FIGURES

TABLES

E1 MOECC Technical Bulletins

This section focuses on bulletins used to drinking water threats assessment of the Assessment Report (**Chapter 5**) in the four vulnerable areas:

- Highly Vulnerable Aquifers (HVA);
- Intake Protection Zones (IPZs); and
- Wellhead Protection Areas (WHPA) – not applicable in Central Lake Ontario Source Protection Area (CLOSPA).

E1.1 Objectives

The objective of the drinking water threats assessment is to complete water quantity and quality risk assessments to identify any activity, condition and issue that could stress or contaminate the municipal drinking water supplies may be associated with Wellhead Protection Areas (WHPAs), intakes (IPZs), or the broader landscape (HVAs).

E1.2 Technical Rules

The following *Technical Rules* describe the requirements for drinking water threats assessment:

- Part IX Local Area Risk Level *(Rule 97 to 109)* – not applicable in CLOSPA*;*
- Part X Drinking Water Threats: Water Quantity *(Rule 110 to 113)* – not applicable in CLOSPA; and
- Part XI Drinking Water Threats: Water Quality *(Rule 114 to 138).*

E1.3 Technical Bulletins

To provide additional clarification and direction, the MOECC released the following technical memos regarding water threats assessment:

- Proposed Methodology for Calculating Percentage of Managed Lands and livestock for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers (November, 2009);
- Provincial Tables of Circumstances: Understanding the Provincial Tables (March, 2010);
- Threats Assessment and Issues Evaluation (March, 2010);
- Delineation of Intake Protection Zone 3 Using the Event-Based Approach EBA (July, 2009);
- *Clean Water Act, 2006.* Addressing Transportation Threats (September, 2010);
- Earth (Geothermal) Energy Systems (November, 2009); and
- Burial of Animals on Farms as a Drinking Water Threats (Deadstock Disposal) (December, 2009).

These seven technical bulletins are available upon request.

E2 Assessment of Threats to Lake Ontario

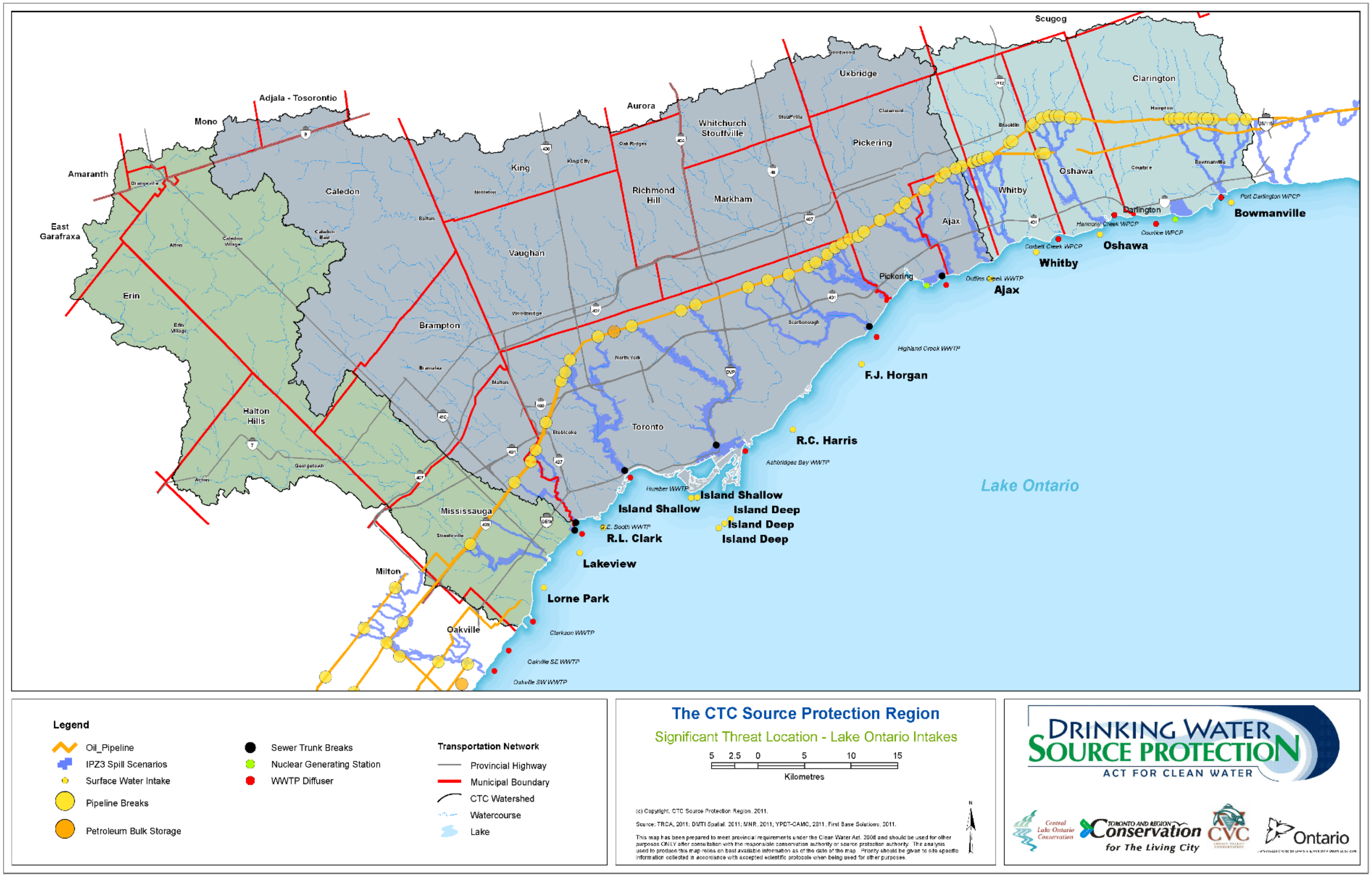
This appendix has been prepared based on input from the Lake Ontario Collaborative (LOC), municipal staff, and consultants. The findings in this appendix have been peer reviewed. In particular, we want to thank Rodney Bouchard, Project Manager from the Region of Peel, Bill Snodgrass from the City of Toronto, and Dr. Ray Dewey, modelling consultant.

E2.1 Rationale for Using the Event-Based Approach

In a large lake system such as Lake Ontario, water quality and the sources and processes that influence water quality are not the same for the near shore area (coastal zone) as compared to that found further offshore (main lake area). In Lake Ontario, the coastal zone can be considered as the area from the shoreline out to the 30 m depth contour (**Figure E2.1** and **Figure E2.2**). In the coastal zone, water quality is influenced by land-based discharges (such as rivers, streams, wastewater treatment plants, and groundwater) which mixes at the boundary of the zone with the off-shore main lake waters. The rate at which this mixing of the coastal and main lake water occurs is subject to hydrodynamic forces such as prevailing wind speed and direction, water and air temperatures and bathymetry. The source of water for Lake Ontario-based municipal drinking water intakes is in this coastal zone.

The quality of water in the main lake area is established largely by water flowing from the upstream Great Lakes (Erie, Huron, Michigan, and Superior) through the Niagara River into Lake Ontario and direct rainfall and atmospheric fallout to the lake’s surface together with biochemical processes that occur within Lake Ontario. **Figure E2.1** and **Figure E2.2** illustrate the importance of protecting the water quality in the coastal zone where most of the source of drinking water is drawn from. The intake pipes are located along the near-shore (0.5 – 5 km). In the western basin of Lake Ontario, expanding urbanization has a dominant influence on the near-shore zone water quality. At current rates, the population growth will be 20% in five years in the area shown in **Figure E2.2**.

This appendix provides a technical summary of how the events-based analyses were done and the findings which are the basis for the information found in **Chapter 5** of the Assessment Report. In carrying out this work, events were modelled based on large releases of contaminants associated with existing activities on land that might result in deterioration of water quality to the point that it is unsuitable for use as a source of drinking water. A number of spill scenarios were modelled as part of the Lake Ontario Collaborative (LOC) project to determine if certain land-based activities could pose a potential drinking water threat to these intakes. Any scenario that identifies conditions under which a contaminant could exceed a threshold in the raw water is identified as a significant drinking water threat. The events that were modelled were: disinfection failures at each municipal waste water treatment plant; accidental large scale release of tritiated water from nuclear power plants; product of waste spills from industrial facilities; and spills from a petroleum pipeline as it crosses major tributaries. The list of events was developed in consultation with municipal staff responsible for water and waste water, conservation authority staff and some industrial representatives.



(c) Copyright. CTC Source Protection Region, 2011.

Source: TRCA, 2011; DMTI Spatial. 2011; MNR, 2011; YPDT-CAMC, 2011, First Base Solutions, 2011.

This map has been prepared to meet provincial requirements under the Clean Water Act. 2006 and should be used for other purposes ONLY after consultation with the responsible conservation authority or source protection authority. The analysis used to produce this map relies on best available information as of the date of the map. Priority should be given to site specific information collected in accordance with accepted scientific protocols when being used for other purposes.

Figure E2.1: Significant Threat Location Lake Ontario Intakes – Oakville to Port Darlington

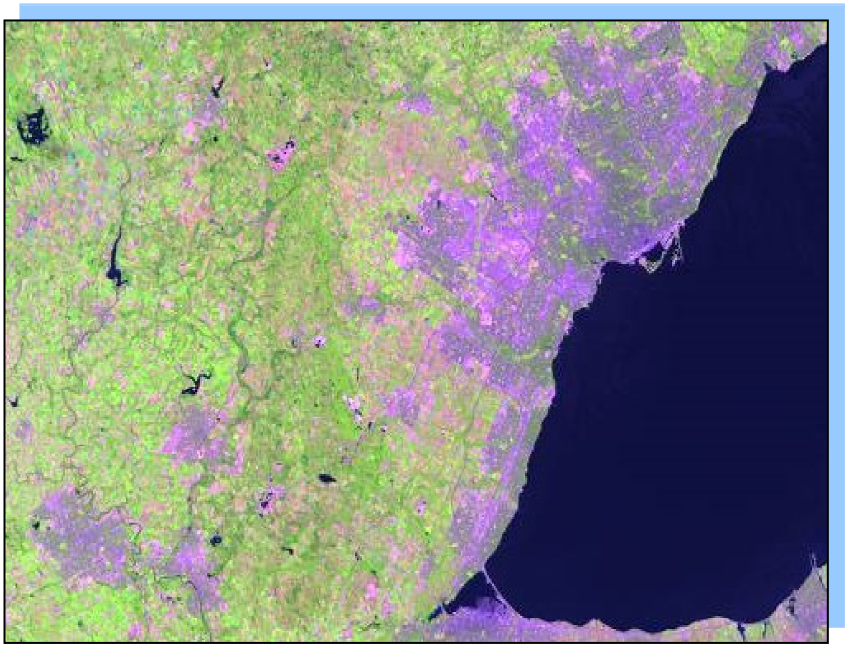


Figure E2.2: Urban (purple) and Rural (green) Areas adjoining Lake Ontario

This work does not represent the complete identification or analysis of all activities that might pose threats to municipal drinking water intakes in Lake Ontario. Nor does it consider the impact of the ongoing or projected future discharge of wastewater or runoff from land. Rather it represents the first step in a systematic consideration of how a major spill or event from an activity that could reach Lake Ontario might impact on specific drinking water intakes. The development of a calibrated and validated three-dimensional model with which to do the events-based scenario modelling also provides a tool that can be used in future to expand this type of analysis to update the respective assessment reports.

- **Section E2.2** summarizes study methods used, including MOECC published rules for IPZ-3 analyses under *Technical Rules (68 and 130),* and the approach used for the LOC (modelling methodology, the evidence-based approach);
- **Section E2.3** documents the modelling results for each intake, which provides the basis for determining what spills are significant under *Technical Rules (68 and 130);*
- **Section E2.4** describes the methodology for extrapolating the modelling results spatially as zones of contamination within Lake Ontario, especially within the near-shore zone;
- **Section E2.5** presents study conclusions and summary comments on event-based areas (EBA) uncertainty and next steps; and
- **Section E2.6** provides the references.

E2.2 Methods

The LOC used the event-based modelling for the identification of significant threats to Lake Ontario drinking water intakes in the study area (see below for a further description of the approach and applicable guidance). Under this approach, the Source Protection Committee (SPC) decides, based on local knowledge, what activities it wants to be evaluated through modelling.

The LOC used an impact assessment method to determine if an activity poses a significant drinking water threat by determining "whether a spill has the potential to reach surface water intake(s) at a sufficient concentration to cause deterioration in water quality (the impact)".

E2.2.1 Ontario Ministry of Environment and Climate Change (MOECC) Guidance

Context and Application for Event-based Approach

In November 2008 (and amended November 2009, September 2013 and March 2017), the MOECC released the *Clean Water Act, 2006 Assessment Report Technical Rules (2009)* which superseded the MOECC source protection Guidance Modules. Prior to the amendments in November 2009, the vulnerability scoring methodology for Intake Protection Zones (IPZs) for Great Lakes intakes identified in the Guidance Modules and embedded in the earlier version of the *Technical Rules* did not allow the identification of significant drinking water threats for Great Lake intakes. In the amended *Technical Rules* there is recognition that there may be circumstances where such significant threats exist and so additional rules were added to allow for the identification of such threats. *Technical Rule 130* allows the use of an event-based approach for the identification of significant threats to Great Lakes water treatment plant (WTP) intakes.

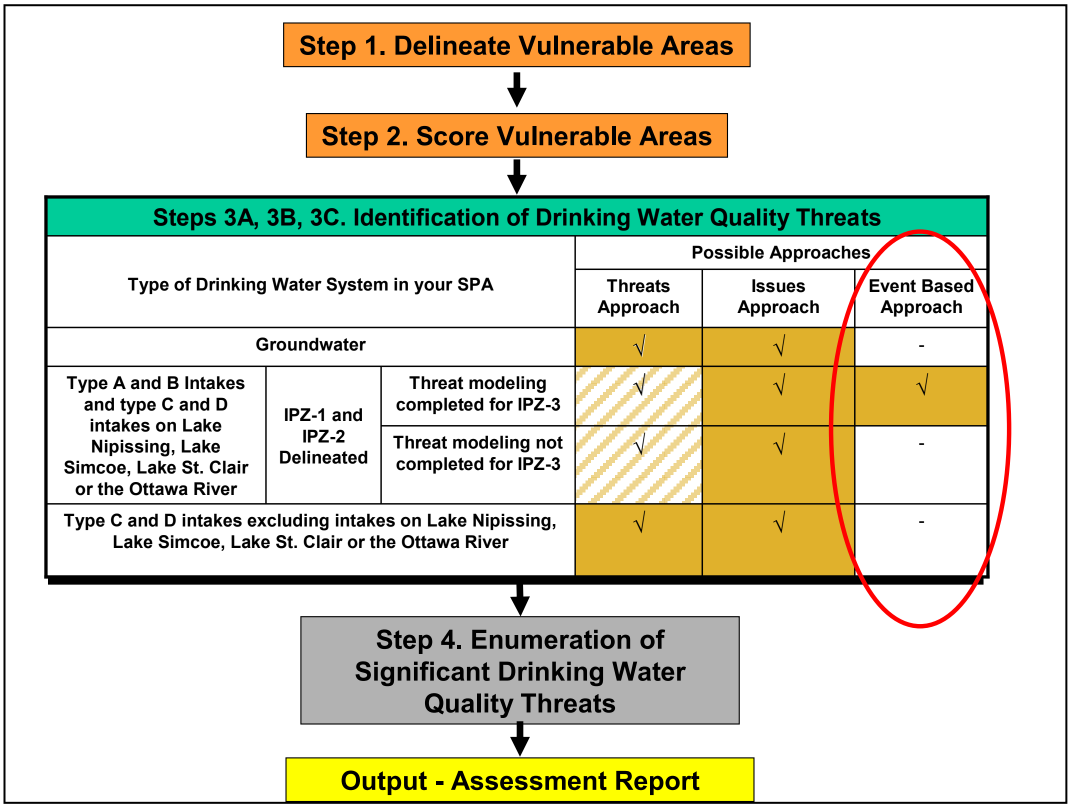
The MOECC and concerned stakeholders conducted several meetings and workshops (December 2008 and June 2009) to support the development of the EBA approach, and to develop an understanding of how to undertake such an approach. This section summarizes the results of these meetings and workshops.

Figure E2.3 provides an overview of the process that can be used for assessing sources of municipal drinking water. The event-based approach applies to all Lake Ontario (Type A and B) intakes. Under this approach, the SPC decides, based on local knowledge, what activities it wants to be evaluated through modelling. This is an iterative process that allows identification of significant drinking water threats:

- Delineation of IPZ-3 based on current knowledge of activities and the transport of contaminants to the intake;

- Can use modelling (e.g., contaminant transport modelling / spill release scenarios) to determine whether the release of contaminant would result in the deterioration of the water for use as a source of drinking water for the intake; and
- Modelling is interpreted broadly, and includes "other analysis".

The IPZ-3 delineation is only required where this modelling has been completed and shows that contaminants released from activities identified by the SPC can reach the intakes at levels above the threshold established by the SPC.



Type of Drinking Water System in your SPA			Possible Approaches		
			Threats Approach	Issues Approach	Event Based Approach
Groundwater			√	√	-
Type A and B Intakes and type C and D intakes on Lake Nipissing, Lake Simcoe, Lake St. Clair or the Ottawa River	IPZ-1 and IPZ-2 Delineated	Threat modeling completed for IPZ-3	√	√	√
		Threat modeling not completed for IPZ-3	√	√	-
Type C and D intakes excluding intakes on Lake Nipissing, Lake Simcoe, Lake St. Clair or the Ottawa River			√	√	-

Figure E2.3: Approaches Used to Determine Significant Drinking Water Threats (Keller, 2009)

The following are the relevant sub-sections of the *Technical Rules (2009, 2013 and 2017)*:

- IPZ-3 includes the areas within each surface water body through which, modelling of a failure of an "activity" demonstrates, that contaminants released during an extreme event, may be transported to the intake (*Part VI.5 Rule 68*(*1*))*;*
- IPZ-3 includes a setback of maximum 120 m setback and Regulation Limit *(Part VI.5 Rule 68(2));* and
- Re Intake Protection Zones 3 – Definition of term, an "extreme event" means:

  a) A period of heavy precipitation or wind up to a 100-year storm event;

b) A freshet; and

c) A surface water body exceeding its high water mark *(Part I.1 Rule 1(1) - Definitions).*

Additional Information

Additional information was forwarded to participants from the September 2010 workshop and is to be taken as "published" guidance *(Letter from Heather Malcolmson, dated Nov 15, 2010 – Relevant portions are extracted (Jacoub, 2011)* and provided in the **Section E2.7.**

The formative basis relevant to the Lake Ontario analysis, developed at the September 2010 workshop includes the following:

1) A variety of methodologies were discussed, ranging from the Impact Assessment method used for the LOC through to delineation of an offshore portion of an IPZ-3, using Reverse Particle Tracking (RPT) under 10 different wind scenarios extending to the tributaries – for example Lake St. Clair;
2) The Impact Assessment method of the LOC focuses on the idea behind the event-based approach for IPZ-3 delineation: "the potential for discharges that could reach surface water intake(s) at a sufficient concentration to cause an effect". It addresses the question: "during such an event, will water reach the intake from spill location; and gives an estimation of how big IPZ-3 could be as a function of each specific contaminant;
3) Based on hydrodynamics and dispersion simulations of the 1992 tritium spill from Pickering, these numerical studies suggested a 30 m water depth in Lake Ontario (a potential definition of the coastal zone of Lake Ontario) could be used (as a minimum) for delineating the offshore portion of IPZ-3. These studies would be expanded to examine the upland areas and certain activities;
4) The *Technical Rules (2009)* which govern the Event Approach, *Rules (68 and 130)*, are read together, to understand the entire picture of identifying certain activities that may release contaminants during extreme events that may reach the intake and cause deterioration to the water quality of raw water. That is, delineating of an IPZ-3 results from the arrival of a contaminant of sufficient concentration to cause a concern;
5) The intent of *Rules (68 and 130)* can be confusing, especially for those professionals who are used to delineating a vulnerable area first and then evaluating a hazard score within the delineated area;
6) The main intent of *Rule (68)* is to look for a specific activity or activities that the SPC is aware of and is concerned about the release of contaminants that may cause deterioration to the water quality at the intake. The intent was not to

determine the type of contaminant and then catch the activities that contribute to that contaminant. If this was the aim, a chemical parameter such as nitrogen or pathogen would be too complex to be modelled because this may result in including the entire watershed of Lake Ontario, for example, as an IPZ-3 (see **Section E2.7** for further clarification)**;**

7) Based on understanding *Rule (130)*, an activity is classified as a significant drinking water threat if a release of contaminant during an extreme event causes deterioration to the water quality. It is up to the SPC to use whatever standard to identify where and how the word "deterioration" applies;
8) The word "deterioration" raises some concerns whether the deterioration to the raw water or the treated water. Some supported that WTP capabilities should not be a criterion in determining whether the raw water is deteriorated or not when contaminants get into the intake during extreme events at a certain concentration. Others suggested that the deterioration is meant to be impairing the water for use as a source of drinking water for the intake, which may include the treated water as well - but this meaning is embedded. However, it should be noted that the Ontario Drinking Water Standards (ODWS) refers to the treated water and not to the raw water;
9) *Rule (130)* has been amended to give the flexibility to the SPC to identify current or future activities that may be examined under *Rules (68 and 130)* using a modelling approach, for all intake protection zones: i.e., IPZ-1, IPZ-2, and IPZ-3. IPZ-3 is generated to capture an activity identified as a significant drinking water threat (SDWT), since the SDWTs must be within a vulnerable area while IPZ-1 and IPZ-2 are delineated first and then the activities are evaluated. The future activities here refer to activities that have been planned / approved to take place and their sites are known but they have not yet commenced operation (see **Section E2.7** for further clarification)**;**
10) Evaluating contaminant–specific, locations of a spill-like discharge could result in delineating different IPZ-3s for the same surface water intake based on the type of contaminant transported to the intake. The intent of *Rule (68)* is to have one single IPZ-3 for a surface water intake (similar to IPZ-1 and IPZ-2). If more than one activity is examined and more than one contributing area is obtained as a result of modelling exercise, an IPZ-3 that merges all contributing areas should be made. If there are two intakes close to each other and their IPZ-3 overlaps, a suggested approach was to merge them together to get one IPZ-3 (see **Section E2.7** for further clarification)**;**
11) The size of IPZ-3 was discussed. The main intent of Ministry guidance is not to have an excessively large IPZ-3 that may impact individuals unnecessarily but

the IPZ-3 should capture the activity(ies) itself. In addition, some discussants suggested that delineating the area between the activity and the intake would capture any other activities that may contribute the same type of contaminant that was the concern of capturing the main activity; and

12) IPZ-3 could be also determined through the issue approach, i.e., the other possibility for delineating an IPZ-3 for Great Lakes intakes. If there is an issue at the intake, currently occurring, the activities that contribute contaminant to the issue should be identified, and their areas will be identified as Issue Contributing Areas; these areas must fall in a vulnerable area, which in this case will be an IPZ-3.

E2.2.2 Introduction to Spill Scenario Modelling

LOC Approach

The event-based approach has been used to identify whether existing facilities, such as bulk petroleum storage facilities, wastewater treatment plants, and industrial chemical facilities, are significant threats to nearby drinking water intakes. If spill scenario modelling results indicate that a spill/release from an existing facility has the potential to impact a drinking water plant (basically reach an intake) at a level that a drinking water plant needs to shut down, then that facility is automatically identified as a significant drinking water threat to that drinking water plant. There is no consideration of time of travel within the event-based approach.

