date on sour gas emissions and population health was conducted by Spitzer et al. in 1986. The study examined communities in southern Alberta exposed to sour gas refinery emissions. The results did not show any significant differences in mortality rates, cancer cases, birth defects, fetal losses, childhood development, trace metal levels, respiratory function or disease, and clinical tests. Additional studies were conducted on solution gas flaring and community-based health monitoring within oil and gas communities in Tilston, Manitoba and Fort McMurray (2000), Grande Prairie (2002), and Fort Saskatchewan (2003). In Alberta there has been no association demonstrated between exposures to air emissions and adverse health effects..

Studies of wildlife and cattle health have also been conducted. Evidence of animal use at abandoned sump and flare pits in northeast British Columbia raised questions regarding long-term impacts of the ingestion of sump and flare pit materials on animal health and potential impacts on human health, particularly First Nations. Cattle health studies (WISSA 2006), which included herds from northeastern British Columbia, have not shown significant associations between measured air emission exposures and adverse health outcomes. Based on the findings of the WISSA study, it is unlikely that further human health studies will be conducted in the near future.

Lessons from Alberta

Municipal governments in Alberta are alerted to sites where oil and gas development and processing has occurred or will be occurring. As subsequent development occurs following oil and gas activity, be it subdivisions, light industrial, hospitals, or schools, the municipality has to consider potential soil and groundwater remediation. While in the past this was not a consideration, now there is a registry of contaminated lands that is shared with regional health authorities.

Development on previous oil and gas sites requires the developer to conduct soil analysis and remediation. This can be very expensive. One site of a former gas processing plant was built on about 30 years ago. Complaints from homeowners about odours and illness prompted the Health Authority to conduct sophisticated air studies. Health and Environment issued an order to the original oil company to remediate the entire site. Work was virtually impossible because of the development and ultimately the oil company had to buy all houses in order to remediate the soil.

A stakeholder consultation process was implemented in 2006 by the Ministry of Energy, Mines and Petroleum Resources (MEMPR) in BC, with some positive results. The Northeast Energy and Mines Advisory Committee (NEEMAC) was set up as a representative stakeholder group for dialogue focused on exploring, understanding and advising on key issues related to oil and gas production. The Ministry of Energy Mines and Petroleum Resources is working with communities, rural landowners, local governments, and other stakeholders directly affected by energy, mines and petroleum resource development in Northeast BC.

Notwithstanding, we have not yet detected a sufficiently widespread public understanding of this consultation process, or a sense that it has fully addressed the desire for dialogue within the community.

In Alberta, a number of recommendations were put forth by the Alberta Advisory Committee on Public Safety and Sour Gas (PSSG) that specifically related to human health and the role of health authorities. These recommendations could be used to inform ongoing sour gas policy development with respect to the role of Northern Health and other affected regional health authorities within British Columbia communities.

There is a perception that consultations regarding oil and gas development initiatives have been insufficient to date in BC. The approach of Alberta's Advisory Committee on Public Health and Sour Gas included extensive stakeholder input on oil and gas policy development. The recommendations put forth by the Advisory Committee may be used to guide ongoing sour gas policy development in British Columbia with respect to the role of the health authority and other relevant regional authorities in the protection of health and safety in British Columbia communities. It is suggested that BC should actively pursue implementation of these recommendations or similar recommendations to enhance the role of the health authorities.

The Current and Future Role of Health Authorities

Within the Health Authority as part of the regular program, Public Health Protection (PHP) provides advice and inspectional services to the industrial sector. Industrial camps that house workers are inspected for general sanitation, housing, food services, sewage disposal and drinking water quality. PHP also responds to any complaints that are received. Emergency response plans are submitted to Public Health Protection routinely, as are reports regarding the results of flare stack emission monitoring. PHP is a member of the technical advisory committee for all Environmental Assessment Office reviews of large scale projects. Tobacco Reduction and Public Health Nursing have been approached by different companies to provide information and services to their employees.

With respect to the future role of the health authority, an important change in approach would include the HA as a participant in a multi-stakeholder committee that will identify general issues before the earliest stages of any proposed developments. Examples include ERP and EAZ planning and evaluation, location of wells, proximity to human settlements, consultation around setback distances, facilitation of research into specific health and social concerns, development of proactive land use planning protocols, sour gas protocols, etc.

In addition to being a participant in a proactive process, Health authorities also require relevant data for surveillance and epidemiological forecasting. The Ministry of Health and other information providers could assist here by ensuring that mechanisms are developed and implemented to allow the provision and integration of information on the physical environment, populations at risk, and health outcomes. Surveillance of health risks depends upon availability of data from multiple sources and the ability to conduct integrated analyses. BC has made significant investment in GIS systems to provide data regarding environmental factors, population distribution, and health outcomes. Framed from a population health perspective these resources could significantly support decision-makers in health and environmental management in their day-to-day responsibilities. The health authorities require support from the Ministry of Health for these data including GIS data, comprehensive maps of setback distances (including EPZ, EAZ, and shelter and evacuation zones) from drill sites, existing wells, and gas plants.

As well, a registry of historic oil and gas activities would be useful for the health authority. It would need to be accessible from municipalities and the regional districts.

CONCLUSIONS

Based on the findings of this study, the following conclusions were made:

- Rapid growth of the oil and gas industry within the province of British Columbia has outpaced our understanding of possible health and safety impacts on communities. With anticipated future growth of this industry, the populations of resource-based communities will likely continue to increase, signaling the need to implement additional public health and safety measures.
- Health and safety concerns expressed by residents and stakeholders during public consultation in northeast BC, specifically around sour gas development, are similar to those voiced by residents and stakeholders in Alberta. The most frequently identified issues included: unease with, and accounts of negative physical health effects attributed to, chronic low-level exposures to H_2S and other compounds from oil and gas activities; public health and safety concerns about emergency response planning and setback distances; and potential social impacts on both community residents and workers in the oil patch.
- The social benefits and risks of resource development on northern communities are well documented. However, there are key data gaps on the social and community health impacts specifically from oil and gas activities in northeast British Columbia communities. Limited published and anecdotal evidence have suggested that oil and gas activities that use a transient workforce impact social and community health. A preliminary analysis of health utilization services in northeastern British Columbia communities, particularly emergency room visits, showed increases during periods of peak oil and gas activity periods. This suggested that influxes of population to these communities during peak activity periods are using health services at increasing numbers.
- Setback distances and emergency response plan regulations for oil and gas development are in place within BC. The current regulations and procedures used in BC are based on best available practices consistent with other jurisdictions. From a health perspective, data gaps exist regarding potential population health impacts from exposure to emissions from oil and gas developments. Reviews are currently ongoing regarding the selection and implementation of alternate approaches for establishment of EPZs.
- To date limited interaction has occurred in BC among provincial authorities, the health authorities, the public, and the oil and gas industry in the planning and developing of setbacks, and organizing and coordinating emergency response plans. Enhancing links among relevant agencies and the public to facilitate better communications around public health and safety is being initiated by MEMPR and is expected to be highly beneficial as it develops.
- There is a public perception that consultations regarding oil and gas development initiatives have been insufficient to date in BC. The approach of Alberta's Advisory Committee on Public Health and Sour Gas established in 2000 included extensive stakeholder input on oil and gas policy development. The recommendations put forth by the Advisory Committee may be used to guide ongoing sour gas policy development in British Columbia with respect to the role of the health authorities and other relevant regional authorities in the protection of health and safety in British Columbia communities.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Facilitate investigations of potential social impacts of resource development on northeastern British Columbia communities, particularly with respect to a transient workforce. The investigation should include, at a minimum, an analysis of community social health effects, the adequacy of social and health services, and the implications of these growing workforces and populations in northern British Columbia communities.
2. Enhance funding to health authorities for provision of health services (acute and public health) that reflects the increased utilization of health services in these regions.
3. Ensure health authorities are integral to the proactive planning process for all new oil and gas developments at the application phase. The health authorities should be apprised of all proposed oil and gas wells, and processing facilities; the characteristics of these facilities including their longevity release rates, of H_2S concentrations, and setback distances. The health authorities should also be provided with emergency response plans that include individual responsibilities.
4. Involve health authorities in emergency response plan development.
5. Expedite the provincial review of current setback regulations and emergency planning zones; in particular apply health-based criteria wherever possible.
6. Enhance the community engagement process. While public consultation guidelines have been implemented there remains a public perception that engagement and education programs are insufficient, particularly related to the establishment of emergency response zones and setbacks and their adequacy to protect public health and safety.
7. Work with the current BC Energy Plan to help establish public consultation processes pre-tenure and throughout all stages of development for British Columbia's sour gas plan, similar to the outreach program of Alberta's Advisory Committee on Public Safety and Sour Gas. Establishment of a provincial advisory committee to provide an opportunity for stakeholder groups is currently underway.
8. Municipal governments are currently alerted to the potential soil and water contamination in areas planned for subsequent development where oil and gas activity previously occurred. To better facilitate subsequent development following oil and gas activities, establish benchmarks by conducting environmental scans of areas planned for oil and gas development to provide baseline water, air, soil, and vegetation quality, and potential contaminant pathways.
9. Ensure the Ministry of Health provides health authorities with relevant data. The Ministry and other information providers need to provide information on the physical environment, populations at risk, and health outcomes. Health Authorities need comprehensive GIS maps of setback distances (including EPZ, EAZ, and shelter and evacuation zones) from drill sites, existing wells, and gas plants. These resources need to be analyzed from a population health perspective and delivered to decision-makers in health and environmental management to support their day-to-day responsibilities.

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1 INTRODUCTION

1.1 Background

The increasing global demand for energy drives exploration, extraction, and production of carbon-based fuels, specifically oil, natural gas, and coal. According to the BP Statistical Review of World Energy June 2005, annual global primary energy consumption increased by 4.3 % in that year, with the strongest increases in demand occurring in Asia. The increase in coal consumption was largest globally at 6.3%, followed by oil at 3.4%, the largest increase since 1986. Oil consumption in 2004 was the largest in volume since 1976. Natural gas use increased by 3.3%, while hydroelectric and nuclear generation rose 5% and 4.4%, respectively (BP 2005).

Canadian coal, oil, and natural gas are currently being consumed domestically and exported to markets, resulting in substantial revenues. The oil and natural gas industry contributes significant revenues to provincial and federal governments.

Oil and gas industry activities in Canada have been largely centred within Alberta. The more recent discovery of marketable natural gas reserves in northeastern British Columbia has led, however, to increasing levels of exploration, extraction, and production activities within the province. Rapid growth of the oil and gas industry within the province of BC has outpaced the development of health and safety policies. The increased demand for these energy resources creates the potential for infringement on populations both globally and locally. A distribution of proved oil reserves as of 2004 is shown in Figure 1-1. As a result, individuals and communities in Alberta, BC, and elsewhere, have expressed concerns related to public health and safety regarding oil and natural gas activities, in particular, those activities within the proximity of public areas.

This preliminary study summarizes available scientific evidence, peer and non-peer reviewed literature, grey literature, and stakeholder input that may assist with the development of health and safety policies within British Columbia.

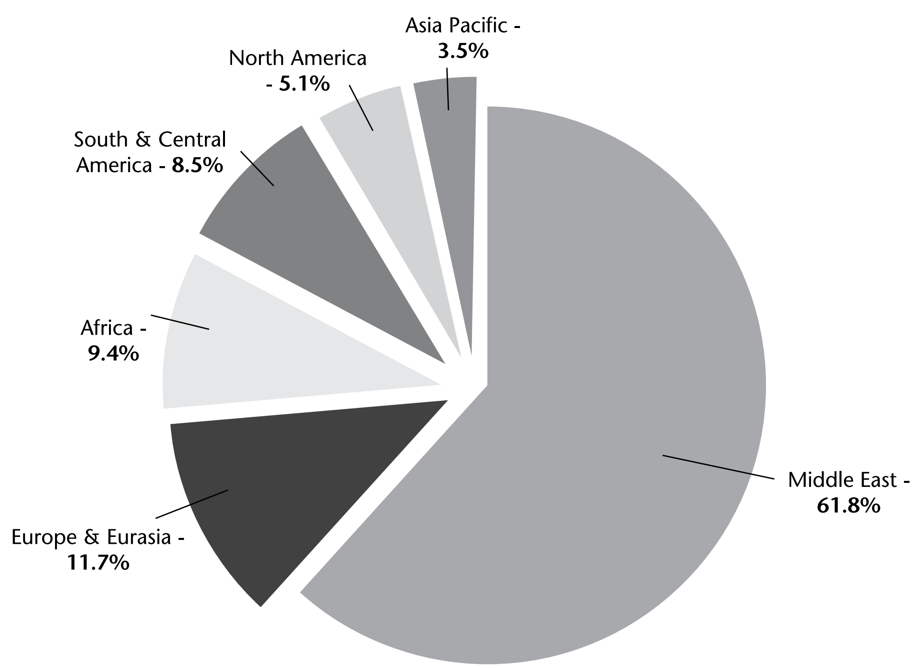

Figure 1-1 Distribution of proved world oil reserves *(Data Source: BP 2005)*

1.1.1 Northeastern British Columbia Communities

In BC, the northeast region is the area of the province where oil and gas production activities are primarily taking place. The communities that are impacted by expansion of the oil and gas industry include those of the Peace River and Northern Rockies Regional Districts. Other regions of the province may also prove economically feasible for oil and gas exploration and production in the future.

The main population centres of the Peace River Regional District include Chetwynd, Dawson Creek, Fort St. John, Hudson's Hope, Pouce Coupe, Taylor, and Tumbler Ridge. The economic drivers of the region are primarily resource-based and include coal mining, oil and gas exploration and development, forestry, and agriculture. The main population centre of the Northern Rockies Regional District is Fort Nelson. Similar to the Peace River Regional District, the economic drivers of the region are resource-based and include forestry, oil and gas exploration and development, and tourism (BC STATS 2005). Northeastern British Columbia communities are illustrated in Figure 1-2.

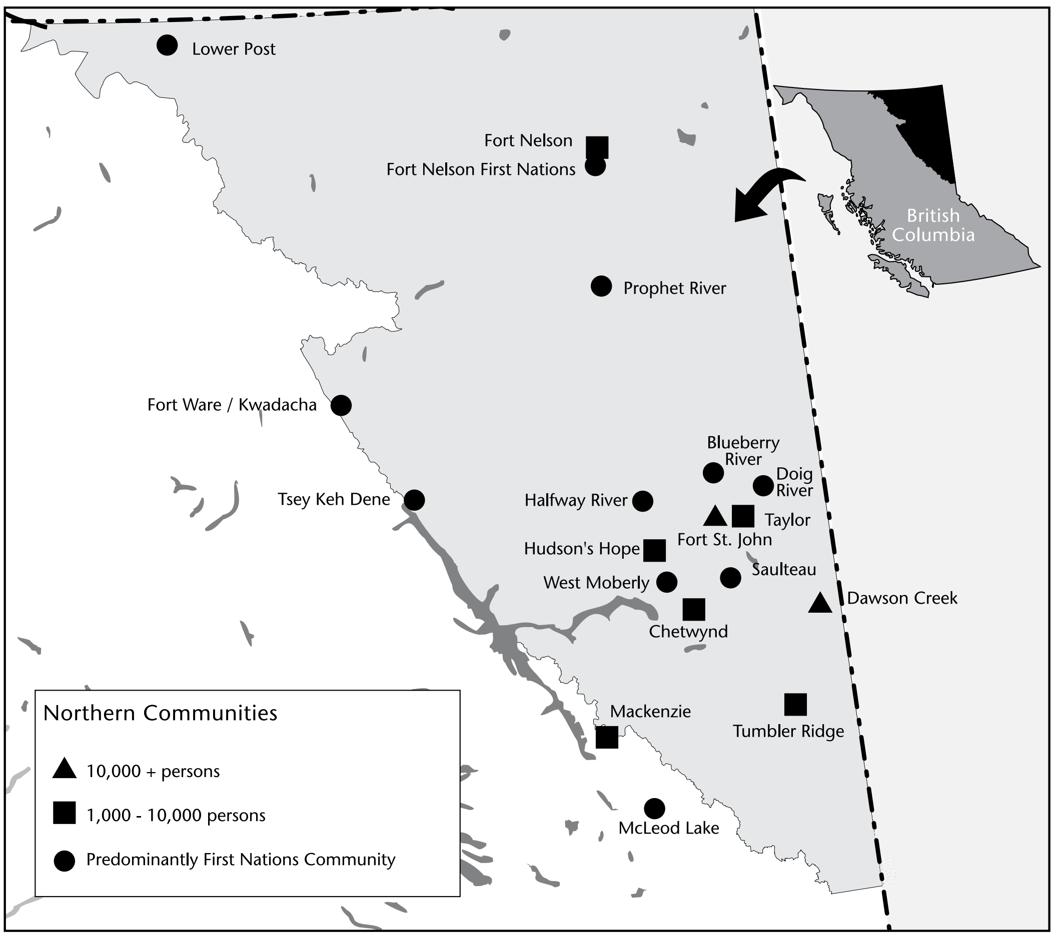

Figure 1-2 Northeast British Columbia communities.

Table 1-1 summarizes the relative sizes of each of the main population centres in northeast British Columbia and the proportion of the total labour force employed in mining and oil and gas extraction. Labour characteristics are based on the North American Industry Classification System (NAICS) and were computed using 2001 census data, while 2004 population estimates are based on annual population estimates (BC STATS 2005). The proportion employed by the mining and oil and gas extraction industry is based on the number of individuals represented by the total labour force.

Table 1-1 Summary of population and mining and oil and gas sector employment rates of main population centres of northeast British Columbia

Region/Community	Population[1]	Total Labour Force[2]	Proportion Employed by Mining and Oil and Gas Extraction[2]
Peace River Regional District	**60 081**	**30 515**	**9.5 %**
Chetwynd	2722	1385	4.1 %
Dawson Creek	11 290	5755	4.8 %
Fort St. John	17 280	9515	13.4 %
Hudson's Hope	1156	500	3 %
Pouce Coupe	862	300	10.3 %
Taylor	1287	655	5.4 %
Tumbler Ridge	2461	1055	30.6 %
Northern Rockies Regional District	**6434**	**3430**	**7.6 %**
Fort Nelson	4694	2600	6.9 %

Source: BC STATS (2005)
1 Population estimates from 2004 annual estimates
2 Labour force estimates based on 2001 census data

Table 1-1 shows that the populations of these centres range from 862 in Pouce Coupe to more than 17 000 in Fort St. John. The proportion of population employed by the mining and oil and gas industry is significant within these communities, ranging from 3% in Hudson's Hope to more than 30% in Tumbler Ridge. These values are based on projected permanent resident population estimates and the labour statistics are based on census data, conducted every five years. The population and labour statistics do not include the number of seasonal workers employed from other areas of the province or from outside British Columbia. Increased levels of oil and gas exploration over recent years have resulted in population growth in Fort St. John and the south Peace River region; this is the only northern region in British Columbia to experience recent population growth (Hanlon and Halseth 2005). With anticipated future growth of the oil and gas industry within British Columbia, the populations of these northeast communities w ill likely continue to increase.

1.2 Evidence of investment and growth related to Oil and Gas industry

1.2.1 Oil and Gas Industry Investments and Revenue

A major challenge in British Columbia has always been access to resource regions, particularly in the far north. In 2003, the Ministry of Energy and Mines implemented and continues to refine an Oil and Gas Development Strategy (OGDS) with a particular focus on the "Heartlands".

Central to the OGDS were initiatives such as royalty credits intended to stimulate the development of an all season road infrastructure that would extend the exploration and drilling seasons, royalty incentives for summer drilling, the cross-training of field staff to execute multiple functions in different seasons, and efforts to raise the industry's profile at trade schools.[1,2]

Oil and gas industry capital investment in British Columbia was $4.5 billion in 2004.[3]

The 1,270 wells "rig released" in BC during 2004 represented a 22 % increase over rig releases in 2003. in 2004, BC was the only province to register an increase in rig releases.[4] Most wells were drilled in the Northeastern portion of the province but some activity was recorded in the interior and in the southeastern sections, centering on coal-bed gas exploration.[5]

1 British Columbia Oil and Gas Exploration Activity Report 2004. BC Ministry of Energy and Mines, page 31.
2 Province of British Columbia News Release 2003EM0008-000536 – May 30, 2003.
3 2005 /06 – 2007/08 Service Plan Update, BC Ministry of Energy and Mines, September 2005.
4 2004 -2005 Annual Service Plan Report, BC Ministry of Energy and Mines, page 6 – June 15, 2005.
5 British Columbia Oil and Gas Exploration Activity Report 2004. BC Ministry of Energy and Mines, page 1.

The Petroleum Services Association of Canada estimated that 1,220 wells would be drilled in BC during 2005. It was also projected that there would be continued industry capital investments of $ 4.5 billion and that provincial oil and gas revenue would reach $2.0 billion in fiscal 2005 /06. [6]

1.2.2 Demographic Shifts - Changes in Populations [7]

In the last few years, net migration in Northeast BC has been positive, leading to overall population increases in the region for the fourth consecutive year in 2005 (+1.5%). Between 2000 and 2005, the population in the Northeast increased by nearly nine percent (+8.9%) while BC's population grew at a comparatively slower 5.3%.

The Northeast has also seen different shifts in the character and structure of its population than has the province as a whole, specifically in terms of age and sex. BC's population of young people aged 15 to 29 increased by 5.7% from 2000 to 2005 while the same age group expanded at nearly three times the pace (+15.1%) in the Northeast.

1.2.3 Employment and Business trends indicating growth [8]

Since 2000, total employment in the Northeast has hovered between 32,000 and 35,000. Based on the North American Industry Classification System (NAICS), the employment pattern in the Northeast is quite different from that of BC as a whole. At 36% of the region's total employment, the goods producing sector had a larger share of employment in the Northeast than in any other region of the province in 2005. Not surprisingly, given the region's wealth of natural resources, this exceeds BC as a whole, where only 21% of overall employment was in this sector. Among goods-producing industries in the region, forestry, fishing, mining, oil & gas and construction employed the most workers in 2005. On the services side, trade, transportation and warehousing and accommodation & food services were the biggest players.

Self employment is a good indicator of confidence in a robust and thriving economy. The Northeast led the province in self-employment growth between 2000 and 2005. Over this period, the number of self-employed in the region grew at a notable average annual rate of nearly 43%, more than double the provincial pace (+17% annually).

