2023

Sarnia Area Environmental Health Project

Environmental Stressors Community Report

Ontario

This report has been prepared by the staff of the Environmental Sciences and Standards Division of the Ontario Ministry of the Environment, Conservation and Parks.

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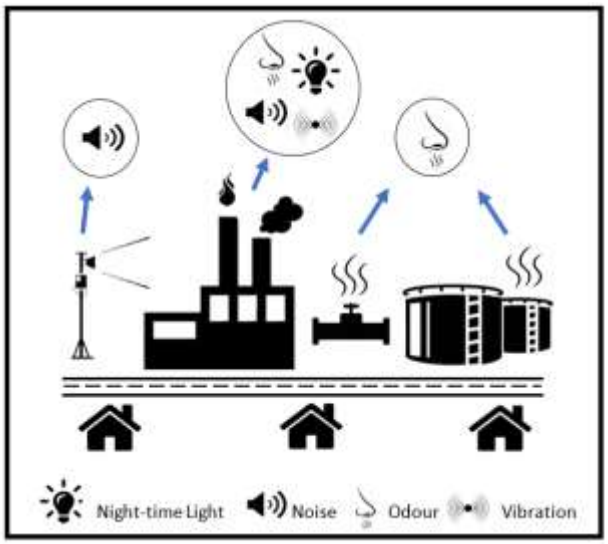
Environmental Stressors Review

In 2020 the Ministry of the Environment, Conservation and Parks (ministry, MECP) and its partners launched the Sarnia Area Environmental Health Project (SAEHP) to address concerns raised by local communities about air pollution and quality of life impacts from living close to industrial operations. During the planning for the project, community members recommended that the ministry look at more than just risk from air pollution and consider noise, vibration, light and other disturbances that impact quality of life and mental health. These kinds of disturbances, which can be seen, smelled, heard and felt, are collectively termed “environmental stressors”.

Community members also expressed concern with the lack of information sharing during industrial emergencies and incidents. For example, when something is happening at one of the big industrial facilities, people want to know: *Where is the incident? What is being released into the environment? Am I in danger? What follow-up actions are being taken? Has the cause been addressed? Will this happen again?*



Sources of Environmental Stressors - odorous emissions originate from tanks and valves, noise from sirens, and flaring events can be a source of all Environmental Stressors.

This report summarizes the ministry’s review of environmental stressors resulting from industrial operations and the experiences shared by community members on how these stressors impact their quality of life and wellbeing. We also worked with local partners to look at alert systems that tell people what’s going on when an environmental incident occurs at local industries. Further details about the review methods and results are provided in a technical appendix.

What information did we review?

1. Academic articles, government reports, and documentaries related to Sarnia-area environmental stressors.
2. Ministry’s Spills Action Centre incidents reported by people in the Sarnia area.
3. Results of a community experience survey conducted by the Aamjiwnaang First Nation Environment Department.
4. Concerns raised and experiences shared at town hall meetings and community engagement meetings.

Finding #1: Local residents have experienced impacts on their physical, mental, and spiritual health from environmental stressors, and trauma from past industrial events contributes to the stress experienced during an industrial incident.

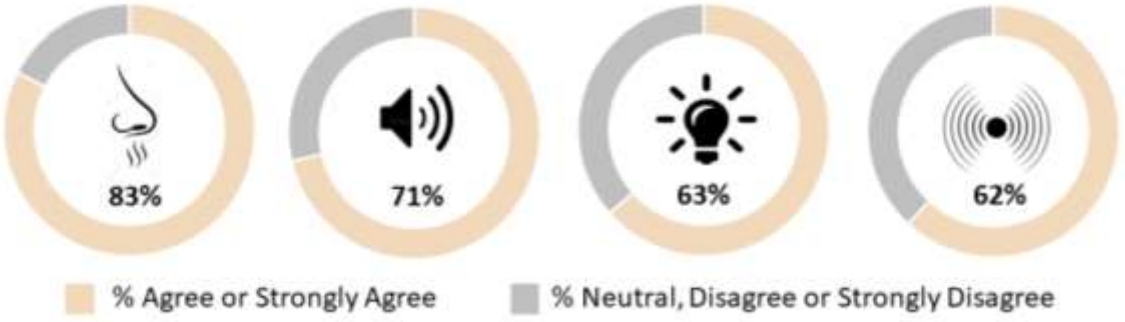
Sarnia area communities, including Aamjiwnaang First Nation, were engaged through town halls and surveys by the Lambton Community Health Study Board from 2008 to 2016, and by the ministry in 2018 during the planning of the SAEHP. Community members said:

- *We are anxious about our health and the impacts of local industry.*
- *It's stressful to worry that our loved ones are being poisoned by their environment.*

"There was a leak and my daughter was outside playing and started puking for no reason then was fine and we came inside and closed the windows and found out there was an alert to stay inside but we didn't know at the time."

- Statement from Aamjiwnaang resident, community experience survey

In 2021, the Aamjiwnaang First Nation shared results from a community survey with us, which indicated widespread concern about the impacts of environmental stressors on physical, mental, emotional and spiritual health.



A majority of those surveyed indicated that they were negatively impacted by industrial odour (83%), noise (71%), night-time light (63%) and vibration (62%).

Many people in the Sarnia area have experienced an industrial emergency in the past such as an industrial explosion and evacuation in 1996[1], a chemical release and shelter-in-place order in 2016[2], and a large flaring event in 2017[3]. Flaring can also cause grass fires (e.g., a 2021 incident[4]) resulting in safety concerns from nearby residents. For people who have lived through these kinds of experiences in the past, environmental stressors experienced today can bring up negative memories, and trigger fears about their own safety or the safety of others.

[1] Irwin, Melanie. 20th Anniversary of Suncor Tank Fire. *Sarnia News Today*, July 19, 2016

[2] Morden, Paul. Shelter-in-place order for Corunna a 'precaution'. *The Sarnia Observer*, April 28th 2016

[3] The Sarnia Journal. Heavy flaring from Imperial Oil stacks. *The Sarnia Journal*, February 24th, 2017

[4] Irwin, Melanie. Grass fire at NOVA St. Clair. *Sarnia News Today*, March 24th, 2021

Finding #2: Odour and noise are the most common causes for complaints in the Sarnia area.

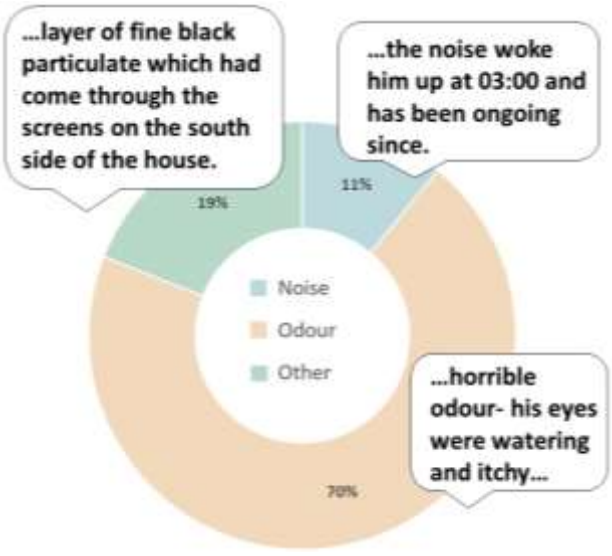
Between 2009 and 2019, about 870 reports were called in to the ministry's Spills Action Centre about community members being impacted by industrial incidents. Here are some key words in those reports. Word size indicates their relative frequency:

"...indicated that himself, his wife, and daughter had all experienced a headache at the time the odours were noted."

- Complaint from Sarnia-area resident, recorded by the Ministry's Spills Action Centre

Foul odour can cause symptoms such as headache, nausea, respiratory discomfort, and inability to sleep or focus on daily activities. Odour can also be a source of stress and anxiety if it is associated with prior bad experiences.

The pie chart to the right organizes incident reports by frequency and type. It shows that odour issues (in orange) are the number one type of impact reported. Noise (in blue) is sometimes a reported concern. Other impacts (green) include a wider range of concerns such as dust or particles, and questions about personal safety during industrial incidents.



Finding #3: Environmental stressors are often related to flaring incidents.

Flaring is an industrial process in which a facility burns flammable gasses (typically while releasing these gasses through tall stacks). It can be an important safety procedure, to prevent over-pressurization of equipment (and prevent risk of fire or explosion), while converting gasses into less reactive chemicals through burning.

There are currently 33 industrial flare stacks in the Sarnia area, 18 of which are within one kilometre of people's homes.

"Caller reports a yellow emission … Caller also reports that noise has been coming from the facility since about 06:00 this morning which woke them up. Caller reports that normally the emission from the towers are white in colour, like steam."
- Sarnia resident, reported to MECP's Spills Action Centre

Noise and vibration: Flaring can be loud – loud enough to rattle windows at nearby residences. The flare stack noise level is similar to standing 50 metres (half a city block) from a jet engine at takeoff.

Odour: Flaring is sometimes odourless, but at other times it can smell like burnt matches or like gasoline. The odour depends on what gasses are being burned and on whether they are completely burned up by the flare.

Night-time light: When flares occur at night, they can be very bright. Nearby residents can experience sleep disruption from the light (as well as from noise).

Not all flaring is equally disruptive. More intense or longer-lasting flaring incidents tend to be more disruptive (such as flaring during industrial start-ups, shutdowns, and emergencies).

When people have previously been impacted by major industrial incidents, they sometimes report flaring incidents as more upsetting and disruptive – for example, if they have experienced an industrial explosion and evacuation.

Finding #4: Environmental stressors have the most impact on people who live closest to major industry.

Noise modelling confirms that loud flares are most disruptive to those living closest, because noise decreases with distance. Flaring during a facility shutdown or start-up can be disruptive to the nearest neighbours, and those more than a kilometre away. A major emergency flare might be loud enough to disturb people across a 4-kilometre radius or more.

