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 below.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Proposed Methodology for Calculating Percentage of Managed Lands and Livestock Density for Land Application of Agricultural Source of Material, Non-Agricultural Source of Material and Commercial Fertilizers

Date: December 2009

Ontario Ministry of the Environment

Support for this guidance provided by
- Lake Erie Source Protection Region (LESPR)
- Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)
- Conservation Ontario

INTRODUCTION

The *Clean Water Act, 2006* sets the legal framework that ensures communities are able to protect their municipal drinking water supplies by developing collaborative, locally driven, science-based protection plans. Communities will identify potential risks to local drinking water sources and take action to reduce or eliminate these risks. Regulation 287/07 and technical rules (updated November 2009) govern the content of the assessment report. The regulation includes a list of prescribed activities that must be considered when identifying and categorizing activities that pose a risk to drinking water. The technical rules include Tables of Drinking Water Threats that set out the circumstances under which the activities in the regulation pose a significant, moderate, or low drinking water threat. Included in these tables are threats that require consideration of the percent managed lands and livestock density within vulnerable areas. The technical rules include a requirement for maps of percent managed land and livestock density to support the analysis of these circumstances. This is explained in more detail below.

In determining the percentage of *managed land,s* source protection committees must determine the areas where there may be application of agricultural source material (ASM), commercial fertilizer, or non-agricultural source material (NASM). These areas are expressed as percentages of the total area being evaluated. In determining the livestock density in an area, expressed in terms of nutrient units/acre (NU/Acre), committees have to determine nutrient units (NU) generated as a percentage of the total agricultural managed lands in the area.

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The combination of the percentage of managed land and the livestock density of an area is then used as a surrogate for representing the quantity of nutrients present as a result of nutrient generation, storage, and land application within an area. This surrogate is then used to determine the potential impact of a single property on water quality.

This methodology has been developed by the Grand River Conservation Authority (GRCA) in the Lake Erie Source Protection Region (LESPR) with the support from MOE, Conservation Ontario and OMAFRA, to map the *percentage of managed lands* and calculate *livestock density* areas for use in determining the "quantity" of land applied nutrients in an area.

This technical bulletin describes a tested, consistent methodology that can be applied by any Source Protection Committee (SPC) in the province, to evaluate the circumstances in which land application of Agricultural Source Material (ASM), Non-agricultural Source Material (NASM), and Commercial Fertilizers could be considered as chemical threats in their source protection area. The approach outlined uses the combination of managed land intensity and livestock density (expressed in terms of NU/acre) to arrive at a surrogate measure of the extent of use of these chemical threats of nitrogen and phosphorus in an area of interest.

The working group also reviewed and set directions on how nutrients can be considered when determining the applicable chemical threat circumstances related to the use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. Note that pathogen threats associated with these same activities are identified and categorized using a separate, independent approach.

Although the proposed methodology is intended to assist all SPC's in calculating the percentage of managed lands and livestock densities required for the development of the Assessment Reports, the Source Protection Programs Branch of Ministry of the Environment recognizes that a SPC may choose to apply an alternative method that may be more appropriate for the local conditions or data availability for its area. The SPC should document any method used to undertake the task.

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1. MANAGED LAND AND AGRICULTURAL MANAGED LAND

1.1 Background

Managed land is land to which nutrients (ASM, fertilizer, NASM) are applied. It includes, but is not limited to, cropland, fallow land, improved pasture, golf courses, sports fields, and lawns.

Managed lands can be broken into 2 subsets: agricultural managed land and non-agricultural managed land. *Agricultural managed land* includes areas of cropland, fallow, and improved pasture that may receive nutrients. *Non-agricultural managed lands* includes golf courses (turf), sports fields, lawns (turf) and other built-up grassed areas that may receive nutrients (primarily commercial fertilizer).

The November 2009 technical rules include the development of a map that shows:

16 (9) One or more maps of the percentage of managed lands within,

(a) a significant groundwater recharge area;

(b) a highly vulnerable aquifer;

(c) each of the following areas within a vulnerable area:

(i) *WHPA-A.*

(ii) *WHPA-B.*

(iii) *WHPA-C.*

(iv) *WHPA-C1, if any.*

(v) *WHPA-D.*

(vi) *WHPA-E.*

(vii) *IPZ-1.*

(viii) *IPZ-2.*

(ix) *IPZ-3, if any.*

If two or more areas in an area referred to in clause (a) to (c) have different vulnerability scores, the percentage of managed land may be determined for each of those areas. Mapping the percentage of managed lands is not required for any area in an area mentioned in clause (a) to (c) where the vulnerability scores for that area are less than those necessary for the following activities to be considered a significant, moderate or low drinking water threat in the Table of Drinking Water Threats: the application of agricultural source material to land,

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the application of non-agricultural source material to land and the application of commercial fertilizer to land. Each map prepared in accordance with this subrule shall be labelled the "managed land map".

(10) One or more maps of livestock density for each area referred to in subrule (9). Livestock density shall be determined by dividing the NUs generated in each area by the number of acres of agricultural managed land in that area where agricultural source material is applied. If two or more areas in an area referred to in subrule (9) (a) to (c) have different vulnerability scores, the livestock density may be determined for each of those areas. Mapping livestock density is not required for any area in an area mentioned in clause (9) (a) to (c) where the vulnerability scores for that area are less than those necessary for the following activities to be considered a significant, moderate or low drinking water threat in the Table of Drinking Water Threats: the application of agricultural source material to land, the application of non-agricultural source material to land and the application of commercial fertilizer to land. Each map prepared in accordance with this subrule shall be labelled the "livestock density map".

Both *managed lands* and *agricultural managed lands* are to be identified within each of the vulnerable areas where the vulnerability score for that area is high enough for activities to be considered a significant, moderate or low drinking water or for subsets of these vulnerable areas. Based on the tables, any area with a score of 6 or higher for groundwater or 4.4 or higher for surface water (including IPZs and WHPA E) can have threats identified. The percentage of managed lands and livestock density are only required for these areas as it is only in these areas where the vulnerability is high enough for a threat to be present.

For example, the *managed land* percentage must be identified within HVAs. This can be done by determining the percentage over the combined HVA area, or within several HVAs combined, or for individual HVA polygons. . Also, the subset of a WHPA-D considered in order to identify the managed lands can be either the sum of all parts of the WHPA D scoring 6, or each individual WHPA-D subset scoring 6, depending on the amount and sizes of WHPA-D subsets that score 6. Professional judgment should be applied for this decision.

The percentage of managed land area within a vulnerable area or subset of the vulnerable area should be the sum of agricultural managed land and non-agricultural managed land, divided by the total land area within the vulnerable area (or subset of the area) multiplied by 100.

Where only a portion of a *managed land* parcel falls within a vulnerable area, only the portion of the parcel within the vulnerable area should be factored into the calculations for the total *managed land* in the vulnerable area.

1.2 Considerations for Percentage of Managed Lands Calculation

(a) Delineating Areas of Agricultural Managed Lands

Agricultural managed land includes farmed areas (cropland, fallow land and improved pasture). Methods to delineate these areas may vary for each SPA and may include GIS, photo interpretation work, field inspection where the vulnerable area to be inspected is small, or a combination of these methods.

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In cases where there are both the time and resources available, or where uncertainty is high as a result of discrepancies in the data collected, a roadside survey/field checking is recommended as confirmation/support of the air photo interpretation or GIS to reduce the uncertainty and make adjustments on the identification of agricultural managed lands. Also, the air-photo interpretation would be best undertaken by an individual with knowledge of general agricultural systems, and it is recommended someone with similar background and skills undertake the roadside survey as confirmation/support of the air photo interpretation, since the data collected during the field checking would also be used to confirm the estimates of the livestock density in the area.

(b) Delineating Areas of Non-Agricultural Managed Lands

Areas of non-agricultural managed lands are grassed areas that may receive commercial fertilizers such as residential lawns, sports fields and golf courses.

Golf Courses

Methods to determine golf course area vary with local availability of data and may include direct measurement using air photo interpretation or GIS where the area is small, subwatershed and stormwater /master plan estimates where they have been done, municipal zoning requirements and golf course irrigation Permits to Take Water (PTTW). Municipal Property Assessment Corporation (MPAC) property layer often categorizes information on golf courses using code 490. As with agricultural managed lands, in cases where there are both the time and resources available, or where uncertainty is high as a result of discrepancies of direct measurement, a roadside survey/field checking is recommended as confirmation/support of the air photo interpretation or GIS to reduce the uncertainty and make adjustments on the identification of golf courses.

Alternatively, the National Golf Course Owners Association of Canada has a list of its members on their website (see www.ngcoa.ca) which can help locate golf courses that are in the region. The Municipal Property Assessment Corporation (MPAC) property layer often categorizes information on golf courses using code 490. Using the MPAC layer would give the location and area of golf courses that may be in the vulnerable areas. Aerial photos help to identify the actual golf course areas that would be considered managed lands, omitting the forested areas, wetlands and large rivers and lakes.

For example, within the Grand River Watershed of the Lake Erie Source Protection Region, GRCA staff examined aerial photos overlaid with UTM coordinates of golf course irrigation PTTWs. Local knowledge helped fill in the gaps to include the rest of the courses that may be on municipal supply and not need a PTTW. Figure 1 shows the golf course locations in the Lake Erie Source Protection Region watersheds.

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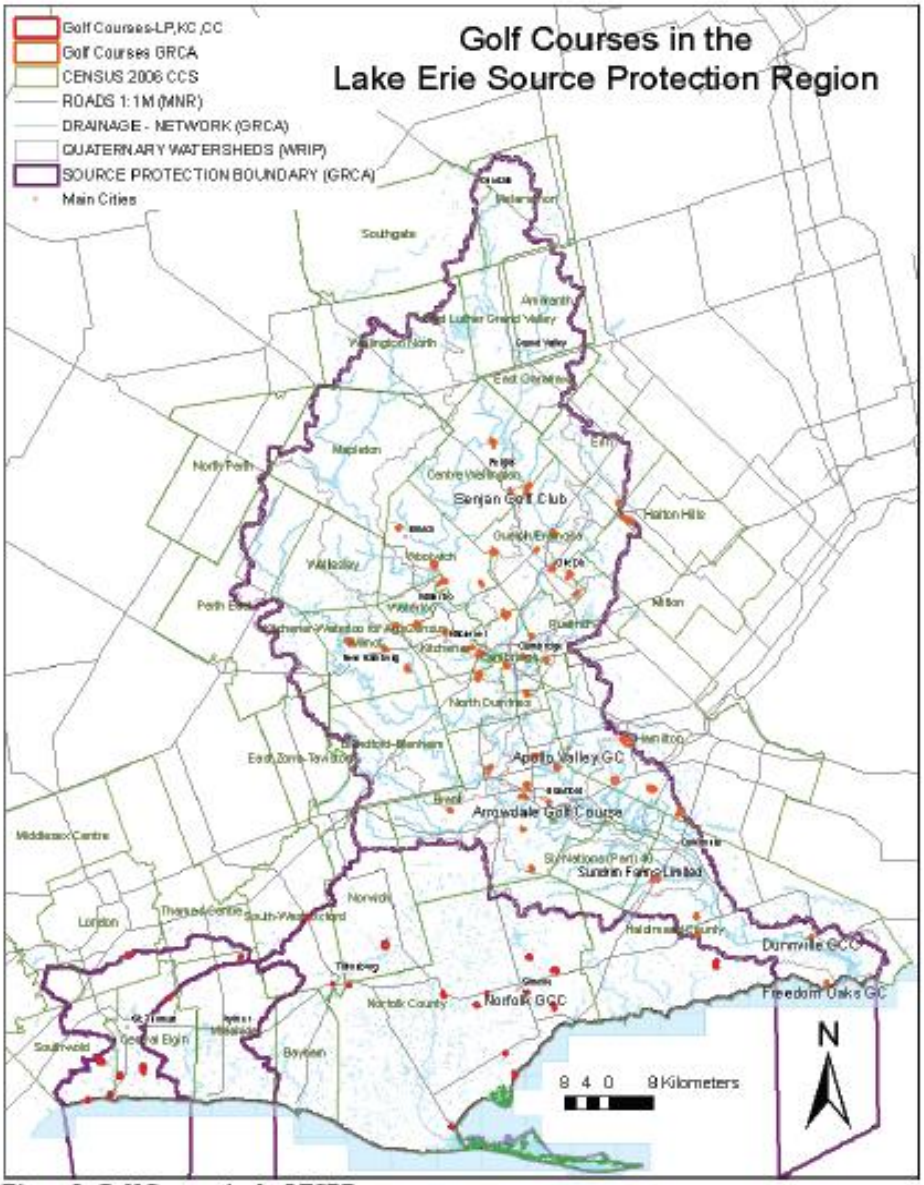

Figure 1: Golf Courses in the LESPR

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Residential/Commercial/Institutional Lawn and Sports Fields

Determination of total managed land includes an estimate of residential, commercial and institutional land area that could receive application of fertilizer (i.e. the lawn/turf area). Recognizing that property size varies across the province, the appropriate method to estimate lawn area will vary by SPA depending on local knowledge and availability of information. Direct measurement and photo interpretation can be used where the area is small. In cases where there are both the time and resources available, or where uncertainty is high as a result of discrepancies in the data collected, a roadside survey/field checking is recommended as confirmation/support of the air photo interpretation to reduce the uncertainty and make adjustments on the identification of pervious urban areas.

Subwatershed plans, storm water management plans/master plans, and other hydrologic studies frequently include estimates of percent impervious surface, which can be used indirectly to estimate the percent grassed area (assuming that pervious surfaces are grassed). Some municipalities will record this information in their official plans (OP's).

Some municipal zoning by-laws specify lot coverage maximums from which grassed areas can be indirectly derived. Some examples:

- In Toronto, for example, the maximum structure size is 35% (municipal zoning lot coverage max) + 10% driveway leaving a grass area of 55%. Similarly in Mississauga, the maximum structure size is 25% + 10% driveway leaving a grass area of 65%.

- In Kitchener, the impervious cover analysis was done for a subwatershed study showing a range between 45% to 65% imperviousness in residential areas, including roads. This would leave between 35% to 55% grassed areas, depending on the age of the subdivision and type of housing (low density or multi-residential).

These estimates try to integrate areas where lot coverage is higher (i.e. townhouses and office complexes with parking lots) with areas where lot coverage is lower (i.e. neighbourhoods containing parks and larger parcels).

(c) Table of Drinking Water Threats: Thresholds for Percentage of Managed Lands

As a conservative estimate of risk, it is assumed that all managed lands receive some type of nutrient application. The thresholds defined in order to evaluate the risk of over-application of nutrients in a vulnerable area or subsets of this area are:

- If managed lands in total account for less than 40% of the vulnerable area or subsets of this area, the area is considered to have a low potential for nutrient application to be causing contamination of drinking water sources,
- If managed lands in total account from 40% to 80% of the vulnerable area or subsets of this area, the area is considered to have a moderate potential for nutrient application to be causing contamination of drinking water sources, and

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- If managed lands in total account for over 80% of the vulnerable area or subsets of this area, the area is considered to have a high potential for nutrient application to be causing contamination of drinking water sources.

2. LIVESTOCK DENSITY (NU/Acre)

2.1 Calculation of Livestock Density

Livestock density is used as a surrogate measure of the potential for generating, storing, and land applying ASM as a source of nutrients within a defined area. The livestock density is expressed in NU/Acre.

The NUs (NUs) is expressed as:

- The number of animals housed, or pastured, at one time on a Farm Unit, that generate enough manure to fertilize the same area of crop landbase under the most limiting of either nitrogen or phosphorus as determined by OMAFRA's Nutrient Management (NMAN) software

  Or, in the case where no animals are housed:

- The weight or volume of manure or other biosolids used annually on a Farm Unit, that fertilizes the same area of crop landbase under the most limiting of either nitrogen or phosphorus as determined by OMAFRA's Nutrient Management (NMAN) software

The Nutrient Management Protocol defines the Farm Unit as:

1. For agricultural operations that generate a prescribed nutrient:
   - Can be no smaller than a single deed, or
   - Can be no smaller than the landbase of a generating facility under a single continuous roof, or
   - Must include all land receiving nutrients generated on the deeded property, as required by the Nutrient Management Strategy and/or Plan; whether or not the land itself is on the same deed; and
   - Must include nutrient generating facilities on other deeds owned by the same person/corporation if the nutrients generated on these other deeds are utilized on the landbase of the first deed; and
   - If nutrients are generated in different locations on your overall operation and those nutrients are not spread on the same landbase, then these different locations can be two or more separate farm units.
2. For agricultural operations that do not generate, but use nutrients
   - The farm unit can be no smaller than a single field

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The calculation of livestock density in a specified area requires the following three steps:

1) Estimate the number of each category of animals present within the specified area,

2) Convert the number of each category of poultry and livestock present into NUs, which are suggested in Section 2.1 of this Technical Bulletin, to enable all livestock to be compared on an equivalent unit of measure in terms of the nutrients produced by each type.

3) Sum the total NU of all categories of poultry and livestock within the specified area and then divide this NU value by the area of agricultural managed land within the same specified area. The applicable area used for the calculation of livestock density (NU/acre) is different for each of the following activities. Rule 1 of the technical rules includes a definition of livestock density, which is calculated over one of two areas described in (a) and (b):

a) In respect of land used for the application of nutrients, the number of NU per acre of agricultural managed land in the vulnerable area or subset of the vulnerable area, and detailed in Section 2.1 of this Technical Bulletin;

For the purposes of estimating the NUs required for the estimation of livestock density in a farm unit, where a portion of a farm unit falls within a vulnerable area, the NUs generated on the entire parcel of land should be factored into the calculations rather than the NUs generated within the portion of land that falls within a vulnerable area.

The rate for livestock density (NU/Acre) shall be calculated by dividing the total NUs generated on the farm unit by the total agricultural managed land within this farm unit. By calculating the rate for livestock density for the entire farm unit, this rate is already prorated to the portion of the farm that is in the vulnerable area.

For example, a farm unit has 200 acres of crop area, and □ of the crop area is located within the vulnerable area. The barn can be located either inside or outside the vulnerable area, and the farm unit has 100 cows, generating about 100 NU. The NU generated on this farm unit very likely will be used on its own crops. Therefore, the NU/acre is 100NU/200 acres = 0.5 NU/acre. Then, for this example, the area of "agricultural managed land" to be accounted within the vulnerable area is 100 acres, and the livestock density is 0.5 NU/acre.

b) In respect of land that is part of a farm unit and that is used for livestock grazing or pasturing, the number of NUs per acre that is used for those purposes, and detailed in Section 2.4 of this Technical Bulletin.

The land use data required for estimation of the above NU/Acre can be obtained from the same sources as the data required for the identification of managed land. The areas considered to calculate the NUs for each of the agricultural activities are described in Sections 2.2 to 2.4 below.

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2.2 Estimating the Number of Animals and Nutrient Units for Use in Livestock Density Calculations

The *Nutrient Management Act* developed a method of comparing livestock nutrient generation by converting the number of individual livestock into NU. This technical bulletin provides two methods to obtain the number of NU in a vulnerable area or subset of the vulnerable area. The first method is using a barn size calculation to estimate NU. The second method is converting actual animal numbers using the NU conversion table in the *Nutrient Management Protocol* of the *Nutrient Management Act*.

(a) *Estimating Nutrient Units based on the Square Footage of the Barn*

To estimate NUs based on square footage requires a three step approach. The first step is identifying the type of livestock operation on a farm unit. This may be accomplished two ways. Firstly, the Municipal Property Assessment Corporation (MPAC) farm classification system can be used to identify the farm use on a property (i.e. Dairy, Swine, Beef, etc.). The air photography and/or road side surveys, as described in Appendix A, can be used to address inconsistencies between MPAC data and local knowledge.

The MPAC data identifying the land use may in some cases be missing, an air photo interpretation helps to confirm the identification of barns and therefore to refine the estimates of the number of animals. For small areas a roadside survey as confirmation/support of the air photo interpretation is recommended to confirm the location of the barns and number of barns, as well to reduce the uncertainty on the identification of the number and type of animals that a farm unit may hold.

Once the type of livestock operation is known, the second step is to estimate the area of the livestock building. The square footage of each identified livestock building can be estimated using air photography and a GIS area measurement tool.

Once the livestock type and the barn dimensions are known, Table 1 below, or Tables 4 through 6, which can be found in Appendix B, may be used to estimate the number of NU on the farm unit. If there is no available detailed data about the property then Table 1 should be used. If more detail about the operation is known then Tables 4 through 6 in Appendix B should be used.

Table 1 below contains barn area per NU conversions based on the MPAC farm classification system. Tables 4 through 6 also provide barn area per NU conversion, but more detailed and specific to livestock sub-type (i.e. milking age cows, heifers, calf) and livestock sub-sub-type (i.e. freestall, tie stall and bedded pack) if such data is available.

For example, if a road side survey determines that a dairy farm houses Jersey cows, then Table 4 should be used to refine the calculation for that farm.

However, local knowledge or direct contact with property owners will always take precedence over any information gathered through this method.

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Table 1: *NU Conversion Factors based on barn size for different MPAC farm classifications.*

MPAC Classification	Sq.ft./NU	Sq.m./NU
Dairy	120	11
Swine	70	7
Beef	100	9
Chickens	267	25
Turkeys	260	24
Horse	275	26
Goat	200	19
Sheep	150	14
Fur	2400	223
Mixed	140	13

(b) ***Estimating Nutrient Units based on documented animal numbers***

The number of animals can be obtained by using the MPAC data and contacting the landowners within the vulnerable areas directly. The MPAC farm classification system can be used to identify the farm use on a property (i.e. Dairy, Swine, Beef, etc.). Information of number of livestock per farm units may also be available for some areas by contacting the Ontario Cattlemen's Association.

For conversion of the number of individual livestock into NUs, see http://www.omafra.gov.on.ca/english/livestock/index.html for each livestock type under Manure and Nutrient Management by commodity. Th poultry and livestock numbers into NUs are als http://www.omafra.gov.on.ca/englis

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Table 2: *Nutrient Unit Conversion Factors for Poultry, Cattle and Swine and Other Types of Livestock*

Livestock Category	Agricultural Census Category(s)	Description of Operation from OMAFRA (or surrogate for AgCensus Category)	Nutrient Unit Conversion Factor	Divide # of Animals by NU Conversion Factor
Poultry	layhen	Laying Hens (number of layer spaces in barn - after pullet stage, until end of laying period)	150 birds/NU	150
	pulets	Layer Pullets (number of pullet spaces in barn - day old to laying)	500 pullets/NU	500
	broiler	Chicken Broilers (8-week cycle)	351 birds/NU	250
		Chicken Broilers (9-week cycle)	300 birds/NU	
		Chicken Broilers (10-week cycle)	250 birds/NU	
		Chicken Broilers (12-week cycle)	199 birds/NU	
		Chicken Broiler Breeders (layers and roosters transferred in from growing barn)	100 birds/NU	
		Broiler Breeders (growing - pullets and cockerels transferred out to layer barn)	300 pullets/NU	
	turkey	Turkeys - Broilers/Hens/Toms/Pullets (total square feet of floor growing area)	58 birds/NU	58
	chick	Average of all chickens	300 chickens/NU	300
	tothplt	Average of all Other Poultry	245 birds/NU	245.33
Cattle	tbfcows	Beef Cows Includes calves to weaning	1 animal/NU	1
	tsteers	Beef Backgrounders 261-408 kilograms (575-900 pounds)	3 animals/NU	3
	bfheif	Beef Feeders 261-567 kilograms (575-1,250 pounds)	3 animals/NU	3
	fdheif	Beef Feeders 261-567 kilograms (575-1,250 pounds)	3 animals/NU	3
	mlkcow bulls	Dairy Cows (Large Frame, i.e. Holstein) 545-636 kilograms (1,200-1,400 pounds)	0.7 animals/NU	0.7
	mlkheif	Dairy Heifers (Large Frame, i.e. Holstein) 182-545 kilograms (400-1,200 pounds)	2 animals/NU	2
	calfu1	Dairy Calves (Large Frame, i.e. Holstein) 45-182 kilograms (100-400 pounds)	6 animals/NU	6
	cow	Average all Cows	0.85 animals/NU	0.85
Swine	tsows	Lactating-Age Sows - includes weaners to 6.8 kilograms (15 pounds)	3.33 animals/NU	3.33
	grwpig	Finishing Pigs Number of spaces in barn for animals between 27.3-104.5 kilograms (60-230 pounds)	6 animals/NU	6
	boars	SEW Sows Lactating-Age Sows - includes weaners to 6.8 kilograms (15 pounds)	3.33 animals/NU	3.33
	nurpig	SEW Weaners 6.8-27.3 kilogram (15-60 pounds)	20 animals/NU	20
		Average of All Swine	0.858 animals/NU	8.165

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Livestock Category	Agricultural Census Category(s)	Description of Operation from OMAFRA (or surrogate for AgCensus Category)	Nutrient Unit Conversion Factor	Divide # of Animals by NU Conversion Factor
Sheep	ewes rams	Sheep - Meat Breeding Ewes - includes lambs to 32 kilograms (70 pounds) (most sheep in GRCA are for meat)	8 animals/NU	8
	lambs	Feeder Lambs 32-57 kilograms (70-125 pounds)	20 animals/NU	20
Other Livestock	horses	Horses Medium Frame Includes foals to weaning from 227-680 kilograms (500-1,500 pounds)	1 animal/NU	1
	goats	Goats – Dairy milking-age does (includes kids, replacements and bucks)	8 animals/NU	8
	wildboar	Wild Boar - Breeding Age Sows Includes boars, replacements, and weaned piglets to 27 kilograms (60 pounds)	5 animals/NU	5
	fox	Fox Breeding Females Includes replacements, market animals and males	25 animals/NU	25
	mink	Mink Breeding Females Includes replacements, market animals and males	90 animals/NU	90
	bison	Bison Adults Includes unweaned calves and replacements	1.3 animals/NU	1.3
	lamas	Llama Adults or Alpaca Adults Includes unweaned young and replacements	5 animals/NU 8 animals/NU	6.5
	elk	Elk Adults" (24 months and older)	2 animals/NU	2
	deer	Deer (average of red, white tail and fallow) (24 months and older)	10.33 animals/NU	10.33
	rabbits	Breeding Does (Includes replacements, market animals and males)	40 animals/NU	40

2.3 Livestock Density for Land Application of Nutrients (NU/Acre)

(a) Area Used to Calculate Livestock Density for Land Application of Nutrients

For the purposes of determining the circumstances related to the application of nutrients, the livestock density (NU/acre) is calculated using the areas of '*managed agricultural land*' within each of the vulnerable areas or subset of the vulnerable areas as the denominator, as described in Section 1.1(a) of this bulletin. In other words, the total NUs of all livestock generated in the vulnerable area or subset of the vulnerable area divided by the acreage of *Agricultural Managed Lands within this area equals the livestock density in NU/acre*.