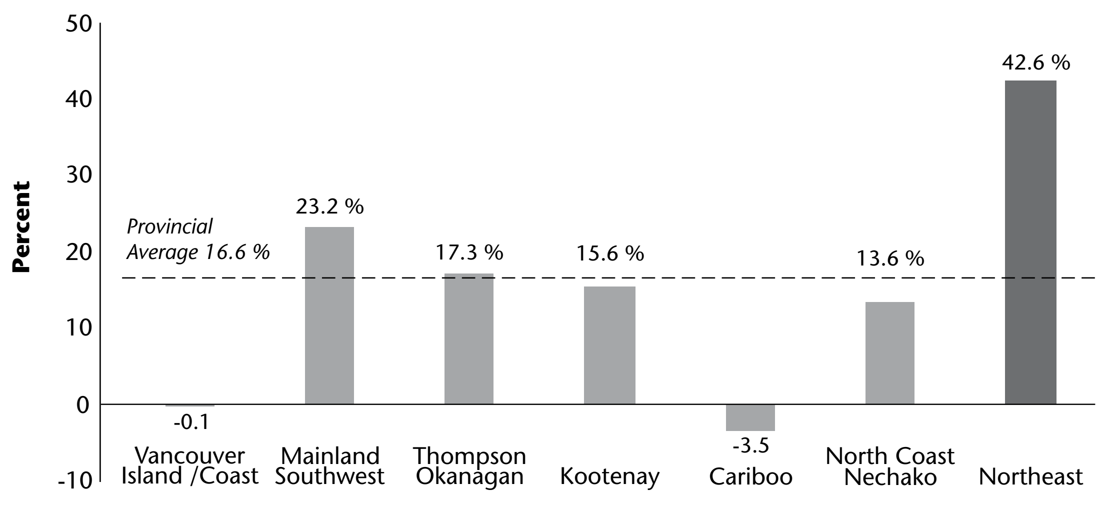

Figure 1-3 Regional self-employment annualized growth rates 2000–2005.

6 British Columbia Oil and Gas Exploration Activity Report 2004. BC Ministry of Energy and Mines, page 32.
7 This section is substantially copied from Regional Outlook: BC's Northeast, which was written by Jade Norton of BC Stats and originally published in Small Business Quarterly Issue 06-2 and republished by BC Stats, Ministry of Labour and Citizens' Services "Infoline" Issue 06-49 – December 8th, 2006.
8 This section is substantially copied from Regional Outlook: BC's Northeast which was written by Jade Norton of BC Stats and originally published in Small Business Quarterly Issue 06-2 and republished by BC Stats, Ministry of Labour and Citizens' Services "Infoline" Issue 06-49 – December 8th, 2006.

1.2.4 *Lowest Unemployment Rates in BC*

With the exception of 2002, unemployment rates have been below the provincial average since 2000. In 2005, the Northeast boasted the lowest unemployment rate in the province (4.7%), well below BC's rate of 5.9%.

1.2.5 *Small Business Start-ups*

The Northeast led the province in terms of small business growth with an average annual growth rate of 3.8%. This translates to an average annual addition of 200 new small businesses to the region and exceeds the average annual provincial growth rate of 1.3% over the same period.

1.2.6 *Room Revenues*

The Northeast accommodation market made up just two percent of total BC room revenues in 2000, but the share has been increasing steadily in recent years and revenue growth has surpassed that of any other region in the province. In 2005, room revenues in the Northeast contributed nearly four percent of total provincial room revenues, almost double its 2000 contribution. In 2005, revenues in the region climbed 22% from 2004 levels, more than any other development region and at a much faster pace than that of the province as a whole (+6%).

Room revenues in Fort St. John climbed more than 30% from 2004 to 2005 and the city has seen an annual increase in room revenue for the past six years. The city of Dawson Creek has also seen significant increases in room revenues, increasing for the third consecutive year in 2005 (+33%)

1.2.7 *Air Travel*

One of the main methods of travel to the Northeast is by plane. The Fort St. John airport is the busiest airport in the Northeast region, followed by Fort Nelson and Dawson Creek. Traffic at the Fort St. John airport, which serves the northern-most areas of the region, increased (+12.9%) to almost 40,500 movements in 2005, ranking it seventh among medium-sized airports (those with flight service stations) in Canada. Air traffic was also up at Dawson Creek airport (+35.4% to 9,200 movements) while traffic was down slightly at Fort Nelson (-4.3% to 18,086).

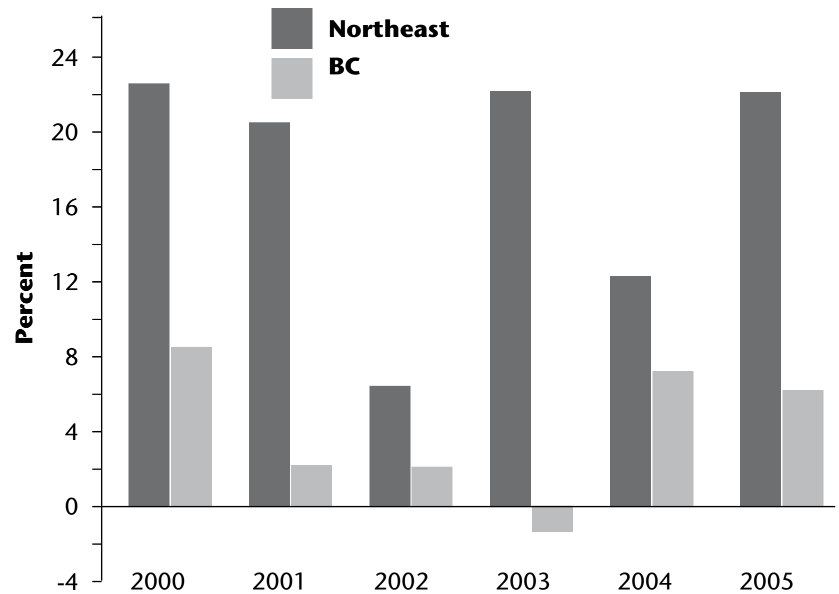

Figure 1-4 Annual room revenues for British Columbia and Northeast BC.

1.3 Summary of selected local communities[9]

With anticipated future growth of the oil and gas industry within British Columbia, the populations of these north-east communities will likely continue to increase.

Table 1-2 Residential and commercial building permits for Northeast communities, 2003–2006.

Fort St. John - City

Year	Population	Percent population change	Residential Building Permits Number	Residential Building Permits Value $ 000	Non Residential Building Permits Number	Non Residential Building Permits Value $ 000
2003	16,959	0.2	197	16,712	19,871	26,583
2004	17,326	2.2	112	21,039	48,741	69,780
2005	17,779	2.6	141	27,777	50,636	78,413
2006	18,270	2.8	229	44,279	92,008	136,287

Fort Nelson – Town[10]

Year	Population	Percent population change	Residential Building Permits Number	Residential Building Permits Value $ 000	Non Residential Building Permits Number	Non Residential Building Permits Value $ 000
2003	4,443	0.9	253	27,506	28,079	55,585
2004	4,706	5.9	187	36,332	69,572	105,904
2005	4,822	2.5	230	44,644	104,429	149,073
2006	4,871	1.0	418	81,349	121,074	202,423

Dawson Creek – City

Year	Population	Percent population change	Residential Building Permits Number	Residential Building Permits Value $ 000	Non Residential Building Permits Number	Non Residential Building Permits Value $ 000
2003	11,175	0.0	26	4,190	15,004	19,194
2004	11,320	1.3	33	5,333	9,559	14,892
2005	11,393	0.6	38	6,882	42,030	48,912
2006	11,615	1.9	51	13,360	24,293	37,653

Chetwynd – District Municipality

Year	Population	Percent population change	Residential Building Permits Number	Residential Building Permits Value $ 000	Non Residential Building Permits Number	Non Residential Building Permits Value $ 000
2003	2,576	- 4.0	-	141	123	264
2004	2,729	5.9	2	961	3,295	4,256
2005	2,770	1.5	9	1,717	1,800	3,517
2006	2,866	3.5	68	8,767	1,025	9,792

Hudson's Hope – District Municipality

Year	Population	Percent population change	Residential Building Permits Number	Residential Building Permits Value $ 000	Non Residential Building Permits Number	Non Residential Building Permits Value $ 000
2003	1,088	1.6	253	27,506	28,079	55,585
2004	1,159	6.5	187	36,332	69,572	105,904
2005	1,157	- 0.2	230	44,644	104,429	149,073
2006	1.159	0.2	418	81,349	121,074	202,423

9 BC Stats Community Fact Sheets – acquired through BC Stats. http://www.bcstats.gov.bc.ca
10 Building permit figures for Fort Nelson and Hudson's Hope reflect the data for Peace River Regional District

1.4 Oil and Reserves in British Columbia: TO COME

Suggestion - Perhaps a summary on projections of how much is left; how much time the industries have left to grow and expand.

1.4.1 Workforce

In BC about 11 400 people were employed in the oil and gas sector in 2004 (BCMEM 2005b). Of these, 6800 were involved in upstream oil and gas activities, (including exploration, production, development, and related activities) and 4600 were employed in downstream activities (including pipeline transportation, natural gas distribution, and petroleum and coal product manufacturing). An estimate of the workforce specifically located within the northeast region was not determined for this study.

The average annual salary of workers in the oil and gas industry is $95 000 (BCMEM, 2000b) compared to 2003 average annual earnings in BC of $31 000 and average annual earnings for full year, full time work of $45 000 (BC STATS, personal communication, August 30, 2005). Higher than average wages are typical of resource towns, since many individuals residing in these communities are employed by the industry (Halseth and Sullivan 2002).

1.4.2 Health Care Utilization

An influx of workers during periods of exploration and production activities may impact health care service utilization within northeastern BC communities. For instance, the community of Fort Nelson currently has two full time doctors providing health care services to the community. During peak oil and gas exploration and drilling activities, the population of Fort Nelson can increase by approximately 10 000 individuals (K. J. Andrews, personal communication, August 11, 2005). A preliminary analysis of health care utilization within these communities is discussed further in Section 3.3.

1.5 Study Rationale

The oil and natural gas industry in BC is a significant source of revenue for the province. A strong North American demand has fuelled increased local exploration to supplement domestic supplies. While benefits are accruing to the province as a whole, there may be health and safety risks borne by the local population as a consequence of this activity.

Northern Health's mandate is to ". . . build and strengthen the health of communities, relationships, and people in Northern BC . . . through community partnerships, health promotion, health services, learning, and research." This report addresses the population health concerns related to the expanding oil and gas industry within the region.

Northern Health (NH) commissioned a preliminary study in March 2005 to identify potential community health and safety impacts from oil and gas activities to the northeast region of BC.

1.6 Study Objectives

The intent of this study was to review relevant scientific literature to develop an **evidence-based approach** that addressed population health and safety concerns identified in northeastern BC communities. The objectives of the study were to:

- outline the potential population health impacts from oil and gas activities in northeastern BC;
- more strongly link NH into the emergency response capacity related to oil and natural gas development activities in BC; and
- make recommendations to the Board of Northern Health and provincial authorities to assist the Health Authority with policy development that addresses public health and safety needs related to the oil and gas industry.

1.7 Methodology

The methods used to assess potential population health impacts from oil and gas activities in northeastern BC were a comprehensive literature review and stakeholder input.

1.7.1 Literature Review

A literature review was conducted to assess potential issues related to population health and safety from oil and gas exploration and development. The literature review focused on published findings of community-based studies in both peer-reviewed and non-peer reviewed or grey literature. Literature searches were conducted using the University of British Columbia Online Index and Databases, specifically *PubMed* and *Web of Science* databases. Reference lists from articles obtained were also reviewed to identify other relevant articles for use in the review. In addition to peer-reviewed literature, a number of articles were also obtained via online internet searching from relevant government agencies, non-governmental organizations, and oil and gas industry representatives.

1.7.2 Stakeholder Input

In conjunction with the literature review, stakeholder consultations were conducted. These stakeholder meetings were held in of Fort St. John, Dawson Creek, and Fort Nelson. The consultation process included meetings with the residents of a Fort St. John subdivision, the Peace River Regional District Board of Directors, the Oil and Gas Commission, Ministry of Environment, workers employed in the oil patch, and First Nations Groups.

As this was a preliminary study, the stakeholder meetings were not intended to be comprehensive, but rather to create awareness of the study, to present and discuss relevant issues and ideas, to obtain feedback from representatives, and to identify the main issues of concern related to oil and gas development within northeast BC. The main themes identified from the stakeholder meetings were used to guide the scope of the current study.

Themes Identified From Stakeholder Input

The main themes identified by stakeholders were used to guide the scope of the study and are outlined as the following:

- health effects from acute and chronic low level exposures to hydrogen sulphide and other compounds related to oil and gas activities, including industry flaring activities, cumulative effects from compound releases from other industries, and emissions from increased transportation including particulate matter;
- public health and safety, including emergency response planning, emergency response, establishment of emergency response zones, and setback distances from residences and public buildings such as schools;
- impacts on the environment from oil and gas activities, including potential impacts on: water flow; water, air, and soil quality; terrain stability; agricultural activities; and fish and wildlife;
- ecosystem health, specifically the links between environmental quality, fish and wildlife health, subsistence living, and human health; a key example being First Nations communities
- domestic animal health, including oil and gas activity impacts on livestock and pets;
- the opportunity for public engagement in the decision-making process;
- social impacts on communities and workers in the oil patch;
- reduced enjoyment of life via impacts from odours, ongoing health concerns, potential re-location from current residence, noise and light from flaring activities, and mental anguish.

1.8 Report Structure

The report contains four sections.

Section 2 discusses the public health and safety issues of oil and gas development as identified through stakeholder consultations and ongoing scientific studies including:

- potential social impacts of resource development in northern communities, including a preliminary assessment of northeast BC communities based on the literature, consultation with public health officials, and an assessment of health care utilization services in these communities;
- an assessment of the current practices of oil and gas setback and emergency response plan development in BC; and
- a review of population health studies of chronic low-level exposures from oil and gas emissions; examples of both human and animal health exposures were obtained from studies conducted with First Nations communities and cattle exposure studies.

Section 3 outlines examples from Alberta's recent history of the development of oil and gas public health and safety concerns including the establishment of the Provincial Advisory Committee on Public Safety and Sour Gas in 2000. Section 4 also outlines the recommendations put forth by the Public Safety and Sour Gas advisory committee that may be applicable to BC Health Authorities for improving public health and safety in communities where oil and gas development is occurring.

Section 4 outlines the findings and recommendations to Northern Health based on the information presented in this report.

2 PUBLIC HEALTH AND SAFETY ISSUES

2.1 Ambient Air Monitoring

The Ministry of Environment (BCMOE) regulates ambient air emissions from oil and gas activities under the Environmental Management Act in the Oil and Gas Waste Regulation. The BCMOE does not conduct continuous air monitoring for individual well sites. Well site monitoring will be conducted on a complaint basis (R. Marquardt, personal communication, May 28, 2005).

The monitored gas processing plants are located in Northeast BC and include the Fort Nelson Gas Plant, Pine River Gas Plant, the Taylor Complex, including the McMahon Gas Plant, and the Kwoen Gas Plant. Each facility requires an air emissions permit that defines the levels of discharges it is legally permitted to release. Concentrations of H_2S and SO_2 are monitored along with local wind speed and direction at the Fort Nelson Gas Plant, Pine River Gas Plant, and the MacMahon Gas Plant. The Kwoen Gas Plant ambient air monitoring program involves modeling flared emissions using on-site meteorological data as well as passive ambient monitoring of SO_2. These emissions must comply with provincial ambient air quality objectives. There are three levels defined for ambient air objectives and these include maximum desirable, maximum acceptable, and maximum tolerable (or Level A, Level B, and Level C). Of these objectives, the maximum desirable or Level A is most stringent. The Canadian and provincial ambient air quality objectives for BC and Alberta for H_2S and SO_2 are outlined in Table 2-1.

In Table 2-1, ambient air quality objectives for H_2S and SO_2 are relatively similar between BC and Alberta, upon comparison of Level A regulations or the maximum desirable concentration. The issue of monitoring ambient air concentrations

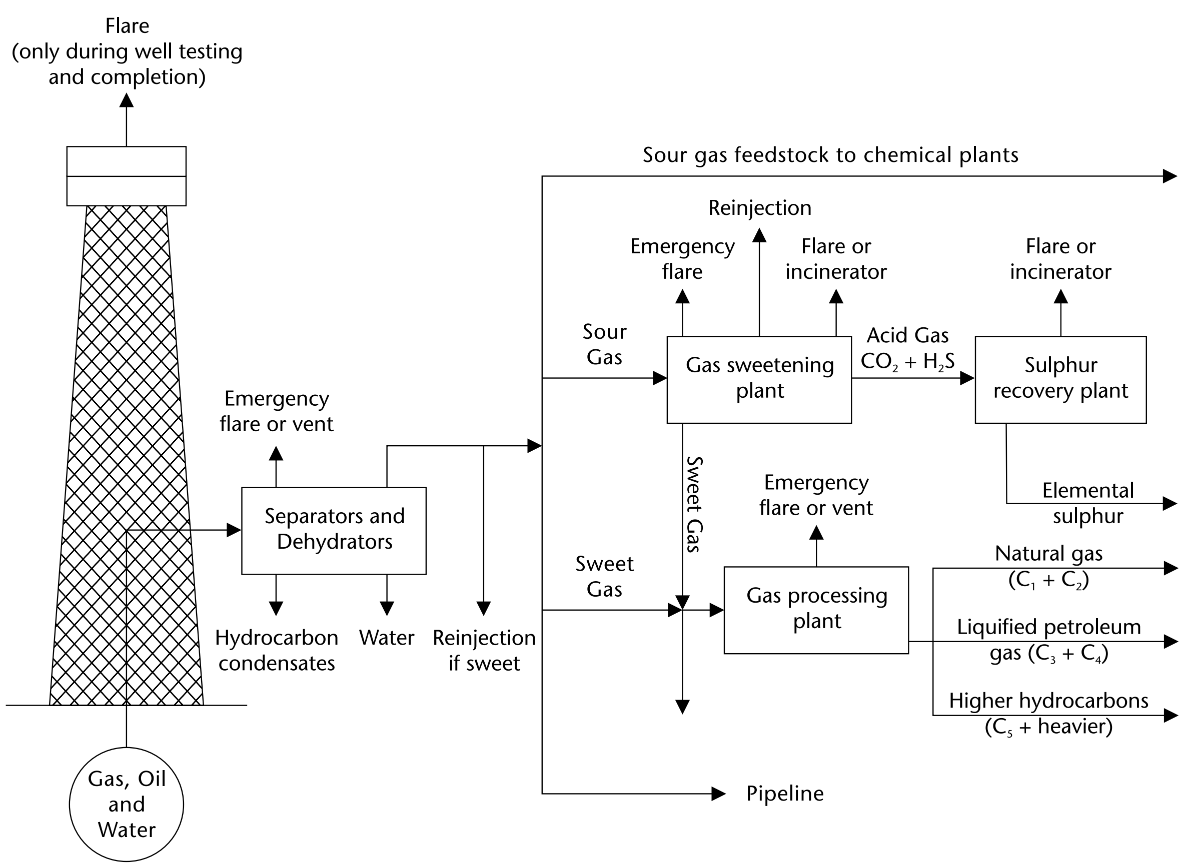

Figure 2-1 Generalized flow diagram of the natural gas industry *(USEPA 1995)*

Table 2-1 Summary of ambient air quality objectives for H_2S and SO_2 †

	Concentration [ppb]						
	Canada			British Columbia*			Alberta
Compound	**Level A**	**Level B**	**Level C**	**Level A**	**Level B**	**Level C**	**Level A**
H_2S							
1-hour average	0.7	11	----	5-10	20-32	30-32	10
24-hour average	----	4	----	3	4-5	5-6	3
SO_2							
1-hour average	172	345	----	172	345	345-498	172
24-hour average	58	115	307	61	100	140	57
annual arithmetic mean	12	23	----	10	19	31	11

† Alberta Environment (2005); BCMOE (2005a)
Level A – maximum desirable concentration
Level B – maximum acceptable concentration
Level C – maximum tolerable concentration
*Values based on the following conversion factors - sulphur dioxide: 1 ppb = 2.61 $\mu g/m^3$; hydrogen sulphide: 1 ppb = 1.39 $\mu g/m^3$

is complicated by the difficulties of measuring low-level concentrations in ambient air. The Oil and Gas Waste Regulation limits H_2S concentrations in air discharges from equipment or facilities at the perimeter of the property to 10 ppb or 0.01 ppm one hour average ambient ground level concentration (Appendix 2). Also, H_2S has an odour threshold as low as 0.003 ppm, making it instantaneously detectable to individuals but logistically difficult to quantify.

In 1985, in response to complaints of odourous emissions from oil and gas activities from residents in the region of Fort St. John, a three-phase study was initiated by BCMEMPR, BCMOE, and Environment Canada to examine concentrations of malodorous emissions from oil and gas production facilities (RTM Engineering Ltd. 1985; Western Research 1987; and Western Research 1989). The purpose of the three-phase study was to develop a database of the atmospheric emissions at selected facilities and to prepare a guidance manual for control of the malodourous emissions. Malodourous compounds associated with crude petroleum and sour gas include H_2S, mercaptans, and other reduced sulphur compounds, such as SO_2 (RTM Engineering Ltd. 1985).

Phase I of the study surveyed concentrations of H_2S, SO_2, and hydrocarbons in ambient air at nineteen oil and gas facilities (RTM Engineering Ltd. 1985). These facilities included oil or natural gas producing, handling, or processing facilities: e.g., oil and gas wells, compressor stations, field batteries, product storage, and transportation facilities. The concentration of H_2S in raw oil or gas was variable between sites, ranging from less than 1% to 11% (RTM Engineering Ltd., 1985). Other sources of odourous compounds that can also be emitted from oil and gas production facilities include carbon disulphide (CS_2), methyl mercaptan (CH_3SH), ethyl mercaptan ($CH_3CH_2{\bullet}SH$), and dimethyl sulphide ($(CH_3)_2S$) (Western Research 1989). A summary of the potential sources of odour emissions from oil and natural gas activities is shown in Table 2-2.

Comparison of ambient air from the various survey sites determined that H_2S was the dominant contaminant in air, followed by hydrocarbons, and SO_2. Although the study did not examine air quality in the vicinity of residential homes, it was suggested that H_2S would likely be the dominant odourous emission at these sites (RTM Engineering Ltd. 1985). In combination with a low odour threshold and adverse effects on human health at high concentrations, H_2S is of particular public health and safety concern. See Appendix 5 for a detailed explanation.

Emissions of H_2S were primarily from dehydrator glycol regenerator vents; other sources included storage tank hatches and vents, instrument vents for systems using sour gas, gas powered pumps, and relief valves that vented directly to the atmosphere. SO_2 emissions were primarily from the combustion of gas streams that contained H_2S. These included heaters, reboilers, compressor engines, and flares. It was observed that fugitive emissions at the sites were typically masked by the higher emissions of H_2S.

Table 2-2 Summary of potential sources of odourous emissions†

Compound	Source
H_2S	• leaking hatches and open vents on oil storage, sour water, and slop tanks • glycol regenerator stack • venting of pumps powered by sour gas • instrument vents on systems using sour gas • flare pits • relief valves venting to the atmosphere • overpressuring of flare headers causing seals to blow
Hydrocarbons	• leaking hatches and open vents on oil storage and slop tanks • glycol regenerator vents • instrument vents on systems using gas • flare pits • relief valves venting to the atmosphere
SO_2	• exhaust stacks from line heaters, treaters, fired reboilers, glycol/water heaters, building heaters, fired tank heaters, and compressor engines fueled with sour gas • flare stacks burning gases containing H_2S • flare pits

†RTM Engineering Ltd., 1985

Fugitive emissions account for a large fraction of the total emissions in refineries and gas processing plants. Since processes at wellheads, such as dehydration separation of gas and liquid components and storage are similar to those in processing plants, it was inferred that fugitive emission sources at wellhead facilities would be similar. The main sources of fugitive emissions (RTM Engineering Ltd. 1985) at a wellhead are:

- Pump seals
- Compressor seals
- Valves
- Flanges
- Vents for dehydrators, treaters, and liquid storage tanks
- Relief valves tanks

For emission audit purposes, the emission sources were classified into three categories, including continuous process vents, combustion equipment, and fugitive emission sources (Western Research 1987). Table 2-3 outlines the main categories and subcategories of emission sources.

