Health Assessment of Residents Residing Near Oil Batteries in the Tilston, Manitoba Area

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EXECUTIVE SUMMARY

Oil was first discovered in the Tilston area about 50 years ago. The largest battery is located at 8-8-6-29 WPM (8-8 battery); two smaller batteries are located at 9-31-5-29 and 16-6-6-28. Increased production occurred at the 8-8 battery in the mid 1990's. Subsequently, concerns began to surface among the nearby residents about adverse human and animal health effects due to potential exposures emanating from the oil battery. Increasing severity and frequency of symptoms, coupled with concerns regarding the battery, ultimately led to four families moving out of their homes in 1999 and 2000.

Due to uncertainties in the cause of the health symptoms, Manitoba Health commissioned an independent assessment of the situation.

The purposes of this assessment were to: a) determine whether environmental exposures that have occurred or emissions that are currently being released from the 8-8 battery have affected or may affect the health of the surrounding residents, b) identify if possible, the causes or contributing factors to these individuals' health complaints, and c) make recommendations for any further evaluations which may be necessary.

Data were collected from a questionnaire followed by in person assessment of community residents, a tour of the facility and air monitoring stations, a review of environmental monitoring data, and review of the appropriate medical literature.

The environmental monitoring program detected levels of Hydrogen Sulfide (H_2S) near or above the hourly ambient air quality guideline of 11 parts per billion (ppb) on an infrequent basis. Based on review of the work process, environmental monitoring, and the toxicology of the products, the most significant potential emission which could be released from the 8-8 battery is

H_2S. Other compounds would not be present in sufficient quantities or at frequent enough intervals to be regularly causing acute or chronic symptoms in exposed community residents.

All 54 individuals who lived within five miles of the 8-8 battery were reportedly contacted by the community group and asked to participate in the survey. Of these, 38 completed the questionnaire and 37 were interviewed and examined in person. Those that reported that odor brought on their symptoms fairly consistently reported symptoms which were consistent with exposure to H_2S. Some individuals reported symptoms in the absence of odor. Analysis of the pattern of these symptoms revealed that they were similar of the symptoms reported by people who were uncertain of the cause of their symptoms or attributed them to other causes.

CONCLUSIONS

1. The emission from the batteries in the Tilston area of greatest significance and greatest frequency, although still infrequent, is H_2S.
2. Emissions from the oil batteries have led to adverse health effects as determined by the symptoms reported in the surrounding community. The pattern of symptoms which have been associated with odor is consistent with that which would be expected following emission of H_2S from the batteries. These symptoms were temporary and would not be expected to be associated with permanent effects or long term sequelae. The pattern of symptoms reported by individuals who believe they are exposed to emissions from the batteries in the absence of odor is not consistent with that which would be expected following exposure to H_2S emissions from the batteries. Symptoms in these individuals may have been influenced by their concern about potential exposures to emissions from the batteries.

3. It is possible that some individuals will be able to smell H_2S at levels below the current provincial guideline for exposure to H_2S of 11 ppb on a one hour average. This level of exposure may be associated with symptoms in some individuals.
4. All the information available at the time of this assessment suggests that individuals who continue to reside near the batteries would not be at increased risk for long term health effects, provided that the battery equipment is maintained properly to ensure exposures are kept below the current provincial guideline. Intermittent low level exposures to H_2S at levels around the current guidelines should not lead to permanent health problems.

RECOMMENDATIONS

1. The improvements in the treatment process of the exhaust gas that have been instituted at the 8-8 battery and the other batteries in the area have led to a decrease in health complaints consistent with exposure. Intermittently, some of these improvements are reported not to work. An effective preventive maintenance program should be in place to make sure that these events occur as infrequently as possible.
2. The levels of emissions of H_2S recorded during the most recent phase of monitoring are intermittent and low. There is no need for further routine environmental air quality monitoring, as sufficient data has been collected to identify the extent of potential exposure.
3. An independent engineering assessment of the control measures used at the batteries be commissioned to ensure that the preventative maintenance program and technology at the batteries are appropriate to ensure that emissions are kept below the current provincial guideline.
4. The engineering assessment should review the feasibility of enclosing the flame at the batteries.

1.0 BACKGROUND

Oil was first produced in the Tilston area in the 1950's. The largest battery in the area is located at 8-8-6-29 WPM (8-8 battery); two smaller batteries are located at 9-31-5-29 and 16-6-6-28. Increased production occurred at the 8-8 battery in the mid 1990's. Subsequently, concerns began to surface among the nearby residents about adverse human and animal health effects due to potential exposures emanating from the oil battery. Evaluation of these complaints and environmental sampling has been performed by the Departments of Health and Conservation (previously Environment) of the Manitoba Government. Concurrently, Tundra Oil and Gas, the company owning the 8-8 battery, initiated a number of improvements to lower emissions. Because of symptoms and health concerns, a number of residents elected to move out of their homes. Figure 1, provided by Manitoba Conservation, shows the sites of the batteries and locations of equipment used to monitor for potential emissions.

To determine the cause of the health symptoms, Manitoba Health commissioned an independent assessment of the situation.

2.0 TERMS OF REFERENCE

The terms of reference of the assessment were to:

a) determine whether exposures that have occurred or emissions that are currently being released from the 8-8 battery have affected or may affect the health of the surrounding residents;

b) identify if possible, the causes or contributing factors to these individuals' health complaints; and

c) make recommendations for any further evaluations which may be necessary.

3.0 DATA COLLECTION INSTRUMENTS

The following information/data collection instruments were used to perform this evaluation:

1. Health history questionnaires (Appendix 1) supplemented by in person evaluation of 37 residents with a focused physical examination performed by Allen Kraut, MD, FRCPC. The interviews were conducted on May 17, 18, and 19, 2000.
2. Tour of the facility and air monitoring stations conducted on May 17, 2000.
3. Review of environmental monitoring data;
    i. Tilston air quality. Summary of air quality monitoring program in July 1998 to August 1999 written by Manitoba Environment, August 27, 1999.
    ii. Tilston air quality update #2 November 1999 to mid January 2000 written by Manitoba Conservation, June 18, 2000.
    iii. Tilston air quality update #3 January to February 2000 written by the Manitoba Conservation, March 8, 2000.
    iv. Tilston air quality update #4 March to April 15, 2000 written by Manitoba Conservation, April 18, 2000.
    v. Tilston air quality estimates of maximum concentrations of air contaminants in the past review of air quality written by Manitoba Conservation, March 7, 2000.
    vi. EnTec environmental report prepared for Tundra Oil and Gas on source emission testing on February 23 and 24, 1999 dated March 16, 1999.
4. Information notices published by Manitoba Environment and Conservation from March 9, 1999 until November 18, 1999.
5. Review of the appropriate medical literature.