"Caller reports noise from the facility across the road from his residence. Reports it has been impacting him for 15 years."
- Sarnia resident, reported to MECP's Spills Action Centre

We also looked at ten years of calls to the Ministry's Spills Action Centre. Most of the calls regarding concerns and impacts from refineries and chemical manufacturers came from people living relatively close to these facilities.

- *53% of calls: people living less than one kilometre away from industrial sites*
- *84% of calls: people living less than three kilometres away*

> *"*Being right across the street from a refinery, that scares me because some days if it's a windy day it's coming this way and [….] you know what the benzene smells like. And that, to me, is scary, when we can start to identify what the smells are. That is not normal, we're not supposed to smell that."
> *– survey respondent, study conducted by Atari and colleagues*[5]

There are various experiences of what it's like to live in the Sarnia area. Proximity to heavy industry greatly impacts one's experience. For example, in a study conducted by Atari and colleagues[5], some community members commented that the Sarnia area is unfairly stigmatized as polluted, while others felt the description was accurate.

Finding #5: There is a shared interest in the community to continue working to enhance understanding and improve communications during industrial incidents and emergencies.

Insufficient community notifications during an industrial incident or emergency can lead to stress, anxiety and confusion. The figure to the right illustrates an example what we have heard about the experience of living near petroleum and petrochemical industry in Sarnia during an industrial incident. To address gaps in information, Aamjiwnaang First Nation introduced its own alert system for their community, providing detailed information about industrial incidents outside of the public-facing industry-led notification system.

Since then, the industry-led Sarnia-Lambton Alerts system (formerly called myCNN) has expanded to also provide a

[5] Atari, D. O., Luginaah, I., & Baxter, J. (2011). "This is the mess that we are living in": residents everyday life experiences of living in a stigmatized community. *GeoJournal, 76,* 483-500.

greater level of detail to the public. Many local industries now make use of the alert system to notify the public of incidents. People can subscribe for alerts from an individual facility or from all participating industries. Alerts may be used to warn neighbours of upcoming flaring and explain the reason, let them know why an emergency vehicle was on-site at a facility, or clarify who to call for more information during an incident.

We also heard that there is some work underway to raise awareness in the community of these alert systems, to increase participation rates. Other areas for potential improvement that we heard about include:

- more sensitivity (in the wording of the alerts) that neighbours may be impacted not only by emitted chemicals but also by environmental stressors
- information during an incident on what specific chemicals may be emitted, if any, and what neighbourhood could be impacted
- an ongoing way for the public to access information about the status of an incident and any follow-up assessments and actions
- providing the community with an analysis of the root causes of incidents, an explanation of how similar incidents will be prevented in future, and confirmation when the corrective actions have been completed

During industrial emergencies, systems are in place to ensure first responders relay important information to health care providers in case community members need medical attention. We heard concerns from some community members that information (such as chemicals released) may not be relayed to health care providers during non-emergency incidents.

The infographic on the following page summarizes where community members can go to sign up for notifications and report pollution incidents.

"*On May 25th, [facility name] can confirm that at approximately 8:30 AM this morning there was a release of hydrocarbon within the refinery. The Emergency Alarm was sounded, and the Emergency Operations Centre activated. The release has been contained at the unit. External air monitoring has been put in place with readings showing no offsite release. All site personnel have been accounted for and the Spills Action Centre (SAC) has been notified and notifications issued. Should you have question or concerns, please do not hesitate to contact the refinery at [facility phone number].*"
- Example Sarnia-Lambton Alert, May 25, 2023

INCIDENT AND EMERGENCY COMMUNICATION INFORMATION

RESOURCES FOR THE SARNIA & LAMBTON AREA

NOTIFICATIONS

SIGN UP HERE!

1 **Sarnia-Lambton Alerts:**
https://lambtonbases.ca

2 **Aamjiwnaang Community Notification:**
https://www.aamjiwnaang.ca/emergency-response-and-planning-notifications/

REPORT INCIDENTS

If you would like to report a pollution release, please contact the Spills Action Centre:

Report Online: https://report- pollution.ene.gov.on.ca/

Report by Phone: 1-866-663-8477

VERIFY INFORMATION

Have you heard information about incidents and emergencies from a peer?

For the most up-to-date information on incidents and emergencies visit the BASES Website: https://lambtonbases.ca

Looking Forward

The ministry and local organizations are working to address environmental stressors in the Sarnia area. For example, since this project began, the ministry has established new regulations on acid gas flaring and sulphur dioxide emissions. These regulations are expected to decrease flaring incidents and reduce the resulting noise, vibrations, odour, and night-time light. Additionally, Sarnia-Lambton Alerts, a local emergency and incident notification service, continues to be improved by BASES (Bluewater Association for Safety, Environment & Sustainability, an industry-led group which collaborates with local government organizations and others).

However, it is clear that important areas for improvement remain, including reducing the release of harmful and odorous chemicals from industry, further minimizing industrial flaring incidents, tracking and assessing incidents to better understand and quantify the impact of these events on the community, and connecting community members with timely information during and after an incident.

Acknowledgements

We would like to acknowledge everyone who has contributed to this report by sharing their information with the ministry – whether through an email or call to the Spills Action Centre, participation in a survey, or comments shared during one of our Sarnia Area Environmental Health Project meetings.

We hope that this report accurately reflects the experiences you have shared with us and helps inform actions to improve the quality of life for Sarnia-area communities.

TECHNICAL APPENDIX:

Detailed Methods and Results

1.0 Methods

To inform the environmental stressors review, perspectives and experiences of community members were collected from published studies, community meetings, surveys, and incident reports submitted to the MECP Spills Action Centre. We also considered noise modeling conducted by MECP noise engineers, and the odour characteristics of chemicals permitted for release in the Sarnia area. While experiences varied, many community members shared similar concerns around living and working close to industry and impacts of the associated noise, vibration, odour, and night-time light on their mental, physical and spiritual health.

1.1 Information Sources

Published Works

- We considered eight studies from the academic literature that assessed the non-chemical impacts of living near heavy industry in Sarnia (Atari et al., 2011; Bagelman and Wiebe 2017; Bedeau, 2006; Jackson, 2010; Jackson, 2011; Luginaah et al., 2010; Smith et al., 2010; Wiebe, 2016).
- Two notable government reports were reviewed, one by the former Environmental Commissioner of Ontario (2017) and the other from a United Nations special rapporteur (Tunkac, 2020).
- A documentary about chemical pollution in Sarnia (Calvert, 2006) also contained information relevant to the environmental stressors review.

Community Engagement Meetings

- The Lambton Community Health Study Board held several open house community meetings in the fall of 2010 (Phil Brown & Associates, 2011).
- Rightsholder and stakeholder meetings were held by the ministry in 2018 with Aamjiwnaang First Nation and with the broader Sarnia community.
- After the initiation of the SAEHP in 2019, community engagement meetings were held with Aamjiwnaang First Nation and with the broader Sarnia community in November 2020, November 2021, and June 2023.

Surveys

- As part of the Lambton Community Health Study in 2010, telephone and online surveys were conducted by consultants in Lambton County to gain an understanding of the views of local residents on the potential health impacts related to industrial pollution (CCI Research 2010; Palleschi 2011).
- A survey was developed by the Aamjiwnaang First Nation Health and Environment departments, to characterize their community's experiences with environmental stressors. Surveying concluded in 2021. Aamjiwnaang shared the results of the survey with the ministry and the results are summarized in this report. Details about how the information was summarized are discussed in section 1.2. A blank copy of the survey can be found in the supplemental material section.

Pollution Incident Reports

The ministry maintains a pollution reporting service called the Spills Action Centre (SAC). Residents who witness pollution incidents (i.e., pollution "spills" to the air, ground or water) can report those incidents to SAC. People who detect unexpected odours or disruptive sounds/vibrations they believe originate from industries sometimes phone in these incidents to SAC, or report them to SAC online. The ministry analyzed all of the pollution incident reports from 2009 to 2019 in the Sarnia area to characterize the types of incidents and proximity of incidents to industrial facilities. The methods used to process and analyze the pollution incident report data can be found in section 1.3.

1.2 Aamjiwnaang Environmental Stressors Survey

The survey was designed to capture the experiences people in the Aamjiwnaang community have had with Environmental Stressors. The collection of surveys was undertaken by the Aamjiwnaang Environment Department. In December 2021 the Aamjiwnaang Environment Department shared the results of 63 completed surveys with the ministry.

Many of the questions in the survey asked people to describe their experiences in a narrative format. Quotes from narrative responses give voice to what people have experienced and examples were included in the Environmental Stressors Report. Some survey questions were more numerical in nature such as "How many days per week do you typically experience odours in your community?" Numerical results were assessed, and averages are presented in figures and tables within this report. Some survey questions asked the respondents to list words that described their experiences such as "What three words would you use to describe the noise(s)?" (following up from another question about noise). These questions included a series of example words; the respondents were not limited to using only the example words. Questions that listed words were summarized in Tables 1 and 3, with the most commonly selected words identified. Other survey questions asked for "Likert" data answers, for example "How true is the following statement: *It is my belief that odours in my community negatively*

affect my physical health" with possible answers: strongly disagree, disagree, neutral, agree, strongly agree. Likert data questions are summarized below in Figure 3.

1.3 MECP Pollution Incident Reports

The Spills Action Centre (SAC) is a service provided by the ministry, which allows people to report a chemical spill or report an environmental stressor incident (disruptive noise, vibration or odour) either by calling SAC (1-866-663-8477) or by reporting online (https://www.ontario.ca/page/report-pollution-and-spills). Industries can also self report incidents or notifications of increased flaring to SAC but those were not included in the current analyses.