Event-based scenario modelling can simulate events up to and including worst-case weather events (i.e., 100-year storm, wind or precipitation) to drive the hydrodynamic model. Instead, we used normal weather conditions using actual measured data for the time during which the event was modelled. The weather conditions and dates used are identified for each scenario below.

Source of Spills

In 2009, the LOC initiated the event-based approach for the purpose of identifying significant drinking water threats to the LOC municipal partners' Lake Ontario sourced drinking water plants. A list of proposed spill scenario simulations for existing facilities was developed in concurrence with municipal partners, Source Protection Committees, and MOECC. The following criteria were used to develop the list of preliminary spill scenarios for various industrial, commercial and municipal facilities:

- Identify the location and possible materials released under normal operation and spill scenarios;
- Using calibrated and validated lake models, predict under what conditions contaminants could reach drinking water intakes;

- Predict the concentration of key parameters and assess risks using threshold concentrations for each contaminant established by the CTC SPC per MOECC *Technical Rules (2009);* and
- Evaluate historical raw water analyses at drinking water plants to assess whether there are observed elevations of parameters that may be linked to storm events, past spills, or weather conditions and to establish threshold levels for some contaminants.

Based on the above criteria and discussions with municipal and SPC partners, the following represent the generalized locations of the spills considered by the LOC:

- A disinfection system failure at each Lake Ontario waste water treatment plant (WWTP) in the study area (data for the remainder of the Durham WWTP will be provided by the LOC during the consultation period and will be included in the finalized assessment reports submitted for approval by July 27, 2011);
- Sanitary trunk sewer break caused by stream erosion in river valleys between the Rouge River and Etobicoke Creek;
- A combined sewer overflow (CSO) release in the City of Toronto;
- Release of contaminants (a spill of *E. coli*) from the lagoon of a rural industry (an industrial animal food processing facility) located adjacent to a tributary of the Credit River;
- A release of gasoline from bulk petroleum fuel storage facilities;
- A spill of gasoline/refined product from large pipelines co-located with transmission corridor across the northern part of the GTA where the pipeline crosses under the watercourses and which would discharge to the major tributaries flowing south to the north shore of Lake Ontario; and
- A discharge of tritium from the nuclear power generating stations located in the Region of Durham.

Another spill scenario evaluated by the LOC (Dewey, 2011), and not discussed in this Appendix is:

- A petroleum/chemical spill from a shipping vessel / tanker travelling across the ‘Skyway Bridge” over the Burlington ship canal.

E2.2.3 Lake and Stream Modelling Methodology

Evaluation of spill scenarios requires a water quality model for the lake and in some instances, a water quality model for watercourses, which transport a spill from an upland source to Lake Ontario.

Lake Modelling Methodology

The water quality model for the lake used the MIKE-3 computer code (Dewey, 2011) and is based on two components:

(i) Hydrodynamic component – which forecasts current speed and direction; and

(ii) Water quality component – which computes constituent concentrations (bacterial densities, radiological activity) based on mass balance theory.

A whole lake model is required to predict the water currents in the nearshore area of interest, (the coastal zone of Lake Ontario). The whole lake model used in this study is based on the DHI (formerly Danish Hydraulic Institute DHI) Water and Environment MIKE-3 model. MIKE-3 uses the full three-dimensional representation of water motion, including thermodynamics. It accurately simulates the seasonal thermal conditions and summer stratification that affects the circulation pattern in Lake Ontario, which is required for accurate predictions of water currents. The MIKE-3 model is based on a mathematical formulation known as the finite difference (FD) method. The lake is represented by a grid of squares with vertical layers. The whole lake is divided up into squares with edges 2,430 m long. Equal length vertical layers are used to represent the water depth.

The calibration process involves selecting the appropriate grid sizing, vertical distribution, wind source and other driving forces, and then adjusting the model parameters (fine-tuning) to make the model predictions agree with observed data. Normally current data collected with instruments deployed in the lake are used to calibrate the hydrodynamic module. Temperature data collected at water intakes are also valuable in this process.

The major forcing function used to drive the currents in the model is wind stress. Wind speed and direction time series from Pearson Airport and other sources were used to provide the surface wind stress. The following sources of wind data have been evaluated and used in this study. Single station data such as airports are used to provide a uniform wind over the whole lake. There has been limited success with combining data from several airports, by some form of bilinear interpolation, to produce a two-dimensional (2-D) wind field. NOAA can provide a 5-kilometre grid of their North American Mesoscale Atmospheric model at 1-hour intervals. The NOAA model is a weather prediction tool, which uses observed data at stations throughout North America and is considered the most accurate 2-D wind field available for model use, but it has been available only during the 2000 decade.

Model Calibration / Validation

The ability of the model to forecast lake physics (currents, thermal character) was evaluated based on extensive calibration effort. This involved comparing model calculations with observations for near-shore current meters located off sites between Darlington and Halton, ambient temperature profiles in the main lake, and temperature data from drinking water plant intakes.

For calibration, the model was driven by NOAA wind field for 2006 and Pearson Airport wind for both 2006 and 2007. Acoustic Doppler Current Profiler (ADCP) data were available at Pickering for 2006 and 2007, and Darlington ADCP had data only for 2006.

To further evaluate the ability of the model to forecast nearshore currents within the coastal zone, the data on the tritium spills of 1992 and 1995 was used together with intake monitoring data which included Oshawa to Hamilton. Since the NOAA wind field data are not available for the early 1990's, single station data were evaluated and the data from the best station (Trenton for forecasting transport to the West) was selected.

For *E. coli,* model forecasts of *E. coli* levels in the Toronto Inner harbour were compared with observations from two field seasons (2007 – a relatively dry year, and 2008 – a relatively wet year) and used to establish the *E. coli* decay rate in the water column of the near-shore zone.

Other Comments about Modelling

For spills to watercourses, a conservative assumption was generally applied that the spill occurred at the location of the discharges to the lake, except for a spill from the 'industrial' lagoon in which a HEC – RAS simulation was used to estimate how the spill was diluted and transported down the Credit River.

A sequential peer review effort is underway; including inter-comparisons between Lake Ontario based modelling groups who used different computer codes, critique of approach and methodology by LOC staff, and a critique of hydrodynamic model calibration by two external reviewers. LOC staff provided the final interpretation of the models' calculations and implications, with input from the modelling consultant.

Lake Model Simulation Period

Both event approaches and continuous simulation approaches were used to evaluate the effects of spills. The main modelling approach used was a continuous simulation.

The simulation period starts with thermal stratification of Lake Ontario, which begins after the spring thaw. Water near the shoreline warms up first and the zone of warmer water slowly spreads out as the heating from the sun increases. Water temperatures start at 4°C and are warmed from there.

The maximum density of water occurs at 4°C and this density difference between water at 4°C and warmer water is the major factor in the formation of the thermal stratification. Water at 4°C will sink below warmer water (and colder water or ice). Wind mixing of the upper water column is only sufficient to keep the top 20 to 35 metres well-mixed during the summer period, causing water below this depth to remain at 4°C. There will be a structured thermal distribution in the water column.

Typically the water column would be 20°C from the surface to say 20 m, over the next 10 m or so the temperature decreases non-linearly to 4°C and from 35 m downward the water is a constant 4°C. The spatial distribution of the layers is not even, typically a dome forms in the lake with the warm layer thinnest in the center of the lake and thickest at the shoreline.

When the lake is stratified, wind stress affects the lake differently than when the lake is isothermal as in the spring and fall. Upwelling and downwelling events occur during stratification, which causes cold deep lake water to flow toward the north shore displacing warmer water with clean fresh cold water; downwelling has the opposite effect. These events are not predicted by two-dimensional models, which is why three-dimensional models are used.

In order to cause warming and cooling of the water in the lake, a thermodynamic balance is required. The heat balance is controlled by latent heat loss by thermal radiation to outer space and evaporation and heat gain by solar radiation (long wave and short wave) and conduction from surface air. The physical parameters required for these calculations are: relative humidity, cloud cover, and air temperature. Hourly time series data for these parameters measured at Pearson Airport and other sources were used in this study.

To accommodate the effects of across-lake transport while providing the spatial resolution needed within the near shore zone, three or four different sizes of linked meshes are used as illustrated in **Figure E2.4** and **Figure E2.5**. All in-lake spill scenario modelling was conducted using the MIKE-3 and is reported in Dewey (2011)

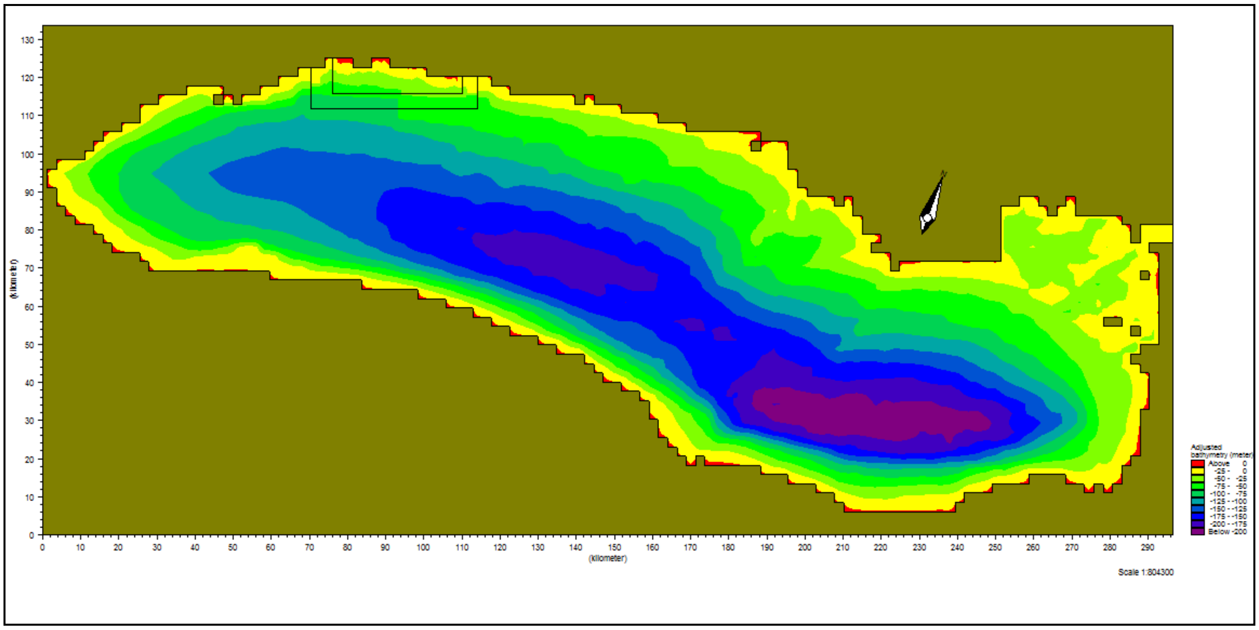


Figure E2.4: 2430 m Whole Lake Grid with Nested Grids

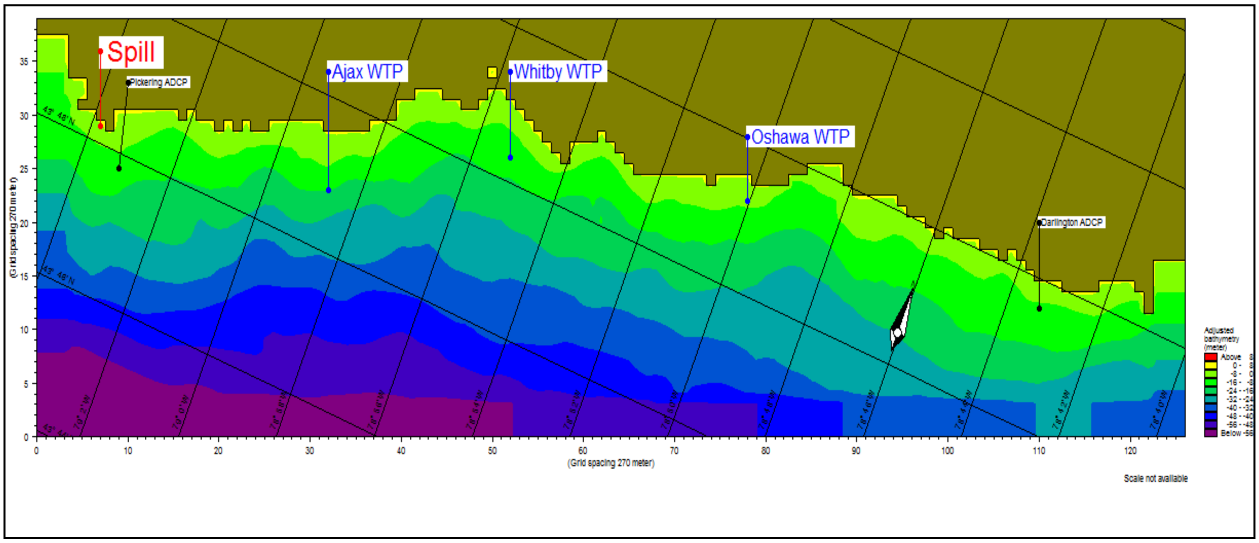


Figure E2.5: 270 m Nested Grid with ADCP Locations

Lake Current Directions

The current rose calculated by the model is displayed for two locations, to assist the reader in understanding the similarities and differences along the Lake Ontario coastline.

Figure E2.6 shows the current distribution offshore of Etobicoke and **Figure E2.7** shows the currents offshore of Pickering. The Etobicoke currents are generally equally distributed to east and west currents with higher speed events flowing westward - possibly due to the larger fetch from the east. The equal distribution would indicate that there is not a stable eddy in the western basin. The Pickering currents are biased to easterly flows in the majority and with stronger speeds over the period. This current distribution with the major easterly flow would indicate a clockwise eddy in the central basin.

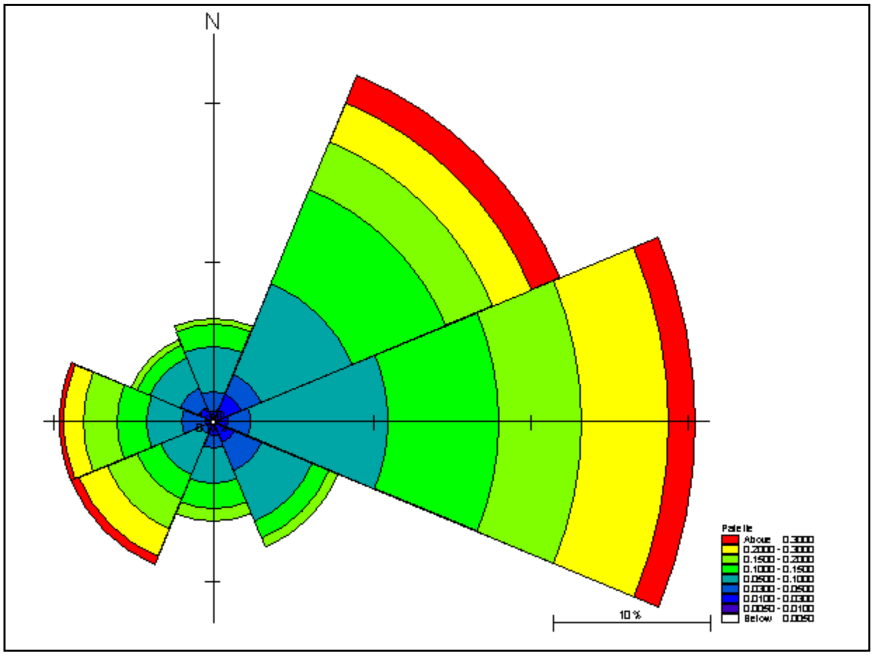


Figure E2.6: Calculated Current Compass Rose in Etobicoke Section of Coastal Zone

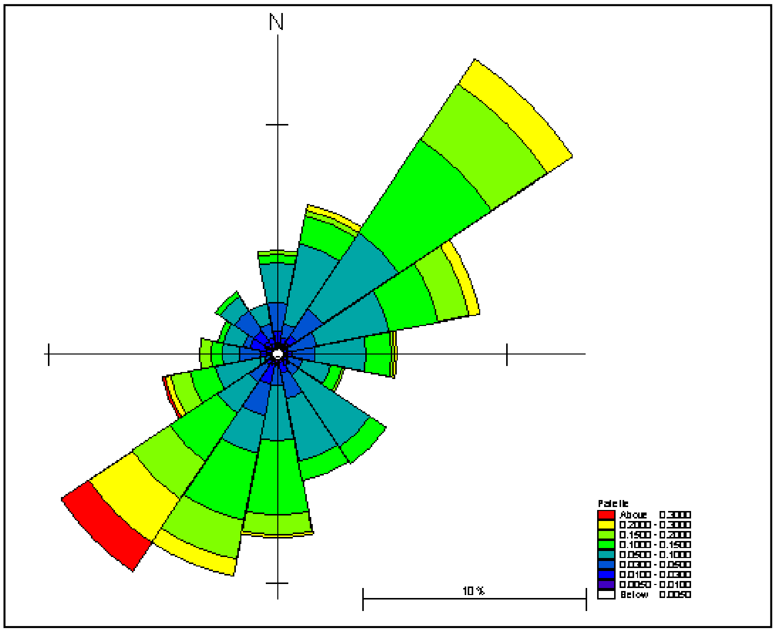


Figure E2.7: Calculated Current Compass Rose in Pickering Section of Coastal Zone

River / Stream Modelling Methodology

River and stream flow modelling was undertaken to estimate 2-year and 100-year return events (storm flows) to calculate travel-time for contaminants released in major tributaries to reach Lake Ontario. This was completed to support spill simulations for the evaluation of drinking water threats from industrial pipelines and facilities located along these tributaries.

Conservative tracer-based travel-time estimation was proposed for 24 selected tributary and petroleum product pipeline intersection sites. The travel time was estimated using U.S. Army Corps of Engineers' HEC-RAS 4.1 model. HEC-RAS model is a hydraulic model, which is widely used for floodplain delineation by conservation authorities. Recently the developers of the model introduced a water-quality module to this model. The new module allows travel-time estimation of conservative tracer and other pollutants between two points of interest. The HEC-RAS modelling was undertaken by the staff of the conservation authorities for the selected tributaries within their specific jurisdiction. The travel-time estimates were received from the participating agencies and the results are presented in **Table E2-1** and **Table E2-2.**

The travel times are a function of the distance between the river and oil-pipe intersection and mouth of the river at Lake Ontario, size of the river, drainage area, and velocity of flow. The travel time for 2 year flows ranged from 0.41-9.75 hrs and for 100-year flow, ranged from 0.34-7.99 hrs. The results indicate that the travel times are short enough that if there is a breach in the oil pipeline close to a river, the miscible constituents of oil will reach Lake Ontario quickly. Therefore, the dominant impact of a spill from a pipeline to the intakes in Lake Ontario is the quantity that leaks into a watercourse and the duration of a spill.

E2.2.4 Description of Scenarios Used in the Evidence-Based Approach Modelling

An evidence-based approach has been used by LOC to undertake these spill scenarios. When possible, past events, such as a pipeline spill near a waterbody, have been used to inform the spill scenarios being undertaken. Further, actual facility data (e.g., bulk petroleum facility tank volume and contents) has been incorporated into each scenario.

It should be noted that the identification of significant threats did not consider any regulated risk management requirements. Current risk management measures and the adequacy of existing regulatory requirements will be considered in the development of the Source Protection Plan. Source Protection Plans are required to reduce or eliminate threats to drinking water.

The following describes the details of the parameters used for each scenario.

Wastewater Treatment Plant (WWTP) Disinfection Failure Scenario

The setting of a wastewater treatment plant is illustrated in **Figure E2.8** together with the regulatory and best practices framework in place. For purposes of spill evaluation, the spill was modelled as a release from the outfall located at the specific off-shore distance for each WWTP site.

WWTP scenarios are based on a 4-month process breakdown in the treatment plant that results in secondary treatment by-pass for that duration of time in the summer months. This scenario is loosely based on an event that occurred at one of Peel's WWTPs several years ago which was the result of a large discharge of orange juice into the sanitary sewer that effectively shut down the biological treatment process at G.E. Booth (formerly Lakeview) WWTP for several months. For each WWTP, actual flow data for the WWTP obtained from each municipality was used for the simulation. For source protection plan development, the scenarios can be re-evaluated using a shorter process breakdown period such as 1 week or 60 days.

Table E2-1: Travel Time for 2 Year Recurrence Flow Conditions

Tributary	Travel Time (hr)	Distance (km)	Average Flow Velocity (m/s)	Average Discharge (m^3/s)
Twenty Creek	5	20	1.10	28.60
Joshua Creek	0.68	3	1.17	23
16 Mile Creek	1.13	5	0.70	159.90
Sheldon Creek	0.68	4	1.17	18.70
Shoreacres Creek	0.43	3	1.84	28.60
Credit River	2.25	13	1.60	120
Etobicoke Creek	0.73	7	2.76	137.20
Humber River	2.93	15	1.43	175
Don River	0.41	2	1.45	160.30
Rouge River	2.33	12	1.38	53.42
Petticoat Creek	2.01	11	1.53	11.99
Duffins Creek	3.99	14	0.99	69.50
Carruthers Creek	8.22	13	0.44	13.20

Tributary	Travel Time (hr)	Distance (km)	Average Flow Velocity (m/s)	Average Discharge (m^3/s)
Lynde (Heber Creek)	9.24	22	0.67	16.88
Lynde Creek	9.75	25	0.70	24.05
Oshawa Creek	2.80	17	1.66	34.89
Harmony Creek	3.25	14	1.20	23.44
Farewell Creek	4.40	17	1.07	17.20
Black Creek	2.47	14	1.58	26.89
Wilmot Creek	1.64	8	1.27	11.90
Graham Creek	4.77	12	1.11	7.30
Ganaraska	1.44	7	1.61	64.30
Cobourg Creek West	3.60	10	1.29	13.30
Cobourg	4.13	10	1.11	13.30

Table E2-2: Travel Time for 100 Year Recurrence Flow Conditions

Tributary	Travel Time (hr)	Distance (km)	Average Flow Velocity (m/s)	Average Discharge (m^3/s)
Twenty Creek	2.10	20	2.70	175.20
Joshua Creek	0.72	3	1.11	58
16 Mile Creek	0.87	5	0.92	311.10
Sheldon Creek	0.55	4	1.45	68.35
Shoreacres Creek	0.42	3	120	175.20
Credit River	1.50	13	2.40	557
Etobicoke Creek	0.56	7	3.59	467
Humber River	1.78	15	2.36	573
Don River	0.34	2	1.75	492.50
Rouge River	1.72	12	1.86	202.67
Petticoat Creek	1.57	11	1.96	45.16
Duffins Creek	3.47	14	1.14	244.80
Carruthers Creek	4.21	13	0.85	54.65
Lynde (Heber Creek)	7.60	22	0.81	86.54
Lynde Creek	7.99	25	0.85	114.69
Oshawa Creek	2.16	17	2.15	163.77
Harmony Creek	5.28	14	0.74	78
Farewell Creek	6.25	17	0.76	17.20
Black Creek	1.76	14	2.22	77.89
Wilmot Creek	1.23	8	2	49.10

Tributary	Travel Time (hr)	Distance (km)	Average Flow Velocity (m/s)	Average Discharge (m^3/s)
Graham Creek	2.59	12	1.68	34
Ganaraska	0.96	7	2.90	425
Cobourg Creek West	2.87	10	2.11	59
Cobourg	3.27	10	1.87	59

Figure E2.8: Illustration of WWTP Site Located on Shore of Lake Ontario

Future modelling evaluations during the source protection plan development phase could consider the likelihood of the spill characteristics and running other scenarios. The source protection plan development will consider the effectiveness and adequacy of risk management measures that are in place.

