Technical Backgrounder on

Multi-Source Air Dispersion Modelling

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1 Multi-source Air Dispersion Modelling - Overview

Multi-source modelling is a key tool that can help identify the combined impact of both industrial and non-industrial sources on air quality in a community. It was used to delineate geographic areas in Hamilton/Burlington and Sarnia/Corunna where risk management actions may be required as described in the Ministry of the Environment and Climate Change's (MOECC's) *Proposal for Cumulative Effects Assessment in Air Approvals* (Proposal) and *Discussion Paper: Cumulative Effects Assessment in Air Approvals*.

This Technical Backgrounder provides information on modelling inputs used in the multi-source modelling assessment for the Proposal including:

- Choice of Model
- Modelling Set-Up
- Model Inputs
- Source apportionment
- Assessing multiple contaminants
- Results (identified action areas)

This Technical Backgrounder includes detailed technical information and is intended for individuals with some knowledge of air dispersion modelling.

2 Selection of Model

2.1 Types of Models

There are a number of air quality models that exist and each predicts concentrations of contaminants in air. There are global, regional, and local scale air quality models. These are further discussed below. Computational Fluid Dynamic models can also be used since they allow the study of the flow around complex structures. However, these are not discussed in this document.

The selection of the model depends on the purpose of the assessment exercise. In addition, the amount of input and work required to run them varies tremendously and has to be considered when selecting a model. A local scale model can be run relatively quickly on a single computer, whereas, a regional model requires significantly larger inputs in terms of variables and computing time. These models all have their own purposes, which are related to the geographic scales that a study requires. The following provides a brief description of global, regional, and local scale air quality models.

Global Air Quality – Scale thousands of kilometers

An example of a global scale air quality model is the Global Environmental Multi-Scale Model (GEM). Global models are generally run by government bodies on a large scale and require input from various departments. These models look at large masses of air and pollution, trans-boundary and impacts which may occur over long distances (e.g. impact of sand storms in Africa on other continents).

Regional Air Quality Models – Scale hundreds of kilometers

Regional models are used to zoom in and scope down to a general geographical area (region) and study emissions from sources within the domain and their contribution to concentrations of contaminants in the area. These models, such as Community Multi-scale Air Quality (CMAQ), most commonly use a 12 km by 12 km resolution but more recently a higher resolution of 1 km by 1 km is possible. Regional scale models require the grouping of all sources into a “grid cell” from which the emissions occur. Based on recent developments, CMAQ is able to accommodate emissions from tall stacks (50 m and up). This particular model is capable of simultaneously handling multiple air pollutants and is used to determine air quality management scenarios for communities, provinces, regions and states. Regional models can be costly and are often run by environmental protection agencies.

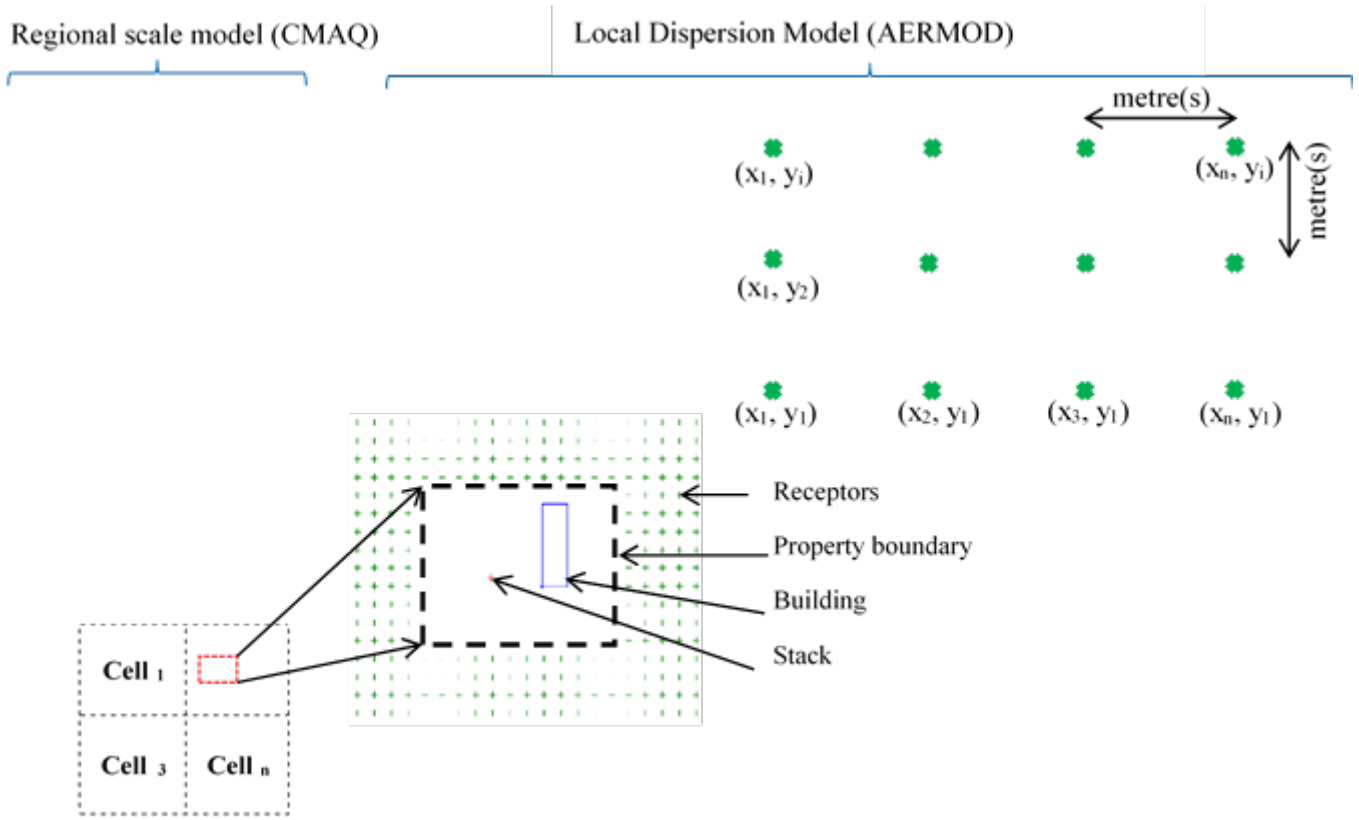
The findings in the regional air quality modelling may outline general areas of interest that may require a closer look at a local scale. Figure 1 shows a simple industrial complex with a stack and building and surrounding receptors which can be metres apart. The footprint of the modelling domain in a local scale model can be a fraction of a cell within the regional model. Global and regional scale models are not an effective tool to understand air pollution effects on a local scale. In a regional model, it is possible for a single grid cell to contain a number of different industrial and non-industrial sources which emit similar contaminants into the air. The

emissions from all sources within a cell are summed up and then spread across that grid cell. A single grid cell in a regional model, for which a single concentration of a pollutant is calculated, does not provide the necessary resolution to assess local air quality impacts.

Local Air Quality Models – Scale kilometers down to meters

To improve on the modelling resolution, another suite of local-scale models can be used for modelling domains up to 50 km by 50 km. They include the United States Environmental Protection Agency (US EPA) approved models AERMOD and CALPUFF. These air dispersion models can be used to predict concentrations for a specific set of grid points that can be within meters of each other. These local scale models capture terrain, and the impact of buildings on a stack or source, allowing the model to calculate the local concentration of a contaminant.