4.0 REVIEW OF WORK PROCESS

The 8-8-6-29 WPM Battery was built in 1985 to produce crude oil. Initially, the battery only produced about 8 m^3 of oil per day. Subsequently, with introduction of horizontal drilling in the mid 1990's, production increased significantly, up to at times approximately 160 m^3 per day.

The oil in the area is reported to be sour and has a hydrogen sulfide (H_2S) concentration of 13.5%. The battery separates crude oil from sour natural gas and salt water. Field pumps pump oil from 16 wells into the battery. In the field, oil is mixed with an anti-corrosion agent consisting of an organic solvent material and benzenesulfonic acid. The anticorrosion agent deposits a thin film over the exposed metal surfaces in the pipes. At the battery, the oil is separated from salt water and gas. Much of the separation occurs by settling. Additional gas is removed from the oil by heat in the treater. Excess gases are burned in the treater. If the amount of gas produced exceeded that which is needed to fuel the treater it was, until 1997, released into the atmosphere. In 1997 a flare system was put in place, and in November 1999, an incinerator was installed to burn excess gas. When burned, H_2S is converted to sulfur dioxide (SO_2). The flare system is currently only used as a backup mechanism. After treatment, the oil is moved to storage tanks and then transferred to trucks. While the trucks are loading oil, air present in the container trucks is pumped out through a scrubber to minimize potential emissions from the facility. The two smaller batteries, 9-31 and 16-6, use similar processes but do not have incinerators or scrubbers.

5.0 POTENTIAL EMISSIONS FROM THE BATTERIES

Review of work process suggests potential exposures can occur to H_2S, SO_2, other sulfur degradation products, and oil combustion products, including various aliphatic and aromatic

hydrocarbons. The most likely exposures and the exposures of greatest concern in this setting would be to H_2S and SO_2.

6.0 ENVIRONMENT EXPOSURE OBJECTIVES

Manitoba Conservation objectives for environment exposure to H_2S and SO_2 are as follows:

H_2S - less than 11 ppb over one hour

SO_2 - less than 0.34 ppm over one hour and 0.11 ppm over 24 hours.

7.0 TOXICOLOGY OF COMPOUNDS OF CONCERN

7.1 Hydrogen Sulfide

Hydrogen sulfide (H_2S) is a potentially toxic colourless gas, with a rotten egg odor. It is produced naturally by decaying organic matter. It may be released from sewage, sulfur hot springs, volcanoes, and natural gas. It is a by-product of a number of industrial processes, including oil refining. Exposures to H_2S can occur in both the parts per million (ppm) and parts per billion (ppb) range depending on the setting. An exposure to 1 ppm is equivalent to an exposure to 1000 ppb. Environmental exposures are typically in the ppb range while occupational exposures can occur in the ppm range.

The odor of H_2S may be first identified by some individuals at levels as low as 0.5 ppb, while others may not detect the smell until levels of 130 ppb (1). At higher levels H_2S is an irritant and at higher levels still it becomes an asphyxiant. In the occupational literature 20 ppm (20,000 ppb) is thought to be the level of H_2S exposure which may lead to significant eye irritation. Based on this information, the American Conference of Governmental Industrial Hygienists has recommended a Threshold Limit Value (ACGIH TLV) of 10 ppm (10,000 ppb) (2) as an eight

hour time weighted average. The Province of Manitoba uses this value as the provincial occupational exposure limit. A study of 170 H_2S exposed workers, however, found eye symptoms to be less common (3). This study reported nervousness, cough, nausea, headache and insomnia to be common symptoms after exposure. At levels of exposure of around 100-150 ppm, (100,000 – 150,000 ppb) olfactory fatigue, the inability to continually smell the compound, develops and, at higher levels, severe pulmonary effects can occur.

In a study of 221 cases of H_2S exposure in Alberta (7), Burnett et al reported primarily neurologic symptoms in overexposed workers. Although the H_2S exposure proved fatal in some workers, there was no long-term neurologic sequelae in the survivors of the accidents. In this study the group of individuals with lower levels of exposure who went to see their physicians, instead of going to, or having to be taken to the emergency room, complained of headache, nausea, conjunctivitis, sore throat, cough, and shortness of breath (7). These workers did not report other neurologic symptoms.

Roth has summarized (1) the various effects of H_2S at various concentrations (Figure 2). This information is similar to other tables such as the one provided by Manitoba Conservation in their Tilston Air Quality Report dated August 27, 1999. Some of the original data used to describe the levels at which toxic effects occur in the occupational setting were collected in the remote past up to 75 years ago (4, 5). It is possible for a variety of reasons that people with community exposures would currently report symptoms at lower levels of exposure than occupationally exposed groups did in the past. Some of these reasons could include, the way the questions were asked, what people felt they had to accept, and concerns in the workplace regarding job security. In addition, occupational groups are typically composed of healthy young people who can tolerate working with the compound in question. This clearly is not the case in the

environmental setting where the whole population including more susceptible and sensitive individuals may be exposed.

Environmental exposures, such as those emanating from the 8-8 battery, typically are lower than occupational exposure due to the dilutional effect of distance and air volume. Environmental exposures to H_2S have been a subject of a number of publications. The health effects on birds of long term exposure to low concentrations of H_2S were studied in Rotorura, New Zealand. This study revealed a wide variety of birds tolerated long-term exposures to H_2S in the range of 0.005-3.9 ppm (5 – 3900 ppb) without apparent problems (6). A recent health study of former workers and residents exposed to H_2S from a desulfurization unit in an oil refinery revealed alterations in some neurobehavioural functions (8). Environmental levels of H_2S of 10 ppb baseline and up to 100 ppb were reported. Other contaminants were present in the air. The study also grouped neighborhood residents with ex-workers. Thus if the effects were caused by exposure, they may not have been solely due to environmental H_2S exposure.

The US Agency of Toxic Substances and Disease Registry has evaluated a number of environmental exposures to H_2S in the United States. Maximum hourly ppb measurements ranged from 1.7 to 46.9 at the environmental monitoring stations in an area in Hawaii (9). Exposures as high as 9 ppb were reported around a landfill site in Hartford, Connecticut (10). Although both of these reports commented that the levels of the exposure were below those that are reported to cause symptoms on a toxicological basis, both acknowledged that the unpleasant odors may make some people feel ill.

The effects of H_2S exposure from a wastewater treatment facility on a surrounding community has been reported (11). The level of odor annoyance reported was associated with the level of H_2S in the air. In addition, the neighborhood with the highest exposure to H_2S reported the

greatest number of complaints. Areas with environmental exposures of around 4 - 6 ppb reported a variety of interferences with their lives including temporally having to leave the neighbourhood. Although some of these individuals felt ill, few felt sick enough to see a physician.

No data could be identified on long term chronic human health effects of exposures to H_2S below the current provincial guidelines.

Human exposure to sulfur compounds, including H_2S, occur at sulfur hot springs throughout the world. Although no air measurements on the level of exposure at these locations could be found, the odor of sulfur compounds is present at these locations. Many individuals seek out these locations for their perceived medicinal benefits and do not report adverse effects from their exposures.