As detailed in Section 2.1, for the purposes of estimating the NUs and therefore the rate of livestock Density (NU/) within the vulnerable area or subset of the area, where a portion of a farm unit falls within a vulnerable area, the NUs generated on the entire parcel of land should be factored into the calculations rather than the NUs generated within the portion of land that falls within a vulnerable area, as this is then prorated by making it a NU/acre rate of application, which will apply to the portion of land in the vulnerable area.

(b) Table of Drinking Water Threats: Livestock Density Thresholds for Land Application of Nutrients

The conservative assumption used as the basis for this calculation is that a higher NU density results in a greater concentration of nutrients (the chemical threat) present in an area for storage, and land application and therefore an increased potential for nutrient contamination of source waters within the vulnerable area. For land application of ASM, a high livestock density in an area suggests an increased potential that over-application of ASM may occur as adequate land-base to properly dispose of all the ASM may not exist. In areas with low livestock density adequate land-base is more likely to exist to properly dispose of the ASM. Commercial fertilizers will likely be used to compensate for any under supply of ASM-based nutrients. The amounts applied, however, are regulated by the fact that this is a purchased crop input. The rational is that growers will want to closely match commercial fertilizer applications to crop requirements to minimize their cost of crop production.

The thresholds defined in order to evaluate the risk of over-application of ASM are:

- If livestock density in the vulnerable area is less than 0.5 NU/acre, the area is considered to have a low potential for nutrient application exceeding crop requirements,
- If livestock density in the vulnerable areas is over 0.5 and less than 1.0 NU/acre, the area is considered to have a moderate potential for nutrient application exceeding crop requirements, and
- If livestock density in the vulnerable areas is over 1.0 NU/acre, the area is considered to have a high potential for nutrient application exceeding crop requirements.

2.4 Livestock Density for Use of Land as Livestock Grazing or Pasturing Land, an Outdoor Confinement Area or a Farm-Animal Yard (NU/Acre)

(a) The Use of Land as Livestock Grazing or Pasturing Land

For the use of land as livestock grazing or pasturing land within the vulnerable areas, the NUs shall be calculated only for animal species that have the potential to be pastured in the same manner as above, but the area used for the calculation of livestock density shall be considered at the farm level. The nutrients generated at an annual rate for the circumstances under Table 1 of the technical rules shall be determined by the number of NU for the farm divided by the size of the livestock grazing land or pasturing land.

As detailed in Section 2.1, for the purposes of estimating the NUs and then the NU/Acre within the vulnerable area or subset of the area, where a portion of a farm unit falls within a vulnerable area, then the entire livestock grazing land or pasturing land should be factored into the calculations over the full area, to create a NU/acre that applies to the portion of land within the vulnerable area.

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(b) The Use of Land as Livestock Outdoor Confinement Area or a Farm-Animal Yard

For the use of land as livestock outdoor confinement area (OCA) or a farm-animal yard within the vulnerable areas, the NUs shall also be calculated only for animal species that have the potential to dwell in an outdoor confinement area at the farm level. The nutrients generated at an annual rate for the circumstances under Table 1 of the Technical Rules shall be determined by the number of NU for the farm divided by the size of the livestock OCA or a farm-animal yard in hectares.

Furthermore, where a portion of the grazing and pasture, OCAs and farm-yards of a farm unit falls within a vulnerable area, then the entire parcel of land for these purposes should be factored into the calculations over the full area, to create a NU/acre that applies to the portion of land within the vulnerable area.

3. CLARIFICATIONS OF THREATS RELATED TO APPLICATION OF NUTRIENTS

Table 1 of the Tables of Drinking Water Threats requires that you consider the maps for both percentage of managed lands and livestock density when evaluating the circumstances with regard to each of the thresholds for land application of nutrients. Table 3 illustrates the chemical hazard scorings for various combinations of percentage of managed lands and livestock densities. These are the consolidated hazard scores, incorporating the quantity, toxicity and fate scores. The highlighted combinations of percentage of managed land and NU/Acre give a hazard rating for land application of nutrients that, when combined with the area vulnerability scores of 9 or 10, would result in significant risk to source waters.

Table 3: *Chemical Hazard Scorings for Various Combinations of Percentage of Managed Lands and Livestock Densities*

Groundwater Chemical Hazard Scores

Percentage Managed Land to Total Land	Nutrient Units per Acre of Cropland		
	< 0.5 NU/acre	0.5 to 1.0 NU/acre	> 1.0 NU/acre
> 80%	**8 Significant in areas of Vuln=10**	**8.4 Significant in areas of Vuln=10**	**8.4 Significant in areas of Vuln=10**
40 to 80%	6.8	7.6	**8.4 Significant in areas of Vuln=10**
< 40%	6	6.8	**8 Significant in areas of Vuln=10**

Technical Bulletin: Managed Lands and Livestock Density

Surface water Chemical Hazard Scores

Percentage Managed Land of Total Area	Nutrient Units per Acre of Cropland		
	< 0.5 NU/acre	0.5 to 1.0 NU/acre	> 1.0 NU/acre
> 80%	**8.8 Significant in areas of Vuln=10**	**9.2 Significant in areas of Vuln=10 or 9**	**9.2 Significant in areas of Vuln=10 or 9**
40 to 80%	7.6	**8.4 Significant in areas of Vuln=10**	**9.2 Significant in areas of Vuln=10 or 9**
< 40%	6.8	7.6	**8.8 Significant in areas of Vuln=10**

4. CLASSIFICATION OF THREATS RELATED TO THE USE OF LAND FOR LIVESTOCK GRAZING OR PASTURING OR OUTDOOR CONFINEMENT AREA OR A FARM-ANIMAL YARD

In general, the use of land as livestock grazing or pasturing land will be a **significant chemical threat in Vulnerable Areas scoring 9 or 10** if:

- **Vulnerable Areas scoring 9** if the livestock density is sufficient to generate nutrients at an annual rate that is more than 1.0 NU/Acre; or
- **Vulnerable Areas scoring 10** if the livestock density is sufficient to generate nutrients at an annual rate that is at least 0.5 NU/Acre for surface water or more than 1.0 NU/Acre for groundwater; and
- the land use may result in the presence of Nitrogen or Phosphorus in surface water or Nitrogen in groundwater.

Note: the tables include Phosphorus in groundwater, but do not identify any threats associated with it.

The use of land as livestock outdoor confinement area or a farm-animal yard will be a **significant chemical threat in**:

- **Vulnerable Areas scoring 10** if the number of animals confined in the area at any time is sufficient to generate nutrients at a rate of more than 300 NUs per hectares of the area annually for groundwater and at a rate of more than 120 NUs per hectares of the area annually for surface water; or
- **Vulnerable Areas scoring 9** if the number of animals confined in the area at any time is sufficient to generate nutrients at a rate of more than 120 NUs per hectares of the area annually for surface water; and
- the land use may result in the presence of Nitrogen or Phosphorus in surface water or Nitrogen in groundwater.

Technical Bulletin: Managed Lands and Livestock Density

5. CLASSIFICATION OF THREATS RELATED TO ASM STORAGE

ASM storage includes: 1) storage at or above grade in or on a permanent nutrient storage facility, 2) storage at or above grade on a temporary field nutrient storage site, 3) storage below grade in or on a permanent nutrient storage facility, and 4) storage where a portion, but not all, of the ASM is stored above grade in or on a permanent nutrient storage facility. A barn is considered a threat when it is used to store ASM.

It is assumed that a high amount of NUs on a farm unit suggests the possibility of point source release of a large quantity of ASM. It is also assumed that if the farm unit has a high value of NUs, the livestock density (NU/acre) for land application would be high.

Therefore, the technical rules state that the use of land to store ASM would be a **significant chemical threat in Vulnerable Areas scoring 9 or 10** if the weight or volume of manure stored annually on a Farm Unit is sufficient to annually land apply nutrients at a rate that is more than 1.0 NU/Acre of the farm unit. The nutrients stored and applied at an annual rate for the circumstances under the Table of Drinking Water Threats of the technical rules for ASM storage is determined by the NU stored **on farm** divided by **the size of farm unit.**

Furthermore, circumstance 3 for ASM storage is that a **spill** of the material **or runoff** from the area where the material is stored (i.e. a point source release) may result in the presence of Nitrogen or Phosphorus in groundwater or surface water.

The tables of drinking water threats assume that generation of ASM is linked to the application of ASM in the farm unit and therefore circumstances are linked to application rates. If this is not the case, the SPC's can consider requesting the addition of other circumstances for ASM storage. For example:

- Storage of ASM where the NUs generated on the farm unit are more than 200 NU;
- Storage of ASM where the NUs generated on the farm unit are less than 200 NU but more than 100 NU;
- Storage of ASM where the NUs generated on the farm unit are less than or equal to 100 NU;

APPENDIX A: EXAMPLE OF CALCULATIONS

This working example has been undertaken by GRCA and OMAFRA in order to illustrate the process of calculating the % of managed land and livestock density for land application of nutrients. A WHPA within the Lake Erie Source Protection Region (LESPR) was selected for this exercise. The vulnerable areas have been delineated according to the technical rules. An illustration of the WHPAs A, B and C is presented in Figure 3 in the example below.

(a) Determining amount of "managed land" and "agricultural managed land"

Section 3 of this bulletin states that the *managed land* and *% managed land* areas must be calculated for each of the wellhead protection areas WHPAs A,B and C, and for each of the intake protection zones IPZ1 and IPZ2. The suggested method is to use a GIS/aerial photo-based approach to calculate the amount of agricultural managed land and tillable land within the vulnerable areas.

For this example, a simplified approach was taken for illustrative purposes, and the managed land and % of managed lands were calculated for a combined area of WHPA A, B and C as:

- WHPA A+B = the 2 year TOT boundary
- WHPA A+B+C = the 5 year TOT boundary

For this wellfield example, the percentage of managed land was calculated using ArcGIS as:

Total defined Vulnerable Area = 5865 acres

This total can be broken down as follows:

- WHPA-A = 76 acres
- WHPA-B = 3262 acres
- WHPA-C = 2527 acres
- Total = 5865 acres

For this example, managed lands within the WHPA were calculated using GIS as:

Managed Lands = Vulnerable Area (WHPA A, B and C) – (build up areas) – (areas of pits and quarries) – (areas of Woodlands) – (Large Rivers and Lakes) – (wetlands)

For illustrative purposes, the example considered that large open spaces (such as golf courses in the picture) are considered "pervious" and may or may not receive nutrients. The example in Figure 2 below (north part of the picture) shows impervious in purple and pervious in green. Therefore, the total managed lands for this example were estimated using GIS as:

- WHPA A + B = 3120 acres
- WHPA A + B + C = 5114 acres

Technical Bulletin: Managed Lands and Livestock Density

Fig 2: Impervious versus Pervious Areas for the WHPAs A, B and C areas

Therefore, the percentage of managed land to total land is calculated as managed land/WHPA:

- WHPA A + B = 93 %
- WHPA A + B + C = 87 %

For this example, the description of managed land included only golf courses and playing fields but not pervious areas within urban areas. The built up area in this case represents about 15% of the area of WHPA A+B and the pervious built up area can be assumed as about 7 to 10 %. However, in some situations the pervious portion of the urban area could represent a significant percentage of the total WHPAs that would affect the scoring for the thresholds for moderate or high risk of contamination. Therefore, for these cases the suggested approach suggested in Section 3.1(b) of this bulletin is recommended for calculation of pervious built up areas of *managed lands*.

Technical Bulletin: Managed Lands and Livestock Density

Agricultural Managed Land (for livestock density calculation) was calculated using GIS as following:

Agricultural Managed Land = (WHPA) – (Built up areas) – (areas of pits and quarries) – (large rivers and lakes) – (wetlands) – (areas of Woodlands)

Resulting in:

- WHPA A + B = 2616 acres
- WHPA B + C = 4534 acres

(b) Determining Nutrient Units (for use in livestock density calculations)

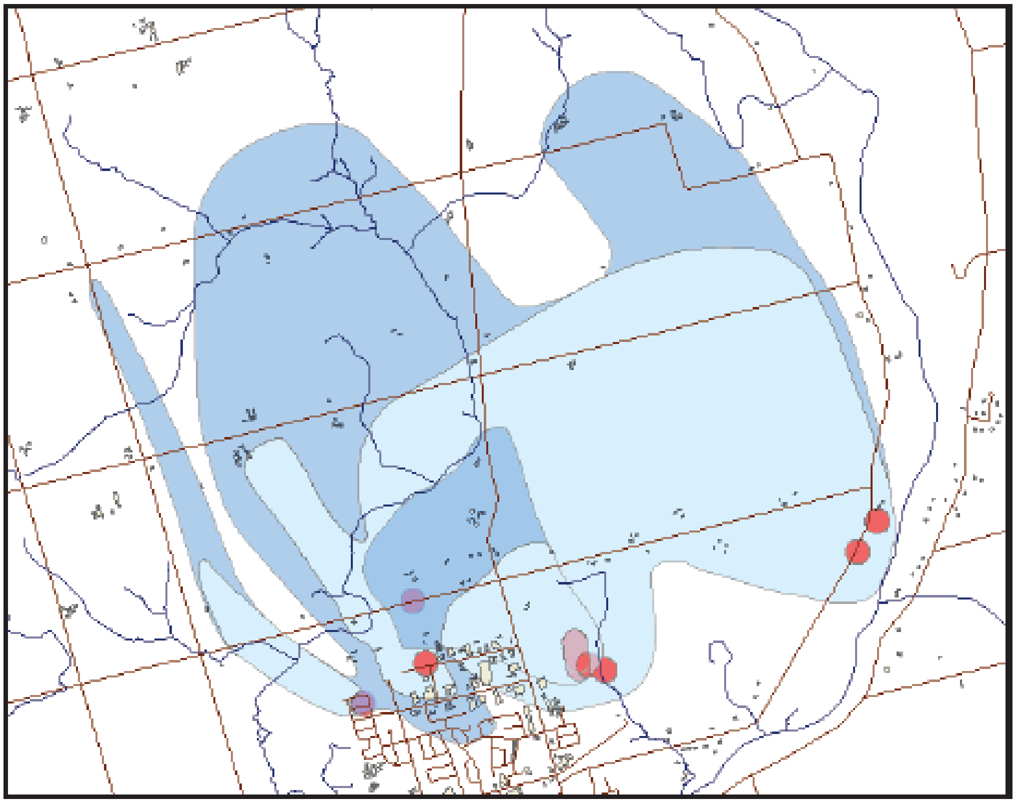
For this example, the NUs within WHPAs A, B and C (i.e. to the 5 year TOT boundary) were calculated using photo interpretation work and MPAC data to identify all buildings that could potentially house farm animals (barns) and estimating the number of animals per barn based on the air-photo-interpreted square footage of the barn.

For illustration, figure 3 shows the locations of Wellheads (red dots represent the WHPA-A), WHPAs B and C, and possible barns within the WHPAs (small black building outlines) using photo interpretation work. Some buildings in the WHPAs were screened out during the photo interpretation since they were obviously not used for livestock housing. Still, in order to briefly verify which building outlined in the photo interpretation work were barns, a quick roadside survey was undertaken to confirm the location of the barns as well as whether the barns would be eventually used to house livestock, and to adjust the findings on number of barns and the type of animals that they may hold.

The air photo interpretation findings in general will take precedence over the MPAC code. For this example, for this area, one farmstead site was identified by MPAC as being "poultry". From the air photos, however, a lot of large grain bins and connecting elevators were observed present around the buildings. This is not a typical building for poultry barns. It was estimated from the air photos and further confirmed by the roadside survey that the building was actually a grain handling facility.

The square footage of each identified livestock building was estimated using the GIS area measurement tool and the NU's within each WHPA were then added up using method described in Section 2.1 (a) and Table 2 of this bulletin. Then, the NUs were divided by the area of agricultural managed farm land.

Technical Bulletin: Managed Lands and Livestock Density



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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Provincial Tables of Circumstances:

Understanding the provincial tables

Date: March 2010

The Clean Water Act (the Act), along with regulations and rules governing the content of the assessment report (AR), requires that source protection committees (SPCs) identify areas and circumstances where activities are or would be significant, moderate or low drinking water threats. To meet the minimum requirements of the Act, the Technical Rules: Assessment Report (the Rules) allow SPCs to reference the Tables of Drinking Water Threats that make up part of the Rules. Although this reference meets the minimum requirement of the Act, it is anticipated that assessment reports will need to provide the public with maps and tables that allow the public to easily determine if an activity is or would be a significant, moderate, or low drinking water threat in a specific area. Therefore, to provide provincial consistency and limit the local work needed to create tables that can be referenced in assessment reports, the province has developed the Provincial Tables of Circumstances posted with this bulletin. The purpose of this Technical Bulletin is to provide these tables along with an explanation of the information contained in these tables.

How the Provincial Tables of Circumstances can be used in the assessment report is described in the companion Technical Bulletin titled "Threats Assessment and Issues Evaluation" available at the following location: http://www.ene.gov.on.ca/en/water/cleanwater/cwa-technical-rules.php.

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PIBS 7584e

Rationale for the Provincial Tables of Circumstances

As part of the AR, SPCs are having vulnerability scoring maps developed for four types of vulnerable areas:

- Highly vulnerable aquifers (HVAs) – groundwater
- Significant Groundwater Recharge Areas (SGRAs) - groundwater
- Wellhead Protection Areas (WHPAs) - groundwater
- Intake Protection Zones (IPZs) – surface water

Within these zones, vulnerability scores range from two to ten (2-10). Theranges in scores for each type of area that can result in the identification of a threat are:

- HVAs – 6
- SGRAs – 4, 6
- WHPAs – 4, 6, 8, 10
- IPZs - 4.2, 4.5, 4.8, 4.9, 5, 5.4, 5.6, 6, 6.3, 6.4, 7, 7.2, 8, 8.1, 9, 10

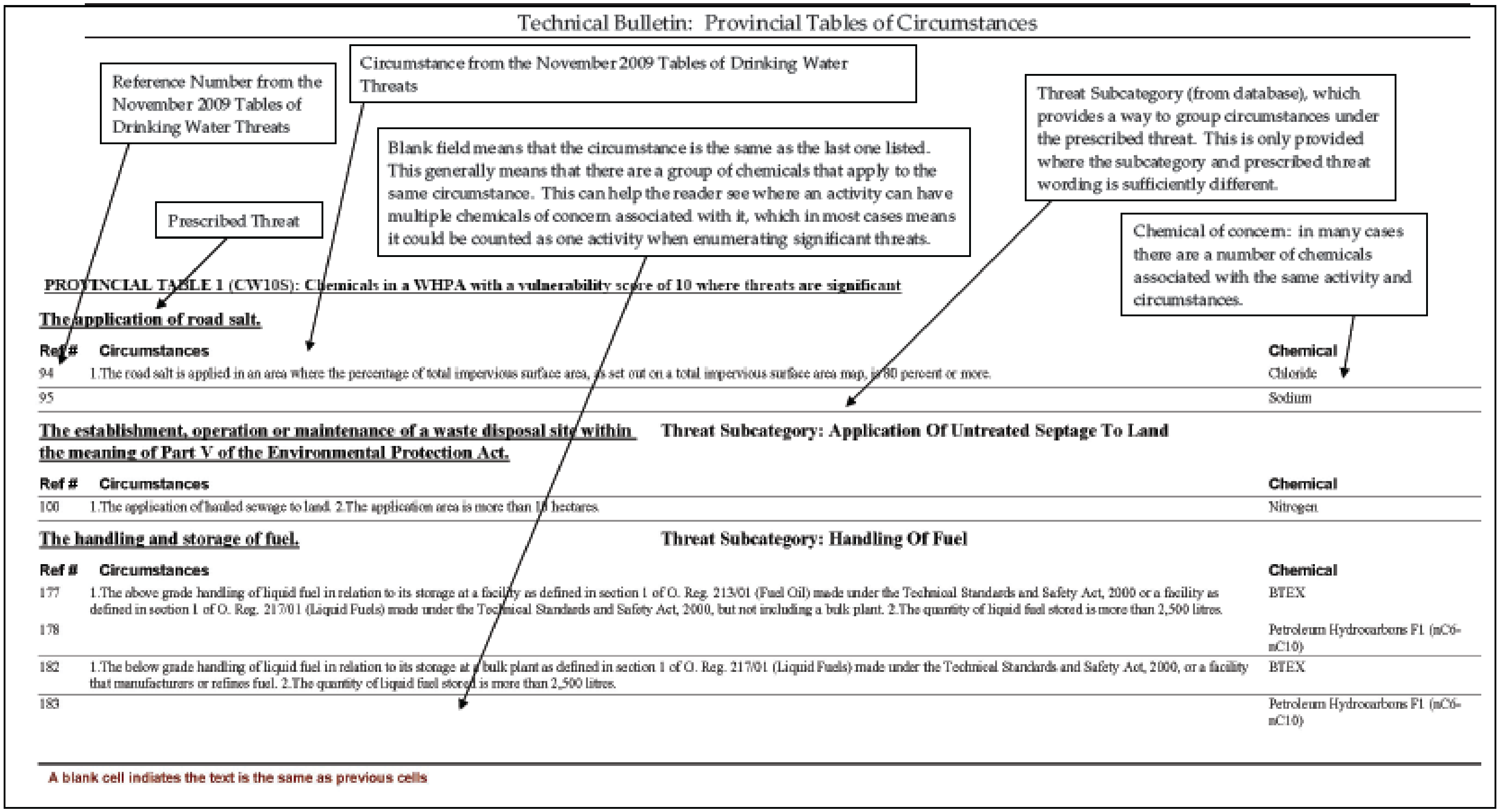
Based on the possible combinations of areas and scores, 76 different Provincial Tables of Circumstances have been created to represent the different combinations for which there are provincially prescribed threats and circumstances within the Tables of Drinking Water Threats. Not all combinations of vulnerable area and score have threats and circumstances associated with them.

The 76 tables are listed in the companion technical bulletin "Technical Bulletin: Threats Assessment and Issues Evaluation". There are a number of components of each table that require an explanation.

1. The tables are broken up into 5 types of tables, chemical tables for groundwater, Dense Non-Aqueous Phase Liquid (DNAPL) tables for groundwater, pathogen tables for groundwater, chemical and DNAPL tables for surface water, and pathogen tables for surface water.

2. Each of the 5 types of tables have been broken out into activities that are significant, moderate, or low drinking water threats for the vulnerability scores available for that type of vulnerable area. For example, chemical based activities in a WHPA with a score of 10, where the activity is a significant drinking water threat.

3. Two names have been given to each table. The first is a provincial table number from 1 to 76. The second, in brackets after the provincial table number, is a table name that used the following identifiers:
   - C – Chemical
   - P – Pathogen
   - D – DNAPL
   - W – WHPA
   - IPZ – IPZ
   - IPZWE – IPZ and WHPA-E
   - (number) - vulnerability score
   - S – Significant Drinking Water Threats
   - M – Moderate Drinking Water Threats
   - L - Drinking Water Threats
   - A – All vulnerability scores
4. For the chemical and DNAPL tables, an explanation of the table set up is provided on page 4.
5. For pathogens, an explanation of the table set up is provided on page 5.



Technical Bulletin: Provincial Tables of Circumstances

PROVINCIAL TABLE 1 (CW10S): Chemicals in a WHPA with a vulnerability score of 10 where threats are significant

The application of road salt.

Ref #	Circumstances	Chemical
94	1.The road salt is applied in an area where the percentage of total impervious surface area, as set out on a total impervious surface area map, is 80 percent or more.	Chloride
95		Sodium

The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act. **Threat Subcategory: Application Of Untreated Septage To Land**

Ref #	Circumstances	Chemical
100	1.The application of hauled sewage to land. 2.The application area is more than 10 hectares.	Nitrogen

The handling and storage of fuel. **Threat Subcategory: Handling Of Fuel**

Ref #	Circumstances	Chemical
177	1.The above grade handling of liquid fuel in relation to its storage at a facility as defined in section 1 of O. Reg. 213/01 (Fuel Oil) made under the Technical Standards and Safety Act, 2000 or a facility as defined in section 1 of O. Reg. 217/01 (Liquid Fuels) made under the Technical Standards and Safety Act, 2000, but not including a bulk plant. 2.The quantity of liquid fuel stored is more than 2,500 litres.	BTEX
178		Petroleum Hydrocarbons F1 (nC6-nC10)
182	1.The below grade handling of liquid fuel in relation to its storage at a bulk plant as defined in section 1 of O. Reg. 217/01 (Liquid Fuels) made under the Technical Standards and Safety Act, 2000, or a facility that manufacturers or refines fuel. 2.The quantity of liquid fuel stored is more than 2,500 litres.	BTEX
183		Petroleum Hydrocarbons F1 (nC6-nC10)

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Technical Bulletin: Provincial Tables of Circumstances

Reference number from November 2009 Tables of Drinking Water Threats

Prescribed Threat

Threat Subcategory (from database), which provides a way to group circumstances under the prescribed threat.

Circumstance: the circumstances from the tables of drinking water threats.

PROVINCIAL TABLE 12 (PW10S): Pathogens in WHPA A, B with a vulnerability of 10 where threats are significant

Ref #	Prescribed Threat	ThreatSubcategory	Circumstances
1944	The application of agricultural source material to land.	Application Of Agricultural Source Material (ASM) To Land	1. Agricultural source material is applied to land in any quantity. 2. The application may result in the presence of one or more pathogens in groundwater or surface water.
1945	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.	Management Or Handling Of Agricultural Source Material - Agricultural Source Material (ASM) Generation	1. The use of land as livestock grazing or pasturing land for one or more animals. 2. The land use may result in the presence of one or more pathogens in groundwater or surface water.
1946	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.	Management Or Handling Of Agricultural Source Material - Agricultural Source Material (ASM) Generation	1. The use of land as an outdoor confinement area or a farm-animal yard for one or more animals. 2. The land use may result in the presence of one or more pathogens in groundwater or surface water.
1956	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Septic System	1. The system is an earth pit privy, privy vault, cesspool, or a leaching bed system and its associated treatment unit and is a sewage system as defined in section 1 of O. Reg. 350/06 (Building Code) made under the Building Code Act, 1992 or a sewage works as defined in section 1 of the Ontario Water Resources Act. 2. A discharge from the system may result in the presence of one or more pathogens in groundwater or surface water.
1957	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Septic System Holding Tank	1. The system requires or uses a holding tank for the retention of hauled sewage at the site where it is produced before its collection by a hauled sewage system. 2. A spill from the tank may result in the presence of one or more pathogens in groundwater or surface water.
1958	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Sanitary Sewers and related pipes	1. The system is a wastewater collection facility that collects or transmits sewage containing human waste, but does not include any part of the facility that is a sewage storage tank or works used to carry out a designed bypass. 2. The discharge from the system may result in the presence of one or more pathogens in groundwater or surface water.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Threats Assessment and Issues Evaluation

Date: March 2010

Background

The Clean Water Act (the Act) requires that source protection committees (SPC) list activities that are or would be drinking water threats in four types of vulnerable areas. Through Ontario Regulation (O. Reg.) 287/07 (General) and the Director's Assessment Report: Technical Rules (the Rules), the province has set out which activities, at a minimum, are considered drinking water threats under specific circumstances. Specifically, section 1.1 of O. Reg. 287/07 lists activities that are prescribed as drinking water threats and the Tables of Drinking Water Threats (the Tables) in the Rules specify under what circumstances these activities are categorised as significant, moderate or low drinking water threats. Categorising drinking water threats is achieved using the ***Threats Based Approach*** (previously called the Semi-Quantitative Risk Assessment), the ***Issues Based Approach,*** the ***Events Based Approach***, or a combination of these three approaches. Appendix 1 provides a summary of relevant sections of the Act, O. Reg. 287/07 and Rules.