Figure 1: Footprint of a local scale model on the regional scale model



2.2 Selected Dispersion Model (AERMOD)

Dispersion models have different capabilities and specialties. The choice of which dispersion model to use depends on the needs of the air quality assessment. As described above, models such as AERMOD and CALPUFF are appropriate to assess local scale impacts whereas regional models such as Community Multi-scale Air Quality (CMAQ) are more commonly used for regional air issues. For the purposes of the Proposal, AERMOD was selected to be the

preferred dispersion model. This is in part because industrial facilities assessed as part of this exercise are already required to use AERMOD under Ontario Regulation 419/05: Air Pollution – Local Air Quality.

Both AERMOD and CALPUFF models accept detailed source information: location, height, temperature, diameter, velocity for stack type of sources, and near-by structures for building downwash. The source parameters necessary to run AERMOD are the same requirements as those used to run CALPUFF. Once this information is collected, the input files can be generated for use with either model. CALPUFF may be selected when emissions from tall stacks are modelled and plumes can de-attach. This phenomenon is not observed by AERMOD. For example, CALPUFF may be a preferred model when there is a large body of water nearby and/or complex terrain. In addition, these models incorporate local terrain and meteorological data as well as building downwash effects for stacks. There are extensive provincial guidelines put in place which identify acceptable setup of the model for regulatory purposes.

For non-industrial sources such as mobile (highways, rivers, and rail), general urban and rural activities, airports etc., there are acceptable techniques developed to treat these sources in AERMOD and CALPUFF. At a minimum, the urban and rural general activities can be grouped into an area source.

At this time, the ministry has selected AERMOD for use in the Proposal.

The modelling for the Proposal was completed using the US EPA steady state model AERMOD version 13350. AERMOD was developed by the AERMIC (American Meteorological Society (AMS)/US EPA Regulatory Model Improvement Committee). AERMOD is designed for short-range dispersion of air pollutants.

The building downwash effect on stacks was calculated by using the Building Profile Input Program for PRIME (BPIPPRM) version 04274. The output from the BPIPPRM is readily acceptable by AERMOD. BPIPPRM calculates downwash values for input into the PRIME algorithm for each point source (stack) entered into AERMOD.

3 Model Set-up

Dispersion models inputs include information about the sources, terrain and meteorological data. The inputs associated with the multi-source models are summarized below.

A summary of the industrial sources used in the models is included in the following sections. Small to medium sized industrial facilities were not included in this analysis. Detailed information about the sources were incorporated based on available Emission Summary and Dispersion Modelling Reports. Stacks were modelled as point sources and buildings and tanks were modelled as volume sources.

Non-Industrial sources were also considered and included:

- off-road vehicles such as fork lifts, lawn mowers, etc.
- waterway traffic
- highways as a series of area sources (Area-line sources as per AERMOD View Interface)
- airport as volume source
- water, urban and rural areas as a polygon area sources

Emission rates and source characteristics for non-industrial sources were obtained from the 2008 Great Lakes Regional Air Toxic Emissions Inventory.

Major highways in Sarnia/Corunna and Hamilton/Burlington were included as part of non-industrial sources. Tailpipe emissions factors were generated using MOBILE6.2c (Sarnia) and MOVES2014a (Hamilton). Traffic information such as vehicle count, travel speed, and vehicle mix were utilized along with tailpipe emission factors to determine appropriate emission rates for the modelled highways.

Local publicly available monitoring data was also used to compare to the modelled results. For more information, see Chapters 3 and 4.

3.1 Meteorological Data

The meteorological data was preprocessed using AERMET version 13350. AERMET, the meteorological pre-processor for AERMOD, uses meteorological data from both a surface station and upper air soundings to calculate parameters required to drive AERMOD such as mixing heights, friction velocity, Monin-Obukov length and surface heat flux. Meteorological station data for the model domain was generated using the Weather Research and Forecasting Model (WRF) model, a mesoscale numerical weather prediction system developed by the US National Center for Atmospheric Research (NCAR). The pseudo-meteorological station data for the modelling domain along with localized land use was used to run AERMET in order to produce AERMOD-ready meteorological datasets. A comparison of the meteorological data at the pseudo and observed stations indicates that the wind patterns and speeds are reasonably consistent.

Computer generated pseudo-meteorological station data was used for this multi-source model assessment instead of observed data primarily because:

- The sources are located over a relatively large area and AERMET is only designed to accept one surface and one onsite meteorological station. Thus using a pseudo surface meteorological station to represent the average conditions over the large domain for this assessment is reasonable.

- In the case of Sarnia, although there are observed meteorological data available from multiple meteorological stations in the modelling domain, it is a challenge to

select a single station to represent the meteorological conditions applicable to all the facilities. Also, the terrain is somewhat variable (i.e. stations located in close proximity to the St. Clair River will be significantly affected by the channeling feature of the river).

- In the case of Hamilton, there is limited observed meteorological data available in the area, and the surrounding terrain is quite complex (i.e. Niagara Escarpment and Hamilton Harbour).

Figures 2 and Figure 3 show comparison of the WRF generated meteorology to the local meteorological stations. In general, the dominant wind directions are similar but the average wind speeds are higher using WRF. A full year of meteorological data was generated for the pseudo station.

The approach generally included:

- Extract the surface and upper air variables
- Reformat these variables into pseudo-surface (CD144 format) and upper air (Forecast Systems Laboratory (FSL) format) station data, that AERMET can take in
- Select pseudo-surface and upper air station data for AERMET
- Run AERMET with localized land use to generate AERMOD-ready meteorological datasets
- QA/QC of the WRF output (e.g. removal of overlap days/hours)
- wind patterns cross-checks (i.e. wind rose/frequency analyses)

Figure 2: Observed and WRF derived wind rose for Hamilton

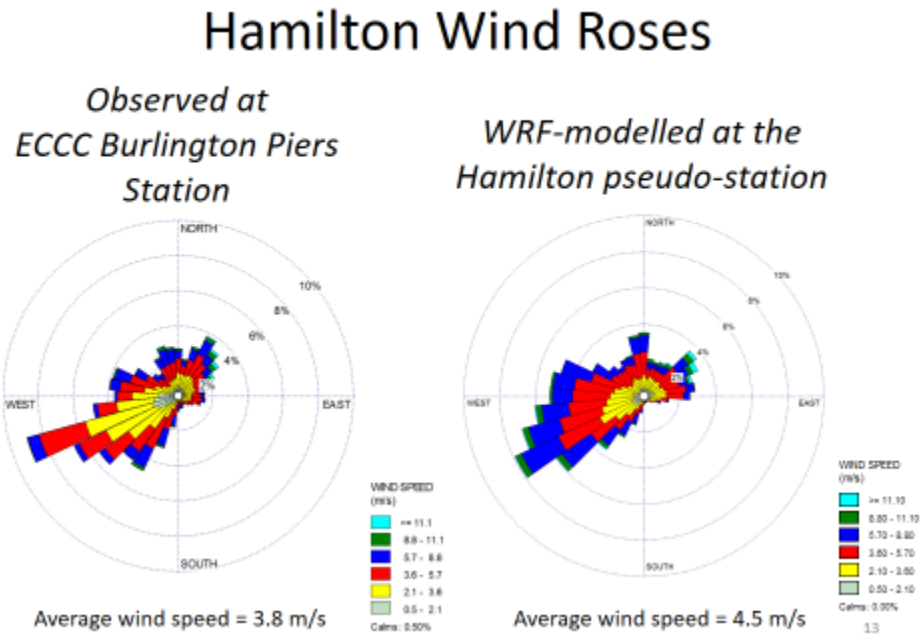
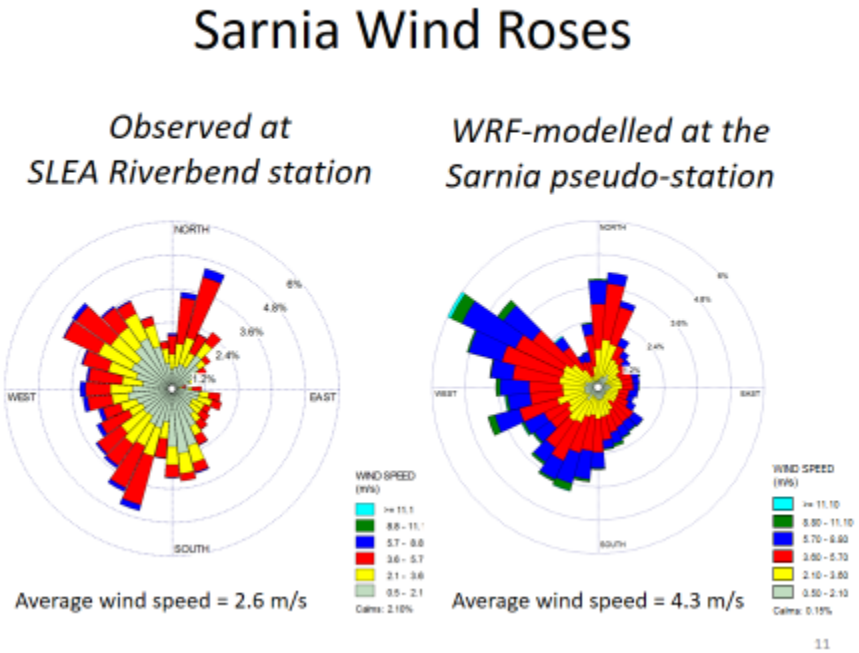