Phase I of the study recommended that reduced emissions of odourous compounds could be achieved by improved maintenance, redesign of system components (such as flare headers), removal of H_2S from gas streams used in the plants, and the incineration of vent streams containing contaminants (RTM Engineering Ltd. 1985).

The Oil and Gas Commission (OGC) has a number of initiatives underway aimed at addressing emissions and fugitive emissions. With respect to the commitments in the Energy Plan, a flare reduction program is in development. Some of the aspects to be addressed include: the conservation of gas; alternative beneficial use of gas that would have otherwise been flared; more efficient combustion; and the possibility of reinjection. Further, through an H_2S strategy, the OGC is working in conjunction with operators to eliminate fugitive emissions. The immediate focus of this program is on high risk (high sour content and populated areas) operations. OGC is working with operators to identify and mitigate sources of fugitive emissions by applying new technology and practices.

Table 2-3 Classification of emission sources at oil and gas production facilities†

Continuous Process Vents	Combustion Equipment	Fugitive Emission Sources
• Glycol reboilers - Still off-gas vent • Storage tank vents	• Engines - Reciprocating engines - Turbine engines • Heater equipment - Boilers - Line heaters - Heat-medium heaters - Reboilers - Treaters • Waste gas disposal devices - Flare pits - Flare stacks - Incinerator units	• Flanges • Pump seals • Compressor vents • Pneumatic instrumentation and control devices • Pressure relief valves • Threaded fittings • Valves

†Western Research, 1987

2.2 Review of Population Health Studies and Chronic Low-Level Exposures from Oil and Gas Air Emissions

The published literature available for population health impacts of chronic, low-level exposures to sour gas activities is limited. The main study conducted to date on sour gas emissions and population health was conducted by Spitzer et al. in 1986. The study examined communities in southern Alberta exposed to sour gas refinery emissions. The results did not show any significant differences in mortality rates, cancer cases, birth defects, fetal losses, childhood development, trace metal levels, respiratory function and disease, or clinical tests. Additional studies were conducted on solution gas flaring and community-based health monitoring within oil and gas communities, Tilston, Manitoba and Fort McMurray Alberta in 2000, Grande Prairie, Alberta in 2002, and in Fort Saskatchewan in 2003. In Alberta there has been no association demonstrated between exposures to air emissions and adverse health effects. Of the human health studies conducted, none was in BC.

Animal health studies of wildlife and livestock health have also been conducted. Evidence of animal use at abandoned sump and flare pits in northeast BC raised questions regarding long-term impacts of the ingestion of sump and flare pit materials on animal health and potential impacts on human health, particularly First Nations. OGC has recognized these concerns and has implemented measures to address them. The OCG has developed an inventory of sumps, and in 2004 the OGC developed initiatives to control animal access to sumps. Operators are now required to secure sumps so that livestock and wildlife cannot ingest the fluids. Also, the OGC has also developed an inventory and restoration program for flare pits to address concerns that wildlife may drink from the pits. Since 2005, 150 flare pits have been decommissioned and another 49 are scheduled for decommissioning in 2006.

Livestock health studies, which included herds from northeastern BC, have not shown significant associations between measured air emission exposures and adverse health outcomes. (In the 70s in Alberta, there was a concern about the impacts of sulphur deposition on the selenium cycle and availability in soils. The Se was thought to replace S in the vegetation. On forested grazing leases and pastures, this could lead to Se deficiencies in livestock, resulting in serious livestock health and fecundity problems.)

It is not likely that further human health studies will be conducted by Alberta. The theme most commonly identified by stakeholders was the potential health impacts from chronic low-level exposures to sour gas emissions. For the purpose of this study, investigation focused on a mixture of contaminants from sour gas operations would prove more useful to assess population health effects than a risk-based evaluation of separate compounds. In response to community concerns, a review of epidemiological studies that assessed health impacts from exposure to sour gas operations was conducted. A substantial body of evidence summarized in Appendix 6 has not uncovered substantive impacts on either human or animal health.

2.2.1 Western Interprovincial Scientific Studies Association (WISSA) Investigation of Animal Health and Oil and Natural Gas Field Emissions

As a result of ongoing concerns regarding animal health and an attempt to address some of the data gaps and uncertainties associated with current animal health epidemiological studies, a six-year $17 million interprovincial study was completed. The study overseen by the Western Interprovincial Scientific Studies Association (WISSA), was launched in 2001,) to assess livestock and wildlife health. The WISSA Board of Directors is composed of government representatives from Alberta, BC, Manitoba, and Saskatchewan. Alberta Environment provided lead funding for the study (more than $14 million), with other funding supplied by Manitoba, Saskatchewan and BC provincial governments; Alberta Cattle Commission, Canada-Alberta Beef Industry Development Fund, BC OGC, Canadian Association of Petroleum Producers and its members, and Environment Canada through the Program for Energy Research and Development. A Science Advisory Panel of 11 internationally recognized researchers was created. They provided evaluation and review of the study with respect to objectives, design, methodology, and other issues related to the scientific quality of the study (WISSA 2003a; WISSA 2003b).

The objective of the WISSA study was to determine if there is a relationship between animal health and average exposure to emissions from oil and natural gas field facilities (WISSA 2004). The study included an assessment of data collected from more than 30 000 beef cattle from 205 herds across Alberta, Saskatchewan, and northeast BC, and collection of data from approximately 500 European Starlings (WISSA 2005). Exposure to emissions was from both sweet and sour oil and gas facilities, specifically fugitive emissions from field facilities, solution gas flaring, localized emissions from small acid gas processing plants, and emissions from larger sulphur recovery facilities. This study is one the most comprehensive studies completed to date on this issue. The scope of the research undertaken in the WISSA study is summarized in the Table 2-4.

The main health outcomes of interest for the cattle study were non-pregnancy, length of breeding-to-calving interval, abortion, stillbirth, and calf mortality. The health outcomes of interest for starlings were reproductive success and immune system structure and function.

Results of the study were released in May 2006. Overall, the study found no associations between measured exposures and most health outcomes in cattle and starlings (WISSA 2006a; WISSA 2006b). Exposure to most emissions was not associated with a greater risk of calf mortality; however, livestock with highest measures of exposure showed slightly higher calf mortality at 5.9% compared to 4.1% for least exposed cattle. Following completion of the WISSA study, it is not certain whether a human health study will be implemented. Alberta Health and Wellness has stated that they will consider a human health study after review of the results (WISSA 2003a).

Table 2-4 Summary of research areas examined in the WISSA study†

Research Area	Description
Beef Cattle Productivity	Location, productivity, and animal health data were collected from approximately 30 000 beef cattle in 205 herds across British Columbia, Alberta, and Saskatchewan. Meteorological data was also collected for the study area.
Beef Cattle Immunology	Immunological data from 676 mixed breed yearling replacement heifers in 27 beef cattle herds. Blood samples were also collected from 325 calves between the ages of 24 hours and 7 days to evaluate neonatal immune system changes.
Avian Study	Data was collected from approximately 500 European Starling nestlings on productivity and immunological data for approximately 150 birds over 2 field seasons. Mean daily temperature and average precipitation data were also collected.
Pathology and Histology	Tissue samples collected from carcasses of aborted fetuses, still-born calves, and live-born calves that died within one hour of birth. These tissues were submitted for histopathological examination.
Air Monitoring Study	Passive sampling program for collection of air concentrations of the following compounds: SO_2, VOCs (measured as benzene and toluene), and H_2S. PM1.0 concentrations measured via active sampling.

† Adapted from WISSA 2005

2.3 Social Impacts on Communities

Local resource development contributes significant economic benefits to local communities and surrounding areas via increases in economic growth, regional development, and the creation of local employment (Lapalme 2003). Resource-based communities are typically characterized by large influxes of an industry-related workforce. Typically, individuals and families are attracted to resource communities by high-paying employment. Many of these opportunities are traditionally for men, resulting in a workforce characterized by single men and young married men with families (Halseth and Sullivan 2002). Associated with this growth are a number of social health impacts that have been identified in frontier resource communities. The resulting rapid influx of outsiders into an area may be of concern to a community because of potential negative impacts, such as increases in prostitution, incidence of sexually transmitted diseases, alcoholism, drug abuse, and violence (Lapalme 2003).

Coping with these issues may require an increase in delivery of health services, including counseling, prevention services, and health education.

The social impacts of development activities occur at various levels including individuals, families, communities (First Nation and non-First Nation) and society as a whole (Lapalme 2003). It was beyond the scope of this study to conduct a social impact assessment, but an increase in such social issues within northern communities could impact health service utilization. We conducted a preliminary examination of potential social health impacts to communities from influxes in workers in northeastern BC This assessment used a qualitative approach and included a preliminary review of published literature and consultations with public health officials in northeastern BC communities.

2.3.1 Identified Social Issues in Resource-based Communities

An investigation of social impacts experienced in other resource-based communities provided an opportunity to identify past industry-related growth issues in these communities. Extrapolation of impacts to the northeast may not be representative of actual effects that occur, but it may suggest areas where monitoring and potential mitigation may be required. For instance, social impacts on a community will be dependent on the size of the project, its location and duration, and the local community conditions and characteristics (P. Eby and Associates Limited and Cornerstone Planning Group Limited 1979). This investigation included examples from communities based on pipeline construction activities in Alaska, mining activities, and sour gas and oil sands development in Alberta.

The Alyeska pipeline consisted of a 1300 km (800 mile) hot oil pipeline from Prudhoe Bay to Valdez, Alaska (Dixon 1978). Construction began in 1974, was completed by 1977, and required an estimated 22 000 labourers and skilled craftsmen. Historically, Alaskan experiences of oil development and gold rushes in communities involve a massive influx of outsiders, housing shortages, lawlessness, increased prostitution and gambling, and other social problems (Dixon 1978). Similar to past development events, impacts on Fairbanks from pipeline construction activities included increased truck and vehicle traffic, higher wages for pipeline workers, housing shortages, increased prostitution, gambling, and increased incidence of crime (Dixon 1978).

Lapalme (2003) outlined the potential social risks and opportunities with respect to development of large-scale mining projects. Table 2-5 identifies potential risks to community health in mining-based communities, including increased incidence of sexually transmitted disease, drug and alcohol abuse, increased prostitution, and increased crime and violence. Further to the direct impacts of drug and alcohol abuse, Lapalme (2003) suggested that women perceived this increase in substance abuse to lead to strained relationships, jealousy, violence, family breakdown, lost job and training opportunities, and financial stress (Lapalme 2003). Other social issues identified by women included concerns for equal employment opportunities, provision of child care and child care facilities, and involvement in community planning processes.

Alberta has undergone extensive growth and development in the oil and gas industry over recent years, including expansion in oil sands development and sour gas extraction and production. These energy-based communities, similar to other natural resource developments, are subject to boom-and-bust cycles of growth and decline. For example Fort McMurray, Alberta is based in the Athabascan Oil Sands Region in Northeast Alberta. The growth of Fort McMurray has been attributed to expansion of the oil and gas industry. This growth includes a high proportion of young, working males (53%)

Table 2-5 Summary of social risks and opportunities for individuals, families, and communities from large-scale resource development†

Social Risks	Social Opportunities
• Loss of life through accidents	• Health and safety at site activities
• Loss of environmental quality through accidents	• Access to health services
• Increase in sexually transmitted diseases	• Access to health education
• Drug and alcohol abuse	• Access to preventative health measures
• Increase in prostitution	• Crime prevention programs
• Increase in crime and violence	• Access to counseling
• Breakdown of family values	• New goods and services
• Illegal hunting and fishing by outsiders leading to destruction of wildlife	• Tourism and related economic growth
• Loss of access to resources, such as biodiversity	• Employment and motivating workers
• Jobs going to outsiders	• Higher incomes and retaining workers
• Disparity of wealth distribution	• Increased financial security through jobs
• No opportunities for youth	• Rise in the standard of living
• Uneven distribution of benefits	• Increased revenues for governments
• Economic opportunities lost to outsiders	• Apprenticeship and training programs
• Community opposition to a development	• Rise in level of education
• Disruption of community life through opposition to project	• Scholarships
• Unequal participation in decision-making	• Economic diversification
• Breakdown of traditional lifestyles and values	• Creation of new local firms
• Changes in values and value systems	• Community participation in development
• Destruction of religious or cultural sites	• Increased community cohesion through partnerships and cooperation
• Dependence on the economic returns from a single development	• Community capacity building
• Loss of access to traditional lands	

† Lapalme, 2003

with 98% under 55 years of age, compared to the provincial average of 50% males and 82% less than 55 years of age. This demographic is characteristic of the jobs typical in the oil sands industry, including construction and heavy machinery (Early 2003). As a result of this rapid growth from a population of 1000 in the late 1960s to 50,000 in 2002, and isolation from surrounding communities, the community has been subject to an array of social impacts (Early 2003).

Social effects in Fort McMurray attributed to the growth in the energy industry included high housing prices coupled with housing shortages and high industrial salaries; high costs of living; shortage of skilled labour, lack of public education, municipal services, and medical services, and illegal drug use, alcohol abuse, children receiving inadequate care, family stress and breakdown, gambling addictions, unaffordable daycare, prostitution, and family violence all at rates higher than elsewhere in Alberta (Early 2003). With industry growth and subsequent population growth expected to continue in northeast BC communities, it is reasonable to suggest that significant social impacts may occur within these communities, without careful planning.

A 2003 study conducted by the I-79 Stakeholder Steering Committee in Alberta aimed to assess both local benefits and local impacts from sour gas development (I-79 Stakeholder Steering Committee 2003). The study examined four Alberta municipalities located in sour gas development regions, including the Municipal District of Rocky View, Municipal District of Foothills, Clearwater County, and Saddle Hills County. The three main areas used to assess the benefits or impacts incurred from sour gas development to these regions included economic benefits (such as employment, income, secondary job creation, net financial benefit to municipalities), and the impact of sour gas development on local residents.

In the assessment of sour gas development on local residents, the study used both qualitative interviews, meetings, and surveys, and quantitative methods. Study results showed that although the sour gas industry is a significant source of revenue to Alberta's economy as well as municipalities where they operate, some residents living near sour gas developments have ongoing concerns. The main impacts of sour gas development on local residents were characterized as follows (I-79 Stakeholder Steering Committee 2003):

- Monetary impacts – personal time to deal with sour gas issues, changes in property values, impacts of sour gas developments on land use; out-of-pocket expenses related to sour gas development, and compensation to land owners for access to land.
- Safety, environmental, and lifestyle impacts – safety regarding the practices of the sour gas industry and the sour gas operators; effects of sour gas development on air, water, and soil quality, noise, and wildlife habitat; and potential changes in the lifestyle of residents.
- Human and animal health impacts – concerns for human and animal health protection and the lack of scientific evidence available for chronic, low-level sour gas exposures.
- Resident, regulator, and industry relationships – the perception of relationships between residents, the sour gas industry, and the EUB.

In contrast to potential risks from emissions associated with oil and gas activities, this assessment provides evidence of both positive and negative socially mediated impacts in resource-based communities.

2.3.2 Preliminary Assessment of Northeastern British Columbia Communities

A preliminary assessment of the potential social health impacts to communities within northeastern BC was conducted. The findings of this assessment were based on a concurrent review of published scientific literature and consultations with public health officials in northeastern BC communities.

Literature Review

A review of the scientific literature located a few studies that assessed the social impacts of oil and gas development on northern BC communities, with the majority of them conducted during the late 1970s and early 1980s. A study examined the impact of the Grizzly Valley gas pipeline construction on the social and economic conditions of the Chetwynd region, namely from the impact of a large, temporary construction workforce in the area (P. Eby and Associates Limited and Cornerstone Planning Group Limited 1979). The Grizzly Valley gas pipeline spanned 104 miles and was constructed during February and November, 1978 with a workforce of 800 men and peak employment of 500. Workers were housed in two main construction camps located approximately 47 miles south and six miles west of Chetwynd, which housed 400 and 250 men, respectively. Construction of a gas processing plant was occurring at the same time also, with a construction camp that housed 400 men on-site.

In response to the increased oil, gas, and mineral exploration activities in the Chetwynd region, accommodation shortages were observed, resulting in motel, apartment, and housing construction and homelessness. Workers reported high visitation and spending in Chetwynd, with hotel and bar facilities, followed by local stores, most often used by the workers than by locals during this period. This increased economic activity in the community resulted in increased demand for accommodation, and inflation in housing, rental accommodations, and land pricing. Increases in crime were attributed to rising expectations and frustration of local residents, not to the construction workforce (see below) (P. Eby and Associates Limited and Cornerstone Planning Group Limited 1979).

It was suggested that the overall economic and social impacts to the local communities from the workforce varied with workforce activity patterns, such as bringing families to the area, the frequency of visits, and the use of local facilities within the community. In addition, camp location and work schedules were determined to be important factors in use of local community facilities, which influenced purchases and personal expenditures. Proximity of the construction camp labour force to the community may have also affected the increase in alcohol consumption within the community, but the workforce was blamed for incidents within the community, such as breaking and entering, theft or alcohol offences (see above) (P. Eby and Associates Limited and Cornerstone Planning Group Limited, 1979).

There was a demonstrated increase in the number of emergency and non-emergency outpatient visits at the Chetwynd hospital. It was estimated that from March to December 1978 during pipeline construction, there was a 50% increase in emergency outpatients compared with the same period of the previous year. It was suggested that the increase in health service utilization increased demands on the two full-time doctors in the community, which affected their service provision to the community during this period. The public health nurse did not observe an increase to the workload as a result of the project.

Two studies, conducted by the Northern BC Women's Task force (1979) and the Women's Research Centre (1979), examined the concerns of women in northern resource-based communities in BC and the Yukon. Communities investigated included Kitimat and Fraser Lake, both mining communities; Mackenzie, a forestry based community; Fort Nelson and Whitehorse, prior to Alaskan Highway pipeline construction. The main concerns identified included access to health care services, including specialty services for women; childcare services; transportation within and outside of the communities; housing; shopping services; provision of recreational and social activities; equal employment opportunities; and access to social services, such as welfare and counseling.

The Women's Research Centre (1979) study assessed the issues of concern to women with respect to the construction of the Alaska Highway Pipeline on the communities of Fort Nelson and Whitehorse. Identified concerns similar to those of the Northern BC Women's Task Force (1979) included access to healthcare for women and their families, adequate education for children and adults, higher food prices and lower quality, shortage of affordable housing, transportation outside of the community, and increased crime rates within the communities.

A three month preliminary study of the social impact of the proposed Alcan pipeline with respect to drug and alcohol issues within northeast BC was carried out by Mucha (1978). The Alcan Pipeline or the Westcoast Transmission System in BC followed a 700 km (439 mile) section of the Alaska Highway from Lower Post to Fort St. John, BC. The study examined the communities of Fort Nelson, Fort St. John, and Dawson Creek, and was initiated to assess the impact of the pipeline construction workforce on the demand for alcohol and drug rehabilitation programs, in order to develop effective service delivery strategies to counteract potential effects (Mucha 1978). The labour force estimated for the BC section was 2000 individuals.

Mucha (1978) conducted a literature review of rapid growth and large-scale resource development in Alaska, Northern Alberta, Yukon and the Northwest Territories. The review showed that a number of social impacts, including: increased alcohol consumption; and introduction of illegal drugs (such as heroin, cocaine, and marijuana) by incoming transient workers. Potential aggravation of existing alcohol issues occurred during project construction periods. Mucha (1978) also conducted site visits to Dawson Creek, Fort St. John, and Fort Nelson, the communities closest to pipeline construction activities. The site visits indicated that the local resource development increased the social service demands and that alcohol and drug services for the communities were inadequate to meet local needs. The suggested factors for increases in substance abuse during the construction of the Alaska pipeline included an increased "outsider" population, greater affluence, changing family roles, and increased feelings of stress among local residents during this period (Mucha 1978).

2.3.3 Input from Public Health Officials

Interviews with local health officials were conducted to assess potential impacts of oil and gas activities on northeastern BC, including Fort Nelson, Chetwynd, Tumbler Ridge, Dawson Creek, and Fort St. John. The community of Fort Nelson is ideal for a community-based study of oil and gas impacts because of the relative isolation from other population centres, with the nearest community almost 250 km away and strong influences on the community by surrounding oil and gas development. The Fort Nelson economy is dependent on forestry, and oil and gas activities. The town has experienced pronounced growth associated with resource boom periods. From 1971 to 2001, the population of Fort Nelson doubled from 2289 in 1971 to 4438 in 2001, largely the result of the expansion of forestry industry between 1971 and 1981 and the increased oil and gas exploration in the late 1990s (Hanlon and Halseth 2005). The community demonstrates demographic characteristics of a "boom frontier" community, with a median population age in 2001 of 29.1, which was well below the provincial average of 38.4. The median household income was 130% of the provincial median income. It is estimated that the Fort Nelson population increases from a base population of 5000 to almost 15 000 during peak periods of oil and gas exploration activities in winter (K. J. Andrews, personal communication, August 11, 2005).

Fort Nelson has been experiencing a boom in oil and gas exploration activities over the past three to four years. Issues observed within the area included an increased need for substance abuse detox programs and the increased potential for oil rig camp worker "homelessness"(a result of oil and gas worker discharge following medical treatment without having established residences within the community) (L. Tokarchuk, personal communication, August 9, 2005). There is generally a lack of support structures available for discharged workers within the community and very limited number of hotel rooms available during peak exploration and drilling activities (K. J. Andrews, personal communication, August, 23, 2005).

Substance abuse within Fort Nelson has historically been an issue. It has been suggested that the affordability and the availability of these substances has increased with the arrival of the transient workforce. Increased evidence of connections between the oil and gas workforce and social impacts within the community of Fort Nelson has been suggested, including increasing use of alcohol and drug use, such as marijuana, crack cocaine, and crystal methamphetamine. This trend follows the apparent seasonal fluxes of enhanced oil and gas exploration and drilling activities from November to March. During this period, occupancy rates in hotels increase, restaurants become busier, and truck and vehicle traffic increases. The increased use of addictive substances, including intravenous drug use, also poses risks to future generations through potential adverse developmental impacts during pregnancy and the increased potential for transmission of blood-borne pathogens such as HIV and Hepatitis C.

Public health nurses in Fort Nelson have recently developed drop-in programs for parents and young children to meet the growing demand for recreational programs for young families. The increased semi-truck traffic within the community during peak oil and gas activity periods may pose health risks to the community from levels of particulate matter emissions, as these vehicles are left idling continuously during winter periods.

Oil and gas developments in the vicinity of Chetwynd and Tumbler Ridge have begun more recently. It has been observed that emergency and ambulatory volumes have increased 12% over the previous year (L. Tokarchuk, personal communication, August 9, 2005). Chetwynd is currently conducting a full impact analysis on health services infrastructure. At present, Dawson Creek and Fort St. John receive all referrals for illness and injuries from work crews, which have been estimated at populations of more than 10 000 at peak times (L. Tokarchuk, personal communication, August, 9, 2005). The increased use of intravenous drugs has been observed in Chetwynd and Tumbler Ridge. There are concerns in Dawson Creek about the birth of crack-addicted babies born to mothers with cocaine addictions.