Shusterman summarized a number of studies on the effect of odor (12). He reports on a number of studies where individuals reported symptoms such as nausea, headache, eye and nose irritation, related to odor exposure. He commented on the fact that in addition to odor, frequency of environmental worry was found to predict the presence of symptoms.

In conclusion, older toxicology studies which assessed occupational exposures to H_2S do not suggest significant symptoms until levels of exposure to H_2S reach about 20 ppm (20,000 ppb). Some community environmental studies, however, show an increase in symptoms at levels of exposure below the current provincial guideline of 11 ppb (11). Although the mechanisms for this discrepancy are not clear, health complaints at lower environmental exposures have been reported in a number of locales. Common symptoms at low level exposures include headache, nausea, and eye and respiratory tract irritative symptoms. These symptoms are transient and should not be associated with long term adverse health effects.

7.2 Sulfur Dioxide

Sulfur dioxide is formed when materials containing sulfur such as H_2S are burned. Although it has an odor, the odor of SO_2 is less noticeable than H_2S. SO_2 is an important cause of air pollution. It causes mucous membrane irritation. Andersen and colleagues showed that exposures to SO_2 for 1-6 hours cause constriction in the upper airways in young healthy adults (13). Since the major health risk of SO_2 appears to be respiratory, susceptible individuals would include asthmatics and other people who have chronic respiratory problems. SO_2 exposure would be expected to cause cough, shortness of breath, and wheeze in susceptible people. Other irritative symptoms such as eye, nose, and throat irritation could also occur. The occupational exposure limit suggested by the ACGIH for SO_2 is 2 ppm on an eight hour average and 5 ppm as a 15 minute short term exposure limit (2).

7.3 Other Potential Exposures

Although there are a myriad of other potential emissions emanating from the batteries, the specific byproducts produced in the gassing procedure would be dependent on the efficiency of the flame and potentially on various other conditions. Based on review of the work process and the available environmental monitoring data (to be discussed) it is unlikely, with the exception of H_2S and SO_2, that concentrated exposures to other compounds would repeatedly occur from the 8-8 battery. Thus it is unlikely that other compounds would be the cause of the symptoms reported in the community.

8.0 REVIEW OF AVAILABLE ENVIRONMENTAL MONITORING DATA

8.1 *Tilston Air Quality: Summary of air quality monitoring program in July 1998 to August 1999. Manitoba Environment, August 27,1999.*

Environmental monitoring was performed in a number of locations east of the 8-8 battery. These locations were chosen based on concerns voiced from the neighbours of the battery and wind direction as they would be down wind from the plant. The first site chosen was in the W. Campbell farm located on 9-6-29, approximately 1.4 km east of the 8-8 battery. Monitoring for SO_2 occurred at this site from July 1998 through March 1999. This monitoring station was later moved to the J. Anderson farm approximately 1 km south at 4-6-29, approximately 2.1 km south east of the battery. A second monitoring station was established in May 1999 about 800 meters east of the battery at a well site (Figure 1). These testing sites were set up to measure SO_2, and in May 1999, H_2S, on a continuous basis. The level of detection of the equipment was 0.02 ppm for SO_2 and 0.05 ppb for H_2S (Personal Communication, Manitoba Conservation).

Data on SO_2 monitoring revealed 4 one-hour samples above the air quality objective of 0.34 ppm at the W. Campbell farm site between July 22, 1998 and March 31, 1999. The elevated readings were identified in August 1998. Three additional hourly recordings of 0.1 ppm, 0.15 ppm, and 0.25 ppm were also identified in August 1998. All of the remaining hourly readings at the Campbell farm site were below the detection limits of the equipment and reported as 0.0 ppm. During one week in January 1999, elevated levels of sulfur dioxide were recorded at the W. Campbell monitoring site. However, it was reported that there was uncertainty regarding the quality of this data due to technical difficulties with the air quality support systems, reported inconsistencies with an informal health survey, and inconsistency with emissions from the nearby oil battery. For these reasons, these results were felt not to be valid and were left out of the evaluation by Manitoba Environment. During interviews with the community residents,

some mentioned these elevated readings and felt they were in fact high. This finding suggests that these explanations were not accepted by all members of the community. Low levels of SO_2, in the 0.02-0.03 ppm range, were detected on a few occasions at the well site east of the battery between May and August 1999. None of the 24-hour samples were above the air quality guideline at the well site east of the battery. SO_2 was detected on one occasion at the J. Anderson farm site. A reading of 0.02 ppm was recorded in May 1999.

Sampling in the well site east of the battery revealed 10 one-hour readings of H_2S above the provincial guideline level of 11 ppb in August 1999 with a peak of 36.0 ppb. At the Anderson farm monitoring site the highest one-hour level was 21.4 ppb. Lower levels of H_2S were detected at the Anderson farm monitoring site on 83 occasions between June 8 and August 12, 1999. Comparison of the timing of recordings of H_2S at the well site and the Anderson farm revealed that on all but one occasion when H_2S was identified at the Anderson farm, a higher reading was recorded at the well site.

Fourteen tests for over 80 volatile organic compounds (VOC) were performed between February and August 1999 in locations around the battery. These results were compared to the VOC measurements in Winnipeg from 1990 through 1996. The measurements in the Tilston area were usually lower than those measured in Winnipeg. Specific measurements for benzene, toluene, ethyl benzene, and xylene revealed lower levels in the Tilston area than in Winnipeg.

Two wind roses were produced to provide details on the prevailing winds. One recorded at the W. Campbell farm monitoring site provided data from July 22, 1998 through March 31, 1999. The results revealed that 26.5% of the time the wind was from the west through north. From April 18, 1999 through August 25, 1999 the wind rose produced at the 8-8 battery revealed that on 34.4% of the time the wind blew from the west through north.

8.2 *Tilston air quality update #2 November 1999 to mid January 2000 Manitoba Conservation January 18, 2000.*

This report details additional monitoring for SO_2 and H_2S at the well site and the Anderson farm site. Low levels in the 0.02 - 0.04 ppm range of SO_2 were recorded on a few occasions at the well site. No SO_2 was recorded at the Anderson farm monitoring station. With respect to H_2S, one reading above 11 ppb was recorded at the well site. At the well site low levels of H_2S were detected approximately 80 times out of the over 1600 hourly monitoring results. Although most of these results were below 2 ppb, a number were above 5 ppb. At the Anderson farm site two recordings above 11 ppb were identified. Twelve additional hourly readings were recorded in the 0.5 to 1.5 ppb range.

8.3 *Tilston air quality update #3 January to February 2000 Manitoba Conservation, March 8, 2000.*

Similar results as those reported in update #2 were provided in this update. Low levels of SO_2 in the 0.02 - 0.06 ppm range were identified on a few occasions. During this time period the highest recording of H_2S was 23.2 ppb recorded at the Anderson farm site. The highest level at the well site, which is considerably closer to the battery, was 9.1 ppb. The wind rose from April 16, 1999 to February 29, 2000 revealed that the winds came from the west 12% and from the remaining directions to north an additional 31% of the time.