Figure 3: Observed and WRF derived wind rose for Sarnia



3.2 Terrain

The terrain data was preprocessed by AERMAP version 11103.The preprocessor generates location and height data for each receptor location and source. It simulates effects of air flowing over hills or splitting to flow around hills. Terrain data is a combination of North America Datum (NAD) 83 for the Canadian portion of the domain and World Geodetic System (WGS) 72 for the USA portion of the domain, both 1 degree Digital Evaluation Model (DEM) type.

The modelling domains were well within the generally accepted steady state limitations of the AERMOD model. The receptor grids of various densities were used to reduce run time and at the same time smooth out concentration plots. This approach allowed easier verification that a true maximum concentration has been captured.

A number of sources were modelled with varying emission rates. For example, the St. Clair River waterway traffic was modelled to be off during winter season (St Lawrence passage report) due to the river freezing. The urban and rural sources were also modelled to reflect seasonal changes. The highway sources were modelled to reflect the daily traffic.

4 Emission Inputs

This section describes the emission inputs used in the multi-source models for Sarnia/Corunna and Hamilton/Burlington.

4.1 Sarnia/Corunna

Multi-source modelling in Sarnia/Corunna was only conducted for benzene and not for benzo[a]pyrene. In 2013, there were 5 industries that reported emissions of benzo[a]pyrene to the National Pollutant Release Inventory (NPRI). Emission rate data for benzo[a]pyrene for non-industrial sources were not available for the same time period. Based on the seasonal monitoring patterns of benzo[a]pyrene, some non-industrial emissions of benzo[a]pyrene may be due to residential wood heating. In addition, the ministry previously determined that the industrial emissions of benzo[a]pyrene did not result in exceedances of the 2016 benzo[a]pyrene air standard significantly beyond the property line of the facilities. Further details are outlined in the Rationale Document for the Technical Standard for the Petroleum Refinery industry, July 2016. For these reasons, multi-source modelling was not conducted for benzo[a]pyrene in Sarnia/Corunna.

Tables 1 and 2 outline the industrial and non-industrial inputs to the multi-source model developed for benzene in Sarnia/Corunna.

Table 1: Sarnia/Corunna sources of Benzene

Sources	Detail	Source of Emissions (g/s)	Source Inputs (SO)
Large Industry* (Canada)	- 3 petroleum refineries - 4 petrochemical plants	- ESDM, 2013** - ESDM, 2013** ** values compared against on site monitors	- 775 point sources (storage tanks with passive vents) - 58 volume sources - 64 area sources - 27 polygon area sources - 7 volume (volume line tool in AERMOD View)
Off – road vehicles	e.g.: fork lifts, lawn mowers, etc.	Great Lakes Inventory, 2008	- 2 polygon area sources
Non-industrial sources	- Highways 402, 40, I-69 and I-94 - Urban and rural activities - Waterway traffic along St. Clair River	- See Table 2 - Great Lakes Inventory, 2008 - Great Lakes Inventory, 2008	- 55 area sources (area-line as per AERMOD View) - 2 area sources - 1 area sources (area-line as per AERMOD View)

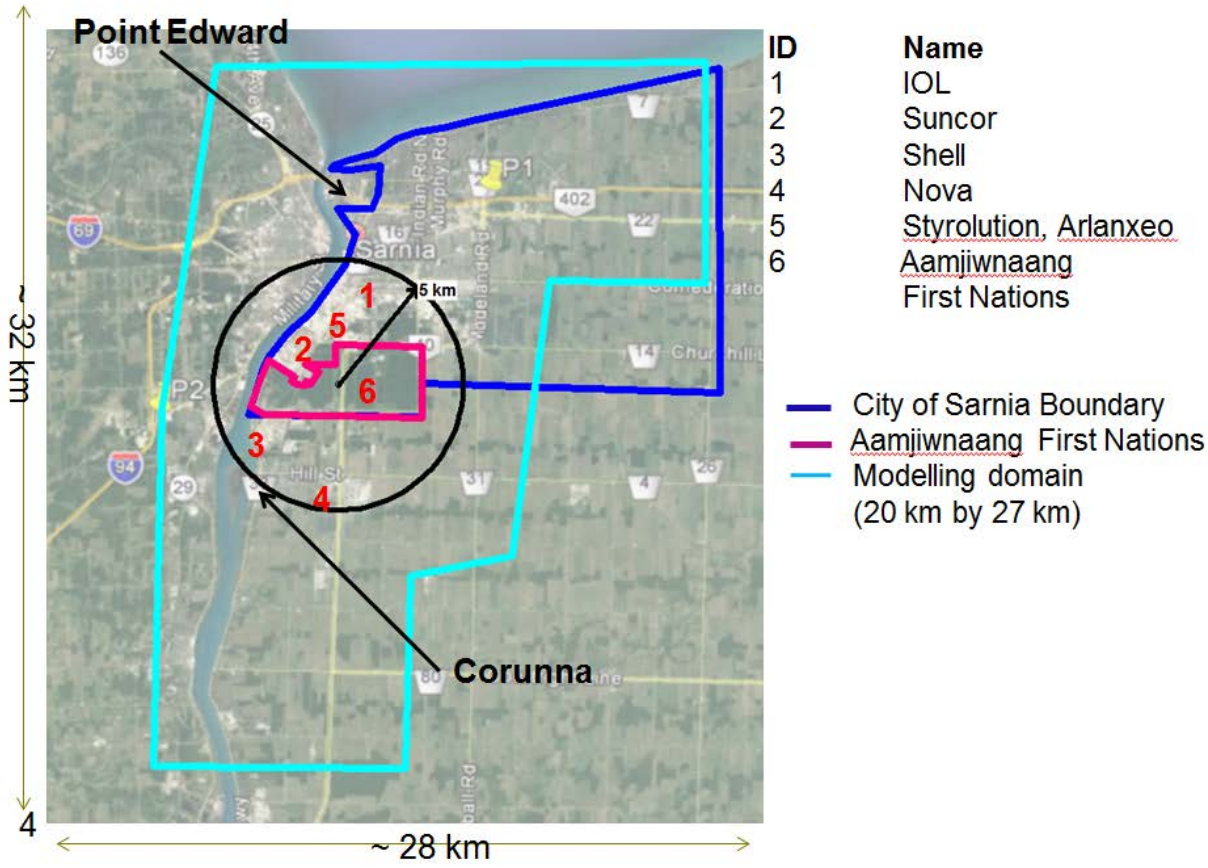
**Small to medium industrial sources were not included.*

Table 2: Roadway model setup, Sarnia/Corunna for Benzene

Criteria	Detailed Criteria	Sarnia
Tailpipe Emission Factor	Emission Factor	MOBILE6.2C
Traffic Information	Vehicle Counts	- Michigan Department of Transportation (MDOT, 2011) - Annual Average Daily Traffic (AADT, MTO, 2012)
	Hourly Distribution	Daily average emission rate was used
	Vehicle Mix	MTO Commercial Vehicle Survey (2006)
	Average Speed	Posted speed
Other	Variable Emission	N/A

Figure 4 shows the modelling domain for Sarnia/Corunna and the approximate locations of the key benzene sources that were included in the multi-source model. For reference, the location of the Aamjiwnaang First Nation is also shown.