In terms of microbial risk from pathogens in LOC intakes, this report has focused on *E. coli* as the main indicator of risk, as there are accepted numerical water quality limits for drinking water. In addition, a limited study has been undertaken to develop an understanding of the levels of pathogens such as *Cryptosporidium* and *Giardia* at intakes in the Peel Region and the nearby Toronto intake. A scoping level evaluation using Quantitative Microbial Risk Assessment (QMRA) techniques was undertaken by Peel

Region. The QMRA study, conducted as an exploratory project, suggests that it is possible to obtain a preliminary assessment of risks and the health burden to the population considering both levels in raw and treated water. However, the study authors point out the need for additional professional effort and sampling to refine the coarse estimates and to relate the observed intake levels to specific sources of contamination and the effectiveness of water treatment. The results are being compiled into a comprehensive LOC study report to be made available in the summer of 2011.

Stream Erosion Causing a Sanitary Trunk Sewer (STS) Break

Figure E2.9 illustrates STS infrastructure which is vulnerable to stream meandering, bank erosion, or bed incision. A break of the Highland STS occurred on August 19, 2005.

Figure E2.9: Picture and Location of STS Erosion in Highland Creek watershed caused by Aug 19th, 2005 Storm Extreme Weather Event

The simultaneous spill from four STS locations (in Etobicoke Creek, Humber River, Highland Creek and Rouge River) was simulated as a sewer pipeline break occurring due to an intense rainstorm; the simulation used a 24-hour break and estimated *E. coli* and TSS concentrations. The sanitary trunk sewer (STS) spill was based on the result of the intense rainstorm of August 19, 2005 event increasing flow in Highland Creek changing the course of the creek and eroding the bank supporting the sewer, which broke, releasing raw sewage. The rainstorm occurred mainly between 3 p.m. and 6 p.m. in the Highland Creek watershed on August 19, 2005. The break was located on Monday morning August 22, 2005, after flood flows had decreased sufficiently to identify the breaking point. The break was isolated in the early evening by redirecting flow from the broken point back into the STS. Thus it is estimated that the break occurred for about 3 days before interception was complete.

In order to model potential impacts on Lake Ontario drinking water plants, two scenarios were evaluated. The first simulated a simultaneous break in each of the STS systems (Etobicoke Creek, Humber River, Highland Creek, and Rouge River), based on a 24-hour spill occurring on August 19, 2005 (i.e., estimated river flows and lake currents of that period).

The second scenario simulated a series of simultaneous 24-hour breaks in each of the above STS systems occurring at 5 to 6-day intervals between May and August 2005. The purpose of this scenario was to capture different river flow and lake current conditions. This was a simulation technique used in lieu of seventeen separate computer runs. Because of the decay rates used for the attenuation of *E. Coli* in the model and dilution from onshore and offshore currents, these simulations did not result in a cumulative assessment of the *E. coli* concentrations (i.e., there was no build-up of *E. coli* from the multiple discharges over the summer simulation period).

For both scenarios, it was assumed that the following design flows and discharge points applied:

- York-Durham STS (1.8 m^3/s; discharge to the Rouge River);
- Highland STS (0.6 m^3/s; discharge to Highland Creek);
- West Don STS (2.2 m^3/s; discharge to Don River);
- Humber STS (1.77 m^3/s; discharge to Humber River); and
- N – E Lakeview STS (1.4 m^3/s; discharge to Etobicoke Creek).

The spill rates from each trunk sewer were estimated as approximately 50% of the design flow in each system, at an *E. coli* density of 5,000,000 CFU/100 ml. (Refer to Dewey, 2011 for details).

Combined Sewer Overflow (CSO) Spill

In older parts of Toronto, some combined sewers discharge to rivers or directly to Lake Ontario during heavy rain events, when the WWTPs cannot handle the volume of incoming wastewater. The picture below (**Figure E2.10**) of the Humber River plume from the May 2000 storm (which caused the tragedy in Walkerton) shows how the material is transported out into the nearshore area.

The CSO spill was simulated as a set of overflow events that occurred in 2008 due to the high rainfall. The watershed simulations were generated using the city's watershed modelling tools (HSPF for the Don River System; INFOWORKS for the CSO service area where it discharges either into the Lower Don River or into the Inner Harbour) (MMM, 2011). These models have been calibrated to water quality measurements in the Lower Don River. The MIKE-3 model was calibrated to the Inner Harbour data for the years 2007 and 2008 (Dewey, 2011).

The effects of CSO spills associated with the 2008 rainfall pattern were simulated from the discharge points (Lower Don River, Inner Harbour), flowing through the Inner and Outer Harbour, and transported by lake currents out to the different intakes for the period of April to August 2008.

Figure E2.10: Discharge from Humber River into Lake Ontario Following a Major Storm in May 2000

The combined sewer system overflow emulates spill-like events that occur in older downtown areas such as Toronto (and other similar urban areas) based on calibrated models which forecast the volume and timing of overflows at the Toronto waterfront. The main areas within the Lake Ontario watershed, which have combined sewer systems from which spill events could occur, are largely contained within the downtown areas of Toronto and Hamilton. Other municipalities have been built largely with separated sewer systems.

The *E. coli* model was calibrated (Dewey, 2011) by using the forecast time series for the Don River and combined sewer overflows to the Toronto Inner Harbour to define *E. coli* loadings to the Inner Harbour and comparing calculations and observations for 2007 (a ‘dry’ year) and 2008 (a ‘wet’ year). This model was used to forecast the *E. coli* levels at nearby drinking water plant intakes (R.L. Clarke, Island, R.C. Harris, and F.J. Horgan) for the summer period of 2008.

A spill from Wastewater Lagoons at Industrial Food Processing Facility

Figure E2.11: Industrial Animal Food Processing Lagoon

Figure E2.11 shows an industrial animal food processing complex and the water management/lagoon system. Wastewater from the animal food process undergoes tertiary treatment for removal of phosphorus, nitrates and pathogens (e.g., *E. coli*). The wastewater is stored in lagoons and flows into two equalization basins with a total storage volume of 105,600 m^3. The spill scenario was based on a breach in the lagoons with 50% of the stored partially treated (before tertiary treatment) wastewater reaching Levi Creek (tributary of the Credit River) within 24-hours. The spilled wastewater was assumed to contain *E. coli* at a level 5,000,000 CFU/100mL. The spill scenario was modelled with the release occurring at different times over the simulation period to assess the effects during most of the possible in-lake current regimes. The time of travel and subsequent dilutions of the plume down the creek eventually reaching Lake Ontario was simulated using the HEC- RAS model as the spill travelled down the river.

Pipeline Rupture Spill Scenario (**Figure E2.12**) below shows a pipeline crossing a water course.

Figure E2.12: Location of Pipeline Crossing below Representative Water Course in GTA Area

Note: (orange posts on right–hand bank mark crossing location of one pipeline; another pipeline crosses upstream (near-field) below gravel bar located in the middle of water course). The watercourse at this specific location is eroding downward, causing a loss of cover above the pipeline.

The pipeline break was modelled as a six-hour event with event dates occurring about 1.5 days apart. This method provides a typical lake response and does not rely upon selected directional events. There are a series of pipelines that transport various petroleum products between Montreal and Toronto, Clarkson (Mississauga), Oakville, Nanticoke, and Sarnia. In the CTC watersheds, pipelines are generally co-located with electrical transmission corridors. Products flow from both east to west, and west to east. There are four companies in the CTC with pipeline systems located within the transmission right-of-ways. The pipeline that has been used for spill scenarios is the mainline that runs from Toronto to Montreal carrying refined products. Spill scenarios were simulated for the release of the product as the pipeline crosses underneath each of the major tributaries that discharge to Lake Ontario.

The basis for selecting the magnitude of the spill for this scenario was the pipeline spill that occurred near Kalamazoo, Michigan in the summer of 2010. Available information indicates that approximately 19,500 barrels of oil (equivalent to approximately 3,028,329 litres) was released into a creek, which ultimately made its way into Lake Morrow and then to the Kalamazoo River – a main tributary discharging into Lake Michigan. The pipeline company information is that the rupture was found near Marshall, Michigan in a 30-inch line carrying 30,000,000 litres/day of synthetic, heavy and medium crude oil from Griffith, Indiana to Sarnia, Ontario. The spill occurred from a ruptured seam approximately five feet in length on this pipeline which was put into service in the late 1960s.

The estimates for quantity of petroleum product, which could spill, were based on the following information. Initial information obtained for pipelines in Ontario indicates that a 30-inch diameter petroleum products pipeline is used for shipping various finished products such as gasoline and extends east-west along the entire GTA and Lake Ontario north shore area. Additional specific information is available from various websites. Section 2.2.1 of the report at the following webpage (http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/trnsprttn/ trnsprttnssssmnt2009/trnsprttnssssmnt2009-eng.pdf), provides the following information on the pipeline which transports refined petroleum products west from Montreal to Toronto and operates bi-directionally between Toronto and Oakville, Ontario. This pipeline also transports refined products from a refinery at Nanticoke, Ontario east to Toronto. Figure 2.10 shows that in the first quarter of 2009, the pipeline throughput averaged 34,900 m^3/d (220 Mb/d) of petroleum products. The pipeline is generally operating at capacity.

Based on information from the report found at http://publications.gc.ca/collections/collection_2009/bst-tsb/TU3-8-02-2E.pdf indicates that the pipeline is 273.1 millimetres in diameter (~10-inch). The capacity of the pipeline is difficult to calculate because it has multiple delivery locations and different capacities on each segment of the pipeline. For example, from Montreal to Farran's Point the capacity is 21,000 m^3/d (132 Mb/d); from Farran's Point to Belleville the capacity is 11,500 m^3/d (72 Mb/d); and, from Belleville to Toronto the capacity is 10,000 m^3/d (63 Mb/d).

For purposes of the LOC event simulations, our scenarios use the lowest rate identified above of 10,000 m^3/d. Regular gasoline, 87 Octane, has between 0.5 and 1% benzene, added to increase the octane number. Assuming a 1% concentration, then 0.00125 m^3/s of pure benzene could be spilled during a pipe rupture. The pipeline flow was assumed to mix with the river flow and discharge at the mouth of the river. Benzene is miscible in water and it is assumed that the benzene in the gasoline will fully mix in the river water.

The temperature in the tributaries was set constant at 20°C, as was the temperature of the gasoline in the pipeline. Different lake temperatures were used by the model, starting from 4 °C isothermal at start up and through to developing the summer stratification. The pipeline break was modelled as a six-hour event. The event dates were randomly chosen - usually about 36 hours apart. This method provides a typical lake response and does not rely upon selected directional events.

Future modelling evaluations during the source protection plan development phase could consider:

(i) Effects of management measures which would reduce the length of a spill, due to spill detection systems and isolation technologies; and

(ii) Effects of spills caused by different means other than pipeline rupture due to failure of the pipeline, e.g., pressure failure, a low loss rate caused by a weep or corrosion pit, or river bed erosion.

Bulk Petroleum Storage and Handling Spill Scenarios

Two types of spill scenarios were simulated for petroleum product storage facilities located near the lakefront in Oakville, as well as an inland facility in North York. An example of a bulk petroleum storage facility is illustrated in **Figure E2.13**.

Figure E2.13: Example of Petroleum Fuel Storage near a Water Body

The first series of scenarios simulated a spill from a large gasoline storage tank. The size of the tanks was based on the Oakville facility. A recent site plan (2010) for this Oakville site was obtained and it indicated that the largest gasoline storage tank was 26 million litres. The site plan also indicates that transport pathways, both natural and man-made, connect the facility to Lake Ontario. For the North York location, travel through the storm sewer network and into the tributaries was estimated using the same approach as was used in the pipeline rupture scenarios described above.

These scenarios were based on the complete loss of product from the largest gasoline storage tank at the facility with benzene present in the product. The release of the 26 million litres of gasoline was assumed to occur over 1 hour. Regular gasoline, 87 Octane, has between 0.5 and 1% benzene, added to increase the octane number. Assuming a 1% concentration, 260,000 litres of pure benzene would be released during the spill. It was assumed that the benzene in the gasoline was fully mixed in the river water. The scenarios considered both easterly and westerly wind and current events that approach the 2-year return period.

To sample a range of lake currents over a range of wind events, both easterly and westerly, the modelling was based on a series of spills, occurring about 5 to 6 days apart. It is recognized that benzene disappears from water over time (e.g., physiochemical processes). This decay rate for benzene is included in the model so there is no accumulation of benzene concentrations over the modelling period. The simulation period was from May 15, 2006 (with isothermal conditions of 4° C) to August 10, 2006. The spill from the Oakville facility was modelled as a discharge from Bronte Creek to Lake Ontario, while the spill from the North York site was modelled as if the product discharged from the mouth of either the Don or Humber rivers because the storage spills are located on the watershed divide between the Humber and Don rivers.

The second series of scenarios were simulated to represent small volume and duration spills from a ship loading gasoline at the pier of the Oakville Storage facility. Again, benzene was assumed to be present at 1% in the gasoline. Three scenarios, with the following volumes of gasoline spillage, were simulated:

1) 20,000 L released in 15 minutes (200 L of Benzene);
2) 50,000 L released in 15 minutes (500 L of Benzene); and
3) 100,000 L released in 15 minutes (1000 L of Benzene).

Pickering and Darlington Tritium Spill Scenario

The tritium spill release scenario is based on an actual tritium release event that occurred in the summer of 1992 from the Pickering Nuclear Plant (**Figure E2.14**). The spill started on August 2 at 4:00 am, continuing for six hours at a release rate of 0.000119 m^3/s of tritium-contaminated water resulting in a total release volume of approximately 2,900 kg. The estimated tritium concentration in the discharge was 7.9×10^{11} Bq/kg = Bq/L. Tritium levels were measured at the water intakes and shoreline locations along the north shore of Lake Ontario for several weeks after the event. These observations were reported in Report NA44-REP-03483.2-0021-R00, 1994, OHN.

Initially, the tritium plume moved eastward, impacting the Ajax intake. Then the winds shifted, and the plume reversed course, travelling west. Tritium was then detectable at all of the drinking water intakes as far as Hamilton.

Figure E2.14: Illustration of Site for Tritium Spill

The actual tritium data measured at the intakes during the 1992 event were used to calibrate the MIKE-3 model which has been used for all the spill scenario modelling events described in this appendix. For the tritium spill scenario, the actual event was recreated in the model and the model results were within acceptable limits for calibration purposes. The model was also run to simulate easterly current conditions to evaluate what effects the tritium spill would have on municipal intakes east of the spill locations.

Spills from the Pickering facility were considered as the primary scenario because the cooling water discharge is located near the shore, and the spill of tritiated heavy water was into the cooling water stream.

To assess the potential impact of the other nearby nuclear generating station, the scenario was modelled using the same size spill as occurred in 1992 but the spill was modelled entering Lake Ontario through the cooling water discharge diffuser, which is located approximately 800 m off-shore at this facility. It should be noted that at this location this cooling system design is different reducing the likelihood that a spill of this magnitude would occur.

E2.3 Modelling Results for CTC Area Intakes

E2.3.1 Overview of Spills Scenario Modelling

The results from the event based modelling are presented as follows:

- Wastewater Treatment Plant disinfection failure **(Section E2.3.2);**
- Sanitary trunk sewer break caused by stream erosion **(Section E2.3.3);**
- CSO spill **(Section E2.3.4);**
- Industrial animal food processing facility lagoon spill **(Section E2.3.5);**
- Pipeline rupture **(Section E2.3.6);**

- Bulk petroleum storage facility spill of gasoline **(Section E2.3.7); and**
- Tritium spill from the nuclear generating station **(Section E2.3.8).**

Spills from the different sources were either modelled as a specific event, or as a series of events. Both a design event approach and a continuous simulation approach are accepted standard approaches in limnological-based, water quality modelling.

For most spill sources, a series of events were modelled, because this method provides a typical lake response, rather than relying on specific directional events. A typical lake response could involve anyone of a spectrum of current directions and speeds that could occur at the specific time that a spill occurs.

The results are presented below in several forms, including:

- Graphical (the calculated concentration over time, for representative intakes);
- Tabular (peak concentration/ density/ activity) at each plant's intake;
- Duration of exceedance of threshold (reported for pipeline spill and disinfection failure); and
- Spatial mapping of the extent of contamination for specific isopleths.

A comprehensive summary of all modelling results for all intakes is presented in Dewey (2011).

E2.3.2 Wastewater Treatment Plant Disinfection Failure Scenario

Figure E2.15 shows the predicted *E. coli* densities at the listed drinking water intakes during the disinfection failure event at the G.E. Booth WWTP modelled over the four-month duration (May through August). The maximum density predicted is nearly 21,000 CFU/100mL at the R. L. Clark intake, but the model results show that densities vary greatly over time and are specific to each intake, reflecting the complexity of the hydrodynamic regime.

Table E2-3, **Table E2-4**, and **Table E2-5** show the resulting peak levels and mean densities of *E. coli* predicted at individual drinking water intakes from disinfection failures at the specific WWTP. The mean values represent the arithmetic average over the simulation period. The peak concentrations are used in **Chapter 5** of the Assessment Report for purposes of determining whether a particular source represents a significant threat to each respective intake. The mean values are relevant to the manager of a water treatment plant in making operational decisions if they had to respond to address this type of failure scenario. **Table E2-6** shows the percentage of the time that the *E. coli* densities are above the threshold level during the four-month duration of this scenario.

The results for these WWTP by-pass scenarios indicate that *E. coli* would be present at the intake at levels that exceed the normal range of *E. coli* typically found in raw water in Lake Ontario at these intakes under normal conditions. Note that these *E. coli* levels would persist for the entire duration of the by-pass event. For example, at the Arthur P. Kennedy (formerly Lakeview) drinking water plant in Peel, the levels of *E. coli* in raw water typically range from 0 to an occasional high of 100 colony forming units (CFU). However, the results of the WWTP by-pass scenario for Peel's GE Booth WWTP indicate that the *E. coli* levels at the G.E. Booth WWTP would average 1,600 CFU/100 ml for the duration of the by-pass event. It should be noted that the model results may over-predict actual results in the event of the scenario as it does not reflect all the natural processes that could reduce *E. coli* levels in the surface waters.

The data in the tables below show that drinking water intakes may be impacted by disinfection failures from WWTPs that are located some distance away. The map showing the areas with maximum predicted *E. coli* densities above 1,000 CFU/100 ml based on the WWTP disinfection failures at the Duffins, Highland Creek, Ashbridges Bay, Humber and G.E. Booth WWTPs is provided in **Figure E2.16** also helps to show that contaminants released in this area travel east and west within the coastal zone at relatively high concentrations before they are mixed with the water in the main lake. This illustrates the importance of protecting water quality in the near shore as this is the source of drinking water for several million residents of Ontario.

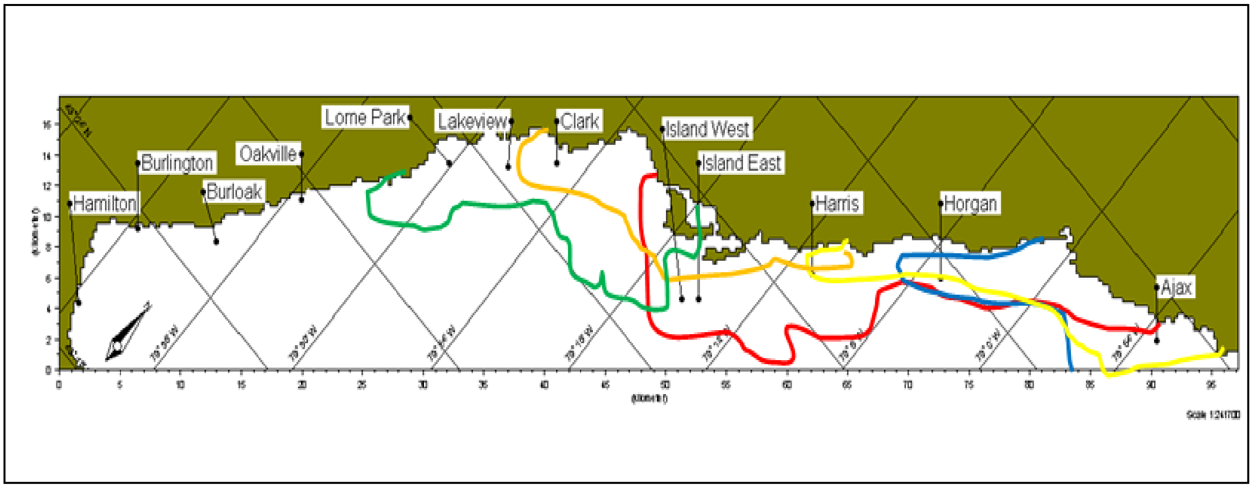


Figure E2.15: *E. coli* Time Series for Clark, Arthur P. Kennedy (previously named Lakeview), Lorne Park and Oakville Intakes

Note: [RED = ABTP, Blue = Duffins Creek, Yellow = Highland Creek, Orange = Humber, Green = G.E. Booth (previously named Lakeview)].