2.3.4 Health Service Utilization in Northeastern British Columbia Communities

An assessment of health utilization data was conducted for Dawson Creek, Chetwynd, Fort Nelson, Fort St. John, and Hudson's Hope. Time periods were divided into April–September and October– March for 2000 to 2005 to reflect potential increases in health service utilization during peak oil and gas activity periods in October– March. Health facility use was measured through total hospital admissions, unscheduled emergency room visits, and baby deliveries.

An increase in health services utilization was observed, particularly with an increase in unscheduled emergency room visits in each of the communities during 2000 to 2005. The highest increases in use were shown during October– March, which corresponds with highest oil and gas activities in these regions. These data suggest that influxes of population to these communities during peak oil and gas activities are using health services at increasing numbers, particularly in Dawson Creek, Fort Nelson, and Hudson's Hope.

2.3.5 Oil and Gas Activities and Property Values

Increased oil and gas exploration and production have resulted in industrial activities near populated areas. In addition to concerns about potential health effects from oil and gas activities, some residents are concerned about other adverse effects, such as the impact of oil and gas activities on property values. A recent study completed by Boxall et al. (2005) addressed the latter issue and examined the impact of oil and gas activities on rural residential property values in the vicinity of Calgary, Alberta. This study is one of the first academic studies of its kind to investigate this issue.

Boxall et al. (2005) used a number of parameters in the analysis, including delineation of property characteristics, such as price, number of acres, and age of the property, etc., and oil and gas activities, such as the effects associated with oil and gas development characteristics, including presence of sour wells, flaring activities, and emergency planning zones, for each of the properties. The variables used are summarized in Table 2-6.

The results of the study suggested that property values negatively correlated with occurrence of oil and gas activities within 4 km of the property. Specifically, values were reduced by the number of sour gas wells and flaring oil batteries within 4 km of the property. It was also shown that health hazards related to a potential H_2S release, using information from emergency response plans, showed a significant negative association with property prices. These parameters were shown to reduce property values between 4 and 8% (Boxall et al. 2005). The findings of the study also showed that property values were more heavily discounted for oil and gas activities, such as sour gas activities, that potentially posed a health hazard. Since land owners in Alberta are required to inform the buyer if one or more EPZs affect the property it was expected that property values would reflect health and safety considerations (Boxall et al. 2005). Figure 2-2 and Figure 3-3 outline the impact of incremental increases in the sum of EPZs and the number of sour gas wells and property values.

Figure 2-2 suggests that the most significant decreases in property values occurred during the inclusion of the first 5 km EPZ, followed by a subsequent decrease in the proportion of property devaluation with each 5 km interval.

Table 2-6 Summary of variables used to assess impact of oil and gas activities on property values†

Variable	Description
Property Characteristics	
RPRICE	Sale price of the property (2001 $CDN)
ACRES	Size of the land associated with the residential structure (acres)
AGE	Age of the residential structure at the time of sale (years)
AREA	Area of the residential structure (m^2)
BATH	Number of bathrooms
BEDRM	Number of bedrooms
CALGARY	Distance from the City of Calgary (km)
DECK	Deck or balcony present
NGARAGE	Number of garage spaces for vehicles
MUNWATR	Water supplied by municipality
NOBASEMENT	Basement of residential structure is not present
RAVP	Monthly average residential property prices in Calgary (2000 $CDN)
VMTN	View of the Rocky Mountains
ROCKY	Located in Municipal District of Rocky View
MOUNTAIN	Located in County of Mountain View
Oil and Gas Activity Variables	
EPZINDEX	Emergency planning zone (EPZ) index – sum of radii of all EPZs a property is located within
BATINDEX	Flaring battery index – sum of H_2S released
NEAREST	Distance to the nearest operating sour gas plant (km)
NEPZWELL	Number of well EPZs the property was located within
NEPZPIPE	Number of pipeline EPZs the property was located within
FLARING	Number of flaring batteries within 4 km of property
SWEETWELL	Number of sweet oil and gas wells within 4 km of property
SOURWELL	Number of sour oil and gas wells within 4 km of the property
ALLWELL	Total number of oil and gas wells (both sweet and sour) within 4 km of property
ALLPIPE	Total number of pipelines with recorded $H_2S > 0\%$ within 4 km of property

† Boxall et al. (2005)

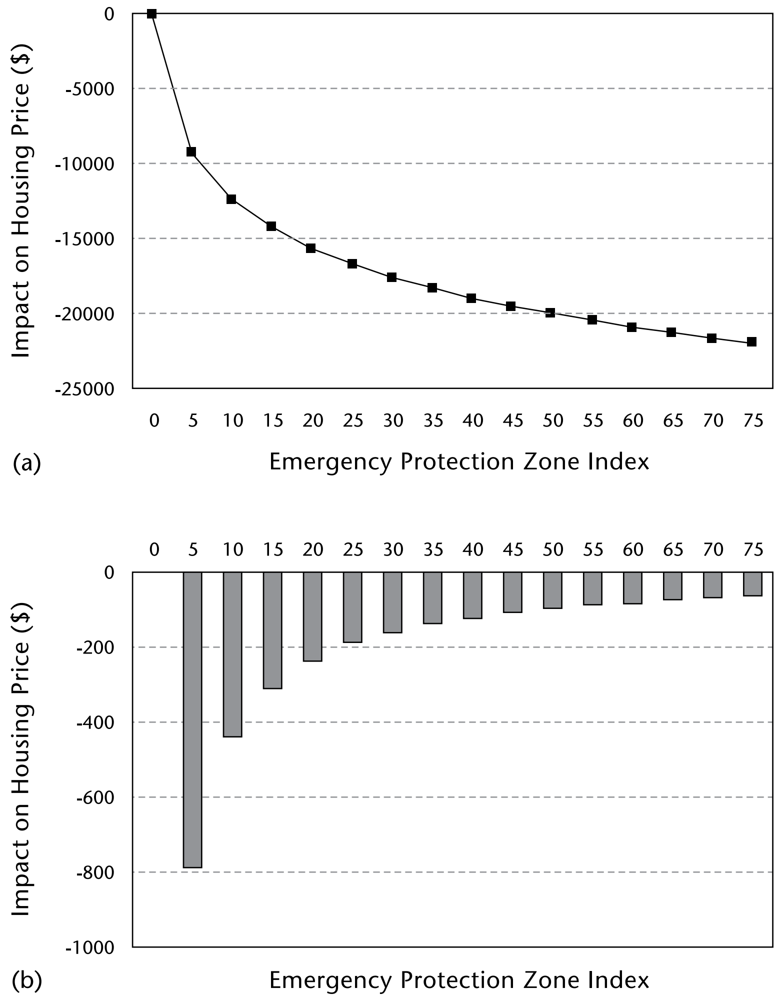

Figure 2-2 Impact of increasing potential for sour gas exposure to residents measured by the emergency planning zones; (a) cumulative effects of additions to emergency planning zone index; (b) marginal effects of increases on the emergency protection zone index and property values *(Boxall et al., 2005)*

Similar to Figure 2-3, the results suggested that the most significant decreases in property values occurred for the establishment of the first few sour wells within 4 km of the residential property. Subsequent well additions still resulted in a decrease in overall property value; however, the rate of decrease was reduced. The results obtained by Boxall et al. (2005) suggested that the presence of oil and gas activities in close proximity to residences decreases property values. This finding may provide some evidence and rationale for the establishment of setback distances.

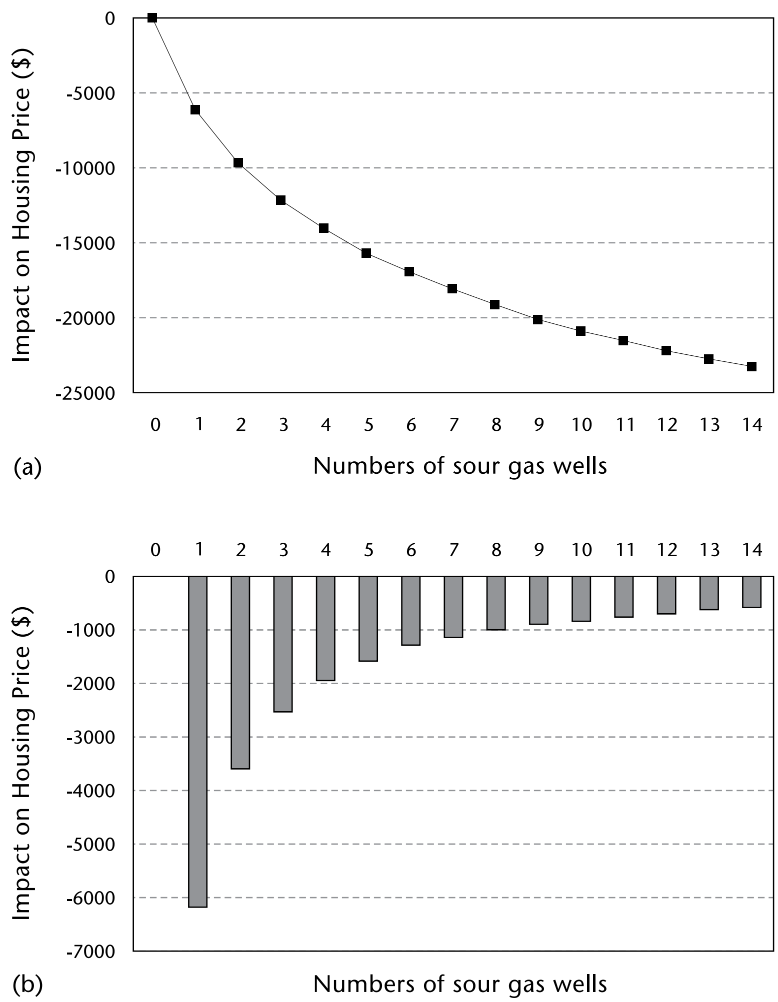

Figure 2-3 Impact of increasing the number of sour gas wells within 4 km of rural residential properties in Alberta; (a) cumulative effects of additional wells; (b) marginal effects of increases of number of wells and property values (*Boxall et al., 2005)*

Recommendations

1. Facilitate investigations of potential social impacts of resource development on northeastern British Columbia communities, particularly with respect to a transient workforce. This study should include, at a minimum, an analysis of community social health effects, the adequacy of social and health services, and the implications of these growing workforces and populations in northern British Columbia communities.
2. Enhance funding to health authorities for provision of health services (acute and public health) that reflects the increased utilization of health services in these regions.

Box 2-1 Communities Working With Industry to Promote Positive Change

The Fort Nelson First Nation (FNFN) recently completed a project in partnership with Canadian Forest Products (Canfor) regarding the oriented strand board (OSB) plant in Fort Nelson, BC. Working together using provincial regulations for ambient air quality, Canfor and FNFN developed design changes to operations of the OSB plant. These changes were based on incorporation of policy, engineering best practices, and community concerns. FNFN participated in the dissemination of information to the community by working with government regulators to interpret the information and return it to the community. As a result of these co-operative efforts, which included the installation of a new scrubber system and increased height of air emissions discharge stack, Canfor's OSB plant has since improved production by 21% and has reduced overall air emissions by 21%.

The Fort Nelson Odour Response Program was initiated by the BC Ministry of Environment (BCMOE) in partnership with FNFN and Canfor to respond to concerns and investigate possible sources of industrial odours as they occur. Residents and workers both on and off the Fort Nelson Reserve can make calls, which are investigated by FNFN and Canfor personnel. A report is prepared, including weather information and photographs, and sent to BCMOE.

2.4 Setbacks and Emergency Response Planning in Oil and Gas Development

Oil and gas drilling, production, pipelining, and processing operations in Alberta and BC are regulated by the Alberta Energy Utilities Board (EUB) and the BC Oil and Gas Commission respectively. The National Energy Board regulates the Westcoast Transmission pipeline system that transports natural gas from BC to Washington State. Regulations are outlined to protect the public during the various stages of oil and gas development, including setback distances from oil and gas facilities and emergency response planning.

2.4.1 Setbacks

A setback is the absolute minimum distance that must be maintained between an energy facility, such as a drilling or producing well, a pipeline, or a gas plant, and a residential dwelling, rural housing development, urban centre, or public facility (EUB 2004b). A public facility is defined as a facility often used by a large number of people, including recreational areas, such as a campground, or a public building, such as a school or hospital, which is located outside of an urban centre (OGC 2003; EUB 2004b). The purpose of setbacks is to provide a buffer zone between the public and the oil and gas facilities in the event of an emergency (EUB 2004b). These setback distances are variable and depend on several factors, including the sour gas content of the facility.

The minimum setback distance for well development in BC is 80 m for sweet wells, as outlined in the Drilling and Production Regulation, and 100 m for sour gas well development, i.e., for wells with greater than 1% H_2S, as outlined in Section 11 of the Oil and Gas Handbook. Similarly, the minimum setback distances for wells in Alberta is 100 m, with this value being the same for both sweet and sour wells. The EUB may approve a setback value closer to the minimum 100 m value only if there is "…minimal risk associated with the proposed well and provided that the landowner and occupant of the dwelling are in agreement" (EUB 1998).

A review of the literature was unable to determine the methods or justification for current setback values, particularly, the minimum 100 m setback value for sour gas development. Discussion with a provincial oil and gas official determined that the setback values were based on historical perception of safety requirements. Establishment of the current setback values was not derived using science-based or health-based criteria. Setback distances are currently under review by the Ministry of Energy, Mines and Petroleum Resources.

In BC and Alberta, sour gas facilities are characterized by four hazard levels based on well release rates, release volumes for pipelines, and hydrogen sulphide concentration (OGC 2003; EUB 2004b). Gas release rates and H_2S concentrations of sour gas wells are highly variable depending on the characteristics of the geological formation from which the gas is extracted. Setback distances are predetermined for each hazard level for sour gas facilities. Setback distances may also be increased depending on the type of public development in the area, such as houses, schools, or hospitals. The setback distances increase with the suspended or producing H_2S release rate and with increasing population density (EUB 1998). A summary of the minimum setback distances for sour gas wells by hazard level are shown in Table 2-7.

An additional classification of sour wells considered in the assignment of setback distances are wells known as "special sour wells", as defined by OGC, or "critical sour gas wells", as defined by the EUB. These wells include sour gas wells that are located near populated areas and wells that have a specified maximum potential H_2S release rate during drilling. In BC and Alberta, all special sour gas wells require the approval of a site-specific emergency response plan. Further, the well licensee must obtain OGC approval to obtain the well authorization application, permission to construct the well site, and site access (OGC 2003). The criteria used for classification of special sour wells or critical sour wells are outlined in Table 2-8.

Table 2-7 OGC and EUB classification of minimum setback distances for proposed sour gas wells from residential and other developments

Classification	Producing/Suspended H_2S Release Rate [m^3/sec]	Sour Pipeline H_2S Release Volume [m^3][1]	Minimum Distance from the Proposed Well to Developments
Level 1	0.01 – <0.3	<300	**100 m**, as stated in Section 2.110 of the *Oil and Gas Conservation Regulations* (Alberta); Section 11.2.3.1 *British Columbia Oil and Gas Handbook*
Level 2	≥0.3 – <2.0	≥300 – <2000	**100 m** to any dwelling **500 m** to any urban centre[2] or public facility
Level 3	≥2.0 – <6.0	≥2000 – <6000	**100 m** to any dwelling **500 m** to an unrestricted country[3] development 1.5 km to an urban centre or public facility
Level 4	6.0	≥6000	As specified by the EUB but not less than Level 3

† EUB, 1998; OGC, 2003
1 OGC, 2003
2 Urban Centre –a city, town, or village or other incorporated district with no less than 50 dwellings; any First Nation reserve; or any similar development the OGC may designate
3 Unrestricted Country Development – includes a collection of permanent dwellings located outside of an urban centre and having greater than eight permanent dwellings per quarter section.
Level 1, 2, 3, or 4 sour wells may also be classified as a special or critical gas well.

Table 2-8 Criteria for classification of special sour gas or critical sour gas wells†

Producing/Suspended H_2S Release Rate	Distance
0.01 - <0.1	located within **500 m** of the corporate boundaries of an urban centre
≥0.1 - <0.3	located within **1.5 km** of the corporate boundaries of an urban centre
≥0.3 - <2.0	located within **5 km** of the corporate boundaries of an urban centre
>2.0	----

Any other well deemed by OGC with respect to the maximum potential H_2S release rate, population density, environment, or sensitivity of the area where the well will be located, and expected complexities during drilling phase may be classified as a special sour well.

† EUB, 1998; OGC, 2003

2.4.2 Emergency Response Plans

In BC, the safe operation of wells and facilities and prevention of waste and spillage are outlined in sections of provincial legislation, including Petroleum and Natural Gas Act, Pipeline Act, the Drilling and Production Regulation, the Pipeline Regulation, and the Sour Pipeline Regulation. In BC, the OGC is responsible for overseeing the approval of ERPs The ERP for oil and gas activities in BC has been shaped by guidelines used by the EUB, which largely governs oil and gas activities within Alberta. Specifically, the requirements for emergency response planning for oil and gas activities in BC are outlined by the OGC in the British Columbia Oil and Gas Commission Emergency Response Plan Requirements (OGC 2004a). Section 11 of the British Columbia Oil and Gas Handbook outlines requirements and emergency response planning for sour wells (OGC 2003).

As outlined by the OGC, the purpose of an ERP is "to ensure a quick, effective and appropriate response to emergencies in order to protect the public, company, and contract personnel from fatalities and irreversible health effects and the environment from damage. An ERP addresses worst-case emergency scenarios, potential hazards to the public, and systems required for adequate response" (OGC 2004a, p. 1). In general, the three types of ERPs are a corporate plan, a site-specific emergency response plan, and a special plan. Corporate ERPs are required for wells or facilities that do not contain permanent residences, public facilities, or places of business within the EPZ. Site-specific EPZs are required for wells or facilities that contain residences, public facilities or places of business or similar activities within the EPZ. A special plan is required for wells or facilities where a number of people may be affected by H_2S release or has a potential maximum release rate greater than 2 m^3/s. An overview of the emergency response preparation and response program is summarized in Figure 2-4.

The Drilling and Production Regulation in BC (Section 58(1)) requires ". . . the submission of an 'outline of emergency procedures' for operations related to wells or production facilities, if the hydrogen sulphide content of the gas exceeds 10mol/kmol [1%] or has the potential to impact public health and safety or cause environmental damage" (OGC 2003).

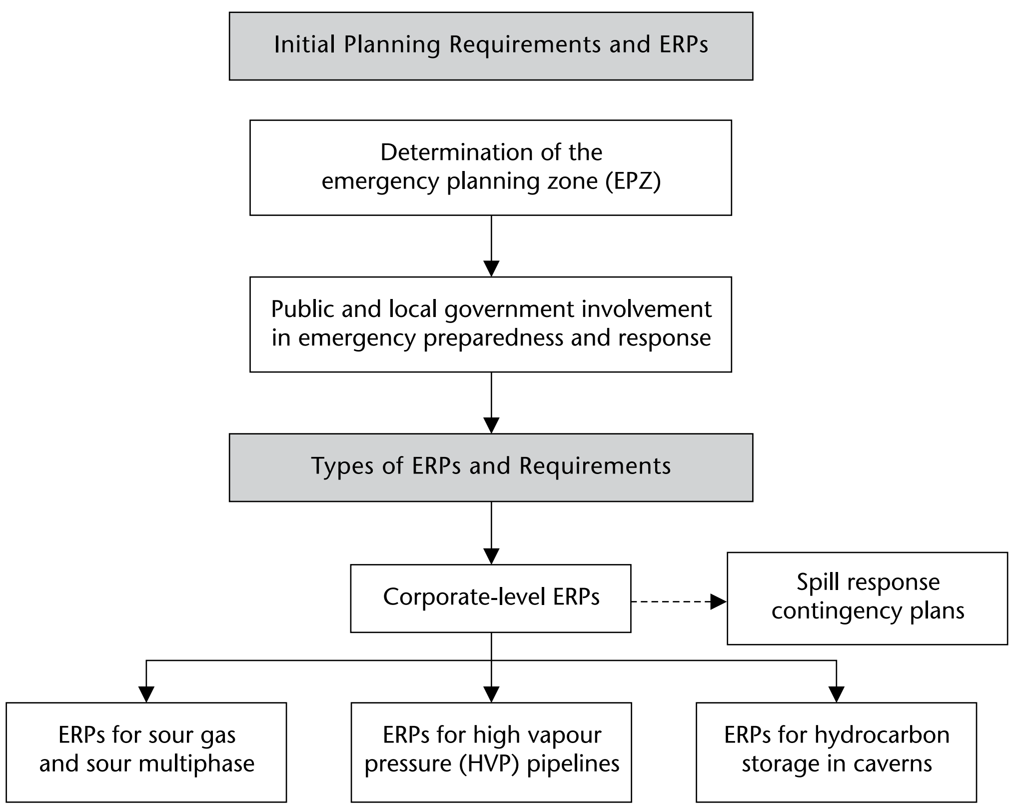

Figure 2-4 Summary of emergency preparedness and response program *(OGC, 2004a)*

In contrast, site-specific ERPs are not required for facilities where there are no permanent residences within 100 m or the proposed well site and the potential maximum release rate is less than 0.01 m^3/sec (OGC 2003).

In general, the type of emergency response plan for a well depends on the following

- magnitude of potential H_2S release; and/or
- number of people within the area that might be affected.

Information that is required within an ERP, as outlined by the OGC is shown in Table 2-9.

Similar to BC, the EUB requires a site-specific Emergency Response Plan (ERP) submitted prior to drilling of a sour gas well. These ERPs ensure that public safety will be protected in the event of an H_2S release and also to provide proof that oil and gas developers are prepared for any emergency that may occur.

Table 2-9 Required information for emergency response plans outlined by OGC†

ERP Information
• Summary Information · location of the well · potential H_2S release rate · topographic setting, land use, and population · company and OGC 24 hour telephone numbers • Emergency Definition and Action • Responsibilities of Company Personnel • Government Roles and Responsibilities • Evacuation and Sheltering Plans • Ignition Procedures • Additional Public Protection Measures • Post Emergency Procedures • Emergency Equipment List • Emergency Contact List • Resident Information • Maps – Emergency Response Plan • Forms

† OGC (2003)

2.4.3 Defining an Emergency

Defining an emergency will determine the actions required to ensure adequate public safety and the degree of emergency response required. In BC, the potential for a situation to threaten public safety is based on three classification levels. Level 1 is a "potential emergency", Level 2 is an "emergency", and Level 3 is a "major emergency". Further description of Level 1, 2, and 3 emergency classifications outlined by the OGC are shown in Table 2-10. The OGC emergency classification criteria closely follow those of Alberta. In Alberta, a criteria matrix outlines a three-level emergency classification system. This criteria matrix is shown in Table 2-13.

In order to define regions where public protection measures would be required in the event of an emergency, zones are defined within the vicinity of the drilling and well operation sites. These zones are referred to as emergency planning zones or EPZs. These EPZs are the designated zones surrounding a sour gas well that form the basis for the ERPs.