Figure 4: **Sarnia/Corunna modelling domain (approximate locations)**



4.2 Hamilton/Burlington

Tables 3, 4 and 5 outline a summary of the benzene and benzo[a]pyrene emission sources used in the Hamilton/Burlington multi-source model.

Table 3: Hamilton sources of Benzene

Sources	Detail	Source of Emissions (g/s)	Source Inputs (SO)
Large Industry* (Canada)	- 2 integrated iron and steel mills - 1 chemical raw materials manufacturer - 1 inorganic chemical manufacturer	- Refined ESDM (2013) in support of SSS **. - Refined ESDM (2013) in support of SSS. - ESDM (2012)	-Total of 100 point sources -136 volume sources - 7 volume sources (line volume in AERMOD View)
Off-Road vehicles	E.g.: fork lifts, lawn mowers, etc.	Great Lakes Inventory, 2008	Captured under Urban/Rural sources
Non-industrial sources	Highways: Burlington Bay James N. Allan Skyway, Queen Elizabeth Way, Red Hill Parkway, Lincoln M. Alexander parkway, 403 - Hamilton Airport - Urban/Rural - Waterway traffic	- See Table 4 - Great Lakes Inventory, 2008 - Great Lakes Inventory, 2008 - Great Lakes Inventory, 2008	- 37 area sources (area-line in AERMOD View) - 1 volume source - 2 polygon area sources - 1 polygon area source

** Small to medium industrial sources were not included.*

*** SSS Site Specific Standard*

Table 4: Hamilton sources of benzo[a]pyrene emissions

Sources	Detail	Source of Emissions (g/s)	Source Inputs (SO)
Large Industry* (Canada)	-2 integrated iron and steel mills - 1 chemical raw materials manufacturer -1 inorganic chemical manufacturer	- Refined ESDM (2013) in support of SSS **. - Refined ESDM (2013) in support of SSS. - ESDM (2012)	-Total of 28 point sources - 160 volume sources - 5 volume sources (line volume in AERMOD View)

** Small to medium industrial sources were not included.*

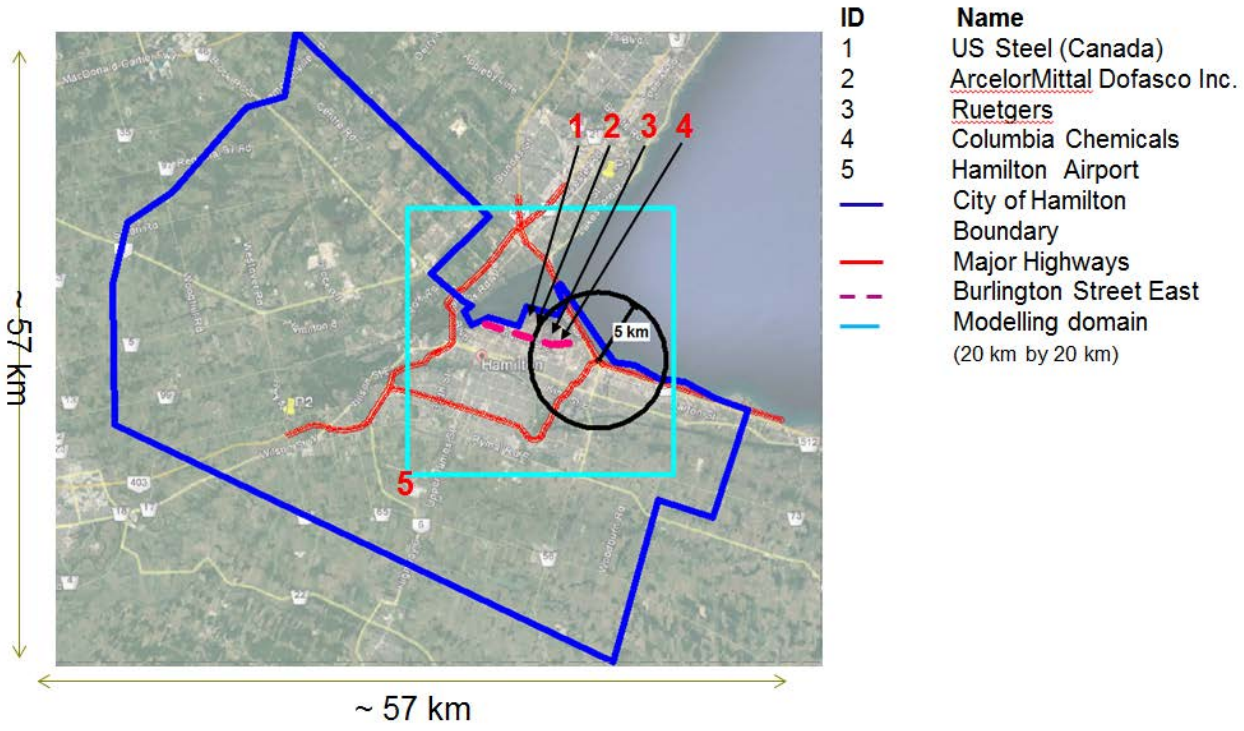
*** SSS Site Specific Standard*

Table 5: Hamilton Roadway model setup for Benzene

Criteria	Detailed Criteria	Hamilton
Tailpipe Emission Factor	Emission Factor	MOVES2014a
Traffic Information	Vehicle Counts	Annual Average Daily Traffic (AADT, MTO 2012)
	Hourly Distribution	Traffic Engineering Handbook (ITE), 6th Edition March 2009
	Vehicle Mix	MTO Commercial Vehicle Survey (2006)
	Average Speed	MTO Travel Time Study 2008
Other	Variable Emission	SEASONHR (4 Seasons plus Hourly variation)

Figure 5 shows the modelling domain for Hamilton/Burlington and the approximate locations of the key benzene sources that were included in the MSM. For reference, the location of Burlington Street East is also shown.

Figure 5: Hamilton modelling domain (approximate locations)



The multi-source model for the Hamilton area included major sources within 20 to 20 km radius consistent with AERMOD's limitations.

5 Modelling Results

Table 6 lists the multi-source modelling scenarios conducted for the proposal.

Table 6: Multi-source Modelling Case Studies

Scenario Reference	Location	Substance and Effects	Modelling Average Times
1A	Sarnia	Benzene (Carcinogen)	Annual
2A	Hamilton	Benzene (Carcinogen)	Annual
2B	Hamilton	Benzo[a]pyrene (Carcinogen)	Annual
3	Hamilton	Benzene + Benzo[a]pyrene (Multi-Pollutant Cancer Risks)	Annual

Figure 6 shows the modelled concentration results for scenario 1A (benzene in Sarnia). The MSM results are expressed as ground level concentration plots of the annual average benzene concentration. In the case of benzene two monitoring stations exist in the area and their annual average values were tabulated along with modelled values for comparison.