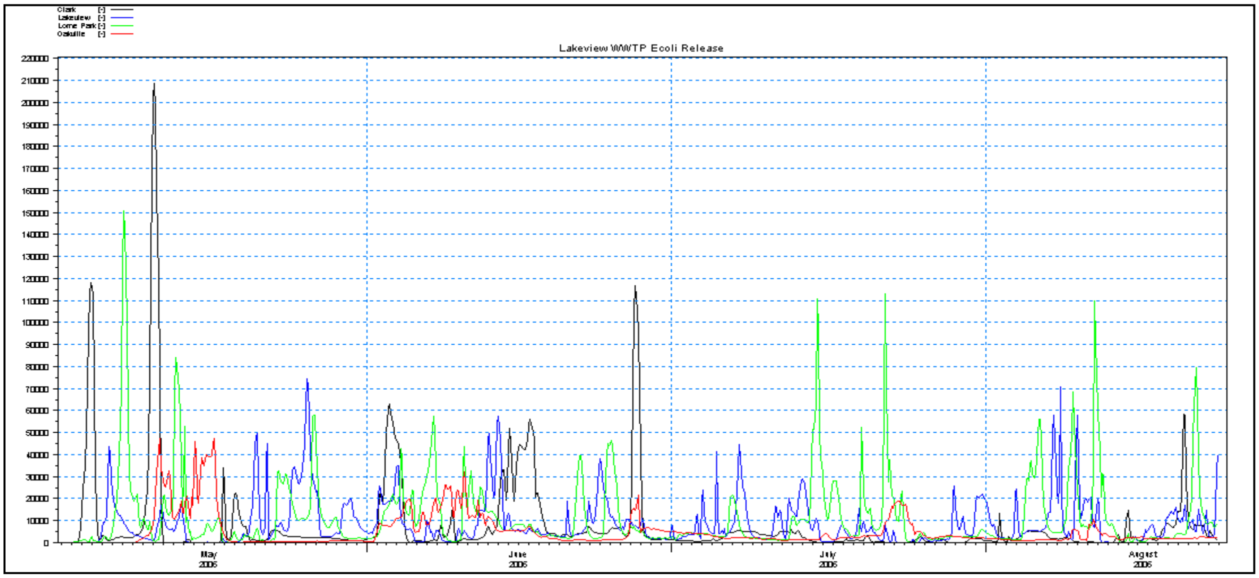


Figure E2.16: Composite Contaminant Map for *E. coli* from Disinfection Failures at GTA area WWTP's

WWTP	**Duffins Creek**		**Highland**		**ABTP**		**Humber**		**G.E. Booth**		**Mid-Halton**		**Oakville SE**		**Oakville SW**		**Clarkson**	
Intake Units are (CFU/100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)	Peak (CFU / 100 mL)	Mean (CFU / 100 mL)
Whitby	6480	460	1064	58	422	16	23	0.3										
Ajax	7320	700	1225	94	423	14	32	0.5										
Horgan	2470	173	10471	810	1373	52	100	3	45	1.2								
Harris	450	21	1308	66	4911	200	216	15	110	6								
Island West Deep	14	0.12	3	0.03	68	1	28	1.1	41	0.3								
Clark	23	0.43	32	0.6	2671	80	11688	334	55600	5500	32	1	52	2	35	1.3	1400	42
Arthur P. Kennedy			37	0.8	780	40	2906	100	83800	1600	62	2	58	3	46	2	1426	59
Lorne Park			13	0.3	756	16	734	33	38000	2400	248	11	539	26	216	14	5600	529

WWTP	Duffins Creek		Highland		ABTP		Humber		G.E. Booth		Mid-Halton		Oakville SE		Oakville SW		Clarkson	
Oakville			2	0.05	108	2	78	2	3070	70	5756	766	1456	105	12168	1820	9950	593
Burloak					56	1.5	66	1.4	1000	22	1367	33	265	9	637	60	889	50
Burlington					11	0.1	6	0.1	20	0.5	6153	425	103	1.7	1050	40	623	9
Hamilton										0.1	369	14	5	0.07	58	1.6	25	0.5

Table E2-3: WWTP Disinfection Failure Scenarios (Duffins Creek Westward)

WWTP/ Intake	Cobourg East		Cobourg West		Port Hope		Corbett Creek		Harmony Creek		Courtice	
	Peak (#/100 mL)	Mean (#/100 mL)	Peak (#/100 mL)	Mean (#/100 mL)	Peak (#/100 mL)	Mean (#/100 mL)	Peak (#/100 mL)	Mean (#/100 mL)	Peak (#/100 mL)	Mean (#/100 mL)	Peak (#/100 mL)	Mean (#/100 mL)
Cobourg	17810	1580	6522	595	647	72						
Port Hope	805	40	721	36	3550	335						
Ajax							479	21	210	13	353	30
Whitby							4342	73	791	50	1813	109
Oshawa							5550	789	4931	428	4946	406

WWTP/ Intake	**Cobourg East**		**Cobourg West**		**Port Hope**		**Corbett Creek**		**Harmony Creek**		**Courtice**	
	Peak (#/100 mL)	**Mean (#/100 mL)**	**Peak (#/100 mL)**	**Mean (#/100 mL)**	**Peak (#/100 mL)**	**Mean (#/100 mL)**	**Peak (#/100 mL)**	**Mean (#/100 mL)**	**Peak (#/100 mL)**	**Mean (#/100 mL)**	**Peak (#/100 mL)**	**Mean (#/100 mL)**
Bowmanville *											4946	406
Newcastle *											1813	109

* NOTE: Bowmanville & Newcastle are estimates based on similar distance from Courtice to Oshawa (Bowmanville) and Courtice to Whitby (Newcastle)

Table E2-4: WWTP Disinfection Failure Scenarios (Courtice WWTP Eastward)

Intake	Skyway WWTP		Woodward WWTP	
	Peak (CFU/100mL)	Mean (CFU/100mL)	Peak (CFU/100mL)	Mean (CFU/100mL)
Oakville	38	0.8	29	1.3
Burloak	6	0.2	2	0.1
Burlington	1380	55	882	64
Hamilton	2300	135	`464	186
Grimsby	32	0.7	4	0.2

Table E2-5: WWTP Disinfection Failure Scenarios (Skyward and Woodward WWTP)

Intake/Source	Cobourg East	Cobourg West	Port Hope	Courtice	Harmony	Corbett	Duffins	Highland	ABTP	Humber	G.E. Booth	Mid-Halton	Oakville SE	Oakville SW	Clarkson	Skyway	Woodward
Cobourg	72	59	24														
Port Hope	15.7	15.6	58														
Bowmanville*				29													
Newcastle*				17													
Oshawa				29	58	42											
Whitby				17	4.4	27	47	13	5								
Ajax				13.2	2.6	3.5	58	27	5								
Horgan							22	33	15	.09							
Harris							8	16	31	3	0.3						
Island Shallow																	
Island Deep																	
Clark									15	22	76						
Arthur P. Kennedy									13	9	52				13		
Lorne Park									4	7	38	2.3			17		
Oakville									0.2		10	63	7	4	51		

Intake/Source	Cobourg East	Cobourg West	Port Hope	Courtice	Harmony	Corbett	Duffins	Highland	ABTP	Humber	G.E. Booth	Mid-Halton	Oakville SE	Oakville SW	Clarkson	Skyway	Woodward
Burloak											6	9	22	74	32		
Burlington												27	.8	24	15	15	20
Hamilton												4	.1	9	2	29	66

Table E2-6: Percent of Time *E. coli* above Threshold of 100 CFU/100ml

E2.3.3 Sanitary Trunk Sewer (STS) Break Due to Stream Erosion

The calculated time series for *E. coli* to the drinking water plant intakes are provided in **Figure E2.17** and the corresponding peak *E. coli* densities at each intake are tabulated in **Table E2-7**.

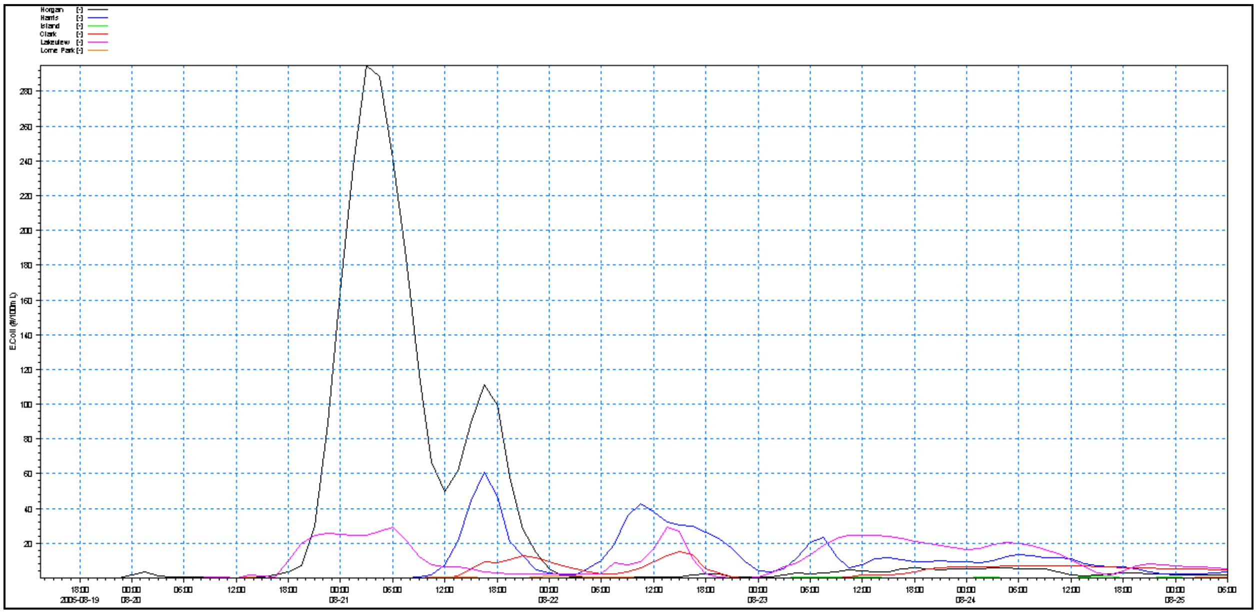


Figure E2.17: *E. coli* Time Series for STS Breaks

Table E2-7: Peak *E. coli* Densities in the STS Break Scenarios

Intake	**Peak *E. coli* Densities (CFU/100ml) for STS Breaks under August 19, 2005 Conditions (Scenario 1)**	**Peak *E. coli* (#/100ml) for STS Breaks under various Summer, 2005** **Meteorological conditions (Scenario 2)**
Ajax	2	2
Horgan	290	300
Harris	60	180
Island Shallow	19	30
Clark	15	1000 (Etobicoke) 340 (Humber)

Intake	**Peak *E. coli* Densities (CFU/100ml) for STS Breaks under August 19, 2005 Conditions (Scenario 1)**	**Peak *E. coli* (#/100ml) for STS Breaks under various Summer, 2005 Meteorological conditions (Scenario 2)**
Arthur P. Kennedy	29	110 (Humber) 180 (Etobicoke)
Lorne Park	1	360
Oakville	<1	160

The results of the two STS break scenarios are provided in the above table. As discussed in **Section E6.2.4**, the first scenario is based on meteorological and limnological conditions that occurred during the August 19, 2005 period. The modelled *E. coli* levels are only above the threshold of 100 CFU *E. coli* /100 ml at the Horgan WTP from the spill caused by erosion of the Highland STS.

The results of the second scenario indicate that different river flow and lake current conditions could cause *E. coli* levels to above the threshold of 100 *E. coli*/ 100 ml for several of the WTPs, rather than just the Horgan intake. It is concluded that STS breaks in the TRSPA, as modelled, represent a significant threat to the following intakes:

- Horgan WTP, caused by discharge from Highland Creek;
- Harris WTP, caused by discharge from Don River;
- Clark and Arthur P. Kennedy (located in CVSPA) WTPs, caused by discharge from Etobicoke Creek and Humber River; and
- Lorne Park (located in CVSPA) and Oakville (located in Halton SPA) WTPs, caused by a discharge from Etobicoke Creek.

E2.3.4 CSO Spill

The risk to local intakes from *E. coli* levels from a spill associated with CSO's is provided in **Figure E2.18** and **Figure E2.19** for the four Toronto intakes. The calculated *E. coli* levels at the F. J. Horgan and R.C. Harris intakes range from 20 – 60 CFU/100 ml, while the results for the R. L. Clark and Deep Island intakes are lower. All the results are below the threshold value of 100 CFU/100ml used to identify significant threats.

When these predicted results are compared with results from *E. coli* monitoring, the modelled results are higher. This is likely due to the conservative assumptions in the model.

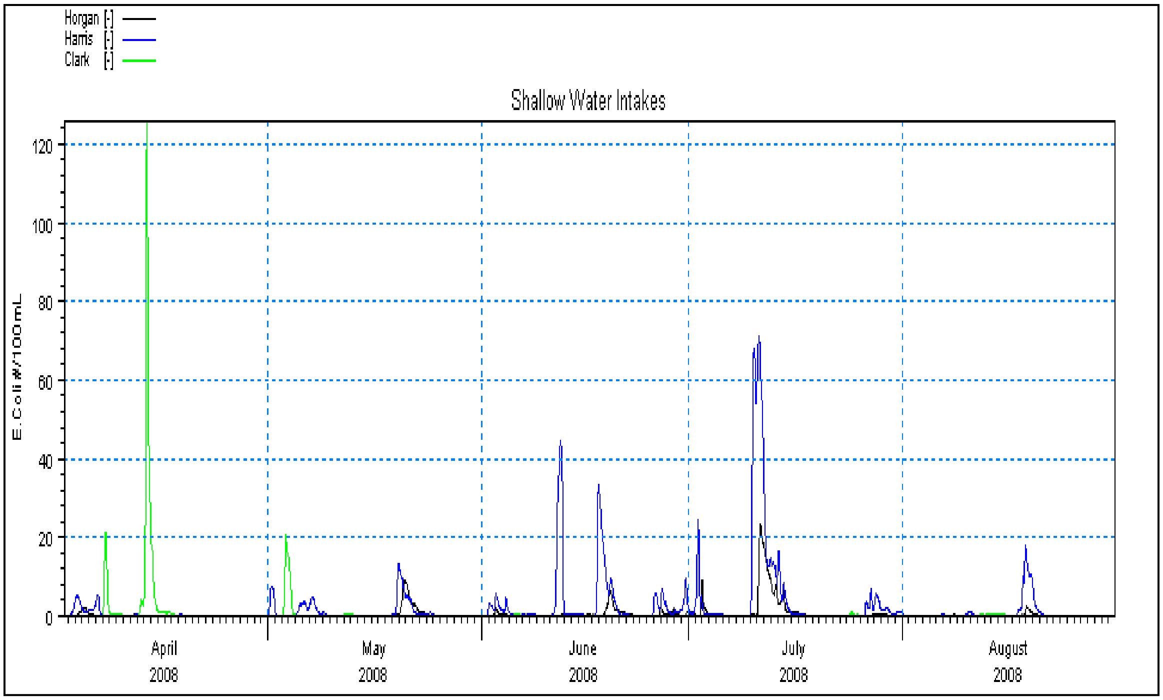


Figure E2.18: *E. coli* Levels for Horgan, Harris and Clark from CSO Spill

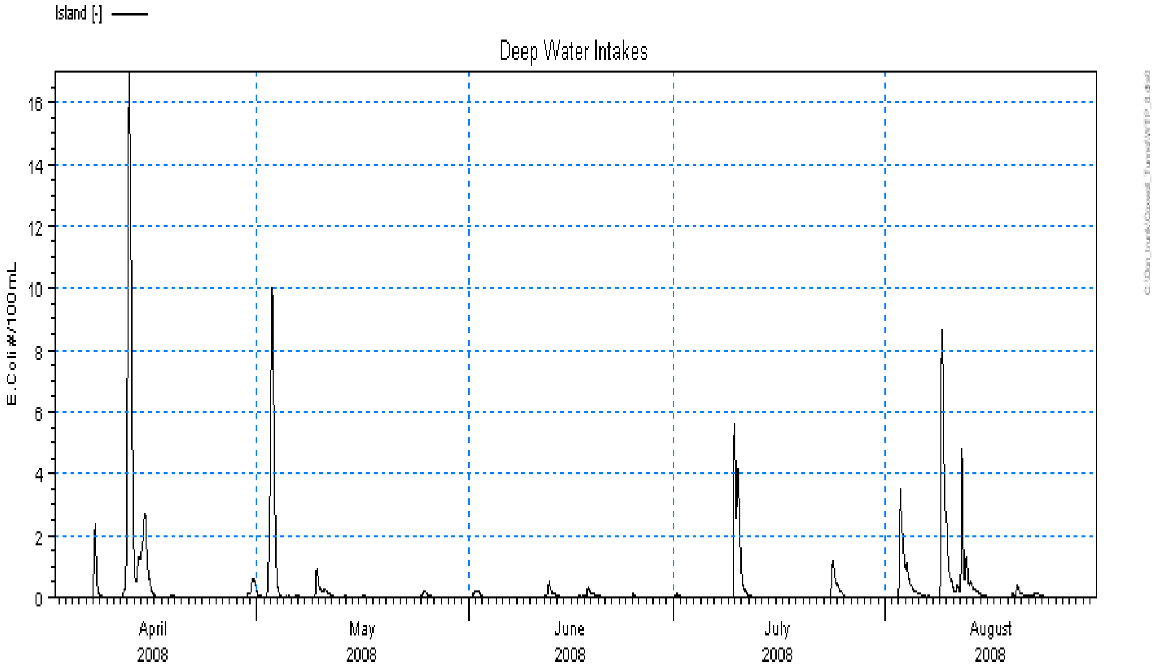


Figure E2.19: *E. coli* Levels Predicted for Toronto Island Intakes from CSO Spill

E2.3.5 Industrial Animal Food Processing Lagoon Spill

Figure E2.20 provides the calculated time series of *E. coli* at intakes near the mouth of the Credit River (Clarke, Arthur P. Kennedy, and Lorne Park). The resultant *E. coli* density at the mouth of the Credit River was estimated at 25 CFU/100ml. As the maximum densities are less than 100 *E. coli* CFU/100 ml at the intakes, a spill from the industrial animal food processing lagoon has not been identified as a significant threat to these intakes.

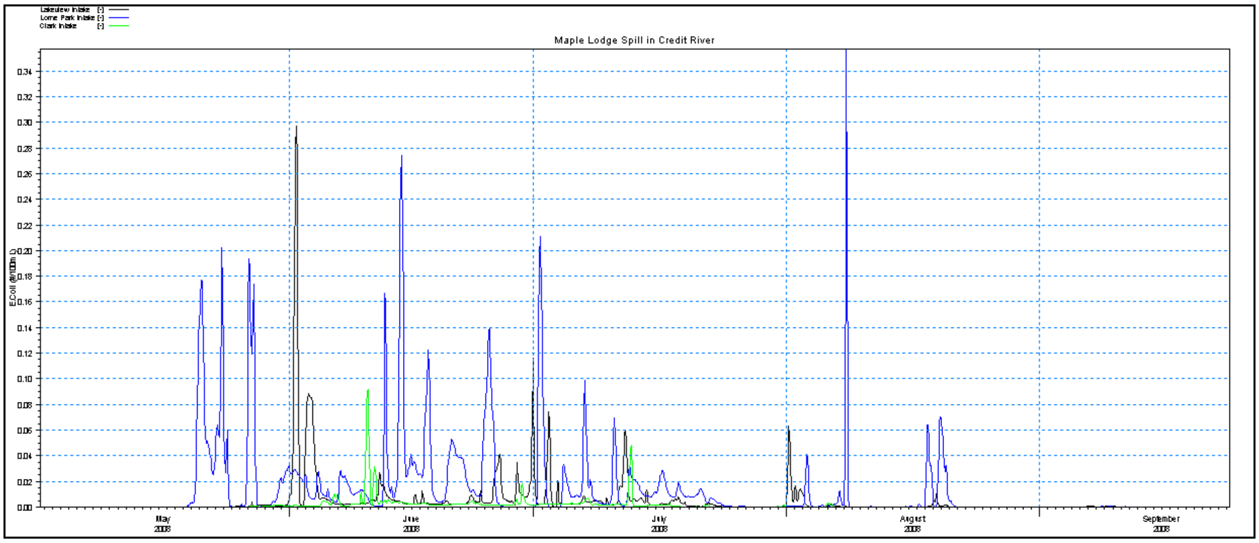


Figure E2.20: Predicted *E. coli* Densities from Industrial Animal Food Processing Lagoon Scenario

(*Lakeview intake has been renamed Arthur P. Kennedy)

E2.3.6 Benzene Spill from Pipeline Rupture

The effects of a pipeline break in crossing the Credit River are significant for the Arthur P. Kennedy, Lorne Park and Clark intakes. **Figure E2.21** shows a representative time series of benzene concentration at the Arthur P. Kennedy drinking water plant intake. **Table E2-8** lists the peak levels of benzene predicted at each intake from the spill locations modelled affecting the CTC Source Protection Region (SPR). The fraction of the simulation period that the concentrations exceed 0.05 mg/L is tabulated on **Table E2-9**; it indicates that typically the drinking water plant would need to deal with the episode for a few days.

The results of each pipeline spill scenario indicate that each spill would reach nearby drinking water plant intakes at concentrations that exceed the ODWS for benzene of 0.005mg/l.

The composite contaminant map for benzene spill from GTA intakes in provided in **Figure E2.22**, using 0.05 mg/l as the mapped contour, as relevant to the Coastal Zone of Lake Ontario. The corresponding maps, using the drinking water limit of 0.005 mg/l is located at the end of this Appendix.

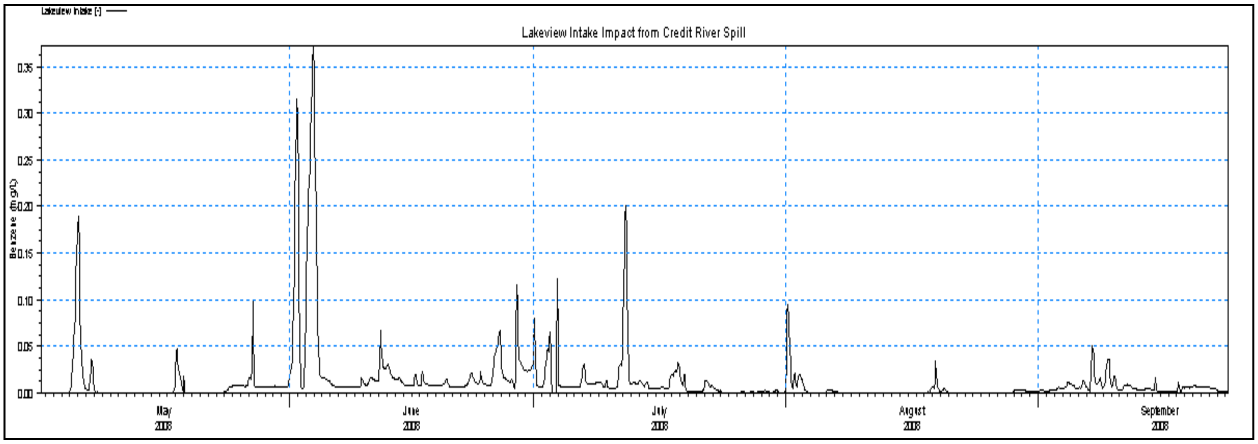
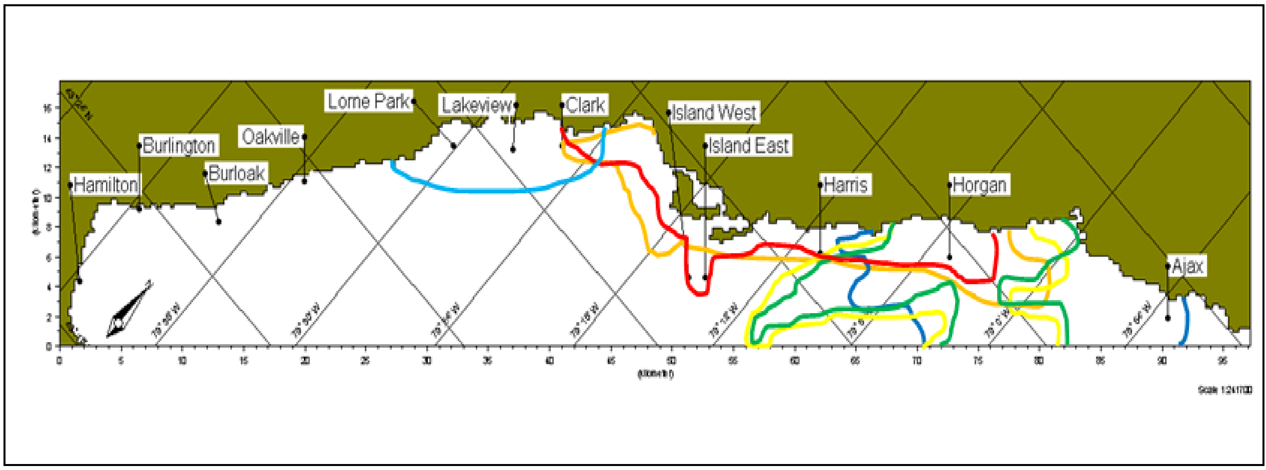


Figure E2.21: Arthur P. Kennedy Time Series from Credit River (*Lakeview intake has been renamed Arthur P. Kennedy)



Note: Red = Humber, Neon Blue = Credit, Orange = Don, Blue = Duffins, Green = Rouge, Yellow = Highland Creek

Figure E2.22: Composite Contaminant Map for Benzene from Pipeline Spill at GTA Watercourse Crossings (*Lakeview intake has been renamed Arthur P. Kennedy)

Table E2-8: Peak Levels Benzene from Pipeline Break at Municipal Drinking Water Intakes (mg/L)

Discharge Intake	Cobourg Creek	Ganaraska River	Wilmot Creek	Graham Creek	Bowmanville Creek	Oshawa Creek	Duffins Creek	Rouge River	Highland Creek	Don River	Humber River	Credit River	16 Mile Creek
Cobourg	3.00	1.0											
Port Hope	1.17	3.0											
Newcastle			3.0	3.0	1.0								
Bowmanville			3.3	3.0	1.0								
Oshawa						1.40							
Whitby						0.32	0.011	0.006	0.008				
Ajax						0.14	0.061	0.011	0.010	0.010			
Horgan							0.075	0.270	0.290	0.250			
Harris							0.047	0.045	0.088	0.310	0.101		
Island Shallow										1.000	0.400		
Island Deep										0.010	0.010		
Clark										0.035	0.790	0.15	
Arthur P. Kennedy										0.023	0.300	0.37	
Lorne Park												2.40	0.012

Discharge Intake	Cobourg Creek	Ganaraska River	Wilmot Creek	Graham Creek	Bowmanville Creek	Oshawa Creek	Duffins Creek	Rouge River	Highland Creek	Don River	Humber River	Credit River	16 Mile Creek
Oakville													0.120
Burloak													0.014
Burlington													0.035
Hamilton													0.007

Table E2-9: Typical Duration of Benzene above the Threshold at Municipal Drinking Water Intakes (hr)

Discharge Intake	Cobourg Creek	Ganaraska River	Wilmot Creek	Graham Creek	Bowmanville Creek	Duffins Creek	Rouge River	Highland Creek	Don River	Humber River	Credit River
Cobourg	48	36									
Port Hope	37	60									
Newcastle			30	24	36						
Bowmanville			24	24	36						
Ajax						36-72	36-72	36-72			
Horgan											
Harris						36-72	36-72	36-72	36-72	36-72	
Island Shallow											
Island Deep									36-72	36-72	
Clark									36-72	36-72	36-72

E2.3.7 Bulk Petroleum Storage and Handling Spill Scenarios

Results from spills from bulk petroleum storage facilities located on the Lake Ontario shoreline (Oakville), as well in North York (which could discharge to the Don or Humber rivers through storm sewers) are documented in this section.