Guidance on the Assessment Report

An integral part of the assessment report and a prerequisite for the threats assessment and issues evaluation is the identification and delineation of vulnerable areas in each source protection area as per section 15(2)(d) and (e) of the Act. Specifically:

- Highly Vulnerable Aquifers (HVAs)

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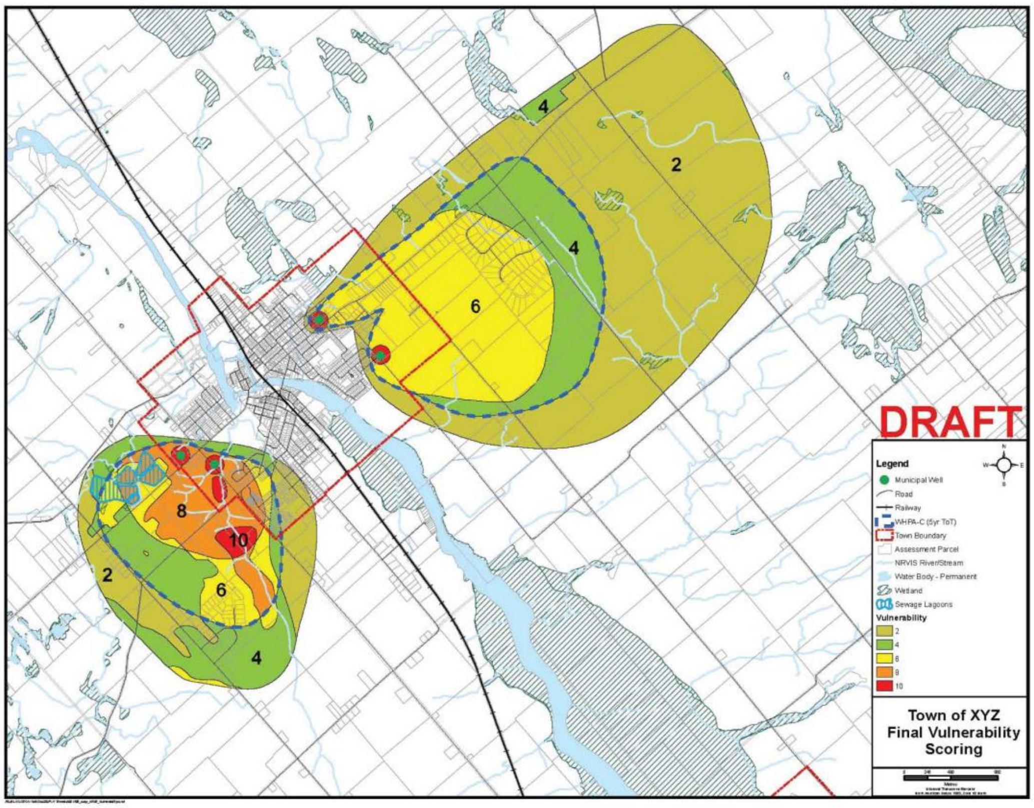
Technical Bulletin: Threats Assessment and Issues Evaluation

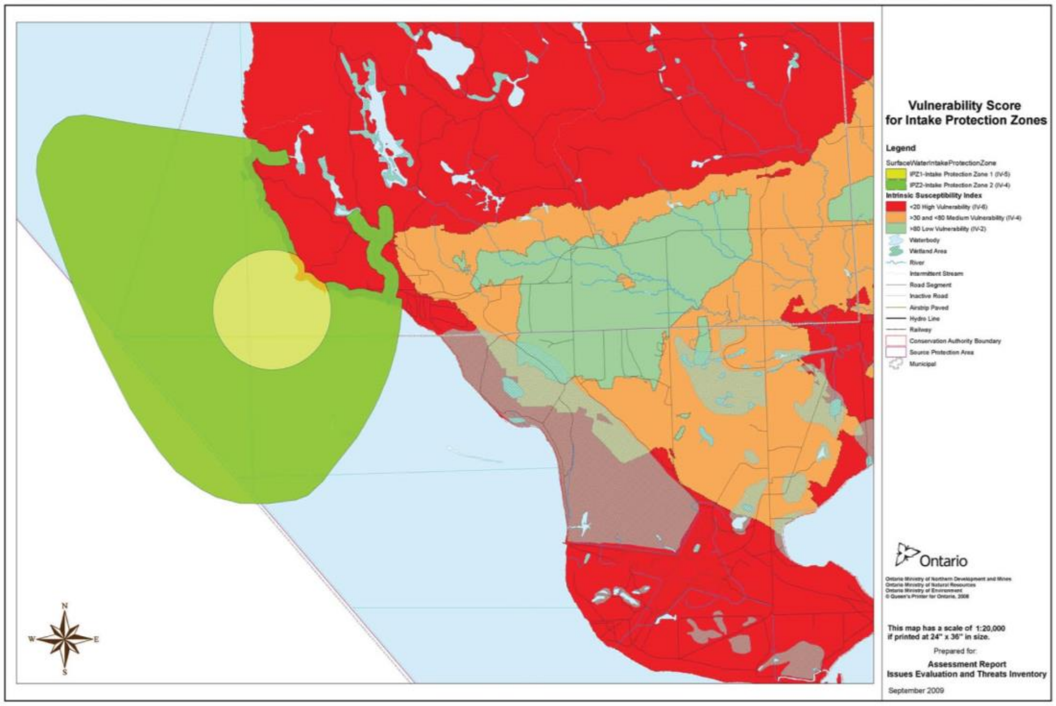
- Significant Groundwater Recharge Areas (SGRAs)
- Wellhead Protection Areas (WHPAs)
- Intake Protection Zones (IPZs)

Vulnerability scores are assigned to all the vulnerable areas identified in a source protection area. Part VII and VIII of the Rules (rules 79 to 96) list the requirements for assigning vulnerability scores. The vulnerable areas and scoring for each area can be shown in one or more maps such as these:

Vulnerable Areas – Groundwater mapping example



Vulnerable Areas – Surface Water mapping example (also includes groundwater vulnerability)



There are four specific requirements set out in O. Reg. 287/07 and the Rules for the completion of the Threats Assessment and Issues Evaluation component of the assessment report for each vulnerable area in a source protection area:

A) Identification of the activities or conditions that are or would be drinking water threats for each type of vulnerable area. These threats are different depending on whether the source of water is groundwater or surface water.

B) A list of the circumstances under which each activity listed above makes or would make the activity a significant, moderate, or low drinking water threat. For conditions, include the information that confirms there is a condition and the hazard rating for the condition.

C) Show the areas (for example, area scoring 10) within each vulnerable areas and the relevant circumstances where an activity or condition is or would be a significant, moderate or low drinking water threat.

D) Determine the number of locations (for example, parcels of land) at which a person is engaging in an activity that is a significant drinking water threat or where there is a condition that is a significant drinking water threat.

Technical Bulletin: Threats Assessment and Issues Evaluation

Detailed Requirements

A) Listing Drinking Water Threats

To satisfy **A)** there are three approaches that you may use to list the activities and conditions that are or would be a threat, meaning this is about existing and future activities to ensure appropriate policies can be written for future activities. Therefore, an inventory of activities is not required in this step. Please note this step does not require you to list the circumstances, only the threats.

1. **Listing prescribed drinking water threats (Activities):** O. Reg. 287/07 prescribes a list of activities that are or would be drinking water threats in all vulnerable areas under certain circumstances. As per Rule 118, you can collectively reference the activities listed in O. Reg. 287/07 and do not have to actually list the threats in the assessment report.

2. **Adding local threats (Activities):** The SPC can add a new activity based on local knowledge. As per Rule 119, the threat can not be added unless that the hazard rating of the activity is >4 and the Director under the Act has provided approval.

   Requests to add local threats can be made through the SPC's provincial liaison officer.

3. **Listing Drinking Water Threats (Conditions):** List conditions that the SPC is aware exist within each vulnerable area as per Rule 126 and provide the documentation on the condition.

Background for Requirements for B) and C)

Understanding the Tables of Drinking Water Threats

The Tables provide the list of circumstances where provincially prescribed activities are drinking water threats. These tables can be used to identify circumstances where activities are significant, moderate, or low drinking water threats (described in more detail in Section B of this bulletin) and to identify areas where activities are significant, moderate, or low drinking water threats (see Section C). To determine these circumstances and areas, it is important to understand how the Tables were set up.

The Tables make a link between the hazard rating of an activity under a specific circumstance and for a specific source water source water, and the vulnerability scores needed to make the activity/circumstance a significant, moderate, or low drinking water threat. By multiplying the hazard rating and the vulnerability score, the risk is assigned as per the following risk score ranges:

Risk Score Range	Drinking Water Threat Classification
80-100	Significant
60-<80	Moderate
>40 and <60	Low

The hazard ratings are not provided in the Tables, but are available within the lookup table database that generated the Tables. The lookup table database has been provided to the lead conservation authority in each source protection area and is available upon request. The database takes the hazard rating for each activity (with a specific set of circumstances) and back calculates the vulnerability scores necessary for the activity to fall in the risk score ranges above. Therefore, if the hazard rating is 8.5 for an activity in a surface water environment, then theoretically that activity would be a significant drinking water threat in a vulnerable area that has a vulnerability score of 9.5 or higher (9.5 multiplied by 8.5 equals 80.75 which is within the significant risk score range). However, the Tables will show a vulnerability score of 10 for surface water under the column labelled significant (column 4 in the figure below). This is because the multiplication of area vulnerability factors and source vulnerability factors do not allow a vulnerability score of 9.5. So the Table includes a vulnerability score of 10 rather than the theoretical vulnerability score range of 9.5 to 10. Further information on the Tables is provided on the following page.

Technical Bulletin: Threats Assessment and Issues Evaluation

Excerpt: Tables of Drinking Water Threats - Chemicals

Activity | **Circumstances** | **Areas where threats are significant, moderate, low**

TABLE 1 – DRINKING WATER THREATS - CHEMICALS

DRINKING WATER THREATS:	Reference number	Under the following CIRCUMSTANCES:	Areas Within Vulnerable Area	Threat is Significant in Areas with a Vulnerability Score of:	Threat is Moderate in Areas with a Vulnerability Score of:	Threat is Low in Areas with a Vulnerability Score of:
Column 1		Column 2	Column 3	Column 4	Column 5	Column 6
The establishment operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	521	1. The system is a storm water management facility designed to discharge storm water to land or surface water. 2. The drainage area associated with the storm water management facility is more than 10 but not more than 100 hectares and the predominant land uses in the area are rural, agricultural, or low density residential. 3. The discharge may result in the presence of Glyphosate in groundwater or surface water.	IPZ-1, IPZ-2, IPZ-3, and WHPA-E		9 - 10	5.6 - 8.1
			WHPA-A, WHPA-B, WHPA-C, WHPA-C1 WHPA-D			8 - 10
			HVA			
			SGRA			
	522	1. The system is a storm water management facility designed to discharge storm water to land or surface water. 2. The drainage area associated with the storm water management facility is more than 10 but not more than 100 hectares and the predominant land uses in the area are rural, agricultural, or low density residential. 3. The discharge may result in the presence of Lead or one or more of its compounds containing Lead in groundwater or surface water.	IPZ-1, IPZ-2, IPZ-3, and WHPA-E	10	8 - 9	4.9 - 7.2
			WHPA-A, WHPA-B, WHPA-C, WHPA-C1, WHPA-D		10	6 - 8
			HVA			6
			SGRA			6
	523	1. The system is a storm water management facility designed to discharge storm water to land or surface water. 2. The drainage area associated with the storm water management facility is more than 10 but not more than 100 hectares and the predominant land uses in the area are rural, agricultural, or low density residential. 3. The discharge may result in the presence of Mecoprop in groundwater or surface water.	IPZ-1, IPZ-2, IPZ-3, and WHPA-E	10	8 - 9	4.9 - 7.2
			WHPA-A, WHPA-B, WHPA-C, WHPA-C1, WHPA-D		10	6 - 8
			HVA			6
			SGRA			6

As shown in the above excerpt, the Tables are comprised of four main fields as follows:

Location in Table	Field
Column 1	Drinking Water Threat, based on the 21 prescribed drinking water threats
Column 2	Set of Circumstances specific to a Drinking Water Threat, including presence of contaminant parameters, volumes, and release into the environment
Column 3	Areas within Vulnerable Areas, grouped whether threat relates to surface water (IPZ and WHPA-E), groundwater (WHPA A-D, HVA, or SGRA)
Columns 4 - 6	Vulnerability scores that make up the significant, moderate and low threat matrix – the vulnerability scores listed identify whether the activity under the set of circumstances in that line of the table is a significant, moderate or low drinking water threat

In summary, to determine whether an activity is a significant drinking water threat, you need to know:

1. if the activity is identified as a prescribed drinking water threat or a local threat
2. the set of circumstances related to the contaminant's presence and/or release into the environment
3. what vulnerable area it is located in; and
4. the vulnerability score for the area where the activity is located.

Once the above information is known, you can determine if the activity is a significant, moderate or low drinking water threat.

B) Listing circumstances for activities

Meeting the requirements for listing circumstances is required for both the provincially prescribed drinking water threats and any local threats as outlined below:

1. **For activities within the Tables**: Rule 118.1 allows you to reference the Tables. However, SPCs may want to use lists more specific to the vulnerable area and vulnerability score. SPCs may also want to develop other lists for consultation purposes. ***Appendix 2 elaborates on the various approaches that can be used to develop these lists.*** One approach is that the province has generated tables of activities and circumstances for all combinations of vulnerable area and vulnerability score. These Provincial Tables of Circumstances can be referenced and would not need to be produced in full in the assessment report.

2. **For local activities or prescribed activities with new circumstances:** Where activities or circumstances have been added locally, a list of the new activities and set of circumstances under which these activities are significant, moderate, or low drinking water threats are necessary. The set of circumstances includes the vulnerability score that makes the activity significant, moderate, or low.

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C) Identifying areas where threats are significant, moderate or low

To satisfy **C)** there should be a map showing the areas where the activities, under the circumstances listed, and conditions are significant, moderate or low drinking water threats. There are three approaches as follows:

1. **Through the Threats Approach based on vulnerability:** To show areas where activities or conditions are significant, moderate or low using this approach you can use the vulnerability score maps and legends that link the activities and circumstances and conditions that are or would be threats in each area. For example, if you have a list of activities that are significant drinking water threats in a groundwater based vulnerable area with a vulnerability score of 8, then a map of all groundwater based vulnerable areas with the vulnerability score of 8 could have a legend referencing a table that lists all activities and circumstances that are significant in these areas. ***See Appendix 2 for further detail on how to develop these lists.*** One approach is that you will be able to use the lists of activities and circumstances for all combinations of vulnerable area and vulnerability score the province has generated.

   For this same example, conditions with a hazard rating of 10 would also have to be included on the legend indicating that these conditions would also be significant in an area with a vulnerability score of 8.

Please note the following:

a. No inventory of existing threats is needed for this step. The requirement is to identify any areas where an activity or condition is or would be a significant, moderate, or low drinking water threat, so the presence or absence of an activity is not relevant. Source protection plans are to have policies for existing significant drinking water threats as well as policies to prevent future significant drinking water threats.

b. For most chemicals, only vulnerability scores >4 need to be shown on maps as a risk score of >40 is needed for an activity or condition to be a significant, moderate, or low drinking water threat.

c. DNAPL and pathogen threats need special considerations. DNAPLs are a significant drinking water threat anywhere in WHPA A, B, C, or C1, and

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pathogen threats can not be a threat outside WHPA B using the threats approach.

d. Therefore, for each vulnerable area, you could produce three maps to show the areas where activities are significant, moderate or low drinking water threats. ***See Appendix 3 for a more detailed description of the three example maps below.***

   1. A map for chemicals that shows all subareas of the vulnerable areas with their respective vulnerability scores. As indicated above, a legend could link the areas with the same vulnerability score to a table that lists the activities that are significant, moderate or low drinking water threats with that specific vulnerability score.

   2. A map for pathogens that shows vulnerability scores in WHPA-A, WHPA-B, WHPA-E and all subareas of an IPZ where the vulnerability score is greater than 4.

   3. A map for DNAPLs that shows WHPA-A, B, and C/C1 as areas where DNAPLs are significant and the areas with vulnerability scores greater than 4 in WHPA-D, WHPA-E, and all subareas of IPZs.

2. **Through the Issues Approach:** The identification of drinking water threats related to issues is an iterative approach.

   - First, you identify an issue, the intake, well, or monitoring well where the issue is defined, and the parameter or pathogen of concern (see below for what to consider)

   - Second, you identify the issue contributing area (ICA) for any issue meeting the tests in Rule 114. This is the "area within a vulnerable area" where an activity or condition can contribute to an issue. The issue contributing area can only be shown within any one of the four vulnerable areas (WHPA, IPZ, HVA, or SGRA).

   - If you don't have enough information to delineate the issue contributing area, you include a plan in the Assessment Report to delineate this area (Rule 116).

- Third, you identify activities or conditions that could contribute to the issue (i.e., they have the chemical or pathogen associated with it that could contribute to the issue.).

- If an analysis of these steps suggests the ICA does not capture threats then a second analysis (iteration) is required to define the appropriate ICA.

- Once the issues and ICA's are defined, the SPC can define the areas where threats are significant, moderate or low drinking water threats. For this, the issue contributing area becomes the area where activities and conditions that could contribute to this issue are:

  - significant drinking water threats for systems to which section 15(2) of the CWA (Clean Water Act) applies (systems in the Terms of Reference); and

  - moderate drinking water threats if the issues are related to any other drinking water system.

Therefore, to show the areas where activities are either significant or moderate drinking water threats as a result of an identified issue, one approach is to provide a:

- map(s) of the vulnerable area and the issue contributing area; and

- reference to all activities or conditions that are either significant or moderate drinking water threats, depending on the type of drinking water system, in the area.

SPCs can create these lists using one of the database tools available for exporting activities related to chemicals or pathogens (the lookup tables data base or the Upper Thames River Conservation Authority Threat Analysis Tool (web based tool). Relevant local threats or conditions should be added to these lists.

Considerations when identifying Issues

SPCs are enabled through the CWA to identify issues related to the drinking water systems in their source protection area. Where an issue meets the following tests, as set out in Rule 114, the SPC is required to identify the issue contributing area and follow the steps in the previous section. The tests in Rule 114 are:

a. Issues can only be identified at an intake, well, or monitoring well.

b. For drinking water systems included in the Terms of Reference (types I, II, and III systems), issues can be identified for parameters in Schedules 1, 2 or 3 of the Ontario Drinking Water Quality Standard (ODWQS) or in Table 4 of the Technical Support Document.

c. For any other drinking water systems as defined under the Safe Drinking Water Act (SDWA), only chemical drinking water issues may be included (Schedules 2 and 3 of the ODWQS or Table 4 of the Technical Support Document).

d. The definition of a drinking water system under the SDWA means any system that takes water for drinking water purposes. This includes any private well or intake.

It is not mandatory that every elevated parameter in the raw water be considered an issue. The SPC should consult with the operators of the system, and the municipality if they are not the operator, to determine if the raw water quality presents a problem for them. Sometimes a water treatment plant easily deals with the elevated concentration of a parameter and treatment would have to continue even if human activities are managed, as natural conditions also cause the parameter to be elevated. In other cases, the water treatment plant adequately deals with the problem, but the costs associated with treatment of the parameter are prohibitive and/or managing human activities could reduce or eliminate the problem and reduce treatment costs. In some cases, an issue is identified, but most activities contributing to this problem are already identified as significant drinking water threats, so the SPC does not see a need to also identify it as an issue. All of these factors should be considered when assessing if something should be identified as an issue.

3. **Event Based Approach:**

> ***Note: This approach is limited to Type A and B intakes and Types C and D intakes in Lake Nipissing, Lake Simcoe, Lake St. Clair or the Ottawa River.***

The event based approach was designed to address threats to drinking water in systems drawing water from larger water bodies where the vulnerability scores are generally low. The approach allows for the use of modeling or other methods (referred to as modeling in this bulletin) to identify existing or future activities or existing conditions as significant drinking water threats if the modeling results indicate that there would be a drinking water issue at an intake if chemicals or pathogens were released from the location under an extreme event. It is a two part process, one part allows you to identify threats that could cause an issue and the second part allows you to develop an IPZ-3. This approach is an iterative process, where you identify an activity or condition of concern, undertake the modeling, and then draw an IPZ-3 to include that location if the modeling shows an issue could occur. You can undertake additional modeling on other activities and/or conditions and expand the area as more information is made available.

The modeling of an activity or condition using this approach can be completed in any of the subareas of an IPZ for drinking water systems to which Rule 68 applies, i.e., within an IPZ-1, IPZ-2, or IPZ-3. Different rules are used to understand how this works. First, using rule 68, modeling that is undertaken for an activity located beyond IPZ-1 and IPZ-2 can be used to determine the extent of IPZ-3. Rules 74 and 75 ensure that IPZ-1 and IPZ-2, which have been delineated separately, are not part of IPZ-3. Therefore, after the modeling has been completed, you now have an IPZ-1, IPZ-2, and IPZ-3 for that specific intake. Under Rule 130, any activity anywhere in an IPZ, i.e. IPZ-1, IPZ-2, and IPZ-3, is a significant drinking water threat if modeling shows that a contaminant released from that activity under an extreme event could cause an issue at that intake. This modeling can be done for an existing or proposed activity. For conditions, Rule 140.1 applies in the same way. If the SPC has not delineated an IPZ-3, modeling can still be undertaken as per rule 130 / 140.1 for activities / conditions in IPZ-1 or IPZ-2.

In essence, modeling can be used in two different ways. First modeling can be used to delineate an IPZ-3 (if undertaken beyond IPZ-2). Second modeling can be used to identify activities / conditions as significant drinking water threats (this applies anywhere in an IPZ).

Once you identify the locations where an activity or condition that could cause an issue "is or would be engaged in", the location of the activity or condition is the area where the activity is a significant drinking water threat. This means the building or property (parcel) where the modelled activity is located and which could cause an issue.

One approach to meet the requirements for the assessment report, is to develop a map of the IPZ (IPZ-1, IPZ-2 and IPZ-3 where delineated), identify the properties (parcels) or areas where there are significant drinking water threats determined through this method, and identify through a table, map, or text what circumstances make that activity or condition a significant drinking water threat.

Delineation of IPZ-3 is only required where modeling or other methods have shown contaminants can reach an intake. You can complete the assessment report without this IPZ-3 and submit an updated assessment report once modeling has been completed.

D) Enumeration of Significant Drinking Water Threats

To satisfy **D)** the assessment report should include the number of existing significant drinking water threats. The following points are considerations when enumerating significant drinking water threats:

- O. Reg 287/07 Section 13(1) (6) refers to "is or would be" significant drinking water threats. In this context:
    - "is" – means the locations where an activity is currently undertaken or a condition exists.
    - "would be" – means the locations where the infrastructure is there to undertake an activity at any time.
    - Vacant lots and areas of future development with associated zoning are <u>not</u> counted as locations where an activity is or would be engaged in.
- The level of effort to confirm the count of significant drinking water threats should be dependent on your knowledge of the source protection area and vulnerable areas, along with the level of comfort of the SPC, stakeholders, and public.
- For activities where there is high certainty that they are a significant drinking water threat (e.g., gas stations, where the quantity of fuel and chemicals are relatively standard), no site visit needs to be completed to enumerate this threat.
- Where there is little information, high uncertainty, or a high level of discomfort around an activity or condition, there may be a need for a site visit.
- In some areas, SPCs and CAs will have to make decisions on how many site visits can be completed based on the time and resources available.

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- SPC's may choose to identify areas where they expect there are significant drinking water threats and list the number of potential locations. For example, for an area potentially serviced by sanitary sewers where, without site visits, you can not confidently confirm the exact number of locations on septic systems. In this case, you may want to draw a line around the area and indicate that there are potentially X number of significant drinking water threats (where X is the number of lots).

APPENDIX 1

The following text is provided in support of the content of this technical bulletin. Readers are referred to the current version of the various acts, regulations and technical rules for complete details.

What do you need when identifying threats in vulnerable areas?

The Clean Water Act, 2006, regulations and technical rules specify the components that need to be contained in the assessment report with respect to identifying drinking water threats in vulnerable areas. The specifics are as follows:

Clean Water Act, 2006:

- Section 15(2(g)): list, for each vulnerable area identified under clauses (d) and (e),
  (i) activities that are or would be drinking water threats, and
  (ii) conditions that result from past activities and that are drinking water threats.
- Section 15(2(h)): identify within each vulnerable area identified under clauses (d) and (e),
  (i) the areas where an activity listed under clause (g) is or would be a significant drinking water threat, and
  (ii) the areas where a condition listed under clause (g) is a significant drinking water threat

General Regulation 287/07

- Section 13(1(2)): For each vulnerable area identified under clause 15 (2) (d) or (e) of the Act, an identification of the following areas within the vulnerable area:
  i. Areas where an activity listed under subclause 15 (2) (g) (i) of the Act is or would be a moderate drinking water threat.
  ii. Areas where an activity listed under subclause 15 (2) (g) (i) of the Act is or would be a low drinking water threat.

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iii. Areas where a condition listed under subclause 15 (2) (g) (ii) of the Act is a moderate drinking water threat.

iv. Areas where a condition listed under subclause 15 (2) (g) (ii) of the Act is a low drinking water threat.