Sarnia-area pollution incident reports (PIRs) were compiled, screened, reviewed, and assessed for their spatial pattern. PIRs reported to the ministry between 2009 and 2019 in the Sarnia area and related to heavy industry (i.e., petrochemical industries, refineries, and waste incineration industries) were assessed. The full list of Sarnia-area PIRs for this 10-year period included 2165 records, however many of these records were not deemed relevant to the environmental stressors review and needed to be separated from relevant incidents. Examples of PIRs considered out of scope for the Environmental Stressors Review include odours from restaurants, odours from agriculture and noise from wind turbines.

To focus this analysis on only the relevant PIRs, a "relevance index" was developed using key words, so that we could identify and assess only the incidents related to petrochemical, refinery, and waste incineration facilities. A word cloud of the key words used in the index is shown in Figure 4. The relevance index was used to screen in the relevant records, for further analysis. A total of 870 records were screened in; 651 records related to petrochemical industries and refineries and 219 records related to the waste incineration facility in the area (Clean Harbors). Relevant records were further assessed for geographical information (i.e., an address indicating where the incident was experienced).

<u>Relevance Index Development</u>

1) PIRs for all of Ontario were downloaded from the ministry's "Integrated Divisional System" (MECP database where this information is stored). Then PIRs were screened for municipal location, to select only Sarnia-area records. Specifically, the database was queried for the term "Pollution Incident Report (PIR)" in the field "Module Type" and the term "Sarnia" in the field "Site District Office".

2) A relevance index was created to sort out relevant records from out-of-scope records. A summary of this process is shown in the flow chart below (Figure 2). Relevance in this project was differentiated by the question "*Does the record describe a complaint related to Sarnia's industrial petrochemical, refinery, and waste incineration operations?".*

3) A list of relevant terms (e.g., flare, chemical, odour) and a list of irrelevant terms (e.g., manure, wind turbine) was developed with ministry staff leading this review, alongside staff from the ministry's Sarnia District Office who have experience with Sarnia area complaints. Synonyms for each relevant and irrelevant term were looked up in a thesaurus and added to each list.

4) The "incident description" field of each record was searched for the number of relevant and irrelevant terms. The numbers of relevant and irrelevant terms were counted in two ways: a) total, which counted the same words multiple times; for example if the relevant words in a record were "odour", "odour", and "flaring" the total number would be three and b) unique, which counted the same word only once no matter how many times it appeared; for example if the relevant words in a record were "odour", "odour", and "flaring" the unique number would be two.

5) 120 randomly selected records, referred to as training records, were manually screened for relevance. The incident description of each record was read in full, then the decision about whether or not it was relevant was made by asking the question "*Does the record describe a complaint related to Sarnia's industrial petrochemical, refinery and waste incineration operations?"*

6) In a spreadsheet (Microsoft Excel) four variables were calculated for each record using spreadsheet functions to count relevant and irrelevant words: i) total number of relevant words, ii) total number of irrelevant words, iii) number of unique relevant words, and iv) number of unique irrelevant words.

7) Each record in the training set also contained the binary variable for relevance (1= relevant, 0 = irrelevant). This training data set was used to assess the best combination of the four variables which could distinguish between relevant and irrelevant records, and to develop an equation that could use the number of relevant and irrelevant words to predict if the record was a relevant record. This was conducted by performing logistic regression with every combination of the four relevant/irrelevant word variables and using Akaike Information Criterion (AIC) model selection to pick the best predictive model. All statistical analyses were conducted in the program R.

8) The best model used the relevance variables "total number of relevant words" (total RW) and "total number of irrelevant words" (total IW) and optimized the coefficients to give the following equation:

$$\text{Relevance index} = -1.01 + (0.8693 * \text{total RW}) + (-2.696 * \text{total IW})$$

A relevance index of greater than 0 screens the record as relevant and a relevance index of less than 0 screens the record as irrelevant.

9) The very first predictive model was not effective at separating relevant from irrelevant complaints (accuracy of 51%). To improve the quality of the model, adjustments were made to the relevant and irrelevant key words and the logistic regression was re-run until accuracy could no longer be improved. The 120 training records were used to quality control the list of relevant and irrelevant terms. If any of the "relevant" terms were only present in irrelevant records, those terms were removed from the relevant term list and vice versa. Additionally, words that only appeared in relevant records were added to the relevant list and words that only appeared in irrelevant records were added to the irrelevant list. The best index that could be achieved was 89% using the training records (Figure 1).

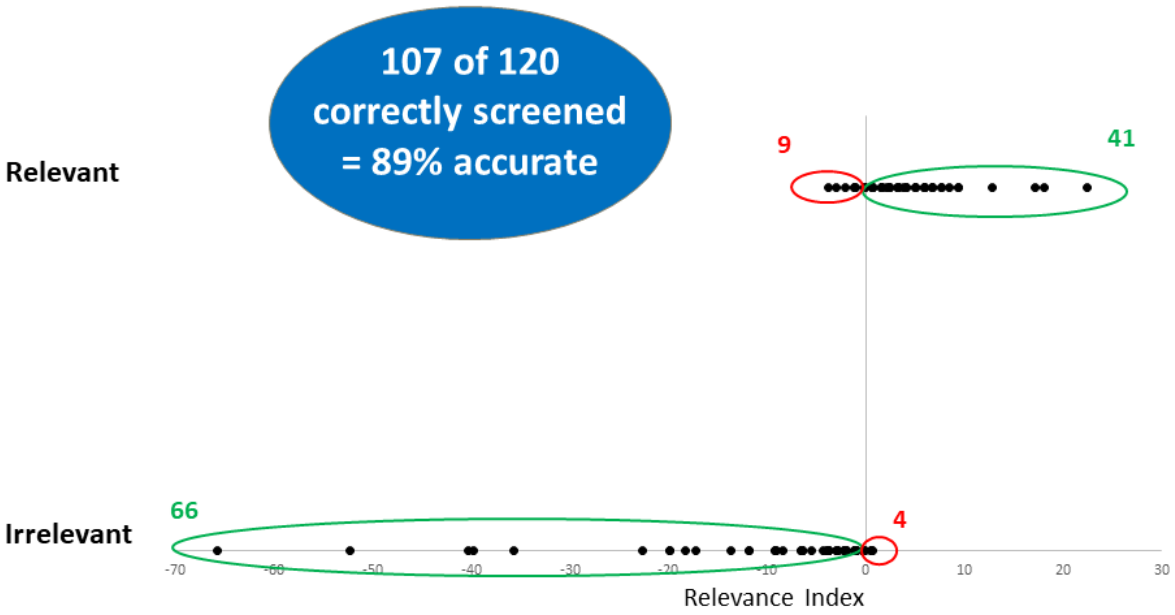


Figure 1. Training data set of 120 randomly selected records comparing the manual sorting of records into relevant and irrelevant categories compared to the relevance index sorting. The relevance index correctly screened in 107 of the 120 manually checked records.

10) To further assure the quality of the index, 40 additional records were then randomly selected, referred to as test records, and manually assessed for

relevance. The test records were not used to optimize the choice of key words and therefore give a better indication of how the index will sort records for the overall data set. The relevance of each record was predicted using the relevance index. The predicted relevance vs. the manually assessed relevance was compared. Eighty-five percent of the test records were correctly sorted by the index. The six records that were not correctly sorted were all relevant records that were sorted as irrelevant.

11) The relevance index was applied to the full list of records. All records that scored less than a 0 were removed.

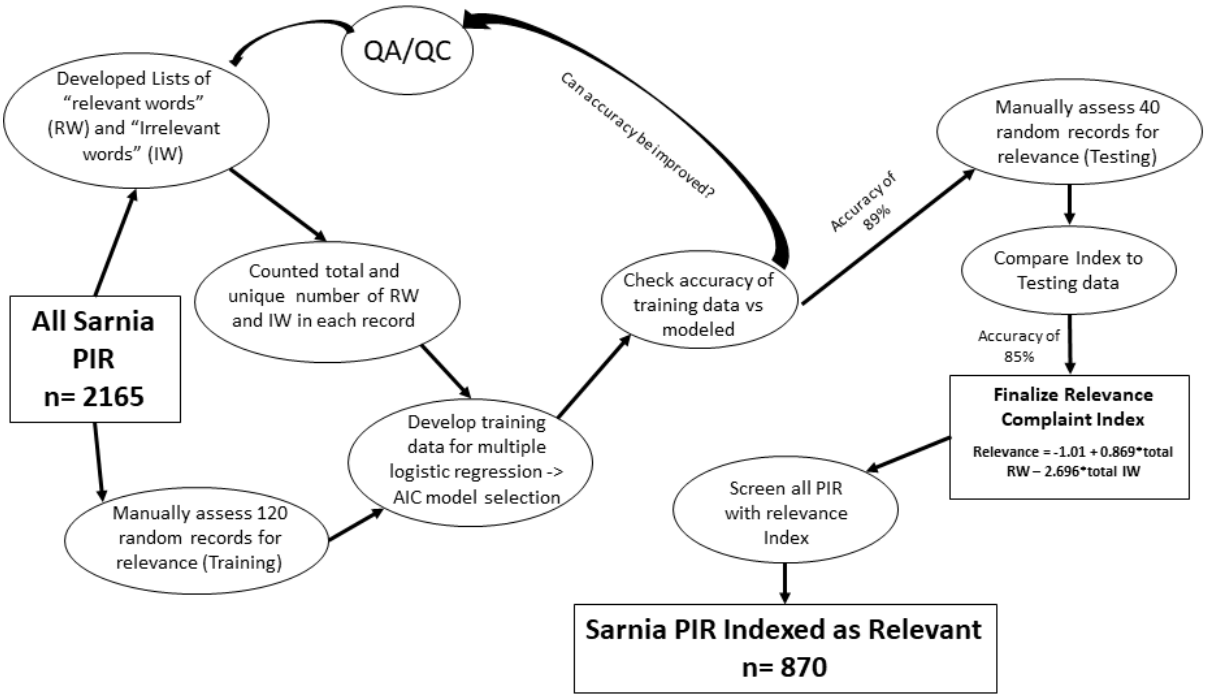


Figure 2. Flow chart of the development and implementation of the relevance index.