Spills from Storage Tanks at the Oakville Site

The peak concentrations of benzene at each of the water treatment plant intakes from storage tank spills at the Oakville facility are listed in **Table E2-10.** The concentrations at the Oakville and Burlington WTP intakes are higher than at the Burloak WTP intake despite Burloak being closest to the Bronte Creek discharge point, because the former intakes are close to shore, while Burloak is much further off-shore in about 16 to 18 metres of water).

Table E2-10: Peak Benzene Concentrations from Petroleum Storage and Handling at Bulk Facilities

Intake	Oakville Bulk Tank Spill Peak Benzene Concentration(mg/L)	North York Bulk Tank Spill via Humber River Peak Benzene Concentration(mg/L)	North York Bulk Tank Spill via Don River Peak Benzene Concentration(mg/L)
Ajax			0.0004
Horgan		0.001	0.0380
Harris	0.0005	0.006	0.0590
Island Deep	0.0020	0.015	0.0090
Clark	0.0140	0.550	0.0004
Arthur P. Kennedy	0.5000	0.317	0.0030
Lorne Park	1.2500	0.078	
Oakville	9.0000	0.003	
Burloak	0.6700		
Burlington	11.0000		
Hamilton	0.8400		

Figure E2.23 graphically shows the benzene levels at the impacted intakes. The benzene plume from each of the spill scenarios is calculated to persist for several days. For example, at the Burlington intake, there are events in June which have levels above 0.4 mg/L benzene for three days. Other intakes have levels above 0.5 mg/L for up to two days.

The results of the westerly gasoline-benzene spill event indicate that the benzene plume persists for several days at each intake. Burlington, two big events in June, has levels above 0.4 mg/L for three days. Other intakes have levels above 0.5 mg/L for up to two days.

The results of the easterly gasoline-benzene spill event indicate that the contaminant reaches the Lorne Park intake first, in less than 24 hours with a peak concentration of 1.25mg/L with levels declining to 0.005 mg/L after several days. The Arthur P. Kennedy intake is not impacted until 11 days later with a level of 0.5 mg/L which increases up to 0.001 mg/L over a week's time. The spill is predicted to reach the R. L. Clark intake two weeks after the spill event with levels eventually reaching 0.14 mg/L. The plume lingers in the vicinity of both the Arthur P. Kennedy and R. L. Clark intakes for several weeks at the 0.001 to 0.0005 mg/L.

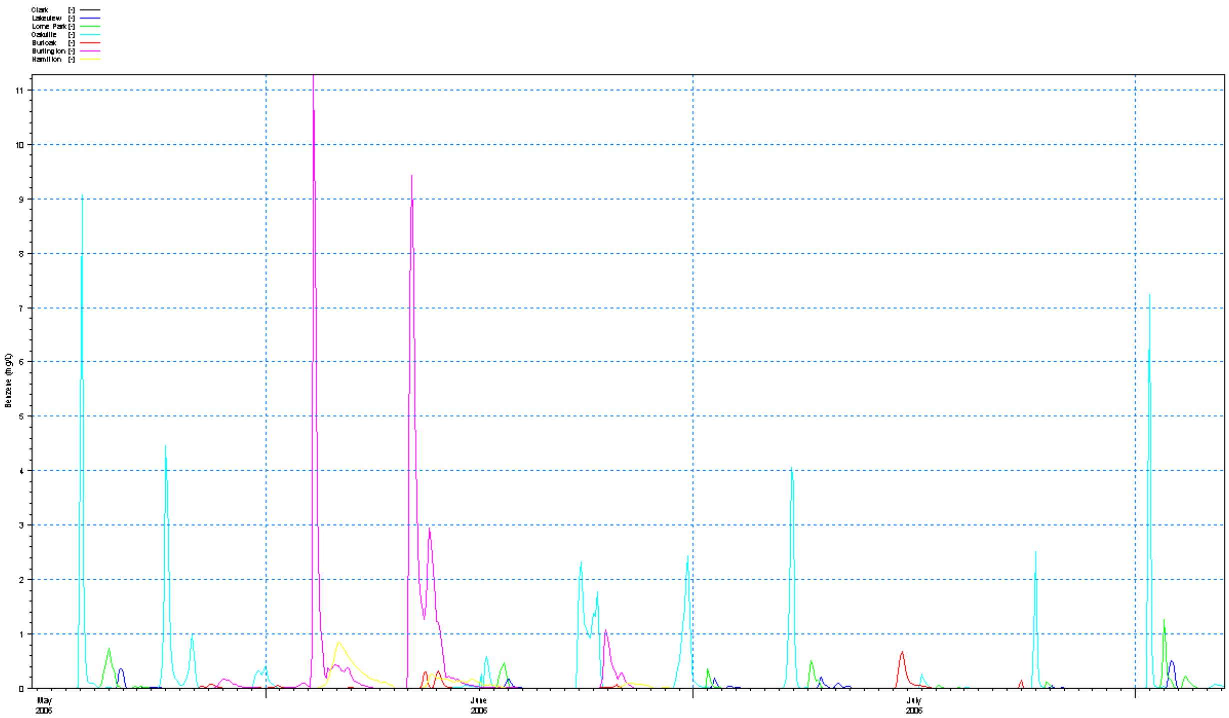


Figure E2.23: Benzene Concentrations (mg/L) at Intakes from Simulated Gasoline Storage Spills (*Lakeview intake has been renamed Arthur P. Kennedy)

The spatial extent of the plume using a 0.05 mg/L isopleth, is shown in **Figure E2.24**. The elevated concentrations are focused on the shoreline between Lakeview WTP to the east and Burlington WTP to the west.

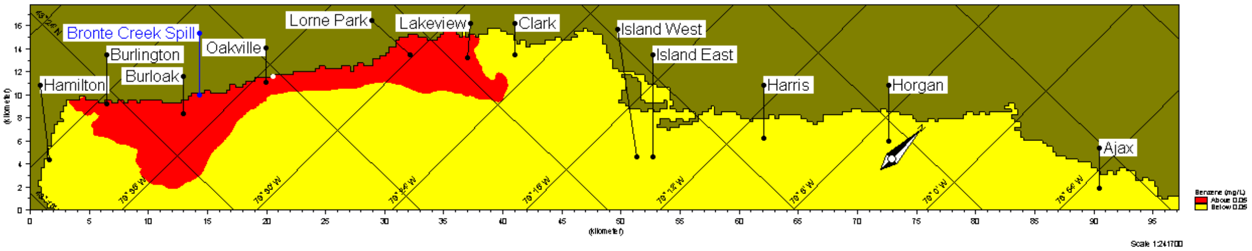


Figure E2.24: Oakville Storage Facility Spill - 0.05 mg/L Benzene Isopleth (*Lakeview intake has been renamed Arthur P. Kennedy)

Spills from Unloading of Gasoline at Oakville Storage Facility

The peak levels of benzene at each water treatment plant intake from each of the three ship unloading spill scenarios are tabulated in **Table E2-11**. The results indicate that the increase in peak concentrations is approximately linear as a function of increase in spill volume. The Burlington intake is estimated to have the highest benzene concentrations. The time that benzene concentrations are predicted to be above 0.005 mg/L is about 2-hours for the 200 litre spill, 10-hours for the 500 litre spill and 13-hours for the 1000 litre spill.

Table E2-11: Peak Benzene Concentrations at Intakes from Ship Spills of Gasoline at Oakville Storage Facility

Intake	**Spill Volume**		
	200 L in 15 minutes	**500 L in 15 minutes**	**1000 L in 15 minutes**
	Benzene (mg/L)	**Benzene (mg/L)**	**Benzene (mg/L)**
Lakeview	0.0003	0.0008	0.0017
Lorne Park	0.0013	0.0034	0.0068
Oakville	0.0080	0.0200	0.0440
Burloak	0.0020	0.0060	0.0130
Burlington	0.0200	0.0050	0.1030
Hamilton	0.0020	0.0050	0.0108

Figure E2.25 shows the 0.05 mg/L isopleth for the 100,000 litre gasoline (1000 litre benzene) spill for the simulation period of May 15 to June 6, 2006 (see Dewey, 2011).

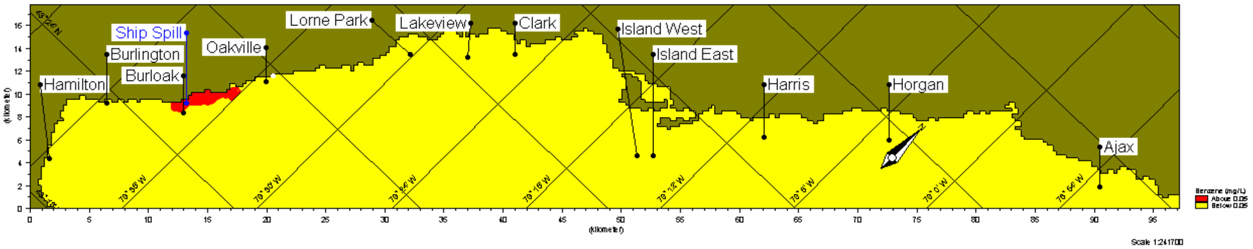


Figure E2.25: Scenario of 1000 L spill with a Benzene Isopleth of 0.05 mg/L

Spill from Storage Tanks at the North York Site

The North York site is located close to the watershed divide between the Humber and Don rivers. Depending on the location of the tank, the spill could either flow into the Humber River or the Don River. The results of the model simulations (**Table E2-12**) show the maximum concentrations for a spill to either river. There is a significant risk to all four City of Toronto intakes, because concentrations exceed the threshold of 0.005 mg/l at F.J. Horgan, R.C. Harris, Toronto Island (shallow) and R.L. Clark.

Table E2-12: Benzene Concentrations at Intakes Due to Petroleum Spill from North York Facility

Intakes	Benzene Concentration from Spill Reaching the Humber River (mg/L)	Benzene Concentration from Spill Reaching the Don River (mg/L)
Ajax	<0.001	<0.001
Horgan	0.001	0.038
Harris	0.006	0.059
Island Deep	0.015	0.009
Clark	0.550	0.004
Arthur P. Kennedy	0.317	0.004
Lorne Park	0.078	< 0.005

Note: see Dewey, 2011, for calculated concentrations at other nearby intakes

E2.3.8 Nuclear generating Station Tritium Spill Scenario

The tritium levels over time at several intakes from the Pickering spill scenario are shown on **Figure E2.26.** The results between the observed and modelled results show a good correlation.

The peak tritium levels in Becquerels per litre predicted by the model are tabulated in **Table E2-13** for drinking water intakes within the GTA environs. The modelled results indicate that the Pickering spill could affect two intakes within the CTC (Whitby, Oshawa) at levels above 7,000 Bq/L, the current Ontario Drinking Water Standard which has been selected as the threshold to identify a significant threat.

The time series of tritium at each intake due to spill from the Darlington outfall is shown in **Figure E2.27**. The data in **Table E2-13** shows that a release from Darlington could exceed the threshold of 7,000 Bq/L for Oshawa and Bowmanville intakes.

Table E2-13: Peak Tritium Activity (Bq/L)

Intake	Pickering Spill (Bq/L)	Darlington Spill (Bq/L)
Hamilton	90	47
Burlington	60	46
Burloak	140	73
Oakville	97	74
Lorne Park	122	131
Arthur P. Kennedy	138	217
R.L. Clark	144	238
Island deep		500 (shallow layer)
R.C. Harris	198	728
F.J. Horgan	354	946
Ajax	2000	3500
Whitby	12,000	4600
Oshawa	20,000	8200
Bowmanville	1160	8700

Intake	**Pickering Spill (Bq/L)**	**Darlington Spill (Bq/L)**
Newcastle	920	4800
Port Hope	810	2500
Cobourg	810	830

(Note: Pickering data from the 270 m grid file; Darlington calculations from 2430 m grid file.)

Since the two nuclear-generating stations have been identified as significant threat activities which are located within the CTC SPR, source protection plan policies must be developed. This will include consideration of the effectiveness and adequacy of existing risk management and spill response protocols.

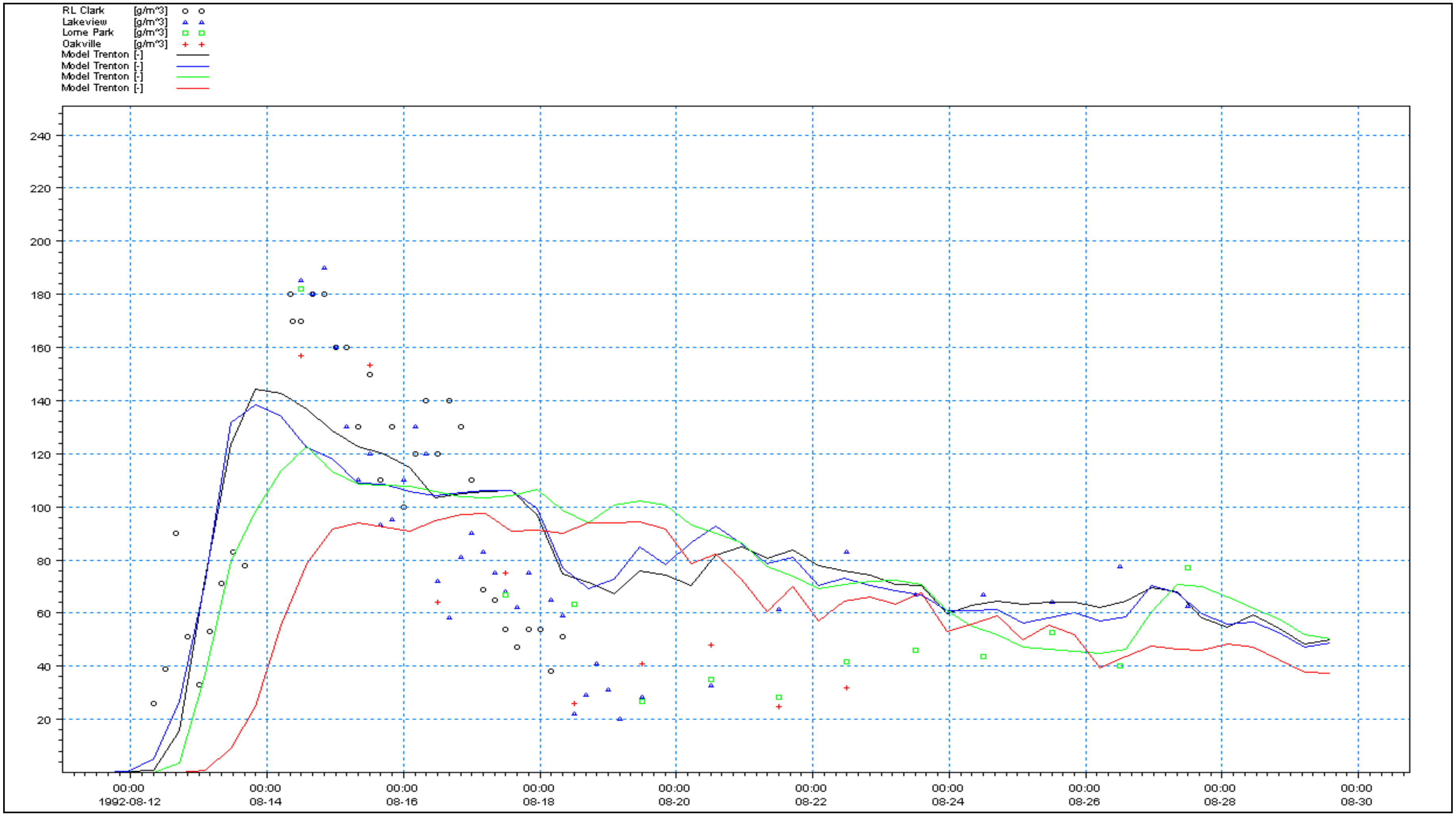


Figure E2.26: Model Calibration: Comparison of Model Calculations with Observations using Trenton Winds for Clark to Oakville Intakes (*Lakeview intake has been renamed Arthur P. Kennedy)

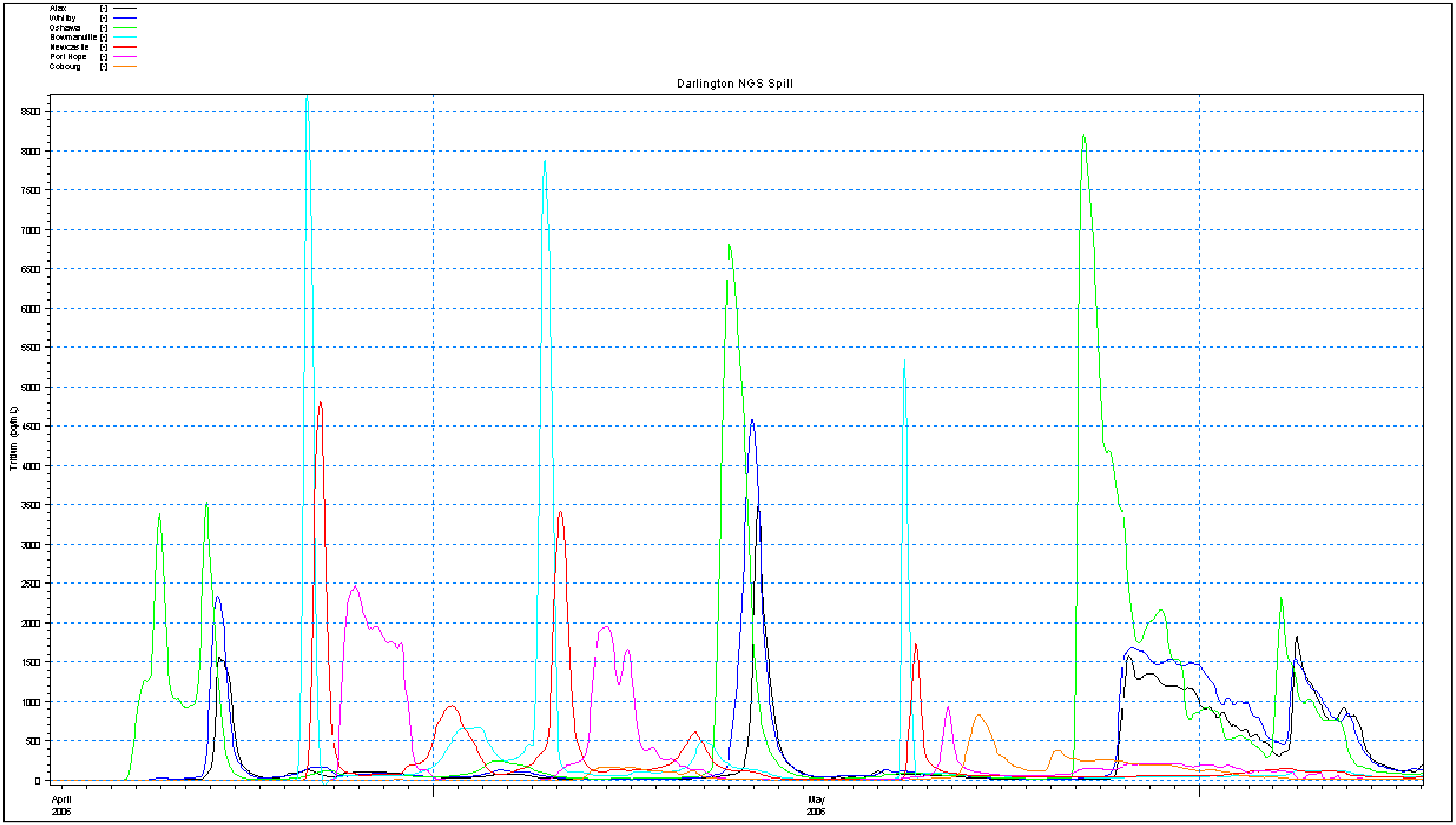


Figure E2.27: Tritium Time Series at Intakes (Ajax to Cobourg) for Release from Darlington Outfall

Background Tritium Levels in the Great Lakes

Internet based sources suggest the background level of tritium is approximately 2 Bq/L in Lake Ontario (Fairlie, 2007). In 2006, Toronto's drinking water concentration for tritium averaged of 3.3 Bq/L, with a maximum value of 12 Bq/L. This is a marked decrease since the mid-1960s peak in tritium concentrations in the environment (Fairlie, 2007). Another report (**Table E2-14**) estimates that levels of tritium in Lake Ontario are 7.1 Bq/L and increasing annually. Tritium has a half time of approximately 12 years so after spills of the type modelled in these scenarios it would take 2-3 decades for the spill effects to be significantly dissipated through radionuclide decay processes.

Table E2-14: Average Tritium Concentrations in the Great Lakes in 1997/98

Great Lakes	Average Tritium Concentration (Bq/L)
Superior	2.0
Michigan	3.0
Huron	7.0
Erie	5.5
Ontario	7.1

Source King *et al.* (1998, 1999)

The contaminant map showing the predicted tritium contours of 150 Bq/L from the Pickering spill scenario is provided on **Figure E2.28.** This illustrates the extent of contamination in the coastal zone that could occur.

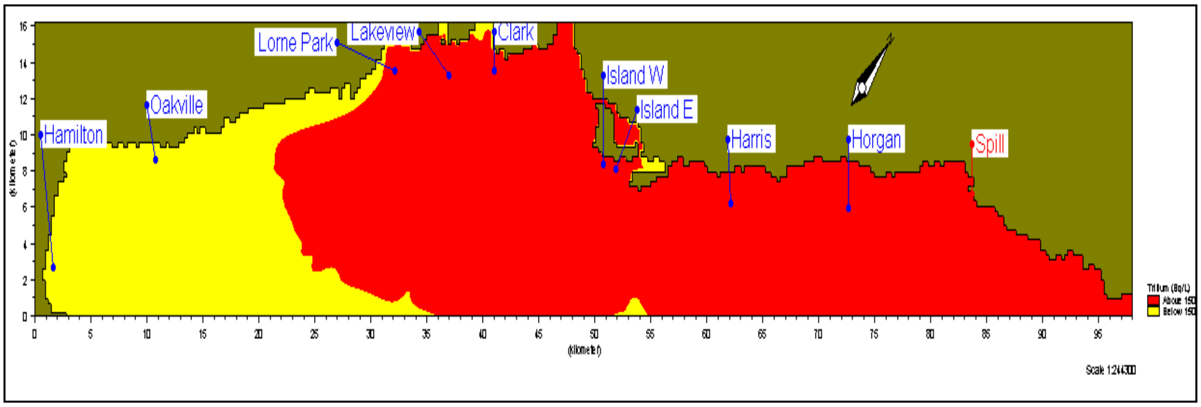


Figure E2.28: Extent of Contamination for Tritium, using a 150 Bq/L Contour (*Lakeview intake has been renamed Arthur P. Kennedy)

E2.4 Spatial Representation of Results

The methodology used to develop the spatial mapping for IPZ-3 delineation by the Lake Ontario Collaborative is summarized in this section. The actual maps are either provided in **Chapter 5** of the main body of the Assessment Report, or in this Appendix.