Table 2-10 OGC incident classification†

Emergency Classification		
Level 1: Potential Emergency	**Level 2: Emergency**	**Level 3: Major Emergency**
• No immediate danger to public or environment as no H_2S has been released; no immediate threat to workers • Release of hazardous substance confined to the lease or company property • Creates little or no media interest • Handled by company personnel • Low potential for it to escalate Examples include: - pipe or tool stuck in hole - lost circulation or inability to circulate - H_2S or soluble sulphides detected at surface in drilling fluids - influx of sour formation fluids	• Potential for risk to the public or environment, as the emergency could extend beyond company property • Control of hazardous substance still possible • Creates local or regional media interest • May require involvement of external emergency services, federal, provincial, or local agencies Examples include: - incomplete combustion of H_2S at flare pit - equipment malfunction that hinders well control while circulating a kick - inability to maintain required volumes of circulation material	• An immediate danger to the public or environment exists • Control of the situation has been lost; uncontrolled release of hazardous substance • Creates provincial or national media interest • Extensive involvement of external emergency services, federal and/or provincial agencies • Emergency extends beyond company property Examples include: - uncontrolled gas flow from the well, which cannot be shut off by operator - H_2S readings reached 15 ppm, over 15 minute time weighted average, at nearest unevacuated residence

† OGC, 2003 and OGC, 2004a

Table 2-11 EUB criteria matrix for classification of incidents†

	Emergency			
Risk	**Alert: Minimal**	**Level 1: Low**	**Level 2: Medium**	**Level 3: High**
Control	Immediate control of hazard, with progressive resolution of the situation	Immediate control of hazard is becoming progressively more complex because of deteriorating conditions	Imminent and/or intermittent control of the hazard is possible	Imminent control of the hazard is not possible
Containment	Control and relief systems functioning correctly	Control and relief systems functioning correctly	Some control and/or relief systems not operational	Key control and relief systems not operational
Impact				
Public/worker safety	On site only	On site, with possible impact off site	On site, with possible impact off site	Potential for public to be jeopardized
Environment	On site only	On site, with some potential off site; minor or short term	On site, with some off site; minor or short term	On site, with significant off site; long term

† EUB (2003)

2.4.4 Establishment of Emergency Planning Zones

An emergency planning zone (EPZ) is the region surrounding a well where residents or other members of the public may be at risk from an uncontrolled "worst-case" release of H_2S (OGC 2003). The emergency awareness zone (EAZ) is defined as the radius to twice the calculated EPZ radius (OGC 2004a). Both the EPZ and EAZ must be identified in the ERP. Direct contact or consultation with the public within the EPZ is required whereas consultation with the public within the EAZ is not required (OGC 2004a).

2.4.5 Public and Local Government Involvement

Local public involvement and consultation with government agencies are important components during the development of an ERP. Public consultation occurs in the form of discussions via public meetings with local residents and those residents included within the EPZ, and distribution of information packages. If the established EPZ intersects with a portion of a rural subdivision, the entire subdivision must be notified and included within the EPZ (OGC 2004a).

In the event of an emergency, OGC's B.C. Oil and Gas Commission Emergency Response Plan Requirements and the EUB's Directive 71 (formerly Guide 71): Emergency Preparedness and Response Requirements for the Upstream Petroleum Industry, Section 2.2.2.1 and Section 2.2.2.2 of the report state: "…coordination of roles and responsibilities with the local municipal authorities, including the director(s) of Disaster Services of all municipalities within and adjacent to the EPZ, the medical officer of health (or designate) and/or the director of environmental health services or affected regional health authorities and/or environmental health officers for First Nations and Inuit Branch Health Canada (FNI-HM-HC) must take place, be well understood, and agreed prior to conducting the public involvement program" (EUB 2003; OGC 2004a). In addition, the OGC states, "during plan preparation, discussion must be made with the applicable agencies to agree on responsibilities and the type of assistance that can be provided" (OGC 2003). The BC government agencies that should be included in the development of ERPs and have clearly identified roles, if any, are outlined in Table 2-12. Agencies that should receive copies of the ERP include the following:

- OGC, Fort St. John
- Provincial Emergency Program
- RCMP (local detachment)
- Ministry of Environment, Regional Office
- Local health unit
- Workers' Compensation Board

Table 2-12 Summary of government agencies included in emergency response planning process†

Government Agency
• RCMP (local detachment) • Oil and Gas Commission, Fort St. John • British Columbia Provincial Emergency Program • British Columbia Ministry of Environment - Fish and Wildlife Branch - Pollution Prevention Branch • Local Municipal Government and First Nation • British Columbia Ministry of Forests, Forest Service • Workers' Compensation Board of British Columbia • British Columbia Ministry of Transportation • Local fire department • Hospitals and ambulance services • Local health units

† OGC (2003)

As outlined in Table 2-12, local health authorities should be involved in the ERP planning process. To date, little consultation on these issues has occurred. It has also been observed that the roles of organizations within this planning process are not clearly defined and confusion exists among industry as to the public health officials that should be contacted when coordinating the planning of response efforts. According to OGC and EUB policy, the protection of public health and safety during an emergency situation occurs via evacuation, shelter in the area, or ignition of the well if evacuation or shelter is not practical. During the public consultation processes, information regarding potential medical conditions or other factors should be collected for each resident. This information is required for the development of evacuation and sheltering plans in the event of an emergency.

In an emergency, the licensee is required to state the evacuation and sheltering procedures for the public, including notification of residents. Factors that influence the need for evacuation include the level of the emergency, the potential for escalation of conditions at the well site, sensitivities and medical conditions of nearby residents, and H_2S levels outside of the EPZ (OGC 2003). In both BC and Alberta, mandatory evacuation of all residents within the EPZ is required at no later than a Level 2 emergency, while mandatory evacuation of residents outside of the EPZ is required if H_2S concentrations equal 10 ppm and the situation dictates that it is safe to do so (EUB 2003; OGC 2003). OGC notification and evacuation requirements for the public outside of the EPZ based on concentrations of H_2S and SO_2 are outlined in Table 2-13.

Table 2-13 OGC notification and evacuation requirements outside of the EPZ†

Concentration in Unevacuated Area	Requirement
H_2S	
1 – 9 ppm	Individuals must be informed of the concentrations and asked to leave. All other individuals should consider leaving the area and seek medical advice if health symptoms develop
10 ppm*	Immediate evacuation of the area must take place or release must be ignited
SO_2	
1 ppm	Voluntary evacuation
2 ppm	Evacuation of the area should begin
5 ppm	Mandatory evacuation of the area

† OGC, 2004a
Note: H_2S evacuation level: When downwind monitoring at the nearest unevacuated downwind residence, outside the emergency planning zone indicates a level of 10 ppm, evacuation procedures will be initiated if safe to do so.

Table 2-14 EUB notification and evacuation requirements outside of the EPZ†

Concentration in Unevacuated Area	Requirement
H_2S	
1 ppm (1 hour average)	Notification of hypersusceptible individuals must begin.
Below 10 ppm (1 hour average)	Hypersusceptible individuals must be informed of the concentrations and advised to leave the area if health symptoms persist or increase. All other individuals should consider leaving the area and seek medical advice if symptoms develop.
Exceeds 10 ppm (3 minute average for 8 hours or more)	Local conditions must be assessed and all persons may be advised to evacuate.
Approaching 20 ppm (3 minute average)	Immediate evacuation of the area must take place or the release must be ignited.
SO_2	
0.3 ppm (24 hour average)	
1 ppm (3 hour average)	Immediate evacuation of the area must take place.
5 ppm (15 minute average)	

† EUB (2005c)

The EUB also has minimum criteria for the notification and evacuation of individuals outside of the EPZ based on monitored levels of H_2S and SO_2 during an emergency. These criteria are summarized in Table 3-14. Mandatory evacuation of individuals outside the EPZ occurs when ambient H_2S concentrations reach 10 ppm and SO_2 concentrations reach 5 ppm. Below these concentrations, evacuation is voluntary and recommended for sensitive individuals. In contrast, EUB guidelines for mandatory evacuation occur at concentrations of approximately 20 ppm H_2S and 1 ppm SO_2. The isopleth concentrations of H_2S are based on 100 ppm exposure for 3 hour duration. The evacuation H_2S criteria are based on a safety factor of 10.

During an emergency, it may be determined that evacuation is not required or it may not be possible due to a potentially higher risk of public injury. In the case of sheltering, individuals are advised to remain within their homes or business. The following circumstances may dictate a sheltering procedure :

- insufficient time to evacuate public safely;
- public may be at higher risk during evacuation;
- buildings are considered within or near toxic or explosive gas plumes;
- escape routes pass through the hazard; or
- release is of short duration.

Box 2-2 Public Safety and the Oilpatch

The importance of emergency response planning and emergency preparedness is critical to ensure the safety of workers and the public in areas where oil and gas activity occurs. During the preparation of this report, a blowout of a gas and oil well occurred near Brooks, Alberta on August 10, 2005 (CBC News, 2005). The well blowout resulted in the death of one oil patch worker and the injury and hospitalization of three others. A well caught fire and forced the evacuation of about 100 area residents . The fire was extinguished after 24 hours, during which residents remained away from their homes. The closest residence to the well was about 400 metres away. Even though the concentration of H2S from the Brooks well was considered low at 120 ppm or 0.01%, it resulted in one death and the evacuation of residents. Recent applications have been put forth to drill sour gas wells outside the city of Calgary. Concentrations of H2S in these wells is roughly 350 000 ppm or 35% and may require the evacuation of 250 000 people in the event of an emergency (see Box 3-3). These two wells illustrate the need for effective emergency response planning in an emergency in order to protect the health and well-being of workers and the public in the oilpatch.

Recommendations

3. Ensure health authorities are integral to the proactive planning process for all new oil and gas developments at the application phase. The health authorities should be apprised of all proposed oil and gas wells, and processing facilities; the characteristics of these facilities, including their longevity release rates), H_2S concentrations, and setback distances. The health authorities should also be provided with emergency response plans that include individual responsibilities.
4. Involve Health Authorities in emergency response plan development.
5. Expedite the provincial review of current setback regulations and emergency planning zones; in particular, apply health-based criteria wherever possible.
6. Enhance the community engagement process. While public consultation guidelines have been implemented there remains a public perception that engagement and education programs are insufficient, particularly related to the establishment of emergency response zones and setbacks and their adequacy to protect public health and safety.
7. Work with the current BC Energy Plan to help establish public consultation processes pre-tenure and throughout all stages of development for British Columbia's sour gas plan, similar to the outreach program of Alberta's Advisory Committee on Public Safety and Sour Gas. Establishment of a provincial advisory committee to provide an opportunity for stakeholder groups is currently underway.

Box 2-3 A Case Study of Public Safety: Compton Petroleum and the Calgary Health Region

Compton Petroleum Corporation (Compton) submitted applications to the EUB to drill up to six wells in the Wabamun-Crossfield Member, a geologic formation containing sour natural gas, located 1.1 km east of Calgary's southeast city limits. The concentration of hydrogen sulphide in Compton's proposed wells is 35.6% or 356 000 ppm (EUB 2005). About one-third of natural gas produced in Alberta is sour gas. These proposed wells are classified by the EUB as critical sour gas wells based on a drilling release rate greater than 2 m^3/s (EUB 2005a). These proposed critical sour gas wells are subject to additional emergency response planning requirements than non-critical gas wells.

There is currently one sour gas well developed within Compton's proposed drilling area. The well was initially drilled in 1969 and put into production in 1984. It produces sour gas from the Wabamun-Crossfield Member, the same formation as proposed for Compton's drilling activities, at a rate of 98 000 m^3/day of sour natural gas with an H2S concentration of 35.6% (365 000 ppm). Projections for well longevity of this well are in the range of 50 to 60 years. The existing Emergency Planning Zone (EPZ) for the well has a radius of 2 km in the current Emergency Response Plan (ERP). There are number of sour gas wells, pipelines, and facilities currently operating along the eastern edge of Calgary.

The EPZ for Compton's proposed wells consist of three phases: the drilling phase, which occurs when the wells are being drilled through the sour gas zones, completion phase, when the wells are being prepared to produce oil and gas, such as running and perforating the well casing. Within the sour gas zone, and production phase, when the wells are under normal long-term production operations (EUB 2005a). The EPZs were calculated for the various phases as 12 km during the drilling phase, 15 km during the completion phase, and 2.2 km during the operation phase. There are 40 communities and approximately 250 000 people within the calculated 15 km EPZ during well completion. The EPZs for Compton's proposed wells are outlined in Figure A4-1.1.

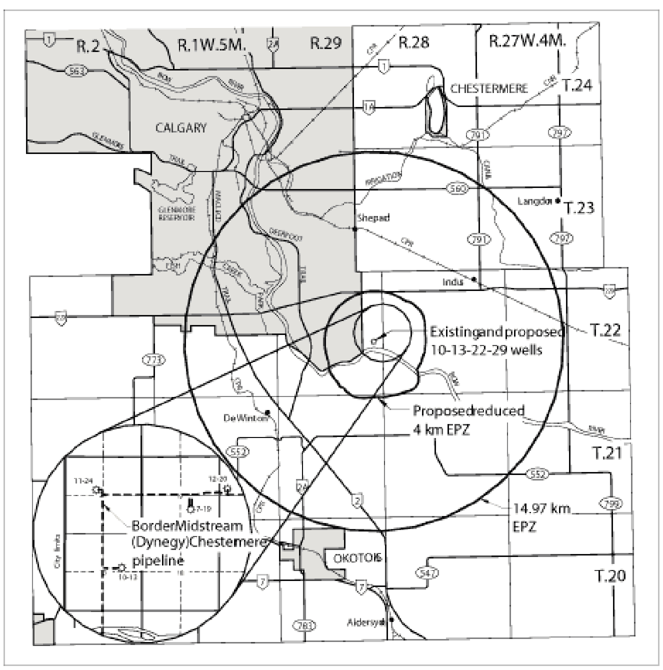

Figure 2-5 Emergency planning zone for proposed Compton Petroleum Corporation wells outside Calgary *(EUB, 2005a)*

The EUB held seven information sessions in the public hearing process in 2003 for community residents within the calculated EPZ. Later, a six-week public hearing process from January 11 to March, 2005 was conducted by the EUB to consider the applications submitted by Compton to drill six critical gas wells and to reduce the EPZ to 4 km, with a corresponding emergency awareness zone (EAZ) of 8 km, and to implement the associated ERP (EUB 2005b). Other applications included the construction and operation of associated surface facilities and a special well spacing unit.

Box 2-3 *continued*

The decision made by the EUB on June 22, 2005 regarding Compton's applications was that wells could be drilled, completed, and operated safely; however, four of six well licenses would be issued for a period of 15 years upon submission of an ERP approved by the EUB.

With respect to the reduced EPZ, the EUB determined the following (EUB 2005b):

- Compton's proposed reduced 4 km EPZ was not sufficiently protective of public safety and was denied approval, as was the corresponding 8 km EAZ;
- Compton must use a reduced EPZ of 9.7 km, which consists of a 5 km radius evacuation zone and a 4.7 km radius sheltering zone; and
- Compton must use a 15 km EAZ.

With respect to ERP, the EUB also directed Compton to "…adopt a unified command approach with the municipalities and the Calgary Health Region (CHR) to provide for progressive and collaborative public protection measures within and beyond the EPZ" (EUB 2005b).

Compton was required to respond to the EUB regarding their decision to pursue approval of its application, with EUB's determinants, by August 15, 2005. Following in accordance with EUB ERP determinants, the deadline for the submission of the revised ERP was November 1, 2005. CHR disagreed with EUB's hearing decision regarding the EPZ and EAZ requirements for Compton's proposed sour gas wells. CHR has since filed for an appeal of the EUB's decision in the Court of Appeal.

CHR recommended an increase to the EPZ from 9.7 km to 10.7 km to allow for the "appropriate protection from the health effects of H2S" and for potential issues of splitting communities (Calgary Health Region 2005, p. 1). CHR also recommended an increase of the EAZ from 15 to 20 km to reflect the health endpoints of SO_2 (Calgary Health Region 2005). It is the position of the CHR that the increase to both the EPZ and the EAZ would address concerns of "… fatalities and irreversible health effects" (Calgary Health Region 2005). It was also indicated by the CHR that following assessment off the site specific health assessment and/or the ERP for the proposed well site, if it was deemed it may impact the health of residents of south east Calgary, an Order may be issued under the Public Health Act to stop drilling of the proposed wells (Calgary Health Region 2005).

A summary of the positions of the EUB, Compton, and the CHR on the EPZ are shown in Table 3-15.

Table 2-15 Summary of EPZ positions for Compton Okotoks Field sour gas wells†

Distance to Hazard	EUB Calculated	Compton Proposed	EUB Decision	Calgary Health Region Position
EPZ	15 km	4 km	Reduced EPZ from 15 to 9.7 km; Increase proposed 4 km EPZ to 9.7 km including: 5 km evacuation zone 4.7 km sheltering zone	Increase from 9.7 to 10.7 km
EAZ	----	8 km	Increase EAZ 15 km	Increase from 15 to 20 km

† Adapted from EUB (2005b); Calgary Health Region (2005)

Further to the position put forth by the CHR, Compton requested an extension to the EUB regarding further pursuit of it's applications (Compton Petroleum Corporation 2005a; Compton Petroleum Corporation 2005b). "The CHR's letter raises the issue of who has jurisdiction over the approval of oil and gas activity in the Province of Alberta" (Compton Petroleum Corporation 2005b, p. 2). Compton was granted an extension to pursue its application process to November 1, 2005 and was granted an extension for submission of an ERP to January 6, 2006 (EUB 2005d). In late December 2005, Compton requested another extension to September 2006 for submission of the ERP. This request for an extension was denied by the EUB. In January 2006, Compton abandoned the applications to drill the proposed wells southeast of Calgary.

3 LESSONS FROM ALBERTA

The oil and gas industry in Alberta is well established and leads the way for Canadian oil and natural gas production. To date, Alberta has had more opportunity to develop and implement policy related to oil and gas development and public health and safety. The Provincial Advisory Committee on Public Safety and Sour Gas (PSSG) was formed by the EUB in January 2000 to review the regulatory system for sour gas as it related to public health and safety (PSSG 2000).

The province of BC has not yet developed interim or regulatory measures with respect to sour gas and public health. Ongoing investigations and public consultations conducted by the Alberta EUB Public Safety and Sour Gas Initiative are being monitored by the OGC to aid in the development of a sour gas plan for BC (Deputy Minister of Energy and Mines, Dr. S. Wynn, Letter to M. P. Alvarez, President Canadian Association of Petroleum Producers, April 26, 2005).

3.1 Alberta Provincial Advisory Committee on Public Safety and Sour Gas

The PSSG advisory committee was comprised of 22 members that represented all major stakeholders in the oil and gas industry. The committee conducted an extensive public outreach program with residents of sour gas impacted areas and stakeholder consultation. The scope of the committee focused on "…a review and assessment of public health and safety-related requirements currently being applied to the approval, development, and operation of facilities respecting Alberta's sour natural gas resources" (PSSG 2000). The mandate did not include an assessment of human and animal health impacts from chronic low-level sour gas exposure, as it was stated that these issues were addressed under other initiatives (PSSG 2000). A summary of the advisory committee representative stakeholder affiliations is outlined in Table 3-1. The OGC and the EUB were involved as regulatory observers within the advisory process.

Table 3-1 Summary of PSSG advisory committee representative stakeholder affiliations†

Representative Stakeholder Affiliations
Public
Aboriginal Relations
Regional Health Authorities
Alberta Association of Municipal Districts and Counties
Alberta Urban Municipalities Association
City of Calgary Administration
Oil and Gas Industry
Land Development Industry
Alberta Health and Wellness
Alberta Environment
Alberta Agriculture, Food and Rural Development
Alberta Municipal Affairs, Local Government Services
Alberta Municipal Affairs, Disaster Services
Alberta Human Resources and Employment
University Risk Research

† PSSG (2000)

Based on the public outreach program and stakeholder consultation, a number of issues of concern were identified. The priority issues were used to guide the directions and the recommendations of the committee. The priority issues, not listed in order of importance, were identified as the following (PSSG 2000):

- Jurisdiction and Development Planning
  - Jurisdiction of Government Departments and Agencies
  - Coordination of Surface and Subsurface Planning
- Health Effects
- Technical Information
- EUB Role
  - Regulations
  - Enforcement
  - Applications and Decisions
  - Industry Procedures and Personnel
  - Setbacks
  - Emergency Response
- Monitoring
- Communications
  - Public Consultation
  - Public Awareness and Understanding
  - Interaction of the EUB with Stakeholders
- Aboriginal (First Nations and Metis) Issues
- Non-mandate but Important Issues

A number of issues were identified by public participants that were beyond the mandate of the PSSG advisory committee. Although formal recommendations were not made on these issues, the committee deemed them of concern, including flaring, monitoring of long-term low levels of H_2S or SO_2, research on the health effects from long-term low level exposures, protection of groundwater, compensation, intervener funding, and seismic exploration activities (PSSG, 2000).

In December 2000, a final report was released by the PSSG which outlined 87 recommendations for the EUB. The recommendations were directed at the following initiatives

- improving understanding of sour gas;
- improving the current sour gas regulatory system in Alberta;
- reducing public health and safety impacts from sour gas; and
- improving the public consultation process with respect to sour gas issues.

It was concluded that the EUB had reasonably addressed public health and safety in making decisions respecting sour gas development (PSSG 2000), but a few areas in need of improvement were identified.

One of the main priority areas identified by the committee for increased understanding was the effects of sour gas on human health. It was stated that, in combination with an understanding of human health effects and standardizing the technical procedures currently used in dispersion modeling and probabilistic risk assessment, reviews to current policy and potential new requirements for protection of public health and safety could be made (PSSG 2000). Specifically, the PSSG recommended that the EUB work with stakeholders to complete the:

- development of comprehensive health effects information for sour gas mixtures and the combustion products of sour gas;
- identification of required research respecting the health effects of sour gas;
- development of a framework and methodology for standardizing dispersion modeling and probabilistic risk assessment, with regular updates;
- upgrade of EUB sour gas databases; and review of the current criteria and approach for establishing sour gas setbacks and for emergency planning zones (EPZs) on the basis of health effects information and standardized dispersion modeling and risk assessment methodology.

3.2 The Current and Future Role of Health Authorities

Based on the previous recommendations, it is suggested that BC should actively pursue implementation of these recommendations or implement similar recommendations within the province. The PSSG recommendations relevant to the role of regional health authorities and oil and gas development and their current implementation status in Alberta (as of July 2005) are summarized in Table 3-2. These recommendations could be used to guide ongoing sour gas policy development with respect to the role of Northern Health and other relevant regional health authorities within BC.

Public Health Protection staff provide advice and inspectional services to the industrial sector. Industrial camps that house workers are inspected for general sanitation, housing, food services, sewage disposal and drinking water quality. PHP staff also respond to any complaints that are received. Emergency response plans are submitted to Public Health Protection routinely, as are reports regarding the results of flare stack emission monitoring. PHP is a member of the technical advisory committee for all Environmental Assessment Office reviews of large scale projects. Tobacco Reduction and Public Health Nursing have been approached by different companies to provide information and services to their employees.