- Section 13(1(3)): For each area identified under subclause 15 (2) (h) (i) of the Act, the circumstances in which the activity listed under clause 15 (2) (g) of the Act is or would be a significant drinking water threat.
- Section 13(1(4)): For each area identified under subparagraph 2 i, the circumstances in which the activity listed under subclause 15 (2) (g) (i) of the Act is or would be a moderate drinking water threat.
- Section 13(1(5)): For each area identified under subparagraph 2 ii, the circumstances in which the activity listed under subclause 15 (2) (g) (i) of the Act is or would be a low drinking water threat.
- Section 13(1(6)): For each vulnerable area identified under clause 15 (2) (d) or (e) of the Act,
  i. the number of locations at which a person is engaging in an activity listed under subclause 15 (2) (g) (i) of the Act that is or would be a significant drinking water threat, and
  ii. the number of locations at which a condition listed under subclause 15 (2) (g) (ii) of the Act is a significant drinking water threat.

Technical Rules

- Part XI.2 – Listing drinking water threats – Activities
- Rules 118 and 118.1 allow for the Regulation 287/07 (General) and the Tables of Drinking Water Threats to be referenced when listing activities and circumstances
- Rules 119 to 125 allows for a process to list activities and circumstances
- Part XI.3 – Listing drinking water threats – Conditions
- Rule 126 lists the information needed when listing conditions that result from past activities

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- Part XI.4 – Identifying areas for significant, moderate and low drinking water threats – Activities
- Rules 127 to 131.1 indicate what makes an activity a significant drinking water threat
- Rules 132 to 134.2 indicate what makes an activity a moderate drinking water threat
- Rules 135 to 137 indicate what makes an activity a low drinking water threat
- Part XI.5 – Identifying areas for significant, moderate and low drinking water threats – Conditions

APPENDIX 2

There are three different approaches to extract the activities and circumstances from the database used to build the Tables of Drinking Water Threats:

Approach 1 – Using the UTRCA (Upper Thames Region Conservation Authority) Threats Analysis Tool: This web based tool allows the extraction of lists into an Excel spreadsheet of activities and circumstances given specified information is provided (e.g. vulnerability score, type of vulnerable area, and whether the threat is a chemical, pathogen or DNAPL). The website can be found at: http://maps.thamesriver.on.ca/SWPThreats/threats/threatsList.aspx

Approach 2 – Querying the MS Access look up tables used to generate the Tables of Drinking Water Threats by using the query functions built into the database.

Approach 3 – Using the Provincial Reference Tables developed by MOE. In response to several inquiries, the Ministry has prepared a series of "provincial reference tables" to assist SPCs in meeting their obligations as set out in the regulations and technical rules regarding the documentation of various lists of potential circumstances that address the terminology "is or would be a significant, moderate or low drinking water threat". These tables are posted with the technical bulletins at http://www.ene.gov.on.ca/en/water/cleanwater/cwa-technical-rules.php.

This approach simply references a specific table name associated with a chemical or pathogen, the vulnerability area and score and contains all of the potential circumstances that meet this set of criteria. Rather than having each SPC "screen" the Tables of Drinking Water Threats for the various circumstances that identify which activity and circumstance meets the above criteria and generate their own list, a "provincial set" of tables has been prepared.

The tables have been generated using the following criteria:

- Chemical, Pathogen or DNAPL
- WHPA, IPZ, HVA or SGRA
- Vulnerability score
- Significant, moderate of low drinking water threat

SPC's will now be able to provide their mapping product of the vulnerability area combined with a reference to a specific provincial reference table (or tables) instead of putting the table(s) itself in the assessment report. These tables will be posted on the Clean Water Act web site and a list of the table numbers and names is provided at the end of this Appendix.

Example: If a SPC is linking a map that illustrates pathogens in an IPZ with a vulnerability score of 10, and they need to indicate what activities are low drinking water threats in that area, they can reference the areas with a vulnerability score of 10 in the map to Table PIPZ10L which provides the list of activities that are low drinking water threats in that area. The province will also include simplified table names.

Similarly, if they have a map that illustrates chemicals in a HVA that has a vulnerability score of 6, and they need to indicate what activities are low drinking water threats in that area, they can now reference Table CSGRAHVA6L to indicate what activities are moderate threats in this area.

Provincial Tables Of Circumstances

Provincial Table Number	Table Name	Table Title
1	CW10S	Chemicals in a WHPA with a vulnerability score of 10 where threats are significant
2	CW8S	Chemicals in a WHPA with a vulnerability score of 8 where threats are significant
3	CW10M	Chemicals in a WHPA with a vulnerability score of 10 where threats are moderate
4	CW8M	Chemicals in a WHPA with a vulnerability score of 8 where threats are moderate
5	CW6M	Chemicals in a WHPA with a vulnerability score of 6 where threats are moderate
6	CW10L	Chemicals in a WHPA with a vulnerability score of 10 where threats are low
7	CW8L	Chemicals in a WHPA with a vulnerability score of 8 where threats are low
8	CW6L	Chemicals in a WHPA with a vulnerability score of 6 where threats are low

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Provincial Table Number	Table Name	Table Title
9	DWAS	DNAPLS in WHPA A, B, C, C1, with any vulnerability where threats are significant
10	DW6M	DNAPLS in WHPA D with a vulnerability of 6 where threats are moderate
11	DW6L	DNAPLS in WHPA D with a vulnerability of 6 where threats are low
12	PW10S	Pathogens in WHPA A, B with a vulnerability of 10 where threats are significant
13	PW10M	Pathogens in WHPA A, B with a vulnerability of 10 where threats are moderate
14	PW8M	Pathogens in WHPA A, B with a vulnerability of 8 where threats are moderate
15	PW8L	Pathogens in WHPA A, B with a vulnerability of 8 where threats are low
16	PW6L	Pathogens in WHPA A, B with a vulnerability of 6 where threats are low
17	CSGRAHVA 6M	Chemicals in an SGRA or HVA with a vulnerability score of 6 where threats are moderate
18	CSGRAHVA 6L	Chemicals in an SGRA or HVA with a vulnerability score of 6 where threats are low
19	CIPZ10S	Chemicals in an IPZ with a vulnerability of 10 where threats are significant
20	CIPZWE9S	Chemicals in an IPZ or WHPA E where the vulnerability score is 9 where threats are significant
21	CIPZWE8.1S	Chemicals in an IPZ or WHPA E where the vulnerability score is 8.1 where threats are significant
22	CIPZWE8S	Chemicals in an IPZ or WHPA E where the vulnerability score is 8 where threats are significant
23	CIPZ10M	Chemicals in an IPZ with a vulnerability of 10 where threats are moderate
24	CIPZWE9M	Chemicals in an IPZ or WHPA E where the vulnerability score is 9 where threats are

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Provincial Table Number	Table Name	Table Title
		moderate
25	CIPZWE8.1 M	Chemicals in an IPZ or WHPA E where the vulnerability score is 8.1 where threats are moderate
26	CIPZWE8M	Chemicals in an IPZ or WHPA E where the vulnerability score is 8 where threats are moderate
27	CIPZWE7.2 M	Chemicals in an IPZ or WHPA E where the vulnerability score is 7.2 where threats are moderate
28	CIPZWE7M	Chemicals in an IPZ or WHPA E where the vulnerability score is 7 where threats are moderate
29	CIPZWE6.4 M	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.4 where threats are moderate
30	CIPZWE6.3 M	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.3 where threats are moderate
31	CIPZWE10L	Chemicals in an IPZ with a vulnerability of 10 where threats are low
32	CIPZWE9L	Chemicals in an IPZ or WHPA E where the vulnerability score is 9 where threats are low
33	CIPZWE8.1L	Chemicals in an IPZ or WHPA E where the vulnerability score is 8.1 where threats are low
34	CIPZWE8L	Chemicals in an IPZ or WHPA E where the vulnerability score is 8 where threats are low
35	CIPZWE7.2L	Chemicals in an IPZ or WHPA E where the vulnerability score is 7.2 where threats are low
36	CIPZWE7L	Chemicals in an IPZ or WHPA E where the vulnerability score is 7 where threats are low

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Provincial Table Number	Table Name	Table Title
37	CIPZWE6.4L	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.4 where threats are low
38	CIPZWE6.3L	Chemicals in an IPZ or WHPA E where the vulnerability score is 6.3 where threats are low
39	CIPZWE5.6L	Chemicals in an IPZ or WHPA E where the vulnerability score is 5.6 where threats are low
40	CIPZWE5.4L	Chemicals in an IPZ or WHPA E where the vulnerability score is 5.4 where threats are low
41	CIPZWE4.9L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.9 where threats are low
42	CIPZWE4.8L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.8 where threats are low
43	CIPZWE4.5L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.5 where threats are low
44	CIPZWE4.2L	Chemicals in an IPZ or WHPA E where the vulnerability score is 4.2 where threats are low
45	PIPZ10S	Pathogens in an IPZ with a vulnerability of 10 where threats are significant
46	PIPZWE9S	Pathogens in an IPZ or WHPA E with a vulnerability of 9 where threats are significant
47	PIPZWE8.1S	Pathogens in an IPZ or WHPA E with a vulnerability of 8.1 where threats are significant
48	PIPZWE8S	Pathogens in an IPZ or WHPA E with a vulnerability of 8 where threats are significant
49	PIPZWE10M	Pathogens in an IPZ with a vulnerability of 10 where threats are moderate

Provincial Table Number	Table Name	Table Title
50	PIPZWE9M	Pathogens in an IPZ or WHPA E with a vulnerability of 9 where threats are moderate
51	PIPZWE8.1M	Pathogens in an IPZ or WHPA E with a vulnerability of 8.1 where threats are moderate
52	PIPZWE8M	Pathogens in an IPZ or WHPA E with a vulnerability of 8 where threats are moderate
53	PIPZWE7.2M	Pathogens in an IPZ or WHPA E with a vulnerability of 7.2 where threats are moderate
54	PIPZWE7M	Pathogens in an IPZ or WHPA E with a vulnerability of 7 where threats are moderate
55	PIPZWE6.4M	Pathogens in an IPZ or WHPA E with a vulnerability of 6.4 where threats are moderate
56	PIPZWE6.3M	Pathogens in an IPZ or WHPA E with a vulnerability of 6.3 where threats are moderate
57	PIPZ6M	Pathogens in an IPZ with a vulnerability of 6 where threats are moderate
58	PIPZ10L	Pathogens in an IPZ with a vulnerability of 10 where threats are low
59	PIPZWE9L	Pathogens in an IPZ or WHPA E with a vulnerability of 9 where threats are low
60	PIPZWE8.1L	Pathogens in an IPZ or WHPA E with a vulnerability of 8.1 where threats are low
61	PIPZWE8L	Pathogens in an IPZ or WHPA E with a vulnerability of 8 where threats are low
62	PIPZWE7.2L	Pathogens in an IPZ or WHPA E with a vulnerability of 7.2 where threats are low
63	PIPZWE7L	Pathogens in an IPZ or WHPA E with a vulnerability of 7 where threats are low
64	PIPZWE6.4L	Pathogens in an IPZ or WHPA E with a vulnerability of 6.4 where threats are low

Provincial Table Number	Table Name	Table Title
65	PIPZWE6.3L	Pathogens in an IPZ or WHPA E with a vulnerability of 6.3 where threats are low
66	PIPZ6L	Pathogens in an IPZ with a vulnerability of 6 where threats are low
67	PIPZWE5.6L	Pathogens in an IPZ or WHPA E with a vulnerability of 5.6 where threats are low
68	PIPZWE5.4L	Pathogens in an IPZ or WHPA E with a vulnerability of 5.4 where threats are low
69	PIPZ5L	Pathogens in an IPZ with a vulnerability of 5 where threats are low
70	PIPZWE4.9L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.9 where threats are low
71	PIPZWE4.8L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.8 where threats are low
72	PIPZWE4.5L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.5 where threats are low
73	PIPZWE4.2L	Pathogens in an IPZ or WHPA E with a vulnerability of 4.2 where threats are low
74	CIPZWE5L	Chemicals in an IPZ or WHPA E where the vulnerability score is 5 where threats are low
75	CIPZWE6M	Chemicals in an IPZ or WHPA E where the vulnerability score is 6 where threats are moderate
76	CIPZWE6L	Chemicals in an IPZ or WHPA E where the vulnerability score is 6 where threats are low

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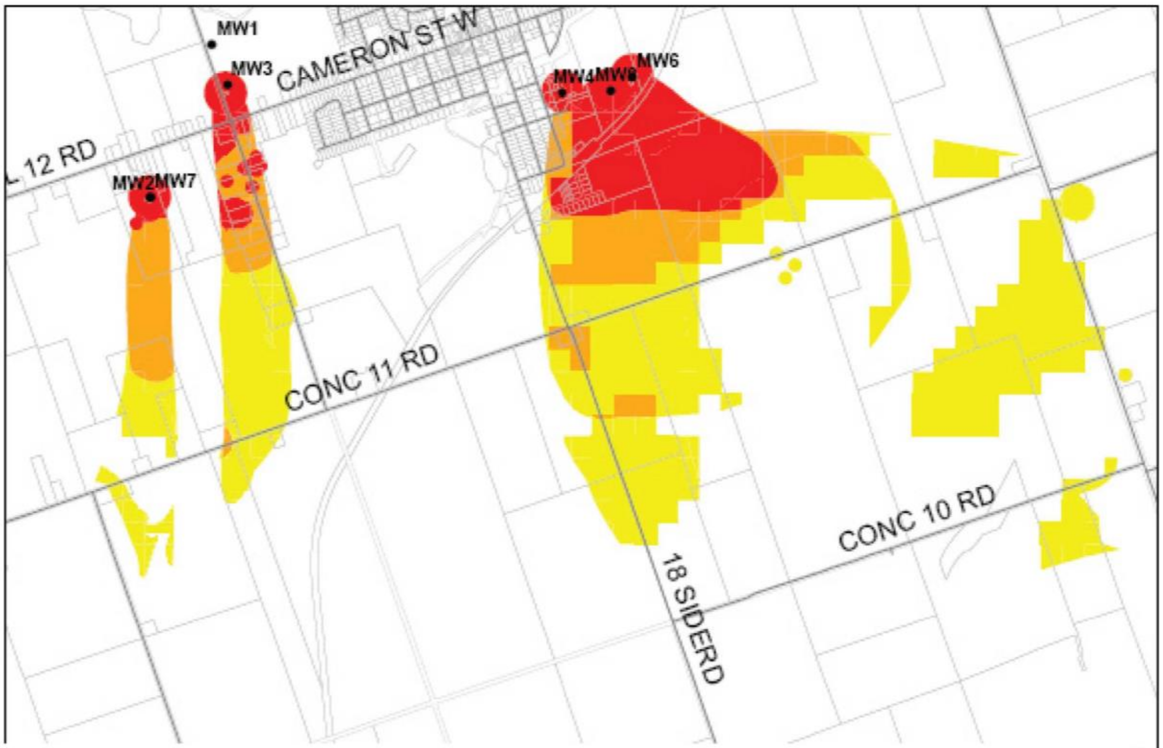
APPENDIX 3

Appendix 3 provides a series of examples illustrating a possible approach to mapping areas where an activity or condition is a significant, moderate, or low drinking water threat in as assessment report.

3.1 CHEMICAL THREAT EXAMPLE

The following example illustrates a possible approach for mapping of chemical threats in a WHPA:



Chemicals			
Vulnerability Score	Provincial Table Number (Table Name)		
	Significant	Moderate	Low
10 (red)	1 (CW10S)	3 (CW10M)	6 (CW10L)
8 (orange)	2 (CW8S)	4 (CW8M)	7 (CW8L)
6 (yellow)	-	5 (CW6M)	8 (CW6L)

The figure and table above illustrates the vulnerability score for each vulnerable area and the areas and Provincial Table of Circumstances with the chemical related activities that are or would be significant, moderate or low drinking water threats. The map would also need references to lists of conditions or new threats/circumstances that apply to these areas.

Extract of Provincial Table 1 (CW10S): Circumstances where the threat associated with a Chemical is or would be a Significant Drinking Water Threat in a WHPA with a vulnerability score of 10.

PROVINCIAL TABLE 1 (CW10S): Chemicals in a WHPA with a vulnerability score of 10 where threats are significant

The application of agricultural source material to land.

Ref #	Circumstances	Chemical
5	1.The agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is less than 40% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen
11	1.The agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is at least 40%, but not more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen
13	1.The agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is than 0.5 nutrient units per acre.	Nitrogen
15	1.The agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is at least 0.5 nutrient units per acre but not more than 1.0 nutrient unit per acre.	Nitrogen
17	1.The agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen

The application of commercial fertilizer to land.

Ref #	Circumstances	Chemical
23	1.The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is less than 40% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen
29	1.The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is at least 40%, but not more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen
31	1.The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is less than 0.5 nutrient units per acre.	Nitrogen
33	1.The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is at least 0.5 nutrient units per acre but not more than 1.0 nutrient unit per acre.	Nitrogen
35	1.The commercial fertilizer is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen

The application of non-agricultural source material to land.

Ref #	Circumstances	Chemical
41	1.The non-agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is less than 40% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen
47	1.The non-agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is at least 40%, but not more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen
49	1.The non-agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is less than 0.5 nutrient units per acre.	Nitrogen
51	1.The non-agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is at least 0.5 nutrient units per acre but not more than 1.0 nutrient unit per acre.	Nitrogen
53	1.The non-agricultural source material is applied to land located in a vulnerable area, where the managed land map shows a managed land percentage for the applicable area that is more than 80% and the livestock density map shows a livestock density for the applicable area that is sufficient to annually apply agricultural source material at a rate that is more than 1.0 nutrient units per acre.	Nitrogen

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3.2 PATHOGEN THREAT EXAMPLE

The following example illustrates a possible approach for mapping pathogen threats in vulnerable areas:

Pathogens			
Vulnerability Score	Provincial Table Number (Table Name)		
	Significant	Moderate	Low
10 (red)	12 (PW10S)	13 (PW10M)	-
8 (orange)	-	14 (PW8M)	15 (PW8L)
6 (yellow)*	-	-	16 (PW6L)

*could be excluded from legend of this example since no area with vulnerability of 6

The figure above illustrates the vulnerability score for each vulnerable area and the areas and the Provincial Table of Circumstances for pathogen related activities that are or would be significant, moderate or low drinking water threats. The map would also need references to lists of conditions or new threats/circumstances that apply to these areas.

Extract of Provincial Table 12 (PW10S): Circumstances where the threat associated with a pathogen is or would be a significant drinking water threat in a WHPA with a vulnerability score of 10.

PROVINCIAL TABLE 12 (PW10S): Pathogens in WHPA A, B with a vulnerability of 10 where threats are significant

Ref #	Prescribed Threat	ThreatSubcategory	Circumstances
1944	The application of agricultural source material to land.	Application Of Agricultural Source Material (ASM) To Land	1. Agricultural source material is applied to land in any quantity. 2. The application may result in the presence of one or more pathogens in groundwater or surface water.
1945	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.	Management Or Handling Of Agricultural Source Material - Agricultural Source Material (ASM) Generation	1. The use of land as livestock grazing or pasturing land for one or more animals. 2. The land use may result in the presence of one or more pathogens in groundwater or surface water.
1946	The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.	Management Or Handling Of Agricultural Source Material - Agricultural Source Material (ASM) Generation	1. The use of land as an outdoor confinement area or a farm-animal yard for one or more animals. 2. The land use may result in the presence of one or more pathogens in groundwater or surface water.
1956	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Septic System	1. The system is an earth pit privy, privy vault, cesspool, or a leaching bed system and its associated treatment unit and is a sewage system as defined in section 1 of O. Reg. 350/06 (Building Code) made under the Building Code Act, 1992 or a sewage works as defined in section 1 of the Ontario Water Resources Act. 2. A discharge from the system may result in the presence of one or more pathogens in groundwater or surface water.
1957	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Septic System Holding Tank	1. The system requires or uses a holding tank for the retention of hauled sewage at the site where it is produced before its collection by a hauled sewage system. 2. A spill from the tank may result in the presence of one or more pathogens in groundwater or surface water.
1958	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Sanitary Sewers and related pipes	1. The system is a wastewater collection facility that collects or transmits sewage containing human waste, but does not include any part of the facility that is a sewage storage tank or works used to carry out a designed bypass. 2. The discharge from the system may result in the presence of one or more pathogens in groundwater or surface water.
1959	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Sewage Treatment Plant Effluent Discharges (Includes Lagoons)	1. The system is a wastewater treatment facility that discharges to surface water through a means other than a designed bypass. 2. A discharge may result in the presence of one or more pathogens in groundwater or surface water.
1960	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Storage Of Sewage (E.G. Treatment Plant Tanks)	1. The system is a sewage treatment tank or sewage storage tank in either a wastewater collection facility or wastewater treatment facility, and any part of the tank is at or above grade. 2. A spill from the tank may result in the presence of one or more pathogens in groundwater or surface water.
1961	The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	Sewage System Or Sewage Works - Storage Of Sewage (E.G. Treatment Plant Tanks)	1. The system is a sewage treatment tank or sewage storage tank in a wastewater collection facility or a wastewater treatment facility and the tank is below grade. 2. A spill from the tank may result in the presence of one or more pathogens in groundwater or surface water.
1962	The storage of agricultural source material.	Storage Of Agricultural Source Material (ASM)	1. Any portion of the agricultural source material is stored at or above grade in or on a permanent nutrient storage facility. 2. A spill of the material or runoff from an area where the material is stored may result in the presence of one or more pathogens in groundwater or surface water.
1963	The storage of agricultural source material.	Storage Of Agricultural Source Material (ASM)	1. The agricultural source material is stored entirely below grade in or on a permanent nutrient storage facility. 2. A spill of the material or runoff from an area where the material is stored may result in the presence of one or more pathogens in groundwater or surface water.
1964	The storage of agricultural source material.	Storage Of Agricultural Source Material (ASM)	1. The agricultural source material is stored at a temporary field nutrient storage site. 2. A spill of the material or runoff from an area where the material is stored may result in the presence of one or more pathogens in groundwater or surface water.

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3.3 DNAPL THREAT EXAMPLE

The following example illustrates a possible approach for mapping DNAPL threats in vulnerable areas.

DNAPLs			
Vulnerability Score	Provincial Table Number (Table Name)		
	Significant	Moderate	Low
WHPA A, B, C, C1 (<5 year TOT) (beige)	9 (DWAS)	-	-
6 (within WHPA D) yellow	-	10 (DW6M)	11 (DW6L)

The figure above illustrates the vulnerability score for each vulnerable area and the areas and Provincial Table of Circumstances with activities where DNAPLs are or would be significant, moderate or low drinking water threats. Note that the vulnerability score is irrelevant within the 5 year TOT and so does not need to be included. The map should also reference lists of conditions or new threats/circumstances that apply to these areas.

Extract of Provincial List DWAS: Circumstances where a threat associated with a DNAPL is or would be a significant drinking water threat in a WHPA A, B, C, and C1 with any vulnerability score.

PROVINCIAL TABLE 9 (DWAS): DNAPLS in WHPA A, B, C, C1, with any vulnerability where threats are significant

The handling and storage of a dense non-aqueous phase liquid. **Threat Subcategory: Handling Of A Dense Non Aqueous Phase Liquid (DNAPL)**

Ref #	Circumstances	Chemical
102	1. The below grade handling of a DNAPL in relation to its storage.	Dioxane-1,4
103		one or more Polycyclic Aromatic Hydrocarbons (PAHs)
104		Tetrachloroethylene (PCE)
105		Trichloroethylene or another DNAPL that could degrade to Trichloroethylene
106		Vinyl chloride or another DNAPL that could degrade to vinyl chloride
107	1. The above grade handling of a DNAPL in relation to its storage.	Dioxane-1,4
108		one or more Polycyclic Aromatic Hydrocarbons (PAHs)
109		Tetrachloroethylene (PCE)
110		Trichloroethylene or another DNAPL that could degrade to Trichloroethylene
111		Vinyl chloride or another DNAPL that could degrade to vinyl chloride

The handling and storage of a dense non-aqueous phase liquid. **Threat Subcategory: Storage Of A Dense Non Aqueous Phase Liquid (DNAPL)**

Ref #	Circumstances	Chemical
1098	1. The storage of a DNAPL at or above grade.	Dioxane-1,4
1099		one or more Polycyclic Aromatic Hydrocarbons (PAHs)
1100		Tetrachloroethylene (PCE)
1101		Trichloroethylene or another DNAPL that could degrade to Trichloroethylene
1102		Vinyl chloride or another DNAPL that could degrade to vinyl chloride
1103	1. The storage of a DNAPL below grade.	Dioxane-1,4
1104		one or more Polycyclic Aromatic Hydrocarbons (PAHs)
1105		Tetrachloroethylene (PCE)
1106		Trichloroethylene or another DNAPL that could degrade to Trichloroethylene
1107		Vinyl chloride or another DNAPL that could degrade to vinyl chloride
1108	1. The storage of a DNAPL if a portion, but not all, of the storage is below grade.	Dioxane-1,4
1109		one or more Polycyclic Aromatic Hydrocarbons (PAHs)
1110		Tetrachloroethylene (PCE)
1111		Trichloroethylene or another DNAPL that could degrade to Trichloroethylene
1112		Vinyl chloride or another DNAPL that could degrade to vinyl chloride

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Delineation of Intake Protection Zone 3

Using the Event Based Approach (EBA)

Date: July 2009

1- Introduction

The Clean Water Act requires the Source Protection Committee to prepare an Assessment Report for each source protection area they represent, in accordance with the regulations, the Director's Technical Rules and the approved terms of reference for that source protection area.

As part of the Assessment Report, committees must identify four types of vulnerable areas within each Source Protection Area. These include wellhead protection areas (WHPAs), intake protection zones (IPZs), highly vulnerable aquifers (HVAs), and significant groundwater recharge areas (SGRAs). Once these areas are delineated, the rules require that vulnerability scores be assigned within these areas.

This technical bulletin provides guidance to Source Protection Committees on the process of identifying and delineating Intake Protection Zone 3 (IPZ-3) using the Event Based Approach (EBA) under the Technical Rules for the Assessment Report – Part VI.5 rules 68 and 69. The event based approach can be used for Type A and B intakes located at Great Lakes and Connecting Channels, and for Type C and D intakes located on Lake Nipissing, Lake Simcoe, Lake St. Clair and the Ottawa River. Requirements for assigning vulnerability scores to the IPZs are set out in Part VIII of the Technical Rules and are not addressed in this bulletin.