8.4 *Tilston air quality update #4 March to April 15, 2000 Manitoba Conservation, April 18, 2000.*

In this update data for an additional 6-week period was presented. During this time period, levels of SO_2 of 0.02 - 0.03 ppm were measured on 10 occasions at the well site. SO_2 was not detected at the Anderson farm monitoring site. H_2S was not detected at the Anderson farm monitoring site and the highest H_2S reading at the well site was 2.1 ppb. Analysis of a variety of VOC's revealed levels similar to the air in Winnipeg.

In this report the results of the wind rose for the year of April 16, 1999 - April 15, 2000 were provided. Winds were from the north through west 43% of the time and north west through west 31% of the time.

8.5 *Tilston air quality: Estimates of maximum concentrations of air contaminants in the past Manitoba Conservation, March 7, 2000.*

An estimate of maximum concentration of air contaminants in the past was prepared for the Tilston Advisory Group by Manitoba Conservation. Estimating past environmental exposures for pollutants using modeling is, as quoted in the report, "difficult and highly uncertain as much of the information is not known unless estimated." This modeling did suggest that H_2S and SO_2 concentrations may have exceeded their respective air quality guidelines and objectives in the past. No firm conclusions could be drawn from this analysis.

8.6 *EnTec environmental report prepared for Tundra Oil and Gas on source emission testing on February 23 and 24, 1999 dated March 16, 1999.*

On February 23 and 24, 1999, EnTec Environmental performed source emission testing for Tundra Oil and Gas. In a report dated March 16, 1999, emissions from the tier stack were found to contain nondetectable levels of sulfur compounds and BTEX compounds (benzene, toluene, ethylbenzene, xylene), and low levels of total hydrocarbons. Analysis of the flare revealed some hydrocarbons, mostly methane, ethane and propane, and that small amounts of total reduced sulfur compounds were not being combusted. Modeling of the SO_2 potentially released from the stack revealed average hourly estimated ground level SO_2 concentrations of 0.125 ppm at 100 meters. At the nearest residence, the average hourly estimated ground level SO_2 concentration was predicted to be 0.044 ppm.

Although the source emission data suggested no emissions of H_2S, subsequent environmental monitoring did identify H_2S on occasion, suggesting that the emission data may not reflect exposure conditions at all times.

8.7 Assessment of Monitoring Data

Overall, the monitoring program revealed that H_2S was detected in an infrequent basis at or above the air quality guideline at the two monitoring sites during the 14 months of monitoring. H_2S was recorded more frequently, although still relatively rarely, at the 1 – 10 ppb range. For SO_2, low levels were detected on a number of occasions and the air quality guideline exceeded only on occasion. The observed trend was to decreasing levels of environmental exposure over time consistent with the introduction of new equipment at the battery. The levels of organic compounds detected in the air around the batteries were not elevated compared to those in Winnipeg.

9.0 IDENTIFICATION OF THE MOST LIKELY COMPOUNDS TO WHICH EXPOSURES COULD OCCUR RELATED TO EMISSIONS FROM THE OIL BATTERIES IN THE TILSTON AREA

Based on review of the work process, environmental monitoring, and the toxicology of the products, the most significant potential exposure which could be related to emissions from the 8-8 battery is to H_2S. H_2S exposure, at the levels which have been intermittently identified by the environmental monitoring in the Tilston area, has been associated with symptoms in other communities (11). SO_2 emissions are less likely to be the source of the problem because symptoms predated the institutions of the flares which led to the production of this compound. In addition, SO_2 was only rarely detected during environmental monitoring. Other compounds would not be present for sufficient time periods at high enough levels to be regularly causing acute symptoms in exposed community residents.

10.0 HEALTH EVALUATION

10.1 Background

Health complaints believed to be due to emissions from the 8-8 battery began to surface in the residents residing around the battery in the mid 1990's. This occurred coincident with the increase in production at the battery. In 1998 the author of this report examined one individual who resided close to the 8-8 facility. This individual reported a variety of symptoms that she/he felt were related to exposures to compounds emanating from the battery. Increasing severity and frequency of symptoms, coupled with concerns regarding the battery, ultimately led to four families moving out of their homes in 1999 and 2000. Subsequent to relocating, these individuals reported improvement in their health.

10.2 Methodology

10.2.1 Questionnaire and Examination

To document the level of symptoms in the community and to determine if these symptoms were consistent with the effects of the emissions from the battery, a health survey was conducted. The investigator was assisted by two individuals from the community advisory group which had been formed to help address community concerns regarding potential emissions from the batteries. Individuals who lived within 5 miles of the 8-8 battery were contacted by these two individuals and asked to participate in the study. The survey was performed on adults (age > 16). Children were not examined as the consultant did not have expertise in evaluating the pediatric age group. In total, 54 individuals were identified. This number included individuals who lived around the 9-31 and 6-16 batteries and the individuals who had relocated due to concerns regarding the 8-8 battery.

The assessments occurred on May 17, 18 and 19, 2000 at the health complex in Reston, MB. Each individual was asked to complete a questionnaire (Appendix 1) which asked demographic and health data. Specific questions were asked regarding a variety of health symptoms. In addition to being asked for the presence of the symptom, participants were asked what they felt caused their symptom and how often it occurred. The questionnaire was reviewed by the investigator to ensure that it was completed properly. During this time the answers were clarified and additional information obtained. A focused physical examination was also performed. In two cases, additional medical documentation was requested.

10.2.2 Analysis

Analysis of questionnaires typically involves grouping individuals into exposure categories and then determining whether a group of symptoms is more common in one group than another. The first task in the analysis of the questionnaire results was to identify what symptoms could be consistent with exposure to the emissions from the batteries. The major emission of concern as identified by the work process, literature review, and environmental monitoring was H_2S. To address the issue of whether health symptoms were currently or had been related to exposure to H_2S released from the battery, a list of symptoms which may be associated with low level H_2S exposure was created. The symptoms chosen were similar to those reported by workers exposed to H_2S who sought care at their physician's office (7). These symptoms included headache, nausea, eye, nose and throat symptoms, chest tightness, shortness of breath, cough, and chest heaviness. This group of symptoms typically occurs at higher levels of exposure to H_2S than that which has been recorded during the recent environmental monitoring at Tilston. However, many individuals reporting a very strong smell of H_2S predominantly prior to the institution of environmental controls and thus may have had higher levels of exposure in the past. These

situations occurred both near the smaller batteries prior to institution of the flare systems and during occupational exposures at the 8-8 battery. For this reason it was thought appropriate to include a symptom complex suggestive of a higher level of exposure than recorded during the recent monitoring.