E2.4.1 Mapping Zone of Contamination within Lake Ontario

Peak concentrations have been used to determine whether a spill from a specific source represents a significant threat to an intake. Two alternatives were considered (Dewey, 2011) to map the spatial in-lake limits of spills from a specific source:

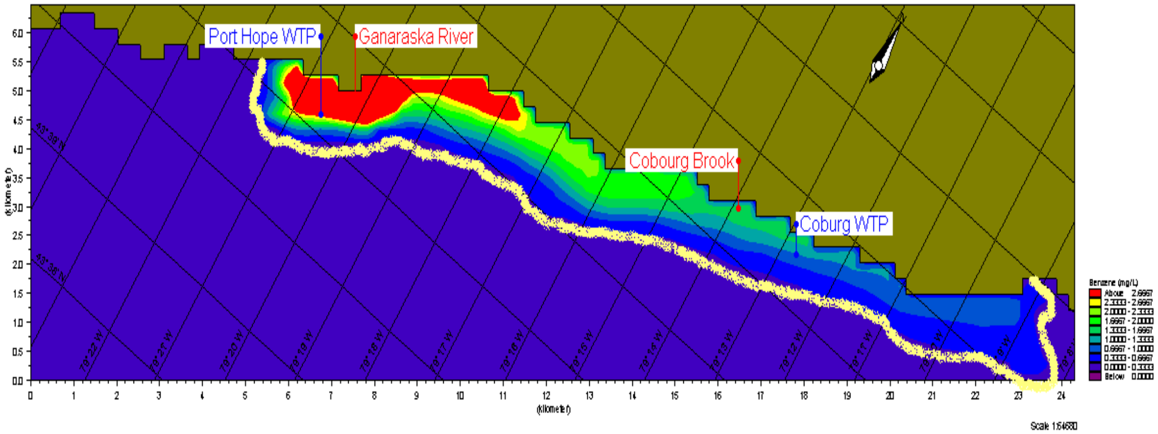
- A specific event; or
- A series of events.

Method 1 – Based on Spatial Extent of a Specific Event

The first method considered was to map the in-lake extent of the maximum concentration in the time series from one event. The term, "elevated concentrations" was defined as concentrations / activity/ density above the selected threshold, is the indicator of impact used in this approach.

The peak concentrations within each grid cell in the geographical area around the intake and between the intake and the spill source was extracted from the model simulations and then concentration contours were calculated. Concentrations calculated for a five-day period around the event was used.

This method was evaluated mainly for the WWTP Disinfection Failure scenario and for the Pipeline Failure scenario. For benzene spills to intakes such as Cobourg and Newcastle, the method predicted impacts which extended both east and west of the intakes (**Figure E2.29**).



Note that the boundary shows the 0.11 to .33mg/L contours

Figure E2.29: Boundary for Benzene Spill for Ganaraska River – Easterly Plume

Evaluation of other intakes and substances indicated that the selected event (largest peak concentration) resulted in a small area around the discharge point, and often was located only in one direction from the discharge. This is illustrated in **Figure E2.30** (time series for Arthur P. Kennedy intake) and **Figure E2.31** (Spatial Extent). This method, therefore, may underestimate the area to which a spill might extend.

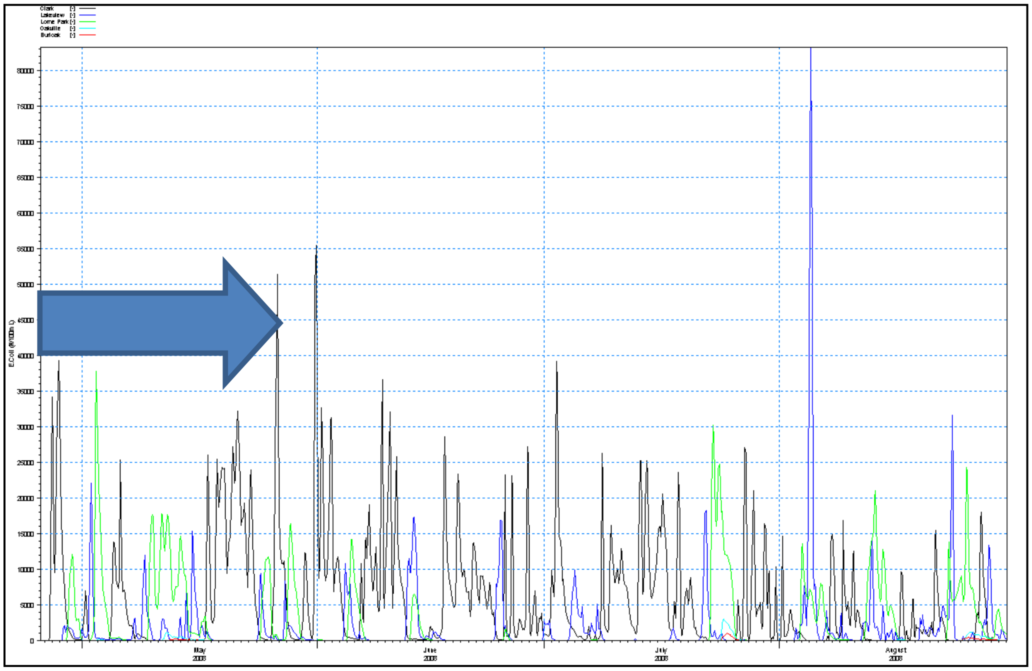


Figure E2.30: Arthur P. Kennedy Time Series (*Lakeview intake has been renamed Arthur P. Kennedy)

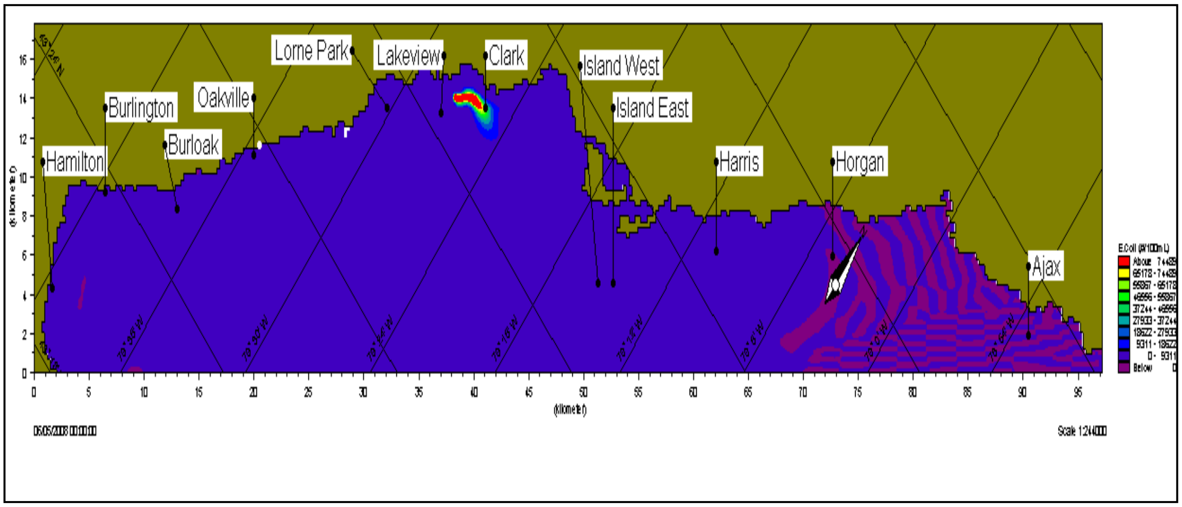


Figure E2.31: Spatial Extent of Impact from Spill occurring August 5 (*Lakeview intake has been renamed Arthur P. Kennedy)

Method 2 – Spatial Extent of Zone of Contamination based on Multiple Peaks at the WTP

A second method was developed to address the potential underestimation of the spill impact extent. The second method involves selecting a time period of several weeks and calculating the peak concentrations around the intake for this period. The period was selected to include a mix of days with east-trending and west-trending currents around the discharge point into Lake Ontario. The results were contoured to produce concentration isopleths, as shown on **Figure E2.32**.

The criteria of ensuring that both east and west currents are part of the modelled period may result in a different time period being used for different discharge points and intake locations. The rationale for choosing different computational periods is that variable local circulation patterns can occur within the same area of the lake.

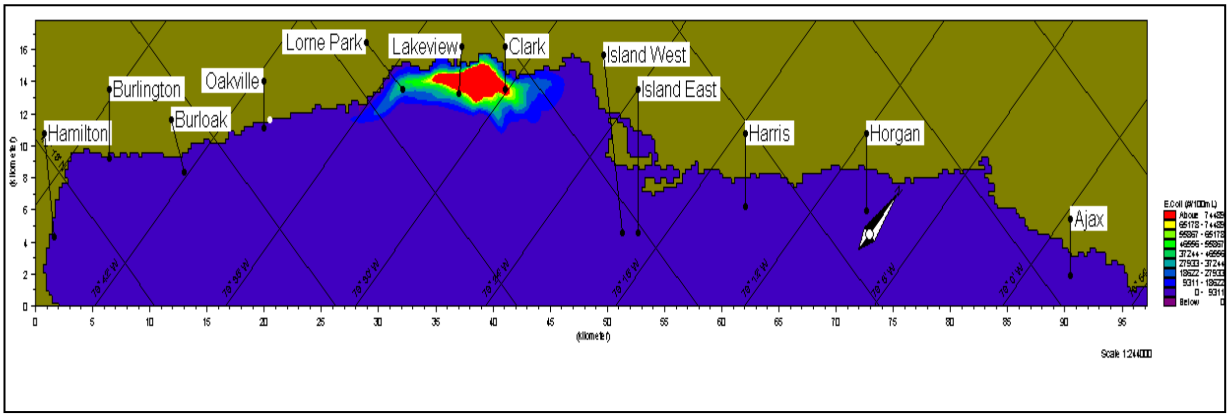


Figure E2.32: Spatial Extent of Impact from Spills starting April 4 for a Four–week period (*Lakeview intake has been renamed Arthur P. Kennedy)

The resultant location of the contour corresponding to the selected threshold value was used to define the in-lake extent for the IPZ-3 boundary. For land-based spill points, the IPZ-3 boundary extends upstream along the river channel to the spill point.

Summary of Threat Mapping for Zones of Contamination

A summary map of all 'significant threat sources' is provided, which summarizes the in-lake and land based sources of discharge. For example, the pipeline rupture threat location is at the stream crossing, while the disinfection failure discharge location is the WWTP outfall.

Example maps of zones of contamination using different numerical criteria for representative intakes are provided on **Figure E2.33** to **Figure E2.37**. The isopleths for the benzene and *E. coli* 'significant threat' thresholds extend further into the lake than those using ten times the threshold value. These are summarized as separate maps shown as for specific thresholds and specific contaminants, as follows:

- *E. coli* zone of contamination for 1000 *E. coli CFU*/100 mL and a 100 *E. coli CFU*/100 mL threshold due to WWTP disinfection failure;
- Benzene zone of contamination for a 0.005 mg/l threshold and a 0.05 mg/l concentration due to pipeline rupture; and
- Tritium zone of contamination for a 20,350, and 7,000 Bq/L due to a spill from a nuclear power generating station.

These maps provide a summary of the extent of impacts from specific scenarios. They indicate that the zones of contamination generally include the complete coastal zone from Cobourg to Hamilton and that the intensity of zones is centered in the CTC area (Peel to Durham), with a lower intensity to the east between Bowmanville and Cobourg.

Additional modelling to identify significant threat activities may be undertaken in the source protection plan policy development phase. This modelling may also further refine the zone delineations and facilitate a better understanding of the key hydrodynamic factors which affect the movement of a spill to the intakes.

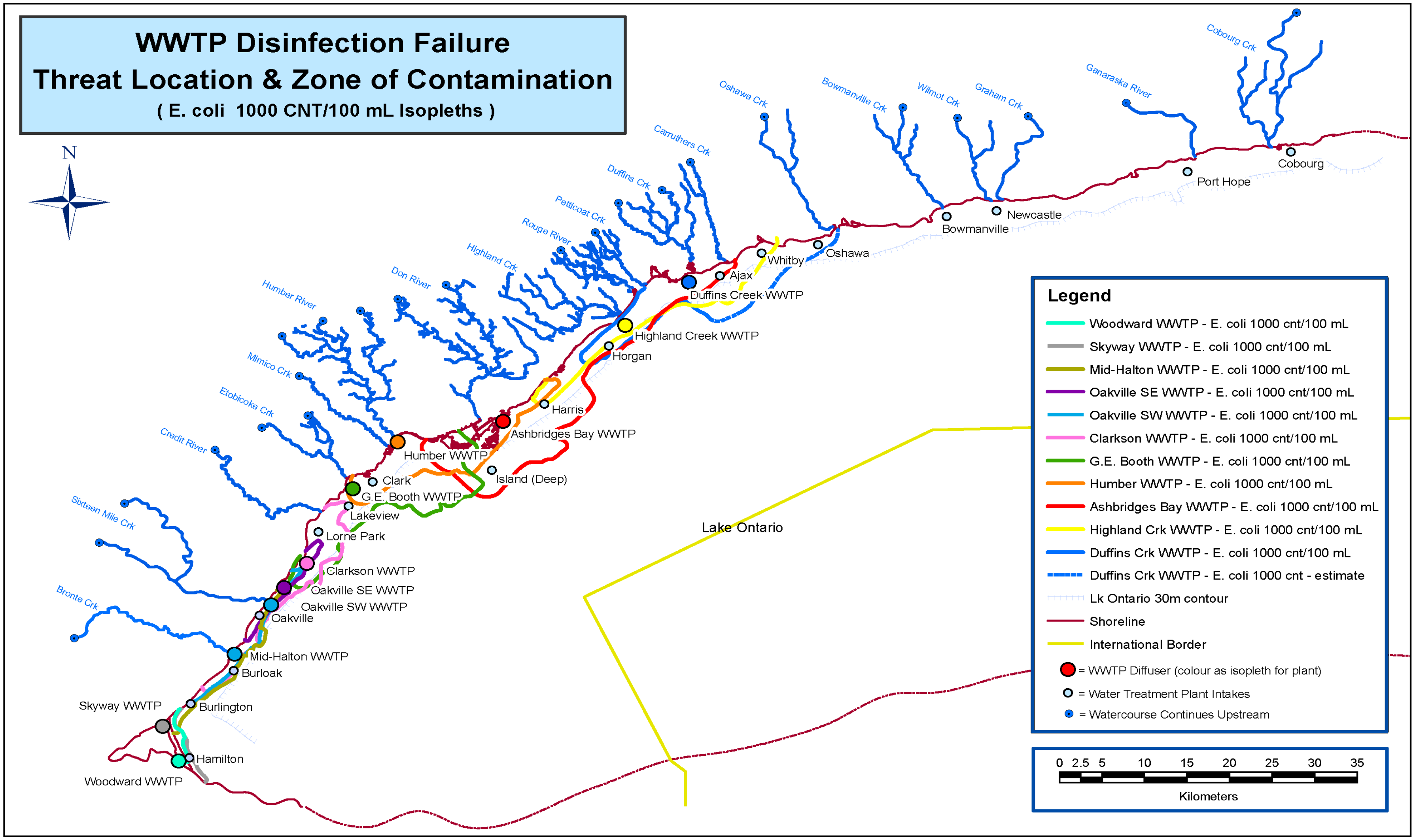


Figure E2.33: WWTP Disinfection Failure Threat Location and Zone of Contamination (E. coli 1000 CFU/100 ml Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

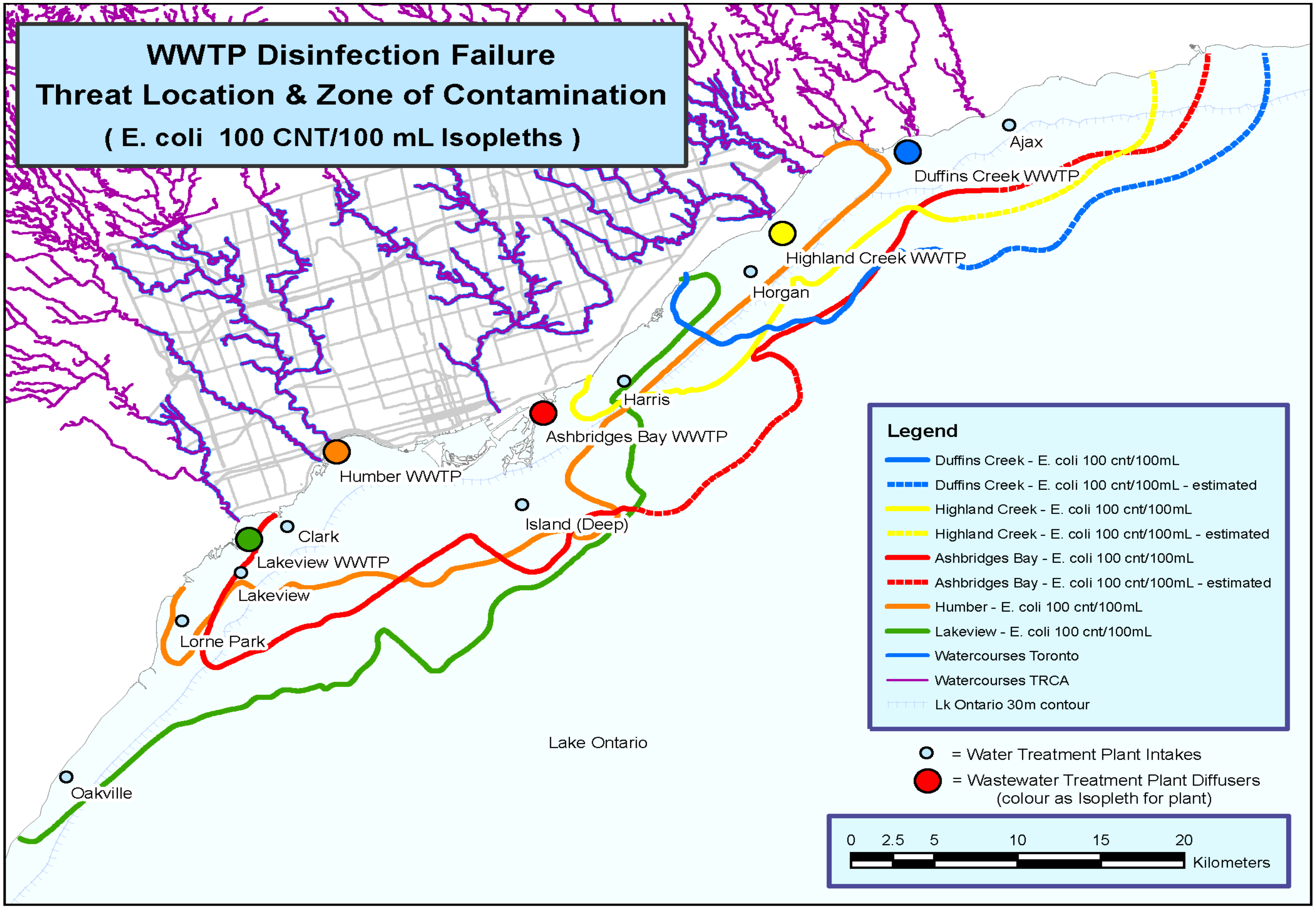


Figure E2.34: WWTP Disinfection Failure Threat Location and Zone of Contamination (E. coli 100 CFU/100 ml Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

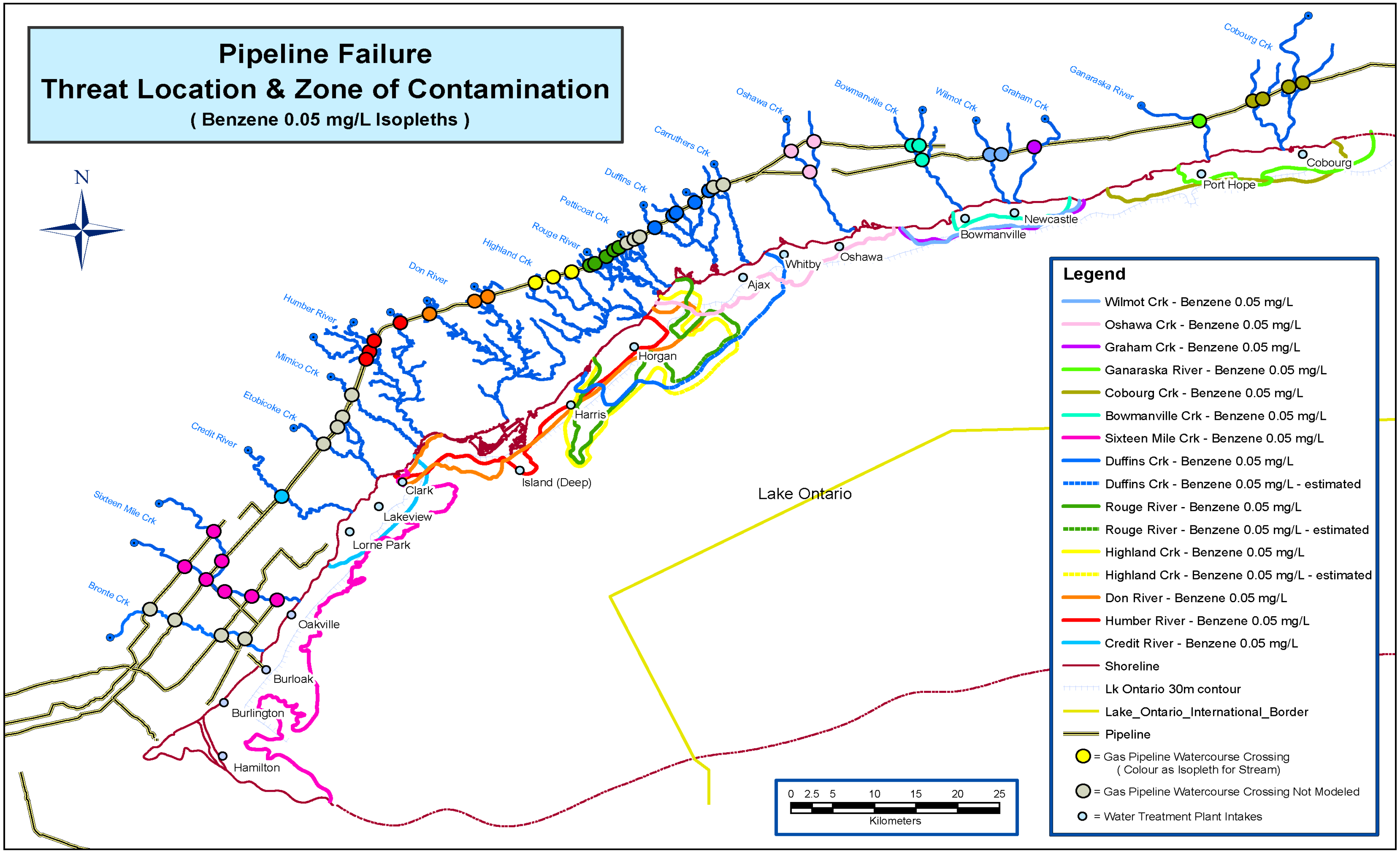


Figure E2.35: Pipeline Failure Threat Location and Zone of Contamination (Benzene 0.05 mg/L Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