The Technical Rules allow the Source Protection Committees to use a number of methods to identify and delineate the IPZ-3 as set out below. This Technical Bulletin

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Cette publication hautement spécialisée n'est disponible qu'en anglais en vertu du règlement 441/97, qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec le ministère de l'Environnement au 416-212-5296, ou sourceprotection@ontario.ca

PIBS 7579e

references that Director's Technical Rules published by the Ministry of the Environment on December 12, 2008.

Part VI.5 of the Technical Rules states,

68. An area known as IPZ-3 shall be delineated for each type A and type B surface water intake and each type C and type D surface water intake located in Lake Nippissing, Lake Simcoe, Lake St. Clair or the Ottawa River, associated with a drinking water system described in rule 58 and shall be composed of the following areas: Subject to rule 69, the area within each surface water body through which, modeling demonstrates, contaminants released during an extreme event may be transported to the intake;

(1) *where the area delineated in accordance with subrule (1) abuts land,*

(a) *a setback of not more than 120 metres inland along the abutted land measured from the high water mark of the surface water body that encompasses the area where overland flow drains into the surface water body; and*

(b) *the area of the Regulation Limit along the abutted land.*

69. The area delineated in accordance with subrule 6868 shall not exceed the area within each surface water body that may contribute water to the intake during or as a result of an extreme event.

The first step in the EBA is to delineate an IPZ-3 that includes areas beyond IPZ-1 and IPZ-2, based on extreme event conditions and an understanding of contaminant transport to the intake. The EBA then allows activities to be identified as a significant drinking water threat if it can be shown through modeling that a release of a specific contaminant from an activity would result in an issue at the intake. The identification of such an activity is governed under rule 130 of the Technical Rules, as follows:

130. An activity listed as a drinking water threat in accordance with rule 118 or 119 is a significant drinking water threat in an IPZ-3 delineated in accordance with rule 68 at the location where the activity is carried on if modeling demonstrates that a release of a chemical parameter or pathogen from the activity would be transported through the surface water intake protection zone to the intake and result in the deterioration of the water for use as a source of drinking water for the intake.

2- IPZ-3 Delineation Options

Figure 1 shows a flowchart with three options to delineate IPZ-3 using the EBA. The SPC may decide which option is appropriate for the drinking water system in question based on the data and information available on the water bodies and any activity(ies) they might be concerned about. The three options are discussed in more detail in sections 2.1 to 2.3.

Two relevant criteria in delineating IPZ-3 (EBA) for all three options are the flood event discharge and time of travel.

The flood event discharge can be estimated by considering an extreme wind storm event or 100 year flood event or snowmelt event during spring times (freshet) or any combination that in the opinion of the SPC represents the 100 year combined probability of an extreme event. The Technical Rules also allow less frequent storm events to be considered.

Time of travel (ToT) is a key issue in determining the IPZ-3 boundary. Based on the understanding of the flood event hydrograph (flood wave duration) and the stream-river system responses to flood events, a time of travel can be estimated with one of the following alternatives:

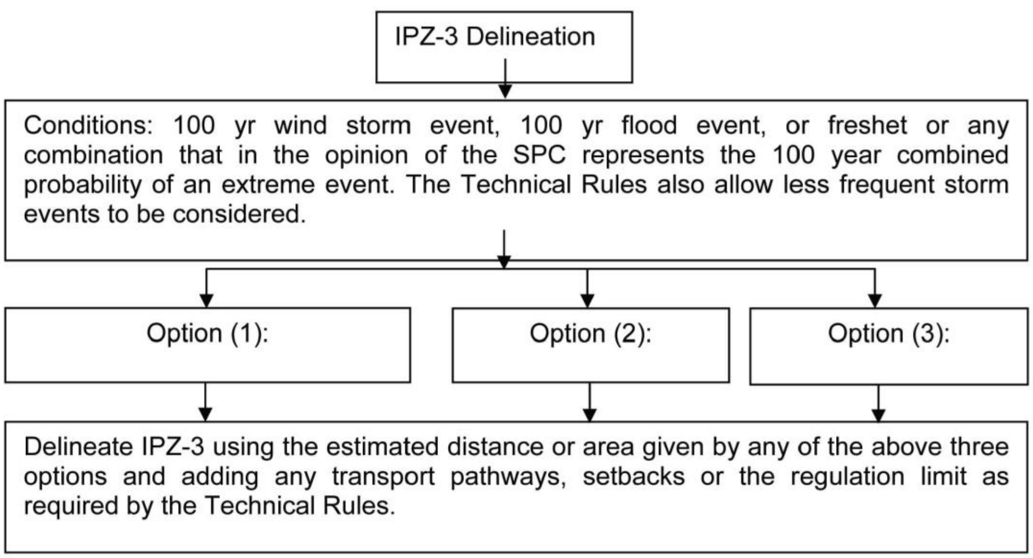

Fig. 1: Flowchart on options used for delineating IPZ-3.

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Using the Event Based Approach (EBA)

Alternative 1: Unit Hydrograph

This method can be applied if the unit hydrographs are known at particular gauging stations. In figure 2, assume there are two gauging stations GS1 and GS2 where the unit flood hydrograph is measured or calculated at those stations. The time difference between the flood peaks, **T**, may represent the time of travel for the distance between the two gauging stations. The time of travel (ToT) from an activity that is being modeled to the intake can be interpolated or extrapolated depending on its distance to either of the gauging stations. For example, assume an activity is located at a certain distance between GS1 and GS2; the time of travel for that activity can be obtained by interpolating the time of travel between the two stations and the distance between the activity and the two stations.

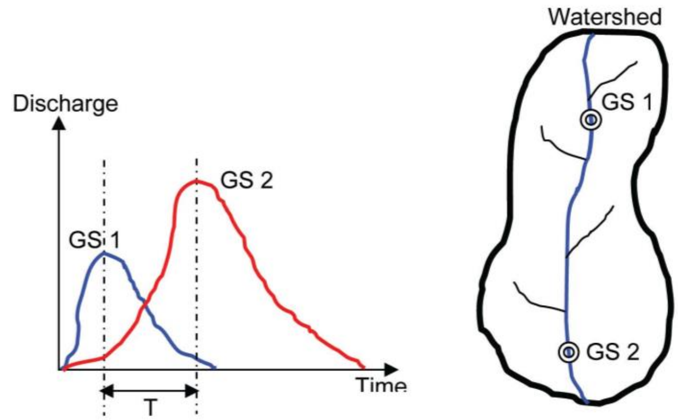

Fig.2: Illustration of unit hydrographs related to time of travel (ToT).

The same concept can be applied if an activity is located outside the distance between GS1 and GS2 but in this case the ToT is obtained by extrapolation. The unit hydrograph method assumes that the flow is uniform and under steady state conditions along the entire stream/river reach, which is not always the case. The estimated time of travel depends on the accuracy of the data and an understanding of the input, output and storage volumes of water within that stream / river system.

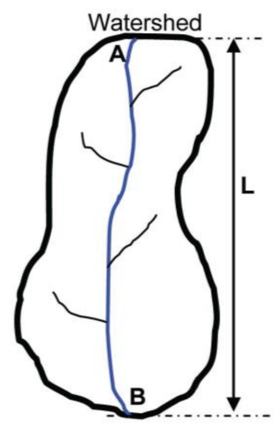

Fig.3: Illustration of a watershed with the longest hydraulic path.

Alternative 2: Time of Concentration

If the unit hydrographs mentioned in method (1) are not available, the time of concentration equation based the Soil Conservation Service (SCS) lag formula can be used, equation 1. The time of concentration, $\mathbf{t_c}$, is defined as the amount of time for the entire watershed to contribute to the outflow or the amount of time for the water to reach the outlet from the furthest point from the outlet. The $\mathbf{t_c}$ formula is a function of the watershed length, **L**, the watershed slope, **Sw**, and the curve number, **CN**. The length **L** can be estimated from the data set related to the watershed and it is the longest hydraulic path in the watershed. The slop, **Sw**, is the average slope of the watershed which equals to elevation difference between point **A** and point **B** over the watershed length, **L**, see figure 3.

$$\mathbf{t_c = 0.00526L^{0.8}\left(\frac{1000}{CN} - 9\right)^{0.7} S_w^{-0.5}} \quad \text{Eq.1}$$

Where $\mathbf{t_c}$ is the time of concentration (min), which is equivalent to the time of travel, **L** is the watershed length (ft), **Sw** is the average watershed slope (ft/ft) and **CN** is the curve number (-).

The curve number, **CN**, is the parameter that represents the potential maximum retention of rainfall. The Curve Number depends on the soil type (Group A, B, C, or D), land use and moisture conditions. Examples of suggested Curve Numbers for use with SCS hydrology is given in Table 1. However, users can calculate an appropriate value for **CN** based on the watershed characterisation. For additional information, see Urban Hydrology for Small Watersheds, Technical Release 55, United States Department of Agriculture, June 1986 and McCuen, 1998.

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Table 1: Curve Numbers for different types of Hydrologic Soil Group (McCuen, 1998).

Land Use Description	Average % impervious[b]	Hydrologic Soil Group A	B	C	D
Fully developed urban areas[a] (vegetation established)					
Lawns, open spaces, parks, golf courses, cemeteries, etc.					
Good condition; grass cover on 75% or more of the area		39	61	74	80
Fair condition; grass cover on 50% to 75% of the area		49	69	79	84
Poor condition; grass cover on 50% or less of the area		68	79	86	89
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads					
Paved with curbs and storm sewers		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
Commercial and business areas	85	89	92	94	95
Industrial districts	72	81	88	91	93
Row houses, town houses, and residential with lots sizes 1/8 acre or less	65	77	85	90	92
Residential: average lot size					
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acre	12	46	65	77	82
Developing urban areas[c] (no vegetation established)					
Newly graded area		77	86	91	94
Western desert urban areas					
Natural desert landscaping (pervious area only)[f]		63	77	85	88
Artificial desert landscaping		96	96	96	96

Land Use Description	Treatment or Practice[d]	Hydrologic Condition	Curve Numbers for Hydrologic Soil Group A	B	C	D
Cultivated agricultural land						
Fallow	Straight row or bare soil		77	86	91	94
	Conservation tillage	Poor	76	85	90	93
	Conservation tillage	Good	74	83	88	90
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Conservation tillage	Poor	71	80	87	90
	Conservation tillage	Good	64	75	82	85
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and conservation tillage	Poor	69	78	83	87
		Good	64	74	81	85

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The time of concentration formula is an empirical formula that is based on a number of assumptions and therefore, will, in most cases, produce a smaller IPZ-3 than if more advanced modelling was available. However, this method is a good starting method to estimate the time of travel within the watershed in the absence of an advanced numerical model. The formula is intended for use on watersheds where overland flow dominates and was developed for non-urban watersheds of 4000 acres or less. This does not mean it can not be used to determine a time of travel in a more urban watershed, but does mean that the numbers may be lower than expected in these types of watershed. Time of travel calculated using this formula is based on the following assumptions: average slope of the watershed, one type of land use and soil and an approximated watershed length.

If neither the alternative (1) nor the alternative (2) can be used, the time of travel (ToT) for a watershed can be the same time of travel of another watershed if both watersheds have similar characterisations.

2.1 Option 1: Contaminant Transport Approach:

If the SPC is concerned about specific activities that are being carried out upstream of the surface water intake, this approach can be used to determine the transport of contaminant(s) to the intake. If the contaminant reaches the intake, the IPZ-3 boundary can be delineated including the area of that activity. With this approach, the SPC would need to determine a concentration threshold to decide whether a contaminant released at the location of the activity in question has reached the intake or not. If not, i.e. the SPC decides the concentration of the contaminant is too low for it to be considered reaching the intake, then the location of that activity may not be included in the delineation of an IPZ-3. An understanding of contaminant transport from a number of activities can then be used to determine the extent of the IPZ-3.

As a second step, if the contaminant reaches the intake and results in the deterioration of the water quality (as per Rule 130), then this activity would be identified as a significant drinking water threat. The IPZ-3 delineation will include the contributing area of the activity(ies) that cause(s) an issue at the surface water intake.

Methods that can be used to delineate IPZ-3:

a- Numerical models (1D, 2D or 3D)

b- Analytical approach (explained below in section 3.4). This approach does not need a time of travel to be determined.

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Required inputs to apply option (1): flood discharge, estimated time of travel, and mass of the contaminant, either continuous or instant. The estimated TOT may be used as the simulation time if a numerical model is used.

2.2 Option 2: Boundary Approach:

This option can be used if in the opinion of the SPC there are no activities of concern upstream of the intake. This approach determines the boundary of IPZ-3 within the water body without analysing specific activity(ies). This approach requires that a time of travel (ToT) is determined as mentioned above. The assumption would be that whatever is released within the chosen ToT would reach the intake (under specific storm event conditions).

Methods that can be used to delineate IPZ-3:

a- Particle Tracking

b- Numerical Model (1D)

c- Manning equation

Required inputs to apply the option (2): flood discharge and estimated time of travel, which may be used as the simulation time if a numerical model is used.

2.3 Option 3: Combined Approach:

This approach is a combination of option (1) and (2). As a first step, option (2) is used to delineate the IPZ-3. As a second step, if the SPC is concerned about specific activities that are located inside or outside the IPZ-3, option (1) would then be used to determine whether the IPZ-3 needs to be expanded or reduced, by determining whether the contaminant from a specific activity reaches the intake or not. As in option 1, the SPC would need to determine a concentration threshold to decide whether a contaminant has reached the intake or not. If yes, modify the delineated IPZ-3 to include (or exclude) the contributing area of that activity. As a third step, the SPC can then determine whether the activity causes an issue or not (as per Rule 130).

Methods that can be used to delineate IPZ-3 in option (3) are a combination of methods mentioned in option (1) and option (2).

3- Supporting Methods

There are several physical processes controlling the transport of contaminants in river systems: mixing; molecular diffusion; turbulent diffusion; dispersion; advection;

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dilution (decay function); and sorption. The mixing process is affected by the spatial variation of velocity on the macroscopic scale according to the Fick's law 1855.

If an activity discharges into a stream, the initial mixing of a contaminant is determined by the momentum and buoyancy forces of the discharge. As the contaminant is diluted, those forces disappear and the transport of the contaminant is dominated by ambient water velocity variation in the stream. Then, the contaminant plume is spread along the stream by dispersion and advection. Typical flow velocities of rivers range from 0.1 m/s to 1.5 m/s corresponding to channel slopes of 0.02% to 1% (Chin, 2006).

Numerical models are one of the tools that can be used to delineate the IPZ-3. Simple analytical approaches or particle tracking are other options to estimate the concentration of contaminants in the water bodies. Particle tracking is one of the more recently developed tools that provide information on the distance from an intake that particles can be transported through by knowing the flow velocities and concentration of the particles. This document presents an overview of the numerical models but focuses more on an analytical approach that can help users to calculate the distance contaminants are transported in a water system.

3.1 Numerical Codes

Several numerical codes are now available to simulate water quality in rivers and streams. Most codes typically provide numerical solutions to the advection-dispersion equation or some other forms of the law of mass conservation. The numerical solutions are produced at discrete locations and times for complex boundary conditions, and spatially and temporally disturbed contaminant transport. The numerical codes used in practical engineering are mostly 1D and 2D. 3D numerical codes are sometimes used but generally more costly. Numerical codes are commonly used to facilitate the analysis of fate and transport process of contaminants in river systems and include QUAL2E, HSPS, WASP6, SED2D, MIKE family, DELFT family, TELEMAC system, and HEC-6. It is up to the user to select the appropriate numerical model to simulate the contaminant transport based on the capabilities and limitations of each model and the local condition.

3.2 Particle Tracking Method

Particle tracking is a technique that is linked to hydrodynamic numerical models. The particle tracking method describes the effects of molecular and turbulent diffusion on the dispersion of constituents with time and can determine path lines in spatially variable parameter domains. When calculations are computed in reverse time, it is called Reverse Particle Tracking (RPT) and when computed in forward time it is call Forward Particle Tracking (FRT). The particle tracking method identifies an area from points of withdrawal that are likely to contribute flow to the intake within a specific time period. To use the particle tracking method, the location of an intake should be determined in both x and y directions if two-dimensional approach is used and in x, y and z directions if a three-dimensional approach is used. The number of hypothetical particles for tracking analyses should be specified as well as the time of travel (ToT) to determine the distance of the traveling particles. The diffusion rate of particles is controlled by flow velocities and longitudinal and transverse diffusions. This method determines the distance traveled in the water body, and as a second step the transport pathways, setbacks or regulation limit need to be added to delineate the IPZ-3.

3.3 Manning Equation

The Manning Equation is the most commonly used equation to analyze open channel flows. It is a semi-empirical equation for simulating water flows in channels and culverts where the water is open to the atmosphere, i.e. not flowing under pressure. The distance from the intake can be determined as follows:

$$D = V.T \qquad , V = \frac{1}{n} R^{2/3} S^{1/2} \ \textbf{(Part a)} \quad \textbf{or} \quad V = \frac{Q}{A} \ \textbf{(Part b)} \quad \text{Eq. 2}$$

Where **D** is the distance from an intake in the water body (m), **T** is the estimated time of travel as explained (s), **n** is the Manning coefficient (friction coefficient), which varies from 0.001 to 0.03 based on type of stream bed material and flow, **R** is the hydraulic radius (m) which in most cases is equivalent to the water depth of river, and **S** is the energy slope which is equivalent to the stream slope.

If the inflow discharge of a flood event is known, then the flow velocity can be determined through equation 2, part b. If the water depth at the flood event is known but not the discharge, then equation 1, part a can be used to calculate the flow velocity. Then the distance, **D**, from the surface water intake can be determined. This approach determines the distance traveled in the water body, and as a second step the transport pathways, setbacks or regulation limit need to be added to delineate the IPZ-3.

3.4 Analytical Approach

The analytical approach provides a mechanism that can be used if the contaminant mass and type entering a water body are known. The analytical approach can be used for point source discharges such as industrial or municipal discharges, stormwater discharges, or spills, and considers the physical properties of the contaminants only. Spills in rivers or streams can be a result of major collisions on transportation routes or failures at large storage sites. Spills can be thought of as large masses of contaminants that are released in a very short period of time.

Non-point sources of contaminants, such as runoff from rural or agricultural areas and urban runoff are not considered in this approach. The main goal is to determine the concentration of a contaminant at the surface water intake according to option (1). There are two concepts that can be used to calculate the concentration of a contaminant: 1) without dispersion and 2) with dispersion.

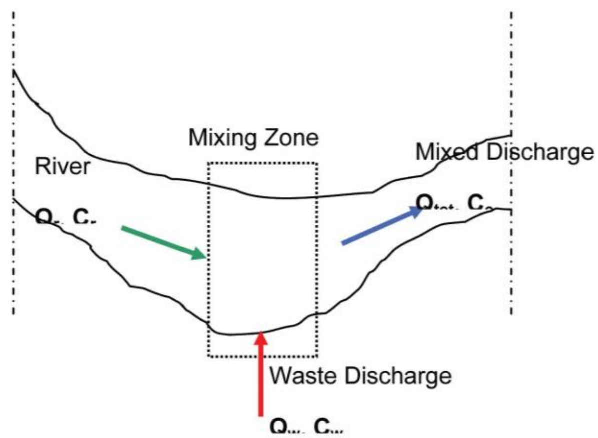
3.4.1 No dispersion

If full mixing, decay and no dispersion are considered, equation 4 calculates the concentration at a certain distance. To do that, first determine the mean concentration of a contaminant after mixing; see figure 4, with the water body of the stream through equation 3:

$$\mathbf{Q_r C_r + Q_w C_w = Q_{tot} C_o \Rightarrow C_o = \frac{Q_r C_r + Q_w C_w}{Q_r + Q_w}} \quad \text{Eq.3}$$

Fig.4:

Initial mixing of waste discharge with stream discharge.



For simplicity, it can be assumed that the discharge of a contaminant is well mixed across the cross section.

$$\mathbf{C(x,t) = C_o e^{-\lambda \frac{XA}{Q}}} \quad \text{Eq.4}$$

Where **C** is the concentration of the contaminant at the surface water intake (kg/m^3), **X** is the distance between the point discharge from an activity projected on the stream flow and the surface water intake along the stream line (m), ⚜ is the decay (s^{-1}), **A** is the wet cross sectional area of the stream (m^2) and **Q** is the discharge that has been determined to represent the extreme event (m^3/s).

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The coefficient, ⚜, can be expressed in terms of the *half-life*, **T_{50}**, which is the time required for 50% of the initial mass to decay as follows, equation 5:

$$T_{50} = \frac{\ln 2}{\lambda} \quad \text{Eq.5}$$

The half-life time depends on the type of chemical or contaminant released. An example of the half-life time of several organic compounds in soils has been compiled by Howard *et al.*, 1991, see Table 2. Users will need to determine the correct value for the contaminant(s) in question.

Table 2: First order decay rates of selected organic compounds in Soil.

Compound	Half-Life, T_{50} (days)	First-Order Decay Rate, λ (day^{-1})
Acetone	2–14	0.050–0.35
Benzene	10–730	0.00095–0.069
Bis(2-ethylhexyl)phthalate	10–389	0.00178–0.069
Carbon tetrachloride	7–365	0.0019–0.099
Chloroethane	14–56	0.0124–0.0495
Chloroform	56–1800	0.000385–0.0124
1,1-Dichloroethane	64–154	0.00450–0.0108
1,2-Dichloroethane	100–365	0.00190–0.00693
Ethylbenzene	6–228	0.00304–0.116
Methyl *tert*-butyl ether	56–365	0.00190–0.0124
Methylene chloride	14–56	0.0124–0.0495
Naphthalene	1–258	0.00269–0.693
Phenol	0.5–7	0.099–1.39
Toluene	7–28	0.0248–0.099
1,1,1-Trichloroethane	140–546	0.00127–0.00495
Trichloroethene	321–1650	0.000420–0.00216
Vinyl chloride	56–2880	0.000241–0.0124
Xylenes	14–365	0.00190–0.0495

Source: Howard et al. (1991).

3.4.2 With dispersion

If full mixing, decay, longitudinal dispersion, mass of contaminant released are considered, the following can be applied:

The governing equation for longitudinal dispersion that is well mixed over the cross sections of rivers and streams is given in equation 6. This equation considers dispersion and first order decay and assumes that a mass of contaminant, **M**, is instantaneously mixed over the cross section of the stream at time **t=0**.

$$\mathbf{C(x,t)} = \frac{\mathbf{M}e^{-\lambda t}}{\mathbf{A}\sqrt{4\pi \mathbf{K_L t}}}\,\mathbf{exp}\left[-\frac{(\mathbf{x}-\mathbf{Vt})^2}{\mathbf{4K_L t}}\right] \quad \text{Eq.6}$$

Where **C** is the concentration of contaminant (kg/m^3) at a point, **M** is the mass of contaminant released from the facility (kg), **V** is the average flow velocity (m/s), $\mathbf{K_L}$ is the longitudinal dispersion (m^2/s), ⚜ is the coefficient that includes dilution (decay); dissolved oxygen concentration; water temperature etc. (s^{-1}), and **A** is the cross-sectional area of the stream (m^2). If the contaminant is assumed to be conservative, then the decay coefficient is equal to zero. The exponential term in equation 6 is equal to 1 if the flow is uniform and steady. This term appears only when the water body is stagnant, i.e., **V=0**.

In equation 6: the flow velocity can be calculated from the determined flow discharge that represents the extreme event discharge, **Q**, and average cross-sectional area of the stream, **A**. The time, **t**, can be calculated by knowing the average flow velocity, **V**, in the stream and the distance between the surface water intake and the projected location of the activity on the stream. The mass of contaminant should be specified based on available data of the activity.

One of the first approaches to estimate the dispersion coefficient in river systems, $\mathbf{K_L}$, is mentioned in Elder 1959 which states that $\mathbf{K_L = 5.93u_{*}\bar{d}}$ where $\bar{\mathbf{d}}$ is the mean depth of stream (m) and $\mathbf{u_*}$ is the shear velocity of flow (m/s). However, several new approaches have been developed to estimate the $\mathbf{K_L}$, and a summary of them is given in Table 3. To apply the equations shown in Table 3, the stream width must be larger than the mean water depth (**w** >> **d**) where longitudinal dispersion is dominated by transverse variations in the mean velocity and the dispersion caused by vertical variations in mean velocity is relatively small. Typical values of $\mathbf{K_L}$ are 0.05m^2/s to 0.3m^2/s for small streams (Genereux, 1991) and as high as 1000m^2/s for larger rivers (Wanner et al., 1989).

Table 3: Estimates of the Longitudinal Dispersion Coefficient in Rivers, Chin 2006.

Formula	Reference
$\frac{K_L}{\bar{d} u_*} = 0.011\left(\frac{w}{d}\right)^2\left(\frac{V}{u_*}\right)^2$	Fischer et al. (1979)
$\frac{K_L}{\bar{d} u_*} = 0.18\left(\frac{w}{\bar{d}}\right)^2\left(\frac{V}{u_*}\right)^{0.5}$	Liu (1977)
$\frac{K_L}{\bar{d} u_*} = 0.6\left(\frac{w}{\bar{d}}\right)^2$	Koussis and Rodríguez-Mirasol (1998)
$\frac{K_L}{\bar{d} u_*} = 2.0\left(\frac{w}{\bar{d}}\right)^{1.5}$	Iwasa and Aya (1991)
$\frac{K_L}{\bar{d} u_*} = 5.915\left(\frac{w}{\bar{d}}\right)^{0.620}\left(\frac{V}{u_*}\right)^{1.428}$	Seo and Cheong (1998)
$\frac{K_L}{\bar{d} u_*} = 0.01875\left[0.145 + \frac{1}{3520}\frac{V}{u_*}\left(\frac{w}{\bar{d}}\right)^{1.38}\right]^{-1}\left(\frac{w}{\bar{d}}\right)^{5/3}\left(\frac{V}{u_*}\right)^2$	Deng et al. (2001)

The shear flow velocity, $\mathbf{u_*}$, in Table 3 can be determined from equation 7,

$$\mathbf{u_*} = \sqrt{\tau_o/\rho}\,;\ \tau_o = \rho \mathbf{gRS};\ \mathbf{R = A/P} \quad \text{Eq.7}$$

Where ✾✽ is the mean shear stress on the wetted perimeter (N/m²), ✾ is the water density (kg/m³), **g** is the gravity (m/s²), **R** is the hydraulic radius (m), **P** is the wetted perimeter (m), **A** is the cross section (m²) and **S** is the energy slope (-). To apply this equation the average water depth in the stream should be known. For simplicity, the energy slope can be assumed to be equal to the stream slope. The wetted perimeter, **P**, is the sum of all wet lengths along the cross section, see figure 5:

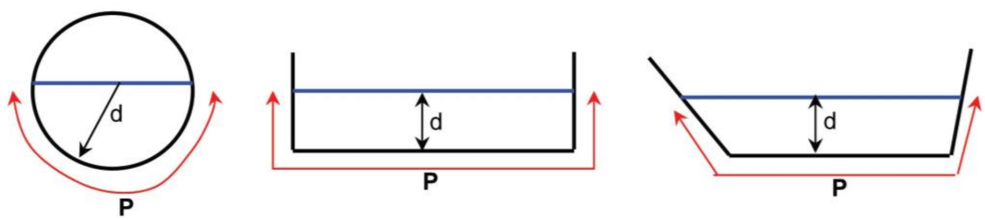

Fig. 5: Illustration of wetted perimeter over different cross sections of streams.