The frequency of other symptoms was also recorded. These included difficulty concentrating, fatigue, nose bleeds, chest pain, vomiting diarrhea, constipation, urine symptoms, menstrual problems, rashes, joint pains, joint swelling, musculoskeletal complaints and depression. Some individuals also reported other symptoms and these were tabulated under the category "other". To identify groups of similar types of potential exposure, individuals were grouped on where they lived and whether they worked close to the 8-8 battery, as well as whether they had moved due to concerns regarding the battery.

10.2.2.1 Symptom-Based Analysis

The purpose of the symptom based analysis was to determine whether the symptoms reported in the community were consistent with those which would be expected to occur following exposures to the potential emissions from the batteries. Since the symptoms listed in the questionnaire may be due to a variety of causes, the responses were divided into three groups based on what the respondent felt was their cause. The three groupings were symptoms which the respondents related to odor; those which the individuals felt were related to exposure, but which they could not relate to odor; and finally those symptoms whose cause was unknown or related to other factors. Odor related symptoms were reported primarily before the improvements in technology were made, which included the institution of the flare systems and incinerator. As such, these symptoms could date back years in some individuals. No data exists on the environmental levels of H_2S associated with these symptoms.

A number of individuals reported symptoms due to exposure even though they did not have an odor stimulus. When asked how they knew their symptoms were related to exposure, responses included, “the wind was blowing from the north west when I didn’t feel well” or "I feel well when I am away form this area and sick when I am here, therefore it must be an exposure from the battery that is making me sick". Some of the individuals who reported these types of symptoms felt that after the improvements at the battery were made, their symptom complex changed. Since there was no clear stimulus to these symptoms and the individual felt they could “sense the exposure”, these symptoms will be referred to as “belief of exposure” symptoms.

A third group of symptoms consisted of those symptoms which the individual felt were due to other causes or whose cause was unknown.

When asked the cause of their symptoms, individuals could easily place it into one of the three categories. Some individuals reported the same symptom first related to odor and then later as a "belief of exposure” symptom. In these cases the symptom was attributed to "belief of exposure”. Individuals could report symptoms due to various causations. One individual could report headache related to odor, and joint pains due to other causes.

All of the symptoms reported by the respondents were then grouped based on reported causation: odor, belief of exposure, and other or unknown. The total number of symptoms in each category was calculated by adding together the number of all of the individual symptoms. The frequency of all of the symptoms consistent with exposure to H_2S for each category of reported causation was also determined. Finally, the percentage of the symptoms consistent with exposure to H_2S was determined for each category of causation. These percentages were then compared between the three types of reported causation: odor, belief of exposure, and other or unknown, using the

Chi square test. The other or unknown category was used as the comparison group for the other two types of reported causation. A p value of 0.05 was set as the level of statistical significance.

10.2.2.2 Person-Based Analysis

Three groups were created based on where individuals lived and worked and whether they had moved due to concerns regarding the battery. Group A consisted of those individuals who had moved. In general, these individuals resided closest to the 8-8 battery. A second group consisted of those that lived close to the 9-31 and 6-6 batteries or had worked near the 8-8 battery (Group B). The remaining individuals were part of the third group (Group C). These individuals tended to live further away from the batteries. The average number of reported symptoms in each group was compared by using a t-test.

Rate ratios of individual symptoms were calculated using Group C as the reference group to compare the relative frequency of the symptoms. Rate ratios above 1.0 suggest an increase in symptoms compared to the comparison group. Ratios of 1.0 suggest a similar number of symptoms. A rate ratio below 1.0 suggests a lower level of symptoms. For example a rate ratio of 2.0 suggests that the symptom is twice as common than in the comparison group. A rate ratio of 0.5 suggests that it is half as common. Statistical analysis of the rate ratios was not performed due to the relatively small numbers in each group, the high frequency of many of these symptoms in society in general, and the multiple potential comparisons. These factors together would make it very difficult to identify statistically significant results using standard criteria. The averages of the rate ratios for the symptoms consistent with exposure to H_2S and the other symptoms were compared.

10.3 Results

Of the 54 individuals contacted, 38 completed the questionnaire and 37 were interviewed and examined in person. Of the 38 individuals who completed the questionnaire, 19 were male and 19 female. The age range was from 16.6 to 80.4 years, with an average age of 48.1 +/- 16.0.

10.3.1 Symptom-Based Results

Table 1 details the frequency of the reported symptoms by self-reported causative factor. Those symptoms which are consistent with exposure to H_2S were added together. Thirty-seven of the 44 symptoms reported as being caused by exposure to odor in the Tilston area (84.1%) were consistent with the symptoms expected after exposure to H_2S. This contrasts with 44.2% of the 154 symptoms thought be of other or unknown causation ($p = 0.00005$). This difference is statistically significant and suggests that the group of symptoms that are being attributed to odor exposures are consistent with H_2S exposure. These symptoms were temporary and would not be expected to be associated with permanent effects or long term sequelae.

When a similar analysis was done for the "belief of exposure" symptoms i.e. those symptoms that the respondents felt were related to exposure, but for which they were not aware of odor, only 39 of the 79 symptoms (49.4%) were consistent with the likely effects of H_2S exposure. This was not different from the types of symptoms in the comparison group ($p= 0.5$). This suggests that the base line frequency of symptoms suggestive of H_2S exposure is quite common and that there is no difference between the frequency of symptoms consistent with exposure to H_2S amongst the symptoms attributed to "belief of exposure" and to unknown or other causes.

10.3.2 Person-Based Results

The average number of symptoms per subject in Group A, Group B, and Group C were 10.4, 7.0 and 5.7 respectively. Persons in Group A reported almost twice as many symptoms as those in Group C. This difference bordered on statistical significance. Those in Group B, individuals

that reported symptoms related to exposure but had not moved, had a slightly higher number of symptoms than those in Group C (p= non significant).

When compared to Group C, Group B appeared to have more symptoms consistent with exposure to H_2S and less of the other symptoms (Table 2). The average rate ratio was 2.15 for symptoms suggestive of H_2S exposure and 0.80 for other symptoms. These numbers suggest that individuals in Group B reported symptoms suggestive of exposure to H_2S about twice as frequently as those in Group C. As well, they reported symptoms not suggestive of H_2S exposure about as frequently as those in Group C.

Although Group A had more symptoms than Group C, elevated rate ratios for both those symptoms consistent with exposure to H_2S and the other symptoms were found. The average of the rate ratios was 2.44 for symptoms suggestive of H_2S exposure and 2.16 for the other symptoms. This suggests that the people in Group A reported approximately twice as many symptoms in both the group of symptoms suggestive of exposure to H_2S and the other group. Elevation of both types of symptoms suggests that the complaints are not specific for the exposures in question. This makes it less likely that environmental exposures are the cause of the entire symptom complex, since there appears to be about an equal elevation of both groups of symptoms.

10.3.3 Medical Examination Results.

Focused physical examinations were performed on the individuals who presented for evaluation. The physical findings suggestive of exposure to H_2S are nonspecific. No physical findings suggestive of current exposure or the past effects of potential exposure were documented. The absence of current physical findings does not rule out problems in the past.