Geographical Information of PIR

The Pollution Incident Report data were also screened to select those records which included an address, to use for additional geographical analysis. This screening process was conducted as follows:

1) Of the 870 relevant records, each record was mined for street address information by developing a computer program that looked for sequences of numbers and letters expected in an address.

2) Some records (n=28) were found to have multiples address. Each of these records were manually checked and the incident description read. In each case there was an address where the incident was experienced, and an additional address mentioned in the record which was not relevant to this project; the irrelevant address was removed. In one case there were two addresses where the incident was experienced; in this case the address used was determined randomly.
3) PIRs that both were indexed as relevant and had address information were geocoded (converting each address to a geographical coordinate) in Google Earth. Google Earth could not geocode 24 of the records (addresses likely contained typos).
4) Each geocoded record was then manually re-assessed for relevance to remove any irrelevant records that may have been screened in from the relevance index. When there was an address in the complaint report but no indication in the description of an association of the address with the complaint, then the address was searched in Google Maps. If the address was related to a residence (or related to the location the complaint was made from, which was occasionally a place of work) it was assumed the address was where the incident was experienced. A total of 118 records were retained after this manual screening step and then were included in the spatial analyses.
5) The 118 records suitable for spatial analyses (relevant complaint and known address where the incident was experienced) were imported into ArcGIS. Geographic land parcels were obtained from the municipality of Sarnia. This included parcels of land defined as “heavy Industry” which encompassed Sarnia’s petrochemical and petroleum refining industries and the property boundary of the Clean Harbours waste incineration facility. These land parcels were imported into ArcGIS. The 118 PIRs clustered into two groups, those specific to a waste incineration facility (Clean Harbors) and those focused on other major industry. As these industries were both geographically and functionally distinct, they were divided into two groups, Clean Harbors (n=63) and those associated with petrochemical industries and refineries (n=55). A proximity tool was used to calculate the distance between incident locations and Clean Harbours property boundary or the nearest heavy industry property boundaries, respectively.

1.4 Flare Noise modeling

Noise (i.e., as represented by sound pressure level) was modeled from flares in the Sarnia area using the CadnaA noise model. This modeling was not conducted to reflect specific real-world geographical locations and did not consider barriers (e.g., trees and buildings). Rather this modeling was done on a hypothetical flat plane and used to estimate how noise disperses from a source with distance from the source. The heights of the investigated flares in Sarnia range from 40 metres to over 100 metres above ground level. The sound power levels (taken from engineering specifications of acoustic assessments conducted by local industries) of the investigated flares in Sarnia range

from approximately 123 dBA (flaring during a facility turnaround event) to 140 dBA (emergency flaring).

The flare sound pressure estimates were based on the following parameters: ground absorption factor = 0.7, height of flare = 61 m, height of point of reception = 4.5 m, frequency of sound power level = 500 Hz, atmospheric temperature = 10°C, and relative humidity = 70%. The accuracy of noise estimates is within three dB within one kilometre and is not defined beyond one kilometre (but expected to be greater than three dB). Barriers will also add variability to noise experienced with distance, however, tall sources of noise (such as flare stacks) are not effectively blocked by barriers as it travels to the receptor from above.

1.5 Odorous Compounds

The ministry reviewed odours associated with chemical compounds that were modeled as part of the SAEHP's Air Exposure Review in addition to all chemicals reported to the National Pollutant Release Inventory from facilities in the Sarnia area that have an odour guideline/standard. An odour description for each chemical was collected from the PubChem website (https://pubchem.ncbi.nlm.nih.gov/). These chemicals were grouped based on similar odour descriptions, and either bolded or highlighted based on the number of facilities in the Sarnia area that emit those chemicals (Table 2).

2.0 Results

2.1 Local residents have experienced impacts on their physical, mental, and spiritual health from environmental stressors, and trauma from past industrial events contributes to the stress experienced during an industrial incident.

Reports, surveys and studies have documented that people living in proximity to industry report having uncertainty about how their health is impacted. In addition to impacts that may be experienced from exposure to airborne chemicals (being evaluated in another component of the Sarnia Area Environmental Health Project, called the Air Exposure Review), residents live with the stress of believing that they and their loved ones are being poisoned. The Lambton Community Health Study 2010 telephone and online surveys found that 73% (telephone) and 83% (online) of surveyed residents were concerned or very concerned about the health risks of living near local industries (CCI Research 2010; Palleschi 2011). The surveys also found that 79% (telephone) and 82% (online) of respondents reported that they believed pollution from the industries causes health problems for residents of Lambton County (CCI Research 2010; Palleschi 2011). Similarly, one of the themes highlighted by community members during a series of town hall meetings was the considerable anxiety regarding their health issues, and the desire

for a broad health study which includes mental health (Phil Brown and Associates, 2011). These findings were consistent with a report from United Nations Special Rapporteur Baskut Tunkac (2020), who characterized the impact of industry to the Aamjiwnaang community as resulting in "…physiological and mental stress among community members regarding the risk of impending explosions or other disasters, and health impacts from unquestionably poisonous chronic exposures."

In the 2019 Aamjiwnaang Environmental Stressors survey, most respondents indicated they agree or strongly agree that noise, vibration, odour and night-time light negatively affect their emotional, spiritual, mental and physical health, with odour tending to have the strongest negative effect (Figure 3).

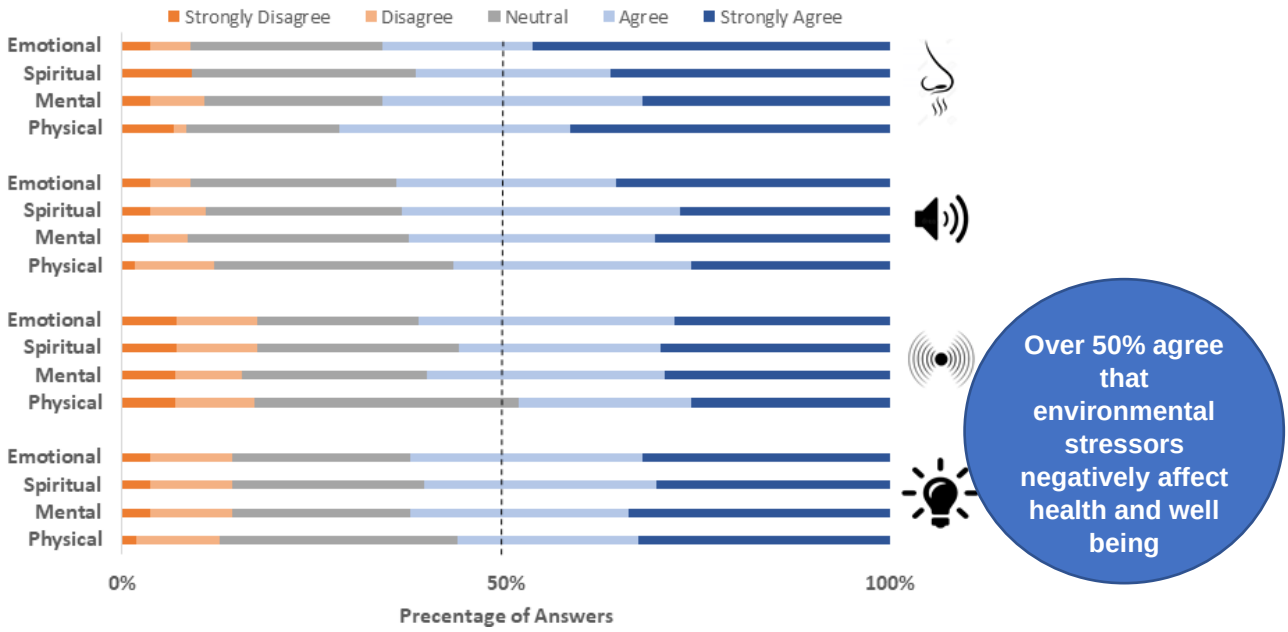


Figure 3. Stacked bar chart showing the percentage of survey respondents who believe odour (nose icon), noise (speaker icon), vibration (point bracketed with waves icon), and night-time light (light bulb icon) impact their emotional, spiritual, mental and physical health. Respondents were given five options (strongly disagree, disagree, neutral, agree, and strongly agree) for each Environmental Stressor and perception of health. Each bar is the summary of 63 survey responses.

The impact of these environmental stressors cannot be understood by considering only the direct physical characteristics of each stressor (how loud it is, how smelly, etc.). Environmental stressors can also play a role in reminding residents of prior traumatic events. A resident from Aamjiwnaang characterized their experience during an evacuation in a documentary interview: "3 or 4 o'clock in the morning, somebody was pounding at my door, 'Come on, we gotta go.' So, I grabbed my kid, away we went, we

gotta go get ma. So, I went knocking at her door, she's not answering. So I went back to her bedroom, and I started pounding on her window, she still wasn't getting up. Then my mouth started getting all numb, I still remember it, it was wow, then I just started pounding, 'Get out of bed!'" (Calvert, 2006).

People in the Aamjiwnaang community have endured the consequences of industrial emergencies that create associations between those experiences and odours, noise, vibrations and night-time light. Environmental stressors can therefore be trauma triggers which go beyond direct toxicity from exposure to chemicals or annoyance from physical sensations such as noise or light. As one resident put it, "There is a sort of a trauma to all of this that doesn't come out in the bodymapping and doesn't come out in the toxicology studies." (interviewed Aamjiwnaang resident from Calvert, 2006).

2.2 Odour and noise are the most common causes for complaints in the Sarnia area.

When someone in Ontario observes a pollution incident, what the ministry calls a spill, they can report that incident to the ministry's Spills Action Centre (SAC). Between 2009 and 2019, a total of 2165 pollution incidents were reported to SAC in the Sarnia area (this area is defined in Figure 7). After screening out non-relevant incidents, 870 reports that were relevant to the environmental stressors review were characterized. A detailed description of the methods used to do this screening can be found in section 1.3.