There is a perception that consultations regarding oil and gas development initiatives have been insufficient to date in BC. The approach of Alberta's Advisory Committee on Public Health and Sour Gas included extensive stakeholder input on oil and gas policy development. The recommendations put forth by the Advisory Committee may be used to guide ongoing sour gas policy development in British Columbia with respect to the role of the health authority and other relevant regional authorities in the protection of health and safety in British Columbia communities. It is suggested that BC should actively pursue implementation of these recommendations or similar recommendations to enhance the role of the health authorities.

A stakeholder consultation process was implemented in 2006 by The Ministry of Energy, Mines and Petroleum Resources (MEMPR) in BC, with some positive results. However, we have not yet detected a sufficiently widespread public understanding of this consultation process, or a sense that it has fully addressed the desire for dialogue within the community.

The Alberta Advisory Committee on Public Safety and Sour Gas has put forth a number of recommendations that specifically related to human health and the role of health authorities. These recommendations could be used to inform ongoing sour gas policy development with respect to the role of NH and other relevant regional health authorities within British Columbia communities. There is a role for the health authorities as participants in a multi-stakeholder committee that will identify general issues before the earliest stages of any proposed developments. Examples include ERP and EAZ planning and evaluation, location of wells, proximity to human settlements, consultation around setback distances, facilitation of research into specific health and social concerns, development of proactive land use planning protocols, sour gas protocols, etc.

Table 3-2 Recommendations of the Provincial Advisory Committee on Public Safety and Sour Gas relevant to Northern Health Authority and British Columbia sour gas development

No.	Recommendation	Implementation Status by EUB (as of July 2005)
Jurisdiction and Development Planning		
1	In its role as the principle regulator of the Alberta oil and gas industry, the EUB work with provincial and federal government departments, municipalities, regional health authorities, tribal councils, Indian Oil and Gas Canada (IOGC), Indian Resource Council (IRC), Indian and Northern Affairs Canada (INAC), and any other agency that has jurisdiction respecting the impacts of sour gas on public health and safety in Alberta to • clarify roles, responsibilities, and relationships respecting sour gas and public health; • identify and eliminate any gaps in the system; and • identify overlaps in jurisdiction and either eliminate the overlap or develop formal working agreements to avoid unnecessary duplication and confusion as to responsibilities.	**Ongoing**
2	The working relationships established between the EUB and other involved jurisdictions (particularly the regional health authorities, municipalities, Municipal Affairs Disaster Services, Alberta Environment, and Alberta Health and Wellness) need to be strengthened to include meaningful involvement of the jurisdictions in establishing effective and efficient standards, criteria, policies, and processes for dealing with the public health and safety aspects of sour gas facility applications.	**Ongoing, end date September 2005**
3	The working relationships established between the EUUB and IOGC, IRC, INAC and other federal government departments recognize the different jurisdictional circumstances respecting First Nations.	**Ongoing, end date September 2005**
4	The EUB work and other involved parties to prepare a sour gas and public health and safety roles and responsibilities document and a summary brochure and widely distribute them to the public, industry, and other interested parties. These documents should be written in understandable language and make clear who should be contacted to answer questions, deal with complaints and concerns, and report emergencies.	**Ongoing, end date September 2005**
5	The immediate formation of a task force of senior decision makers that would investigate the possibility of improving coordination between subsurface and surface planning and development. The task force should be empowered to look at all relevant aspects of planning and development, including the mineral leasing system, and should include appropriate representation from Alberta Resource Development, Alberta Municipal Affairs, Alberta Health and Wellness, Alberta Environment, the Alberta Energy and Utilities Board, Aboriginal groups, urban and rural municipalities, regional health authorities in sour gas areas and their associations, surface land developers, the public, and the oil and gas industry.	**Ongoing, end date March 2006**
Health Effects		
9	The EUB work with Alberta Health and Wellness, regional health authorities, Alberta Environment, Alberta Human Resources, industry, and other stakeholders to ensure that comprehensive health effects information (qualitative and quantitative) is developed, as soon as practical due to its urgency. this information is needed to review the approach to emergency response planning referred to in *Recommendation 58*. The review should cover both the constituents off sour gas mixtures and the combustion products of sour gas, including SO_2, reduced sulphur compounds, and complex hydrocarbons. (Alberta Health and Wellness has committed to lead the review for H_2S).	**Ongoing, end date August 2005**

Table 3-2 Continued

No.	Recommendation	Implementation Status by EUB (as of July 2005)
10	The EUB, Alberta Health and Wellness, Alberta Environment, Alberta Agriculture, Food and Rural Development, Alberta Research Council, regional health authorities, industry and other interested parties including Alberta university, jointly establish an independent Scientific Review and Advisory Committee to provide recommendations on required research programs related to sour gas and health. This should be an ongoing activity to ensure that the research activity supports best practices by all parties. Among the tasks of this committee would be to ensure recognition and thorough assessment of completed and ongoing studies and dissemination of the information.	**Ongoing, links to all other health recommendations**
11	The EUB work with the Alberta Government to ensure financial support is available to address gaps in research respecting the health effects of sour gas. Such research should complement the multi-government *Western Canada Study on Animal and Human Health Effects Associated with Exposure to Flare Emissions.* This research study should review the current gaps in human health research to ensure the proposed study plan addresses the relevant issues.	**Ongoing, links to all other health recommendations**
12	Alberta Health and Wellness work with regional health authorities and physicians, through the Alberta Medical Association, to ensure a consistent, appropriate, and coordinated response to individuals exposed to major H_2S releases. This should be a 24-hour, seven-day-a-week response, possibly utilizing the Poison and Drug Information Service.	**Ongoing, links to all other health recommendations**
13	The EUB work with Alberta Health and Wellness and Alberta Human Resources to establish a high-level exposure registry to track individuals who have been knocked down or had other substantial exposures to sour gas. This would enable tracking of significant human exposures to H_2S and help ensure the consistent follow-up of exposed individuals.	**Ongoing, links to all other health recommendations**
14	The EUB, First Nations, Health Canada, and regional health authorities ensure there is effective communication of the health service expectations of the various parties related to sour gas in the vicinity of First Nations communities.	**COMPLETE AND IMPLEMENTED**
15	The EUB, industry, Alberta Environment, Alberta Health and Wellness, regional health authorities, and federal regulators, as required, ensure that there is a thorough follow-up process after major sour gas releases (such as well blowouts or pipeline failures) to determine impacts and identify opportunities for response improvement.	**COMPLETE AND IMPLEMENTED**
Technical Information		
17	The EUB, in cooperation with stakeholders, develop a framework and methodology for standardizing dispersion modeling and probabilistic risk assessment that will provide clarity to the industry and the public. This would include a review of existing models and defining a set of standard models and methods that will be accepted for evaluating health and safety exposure hazards and probabilistic risk from sour gas releases. Alberta Environment has developed a set of standard dispersion models for routine industrial releases that should be reviewed by the EUB. These models and methods should be suitable for assessing exposure close to the source, and evaluating policies for setbacks, emergency planning zones, and mitigation strategies, such as ignition and sheltering indoors.	**Being completed, end date March 2006**

Table 3-2 Continued

No.	Recommendation	Implementation Status by EUB (as of July 2005)
Role of the Alberta Energy and Utilities Board		
34	The EUB increase and improve coordination between itself and Alberta Environment, other involved government departures, and municipality and regional health officials. It should develop a system that provinces for their early involvement in relevant EUB policy making and, where applicable, for their early, efficient, and effective involvement in the review of applications dealing with sour gas and public health and safety. This matter is also dealt with in *Recommendations 1* and *2*.	**Ongoing, end date March 2006**
43	The EUB ensure that appropriate expertise is special subject areas, such as health and probabilistic risk assessment, is available in the form of staff, consultants, EUB Board Members, and Acting Board Members to participate in decisions and to ensure that these subject areas are appropriately dealt with in decision reports. Given the increasing importance of health issues relative to sour gas applications, consideration should be given to appointing a medical doctor with toxicological and health impact experience as a full- or part-time EUB Board member.	**COMPLETE AND IMPLEMENTED**
52	Once the framework and methodology for dispersion modeling and probabilistic risk assessment methodology have been developed (*Recommendation 17*), the EUB use them as the basis for a review of the current criteria for sour gas setbacks. • The review should be carried out by a stakeholder group including representatives of the relevant regulatory agencies, government departments, First Nations, Metis, municipalities, regional health authorities, the public, the land development industry, and the oil and gas industry. • There should be some overlap in membership with the group studying dispersion modeling and probabilistic risk assessment. • The review should address, among other questions, whether the current approach to setbacks is appropriate, the number of levels of categories is acceptable, and whether the actual setback distances are appropriate. It should also assess whether a common set of setback distances can be agreed upon by different jurisdictions. • If changes in setbacks are to occur, the stakeholder group should address the appropriate manner for handling those situations where current facilities are based on existing approvals.	**Ongoing, end date September 2005**
53	The EUB should initiate a review of the implications of setbacks on the ability to develop property. The review should be carried out by the same stakeholder group noted in *Recommendation 52* to review the criteria of setbacks.	**Ongoing, end date September 2005**
56	The EUB audit existing ERPs on a more frequent basis to ensure that: • the operator has the capability to implement its ERP; • plans are updated according to the requirements regarding frequency of updates; • updating takes place immediately upon change of ownership and prior to a new operator physically operating the facility; and • adequate communication of updates with EPZ residents and emergency responders takes place.	**Ongoing, end date June to December 2005**
57	The EUB require the operator to coordinate roles and responsibilities to be followed in the event of an emergency with other emergency responders through early and effective discussions with the municipal Director of Disaster Services and regional health authority's Medical Officer of Health during plan development.	**COMPLETE AND IMPLEMENTED**
58	The EUB review the approach it uses for determining EPZs on the basis of the health effects information (*Recommendation 9*) and the review of dispersion modeling and probabilistic risk assessment methodology (*Recommendation 17*). The review of EPZs should be through a stakeholder process that includes involved government departments, municipalities, regional health authorities, the public, Aboriginal representatives, the land development industry, and the oil and gas industry. There should be some overlap in the membership of this review group and the one reviewing dispersion modeling and probabilistic risk assessment.	**Being completed, end date March 2006**

Table 3-2 Continued

No.	Recommendation	Implementation Status by EUB (as of July 2005)
59	The EUB work with Alberta Health and Wellness, regional health authorities, and other stakeholders to develop clear requirements and evacuation criteria to address the hazard of SO_2 as a result of ignition.	**Ongoing, end date August 2005**
61	In the interim until the review of the approach to EPZs is completed the EUB not approve a reduced EPZ unless it is conditional on the immediate ignition of the well, and the EUB is satisfied that the well can be immediately ignited and kept continuously burning. The EUB must also be satisfied that the ERP also adequately addresses the potential hazards to the public within the reduced zone and also within an awareness zone out to the distance of the calculated EPZ based on the current EUB approach (EPZ curves), and that specific assessment demonstrates protection of human health.	
64	The EUB continue its initiative to work with stakeholders to develop clear, complete, and concise guidelines, and requirements for ERP development and implementation. This should consider, among other items, referring critical sour gas well ERPs by the EUB to relevant municipal responders and regional health authorities, at the application stage, for comment regarding response capability.	**COMPLETE AND IMPLEMENTED**
Communications		
75	The EUB conduct information sessions, workshops, and panel discussions involving the public, industry, and other stakeholders specifically focusing on raising awareness and understanding of sour gas developments, rights of surface and subsurface owners, and how the EUB determines the public interest in making decisions on applications.	**COMPLETE AND IMPLEMENTED**
80	The EUB put greater emphasis on developing relationships with all of its stakeholders. This might involve the holding of more EUB open houses, making staff more readily available to participate in meetings of concerned citizens, and making presentations about its role to interested groups throughout Alberta. This is also addressed in *Recommendation 75*.	**COMPLETE AND IMPLEMENTED**
Aboriginal (First Nations and Metis) Issues		
87	The EUB work with INAC, Health Canada (regarding First Nations), and Alberta Municipal Affairs (regarding Metis settlements) to provide adequate infrastructure and resources to the First Nations and Metis for planning and development of disaster services capability. The planning should include the following measures: • identification of overlap between plans; • understanding of the roles of all parties, as they relate to evacuation procedures; • effective communication in the case of emergencies with the First Nations and Metis if they are in the affected region, even if outside of the EPZ; • identification of resources needed for the development and implementation of disaster plans and/or perhaps a disaster office or a disaster fund; and • development of mutual aid agreements.	**COMPLETE AND IMPLEMENTED**

† PSSG, 2000; adapted from PSSG, 2005a

Health authorities require relevant data. The Ministry of Health and other information providers need to ensure that mechanisms are developed and implemented that will allow the delivery and integration of information on the physical environment, populations at risk, and health outcomes. Surveillance of health risks depends on the availability of data from multiple sources and the ability to conduct integrated analyses. BC has made significant investment in GIS systems to provide data regarding environmental factors, population distribution, and health outcomes. These resources need to be framed from a population health perspective and delivered to decision-makers in health and environmental management to support their day-to-day responsibilities. The health authorities require support from the Ministry of Health for these data including GIS data, comprehensive maps of setback distances (including EPZ, EAZ, and shelter and evacuation zones) from drill sites, existing wells, and gas plants. A registry of historic oil and gas activities would be useful for the health authority. It would need to be accessible from municipalities and the regional districts.

3.3 Municipal Involvement

Municipal governments are alerted to sites where oil and gas development and processing have occurred or will be occurring. As subsequent development occurs following oil and gas activity, be it subdivisions, light industrial, hospitals, or schools, the municipality has to consider potential soil and groundwater remediation. While in thepast this was not a consideration,now there is a registry of contaminated lands that is shared with regional health authorities.

The Northeast Energy and Mines Advisory Committee (NEEMAC) is a representative stakeholder group for dialogue focused on exploring, understanding and advising on key issues related to oil and gas production. The Ministry of Energy Mines and Petroleum Resources works with communities, rural landowners, local governments, and other stakeholders directly affected by energy, mines and petroleum resource development in Northeast BC.

Recommendations

8. Municipal governments are currently alerted to the potential soil and water contamination in areas planned for subsequent development where oil and gas activity previously occurred. To better facilitate subsequent development following oil and gas activities, establish benchmarks by conducting environmental scans of areas planned for oil and gas development to provide baseline water, air, soil, and vegetation quality, and potential contaminant pathways.
9. Ensure the Ministry of Health provides Health Authorities with relevant data. The Ministry and other information providers need to provide information on the physical environment, populations at risk, and health outcomes. Health Authorities need comprehensive GIS maps of setback distances (including EPZ, EAZ, and shelter and evacuation zones) from drill sites, existing wells, and gas plants. These resources need to be analyzed from a population health perspective and delivered to decision-makers in health and environmental management to support their day-to-day responsibilities.

4 CONCLUSIONS

The findings of this study have resulted in the following conclusions:

- Rapid growth of the oil and gas industry within the province of British Columbia has outpaced our understanding of possible health and safety impacts on communities. With anticipated future growth of this industry, the populations of northeast communities will likely continue to increase, signaling the need to implement additional public health and safety measures.
- Health and safety concerns expressed by residents and stakeholders during public consultation in northeast BC, specifically around sour gas development, are similar to those voiced by residents and stakeholders in Alberta. The most frequently identified issues included: unease with, and accounts of, negative physical health effects attributed to chronic low-level exposures to H_2S and other compounds from oil and gas activities; public health and safety regarding both emergency response planning and setback distances; and potential social impacts, on both community residents and workers in the oil patch.
- The social benefits and risks of resource development on northern communities are well documented. However, there are key data gaps on the social and community health impacts specifically from oil and gas activities in northeast British Columbia communities. Limited published and anecdotal evidence suggests that oil and gas activities that use a transient workforce impact social and community health. A preliminary analysis of health utilization services in northeastern British Columbia communities, particularly emergency room visits, showed increases during periods of peak oil and gas activity periods. This suggests that influxes of population to these communities during peak activity periods are using health services at increasing numbers.
- Setback distances and emergency response plan regulations for oil and gas development are in place within BC. The current regulations and procedures used in BC are based on best available practices consistent with other jurisdictions. From a health perspective, data gaps exist regarding potential population health impacts from exposure to emissions from oil and gas developments. Reviews are currently ongoing regarding the selection and implementation of alternate approaches for establishment of EPZs.
- To date very limited interaction has occurred in BC between provincial authorities, the health authorities, the public, and the oil and gas industry in the planning and developing setbacks, and organizing and coordinating emergency response plans. Enhancing links among relevant agencies and the public to facilitate better communications around public health and safety is being initiated by MEMPR and is expected to be highly beneficial as it develops.
- There is a public perception that consultations regarding oil and gas development initiatives have been insufficient to date in BC. The approach of Alberta's Advisory Committee on Public Health and Sour Gas established in 2000 included extensive stakeholder input on oil and gas policy development. The recommendations put forth by the Advisory Committee may be used to guide ongoing sour gas policy development in British Columbia with respect to the role of the health authorities and other relevant regional authorities in the protection of health and safety in British Columbia communities.

5 RECOMMENDATIONS

Analysis of the information compiled in this studied has produced the following recommendations:

Recommendation 1. Facilitate investigations of potential social impacts of resource development on northeastern British Columbia communities, particularly with respect to a transient workforce. This study should include, at a minimum, an analysis of community social health effects, the adequacy of social and health services, and the implications of these growing workforces and populations in northern British Columbia communities.

Recommendation 2. Enhance funding to health authorities for provision of health services (acute and public health) in line with the increased utilization of health services in these regions.

Recommendation 3. Ensure health authorities are integral to the proactive planning process for all new oil and gas developments at the application phase. The health authorities should be apprised of all proposed oil and gas wells, and processing facilities; the characteristics of these facilities including their longevity release rates, H_2S concentrations, and setback distances. The health authorities should also be provided with emergency response plans that include individual responsibilities.

Recommendation 4. Involve Health Authorities in emergency response plan development.

Recommendation 5. Expedite the provincial review of current setback regulations and emergency planning zones; in particular apply health-based criteria wherever possible.

Recommendation 6. Enhance the community engagement process. While public consultation guidelines have been implemented there remains a public perception that engagement and education programs are insufficient, particularly related to the establishment of emergency response zones and setbacks and their adequacy to protect public health and safety.

Recommendation 7. Work with the current BC Energy Plan to help establish public consultation processes pre-tenure and throughout all stages of development for British Columbia's sour gas plan, similar to the outreach program of Alberta's Advisory Committee on Public Safety and Sour Gas. Establishment of a provincial advisory committee to provide an opportunity for stakeholder groups is currently underway.

Recommendation 8. Municipal governments are currently alerted to the potential soil and water contamination in areas planned for subsequent development where oil and gas activity previously occurred. To better facilitate subsequent development following oil and gas activities, establish benchmarks by conducting environmental scans of areas planned for oil and gas development to provide baseline water, air, soil, and vegetation quality, and potential contaminant pathways.

Recommendation 9. Ensure the Ministry of Health provides Health Authorities with relevant data. The Ministry and other information providers need to provide information on the physical environment, populations at risk, and health outcomes. Health Authorities need comprehensive GIS maps of setback distances (including EPZ,EAZ, and shelter and evacuation zones) from drill sites, existing wells, and gas plants. These resources need to be analyzed from a population health perspective and delivered to decision-makers in health and environmental management to support their day-to-day responsibilities.

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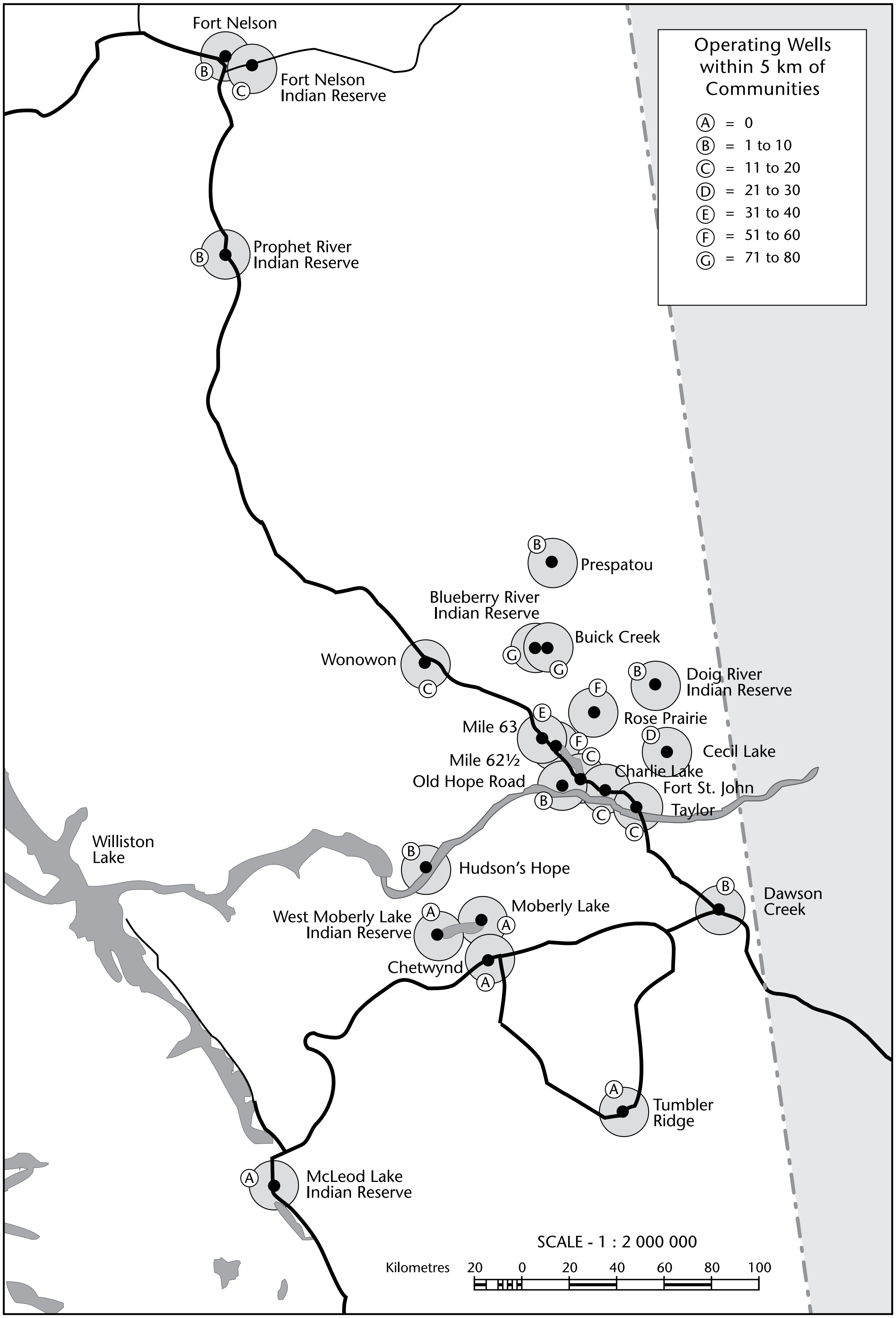
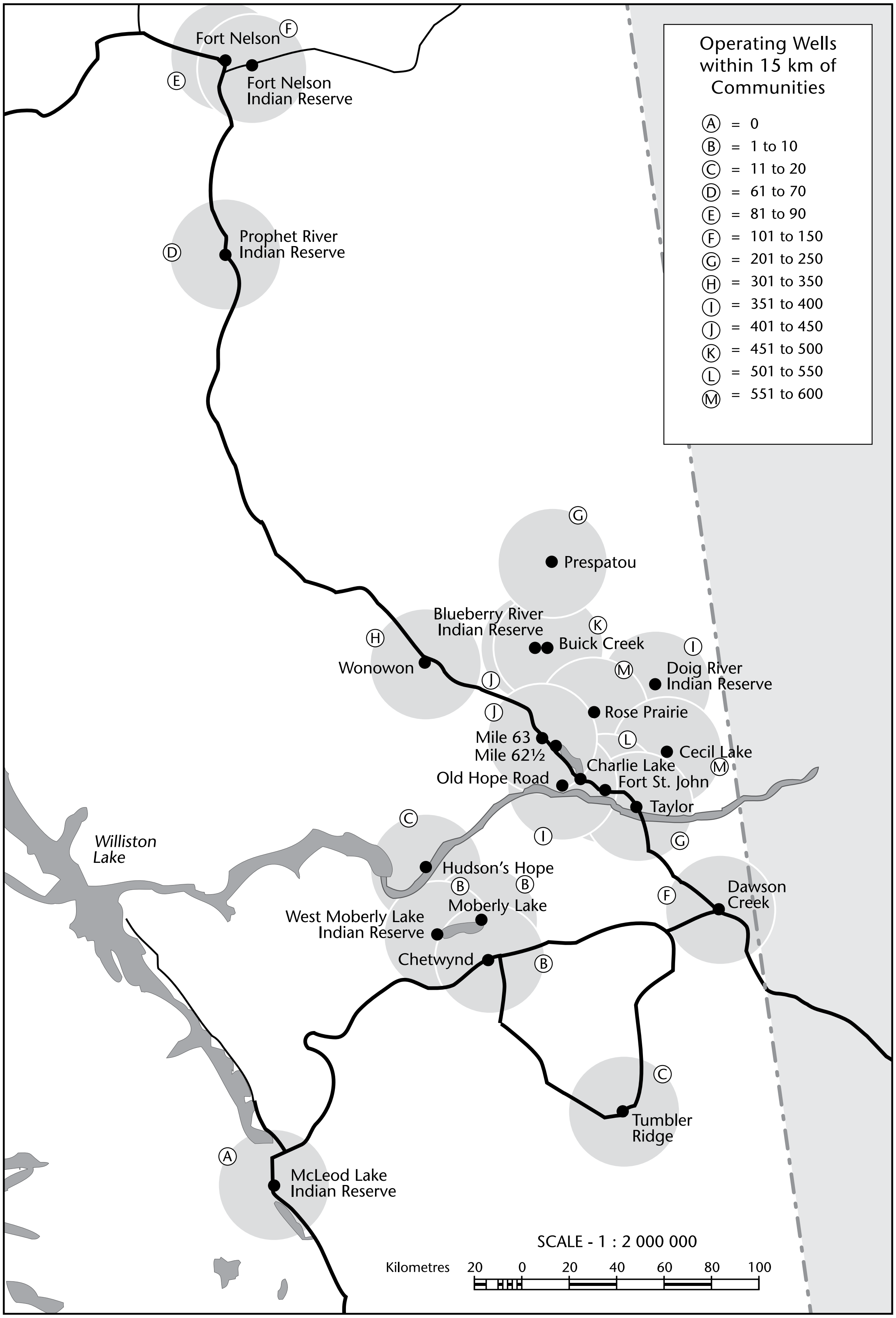
APPENDIX 1 OPERATING WELLS WITHIN 5 KILOMETRES OF COMMUNITIES