If the cross section of a river or stream changes significantly along the distance, the above approach can be used with some adjustment for each cross-section change as follows: Assume there is a longitudinal section of a river as shown in figure 6, the section consists of four reaches and each reach has a different width and small changes

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in water depth. Each reach has two cross sections 1 and 2 that represent the beginning and end of each reach.

The goal is to calculate the contaminant concentration at section 2 of reach 4, i.e. $C_{2\text{-}4}$. Continuity is valid which means that the amount of flow through each reach is the same, i.e. no losses in the total volume of water passing. To calculate the contaminant concentration $C_{2\text{-}4}$, follow the steps below.

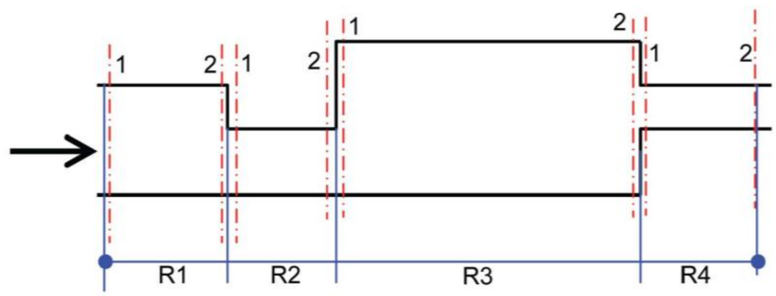
1- Calculate $V_{1\text{-}1}$, $A_{1\text{-}1}$, $C_{1\text{-}1}$, M is known;

2- Calculate $C_{1\text{-}2}$;

3- Use $C_{1\text{-}2} = C_{2\text{-}1}$, then calculate $M_{2\text{-}2}$ and $C_{2\text{-}2}$;

4- Use $C_{2\text{-}2} = C_{3\text{-}1}$; then calculate $C_{3\text{-}2}$ and etc.

Fig. 6: Illustration of varied longitudinal section of river.



River or stream calculations can be done either manually by assuming one or two reaches for the entire stream length or by using a spreadsheet calculation (as shown below) or any other tool that users find appropriate.

4- Examples

This section provides two examples that illustrate the method and analytical solution shown above.

Example 1:

Let us assume a wastewater treatment plant discharges its effluent into a small stream with a water depth of 0.8m and a width of 6.0m and a flow velocity of 0.2m/s, figure 7. The wastewater treatment plant discharges $0.04m^3/s$ of chemical A with a concentration of 18mg/l into the stream. The concentration of chemical A in the stream upstream of the wastewater treatment plant is 0.22mg/l. Assume no dispersion and full instantaneous mixing with a dilution coefficient of $1.2d^{-1}$. What is the concentration of chemical A 3km downstream of the wastewater treatment plant? At what distance downstream from the wastewater treatment plant will the concentration of chemical A in the stream be 0.22mg/l?

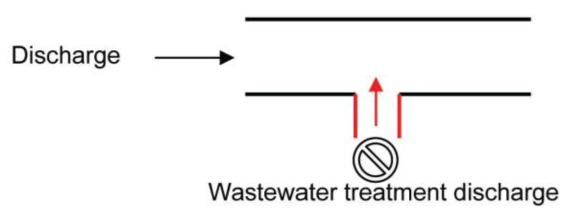


Fig. 7: Illustration of example 1.

Solution:

Q stream = 0.8*6.0*0.2 = $0.96m^3/s$

Velocity after the WWT= (0.96+0.04)/(0.8*6) = 0.21m/s

C downstream of the WWT, Eq. 3 = (0.96*0.22 + 0.04*18)/ (0.96+0.04) = 0.9312mg/l

C at 3000 m, Eq.5 = 0.9312 *$e^{(-[1.2*3000/(3600*24*0.21)]}$ = 0.7636mg/l

X at C=0.22 mg/l, Eq.5 => 0.22=0.9312* $e^{(-[1.2*t/(3600*24)]}$ → t = 149874.3s, V=0.21m/s

Then X= 21,706m from the discharge position.

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Example 2:

Let us assume an intake as shown in figure 8. In this figure, the distance of the boundaries of IPZ-1, 2, and 3 from the intake is $\mathbf{D_1}$, $\mathbf{D_2}$, and $\mathbf{D_3}$, respectively and the flow direction is from left to right.

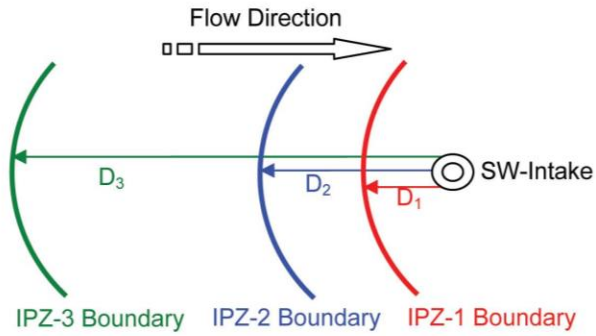

Fig. 8: Illustration of intake protection zone distances, example 2.

Assume a spill of a specific contaminant of 10,000kg occurred at a point upstream from the intake. The river has a width **w** = 75m and an average water depth **d** = 1.5m, a discharge of **Q** = 90m^3/s and an energy slope of 0.0004. Assume the first order decay rate of this contaminant is 5.E-5s^{-1}. Calculate the concentration of the contaminant at a distance 40km from the spill location with decay and without decay.

Solution:

A spreadsheet is used to calculate the maximum concentration at a distance of 40km from the intake. Figure 9 shows the distance **X** that represents $\mathbf{D_3}$ for the delineation of **IPZ-3**. Based on the type of contaminant of concern, the parameters shown in figure 9 may change. The spreadsheet can now be used to calculate the maximum concentration that reaches the intake. The user will need to determine the concentration at the intake that could be used as a threshold to decide whether the contaminant has reached the intake or not.

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GIVEN

Mass M(kg)	10000
River width w (m)	75
River depth d (m)	1.5
Discharge Q(m^3/s)	90
Energy Slope S (-)	0.0004
Decay coefficient l (s^{-1})	5.00E-05

REQUIRED

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Distance X(m)	100	1000	5000	10000	15000	20000	25000	30000	35000	40000

CALCULATED

Hydraulic Piermeter P (m)	78									
Hydraulic Radius (m)	1.44230769									
Shear velocity u_* (m/s)	0.07523042									
Velocity V(m/s)	0.8									
Long. Dispersion K_L (m^2/s)	169.268434									
Max. Con. w/o decay (kg/m^3)	0.17242874	0.0545268	0.024385107	0.01724	0.01408	0.01219	0.01091	0.00996	0.00922	0.00862
Max. Con. with decay (kg/m^3)	0.17135442	0.0512231	0.017840525	0.00923	0.00551	0.00349	0.00229	0.00153	0.00103	0.00071

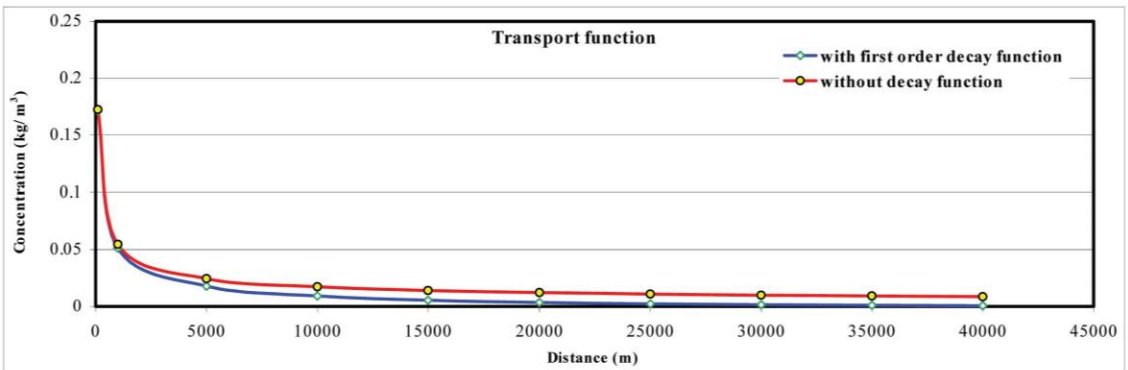

Fig. 9: Illustration to calculate the maximum concentration as a function of distance.

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DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Addressing Transportation Threats

Date: April 2009

Background

- The Clean Water Act requires that source protection committees list activities that are or would be drinking water threats. Through regulations and technical rules, the province has set out which activities must be considered drinking water threats under specific circumstances. Specifically, Section 1.1 of Ontario Regulation 287/07 (General) lists activities that are prescribed as drinking water threats and the Table of Drinking Water Threats in the Technical Rules specify under what circumstances these activities are considered threats.
- The regulations and technical rules provide a mechanism through which source protection committees can add drinking water threats or add additional circumstances to activities the province has already listed as a threat.
- The list of activities that are prescribed as drinking water threats was established using input from multiple stakeholder groups and committees. The method of determining when an activity is a threat, and more specifically a significant, moderate, or low drinking water threat, is based on a semi-quantitative risk assessment that considers both the nature of the activity itself (the hazard rating) and the vulnerability of the area in which the activity is located. This is used to determine a risk score. The methodology was widely consulted on in advance of the posting of the regulations and technical rules around the assessment report.
- During the consultation on the regulations and technical rules for the assessment report, questions were raised around the inclusion of transportation corridors as drinking water threats. Corridors were not included in the list of prescribed activities in the current regulations and technical rules as the inclusion of corridors did not fit within the semi-quantitative risk assessment process, and therefore, had not been consulted on. In addition, the current rules around the addition of threats and circumstances do not provide a method for the inclusion of transportation corridors.

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- Although transportation corridors have not been included as a prescribed threat and cannot be added, there are a number of ways that specific activities taking place within a transportation corridor could be identified as a threat at the discretion of the Director under the Clean Water Act.

Including Transportation Threats in the Assessment Report

- Not being listed as a prescribed threat does not preclude the source protection committees (SPCs) from determining that, on a local level, transportation of *specific* substances along certain routes does pose a threat to local source waters and SPCs have the flexibility to include them in the assessment report.

- Transportation threats can be considered by adding a new drinking water threat as per Rule 119 of the Technical Rules. An SPC can include a threat that is not prescribed in O. Reg. 287/07 if:

  (1) the activity has been identified by the SPC as an activity that may be a drinking water threat;
  (2) in the opinion of the Director,
  (a) the chemical hazard rating of the activity is greater than 4, or
  (b) the pathogen hazard rating of the activity is greater than 4; and
  (3) the risk score for an area within the vulnerable area in respect of the activity calculated in accordance with rule 122 is greater than 40.

- Rules 120 and 121 set out how the hazard rating is determined:

  120. The chemical hazard rating of an activity that is not prescribed to be a drinking water threat under O. Reg. 287/07 (General) shall be a rating that in the opinion of the Director reflects the hazard presented by the chemical parameter associated with the activity, if any, considering the following factors:

  (1) Toxicity of the parameter.
  (2) Environmental fate of the parameter.
  (3) Quantity of the parameter.
  (4) Method of release of the parameter to the natural environment.
  (5) Type of vulnerable area in which the activity is or would be located.

  121. The pathogen hazard rating of an activity that is not prescribed to be a drinking water threat under O. Reg. 287/07 (General) shall be a rating that in the opinion of the Director reflects the hazard presented by pathogens associated with the activity, if any, considering the following factors:

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(1) The frequency of the presence of pathogens that may be associated with the activity.
(2) Method of release of the pathogen to the natural environment.
(3) Type of vulnerable area in which the activity is or would be located.

- Before adding a transportation threat to the assessment report, Director approval of the hazard rating and the risk score must be obtained.

- Once a new threat is added, then the SPC must follow the same process around identifying where the threat is significant, moderate or low and how many significant drinking water threats are in each vulnerable area.

Source Protection Plans and Transportation Threats

NOTE: *Because no source protection plan regulation is in place, the following policy options cannot yet be confirmed and are subject to change. They are provided merely for the purpose of considering the implications of adding transportation threats to the assessment report.*

- When making the decision regarding whether to add transportation-related threats to the assessment reports, there are a number of things SPCs should consider relating to the source protection plan.

- If a transportation threat is identified as a significant threat in the assessment report, the *Clean Water Act, 2006* requires the source protection plan to contain a policy that satisfies the objectives of ensuring this threat ceases to be and never becomes significant (policies that result in “managed threats” may satisfy these objectives). There are several options for addressing significant transportation threats in source protection plans.

  1. Reducing the likelihood that a spill will occur.

     - There are various policy approaches which an SPC could use when formulating a policy to reduce the likelihood that a spill will occur in a vulnerable area:

       - Policies relating to education and outreach could be developed, including those that require the installation of signs making transporters aware that they are travelling through a vulnerable drinking water source protection area, and thus motivating them to voluntarily undertake appropriate precautions.

       - Policies could be developed that reduce the speed of the vehicles or restrict the route used to transport certain substances on some roads (where municipalities have the jurisdiction to make such policies). However, it should be noted

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that SPCs do not have the authority to make policies to change transportation routes on provincial or federal transportation corridors, nor do they have the power to change where existing corridors are located.

2. Reducing the impact of a spill, should it occur.

   - There are also several policy approaches which an SPC could use when developing a policy to address the impact of spills:

     - Policies relating to structural and operational risk management measures, including the construction of berms or setbacks, which could reduce the speed at which spilled contaminants would reach the drinking water source.

     - Plan policies could direct that municipal emergency response plans be reviewed to ensure that the response plans consider drinking water systems and their associated vulnerable areas and have effective measures to address a spill of the substances identified as a transportation threat in the assessment report when it is being transported through vulnerable areas.

   - It should be noted that any policy in a plan to address a significant drinking water threat may have to provide supporting rationale or otherwise demonstrate the extent to which it effectively manages or reduces the risk of the threat so that it ceases to be or become significant.

Addressing Transportation Threats Outside of the *Clean Water Act, 2006*

- The Rules around the inclusion of additional drinking water threats are enabling and do not require that SPCs add any threats. SPCs, at their own discretion, may request that the Director approve the hazard rating and inclusion of local threats that are not already prescribed in regulation under the Clean Water Act.

- An SPC may decide not to include transportation threats in the Assessment Report and instead choose to advise municipalities of their concerns with respect to transportation threats and may also choose to work with municipalities to ensure effective management of these threats.

- In the event that SPCs do not add transportation threats to a source protection plan, municipalities have the power to implement most actions listed in the previous section through official plans and by-laws, education and outreach, and emergency planning.

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- It should be noted that an SPC cannot include policies for addressing transportation threats in a source protection plan if the assessment report does not list any related transportation activities as threats.

Important Considerations

- SPCs should consider the nature of transportation threats in their Source Protection Areas. It may only be necessary to include one transportation threat in the assessment report (e.g., one about which much information is known) if plan policies to address this threat (which are often broad reaching) could also address all incidences of transportation threats in the area. For example, reduction in speeds or rerouting truck traffic could apply to all transportation.

- The assessment report may identify that transportation threats are a moderate or low threat and then the SPC could exercise their discretionary authority under the Act to establish policies in the plan. However, policy options for addressing these moderate or low transportation threats may be limited and public bodies need only "have regard to" (i.e., consider, as opposed to "conform with") moderate and low threat policies.

- The Emergency Management and Civil Protection Act requires municipalities to complete a HIRAI (hazard identification and risk assessment) and to identify critical infrastructure. It also requires municipalities to have emergency response plans but does not specify that drinking water systems and associated vulnerable areas be included.

- If additional systems are elevated into the source protection planning process, these systems and their associated vulnerable areas may not have been identified in municipal emergency response plans. SPCs should consider this when thinking about recommendations for emergency response plans.

Summary

- Transportation corridors are not included in the list of prescribed threats.

- SPCs could seek approval of the Director to have site-specific transportation threats related to the transport of specific substances included as a local drinking water threat in the assessment report through the process set out in the rules to include additional threats.

- Including transportation threats as significant threats in the assessment report has important ramifications for the source protection plan – all significant threats must cease to be or never become significant.

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- Policy options for addressing significant transportation threats could address the likelihood of a spill or the impact of a spill once it occurs.
- SPCs may decide to make municipalities aware of transportation threats outside of the *Clean Water Act, 2006* and help them address these threats through existing tools. This may simplify the analysis and achieve similar outcomes, potentially in a timelier manner.

Future Steps

- The province is proposing to consult on the inclusion of transportation corridors as threats as the first round of assessment reports is being developed with an eye to proposing options for the inclusion of corridors for future rounds of planning.

Example:
Adding the threat of "transportation of fuel" to address transportation of fuel through an IPZ.

Step A. Determine threat and circumstances to be added.

Threat: Transportation of fuel.

Circumstances:
1. The fuel is transported in a quantity that is more than 10,000 litres (Large trucks transporting fuels typically have capacities ranging from 28,400 litres to 37,500 litres).
2. A spill of the fuel may result in the presence of BTEX in groundwater or surface water.

Step B. Determine the hazard rating according to rule 120

The hazard rating would be calculated by considering the factors listed below:

(NOTE: the values given are hypothetical and should not be used as a basis for further calculations without confirmation)

1. Toxicity of the parameter	BTEX: 8
2. Environmental fate of the parameter	BTEX: 6 (direct)
3. Quantity of the parameter	BTEX: 15,000 L (scoring 10)
4. Method of Release (RIM score):	BTEX: 6 (low)
5. Type of Vulnerable Area	IPZ

For this hypothetical example, the **Hazard Rating would be 7.8**.

Technical Bulletin: Addressing Transportation Threats

Step C. Determine where the activity would be a significant, moderate or low drinking water threat, according to rules 129, 134 and 137.

With a hypothetical hazard rating of 7.8, handling of fuel according to the circumstance described above would be a moderate drinking water threat in areas within the IPZ with vulnerability scores from 8 to 10. It would be a low drinking water threat in areas within the IPZ with vulnerability scores of 6 and 7.

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Earth (Geothermal) Energy Systems

Date: November 2009

This fact sheet is for earth energy systems, also known as geothermal heating systems, as they relate to drinking water source protection. It explains the types of activities that are associated with the construction and operation of systems which utilize water, either directly or indirectly, for heating or cooling. It also identifies how such activities are or could potentially be addressed under the Clean Water Act requirements.

Installing earth energy systems requires making holes in the ground. If these holes are wells, which would apply if there were any tests for or on groundwater in the boring or installation, they must meet the requirements of Regulation 903 to minimize the risk of contaminating groundwater. Improperly constructed, maintained and abandoned wells can create pathways for contamination to move from the surface down into the groundwater or from one water-bearing horizon to another. Most of these systems will not be on record, so this creates an unknown in terms of pathways and vertical vulnerability. The Canadian Standards Association has published C448.2-01 and C448.2-02 for the Design and Installation of Earth Energy Systems, which recommends using high density polyethylene plastic pipe and pressure testing the system at key points to determine if there are any leaks at key points during the installation. Furthermore, the CSA standard also requires that boreholes be filled with grout for the entire length of the hole which would minimize the potential for contamination or leakage. However, the CSA Standard is only applied when there is an application for a building permit and there is a poor understanding of

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the need for the permit.

What is an earth energy system and how does it work?

O.Reg. 177/98 under the Environmental Protection Act defines a ground source heat pump as a heating and cooling system for buildings that use a liquid to exchange heat with the ground or ground water.

Geothermal (or earth) energy comes from the soil and rock of the earth. Ground temperature is relatively constant all year long. Groundwater flowing slowly through soil pores and bedrock fractures also has similar constant temperatures. In winter, the ground is warmer than the air, and in summer, it is cooler. An earth energy system (heat pump) harnesses this underground temperature to heat and cool buildings.

There are two basic types of earth energy heat pump systems - open and closed loop. Stated simply, open loop systems extract water from the environment to use for heating and cooling and then discharge the water back to the environment either directly or indirectly. Closed loop systems circulate a heat transfer fluid (HTF) through pipes installed in the environment (typically in the ground) to utilize the thermal gradient between the HTF and the environment for heating or cooling. HTFs typically used include ethanol or propylene glycol.

How are earth energy systems considered for Drinking Water Source Protection?

Earth energy systems have the potential to affect both the quantity and quality of source water for drinking purposes. The taking of water from surface water or groundwater regimes for open loop systems could have an affect on the water budget for a given area. The presence of the HTF has the potential to impact the quality of source waters if it is released into the environment and could, therefore, be considered a threat to the quality of the source water. The presence of wells for the purpose of earth energy systems may also serve as a conduit or transport pathway for the potential transfer of contaminants from the surface down to aquifers or for water between aquifers within the ground.

Earth Energy Systems and Water Quantity Risks

Where these systems extract water from the environment, this withdrawal should be considered under the water budget and water quantity risk assessment, where applicable. It is estimated that single residential systems typically use 25 to 40 litres per minute for heating and cooling, with maximums of 25000 to 40000 litres per day. Larger commercial or industrial systems would use even greater amounts of water.

While permits to take water for residential earth energy water taking systems are not required if they are for normal household use (such as heating), the withdrawal should be considered in the overall water budget, particularly at a Tier 3 stage.

It should be further noted that the operation of open loop systems could have a notable effect on the groundwater flow regime through the induction of piezometric changes due to the withdrawal and recharge of the water used.

Earth Energy Systems and Water Quality Risks

The withdrawal and recharge of water for use in earth energy systems can result in a thermal gradient in the groundwater regime, but this is typically limited to a local effect. Depending on the degree to which the temperature of the water changes, the configuration of the system and the nature of the hydrogeochemical environment, it could also induce minor changes in groundwater chemistry but not likely induce threats to water quality.

The presence of HTFs in the subsurface in earth energy systems can pose a threat to water quality, particularly if they should leak in the subsurface piping. While this activity is not a prescribed threat under the current legislation, preliminary analysis suggests that:

- residential systems with low volumes of HTFs, would be considered a low drinking water threat in areas with a vulnerability of greater than 7, and
- larger commercial or industrial systems with higher volumes of HTFs would be a:
  - significant drinking water threat in areas with a vulnerability score of 10,

- moderate threat in areas with vulnerability scores between 7.5 and <10, and
- low threat in areas with vulnerability scores between 5 and <7.5.

Earth Energy Systems as Transport Pathways

The presence of boreholes or wells associated with these systems could be considered a transport pathway in the Assessment Report, where its construction provides a conduit from the surface down to an aquifer or allows for enhanced flow between aquifers. In this circumstance, the groundwater vulnerability may be adjusted higher to account for the transport pathway. Under the current legislation, where a transport pathway is confirmed as a factor in contributing to a significant drinking water threat, addressing the pathway could be part of the risk management plan for addressing such a threat. This could include, but not be limited to:

- requiring or confirming that the construction complies with CSA requirements
- testing the well or boring, where possible, to determine if it provides a conduit for flow
- monitoring the system to determine if there is enhanced flow or if there is any loss of HTF from the system
- providing an emergency contingency plan in the event that there is a leak to minimize the impact on source waters
- restricting the installation or application of earth energy systems
- decommissioning faulty or high risk earth energy systems

Earth Energy Systems with Source Water Issues

Where there is an existing deterioration of water quantity or quality for a municipal residential drinking water system, this can be considered an issue under the Clean Water Act. Where such an impact on source water is associated with an earth energy system, the system could be considered a significant threat and require risk management measures, as mentioned above, to mitigate the risk to the drinking water supply.

Summary

Considerations of Earth Energy Systems in drinking water source protection can be done as part of the assessment of transport pathways. Where such pathways are associated with significant threats to drinking water sources, they could be addressed in a risk management plan for that threat.

The activity of Earth Energy Systems is not a prescribed threat under the current regulations. However, if it were to be added, preliminary analysis suggests that it would only be a significant threat for ethanol and propylene glycol heat transfer fluids in a relatively large volume commercial/industrial system in a vulnerable area with a score of 10. Within a vulnerable area of any lesser score with such a system or any residential system, this activity would not be a significant threat under the current assessment.

Additional Information

For more information on these types of systems, please refer to the Technical Bulletin on Constructing Earth Energy Systems in Ontario released in September 2009. http://www.ene.gov.on.ca/publications/7219e.pdf

DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Technical Bulletin: Burial of Animals on Farms as a Drinking Water Threat (Deadstock Disposal)

Date: December 2009

The *Clean Water Act, 2006* provides source protection committees (SPCs) with the authority to protect their municipal drinking water supplies by developing collaborative, locally driven, science-based protection plans. SPCs identify potential risks to local water sources and take action to set out policies in source protection plans that reduce or eliminate these risks. Regulations and technical rules governing the content of the assessment report became law in late 2008 and were amended in November 2009.

Regulation 287/07, under the Clean Water Act, includes a list of prescribed activities that must be considered when identifying activities that pose a risk to sources of drinking water. The technical rules include Tables of Drinking Water Threats that set out the circumstances under which the activities in the regulation pose a significant, moderate, or low drinking water threat.

Until recently the burial of dead animals was governed under Part V of the Environmental Protection Act (EPA) with respect to the disposal of on farm animals and the Deadstock Disposal Act, 1968 (DDA) for the use of deadstock. The November 2008 technical rules under the Clean Water Act included the burial of farm animals as a circumstance in which the “Establishment or Maintenance of a Waste Disposal Site within the meaning of Part V of the Environmental Protection Act” was considered a threat to drinking water. In March 2009, amendments were made to regulations under the EPA, the DDA

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was repealed, and a new regulation was made under the Nutrient Management Act, 2002 (NMA) such that the burial of farm animals on farms is now regulated through Ontario Regulation 106/09, Disposal of Dead Farm Animals. Changes were also made to the Food Safety and Quality Act, 2002 (FSQA) to govern off farm animal use and disposal. The Clean Water Act (CWA) and its regulations stipulate that an activity can only be identified as a drinking water threat if it is listed in O. Regulation 287/07 or added locally with the approval of the director. With the change in the regulatory framework, the deadstock burial no longer falls under any of the 21 activities listed in the regulation and therefore, circumstances in the Technical Rules: Tables of Drinking Water Threats had to be removed. These tables only list circumstances related to activities in the O. Regulation 287/07. Without amending Regulation 287/07, the only option for identifying deadstock burial as a threat is to add this activity locally through Director's approval.