For two individuals, additional medical information was requested from either their attending physician or a hospital. This additional information did not assist in assessing environmental causation of symptoms.

10.4 Discussion Of Results

This analysis supports the position that exposure to odor is associated with health symptoms in the Tilston area. There is some debate in the medical community on the cause of symptoms associated with odor. Some argue that it is due to annoyance from the odor itself, while others feel it is due to a toxicologic mechanism. Regardless of the mechanism, it would be important to control the source of the odor to minimize the symptoms associated with it. For this reason, efforts to decrease emissions to H_2S to a level where they cannot be smelled, have led to a decrease in the level of health complaints associated with H_2S exposure in this community. This analysis does not support the position that the entire symptom complexes that are attributed to exposure which individuals cannot smell are related to emissions coming form the batteries. It however, does not rule out the possibility that these individuals may have had symptoms in the past that were due to exposures to emissions from the batteries.

During the interviews individuals spoke of a variety of symptoms which were attributed to exposure without an odor stimulus. These varied in onset and pattern from person to person. For example, one individual felt their exposure to emissions from the battery would cause a symptom complex the following day, while another reported a different immediate symptom complex. A further individual attributed daily symptoms to battery exposures, even though the prevailing winds would not blow potential emissions towards this person's home daily. Collectively these descriptions are not consistent with an environmental cause related to

emissions from the batteries. This analysis, however, does not rule out the possibility that some of the symptoms reported which are consistent with exposure are in fact due to emissions from the oil batteries.

Many of the individuals who believed they had exposures in the absence of odor, were those that moved out of the community. These individuals reported many symptoms that are quite common in our society. Their decrease in health complaints after leaving the community may be related to a combination of decreased awareness or concern about their symptoms and a decreased level of psychosocial stress due to leaving an environment that they perceive to be toxic. A further possibility, although remote, is that there may be indoor air pollution sources in their homes which could be contributing to the problem.

The issue of potential health effects related to emissions from the oil batteries in the Tilston area has been present for a number of years. It is likely that prior to the institution of control measures at the 8-8 battery, emissions from the battery were associated with some symptoms in the surrounding residents. The interviews of the residents residing near the smaller batteries in the area were useful as they gave an indication of what conditions may have been like around the 8-8 battery a number of years ago. Some of the symptoms which individuals attribute to the emissions are likely related to them, while others are not. Addressing the issue of exposure, however, does not require that 100% of the symptoms attributed to exposure be in fact related to the emissions. As such, it is important to ensure emissions from the batteries are controlled. Controlling emissions to the current guideline levels will be sufficient to prevent symptoms in most individuals. However, as some individuals may still smell H_2S at this level, it is possible that some people will still have symptoms. Since some of the symptoms attributed to emissions

are not related to them, attempts to control emissions to eliminate these symptoms will not be useful.

10.5 Additional Comments From The Interviews

A common theme in discussion with residents who lived around the 8-8 battery was that although recent efforts had led to a lowering of exposure levels in the community, there was a concern that the new technology may not work well or be applied properly. Temporary failures in the equipment were pointed out to support this position. Malfunctions in the equipment were felt to lead to intermittent, but ongoing, exposure. Addressing the engineering aspects of these concerns is beyond the scope of this health assessment. It is recommended that an independent engineering assessment be arranged to address these issues.

Individuals viewed the flaring of the gas at the 8-8 battery as a failure of the incinerator. Individuals were able to see the flaring from the highway. The flaring of gas in this situation is viewed in the community as potentially exposing them to toxic compounds. To address this concern, it is recommended that the engineering evaluation assess the feasibility for venting the exhaust from the flare and the treater through the scrubber which is on the premises.

Another concern raised was whether it was safe to continue living in the community. All the information available at the time of this assessment suggests that individuals who continue to reside near the batteries would not be at increased risk for long term health effects, provided that the battery equipment is maintained properly to ensure that emissions are below the current provincial guidelines. Intermittent low level exposures to H_2S at levels around the current guidelines should not lead to permanent health problems.

11.0 **CONCLUSIONS**

1. The emission from the batteries in the Tilston area of greatest significance and greatest frequency, although still infrequent, is H_2S.
2. Emissions from the oil batteries have led to adverse health effects as determined by the symptoms reported in the surrounding community. The pattern of symptoms which have been associated with odor is consistent with that which would be expected following emission of H_2S from the batteries. These symptoms were temporary and would not be expected to be associated with permanent effects or long term sequelae. The pattern of symptoms reported by individuals who believe they are exposed to emissions from the batteries in the absence of odor is not consistent with that which would be expected following exposure to H_2S emissions from the batteries. Symptoms in these individuals may have been influenced by their concern about potential exposures to emissions from the batteries.
3. It is possible that some individuals will be able to smell H_2S at levels below the current provincial guideline for exposure to H_2S of 11 ppb on a one hour average. This level of exposure may be associated with symptoms in some individuals.
4. All the information available at the time of this assessment suggests that individuals who continue to reside near the batteries would not be at increased risk for long term health effects, provided that the battery equipment is maintained properly to ensure exposures are kept below the current provincial guideline. Intermittent low level exposures to H_2S at levels around the current guidelines should not lead to permanent health problems.

12.0 RECOMMENDATIONS

1. The improvements in the treatment process of the exhaust gas that have been instituted at the 8-8 battery and the other batteries in the area have led to a decrease in health complaints consistent with exposure. Intermittently, some of these improvements are reported not to work. An effective preventive maintenance program should be in place to make sure that these events occur as infrequently as possible.
2. The levels of emissions of H_2S recorded during the most recent phase of monitoring are intermittent and low. There is no need for further routine environmental air quality monitoring, as sufficient data has been collected to identify the extent of potential exposure.
3. An independent engineering assessment of the control measures used at the batteries be commissioned to ensure that the preventative maintenance program and technology at the batteries are appropriate to ensure emissions are kept below the current provincial guidelines.
4. The engineering assessment should review the feasibility of enclosing the flame at the batteries.