Figure 6: Scenario 1A, concentration plot of annual benzene ground level, Sarnia/Corunna

Legend

>AAQC to 10x AAQC

>10x AAQC to 100x AAQC

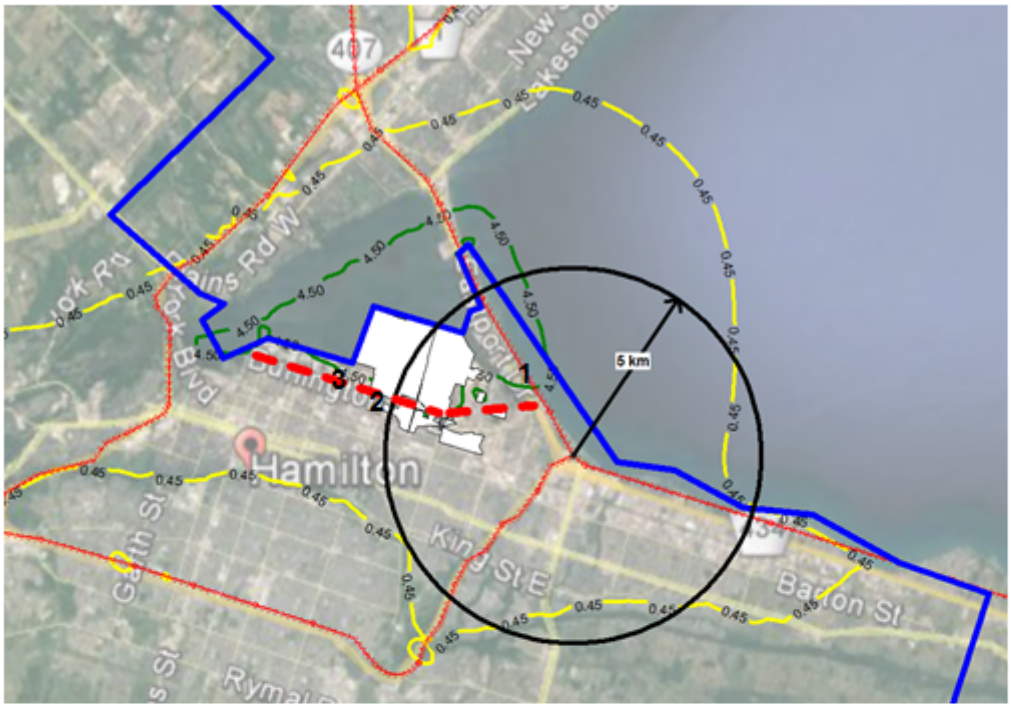
Note: Maximum modelled cumulative ~3x AAQC

Monitoring station data

Annual average concentration of benzene (µg/m³)						
Station ID	2009	2010	2012	2013	2014	Modelled
1-61004	0.85	0.961	0.903	0.820	1.007	~0.4
2-61007	0.510	1.234	1.122	0.997	-	~0.5

Figures 7 and 8 show concentrations resulting from the modelling for scenario 2A (benzene in Hamilton) and 2B (benzo[a]pyrene in Hamilton). The multi-source modelling results are expressed as ground level concentration plots of annual average benzene and benzo[a]pyrene concentrations. Information from local monitoring stations was tabulated along with the modelled values for comparison.

Figure 7: Scenario 2A, concentration plot of annual benzene ground level, Hamilton

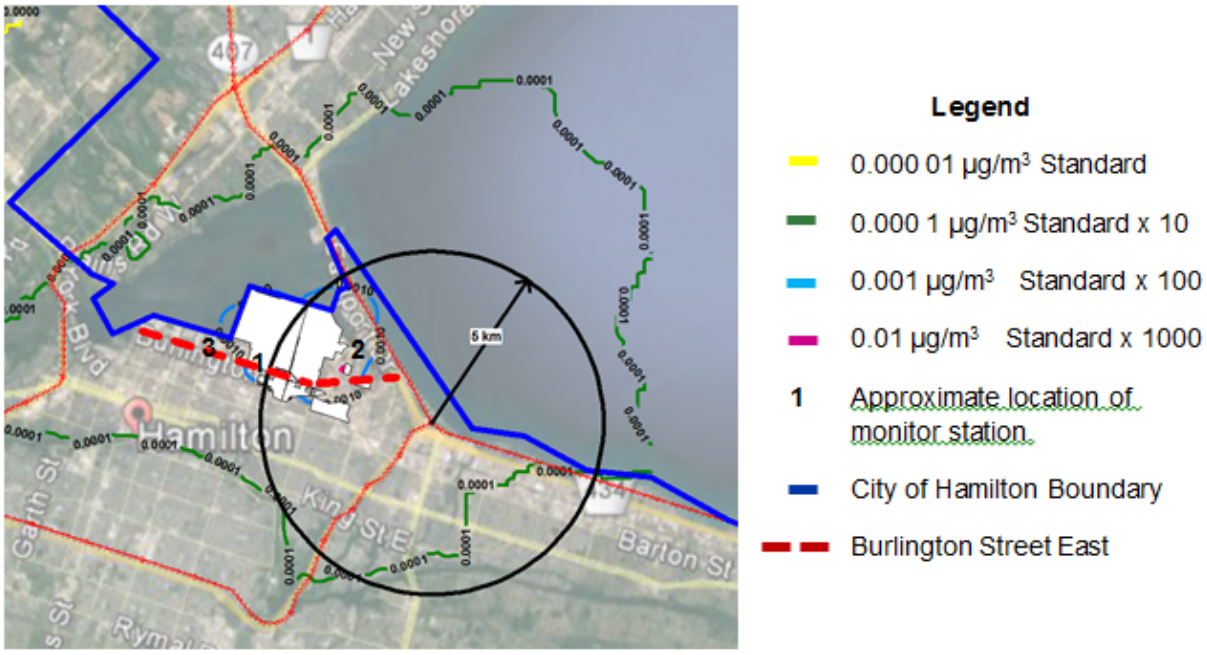


Legend

- 0.45 µg/m³
- 4.5 µg/m³
- 45 µg/m³
- 1 Approximate location of monitor station
- City of Hamilton Boundary
- Burlington Street East

Annual average concentration of benzene (µg/m³)					
Monitor Station	**2010**	**2011**	**2012**	**2013**	**Modelled**
1-29102	2.5	2.0	1.6	1.3	5
2-29113	3.7	1.8	3.3	3.1	3.5
3-29567	1.9	1.5	1.8	1.7	3

Figure 8: Scenario 2B, concentration plot of annual benzo[a]pyrene ground level, Hamilton



Annual average concentration of benzo(a)pyrene (ng/m³)					
Monitor Station	**2010**	**2011**	**2012**	**2013**	**Modelled**
1-29113	1.44	1.08	0.86	0.54	1
2-29547	1.40	1.53	1.50	1.22	1.5
3-29567	1.02	0.80	1.84	1.06	0.8