The most common keywords used to identify incidents relevant to the environmental stressors review give a sense of what people said when reporting their experiences with Environmental Stressors (Figure 4). Commonly used words were: odour, flaring or flare, light, smell, noise. Less commonly used words, but still related to environmental stressors, include: shock, rumble, frustration, toxic release, stack emission.

Figure 4. Word cloud displaying the words used to identify “relevant” complaints. Size of the word is related to the frequency at which the word was identified in the “relevant” complaints.

Of the 870 incidents relevant to the environmental stressors review, 70% were about odours, 11% were about noise/vibrations, and the remaining 19% were classified as “other”. Several of the incidents labeled “other” indicated an observation of particulate matter (dust, grit) and concerns about what those particles were. Flaring was mentioned amongst all the different incident categories as it can be a source of multiple stressors. Incidents related to flaring accounted for 18% of all relevant incidents. Examples of each of the different types of incident reported about the petroleum and petrochemical industry are shown in Figure 5. Incidents reported about the Clean Harbors waste incineration facility (219 of the 870) were about odour 93% of the time and fell into the “other” category 7% of the time. About half of the incident reports related to Clean Harbors over the 10-year period occurred as a clump in the latter half of 2011, suggesting that a transient issue occurred in that timeframe.

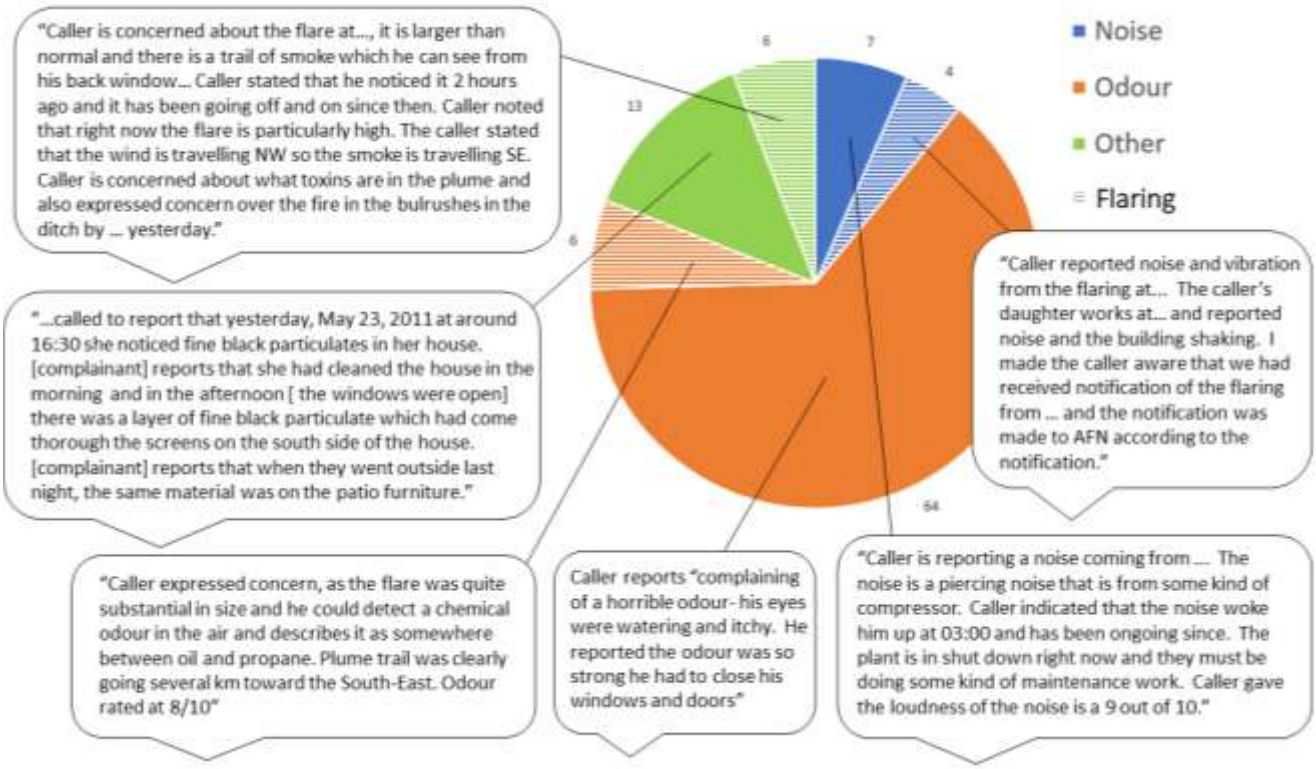


Figure 5. Proportion of relevant complaints that are related to noise, odour and other (n=870). Each of the three categories is further subdivided by whether the complaint was related to flaring (striped) or unrelated to flaring (solid). An example of each category is quoted from the complaint database.

The Aamjiwnaang Environmental Stressors Survey results indicated that odour, noise, and night-time light are all experienced on average between four and five days per week, at an average subjectively rated intensity of between three and four out of five. Vibration was both experienced less frequently and less intensely than the other stressors. Respondents were asked to use three words to describe their experience of each of the four stressor categories (odour, noise, vibration, night-time light). Odours were often described as unpleasant, foul and rotten (Table 1). Jackson (2011) argues that the present industrial proximity of Aamjiwnaang has changed the way Aamjiwnaang people experience the land, in particular through their sense of smell, from a healing to a perceived toxic scent-scape.

Table 1. Ten most common words used to describe odours, night-time light, noise, and vibration associated with environmental stressors at Aamjiwnaang First Nation (n=63). Respondents were asked to use three words to describe what they experience.

Odour		**Night-time light**		**Noise**		**Vibration**	
Word	Count	Word	Count	Word	Count	Word	Count
Unpleasant	18	Bright	34	Loud	19	Random	19
Foul	16	Yellow	11	Rumbly	15	Strange	11
Rotten	15	Red	11	Excess	8	Sudden	10
Strong	13	Steady	9	Unwanted	8	Continued	8
Pungent	13	Intense	8	Sudden	6	Mechanical	8
Sour	9	White	8	Constant	6	Strong	7
Nauseating	8	Orange	7	Random	6	Heavy	6
Offensive	8	Visible	7	Low	6	Deep	6
Disgusting	7	Artificial	5	Thunderous	6	Excessive	5
Nauseous	7	Harsh	5	Steady	6	Acoustic	5

Odour is not straightforward to characterize, in part because sense of smell varies greatly from person to person. However, there are numerous compounds known to be odorous that are released to air by Sarnia industries. Chemicals permitted to be released by industries in the Sarnia area, for which Ontario has odour-based guidelines or standards, are grouped by like odours in Table 2. Some examples of chemicals of interest and their odour profiles include the following:

- The two main sulphurous compounds in the Sarnia area are hydrogen sulfide (H_2S) and sulphur dioxide (SO_2) which are produced as by-products of refining crude oil. H_2S has an odour similar to rotten eggs. Much of the H_2S produced is either removed by sulphur recovery units or oxidized to SO_2. SO_2 is formed from other sulphur compounds during acid gas flaring and has a smell similar to a burnt match.
- Benzene and other small volatile organic compounds such as Styrene, Toluene and Xylenes are associated with the petrochemical industry and are often described as sweet smelling, with some also having a gasoline-like odour.

- 1,3-Butadine also has a gasoline-like odour.
- Benzo[a]pyrene is odourless, although it is within a family of compounds (polycyclic aromatic hydrocarbons or PAHs) which tend to have petrochemical (i.e., oily/gasoline) type odours. Since Benzo[a]pyrene tends to occur in mixtures of PAHs from incomplete combustion, it will likely be associated with petrochemical-type odours.

Based on a review of the chemicals in the NPRI database released in the Sarnia area, there are five odorous compounds that are permitted to be released by at least 20 facilities in the area, and three of them have “petrochemical” or “sweet and petrochemical” odours. The other two chemicals permitted to be released by at least 20 facilities have “sweet or fruity” odours. There are also many chemicals that are permitted to be released by at least 10 facilities, in many of the odour description categories in Table 2.

Given the wide range of potentially odorous compounds it is likely that more than one odorous compound may be encountered simultaneously, which may change the perceived odour. The odour descriptions below are of odorous compounds by themselves, and do not provide an explanation of the odour of chemical mixtures. The odour of chemical mixtures is very complex, difficult to predict (Laing, 1994; Singh et al., 2019) and consequently out of scope for this review.

Table 2. Odorous compounds permitted to be released by industries in the Sarnia area that have an odour guideline or standard. Chemicals are organized by their odour description. Chemicals released by at least 10 different facilities are bolded, and chemicals released by 20 or more facilities are bolded and italicized.