Background information on the new framework regulating deadstock can be found at the following link
http://www.omafra.gov.on.ca/english/nm/regs/deadstock/summary.htm

INCLUDING DEADSTOCK DISPOSAL THREATS IN ASSESSMENT REPORTS

Although burial of farm animals is no longer in the Tables of Drinking Water Threats, the Clean Water Act, regulations and technical rules provide a mechanism by which SPCs can add drinking water threats or add additional circumstances to activities the province has already listed as a prescribed drinking water threat. Therefore, an SPC can request that "burial of farm animals on a farm under the O. Regulation 106/09 of the Nutrient Management Act" be added as a drinking water threat by making a request to the Director under the Clean Water Act. The activity can only be considered a local threat, according to the technical rules, if:

(1) the activity has been identified by the SPC as an activity that may be a drinking water threat;

(2) in the opinion of the Director,

(a) the chemical hazard rating of the activity is greater than 4, or

(b) the pathogen hazard rating of the activity is greater than 4; and

(3) the risk score for an area within the vulnerable area in respect of the activity calculated in accordance with rule 122 is greater than 40.

Rules 120 and 121 set out how the hazard rating is determined by the province:

120. The chemical hazard rating of an activity that is not prescribed to be a drinking water threat under O. Reg. 287/07 (General) shall be a rating that in the opinion of the Director reflects the hazard presented by the chemical parameter associated with the activity, if any, considering the following factors:

(1) Toxicity of the parameter.

(2) Environmental fate of the parameter.

(3) Quantity of the parameter.

(4) Method of release of the parameter to the natural environment.

(5) Type of vulnerable area in which the activity is or would be located.

121. The pathogen hazard rating of an activity that is not prescribed to be a drinking water threat under O. Reg. 287/07 (General) shall be a rating that in the opinion of the Director reflects the hazard presented by pathogens associated with the activity, if any, considering the following factors:

(1) The frequency of the presence of pathogens that may be associated with the activity.

(2) Method of release of the pathogen to the natural environment.

(3) Type of vulnerable area in which the activity is or would be located.

Before adding a deadstock disposal threat to the assessment report, Director's approval of the hazard rating and the risk score must be obtained. A request can be made by the SPC through the provincial liaison officer to the SPC.

Once a new threat is added, the SPC must follow the same process in the technical rules to identify where the threat is significant, moderate or low and how many significant drinking water threats exist within each vulnerable area.

Background on the new framework regulating deadstock is provided below.

Nutrient Management Act, 2002

The NMA came into force in 2002 and enhances the protection of Ontario's water resources by minimizing the effects of livestock manure and other nutrients that are stored on farm properties or land applied. The preparation of nutrient management plans, non-agricultural source material (NASM) plans, and nutrient management strategies is a key requirement of the NMA. The NMA provides clear requirements for environmental protection for Ontario's agricultural industry, municipalities and other generators and receivers of materials that contain nutrients.

Application of the NMA for Deadstock Disposal

The regulation under the NMA sets out requirements for the disposal of dead farm animals on the farm. This regulation applies to all farm operations, regardless of the requirement to have a nutrient management strategy or plan under O. Regulation 267/03. The DDA and its regulations were repealed and replaced by the Disposal of Dead Farm Animals regulation under the NMA and the Disposal of Deadstock Regulation under the FSQA. The new regulations came into force on March 27, 2009. They provide more disposal options for livestock producers and meat plant operators, with measures that will protect the environment.

The new framework builds on the past requirements in the DADA and continues to focus on minimizing potential food safety and animal health risks while also minimizing environmental impacts and disease threats. The regulation under the NMA addresses on-farm disposal. The regulation under the FSQA addresses disposal when the animal dies at places other than the farm. Both regulations provide greater flexibility for industry in the disposal of deadstock.

The regulations set out requirements for the disposal of not only cattle, goats, sheep, horses and swine as per the DADA, but also deer, elk, alpacas, llamas, bison, yaks, donkeys, ponies, rabbits, poultry and fowl, ratites, and fur bearing animals.

The operator of the farm is responsible for disposing of the animal within 48 hours of its death, which was the requirement within the DADA. The two exceptions to this rule are:

- If a delay occurs in order to perform a post mortem on the animal, or

- If the animal is put into temporary storage conditions as specified in the regulation.

Additional disposal options for greater flexibility to manage deadstock include:

- Burial
- Incineration
- Composting
- Disposal vessels
- Collection by a licensed collector
- Anaerobic digestion
- Delivery to a waste disposal site approved under the EPA
- Delivery to a disposal facility as defined under the FSQA
- Delivery to a licensed veterinarian for post mortem and disposal.

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.

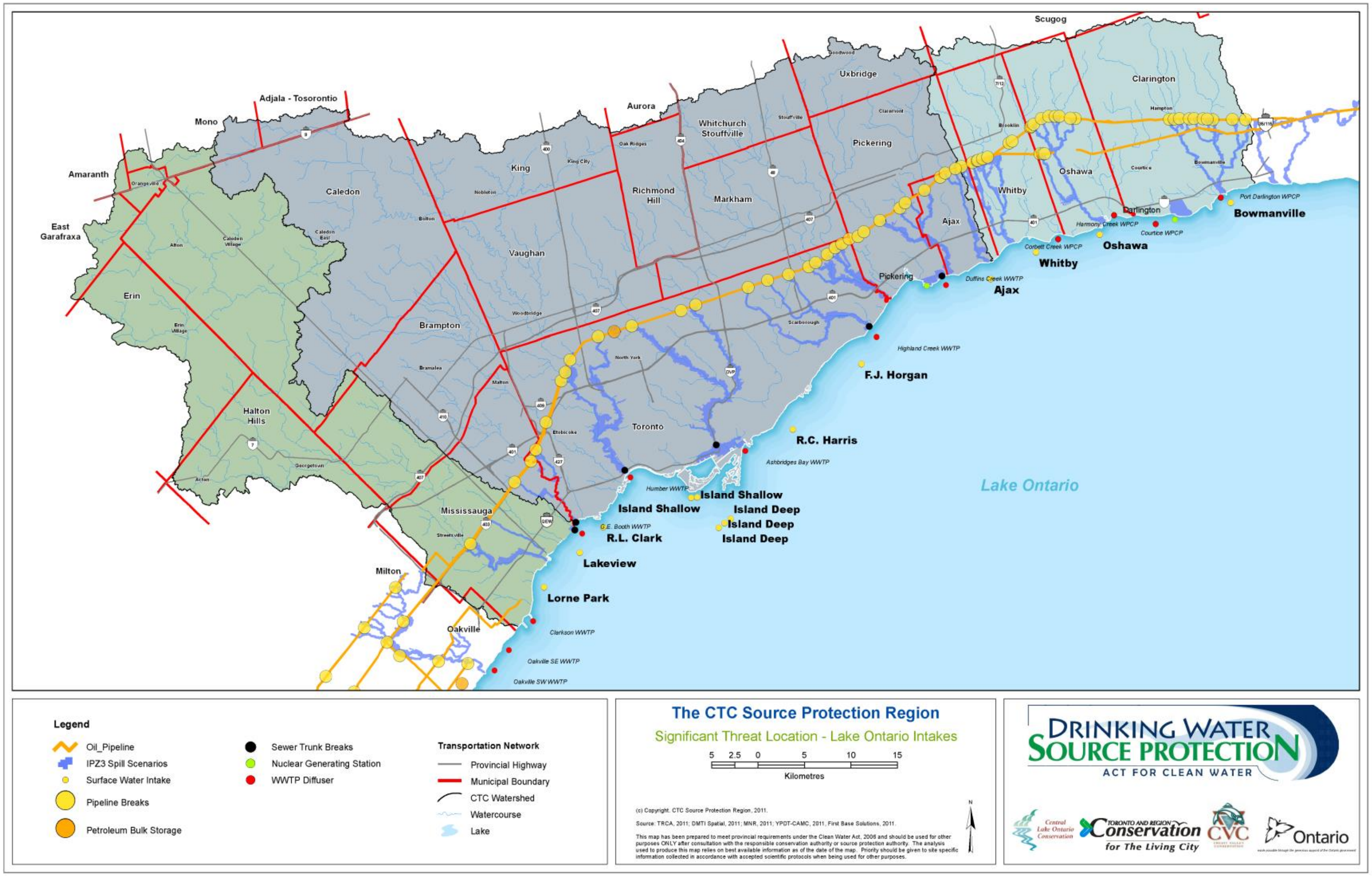


Figure E2.1: Significant Threat Location Lake Ontario Intakes – Oakville to Port Darlington

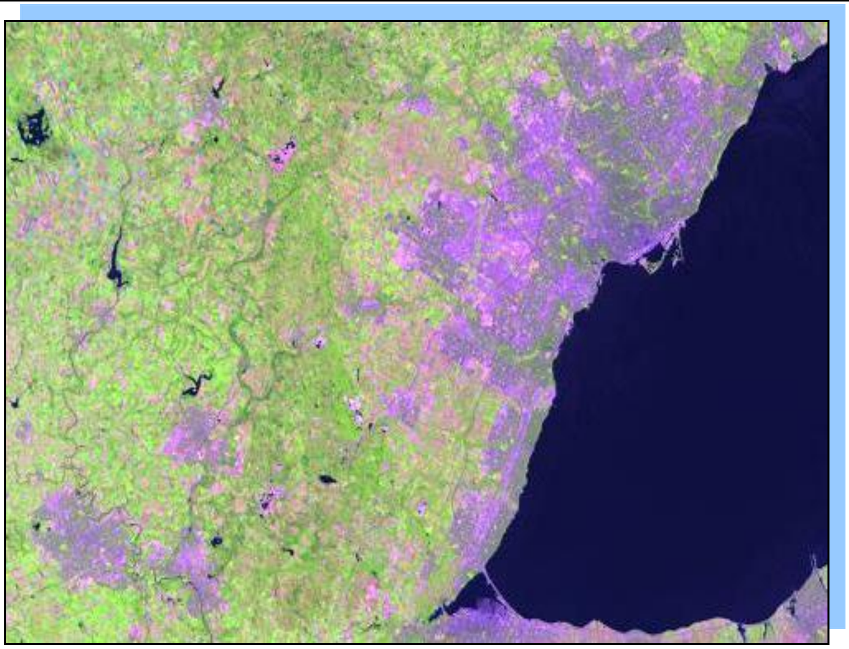


Figure E2.2: Urban (purple) and Rural (green) Areas adjoining Lake Ontario

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.

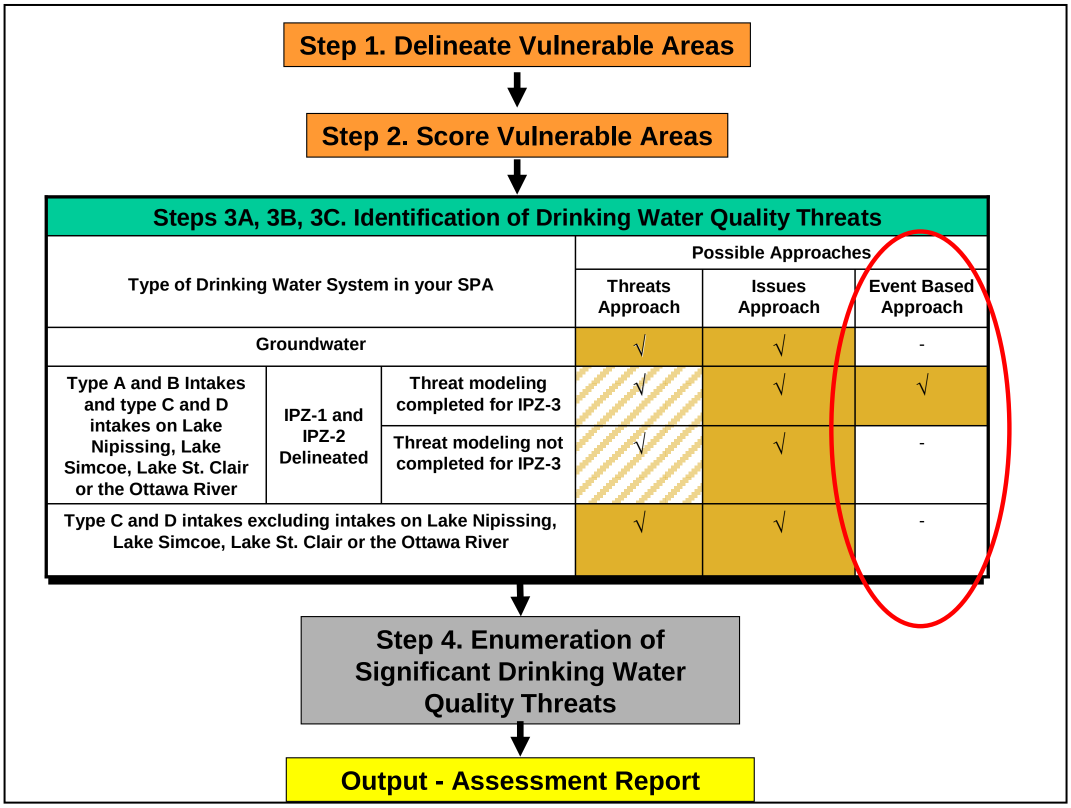


Figure E2.3: Approaches Used to Determine Significant Drinking Water Threats (Keller, 2009)

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).

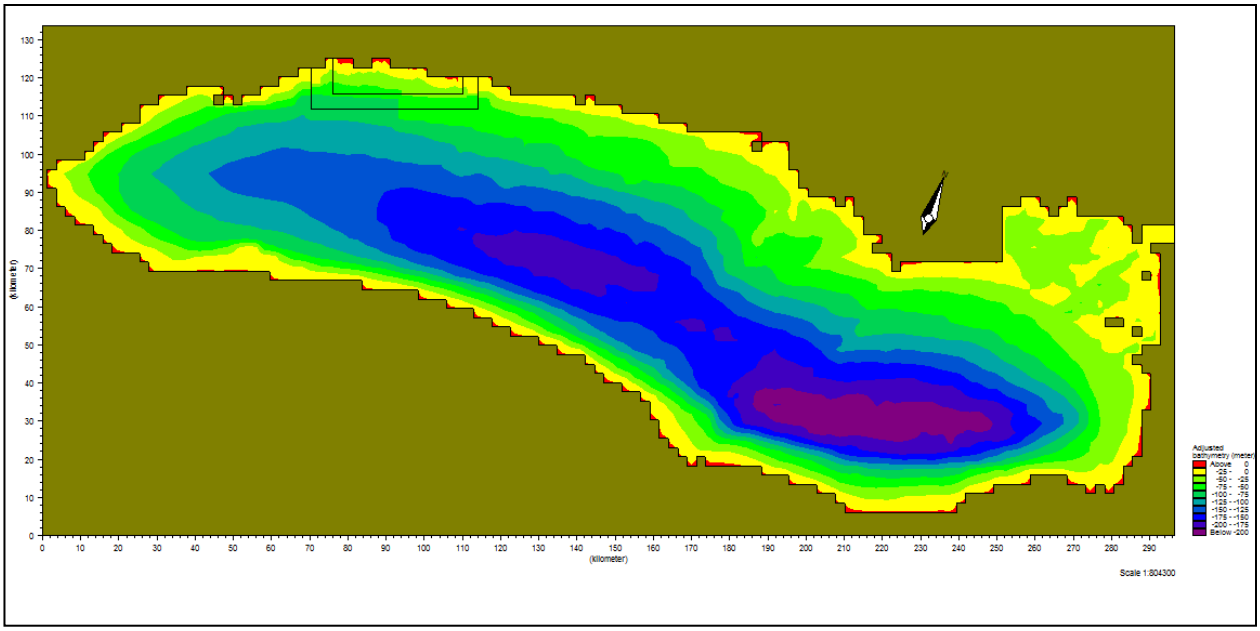


Figure E2.4: 2430 m Whole Lake Grid with Nested Grids

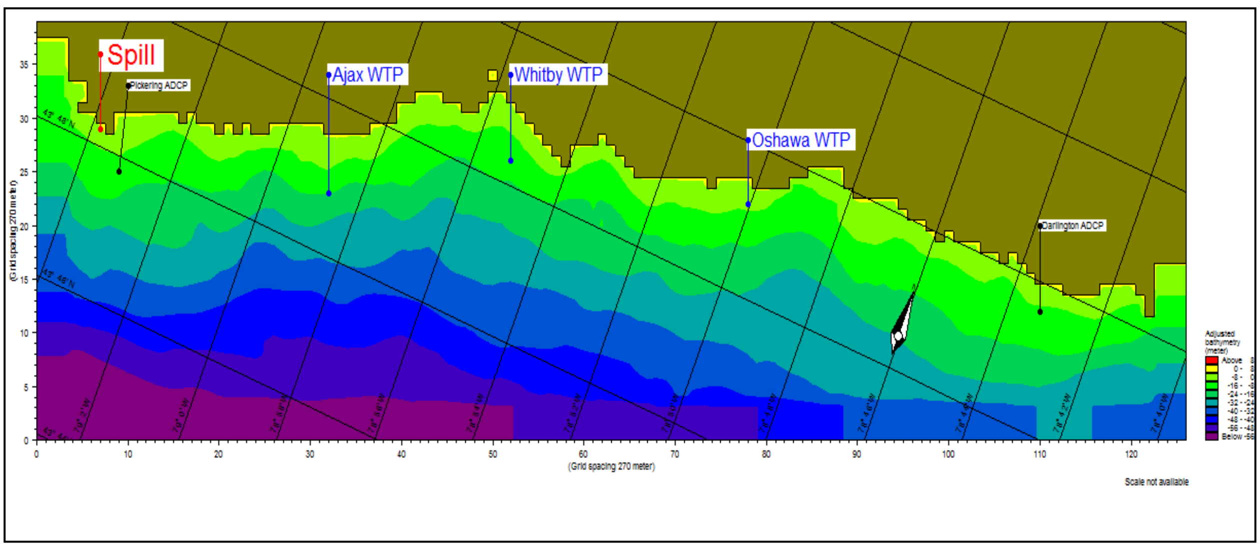


Figure E2.5: 270 m Nested Grid with ADCP Locations

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.

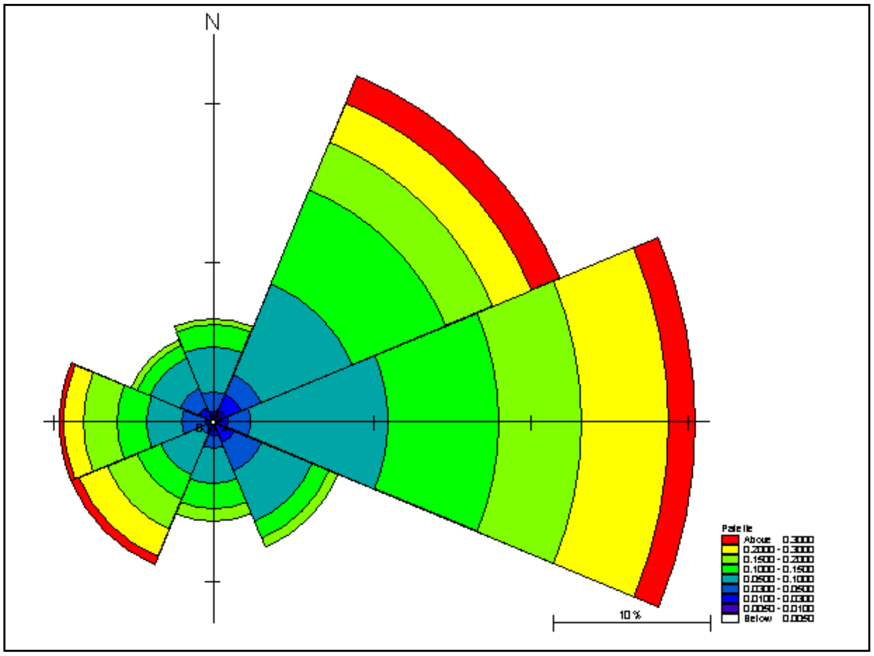


Figure E2.6: Calculated Current Compass Rose in Etobicoke Section of Coastal Zone

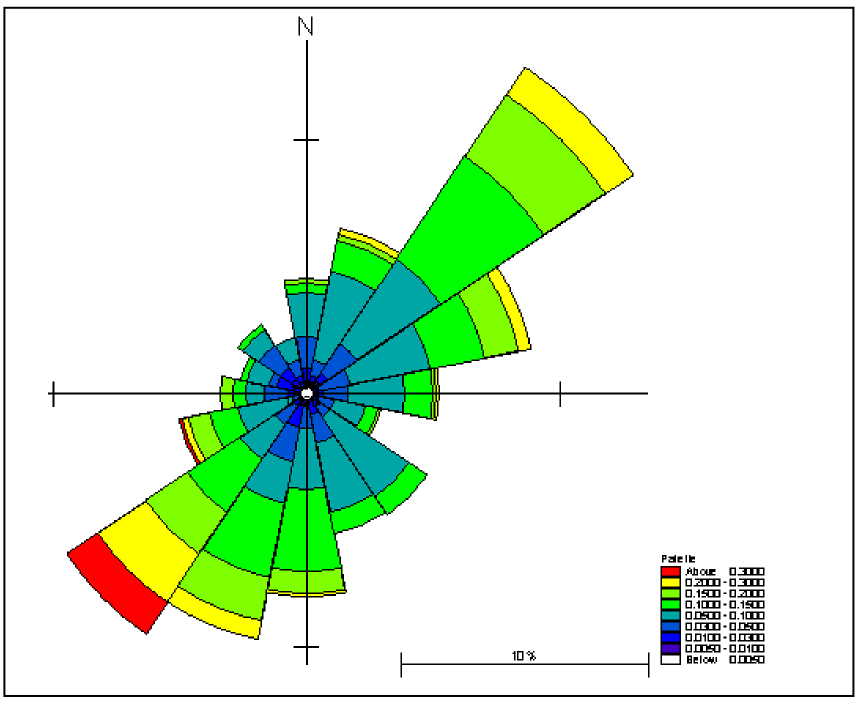


Figure E2.7: Calculated Current Compass Rose in Pickering Section of Coastal Zone

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.

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
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 E2-1: 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	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
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

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

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.

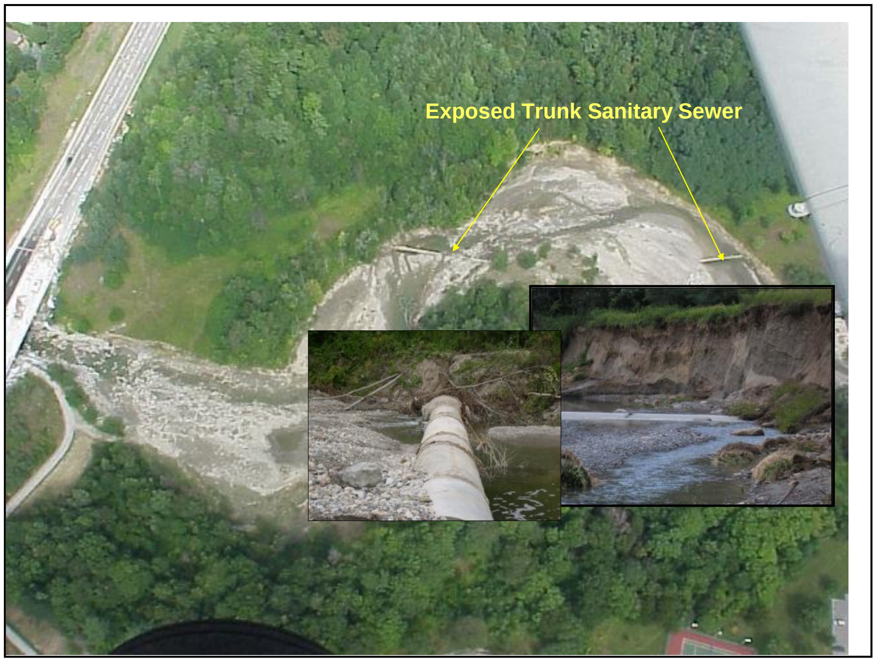


Figure E2.9: Picture and Location of STS Erosion in Highland Creek watershed caused by Aug 19th, 2005 Storm Extreme Weather Event

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 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.

Figure E2.11: Industrial Animal Food Processing Lagoon

Pipeline Rupture Spill Scenario

The picture (

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 $x10^{11}$ 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.