6 Source Apportionment

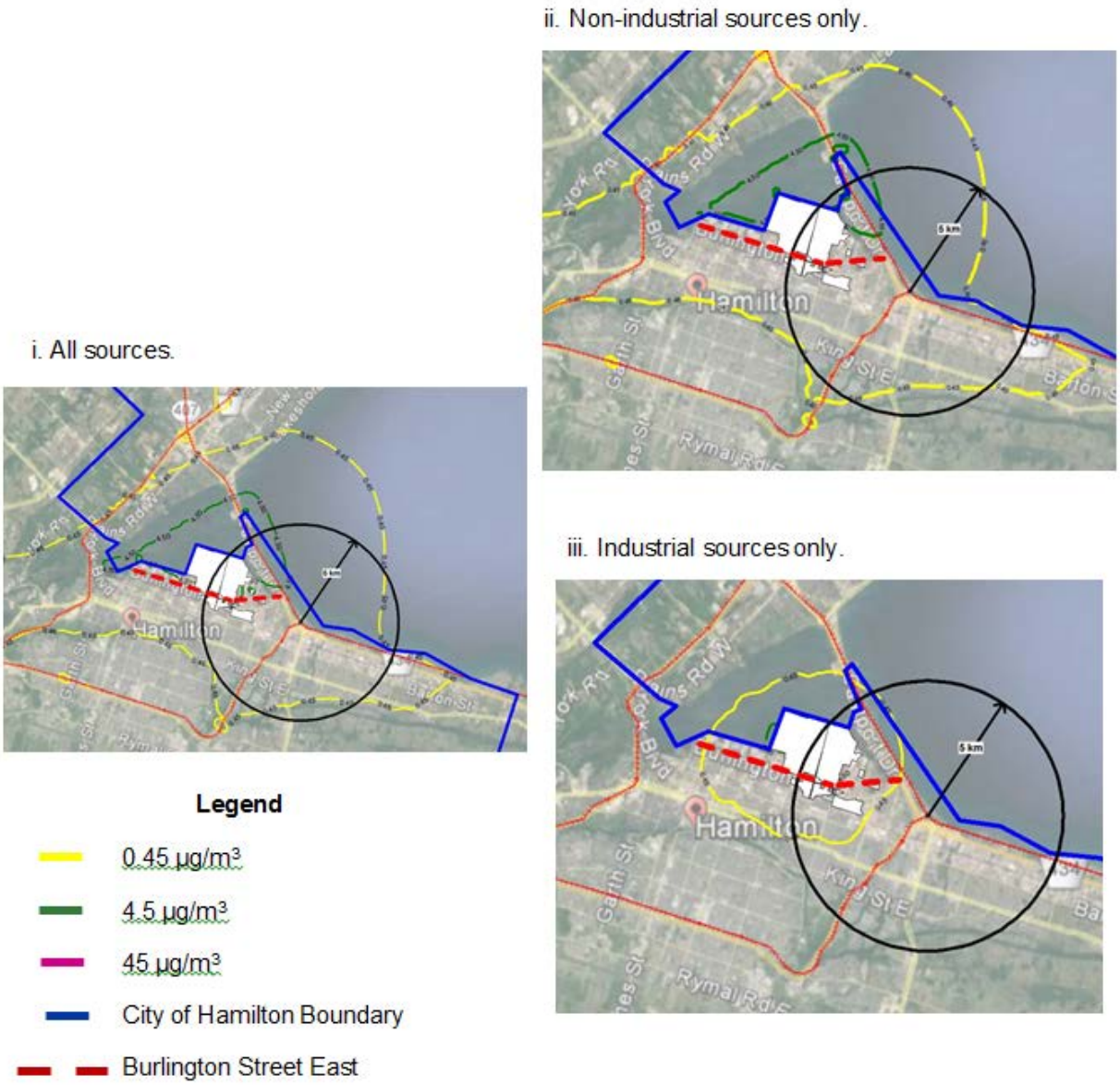
6.1 Tool for source apportionment

Source apportionment is an approach used in local scale dispersion models to determine the dominant sources. The AERMOD or CALPUFF input files can be set up to specifically capture grouped or individual sources and their modelled concentration contribution. This is possible due to the fact that these models incorporate source characteristics (e.g., stacks, structures, etc.). This in turn can be compared to overall modelled concentrations when all sources emit at the same time in a specific scenario.

Source apportionment can be used to determine major sources and study contribution of a source to the total cumulative concentrations of contaminants in air in a geographic area. In the multi-source models, the contributions from industrial sources alone and non-industrial sources alone were also assessed.

The local scale dispersion models can be used to generate source apportionment concentrations contour plots. For example, Figure 9 shows source apportionment for scenario 2A in Hamilton.

Figure 9: Scenario 2A, concentration contour plot of modelled, annual, ground level benzene, non-industrial and industrial source apportionment, Hamilton



7 Assessing Multiple Contaminants

A multi-source model can also be used to assess compounds with similar effects by grouping them together for assessment purposes. For example, since both the benzene and benzo[a]pyrene air standards are based on carcinogenic effects, these contaminants can be summed and assessed together. There are two ways to do this:

1. By multiplying the predicted concentration of a contaminant (generated by the model) by its unit cancer risk and summing the product for each contaminant; or
2. To normalize emission rates that can be added together to obtain isopleths that represent the combined cancer risk (e.g. 3 in 1 million).

Both approaches are described below. The ministry tested both approaches and compared results before adopting Approach 2, as it provided the same results as Approach 1 with fewer post-processing steps required.

Approach 1:

For single contaminants, Lifetime Incremental Cancer Risk Level = Concentration of the contaminant in the environment (C1) x its unit cancer risk (UCR1) or concentration of a contaminant in the environment divided by an air standard set at a given risk level.

For multiple contaminants – sum of the cancer risk levels CCR = C1 X UCR1 + ... + (Cx X UCRx)

where:

- C1 = Concentration of contaminant 1
- Cx = Concentration of the xth contaminant
- UCR1 = unit cancer risk contaminant 1
- UCRx = unit cancer risk of xth contaminant

Minnesota, U.S. does this summation of cancer risks for assessment of cancer risk for specific locations in Minneapolis. Ontario, Wisconsin, and the U.S. EPA use a target cancer risk of 1 in 1 million for each individual contaminant. Wisconsin uses a total target cancer risk for all summed contaminants of 1 in 100,000.

In Ontario, the Ambient Air Quality Criteria (AAQC) for benzene and benzo[a]pyrene reflect a lifetime incremental cancer risk of 1 in 1 million. Modelled concentrations can also be divided by an AAQC set at 1 in 1 million incremental cancer risk to calculate associated cancer risk (e.g., a contaminant in air with a concentration of 5 times the AAQC would be associated with an incremental lifetime cancer risk of 5 in a million). This ratio can be summed for multiple contaminants and expressed as cumulative cancer risk. In this context, the modelled cumulative incremental cancer risk assumes a person is exposed continuously over a lifetime to the air concentrations generated by the multi-source model.

Approach 2:

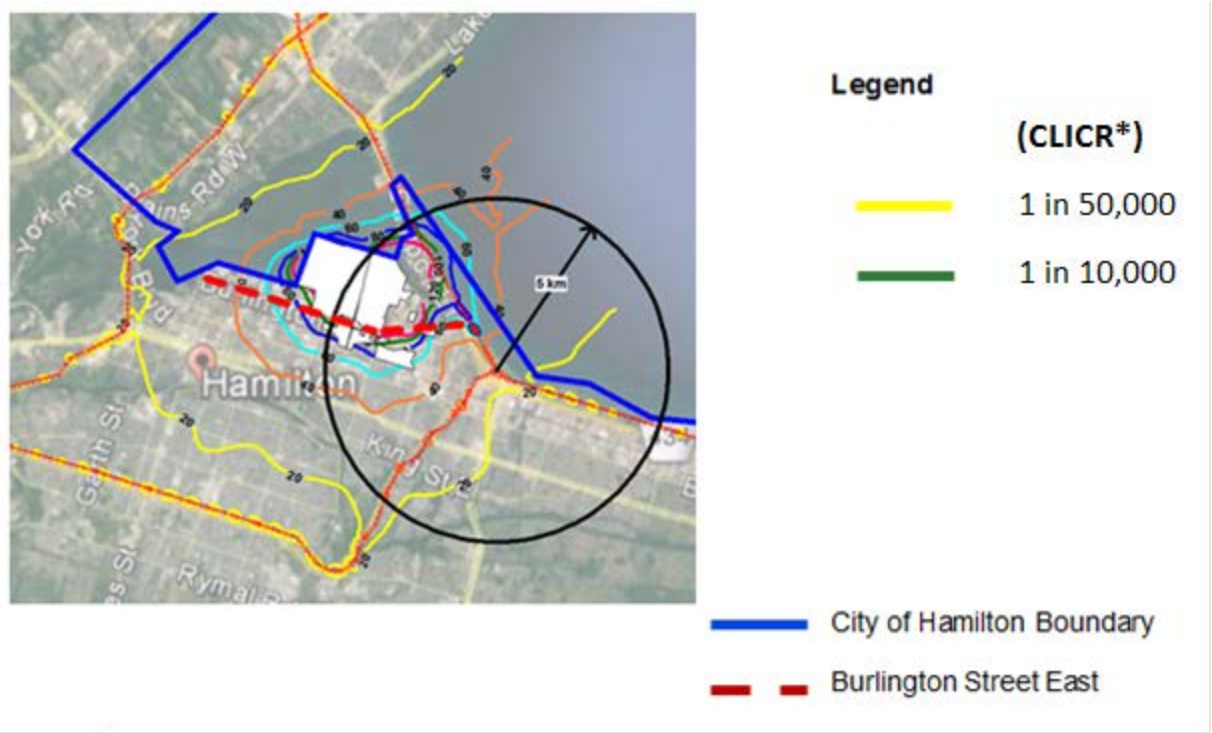
In this approach, the emission rate (g/s) for each contaminant is divided by its AAQC and then summed. These normalized values are then entered into the model as a surrogate emission rate, along with all the other modelling inputs such as source flow rates, resulting in predicted incremental cumulative cancer risk at modelled receptor points.

	Benzene:	B(a)P:
AAQC, annual:	B = 0.45 $\frac{\mu g}{m^3}$	BaP= 0.000 01 $\frac{\mu g}{m^3}$
Emission rate:	B $\frac{g}{s}$	BaP $\frac{g}{s}$
Normalized:	N(B) = $\frac{B\ \frac{g}{s}}{0.45\ \frac{\mu g}{m^3}}$	N(BaP)=$\frac{BaP\ \frac{g}{s}}{0.000\ 01\ \frac{\mu g}{m^3}}$

- Enter the normalized emissions into the model = N(B) + N(BaP)
- The model predicts a combined incremental cancer risk expressed as a probability of X people in the population of one million.
- Cancer risks can be plotted as isopleths (e.g. 10, 80, 100 per million).

This approach is illustrated in Figure 10 for combining benzene and benzo[a]pyrene in Hamilton. Note that for these contaminants in Hamilton, the points on the isopleth are based on annual averages using one year of meteorological data.

Figure 10: Modelled benzene and benzo[a]pyrene as cumulative lifetime incremental cancer risk, Hamilton.



* CLICR: Cumulative lifetime incremental cancer risk is the calculated additional risk of cancer from a continuous lifetime exposure to benzene and benzo[a]pyrene at the modelled levels.

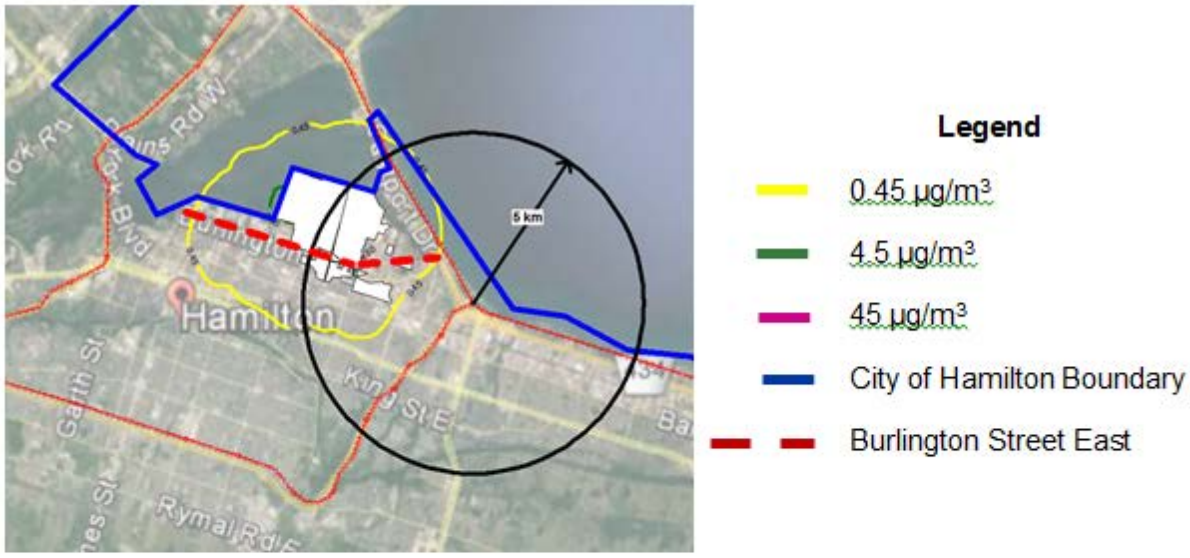
8 Assessing Multiple Contaminants and Projected Concentrations

Dispersion models can simulate the current state of air quality, but can also be used for forecasting purposes or simulations of scenarios. For example, facilities in the Hamilton area are operating under site-specific standards and are currently implementing required actions to address benzene and benzo[a]pyrene emissions. This information was used to project the changes in concentrations 5 years from now.

Figure 11 is a plot of benzene concentration contours of modelled, annual, ground level concentrations of benzene showing current and 5 year projection for Hamilton.

Figure 11: Scenario 2A, concentration contour plots of modelled, annual, ground level benzene, industrial sources only, 5 year projection, Hamilton.

Current time, industrial sources only.



Projected 5 years, industrial sources only.

Figure 12 is a plot of benzo[a]pyrene concentration contours of modelled, annual, ground level concentrations of benzo[a]pyrene showing current and 5 year projection for Hamilton.

Figure 12: Scenario 2B, concentration contour plots of modelled, annual ground level benzo[a]pyrene, industrial sources only, 5 year projection, Hamilton.

Current time, industrial sources only.

Projected 5 years, industrial sources only.