Odour Descriptor	**Chemical(s)**
Acrid†	Methacrylic acid, Methyl acrylate, Ethyl acrylate, Chlorine, **Formaldehyde**
Alcohol	**Ethanol**, **n-Butanol**
Buttery and Distinctive	Biphenyl
Ethereal‡	Propylene glycol methyl ether, Dimethyl ether, Methyl tert-butyl ether
Ethereal and Rancid	Ethylene glycol butyl ether
Ethereal and Savory	Acetylene

Ethereal and Sweet	Carbon disulphide, Dimethyl sulphide, Ethyl ether, Propylene dichloride, **Propylene glycol monomethyl ether acetate**, Isobutyl acetate, Ethylene glycol ethyl ether, **Ethyl acetate**
Fruity/ Minty	**Methyl isobutyl ketone**, Diisobutyl ketone, 5-Methyl-2-hexanone, Ethylene glycol ethyl ether acetate, Ethylene glycol butyl ether acetate, Diacetone alcohol, ***n-Butyl acetate*****,** n-Propyl acetate
Petrochemical††	***Naphthalene****,* ***Ethyl benzene***, Octane, n-Decane, **Isopropyl benzene**
Rancid and Rotting	Trimethyl amine, Propionic acid, Pyridine, Dimethyl amine, Dimethyl disulphide, **Hydrogen sulphide**, methyl mercaptan
Sweet	Diethylene glycol monoethyl ether, Styrene, ***Xylenes***
Sweet and Bitter	Isobutanol, Methyl methacrylate, Furfural, Propionaldehyde, **Ethyl-3-ethoxy propionate**
Sweet and Petrochemical	2-Ethyl hexanol, ***Toluene***, Monochlorobenzene
Vinegar	Acetic acid

†Acrid – smells sharp, bitter (e.g., burning rubber, cigarette ashes)

‡Ethereal – smells like ether/chemical cleaning solution (e.g., dry cleaning fluid)

††Petrochemical – oily and gasoline like odours

2.3 Environmental stressors are often related to flaring incidents.

Flares are a means of safely disposing of waste gases and toxic compounds through the use of an open flame combustion at the top of flare stack. They are meant to protect process equipment and piping from over-pressurization that may result in fire and explosion. Flares can also disturb nearby residents by producing noise and vibrations, by releasing odorous compounds like sulphur dioxide during acid gas flaring, and by producing night-time light. Incidents reported to the MECP Spills Action Centre have described flares as being disruptive to surrounding residents. Callers have described the noise from a flare as “violent” making it difficult to sleep and being “8/10 loud”. During 2018 community engagement meetings, it was recommended that the ministry investigate why so much flaring, leaking, spills and fires occur.

Ministry information shows that there are thirty-three (33) industrial flare stacks within the Sarnia area. To understand the potential for noise disturbance associated with flaring incidents, the 20 closest “points of reception” (nearest and most exposed

houses) to each of the identified flare stacks were assessed. On average those 20 receptors were within 800 m of a flare and each receptor had one to two flares within a one-kilometre proximity. There is a large variety among flare stacks and among flaring events: some can be small and relatively quiet, others are much larger and potentially louder (depending on operating conditions, e.g., when steam is added to suppress smoke, it can create more noise). Therefore, the experience of a resident living near a flare stack would also be affected by the size and height of flare stack, the type of smokeless operation, its frequency of use, and the volume of gas it flared.

Flaring can generally be described as two types: “acid gas” flaring (sulphur compounds are burned) and “hydrocarbon” flaring (no sulphur compounds are burned). The ministry has a growing dataset regarding the frequency and duration of acid gas flaring. Acid gas flaring is the most relevant form of flaring when it comes to sulphur release and the release of sulphur odours. However, hydrocarbon flares can also produce noise and vibration, night-time light, and potentially also odours (if there is incomplete combustion). During the period between 2013 and 2016 there were 17 or 18 acid gas flaring events reported each year, but the total number of hours of flaring varied widely from year to year (ranging from 57 to 707 hours per year).

Flaring can produce significant noise and vibrations, particularly during start-up/shut-down procedures and emergencies. As part of the permitting process, industries complete acoustic assessments of the noise-producing processes that operate within their facility, including flares. These acoustic assessments involve modeling how loud a flare can be based on the parameters of that flare.

Data from flare acoustic assessments in the Sarnia area indicate that flares can reach levels up to 140 dBA (dBA is a measure of sound in decibels that is normalized to include only frequencies that humans can hear) at the flare stack during emergency flaring. Noise decreases over distance, so noise up at a flare stack is not what will be experienced in the surrounding neighbourhood closer to ground level. To better understand how flaring noise produced at the flare stack can be experienced in the neighbourhood around a flare stack, noise with distance from a source was modeled using two flaring scenarios: i) 120 dBA at the flare stack which is the noise produced at the flare stack from a typical start up/shut down flare, and ii) 140 dBA at the flare stack from a worst-case emergency flare. Noise was modeled without considering local geography or barriers, which was intended to give a general sense of how noise decreases with distance from a source but was not intended to accurately predict noise levels at any specific location.

Based on this modelling, noise levels experienced during start-up/shut-down flaring would be above MECP urban noise limits (MECP, 2013) within one kilometre of the flare. Emergency flaring can be louder and further-reaching, however after several kilometres there are likely barriers in the landscape that would significantly reduce the noise experienced (Figure 6).

It is not feasible to monitor the actual noise at every home that could be impacted every time a flare stack is flaring, but there is one example of such monitoring in the Sarnia area that was examined as part of this review. In 2008, noise monitoring was conducted during a flaring event by consultants GTA Environmental (2008) at the request of Aamjiwnaang First Nation, who shared these noise monitoring results with the MECP to support the Environmental Stressors Review. Noise from the flare was measured for two locations 38 metres from the flare stack, at 71.8 and 72.7 dBA and at a residence ~300 metres from the stack at 57.6 dBA. In addition to the total amount of noise, noise can be measured at specific octave bands (a set of wave lengths) and some agencies such as Health Canada have noise guidance for noise at specific octave bands. At the residence ~300 metres from the flare stack noise measured at the octave band centred around a 16Hz frequency was 77.3 dB. This measurement would exceed the Health Canada low frequency noise guidance after 85 minutes in a single day (Health Canada, 2021). Also, the resident informed the noise consultant that other flares have been so loud you had to yell to be heard in the backyard, from which the noise engineer concluded: “This indicates that the noise levels may well exceed 80 dBA” (GTA Environmental, 2008). As can be seen from Figure 6, approximately 80 dBA is what would be predicted at 300 metres’ distance during a sound power level of 140 dBA at the flare stack, which is the upper limit of what the flare stacks are expected to emit during an emergency flare.

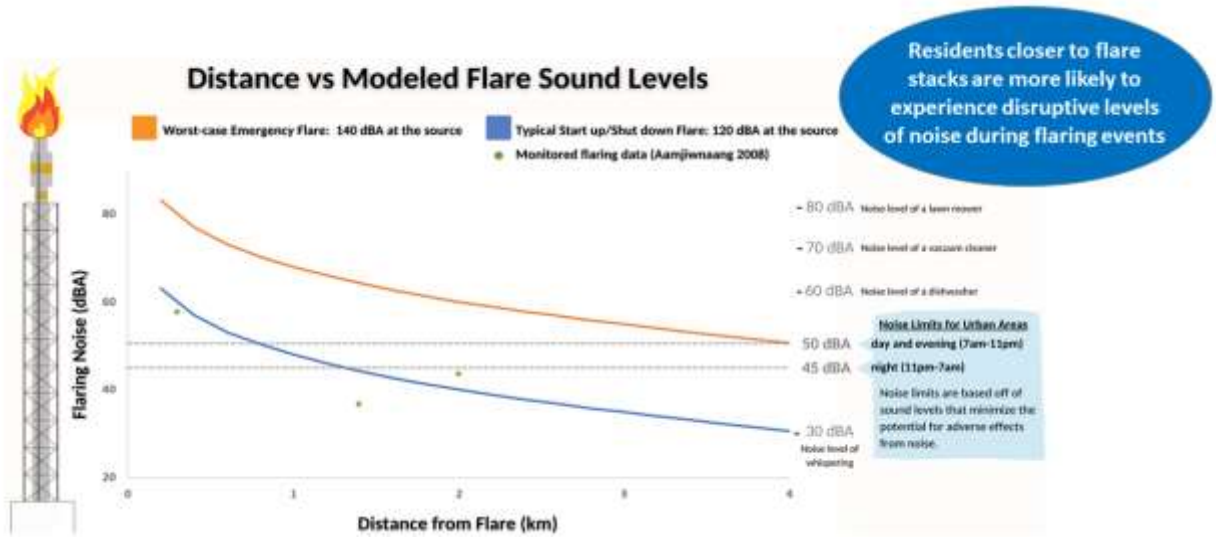


Figure 6. Modeled noise against distance from i) worst- case emergency flare of 140 dBA and ii) a typical start up/shut down flare of 120 dBA. Also included in the diagram are points from a noise monitoring survey conducted at Aamjiwnaang in 2008. The two dashed lines show MECP noise limits for urban areas (MECP, 2013) and right side of the graph shows noise levels of familiar noise sources, for comparison.

2.4 Environmental stressors have the most impact on people who live closest to major industry.

In the Sarnia area, heavy industry is dominated by petroleum refineries and petrochemical industries. To investigate if there was a proximity relationship with impacts of environmental stressors, we investigated environmental stressors incidents reported to SAC that also had address information (see section 1.3 for a description of methods). Approximately half of the incidents with an address were associated with a single facility (Clean Harbors) which is distinct both in its operation (waste incineration) and in being geographically distant from much of the petrochemical industry in Sarnia. Consequently, the incidents were separated into two categories and graphed separately. Figure 8 indicates that the majority of incidents related to heavy industry come from within one kilometer of heavy industry property boundaries with a sizable minority coming from between one and three kilometers of the industrial areas. Ontario's current guide for land use planning (D-6-3 Separation Distances) indicates that is a one-kilometre potential influence area around heavy industries (referred to as "Class III industrial areas") (MECP, 2021). This is consistent with the study finding that the largest proportion of incident reports were within one kilometre of industry. The guide for land use planning does not consider different kinds of heavy industries and may not reflect the extent of disturbances associated with petroleum refineries and/or petrochemical industries specifically. Australian and New Zealand state governments have guidance for separation distance for land use planning that consider different kinds of industries (Northern Territory Environment Protection Authority, 2017; Victoria State Government, 2013; Wickham, 2012) which recommend a two-kilometre separation distance between petroleum refineries and other types of sensitive land use.

There were no incident reports related to the Clean Harbors facility within one kilometer of its property boundary. Clean Harbors has a community liaison committee program where it directly engages with residents within one and a half kilometers of the facility (Clean Harbors, 2023) which may help address the concerns of nearby citizens directly. Also, the one-kilometer area around Clean Harbors is less populated than the one-kilometer areas around most of the petrochemical industry in Sarnia. Many of the complainants related to Clean Harbors were made from residences between one and three kilometers from the property boundary and no complaints were recorded further than eight kilometers from the facility (Figure 8).