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TABLE 1

Frequency of Symptoms by Reported Cause

	Number of Symptoms			% of Total Number of Symptoms Attributed to the Cause		
Symptom	**Odor**	**Belief of exposure**	**Other or Unknown**	**Odor**	**Belief of exposure**	**Other or Unknown**
Headache*	9	8	11	20.4	10.1	7.1
Difficulty concentration	3	6	10	6.8	7.6	6.5
Fatigue	4	7	13	9.1	8.9	8.4
Eye*	6	4	12	13.6	5.1	7.8
Nose*	6	6	11	13.6	7.6	7.1
Nosebleed	0	1	4	0.0	1.2	2.6
Throat*	4	5	7	9.1	6.3	4.5
Chest tightness*	4	3	4	9.1	3.8	2.6
Cough*	1	2	9	2.3	2.5	5.8
Short of breath*	2	3	9	4.6	3.8	5.8
Chest pain	0	2	4	0.0	2.5	2.6
Chest heaviness*	3	4	2	6.8	5.1	1.3
Nausea*	2	4	3	4.6	5.1	1.9
Vomiting	0	1	1	0.0	1.2	0.6
Diarrhea	0	2	7	0.0	2.5	4.5
Constipation	0	0	3	0.0	0.0	1.9
Urine symptoms	0	1	3	0.0	1.2	1.9
Menstrual problems	0	0	6	0.0	0.0	3.9
Rash	0	4	7	0.0	5.1	4.5
Joint pain	0	4	8	0.0	5.1	5.2
Joint swelling	0	0	3	0.0	0.0	1.9
Musculoskeletal	0	3	10	0.0	3.8	6.5
Depression	0	1	4	0.0	1.2	3.2
Other	0	8	3	0.0	10.1	2.6
Total	44	79	154	100	100	100
Symptoms consistent with H_2S exposure	37	39	68	84.1	49.4	44.2

* Symptoms consistent with lower level H_2S exposure

TABLE 2

Frequency of Symptoms by Exposure Group+

	Group A	Group B	Group C	Rate Ratio GroupA/GroupC	Rate Ratio GroupB/GroupC
Number	9	14	15		
Symptoms suggestive of environmental exposure to H_2S					
headache	8	11	9	1.48	1.31
eye	6	9	7	1.43	1.38
nose	5	10	8	1.04	1.34
throat	5	9	2	4.17	4.82
chest tightness	3	5	3	1.67	1.79
cough	4	3	5	1.33	0.64
shortness of breath	4	6	4	1.67	1.61
chest heaviness	3	5	1	5.00	5.36
nausea	5	2	2	4.17	1.07
Average Ratio Rate				**2.44**	**2.15**
Other symptoms					
nose bleed	1	2	2	0.83	1.07
chest pain	2	1	3	1.11	0.36
difficulty concentration	5	7	7	1.19	1.07
fatigue	7	10	7	1.67	1.53
vomiting	1	0	1	1.67	0.00
diarrhea	4	3	2	3.33	1.61
constipation	1	1	1	1.67	1.07
urine symptoms	2	1	1	3.33	1.07
menstrual problems	2	1	3	1.11	0.36
rash	3	5	3	1.67	1.79
joint pain	4	4	4	1.67	1.07
joint swelling*	3	0	0	5.00	0.00
musculoskeletal symptoms	6	2	5	2.00	0.43
depression	2	1	2	1.67	0.54
other symptoms	8	0	3	4.44	0.00
Average Rate Ratio				**2.16**	**0.80**
Total number of symptoms	94	98	85		
Average number of symptoms	10.44	7.00	5.67		

+ Group A – Individuals who moved due to concerns about exposure.
Group B – Individuals who reported symptoms related to exposure but who did not move.
Group C – Other individuals.

*As no individuals in Group C reported joint swelling, for the purposes of calculating the rate ratio it was assumed that one person in Group C had joint swelling.

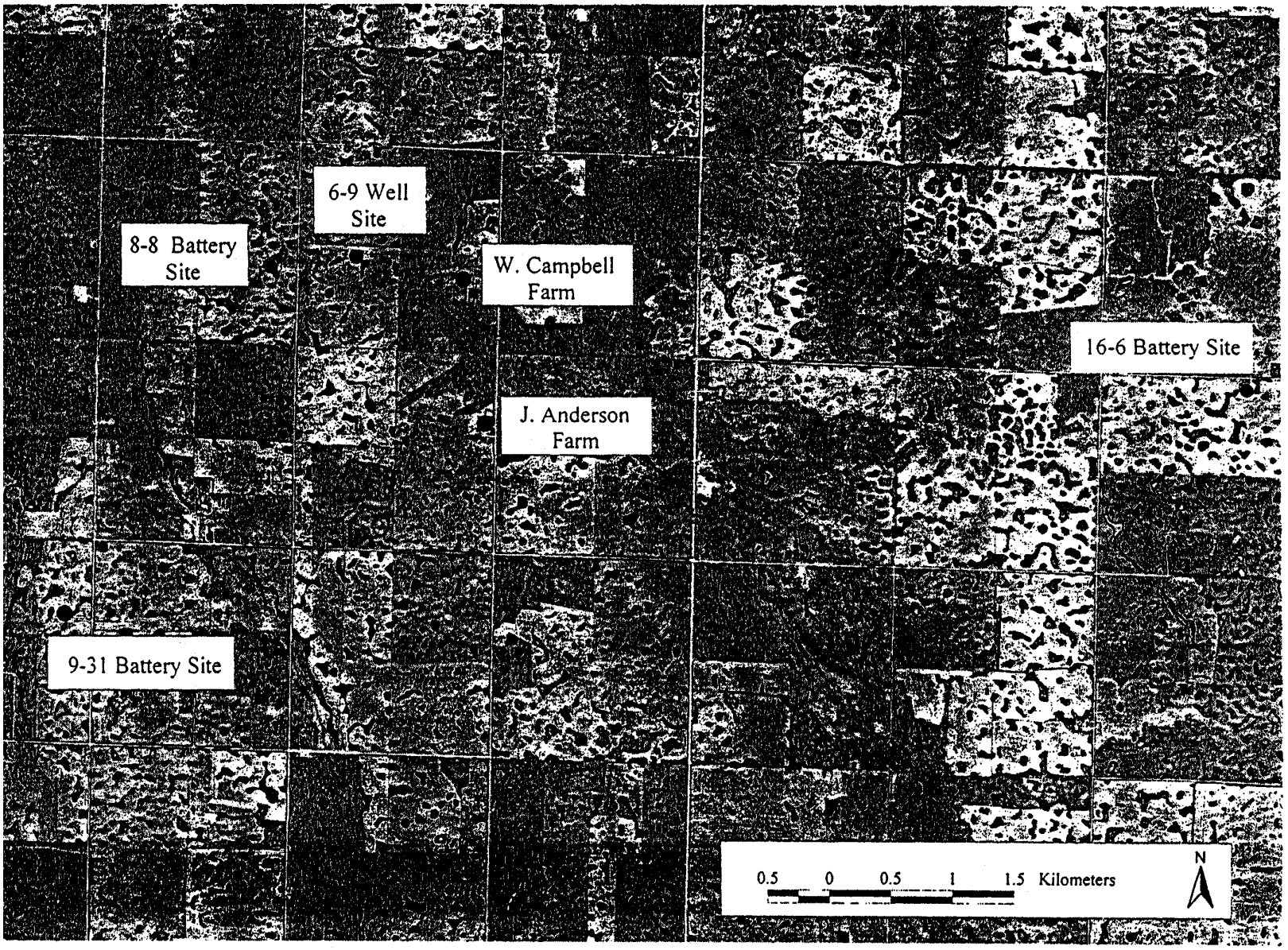
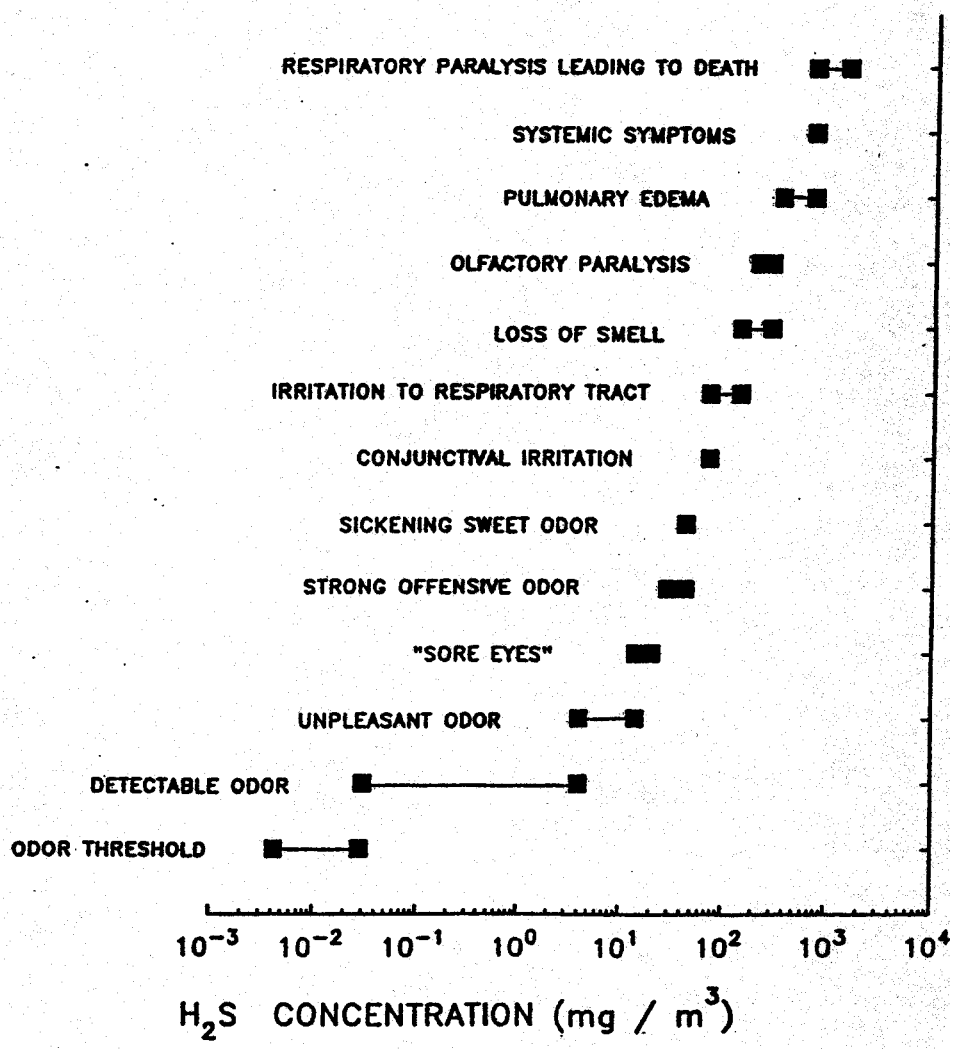