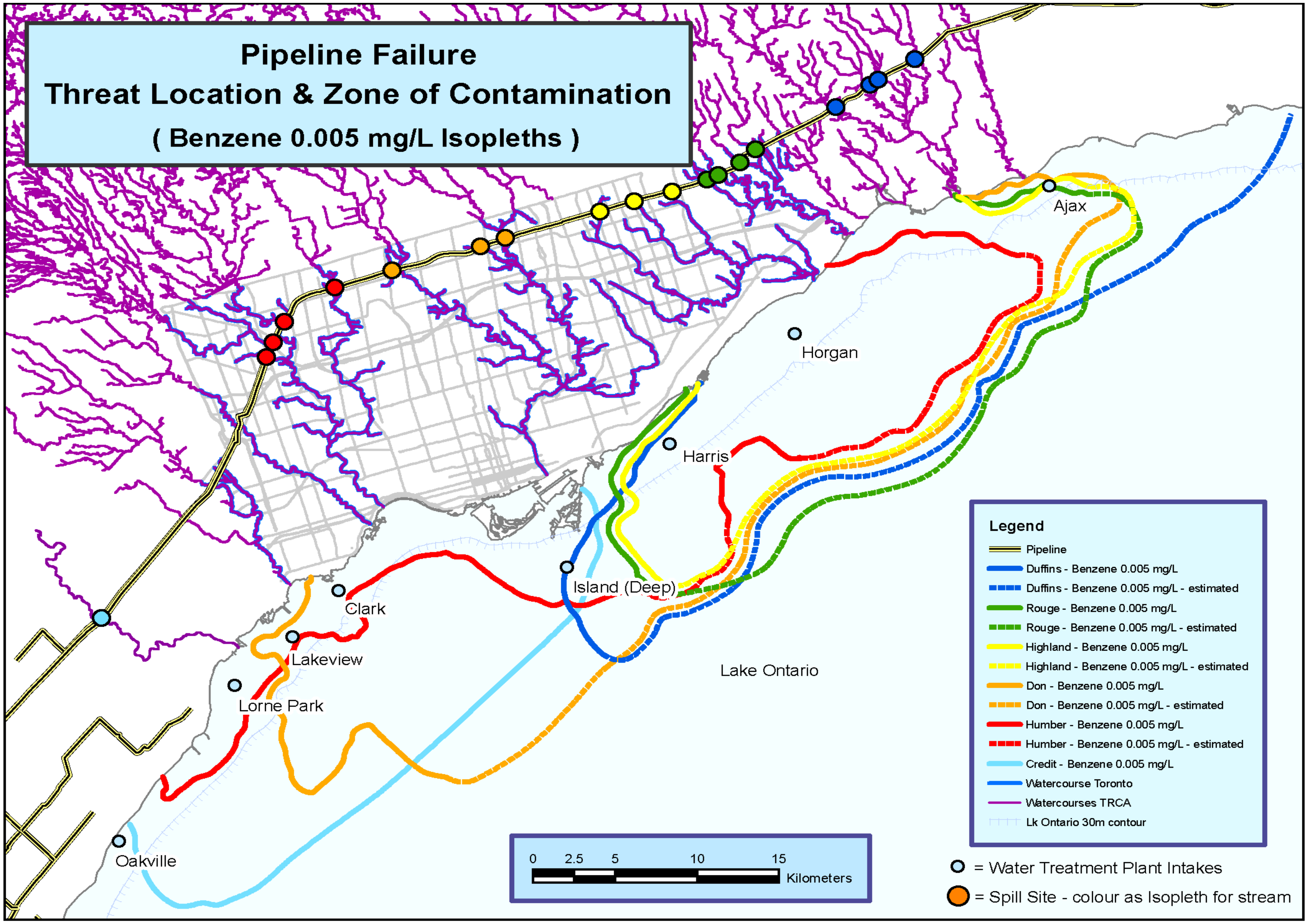


Figure E2.36: Pipeline Failure Threat Location and Zone of Contamination (Benzene 0.005 mg/L Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

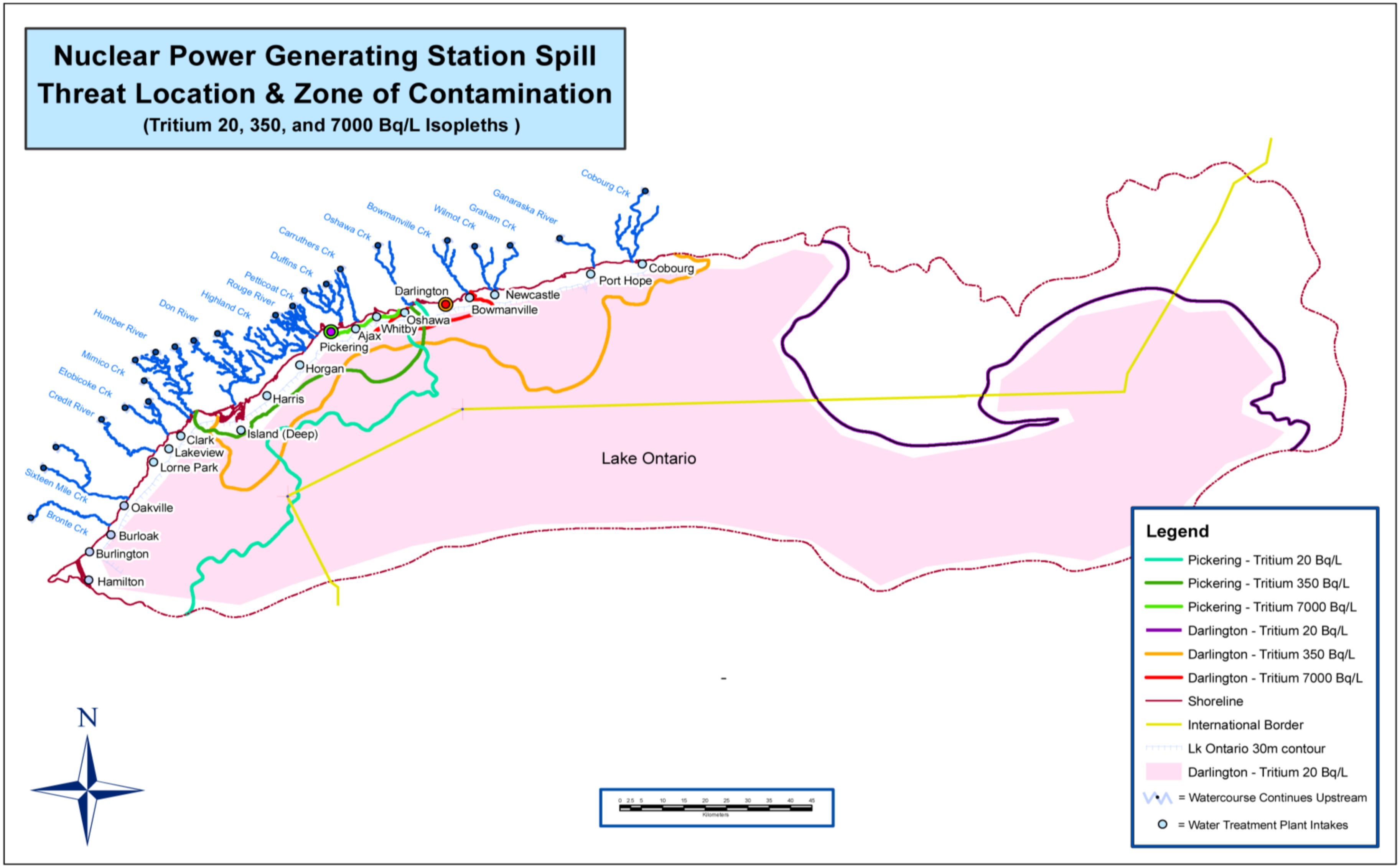


Figure E2.37: Nuclear Power Generating Station Spill Threat Location and Zone of Contamination (Tritium 20, 350 and 7000 Bq/L Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

E2.4.2 Linking each WWTP Intake to Source of Contamination to address Technical Rules

A decision was made by the CTC Technical Working Group that dotted lines would be used within the lake to link intakes to sources of contamination where they enter the lake. For purposes of mapping the flow of the contaminant from the spill point within a watershed, the Technical Rules (68 and 130) specified width along a river channel is used as the physical limit.

Where pipeline spills into specific riverine sources were not modelled, but a significant threat was demonstrated between riverine sources on either side of the 'non-modelled river source' this source is concluded to be a significant threat and is also mapped.

E2.4.3 Addendum to Spill Scenario Modelling for Lake Ontario Intakes Report: Sanitary Trunk Sewer Impacts

Purpose: Updated evaluation of the impacts of rupture/break in Sanitary Trunk Sewer (STS) on the water quality at some specific intakes located in CTC Source Protection Region by:

i) Considering STS breaks at the location below which no additional major lateral is flowing into the STSs;
ii) Applying instream *E. coli* decay to estimate *E. coli* concentration at the mouth of the river(s)/creek(s) where the spill would reach;
iii) Comparing the concentrations resulting from step (ii) with the concentrations at the mouth used in the LOC model; and
iv) Determining the *E. coli* concentrations at the intakes and estimating the size of the event-based area where the LOC model results together with the estimate of *E. coli* in steps (ii and iii) would still be valid.

Background: In the previous version of this Assessment Report the IPZ-3 was represented only by a dotted line connecting the location of the modelled spill to the drinking water intake (now referred to as the 'spill collector'). Similar to the IPZ-1s and IPZ-2s, the *Technical Rules*, however, requires the creation of a spatial file where policies will be applied including setbacks**.** Once a contaminant is modelled to reach an intake at a level at or above the threshold to be a significant threat, the event-based area (EBA) portion for the IPZ-3 was delineated using the required setbacks, from the point of its release in the tributary to a point representing the maximum landward extent of the IPZ-2. In 2015, the MOECC reviewed the Spill Scenario Modelling for Lake Ontario Intakes Report and requested revisions to "Section 6.5: Sanitary Trunk Sewer Impacts" of the EBA mapping by considering:

i) Limiting the upstream boundary of the EBA to coincide with the location where the first major lateral joins the STS. This is where the STS pipe diameter is at its largest and stays constant to the wastewater treatment plant. Thus a break anywhere from this point to the wastewater plant can be assumed to discharge a similar volume of sewage; and

ii) Whether there could be instream *E. coli* decay which would reduce the level of contaminants entering Lake Ontario. The modelling of this scenario already includes consideration of the in-lake decay of *E. coli*.

Approach and Outcomes:

The following describes the analysis and subsequent revisions to EBA mapping that was used to address MOECC's suggestions:

i) **Location of the STSs break**:

The sanitary sewer network of the study area was revisited and locations were identified where the STSs cross Etobicoke Creek, Humber River, Don River, and Highland Creek. There were multiple locations where STSs crossed the rivers/creeks; however, the locations of the largest STSs below all major laterals discharging into the STSs were selected for EBAs. **Figure E2.38** shows the new locations of the EBAs for the study area.

ii) **Instream *E. coli* decay**:

Instream *E. coli* decay was estimated using the first order decay equation (the same approach that was used in the lake modeling).

$$C_t = C_o * e^{(-kt)},$$

where C_t = the bacteria density at elapsed time t, in colonies per 100 milliliters;

C_o = the initial bacteria density in colonies per 100 milliliters;

k = the decay constant in hours^{-1}; and

t = the elapsed time in hours.

Table E2-15 shows the values of C_o, k, and t used in this equation to estimate bacteria concentration at the mouths of the rivers/creeks. The values of these parameters were extracted from the assessment report, the ones used for lake modelling and/or for travel time estimation. Overall, there is a 1-6% reduction in the *E. coli* concentration due to decay within the longitudinal section selected for each spill at the relevant creek/river. **Table E2-15** presents the new *E. coli* concentrations at the mouth of the rivers/creeks.

iii) ***E. coli* concentration at the water treatment plants:**
The lake model was not rerun using the new *E. coli* values at the mouths of the rivers/creeks to estimate *E. coli* concentrations at the intakes of the water treatment plants; however, proportional decay in the *E. coli* levels was assumed. For example, if the percent decay at the mouth of the river was 4%, it was assumed that *E. coli* concentration at the water intakes would drop by 4%. This assumption was made in the absence of a better modelling tool to determine the

size of the EBA in a reasonable manner. **Table E2-16** shows the *E. coli* concentrations that were presented in the Spill Scenario Modelling for Lake Ontario Intakes Report (December 2011 version). **Table E2-17** shows the new values of *E. coli* at the intakes considering decay. The highlighted cells in **Table E2-17** and **Table E2-16** indicate that the modelled spill at the relevant creek/river of the STS has exceeded the benchmark values selected by the CTC SPC (100 CFU/100ml) at the intakes. Therefore, the STSs at these locations and within the relevant EBAs remain significant drinking water threats.

Conclusion

Based upon the presented methodology, **Figure E2.38** presents the new EBAs for the study area.

Table E2-15: *E. coli* concentrations at the mouth of rivers/creeks using first order decay equation

	Ecoli Concentration (Co, #/100mL)	Decay Coeff (1/s) (k)	Travel elapsed (s)	Length of Travel (km)	Ecoli at the mouth	% decay
Etobicoke Cr	50000000	0.000011	1268.12	3.5	49307378.25	1%
Humber River	50000000	0.000011	4545.45	6.5	47561471.23	5%
Don River	50000000	0.000011	5862.07	8.5	46877613.94	6%
Highland Park Cr	10000000	0.000011	3600.00	4.5	9611738.318	4%

Table E2-16: *E. coli* concentrations at the water treatment plant intake as presented in the Spill Scenario Modelling for Lake Ontario Intakes Report (December 2011 version) (*Lakeview intake has been renamed, Arthur P. Kennedy)

Intake	Mega Event from Table 13 E. coli (#/100mL)	Highland Sole Source E. coli (#/100mL)	Don Sole Source E. coli (#/100mL)	Humber Sole Source E. coli (#/100mL)	Etobicoke Sole Source E. coli (#/100mL)	Total Sole Source E. coli (#/100mL)
Ajax	2	0.39	0.03	0.007	0.006	0.42
Horgan	299	288	13	13	13	327
Harris	175	91	127	2.9	1.4	222
Island Shallow	28	13	5	15	25	58
Clark	1252	3.2	15	343	1013	1374
Lakeview	182	2.5	4	109	183	298
Lorne Park	363	1.9	0.25	39	367	408
Oakville	162	0.27	0.03	1.4	144	145
Burloak	17			1	21	22
Burlington	6			0.22	5.8	6

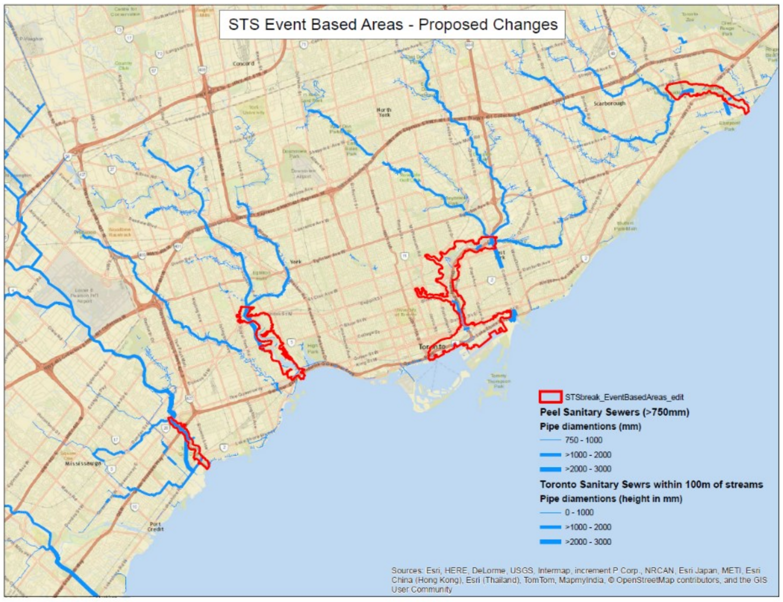
Table E2-17: *E. coli* concentrations at the water treatment plant intake using new at the mouth *E. coli* concentrations (*Lakeview intake has been renamed, Arthur P. Kennedy)

Intake	Mega Event from Table 13 E. coli (#/100mL)	Highland Sole Source E. coli (#/100mL)	Don Sole Source E. coli (#/100mL)	Humber Sole Source E. coli (#/100mL)	Etobicoke Sole Source E. coli (#/100mL)	Total Sole Source E. coli (#/100mL)
Ajax	2	0.4	0.0	0.0	0.0	0.4
Horgan	299	276.8	12.2	12.4	12.8	307.4
Harris	175	87.5	119.1	2.8	1.4	208.7
Island Shallow	28	12.5	4.7	14.3	24.7	54.5
Clark	1252	3.1	14.1	326.3	999.0	1291.6
Lakeview	182	2.4	3.8	103.7	180.5	280.1
Lorne Park	363	1.8	0.2	37.1	361.9	383.5
Oakville	162	0.3	0.0	1.3	142.0	136.3
Burloak	17			1.0	20.7	20.7
Burlington	6			0.2	5.7	5.6

Setbacks:

The Director's Rule (68) guides the delineation of IPZ-3s, which requires that setbacks from tributaries where the modelled contaminant could travel to reach Lake Ontario be determined based on the greater of the area of land measured from the high water mark (not exceed 120 metres) or the Conservation Authority regulation limit.

In the case of the Don River, in delineating the pipeline EBA, it was determined that with the alignment and configuration of the valleys, there would be spillage over land. This was considered in the delineation of the EBAs for the STSs to be consistent. The Sanitary Trunk Sewers are located in the valley and the regulated limit files were used to delineate the valley extents. The EBA in the lower Don follows the existing Regulation Limit, which corresponds to the Lower Don Special Policy boundary which was based on flood modelling. These setbacks have been incorporated into the delineation of the EBAs for the revised STS break scenarios using this new approach. The EBAs capture all the modelled locations of the STSs.



Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure E2.38: Revised STS EBAs for CTC study area (2015)

E2.4.4 Conclusions

The results of preliminary spill scenario modeling simulations as described in this report indicate the following:

- Wastewater treatment system disinfection failure scenarios impact Durham Region, Toronto, Peel Region, Halton Region, Hamilton, and Niagara Region municipal drinking water intakes at levels above the selected 100 *E. coli* CFU/100ml threshold;
- Spill of sewage from sewer trunk sanitary break scenarios impact nearby municipal drinking water intakes above the selected 100 *E. coli* CFU/100ml threshold;
- Spill of gasoline containing benzene from a bulk gasoline storage facility in Oakville indicated impacts to Peel and Halton municipal drinking water intakes above the selected 0.005 mg/l benzene threshold;
- Spill of gasoline containing benzene from a bulk gasoline storage facility in North York indicated impacts to some Toronto municipal drinking water intakes above the selected 0.005 mg/l benzene threshold;
- Spill of gasoline containing benzene from a petroleum products pipeline that intersects Lake Ontario tributaries along the north shore of Lake Ontario indicated impacts to Cobourg, Port Hope, Durham Region, Toronto, Peel Region, Halton Region and Hamilton municipal drinking water intakes above the selected 0.005 mg/l benzene threshold; and
- Release of tritium from nuclear generating stations on north shore of Lake Ontario indicated impacts to three Durham Region municipal drinking water intakes above the selected 7,000 Becquerels/l threshold.

It should be noted that these preliminary results are based on specific scenarios with selected parameters such as volumes of material release, chemical/pathogen concentrations, wind and lake current velocity and direction. Changing the spill circumstance could significantly affect these results.

E2.5 Summary

Combinations of sources of spills and potential contaminants of concern were screened by the Lake Ontario Collaborative. Both contaminant-based issues (benzene, *E. coli*) and WTP operational issues were considered.

Contaminant spill scenario modelling was carried out to identify significant drinking water threats as per the *Clean Water Act, 2006*. Operational issues were considered through both operational experience and scenario modelling and have been used to support analysis of the contaminant spill scenario modelling.

Contaminant mapping has been developed to identify IPZ-3s for substances whose release causes a significant drinking water threat at an intake. *Technical Rule (68)* is used with *Rule (130)* to identify activities that may release contaminants that may reach the intake and cause deterioration to the water quality of raw water.

Spill scenarios were developed, using an evidence-based approach based on actual events. The activities of concern were located and scenarios were developed to evaluate the impact on nearby municipal drinking water intakes. The spills were modelled for the specific time period and over a multiple number of times within a season to capture a variety of conditions.

Chemical concentrations, radiological activity, and *E. coli* density levels at each intake were used in the initial screening to determine potential intakes impacted by the spill (release) from each specific source. Results from the simulations were graphed as a time trend of concentrations for a season at each intake, and tabulated as peak concentrations calculated for each intake.

E2.5.1 Uncertainty Analysis

For the LOC IPZ-3 delineation, a calibrated model was used. **Table E2-18** summarizes the level of uncertainty in the analysis.

Table E2-18: Uncertainty Assessment

Spill Source	**Lake Hydrodynamic Model**		**Source Term (as Lake Input)**	
	Uncertainty Level	**Comment**	**Uncertainty Level**	**Comment**
Tritium	Low	Model Calibrated to specific event	Low	Measured Discharge
E. coli at WWTP	Low	Model calibrated to both hydrodynamics and decay	Low	Evidence – based Discharge
E. coli from STS break	High	Model calibrated to general hydrodynamics	Low	Evidence – based Discharge
E. coli from CSO spill	Low	Based on calibrated Inner Harbour model for both hydrodynamics and *E. coli* decay	Low	Based on calibrated rainfall- runoff model
Rural industrial spill of *E. coli*	High	Model calibrated to general hydrodynamics	Low	Evidence – based Discharge, transformed by river modelling
Benzene spill from Storage Farm	High	Model calibrated to general hydrodynamics	Low	Evidence – based Discharge
Pipeline break of Benzene	High	Model calibrated to general hydrodynamics	High	Evidence – based Discharge without river modelling

E2.6 References

Dewey, R. (2011). IPZ 3 Lake Ontario Report. Report prepared for Lake Ontario Collaborative. Toronto: ON, Modelling Surface Water Ltd.

Fairlie, I. (2007). Tritium Hazard Report. Available athttp://www.greenpeace.org/raw/content/canada/en/documents-and-links/publications/tritium-hazard-report-pollu.pdf.

Jacoub, G. (2010). Follow-up correspondence forwarded to September 16th 2010 Workshop Participants for Source Water Protection. Held at MOE Laboratory Building, 125 Resources Road, Etobicoke, Ontario.

Keller. (2009). Presentation to Great Lakes Source Protection Technical Experts Workshop (June 11, 2009). Toronto, Ontario.

King K.G., et al. (1998). Tritium in the Great Lakes in 1997. AECL Report RC-1981.

King K.G., et al. (1999). Tritium in Lake Michigan in 1998. AECL Report RC-2247.

Snodgrass, W. J. (1974). A Total Phosphorus Model for Lakes: Development and Testing. PhD Dissertation. University of North Carolina. 309 pp.

E2.7 Addendum to Appendix E2

Ministry Offices	
Ministry of the Environment	**Ministère de l'Environnement**
Source Protection Programs Branch	Direction des programmes de protection des sources
14th Floor	14e étage
40 St. Clair Ave. West	40, avenue St. Clair Ouest
Toronto ON M4V 1M2	Toronto (Ontario) M4V 1M2

15 November 2010

From: Heather Malcolmson, Manager, Source Protection Planning,

Source Protections Programs Branch, Ministry of the Environment.

RE: Clarifications on items raised during the GL Technical Workshop held on Sept 16th, 2010.

Thank you for attending our workshop on Sept 16th, 2010. At the workshop, we identified a number of items where additional guidance was needed. We trust that you will consider this guidance. If you have questions or concerns, please contact George Jacoub or Clara Tucker, Source Protection Programs Branch, MOE.