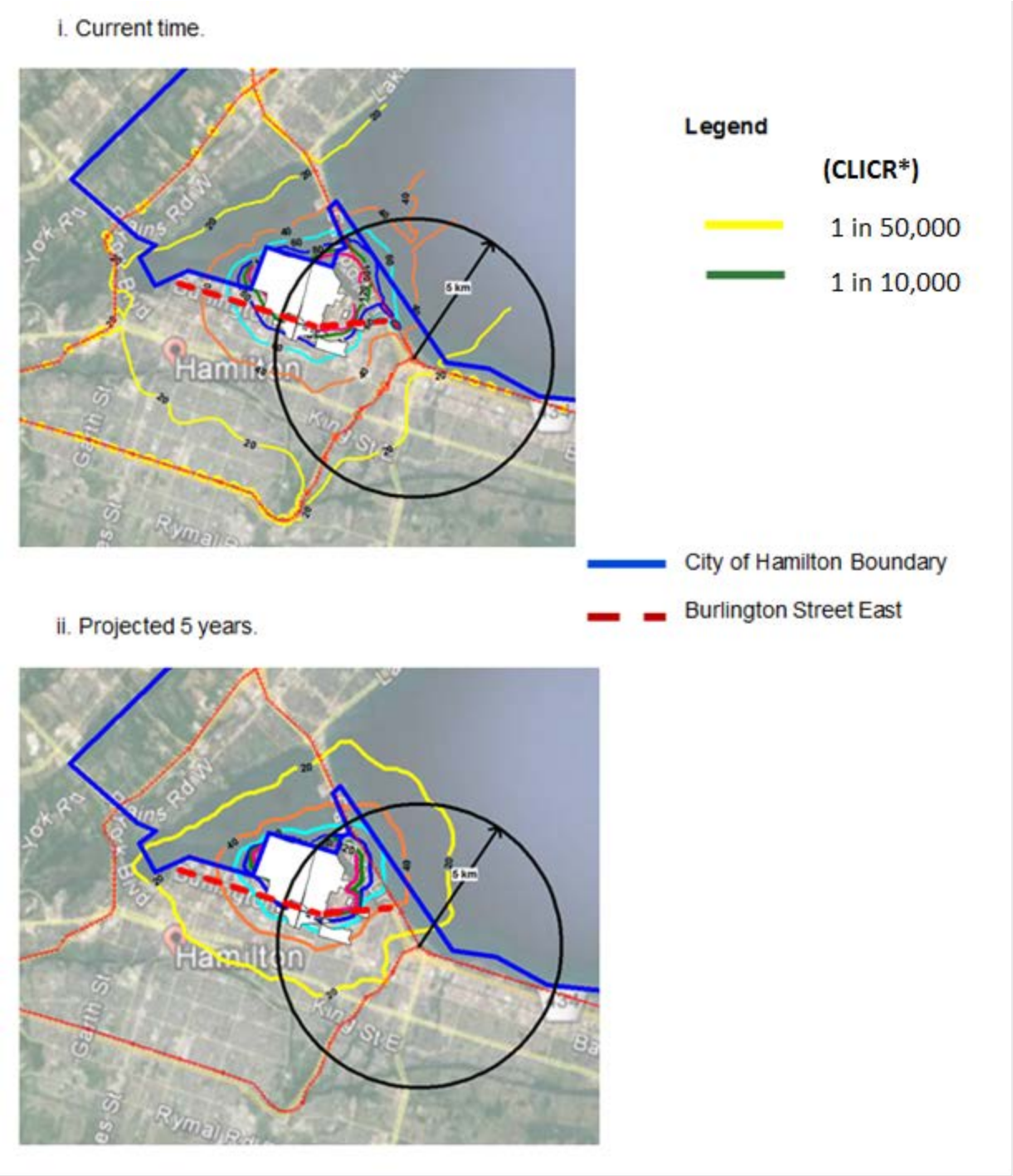
Legend

- 0.000 01 µg/m³ Standard
- 0.000 1 µg/m³ Standard x 10
- 0.001 µg/m³ Standard x 100
- 0.01 µg/m³ Standard x 1000

- City of Hamilton Boundary
- Burlington Street East

Figure 13 shows the projected 5 years change in concentration for Hamilton. The figures show plot of modelled, annual, combined risk for benzene and benzo[a]pyrene, Hamilton.

Figure 13: Plot of modelled, annual, cumulative lifetime incremental cancer risk (benzene and benzo[a]pyrene) at current time and projected 5 years, Hamilton.



* CLICR: Cumulative lifetime incremental cancer risk is the calculated additional risk of cancer from a continuous lifetime exposure to benzene and benzo[a]pyrene at the modelled levels.

Although this is an example of projected contours of 5 years in the future for Hamilton, this approach could also be done in Sarnia once more information is available. As part

of the Petroleum Refining – Industry Standard and Petrochemical – Industry Standards additional monitoring information will be collected and could be used to inform a future projected scenario.

9 Resulting Action Level Diagrams

The above results have been translated into maps that identify areas that require actions under the proposed policy. Each action level area is identified based on the modelled contours from the multi-source models and Action Levels identified in the Proposal. Because there is always some uncertainty with air dispersion modelling, the areas defined by the action levels do not reflect actual exposure at any given location but can be used to identify the need for risk management measures. The ministry is working on creating an interactive tool whereby a street address or co-ordinate can be entered and the associated action level will be provided.

Figure 14: Hamilton/Burlington Action Level Areas for the Combined Risk of Benzene and Benzo[a]pyrene

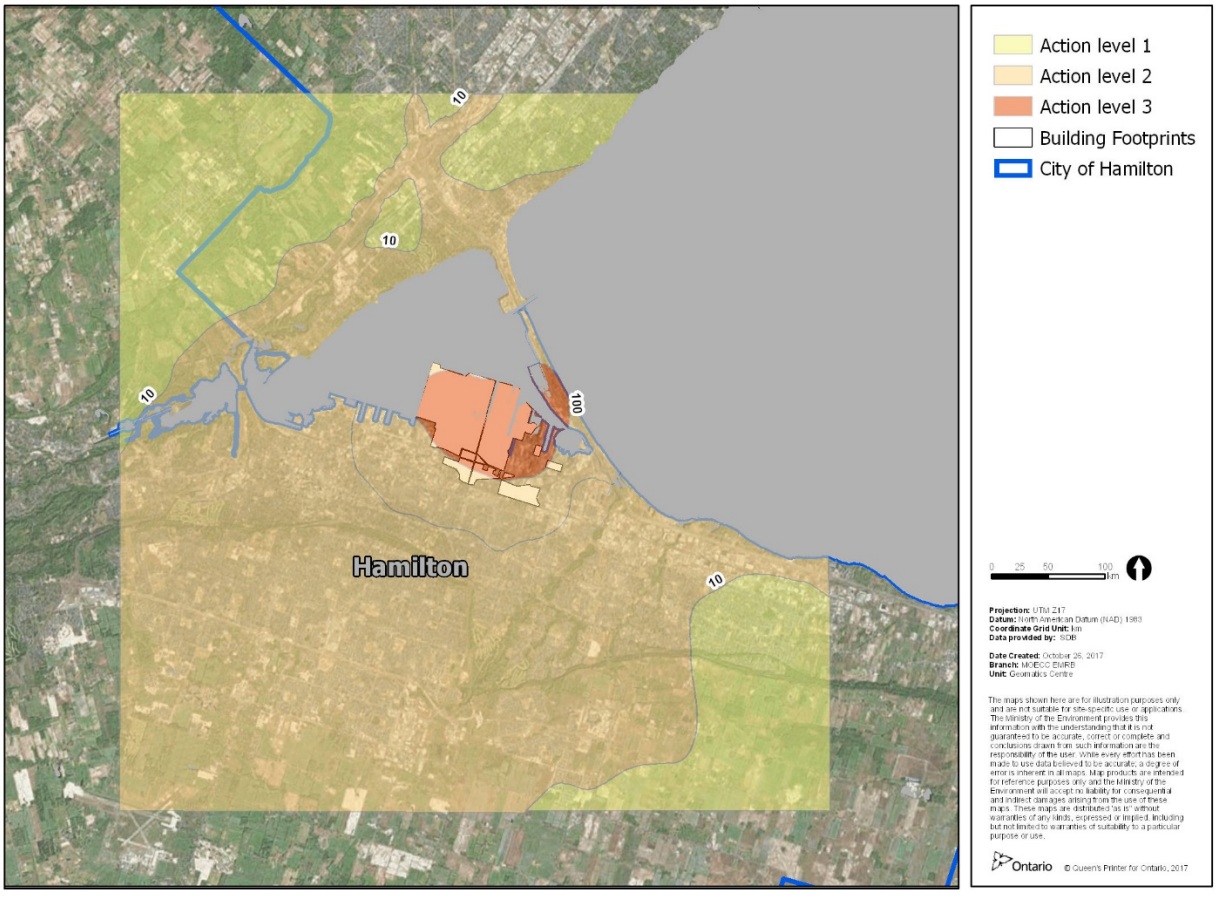


Figure 15: Sarnia/Corunna Action Areas for Benzene