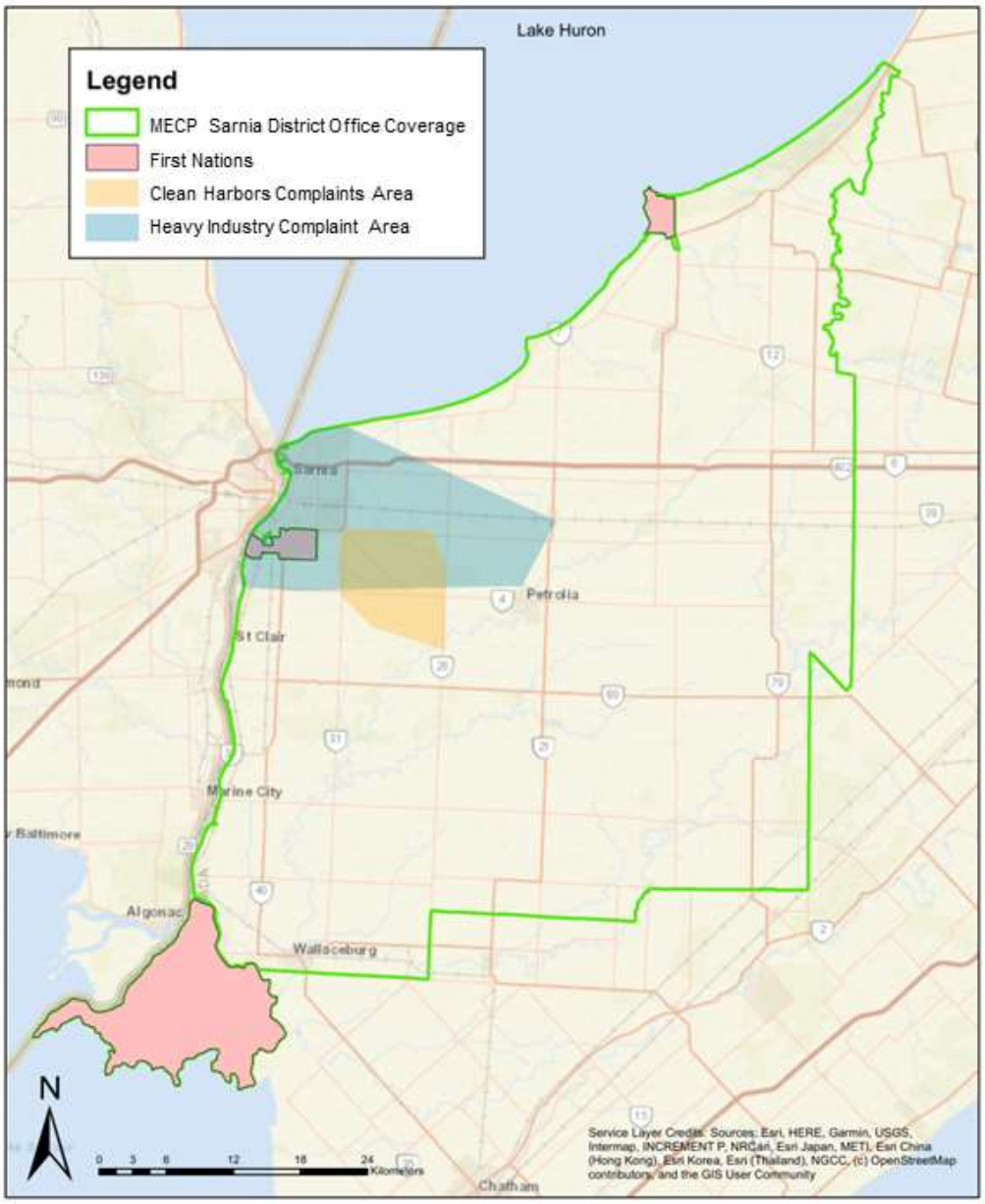


Figure 7. Geographic extent of the environmental stressor incident reports related to petrochemical industry and Clean Harbors

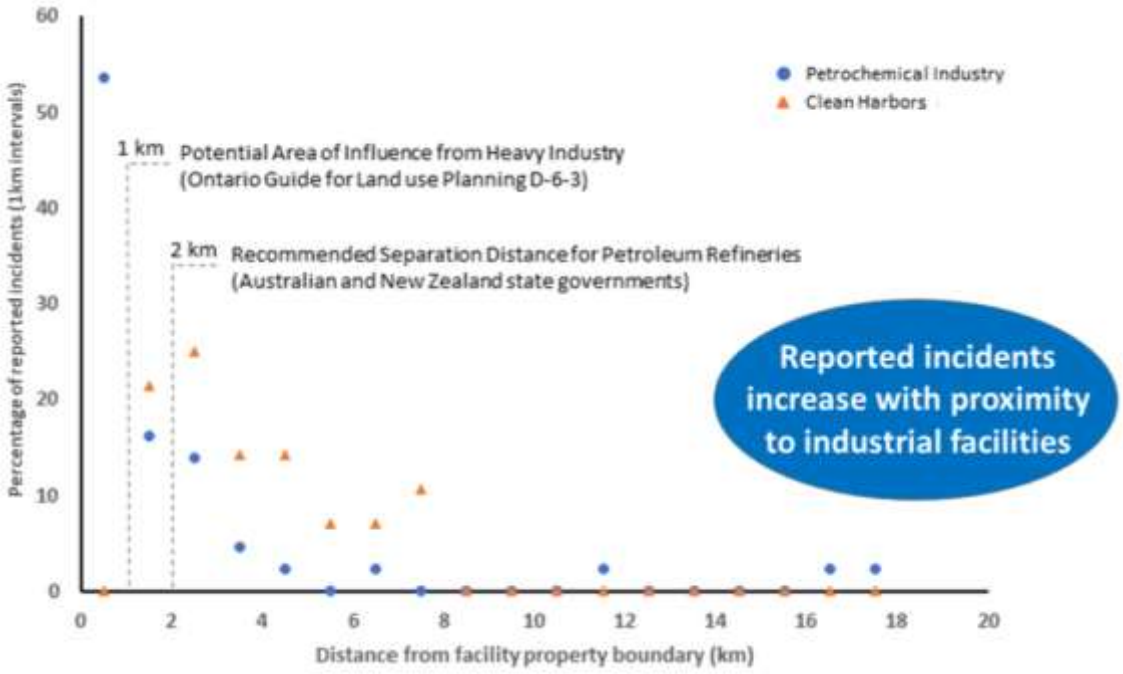


Figure 8. The proportion of environmental stressors incident reports from individual addresses in one-kilometer intervals related to the distance between the complaint and either the closest petrochemical industry or the Clean Harbors facility.

Although reported environmental stressor incidents spanned an area covering much of Sarnia (Figure 7), the majority of incidents occurred in close proximity to heavy industry (Figure 8). This information helps to demonstrate that where you live in the Sarnia area can strongly influence your experience of environmental stressors.

Other studies have produced information consistent with this finding. Atari et al., (2011) captured a variety of perspectives, intentionally seeking out community leaders, corporate leaders, local activists, and residents. Data on the proximity of respondents to industry was captured. There were participants in the Atari survey who considered Sarnia's image of being highly polluted as exaggerated, perhaps related to a legacy of when pollution was worse in the area. These participants suspected that when people got sick of typical aliments, they would mistakenly believe being near Sarnia industry caused it. People who made specific mention of being near petrochemical industries e.g., "Being right across the street from a refinery" or "I think the further south you go, particularly south…the south end of Sarnia" did have concerns about the how proximity to industry was impacting their wellbeing.

There is not one experience of Sarnia and an understanding of how industrial operations impact people's quality of life needs to consider proximity to industry, as those living closer to petrochemical industry facilities are more likely be impacted.

Proximity of Aamjiwnaang First Nation

Aamjiwnaang First Nation is located in close proximity to much of Sarnia's heavy industry. This fact has attracted the attention of researchers and public officials. The Environmental Commissioner of Ontario (2017) identified that stress is an under-acknowledged consequence of residents in Sarnia living near petrochemical industries. She cited, as an example, uncertainty around when the next dangerous accident will occur. Her report noted that beyond perceived health impacts, the proximity of industry is understood to have significant cultural impacts to the people of Aamjiwnaang.

Bedeau (2006) concluded that where Aamjiwnaang people live is more than just a place to call home, it has historical foundations and sacred places that are part of Aamjiwnaang identity; thus, impacts from nearby industry go beyond direct health impacts to also include impacts on cultural integrity. Similarly, Atari et al. (2011) argues that even though there are issues with living in the Sarnia area, the people of Aamjiwnaang have social, cultural and economic attachments to that land. Jackson (2010) makes a similar point. For example, Jackson interviewed an Aamjiwnaang resident explaining multi-generational ties to the land: "When I take my son out on the land, I'm giving him the teachings of the land. I'm telling him the stories of our lives, I'm telling him the stories of our ancestors: 'This is where your granddad used to do this', [and] 'Here's where your great-granddad did that…' He's learning about being Anishinaabe, he's learning how to be an Anishinaabe man." The understanding of Aamjiwnaang as a meaningful cultural area is juxtaposed to its proximity to heavy industry. Surveys conducted by Smith et al., (2010) highlighted that the natural environment was being experienced both as a source of therapeutic healing, and also as a place of contamination, with uncertainty over whether it is negatively impacting health.