E2.7.1 Intent of Rule (68) and Rule (130) of the Technical Rules (2009)

Rule (68) prescribes the approach that should be used for delineating IPZ-3 for Type A, Type B and certain Types of C and D intakes (as stated per *Rule (68)*). The approach, known as Event Based Approach (EBA), was added to the *Technical Rules (2009)* in response to public comments related to the vulnerability of systems in large water bodies. Through this approach, the source protection committee (SPC) can identify threats based on site specific evaluations instead of the semi-quantitative risk assessment approach, and then include them in a vulnerable area.

Basically, *Rule (68)* prescribes that, if the modelling exercise or other method shows that a contaminant (i.e. chemical parameter or pathogen) released from an activity would be transported through the water system and would reach the intake causing a deterioration to the water quality at the intake, an IPZ-3 shall be delineated capturing the area of this activity. If the contaminant transported through the water system does not reach the intake, there is no obligation to delineate an IPZ-3. The concentration used to determine if the contaminant has reached the intake is not defined and is at the discretion of the SPC in consultation with the plant operator. The delineation of IPZ-3 using EBA is an iterative approach following *Rules (68 and 130).*

The intent of *Rules (68 and 130)* was that the location and type of activity of concern would be identified, and based on an understanding of that type of activity estimates would be made of the type of contaminant that may be released from that activity and the volume or mass for this contaminant(s) of concern. Then based on the outcome of the EBA application, the SPC would determine whether or not an IPZ-3 should be delineated for the intake, and then identify the location as a location, where an activity, under the modelled circumstance, would be a significant drinking water threat.

Once an IPZ-3 is delineated using the approach described above, the SPC can evaluate any other existing, proposed or future activity, using the same EBA to determine if a release of contaminates from that activity would reach the intake and result in the deterioration of the water for use as a source of drinking water, as prescribed in *Rule (130).* Based on this evaluation the IPZ-3 may be extended if other modelling or methods show a larger area IPZ-3 is warranted.

It should be noted that the area delineated as an IPZ-3 in *Rule (68)* can only be delineated beyond the IPZ-1 and IPZ-2. *Rule (130)* applies to the full IPZ, which is the sum of the IPZ-1, IPZ-2, and IPZ-3. The Technical Bulletin released by MOE (EBA, MOE 2009) describes different numerical approaches for delineating this EBA IPZ-3. This evaluation can also be done through in-stream water quality transport models or hydraulic models with water quality sub-routing (e.g. HEC-RAS). These models should be capable of simulating the point-source release/spill, the transport and the fate of a known quantity of a contaminant through a water system to the intake and estimate the concentration of the contaminant that would reach the intake.

Moreover, the intent of *Rules (68 and 130)* was not to run a modelling exercise to back-track the sources of a specific contaminant that has been identified at one intake. The assessment required for this approach, known as an Issue Approach, is prescribed in *Rules (114, 115, 131, 134.1, and 141).*

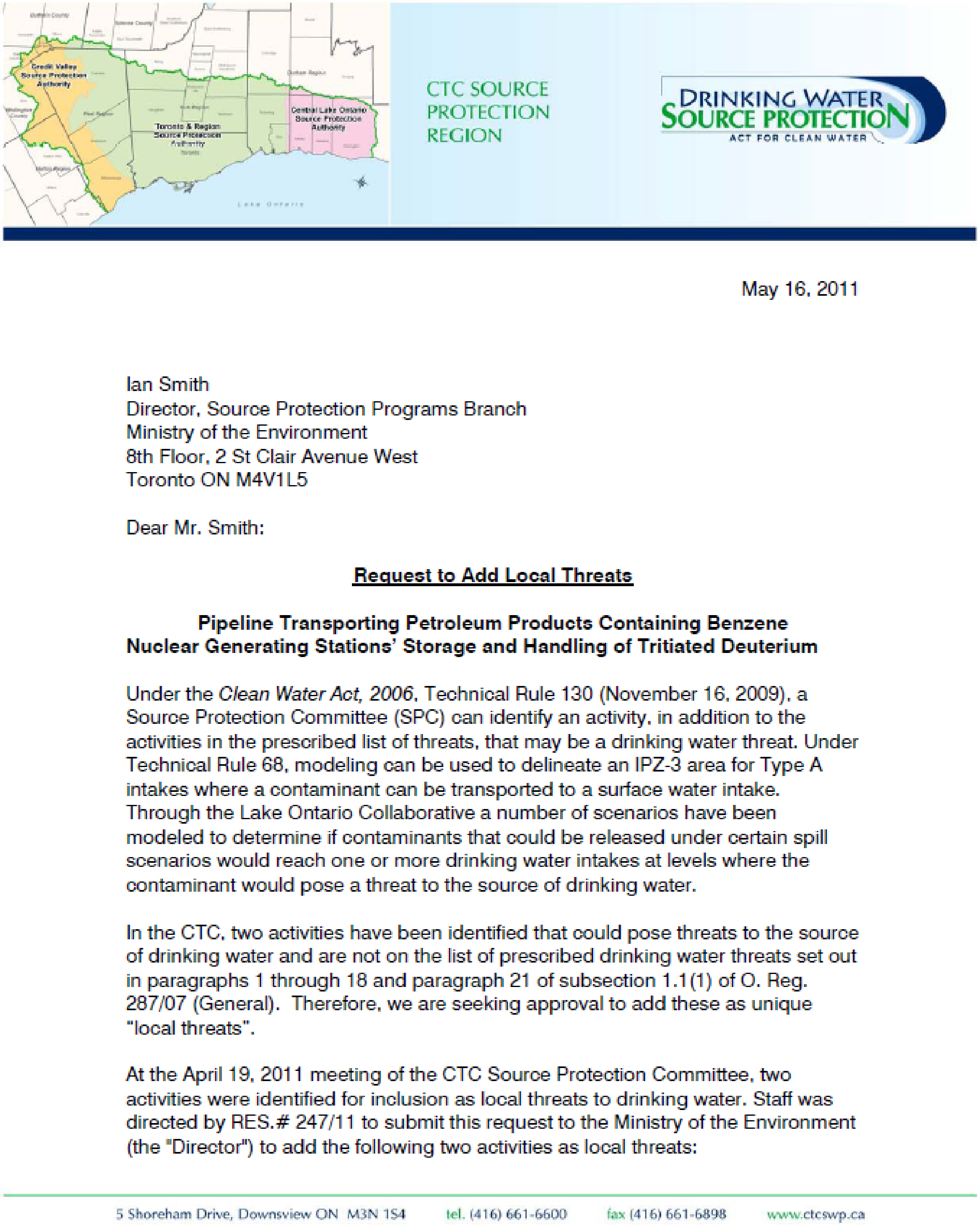
E2.7.2 Different Contributing Areas in IPZ-3

Rule (58) requires that, an area of IPZ-1, IPZ-2 and IPZ-3 should be delineated for each surface water intake associated with a Type I system or a Type II system or a Type III system, meaning that one IPZ-3 is allowed to be delineated for a surface water intake.

For surface water intakes where *Rule (68)* applies, the activity(ies) that may release a certain contaminant or several contaminants to the intake may be located in more than one contributing area to the intake. Then for these cases, if the test of applying *Rule (68)* is met, the individual contributing areas should be merged into one IPZ-3.

For example, if the activities identified for the modelling exercise are one refinery that could release a significant quantity fuel and one Sewage Treatment Plant that could release Pathogens, and both contaminants would reach the intake, the contributing areas for these two activities should be merged into one IPZ-3.

E3 CTC SPR Request for Addition of Local Threats and MOE Response



CTC SOURCE
PROTECTION
REGION

DRINKING WATER
SOURCE PROTECTION
ACT FOR CLEAN WATER

May 16, 2011

Ian Smith
Director, Source Protection Programs Branch
Ministry of the Environment
8th Floor, 2 St Clair Avenue West
Toronto ON M4V1L5

Dear Mr. Smith:

Request to Add Local Threats

Pipeline Transporting Petroleum Products Containing Benzene
Nuclear Generating Stations' Storage and Handling of Tritiated Deuterium

Under the *Clean Water Act, 2006*, Technical Rule 130 (November 16, 2009), a Source Protection Committee (SPC) can identify an activity, in addition to the activities in the prescribed list of threats, that may be a drinking water threat. Under Technical Rule 68, modeling can be used to delineate an IPZ-3 area for Type A intakes where a contaminant can be transported to a surface water intake. Through the Lake Ontario Collaborative a number of scenarios have been modeled to determine if contaminants that could be released under certain spill scenarios would reach one or more drinking water intakes at levels where the contaminant would pose a threat to the source of drinking water.

In the CTC, two activities have been identified that could pose threats to the source of drinking water and are not on the list of prescribed drinking water threats set out in paragraphs 1 through 18 and paragraph 21 of subsection 1.1(1) of O. Reg. 287/07 (General). Therefore, we are seeking approval to add these as unique "local threats".

At the April 19, 2011 meeting of the CTC Source Protection Committee, two activities were identified for inclusion as local threats to drinking water. Staff was directed by RES.# 247/11 to submit this request to the Ministry of the Environment (the "Director") to add the following two activities as local threats:

5 Shoreham Drive, Downsview ON M3N 1S4 tel. (416) 661-6600 fax (416) 661-6898 www.ctcswp.ca

- Pipeline transporting petroleum product (containing benzene) which crosses a tributary flowing into Lake Ontario.

  MODELED CIRCUMSTANCE: The scenario is based on the parameters from an actual spill from a similar pipeline transporting similar products in Kalamazoo, Michigan in the summer of 2010. Using modeling of the individual streams, the concentration of benzene reaching the lake was calculated and the Lake Ontario version of the MIKE-3 model was used to estimate the concentrations of benzene that could reach each intake. The model considers how the contaminant can move from the surface to the depth where the intake is located. A pipeline rupture at most streams in the CTC, where the existing pipeline crosses the stream, has the potential to release benzene at concentrations that would result in levels above the Ontario Drinking Water Standard (ODWA) at the nearby intake.

- Handling and storage of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations.

  MODELED CIRCUMSTANCE: The scenario is based on the parameters from the actual tritium spill in 1992 from the Pickering Nuclear Generating Station. The modeled spill scenario resulted in tritium levels exceeding the ODWS at the Whitby and Oshawa intakes. Note a number of other intakes, including all of those in the CTC and some beyond the CTC had predicted tritium concentrations above the proposed revised tritium standard of 20 Bq/litre recommended by the Minister's Advisory Committee on Testing and Standards.

Technical staff from your branch have attended briefings on the work and have been provided draft reports. We are still awaiting the final report from the consultants but intend to include a description of the relevant spill scenario modeling work and findings in the updates to each of the assessment reports in the CTC currently in progress.

Accordingly, I request that these activities be included as local Drinking Water Threats for the CTC Source Protection Region.

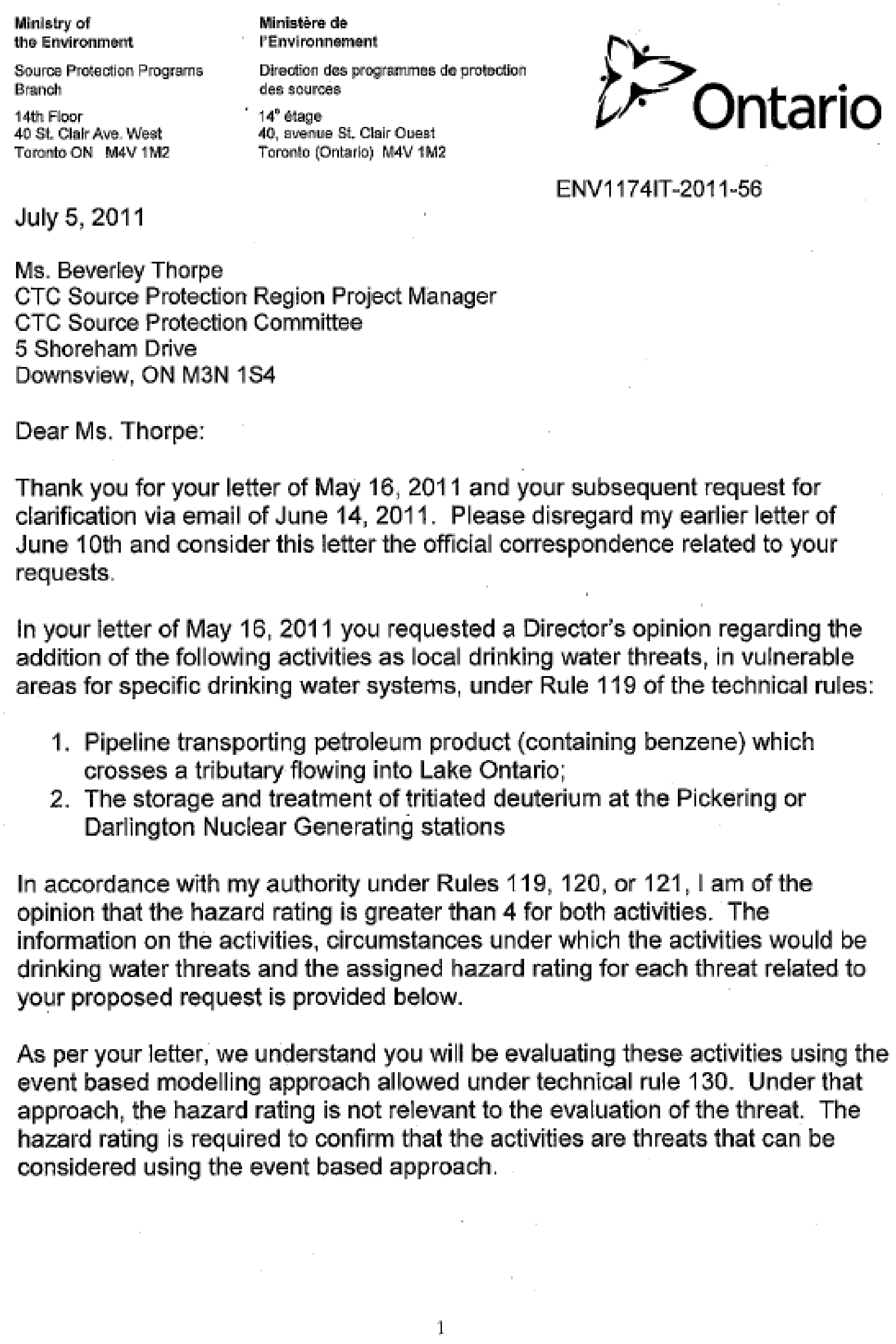
Your consideration of this matter is appreciated. Please do not hesitate to contact me if you require any further explanation or information – telephone 416-844-3875 (cell) or mailto:bthorpe@trca.on.ca.

Yours truly,

Beverley Thorpe

Beverley Thorpe
CTC Source Protection Region Project Manager

cc. Susan Self, Chair CTC SPC
Brian Denney, Chief Administrative Officer, TRSPA
Rae Horst, Chief Administrative Officer, CVSPA
Russ Powell, Chief Administrative Officer, CLOSPA
Deb Martin-Downs, CTC Executive Lead
Heather Malcolmson, Manager, Source Protection Planning Branch
John Westlake, CTC MOE Liaison Officer
Jennifer Stephens, Project Manager, Trent Conservation Coalition
Brian Wright, Project Manager Niagara Peninsula Source Protection Area
Diane Bloomfield, Project Manager Halton-Hamilton Source Protection Region
Keith Taylor, Project Manager Quinte Source Protection Region



Ministry of
the Environment

Source Protection Programs
Branch

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Ministère de
l'Environnement

Direction des programmes de protection
des sources

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Ontario

ENV1174IT-2011-56

July 5, 2011

Ms. Beverley Thorpe
CTC Source Protection Region Project Manager
CTC Source Protection Committee
5 Shoreham Drive
Downsview, ON M3N 1S4

Dear Ms. Thorpe:

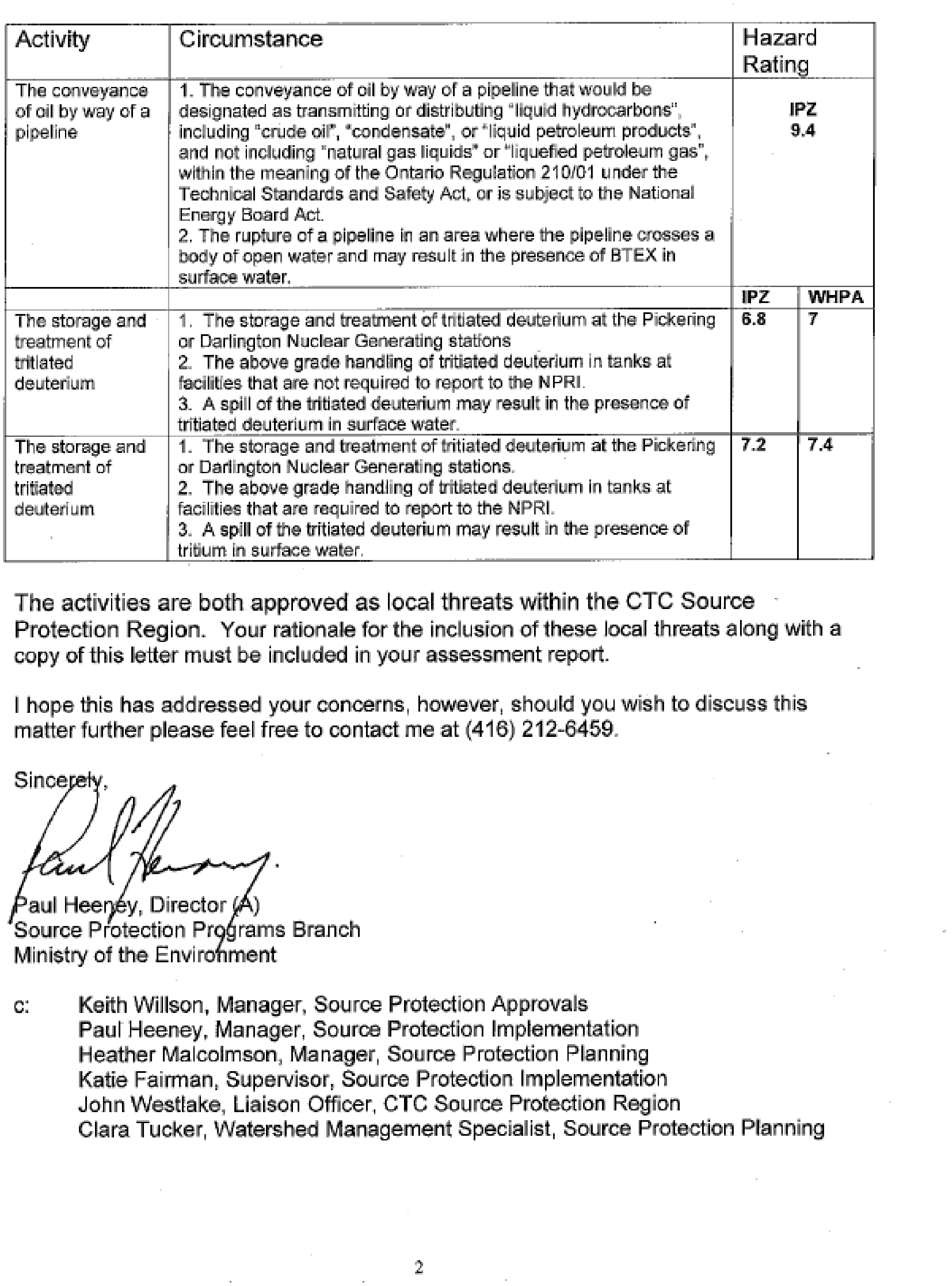
Thank you for your letter of May 16, 2011 and your subsequent request for clarification via email of June 14, 2011. Please disregard my earlier letter of June 10th and consider this letter the official correspondence related to your requests.

In your letter of May 16, 2011 you requested a Director's opinion regarding the addition of the following activities as local drinking water threats, in vulnerable areas for specific drinking water systems, under Rule 119 of the technical rules:

1. Pipeline transporting petroleum product (containing benzene) which crosses a tributary flowing into Lake Ontario;
2. The storage and treatment of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations

In accordance with my authority under Rules 119, 120, or 121, I am of the opinion that the hazard rating is greater than 4 for both activities. The information on the activities, circumstances under which the activities would be drinking water threats and the assigned hazard rating for each threat related to your proposed request is provided below.

As per your letter, we understand you will be evaluating these activities using the event based modelling approach allowed under technical rule 130. Under that approach, the hazard rating is not relevant to the evaluation of the threat. The hazard rating is required to confirm that the activities are threats that can be considered using the event based approach.



Activity	Circumstance	Hazard Rating	
The conveyance of oil by way of a pipeline	1. The conveyance of oil by way of a pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of the Ontario Regulation 210/01 under the Technical Standards and Safety Act, or is subject to the National Energy Board Act. 2. The rupture of a pipeline in an area where the pipeline crosses a body of open water and may result in the presence of BTEX in surface water.	**IPZ** **9.4**	
		IPZ	**WHPA**
The storage and treatment of tritiated deuterium	1. The storage and treatment of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations 2. The above grade handling of tritiated deuterium in tanks at facilities that are not required to report to the NPRI. 3. A spill of the tritiated deuterium may result in the presence of tritiated deuterium in surface water.	**6.8**	**7**
The storage and treatment of tritiated deuterium	1. The storage and treatment of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations. 2. The above grade handling of tritiated deuterium in tanks at facilities that are required to report to the NPRI. 3. A spill of the tritiated deuterium may result in the presence of tritium in surface water.	**7.2**	**7.4**

The activities are both approved as local threats within the CTC Source Protection Region. Your rationale for the inclusion of these local threats along with a copy of this letter must be included in your assessment report.

I hope this has addressed your concerns, however, should you wish to discuss this matter further please feel free to contact me at (416) 212-6459.

Sincerely,

Paul Heeney, Director (A)
Source Protection Programs Branch
Ministry of the Environment

c: Keith Willson, Manager, Source Protection Approvals
Paul Heeney, Manager, Source Protection Implementation
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Table 1: **Conveyance of Petroleum Hydrocarbons Using Pipelines which are exposed above ground and cross a surface water body**

Activity	Vulnerability Score to produce a Significant DWT	Vulnerability Score to produce a Moderate DWT	Vulnerability Score to produce a Low DWT
	IPZ-1,2,3, WHPA-E	IPZ-1,2,3,WHPA-E	IPZ-1,2,3, WHPA-E
1. The conveyance of oil by way of a pipeline that would be designated as transmitting or distributing "liquid hydrocarbons", including "crude oil", "condensate", or "liquid petroleum products", and not including "natural gas liquids" or "liquefied petroleum gas", within the meaning of the Ontario Regulation 210/01 under the *Technical Standards and Safety* Act, or is subject to the National Energy Board Act. 2. The rupture of a pipeline in an area where the pipeline crosses a body of open water and may result in the presence of BTEX in surface water.	10	7 – 9	4.8 – 6.4

Table 2: Storage and treatment of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations

Activity	Vulnerability Score to produce a Significant DWT	Vulnerability Score to produce a Moderate DWT	Vulnerability Score to produce a Low DWT
	IPZ-1,2,3, WHPA-E	IPZ-1,2,3, WHPA-E	IPZ-1,2,3, WHPA-E
1. The storage and treatment of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations 2. The above grade handling of tritiated deuterium in tanks at facilities that are not required to report to the NPRI. 3. A spill of the tritiated deuterium may result in the presence of tritiated deuterium in surface water.	n/a	9-10	6-8.1
1. The storage and treatment of tritiated deuterium at the Pickering or Darlington Nuclear Generating stations. 2. The above grade handling of tritiated deuterium in tanks at facilities that are required to report to the NPRI. 3. A spill of the tritiated deuterium may result in the presence of tritium in surface water.	n/a	8.1-10	5.6-8