APPENDIX 2 OPERATING WELLS WITHIN 15 KILOMETRES OF COMMUNITIES



APPENDIX 3 HYDROGEN SULPHIDE AMBIENT (LOW LEVEL) EXPOSURES

Hydrogen Sulphide

Natural gas development results in the release of various air emissions including carbon monoxide and carbon dioxide; nitrogen oxides; volatile organic compounds, such as benzene – a known carcinogen, styrene, toluene, xylenes; and reduced sulphur compounds, including SO_3 and H_2S. Based on information collected from public consultation meetings, H_2S was identified as the contaminant of most concern regarding public health and safety.

H_2S has been identified as the main chemical hazard associated with natural gas production, particularly in sour gas production (Guidotti, 1996) and one of the main contaminants of public health concern (Roth and Goodwin, 2002). H_2S is a dense, colourless gas with a strong smell of rotten eggs at low concentrations. H_2S is produced naturally via the bacterial decomposition of organic materials, including plant and animal proteins and is a natural component of crude petroleum, natural gas, volcanic gases, and sulphur springs (National Research Council, 1978; WHO 1981; Beauchamp et al., 1984; Bates et al. 1997).

Reviews of the toxicological properties of hydrogen sulphide and human health effects have been conducted elsewhere (National Research Council 1979; WHO 1981; Beauchamp et al. 1984; Glass 1990; Reiffenstein et al. 1992; Guidotti 1996; Milby and Baselt 1999a; Milby and Baselt 1999b; Roth and Goodwin, 2002; ATSDR, 2004). It is widely accepted among health experts that exposure to hydrogen sulphide at high concentrations causes adverse effects to human health. H_2S acts as both an irritant of mucous membranes, which results in the irritation and inflammation of eyes and the respiratory tract, and an asphyxiant, affecting the nervous system and may cause paralysis of the respiratory tract, resulting in death (Beauchamp et al., 1984). Adverse health effects at variable concentrations include reversible unconsciousness or "knock-down", eye damage (keratoconjunctivitis or "gas eye"), pulmonary edema, olfactory paralysis, and death. H_2S is rapidly oxidized within the blood and is not considered to be cumulative.
The primary route of adsorption of H_2S in humans is via the lungs (Beauchamp et al., 1984). Perhaps one of the key dangers of H_2S is odour characteristics. Up to 30 ppm, H_2S smells of rotten eggs; however, above 30 ppm, the odour is described as sickening sweet, with no odour at concentrations above 100 ppm due to olfactory fatigue. At higher concentrations H_2S is not perceptible by odour, which can result in adverse toxic effects and make it difficult to detect. Toxicological studies have shown that knockdown can occur in individuals at concentrations of H_2S of 500 ppm, with concentrations of 750 to 1000 ppm resulting in abrupt collapse, i.e. a few breaths, while death can occur at concentrations between 500 and 1000 ppm (Beauchamp et al., 1984; Guidotti, 1996). Knockdowns may be acutely fatal, as a result of respiratory paralysis and cellular anoxia (Guidotti, 1994).

A summary of human physiologic responses to H_2S exposure at various concentrations is shown in Table A3-1.

Table A3-1 Human physiologic responses to H_2S exposure†

Concentration [ppm]	Physiological Responses
0.003 – 0.02	Odour threshold
3 – 10	Obvious unpleasant odour
	8-hour occupational exposure limit – 10 ppm (British Columbia, Alberta)
15	15 minute occupational exposure limit
20 – 30	Strong offensive odour ("rotten eggs")
30	Sickening sweet odour
50	Conjunctival (eye) irritation first noticeable
50 – 100	Irritation of the respiratory tract and eyes
100 - 200	Loss of smell (olfactory fatigue); severe eye and respiratory irritation
150 - 200	Olfactory paralysis
250 - 500	Pulmonary edema (accumulation of fluid in the lungs) may occur, especially if exposure is prolonged
500	Anxiety, headache, ataxia (loss of muscle coordination), dizziness, stimulation of respiration, amnesia, unconsciousness ("knockdown")
500 - 1000	Respiratory paralysis leading to immediate collapse, neural paralysis, cardiac arrhythmias, death

† Adapted from Beauchamp et al. (1984); Reiffenstein et al. (1992); Guidotti (1996)

Also of concern with exposure to H_2S is the potential for neurological effects. Reiffenstein et al. (1992) identified a number of neurological effects from acute exposures, including fatigue, vertigo, anxiety, convulsions, unconsciousness or knockdown, and respiratory failure. Kilburn and Warshaw (1995) suggested that neurobehavioural abnormalities were associated with reduced sulphur gases, including H_2S at concentrations between 10 and 100 ppb from crude oil desulphurization. However, the study was commissioned by a plaintiff's law firm and many of the exposed participants were plaintiffs in a class action lawsuit; therefore, subject bias may have impacted results of the self-administered questionnaire. Further, controls for the study were friends and relatives nominated by the exposed subjects, which may lead to potential subject bias in the results. Due to the potential for subject bias within the study, the results of Kilburn and Warshaw (1995) may be questioned.

Recent studies conducted by Rosenegger et al. (2004) suggested that exposure of snails to low levels of H_2S (50–100 μmol/L) adversely affected learning and memory function. Roth and Goodwin (2002) conducted an extensive review of the state of knowledge of H_2S and concluded that "…there is evidence that cumulative health effects of repeated low-level H_2S exposure exist, which does not support earlier claims that H_2S is only an acute toxicant due to its rapid metabolism to non-toxic products. It still remains a challenge to conclude what levels of exposure to H_2S pose a health risk to the general population and the sensitive individual. An understanding of exposure response relationships is of primary importance and priority should be given to establish dose-response curves in all areas of investigation" (p. xi). Cumulative effects refers to the combined and accumulated biological impacts of repeated H_2S exposure on cells, organs, and animals or animal populations, which may lead to changes in pathology or disease.

A recent review conducted by Davies and Haggerty (2002) assessed the health effects associated with acute exposures to low levels of H_2S. For purposes of their review, only studies that investigated exposures to H_2S via inhalation for test periods of up to 30 days and concentrations in the range of 0 to 100 ppm. 45 studies met the study criteria, including clinical studies that involved controlled exposures of volunteer human subjects, non-clinical investigations involving controlled exposures of test animals, and case-control studies involving evaluation of individuals exposed to H_2S as a result of accidental release. Of these studies, 75% were non-clinical investigations that used animal testing. Only a limited number of studies were deemed of high confidence, with 50% of the studies classified with relatively low confidence of results. Common weaknesses outlined in these studies included failure to follow conventional testing protocols, failure to follow good laboratory practice guidelines, use of a single exposure concentration only, use of a single sex only, use of too few test subjects, lack of routine measures of toxicity, and inadequate descriptions of exposure conditions (Davies and Haggerty, 2002).

The results of the acute low-level studies suggest that healthy adults can tolerate up to 10 ppm H_2S without significant effects. However, for individuals with mild to moderate asthma, exposures of 2 ppm may be capable of inducing bronchial obstruction, based on measures of specific airway resistance and conductance. Clinical studies above 10 ppm were not of sufficient quality to provide an adequate assessment. No reliable studies were available to assess H_2S exposures on human reproductive health. Mortalities were not recorded for any clinical or case-control studies reviewed. The findings of the study were limited in that it did not address potential health effects of hypersusceptable individuals or potential health effects that may have resulted from odour of H_2S.

To date, much of the research on H_2S toxicity on humans is focused on acute high-level exposures, primarily a result of accidental occupational exposures. A limited number of reliable studies were available for assessment of health effects from acute low-level H_2S exposure.

Occupational Exposure

Exposure to toxic substances remains a cause of morbidity and mortality in the workplace, although the majority of occupation-related deaths are a result of traumatic injuries (Hendrickson et al., 2004). In addition to the oil and natural gas industry, H_2S is found in a number of other industries including wastewater treatment facilities, municipal sewers (Richardson, 1995), pulp mill operations (Jäppinen and Tola, 1990; Jäppinen et al., 1990), viscose rayon production (Vanhoorne et al., 1995), solid waste management (Fielder et al., 2000), and others. It is suggested that H_2S as a hazard is most common in the oil and gas industry (Guidotti, 1994; Guidotti, 1996). A number of studies have been conducted on human exposures related to acute high-level occupational-exposures of H_2S; however, the scope of this assessment was limited to investigations of health impacts on sour gas workers. Hessel et al. (1997) suggested that workers that experience a knockdown, are likely among the most highly exposed individuals available for study.

Three peer-review studies were identified that examined occupational exposures of workers in the sour gas industry (Guidotti, 1994; Hessel et al., 1997; Mostaghni et al., 2000).

Guidotti (1994) outlined that in addition to H_2S, there are a number of other chemical exposures that occur within the sour gas industry. A number of different compounds are used in the drilling, extraction, processing, and separation of sour gas. Characteristics of each sour gas plant are different and for purposes of study, would require detailed analyses of specific plant procedures and characteristics. For example, an occupational hygiene assessment of an Alberta sour natural gas plant conducted by Evans (1989), emphasized benzene as potential worker exposure hazard.

Cottle and Guidotti (1990) reviewed potential occupational hazards from process chemicals used at various stages in the oil and gas industry, including drilling, cementing, completion, stimulation, and production. A summary of the principal exposures in the sour gas industry, as outlined by Guidotti (1994), is shown in Table A3-2.

Evidence of occupational-related morbidity and mortalities from acute level H_2S exposures are documented. Hendrickson et al. (2004) conducted a review of the United States Bureau of Labour Statistics Census of Fatal Occupational Injuries for occupation deaths related to H_2S from 1993 to 1999. During this seven year period, 52 workers died of H_2S toxicity, with the most common industries including waste management (24%), and petroleum and natural gas (18%). It was suggested that although the data sources were trustworthy, these values could be lower than actual values due to under reporting of occupation-related deaths (Hendrickson et al., 2004). It has been estimated that occupation-related sour gas exposures in Alberta's oil patch has resulted in the death of 36 workers over the past 30 years (Staples, 2004). In British Columbia, 819 claims were filed from 1997 to 2004 with the Worker's Compensation Board for oil and gas related occupations, of which 70 were exposure related (British Columbia Worker's Compensation Board, 2005).

Hessel et al. (1997) conducted a cross-sectional study that examined the effects of H_2S exposure on respiratory symptoms and lung function in 175 workers involved in the extracting and processing of oil and natural gas in Alberta. The study was conducted based on a respiratory symptom questionnaire and spirometric testing. Exposure assessment to H_2S used the following two questions: one asked whether the respondent had ever been exposed to "sour gas that was so strong it caused symptoms" and the other question asked whether they had ever had a "knockdown". Respiratory symptoms of individuals were compared between workers that had reported exposures and those that did not. Approximately one-third of workers reported having an exposure to sour gas strong enough to cause symptoms, while 8% of workers reported hav-

Table A3-2 Summary of principle exposures in the sour gas industry†

Exposure	Source
Hydrogen sulphide	Raw gas
Mercaptans	Raw gas and extracted sulphur
Carboxyl sulphide	Raw gas and extracted sulphur
Hydrocarbons (C1-C5)	Raw and product gas
Solvents	Maintenance and installation of equipment
Amines (mainly monoethanolamine and diethanolamine)	Desulphuration
Elemental sulphur	Sulphur recovery
Methanol	Wax solvent, antifreeze
Demulsifiers (detergents)	Separation
Ethylene glycol	Dehydration
Corrosion agents	Pipeline and tank protection
Bactericidals	Production water, wastewater treatment
Defoamers	Separation
Asbestos	Plant insulation (significant exposure unlikely)
Noise	Multiple

† Guidotti, 1994

ing a knockdown. Results of the study did not show an association between sour gas exposure and measurable pulmonary health effects or an increased prevalence of respiratory symptoms; workers reporting a knockdown showed an increase prevalence of respiratory symptoms. These symptoms included shortness of breath while walking up a slight hill, wheeze with chest tightness, and attacks of wheeze. Despite the increase in the prevalence of respiratory symptoms, the results of this study did not show a change in lung function related to H_2S exposure. Hessel et al. (1997) also suggested that this result may be because the main toxic effects of H_2S exposure may be neurological, rather than strictly respiratory.

Similar to the study conducted by Hessel at al. (1997), Mostaghni et al. (2000) assessed the respiratory health of 62 sour gas refinery employees in Iran, and 30 controls from an oil refinery for chronic low-level exposures to sour gas plant emissions. The study used an evaluation of respiratory symptoms and spirometric data to assess worker health. The results suggested that although sour gas refinery workers experienced more respiratory symptoms than the controls, pulmonary function data were not statistically different. These differences may be attributed to lack of sensitivity of the spirometric values or reporting bias among workers (Mostaghni et al., 2000). Several limitations of the study were suggested including a lack of any exposure data, such as H_2S and SO_2 concentrations and the duration of employment, from 2 to 9 years may not have been sufficient to cause adverse respiratory effects (Mostaghni et al., 2000). A statistically significant difference between respiratory health, may not have been seen between sour gas refinery workers and the oil refinery workers due to confounding chemical exposures. Guidotti (1994) suggests that even a comparison of workers between "sweet" gas and sour gas industries may not be effective due to differences in the desulphuration process. He suggested that an individual exposure assessment for workers within both industries would be required. In addition, without characterization of emissions and occupational exposures from either industry, identification of potential causation for any adverse health effects is next to impossible.

One of the main limitations of occupationally-related epidemiological studies is that studies often do not have H_2S measures at time of exposure. Therefore, establishment of dose-response relationships and levels of exposure are not possible. Guidotti (1994) argues that comprehensive studies within the sour gas industry are difficult to conduct due mainly to confounding exposures and endpoints that are difficult to measure and have uncertain impacts.

Evidence of morbidities and mortalities from acute level exposures to H_2S within the oil and natural gas industries is apparent; however, occupational exposure studies related to chronic exposure from sour gas industry activities are limited. Occupational exposure studies conducted to date show relatively weak associations between adverse respiratory and pulmonary functions related to exposure to sour gas emissions. The main weakness in each of the studies is a consistent lack of exposure characterizations, which may reduce the studies' ability to detect associations. There is a need for further studies that examine worker health including neurological effects as well as respiratory effects that accurately characterize levels of chronic exposure to emissions from sour gas operations.

APPENDIX 4 ANIMAL HEALTH AND SOUR GAS EXPOSURE

A number of community-based studies that examined exposure to oil refinery emissions and health effects have been published and reviewed elsewhere (Kennedy et al., 2002). However, due to differences in the mixtures of contaminants encountered in oil refineries compared to sour gas processing facilities and the absence of these types of facilities within northeastern British Columbia, oil refinery health impact studies were not included in this review.

An assessment of population health impacts from chronic low-level exposures to sour gas revealed that community health impacts related to oil and gas activities, specifically sour gas, were limited. This is attributed to the difficulty of conducting epidemiological studies that will determine the links between sour gas activities and adverse health outcomes. An examination of the diseases or symptoms may be linked to a number of causes, some of which are not known. For an epidemiological study to establish links to a cause, such as sour gas emissions, over background variations of other causes and natural fluctuations, a large population is required, i.e., on the order of hundreds of thousands of individuals (Kennedy et al., 2002).

A review of population-based studies that assessed health impacts associated with sour gas activities found one epidemiological study that evaluated community health effects from exposure to sour gas refinery emissions (Spitzer et al., 1987) and a study conducted by Alberta Health (1998) that examined the relation between health data and socioeconomic and environmental factors. Both of these studies were conducted in Alberta

Health Effects Associated with Exposure to Sour Gas Refinery Emissions

Spitzer et al. (1987) conducted the only comprehensive epidemiologic study that assessed population health effects from sour gas activities. This study evaluated a number of health outcomes including respiratory health (Dales et al., 1989), cancer incidence (Schechter et al., 1989), and mortality (Schechter et al., 1990). The study also assessed whether emigration or moving from the area was based on health rather than employment, education, or marriage (Spitzer et al., 1987; Tousignant et al., 1994). At the time, this study was one of the largest and most intensive epidemiological studies conducted in Canada (Dales et al., 1989). The total cost for the study was $3.3 million (Spitzer et al., 1987). The study was implemented as part of an initiative of the Alberta Government and a consortium of industries known as the Acid Deposition Research Program (ADRP) (McGill Inter-University Research Group, 1986a; 1986b; 1986c). The study results are summarized in the following paragraphs.

In 1985, a clinical epidemiological study was designed and carried out by a team of researchers from McGill University to address potential health concerns of residents living downwind of a sour gas processing plant in a rural area southeast of Pincher Creek, Alberta. The study involved comparison of an exposed group of 2350 rural southwestern Alberta residents, those individuals living downwind from two sour gas processing plants, and 900 unexposed individuals of rural southwestern Alberta residents. This study population was defined by exposure to emissions from sour gas plants using air quality measurements obtained from Alberta Environment and community leaders opinions as to the extent of the area potentially affected (Dales et al., 1989). An additional reference group of 4000 exposed individuals was selected from another part of rural Alberta at a distance of 240 km from the study site. Two historical cohort populations were also constructed. The first cohort included individuals that had lived in any of the three areas since 1958. Ascertainment of birth defects through to 1984 were assessed in emigrants and remaining residents. The second cohort identified individuals living in the study area since 1970. This cohort was assessed for potential cancer incidence and chronic disease mortality. Emigrants and current residents were also followed for cancer and mortality incidences through to end of 1984. Additional environmental measurements or emissions characterizations were not taken during the course of the study (Dales et al., 1989). The study included a standardized interview that examined history, symptoms, physical function, and exposure. A structured physical examination was also performed on each subject. In total, 3695 individuals were examined.

The results of the study did not show any significant differences between the three study areas for mortality rates (Spitzer et al., 1989; Schechter et al., 1990), incidence of cancer (Schechter et al, 1989; Spitzer et al., 1989), birth defects, fetal losses, childhood development, trace metal levels (Spitzer et al., 1989), respiratory function and respiratory disease (Dales et al., 1989), and clinical tests (Spitzer et al., 1987). The results of Dales et al. (1989) showed an increased prevalence of respiratory symptoms among children aged 5 to 13 and in never-smokers over the age of 14 associated with greater exposure to natural gas plant emissions. However, in both adults and children, there was no evidence of association between exposure and reduced lung function. It was suggested that because the study was prompted by health concerns in the area, there was a potential for recall bias, which may have increased self-reporting of symptoms in the area, with respect to children's health (Dales et al., 1989). There was no evidence that adverse health resulted in individuals moving from the area, as only 1% of emigrants that were contacted had moved out of the region because of health reasons (Spitzer et al., 1987).

The results of the study showed that 20% of the individuals in the main exposed study area were worried about their health, compared to 13% in the two reference areas. Similarly, 79% of individuals within the exposed area reported the occurrence of at least 1 cardinal symptom in the past 2 weeks, which was 5% higher than responses from individuals in both reference areas. The presence of at least one cardinal physical sign was shown in 37% of individuals. This value was 8% lower in the index area than the main reference area; the reported cardinal physical signs in the third ancillary reference area were even lower at 30%.

Health Effects Associated with Solution Gas Flaring

Prompted by ongoing health concerns of solution gas flaring, particularly potential adverse health effects, a study was conducted in 1998 by Alberta Health to investigate the potential association between respiratory disorders and solution gas flaring volumes in Alberta (Alberta Health, 1998). Solution gas is the natural gas that is found with crude oil in underground reservoirs. Upon extraction of the oil at the surface, the gas expands and comes out of solution.

The study compared population demographic data and physician claims and hospitalizations to flaring volumes throughout Alberta for the 1994 to 1996 period. The health outcomes studied included asthma, bronchitis, pneumonia, and respiratory infections. Exposure to solution gas flaring was estimated via average volumes of gas flared per square kilometer, annually for the 1989 to 1996 study period and monthly for 1996. Specific characterization of the solution gas flares was not conducted. The results of the study did not show a significant correlation between solution gas flaring volumes and rates of physician claims or hospitalization for respiratory disorders regardless of the type of health outcome, rural or urban status, ethnicity, or age.