Representatives from Aamjiwnaang First Nation have voiced concerns about how their proximity to heavy industry is impacting them, such as "our community is sick" and "we are the guinea pigs" (Lockridge, 2011). When respondents from the 2019 Aamjiwnaang Environmental Stressor Survey were asked about what they believed the causes of the environmental stressors were, the majority of respondents mentioned the nearby industry as the cause for odour, noise, vibration and night-time light. Some respondents gave more specific perspectives. For example, flares and trains were believed to be important sources of noise/vibrations, while vehicles and planes were also named as noise sources to a lesser extent. Flares were noted to be an important source of night-time light, while some surveys also mentioned lighting at the industrial plants (Table 3).

Table 3. What respondents believed to be the cause of odour, noise, vibrations, and night-time light. Respondents were not prompted with a list of options (example question: *In your opinion, what is/are specific cause(s) of the odour?*). The results are expressed as a percentage of respondents who gave an answer that is best

represented by each category listed along the top row (industry generally, flares, trains, etc.), when asked what they believed to be a cause of each type of stressor. Some respondents gave more than one answer to what they believed that cause to be. Only causes that were chosen by at least 10% of respondents for at least one stressor are shown.

Environmental Stressor	Industry generally (%)*	Flares (%)	Trains (%)	Vehicle traffic and Planes (%)	Industry Lighting (%)
Odour	92	2	2	2	0
Noise	93	28	37	11	0
Vibrations	76	22	35	11	0
Night-time light	91	51	3	3	11

* Example answers for "Industry generally": the chemical plants, the stacks, the refineries, industry, chemical release, chemical valley, emissions

While some of those who live closest to industry and would be most impacted are members of Aamjiwnaang First Nation, many Aamjiwnaang residents have expressed concerns about environmental quality that extend beyond their own community. For example, Luginaah et al., (2010) concluded from surveys that many members in the Aamjiwnaang community had an inclusive sense of responsibility that went beyond people living at Aamjiwnaang and included the health of all living things and the environment both within and outside of the Aamjiwnaang community.

2.5 There is a shared interest in the community to continue working to enhance understanding and improve communications during industrial incidents and emergencies.

Community members have noted that much of their distress during incidents and emergencies is the vagueness in the notifications and the lack of follow up. This can leave people knowing that there is a problem, without understanding what it means or what particular risks it poses, leaving them with a feeling of unease and uncertainty.

Reliable and predicable reporting was suggested as an important tool to build the confidence of local residents in their industrial neighbours. There is air quality monitoring data available through the Clean Air Sarnia and Area (CASA) website (https://www.cleanairsarniaandarea.com). Community members have also requested access to information on why an emergency occurred and what is being done to address it and prevent recurrence of the issue, where possible. Residents have told us that reporting, and communication needs to include more than just emergencies and also address planned incidents (e.g., unit start-ups and shut-downs). Members of the Aamjiwnaang community said they would like to know how incidents and emergencies

affect community members in real time and what is being done about it. There was a desire for a proactive notification system that does not need to be constantly checked (e.g., Facebook requires the user to constantly check in). Aamjiwnaang First Nation community members also stated they wanted to understand whose role or responsibility was what when an emergency was occurring.

Since the project's initiation, the Sarnia-Lambton Alerts system (formerly called myCNN) has expanded in scope and function. Many local industries now make use of the alert system to proactively notify the public of incidents. People can subscribe for alerts from an individual facility or from all participating industries. Alerts may be used to warn neighbours of upcoming flaring and explain the reason, let them know why an emergency vehicle was on-site at a facility, or clarify who to call for more information during an incident. Local residents have informed us that these improvements have made a positive difference and were an important step in the right direction. However, we have also heard that more needs to be done, for example including more information in notifications such as wind direction.

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4.0 Supplemental Material

Table 4. Odorous compounds permitted to released in the Sarnia area which have MECP odour thresholds, shown with the number of facilities permitted to release the compound and a description of the compound odour.

CAS RN	Contaminants with MECP limits based on odour	MECP limit	Type of limit	Limiting Effect	№ of emitting facilities	Odour Description
60-29-7	Ethyl ether	950 (10-minute)	Guideline	Odour	1	pungent, sweet
64-17-5	Ethanol (Ethyl alcohol)	19,000 (1-hour)	Guideline	Odour	14	alcohol, vinous
64-19-7	Acetic acid	2,500	Guideline	Odour	5	vinegar
71-36-3	Butanol, n-	2,100 (10-minute)	Guideline	Odour	22	alcohol, vinous
74-86-2	Acetylene	56,000	Guideline	Odour	4	Garlic, ethereal
75-15-0	Carbon disulphide	330	Guideline	Odour	4	Sweet, ethereal
75-18-3	Dimethyl sulphide	30 (10-minute)	Guideline	Odour	3	Sweet, ethereal, chloroform
75-50-3	Trimethyl amine	0.5 (1-hour)	Guideline	Odour	3	Fish, ammonia
78-83-1	Isobutanol	2,340 (10-minute)	Guideline	Odour	6	Sweet, musty, vinous
78-87-5	Propylene dichloride	2,400	Guideline	Odour	2	Chloroform, sweet
79-09-4	Propionic acid	100 (1-hour)	Guideline	Odour	1	Sharp, pungent rancid
79-41-4	Methacrylic acid	2,000	Guideline	Odour	1	Pungent, acrid
80-62-6	Methyl methacrylate	860	Guideline	Odour	3	acrid, fruity
91-20-3	*Naphthalene*	*22.5 (24-hr)*	Guidelines	*Health*	21	Mothball, coal-tar
		50 (10-minute)		Odour		

92-52-4	Biphenyl	60 (1-hour)	Guideline	Odour	4	Pleasant, distinctive
96-33-3	Methyl acrylate	4 (1-hour)	Guideline	Odour	2	acrid
98-01-1	Furfural	1,000 (1-hour)	Guideline	Odour	2	Peculiar, almond
100-41-4	Ethyl benzene	1,900 (10-minute)	Guideline	Odour	39	Gasoline
104-76-7	Ethyl hexanol, 2-	600 (1-hour)	Guideline	Odour	2	Oily, sweet, floral
107-98-2	Propylene glycol methyl ether	121,000 (10-minute)	Guideline	Odour	9	ethereal
108-10-1	Methyl isobutyl ketone	1,200	Guideline	Odour	17	Ketonic, fruity, pleasant
108-65-6	Propylene glycol monomethyl ether acetate	5,000	Guideline	Odour	13	Sweet, ethereal,
108-83-8	Diisobutyl ketone	*3500 (24-hr)*	Guidelines	*Health*	2	Sweet, peppermint
		649 (10-minute)		Odour		
108-88-3	Toluene	2,000	Guideline	Odour	36	Sweet, pungent, benzene
108-90-7	*Monochlorobenzene*	*3,500 (1-hour)*	Guidelines	*Health*	2	Sweet, almond, benzene
		4,500 (10-minute)		Odour		
110-12-3	Methyl-2-hexanone, 5-	630 (10-minute)	Guideline	Odour	7	Fruity
110-19-0	Isobutyl acetate	1,660 (10-minute)	Guideline	Odour	7	Fruity, floral, acetone
110-80-5	*Ethylene glycol ethyl ether (Cellosolve)*	*380 (24-hr);*	Guidelines	*Health*	1	Sweet, ethereal,
		1,100 (10-minute)		Odour		
110-86-1	*Pyridine*	*150 (24-hr);*	Guidelines	Health	1	Nauseating, fish,
		80 (10-minute)		Odour		
111-15-9	Ethylene glycol ethyl ether acetate (Cellosolve acetate)	540 (24-hr);	Guidelines	*Health*	1	Pleasant, fruity
		300 (10-minute)		Odour		
111-65-9	Octane	61,800 (10-minute)	Guideline	Odour	4	gasoline
111-76-2	*Ethylene glycol butyl ether (Butyl cellosolve)*	*2400 (24-hr);*	Guidelines	*Health*	7	Ethereal, rancid
		500 (10-minute)		Odour		
111-90-0	Diethylene glycol monoethyl ether	1,100 (10-minute)	Guideline	Odour	1	Sweet, pleasant
112-07-2	*Ethylene glycol butyl ether acetate (Butyl cellosolve acetate)*	*3250 (24-hr);*	Guidelines	*Health*	9	Fruity, sweet
		700 (10-minute)		Odour		
115-10-6	Dimethyl ether	2,100	Guideline	Odour	1	Ethereal
123-38-6	Propionaldehyde	10 (10-minute)	Guideline	Odour	2	Fruity, pungent, overpowering
123-42-2	Diacetone alcohol	1,350 (10-minute)	Guideline	Odour	2	Minty, pleasant
123-86-4	*Butyl acetate, n-*	*15,000 (1-hour);*	Guidelines	*Health*	25	Fruity
		1,000 (10-minute)		Odour		
124-18-5	*Decane, n-*	*60,000 (1-hour)*	*Guideline*	*Health & Odour*	4	gasoline
124-40-3	*Dimethyl amine*	*1,840 (1-hour)*	*Guideline*	*Health & Odour*	1	Ammonia, fish
140-88-5	Ethyl acrylate	4.5 (1-hour)	Guideline	Odour	2	Acrid, sour, pungent, “hot plastic”
141-78-6	Ethyl acetate	19,000 (1-hour)	Guideline	Odour	11	Fruity, ethereal
624-92-0	Dimethyl disulphide	56 (10-minute)	Guideline	Odour	1	Garlic, onion, nauseating

763-69-9	Ethyl-3-ethoxy propionate	200 (10-minute)	Guideline	Odour	10	fruity, unpleasant
1330-20-7	Xylenes	3,000 (10-minute)	Guideline	Odour	45	distinctive, sweet
7782-50-5	Chlorine	230 (10-minute)	Guideline	Odour	4	Pungent, suffocating, irritating, bleach
7783-06-4	*Hydrogen sulphide*	*7 (24-hr);*	Standards	*Health*	14	Rotten eggs
		13 (10-minute)		Odour		
74-93-1	methyl mercaptan	13 (10-minute)	Standard	Odour	3	Sharp, garlic, rotten cabbage,

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