Figure 1. Air quality monitoring sites in vicinity of 8-8-6-29 WPM and other oil batteries in the Tilston area.

Figure 2 Physiologic responses of humans to hydrogen sulfide[1]



Appendix 1

Name: _____ Date of Birth: _____

Address: _____ MHSC # _____

_____ PHIN # _____

_____ SEX: ☐ Male ☐ Female

_____ Phone # _____

How long have you lived in your current house? Number of Years: _____

Have you moved in the last 3 years?

☐ Yes ☐ No

If yes, why? _____

_____

_____

How old is your home? Number of Years. _____

How is your home heated? _____

Do you have any mould in your home?

☐ Yes ☐ No

Do you have pets in your home?

☐ Yes ☐ No

If yes:

☐ Cats

☐ Dogs

☐ Rabbits

☐ Bird(s) Type: _____

☐ Fish

☐ Other _____

1. Please complete the following chart regarding symptoms:

Symptom	**I have this symptom.**	**How often does it occur?**	**What brings this symptom on?**	**Comments**
(i) Headache				
(ii) Fatigue				
(iii) Difficulty concentrating				
(iv) Eye irritation				
(v) Nasal stuffiness				
(vi) Nose bleeds				
(vii) Throat irritation				
(viii) Chest tightness				
(ix) Cough				
(x) Shortness of breath				
(xi) Chest pain				
(xii) Chest heaviness				
(xiii) Nausea				
(xiv) Vomiting				
(xv) Diarrhea				
(xvi) Constipation				
(xvii) Burning or painful urination				
If female: (xviii) Problems with periods				
(xix) Rash				
(xx) Joint pain				
(xxi) Joint swelling				
(xxii) Muscle aches				
(xxiii) Depression				
(xxiv) Other (1)				
(xxv) Other (2)				
(xxvi) Other (3)				

2. Please check any major illnesses you have had in the past or still have:

☐ (a) Heart attack
☐ (b) High blood pressure
☐ (c) Diabetes
☐ (d) Stroke
☐ (e) Heart Failure
☐ (f) Asthma
☐ (g) Bronchitis/Emphysema
☐ (h) Ulcers
☐ (i) Depression
☐ (j) Cancer
☐ (k) Other Please list _____
_____

3. Please list all medications you are currently taking:

(a) _____ (f) _____
(b) _____ (g) _____
(c) _____ (h) _____
(d) _____ (h) _____
(e) _____ (i) _____

4. Do you have any allergies?

☐ Yes ☐ No

5. If yes, what are your allergies? _____

_____

_____

6. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette a day for 1 year.)

☐ Yes ☐ No (*If No, Skip To Question 11)*

7. If yes, do you now smoke cigarettes (as of 1 month ago)?

☐ Yes ☐ No

8. How old were you when you first started regular cigarette smoking?

Age in years _____

9. How many years ago did you stop smoking cigarettes completely?

Number of years _____ ☐ I still smoke cigarettes

10. On the average of the entire time you smoked, how many cigarettes did you smoke per day?

Cigarettes per day - _____

11. Have you ever smoked a pipe regularly? (Yes means more than 12 oz. Of tobacco in a lifetime.)

☐ Yes ☐ No

12. If yes, do you still smoke a pipe?

☐ Yes ☐ No

13. Have you ever smoked cigars regularly? (Yes means more than 1 cigar a week for a year)

☐ Yes ☐ No

14. If yes, do you still smoke cigars?

☐ Yes ☐ No

15. How much alcohol do you drink on average per week?

(a) Bottles of Beer_____ (b) Glasses of wine_____ (c) Shots hard liquor_____

16. Comments:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Thank you.