A number of limitations were identified in this study, including the potential for determining associations of aggregated data that may not be representative at the individual level; and potential confounding of actual health effects by geographical variation in physician billing practices. In addition, the exposure assessment aggregated data to represent flaring by postal code. Using this approach for other factors smaller than postal code boundaries would not be detected and potential confounding may have occurred during establishment of postal code boundaries. There was also potential for misclassification via rural-urban status based on the use of postal code areas.

Population Health Monitoring Studies in Oil and Gas Industrial Communities

Population-based health monitoring studies were conducted in Alberta and Manitoba communities to assess potential adverse health effects from air emissions.

Studies in Alberta were conducted by Alberta Health and Wellness in Fort McMurray (Alberta Health and Wellness, 2000), Grande Prairie (Alberta Health and Wellness, 2002), and Fort Saskatchewan (Alberta Health and Wellness, 2003). These communities are characterized by a number of industrial activities within the region, including oil and gas industry. The exposure assessment methodologies within each of these studies were similar. The aims of the studies were to characterize the population and personal distribution of exposure to airborne chemicals and particulates. Contaminants assessed included SO_2, nitrogen dioxide (NO_2), ozone (O_3), some volatile organic compounds (VOCs), and particulate matter of 2.5 µm diameter (PM2.5). These studies did not identify significant adverse exposures or health status associated with air emissions.

A significant limitation of these studies in determining health impacts associated with oil and gas activities is the significant number of industries located within the regions. While the approach may be valid to determine health effects from cumulative exposures, attribution of potential impacts to a particular industry, such as oil and gas, was not possible. For purposes of this review, these studies were not appropriate for the assessment of potential health impacts from oil and gas activities. It was suggested that difficulties with volunteer recruitment in the Grande Prairie and Fort Saskatchewan studies were indicative of a lack of public concern for exposure to air emissions. This finding is questionable, as there are a number of other reasons for issues with recruitment than simply disinterest.

A study was conducted by Kraut (2000) in Tilston, Manitoba to assess whether emissions from an sour oil battery with H_2S concentration of 13.5% had or may have the potential to affect health of residents in the area. An oil battery is used to separate crude oil from sour natural gas and salt water. Waste gases were flared from 1997 to 1999 and in November 1999 an incinerator was installed to burn the gas. The health assessment of residents included a questionnaire, answered by 38 residents, and an interview and in-person examination by a physician, completed by 37 residents. Based on an assessment of air quality monitoring data, H_2S was determined to be the emission of most significant health concern. Residents identified symptoms consistent with H_2S exposure, associated with odour; however, a number of individuals also reported symptoms in the absence of odour. This finding suggested that symptoms in these individuals may have been more influenced by a concern about potential exposure to emissions rather than an environmental exposure. The findings of this assessment suggested that the residents living near the battery would not be at an increased risk for long-term health effects.

First Nations

First Nations communities in northeastern British Columbia, within the Treaty 8 Tribal Association have expressed concern regarding the health effects of oil and gas industry activities on environmental quality and health effects resulting from exposure to emissions (Arocena et al., 1996a; Arocena et al. 1996b). This link between environmental, wildlife, and human health is particularly critical for First Nations communities because of the links to traditional diet and to the ecosystem. To address these concerns, studies have been conducted within the traditional territories of northeastern British Columbia to assess potential health and environmental risks.

In 1995, Treaty 8 First Nations partnered with Health Canada and the University of Northern British Columbia (UNBC) to initiate the Great Bear Flare Pit Project, designed to assess the risks posed to First Nations people and wildlife by flare pit emissions (Ridal et al., 1998). The major goals of the Great Bear Flare Pit Project were the following (Ridal et al., 1998):

- identify potential contaminants in wells;
- develop sampling protocols and experimental designs for suspected contaminants;
- carry out the sampling and analysis programs to establish contaminant pathways from wells into air, water, and soil;
- quantify the risks associated with these contaminant transfers to wildlife and Treaty 8 First Nations peoples.

The study consisted of two major research initiatives including a literature review of potentially toxic agents associated with flare emissions in the traditional territories of Treaty 8 First Nations and the Flare Pit Contaminants Sampling Program. The literature review was not available for use in this study but, the results of one of the three environmental quality assessment studies conducted under the Great Bear Flare Pit Project are discussed below.

A background environmental quality assessment study was initiated out of concerns of the Treaty 8 Tribal Association regarding the health of individuals that consumed a traditional diet consisting of wildlife and plants within their traditional territories (Arocena et al., 1996a; Arocena et al., 1996b). As a result of these concerns, some members of the community altered hunting activity in regions that they have identified as a potential risk for reasons such as strong and unpleasant odours and chemical hazard warning signs. Observations of diseased or abnormal animals within traditional hunting areas were attributed to the potential hazards of the area (Arocena et al., 1996b). The regions of concern were identified as areas around oil and gas flares and areas characterized by odours, warning signs, and visible residues on surrounding soil and vegetation (Arocena et al., 1996).

The objective of the study was to conduct an assessment of soil and water quality, in particular, for elements that may pose a risk to health and the environment. Arocena et al. (1996a) examined concentrations of metals, and hydrocarbons including PAHs, BTEX compounds (benzene, toluene, ethylbenzene, and xylenes) and total polychlorinated biphenyls (PCBs), in soil and water in samples collected from oil and gas flare pits within the Doig Basin and Del Rio areas. These samples were collected from sites within traditional hunting areas perceived by elders and members of the Treaty 8 First Nations to be impacted by oil and gas exploration (Arocena et al., 1996). The results of the study suggested that concentration of some metals in soils around gas flare pits exceeded federal environmental regulations. A significant limitation of the study was that background soil concentrations were not available.

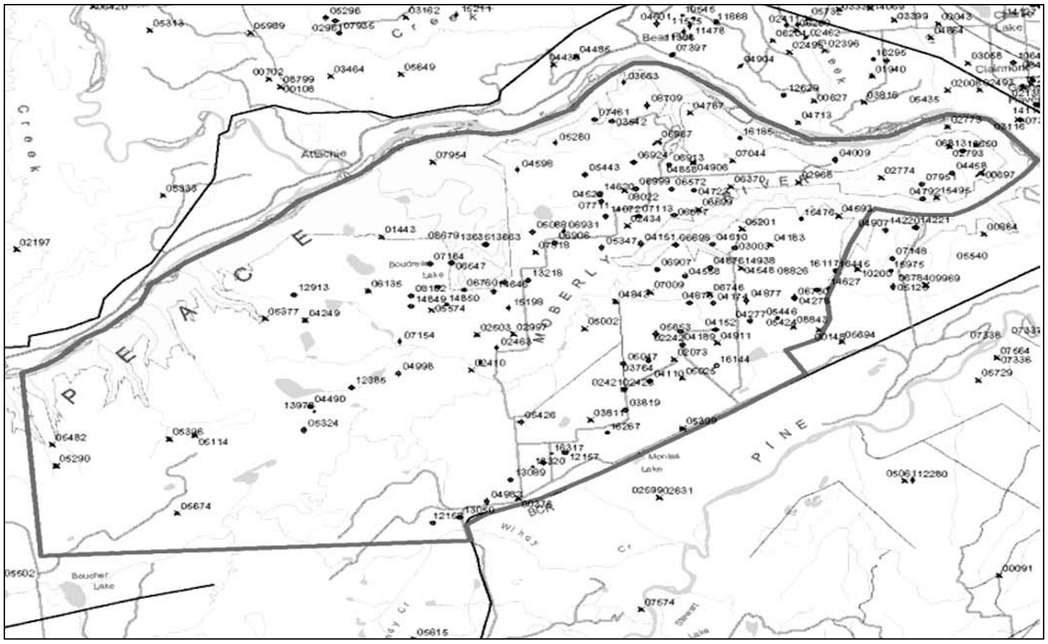


Figure A4-1 Map of study area and distribution of 135 well sites *(Houwers, 2004)*

Concerns expressed by First Nations regarding potential impacts of oil and gas activities on wildlife, initiated a study in 2003 by the Saulteau Nation and the West Moberly Nation to investigate the effects of oil and gas activities on wildlife in the Del Rio area near Moberly Lake, British Columbia (Houwers, 2004). The study was initiated to address the concerns of First Nations communities that oil and gas activities were adversely impacting wildlife within their traditional hunting area and Treaty 8 Territory. It was suspected that animals that previously ingested fluids out of sump and flare pits were becoming contaminated. A number of site investigations, track surveys, wildlife observations via remote cameras, and sampling and analysis of water and soil collected from the well sites. The study area was approximately 75 000 hectares and contained approximately 135 well sites. The study site is outlined in Figure A4-1.

The results of the study suggested that oil and gas activities adversely affected wildlife in the Del Rio area via ingestion of contaminated water and soil. It was determined that of the sump and flare pits sampled, 75% of the 16 sites showed signs of hydrocarbon, metal, and salt contamination when compared to federal and provincial environmental quality

Figure A4-2 Remote camera photographs of moose and deer at well sump sites *(Houwers, 2004)* guidelines. Of the 78 well sites surveyed, 95% of the sites showed moderate to high animal use. It was shown that animals ingested fluids and soil out of the sump and flare pits via use as watering holes. Ungulates, such as moose and deer used the site as licks, and other animals, such as bear, wolf, and coyote used the sites to find prey and as watering holes, which resulted in the ingestion of fluid out of the sumps and flare pits (Houwers, 2004). Examples of animal use at well sump sites are shown in Figure A4-2.

The results obtained by Houwers (2004) raise questions regarding the potential long-term effects of ingestion of sump and flare pit materials on animal health and the potential effects of consuming these animals on the human health, particularly in First Nations communities.

Animal Health and Sour Gas Exposure

Epidemiological methods have also been used to assess potential impacts on animals, specifically beef and dairy cattle. These studies have examined cattle health and emissions from oil and gas activities in Alberta, including a sour gas pipeline (Waldner et al., 1998), oil and gas well sites (Waldner et al., 2001a), processing facilities (Waldner et al., 2001a; Scott et al., 2003a; Scott et al., 2003b; Scott et al., 2003c; Scott et al., 2003d), and flaring (Waldner et al., 2001a).

To date, epidemiological study results on animal health have been conflicting. Waldner et al. (1998) conducted a prospective investigation of a sour gas (33.9% H_2S) pipeline leak and beef cattle productivity that did not indicate a significant association with emissions. In contrast, an examination of cattle reproduction and calf mortality by Waldner et al. (2001a, 2001b) showed that among seven beef cow-calf herds in western Canada, there was potential increased risk of reproductive effects associated with sour gas emissions. These effects included a potential increased risk of non-pregnancy from exposure to one or more sour-gas flaring facilities, battery flaring sites, active gas wells, and larger field facilities. An increased risk of stillbirth was associated with volume of flared sour gas from battery sites and increased calf mortality from sour gas flaring exposure for one year of calf crop. The composition of the flared gas was not well defined in this study.

Although suggestive of a potential association between sour gas exposure and animal health effects, the application of Waldner et al.'s (2001a; 2001b) results has been questioned. It was suggested by Scott et al. (2003c) that the limited geographical extent of the study and the narrow range of exposures from oil and gas industry emissions, which included both gas plant emissions and flaring activities from sour oil and solution gas well facilities, limited the generalizability of study results.

A province-wide retrospective longitudinal study of dairy and beef cattle health was conducted by Scott et al. (2003a; 2003b; 2003c; 2003d) over a 10 year period. In contrast to the air monitoring approach used by Waldner et al. (2001a; 2001b) to assess emissions, this study used dispersion-modeled estimates of SO_2 concentrations as a surrogate measure of cattle exposure to combusted sour gas emissions from gas processing plants in Alberta. The results of the study provided no evidence for higher risks of herd culling or mortality in dairy cattle (Scott et al., 2003b); dairy herd reproduction, including stillbirth and twinning (Scott et al., 2003d); cattle health and productivity of beef cow-calf operations, including stillbirth and twinning risks; and calf-crop delivered and calving-season profile, overall and disease-specific calfhood-mortality risk, calf-crop weaned, and overall and disease-specific culling risks (Scott et al., 2003c), associated with higher exposure to air emissions from sour gas plants. A small association was identified between sour gas emissions (>9 µg/m^3 or >3 ppb SO_2) and the age at first-calving and herd-average calving interval (Scott et al., 2003d).

Scott et al. (2003c) also identified a number of limitations of the methodology used in this epidemiological study, which included a restrospective assessment and dispersion modeling. Using a modeling approach, the study represented air emissions from one source and did not include other potential emissions, including air, water, and soil from oil and gas activities. The approach did not capture significant emission events that may also occur, including gas plant upsets, emergency flaring and venting, or emissions from the well sites. Individual or herd-level exposures were based on modeled SO_2 concentrations, not sour gas mixtures and since the study was historical in nature, data analyses of exposure and health outcome data were limited to existing data.

The results from animal health studies conducted to date are not clear. Waldner et al. (2001a; 2001b) and Scott (2003d) showed a weak association between cattle reproduction and sour gas emissions. In contrast, Waldner et al. (1998) and Scott et al. (2003b, 2003c) did not show that emissions from sour gas emissions adversely affected animal health and productivity.

APPENDIX 5 COMPUTING THE EMERGENCY PLANNING ZONE

The size of the Emergency Planning Zone (EPZ) is determined by the potential release rate during drilling and/or well completion. The EPZs are currently computed using mathematical equations that approximate Gaussian dispersion models for the steady state maximum H2S release potential or "worst case" release scenario. The greater the H2S release potential of the well and the higher the concentration of H2S gas, the larger the EPZ will be. A summary of the mathematical formulas used to determine an EPZ are shown in Equation 1 to Equation 3 (EUB, 2005c; OGC, 2003).

For $Q_{H_2S} < 0.3\ m^3/s$:

$$EPZ\ [km] = 2.0 \times Q_{H_2S}^{\ 0.58} \qquad \text{Equation [1]}$$

For $0.3\ m^3/s \leq Q_{H_2S} < 8.6\ m^3/s$:

$$EPZ\ [km] = 2.3 \times Q_{H_2S}^{\ 0.68} \qquad \text{Equation [2]}$$

For $\geq 8.6\ m^3/s$:

$$EPZ\ [km] = 2.3 \times Q_{H_2S}^{\ 0.68} \qquad \text{Equation [3]}$$

In the above equations, Q_{H_2S} refers to the maximum H_2S release rate in cubic meters per second (m^3/s) (dimensionless number) and EPZ is the radius of the emergency plan zone in kilometers. Graphically, Equation 1 to Equation 3 are shown as the relationship between EPZ distances in km and the maximum release rates of H_2S for sour wells, known as nomograms, and are illustrated in Figures A5-1 and A5-2.

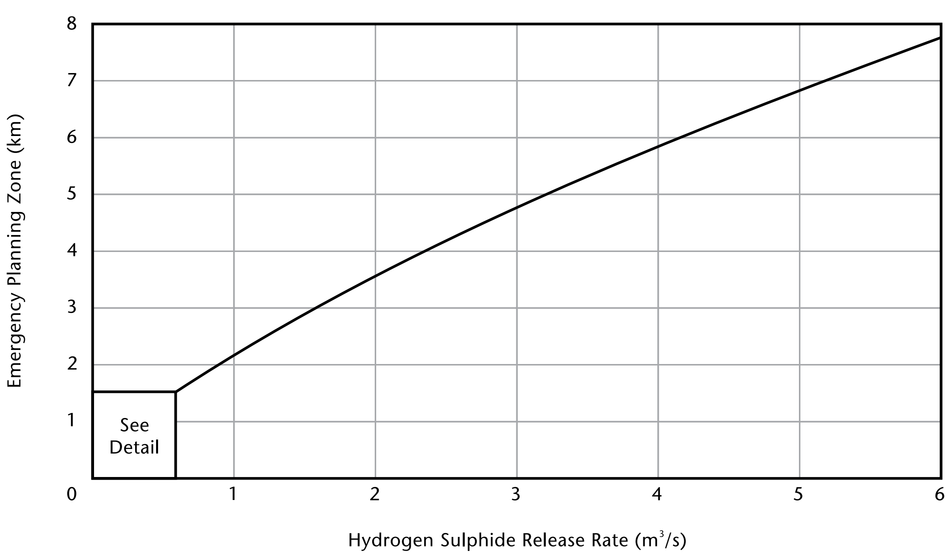


Figure A5-1 Emergency planning zone guidelines for sour wells for H_2S release rates between 0.6 m^3/s and 6 m^3/s *(OGC, 2003)*

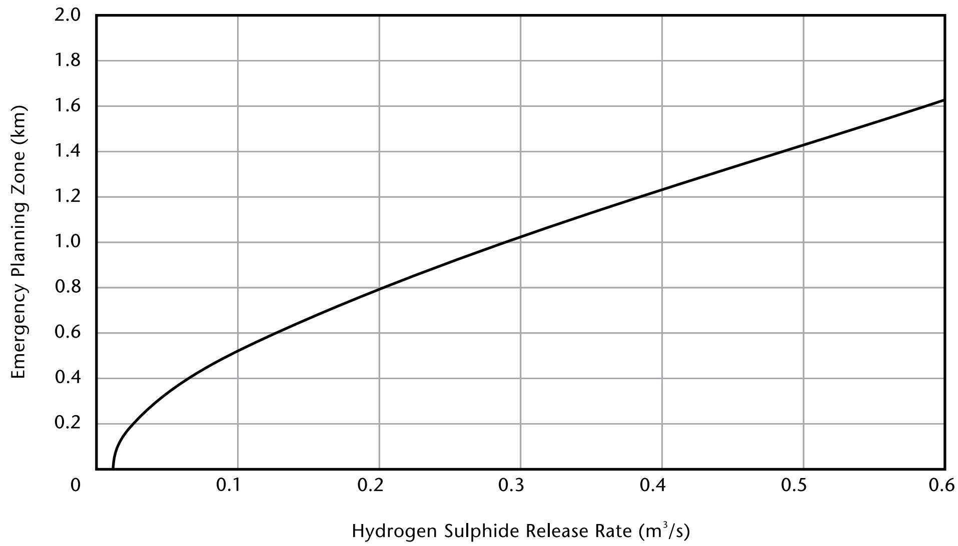


Figure A5-2 Emergency planning zone guidelines for sour wells for H_2S release rates between <0.1 m^3/s and 0.6 m^3/s *(OGC, 2003)*

A similar mathematical procedure is followed for sour gas plants, pipelines, and production facilities, using different equations (not shown). In this case, the maximum release volumes are considered, which would be the volume of gas released between emergency shutdown valves within the pipeline. The relationship between the EPZ and the maximum H_2S release volume for pipelines is shown in Figure A5-3.

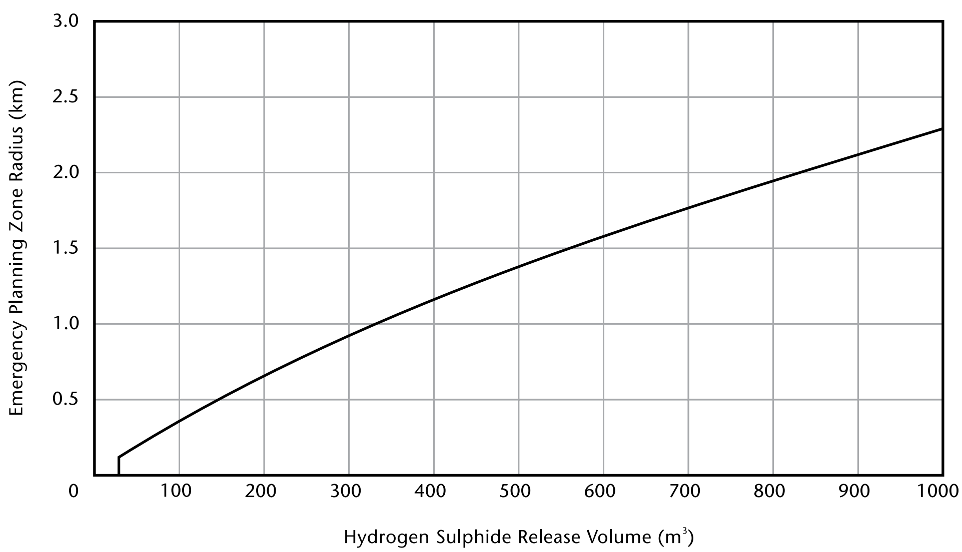


Figure A5-3 Emergency planning zone guidelines for sour gas plants, pipelines, and facilities with H_2S release volumes between <100 m^3 and 1000 m^3 *(OGC, 2003)*

Currently, research efforts are ongoing at the EUB to develop new requirements for computing EPZs for sour wells, sour pipelines and sour production facilities. The new requirements will eventually replace the simple equations and nomograms (EUB, 2004d). A new proposed modeling tool, EUBMODELS was developed in consultation with stakeholders and released in December 2003 for review. The work was undertaken as a result of recommendations put forth by the Provincial Advisory Committee on Public Safety and Sour Gas in *Findings and Recommendations Final Report* in 2000 (PSSG, 2000). This proposed modeling procedure is currently in draft form online as the following report *EUBMODELS for Calculating Emergency Planning Zones for Sour Wells and Sour Pipelines* (EUB, 2003). Using a hazard analysis approach, it was identified that the most significant hazard to consider was H_2S. As developed through stakeholder consultation meetings, the EUB emergency planning criteria for H_2S is "…the airborne exposure concentration of hydrogen sulphide and exposure time that provides a conservative margin of safety to protect people from serious irreversible health effects including fatalities" (p. 3, EUB, 2003).

One of the current issues of debate is the establishment of appropriate "endpoints" for EPZs. An endpoint, as defined by the EUB, is "…a combination of exposure concentration and exposure time that produces a specific human (or animal) health effect" (p. 1, EUB, 2004d). H_2S emergency planning criteria and endpoint ranges were derived by the EUB from a review of H_2S exposure and health effects literature, emergency response guidelines from other jurisdictions, and stakeholder input (EUB, 2004d). A stakeholder meeting was held in November 2004 to get feedback on and to discuss the proposed H_2S endpoint values (EUB, 2005e).

The EUBMODELS approach is viewed as a more realistic approach to calculate EPZs, as it incorporates a toxicological approach referred to as "toxic load", which describes the relation between exposure concentration and exposure time. The EUBMODELS approach uses dispersion modeling of the uncontrolled release to estimate distance to a specified toxic load limit, i.e., endpoint, and allows definition of an appropriate planning distance. Toxic load is a non-linear approach to estimate the response from exposure to H_2S and is computed using the following approach:

$$\textit{Toxic Load} = \textit{Concentration}^{n} \times \textit{Time} \qquad \text{Equation [4]}$$

As shown in Equation 4, n refers to the potency of the chemical of concern and is ongoing review as to an appropriate value for H_2S. Following the stakeholder meeting held in November 2004, responses were compiled and presented to the EUB to determine an appropriate endpoint for H_2S and/or to determine next steps in the process. These comments from the stakeholder meeting were released in a report in July 2005 (EUB, 2005e). The results will eventually be incorporated into the *EUBMODELS Technical Descriptions and Formulations* report and model, but it is not known when a final decision will be released by the EUB on H_2S endpoint values for adequate protection of public health and safety.