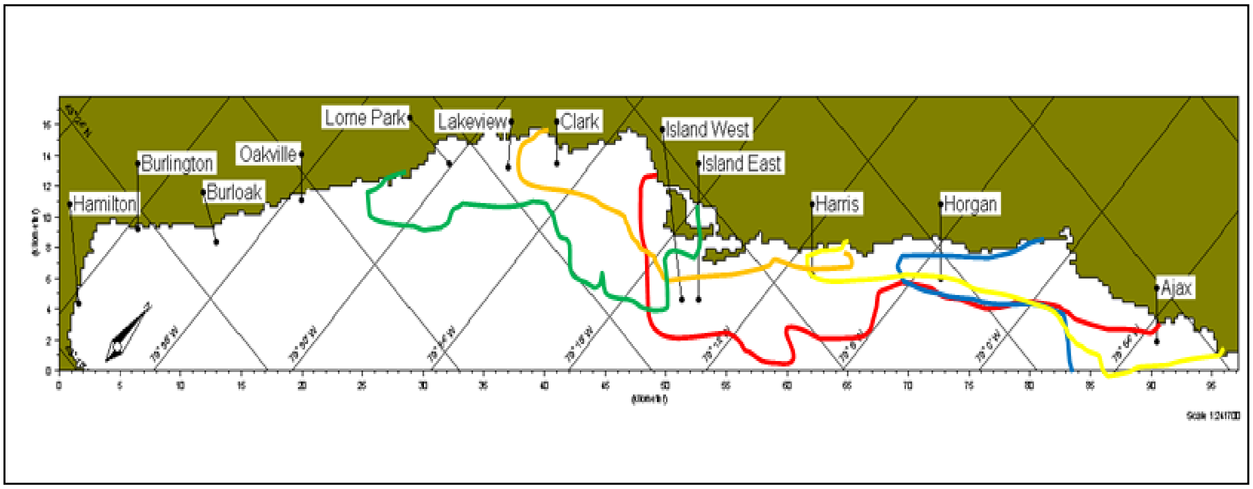
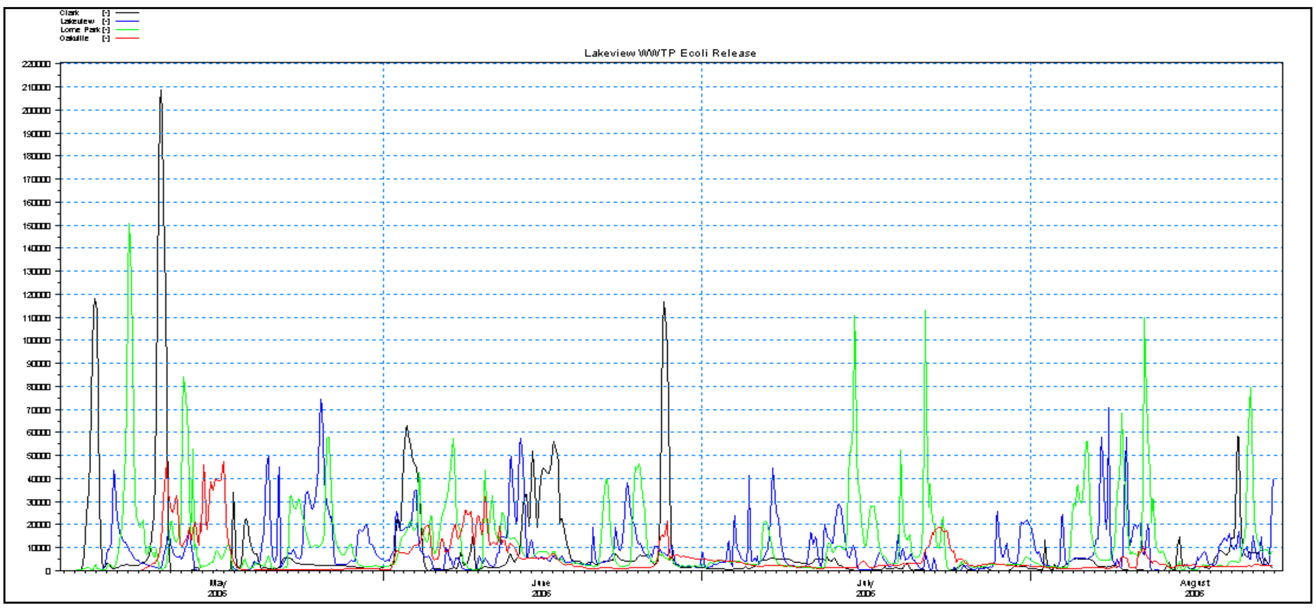


Figure E2.15: *E. coli* Time Series for Clark, Arthur P. Kennedy (previously named Lakeview), Lorne Park and Oakville Intakes



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/100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)	Peak (CFU/ 100mL)	Mean (CFU/ 100mL)
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
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 (#/100mL)	Mean (#/100mL)	Peak (#/100mL)	Mean (#/100mL)	Peak (#/100mL)	Mean (#/100mL)	Peak (#/100mL)	Mean (#/100mL)	Peak (#/100mL)	Mean (#/100mL)	Peak (#/100mL)	Mean (#/100mL)
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
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		
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 E2.1** and the corresponding peak *E. coli* densities at each intake are tabulated in **Table E2-7**.

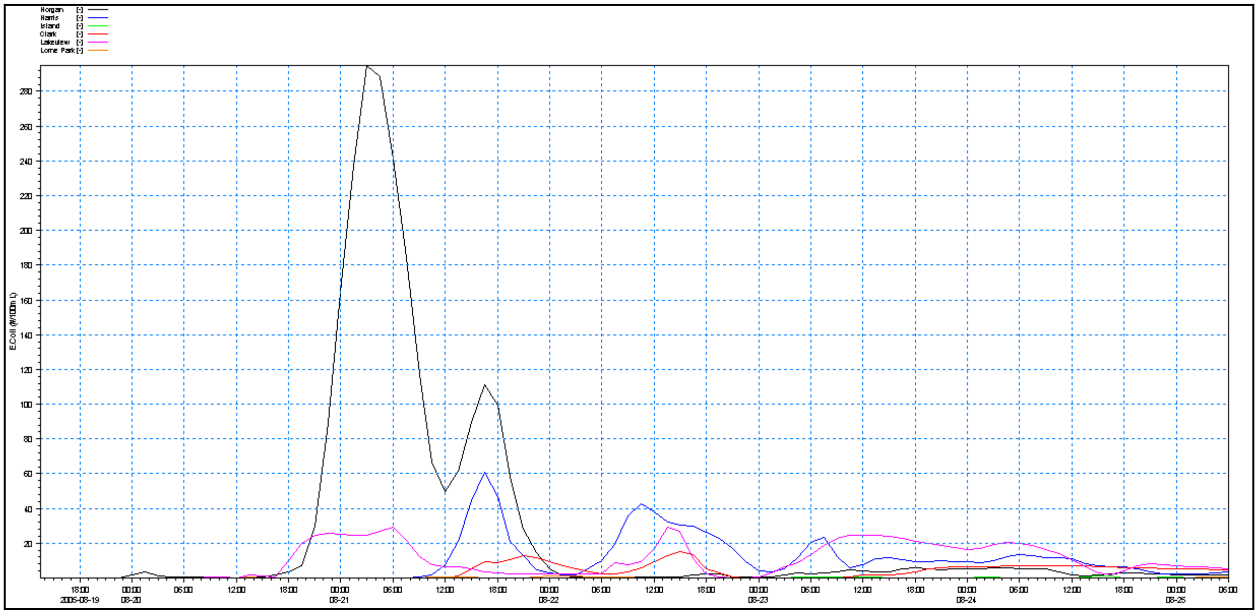


Figure E2.17: *E. coli* Time Series for STS Breaks

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)
Arthur P. Kennedy	29	110 (Humber) 180 (Etobicoke)
Lorne Park	1	360
Oakville	<1	160

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

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 for 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.

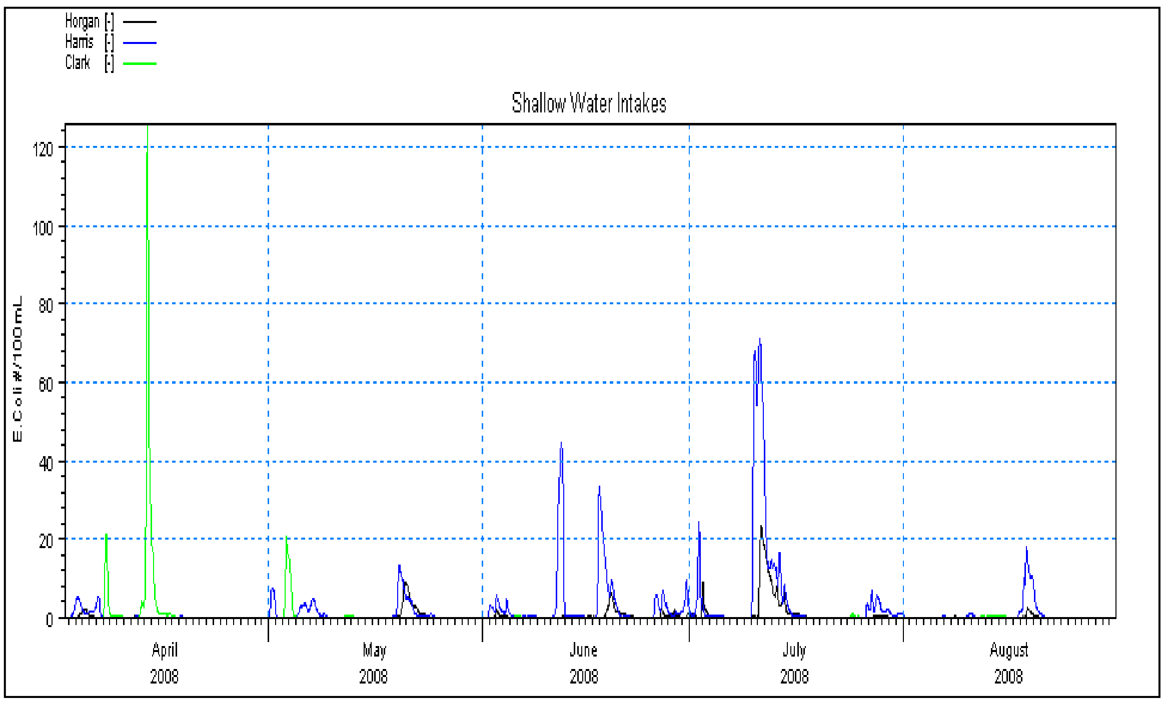


Figure E2.18: *E. coli* Levels for Horgan, Harris and Clark from CSO Spill

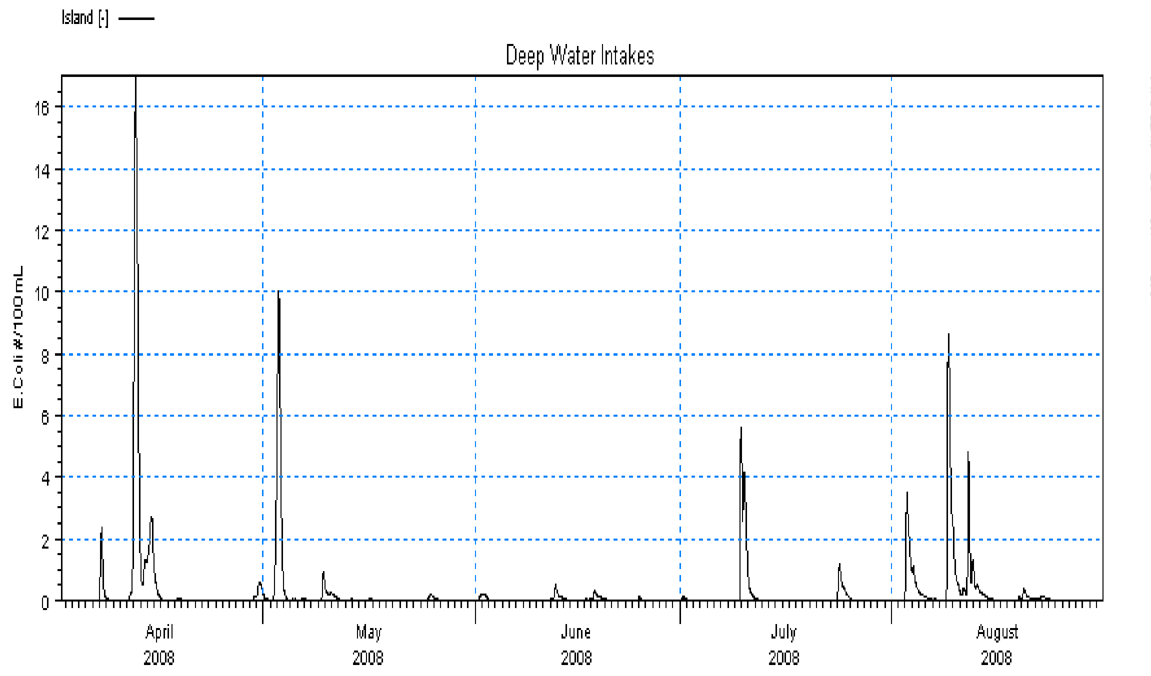


Figure E2.19: *E. coli* Levels Predicted for Toronto Island Intakes from CSO Spill

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.

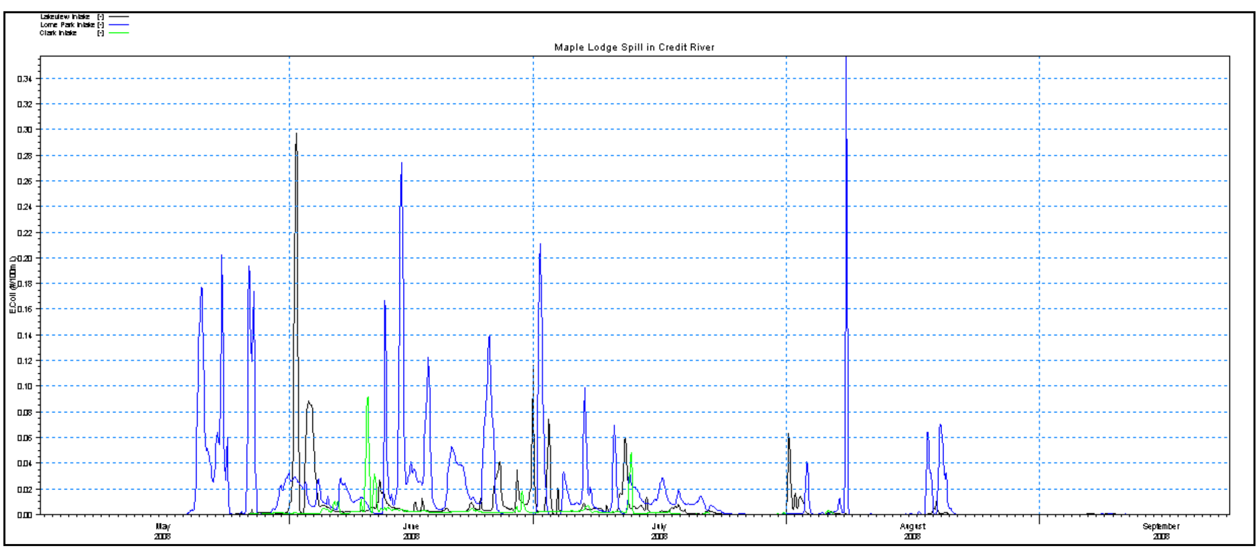


Figure E2.20: Predicted *E. coli* Densities from Industrial Animal Food Processing Lagoon Scenario

(*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.

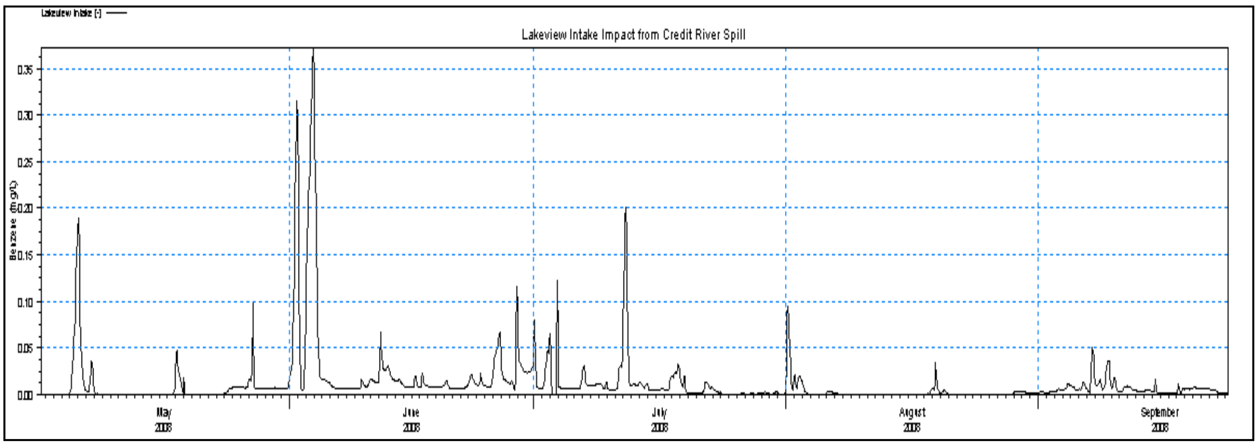
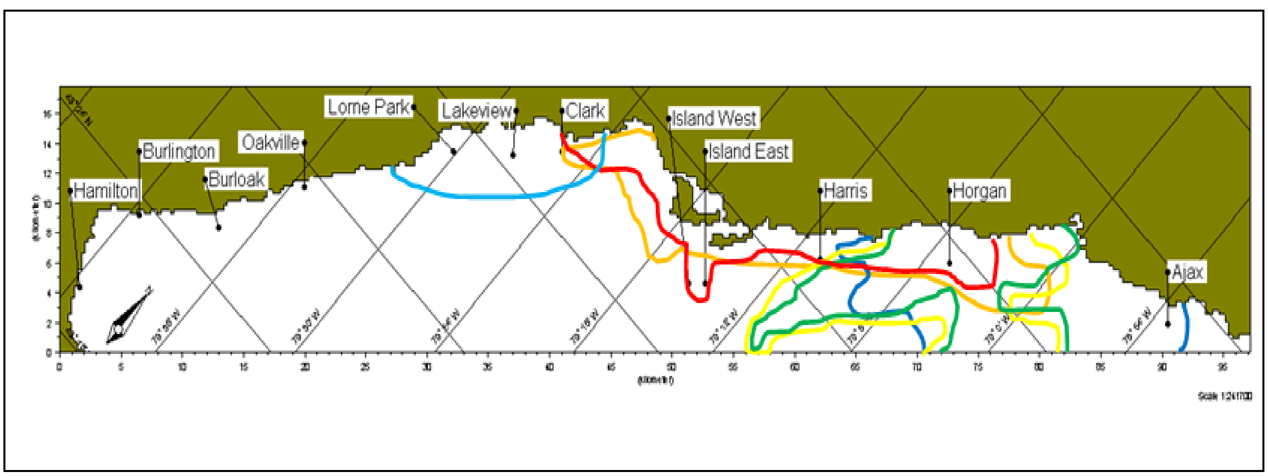


Figure E2.21: Arthur P. Kennedy Time Series from Credit River (*Lakeview intake has been renamed Arthur P. Kennedy)



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)

Intake \ Discharge	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
Oakville													0.120
Burloak													0.014
Burlington													0.035
Hamilton													0.007

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

Intake \ Discharge	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

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

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).

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		

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

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.

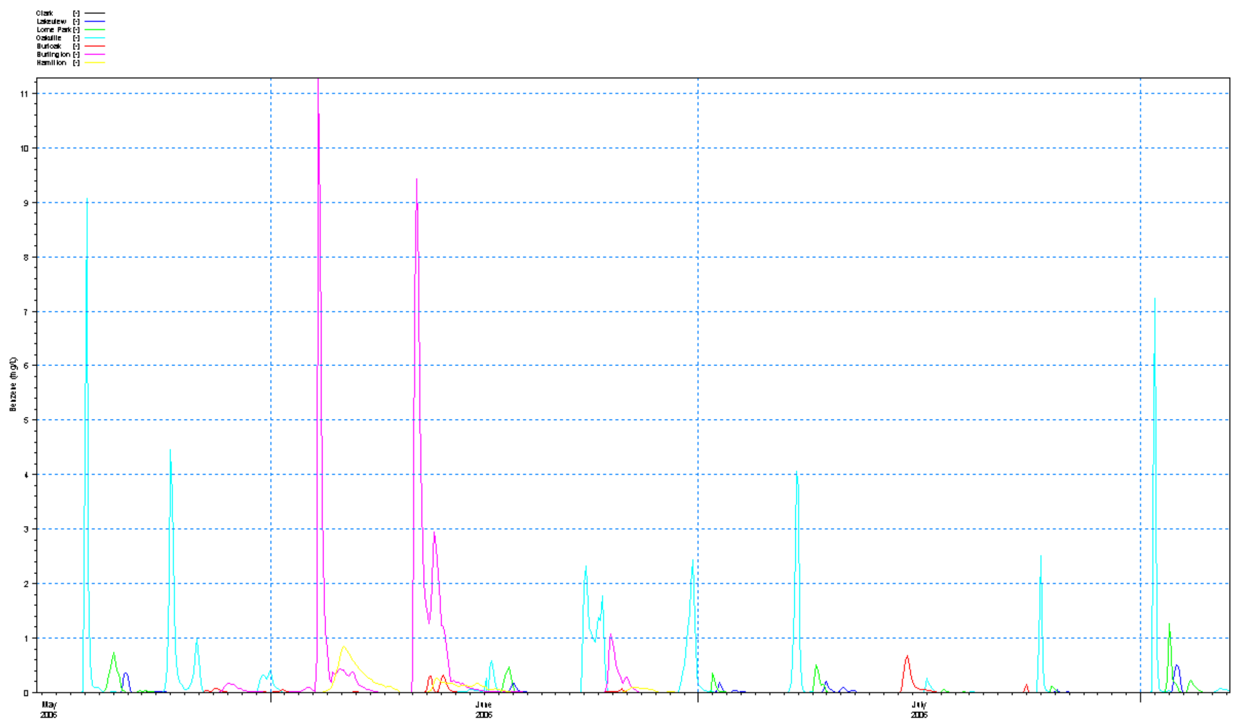


Figure E2.23: Benzene Concentrations (mg/L) at Intakes from Simulated Gasoline Storage Spills (*Lakeview intake has been renamed Arthur P. Kennedy)

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

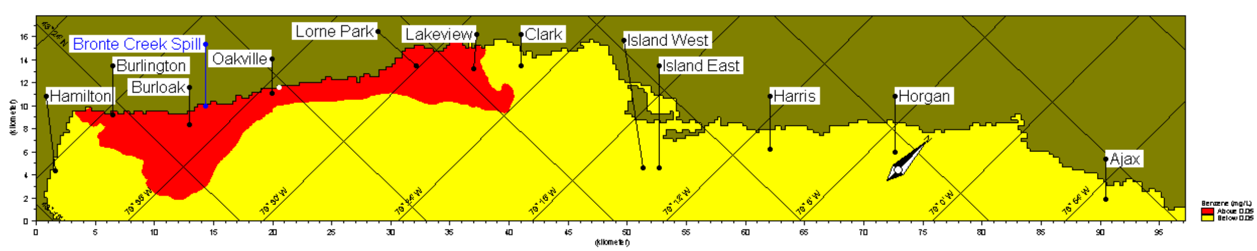


Figure E-24: Oakville Storage Facility Spill - 0.05 mg/L Benzene Isopleth (*Lakeview intake has been renamed Arthur P. Kennedy)

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.

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

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

Figure E2.24 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).

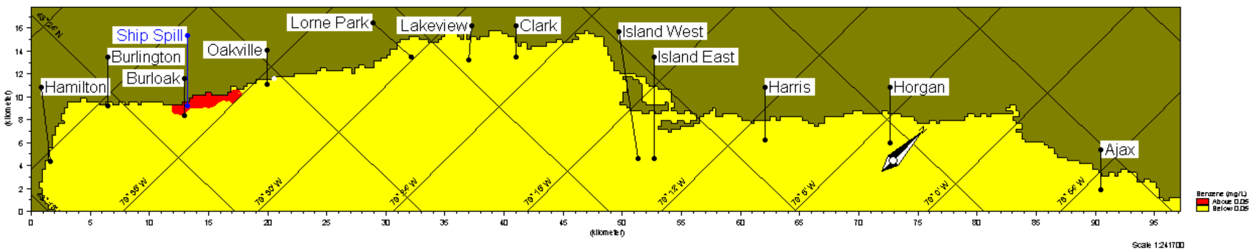


Figure E2.24: Scenario of 1000 L spill with a Benzene Isopleth of 0.05 mg/L

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.

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

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

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 E2.26**. 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.

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
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.)

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

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.

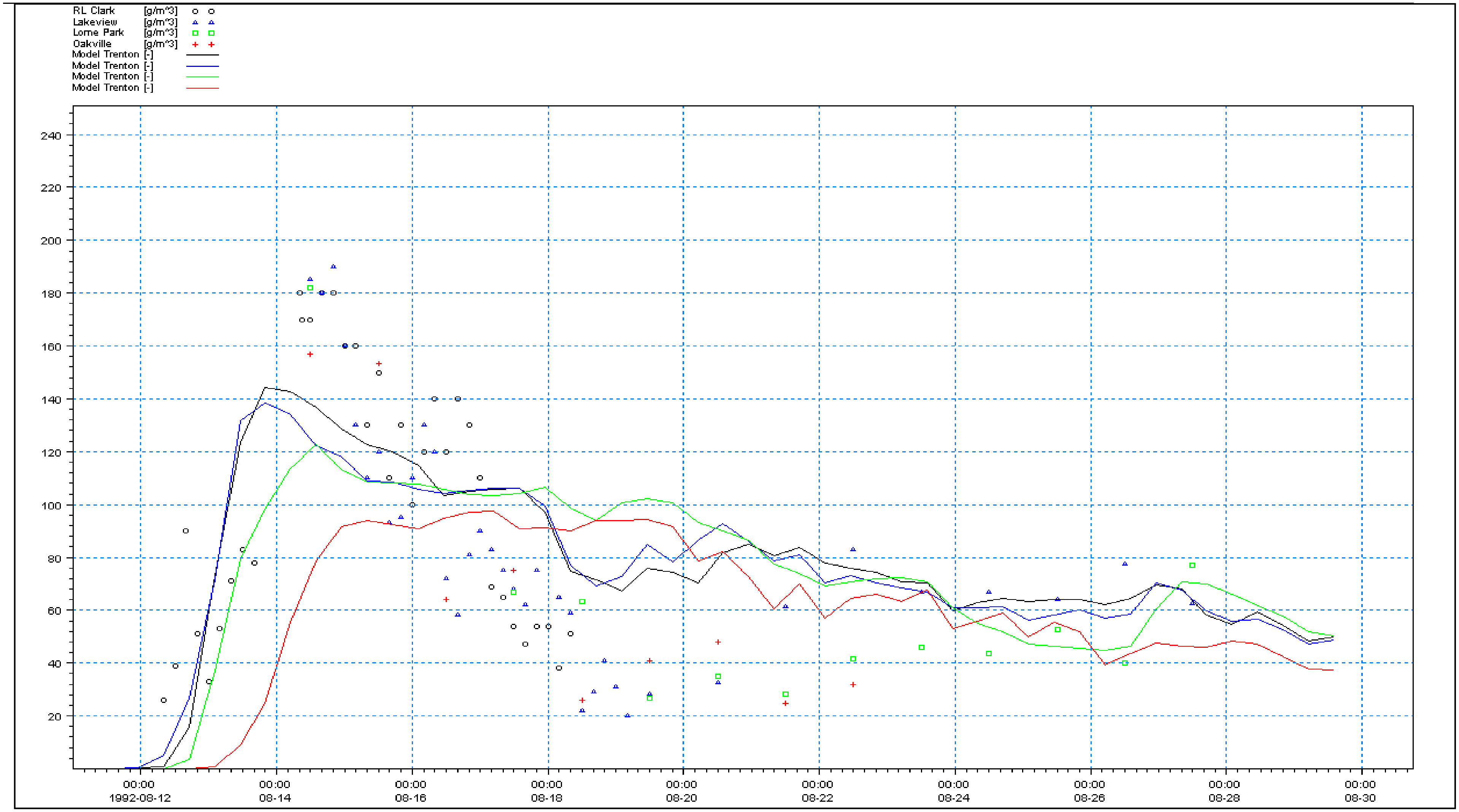


Figure E2.25: Model Calibration: Comparison of Model Calculations with Observations using Trenton Winds for Clark to Oakville Intakes (*Lakeview intake has been renamed Arthur P. Kennedy)

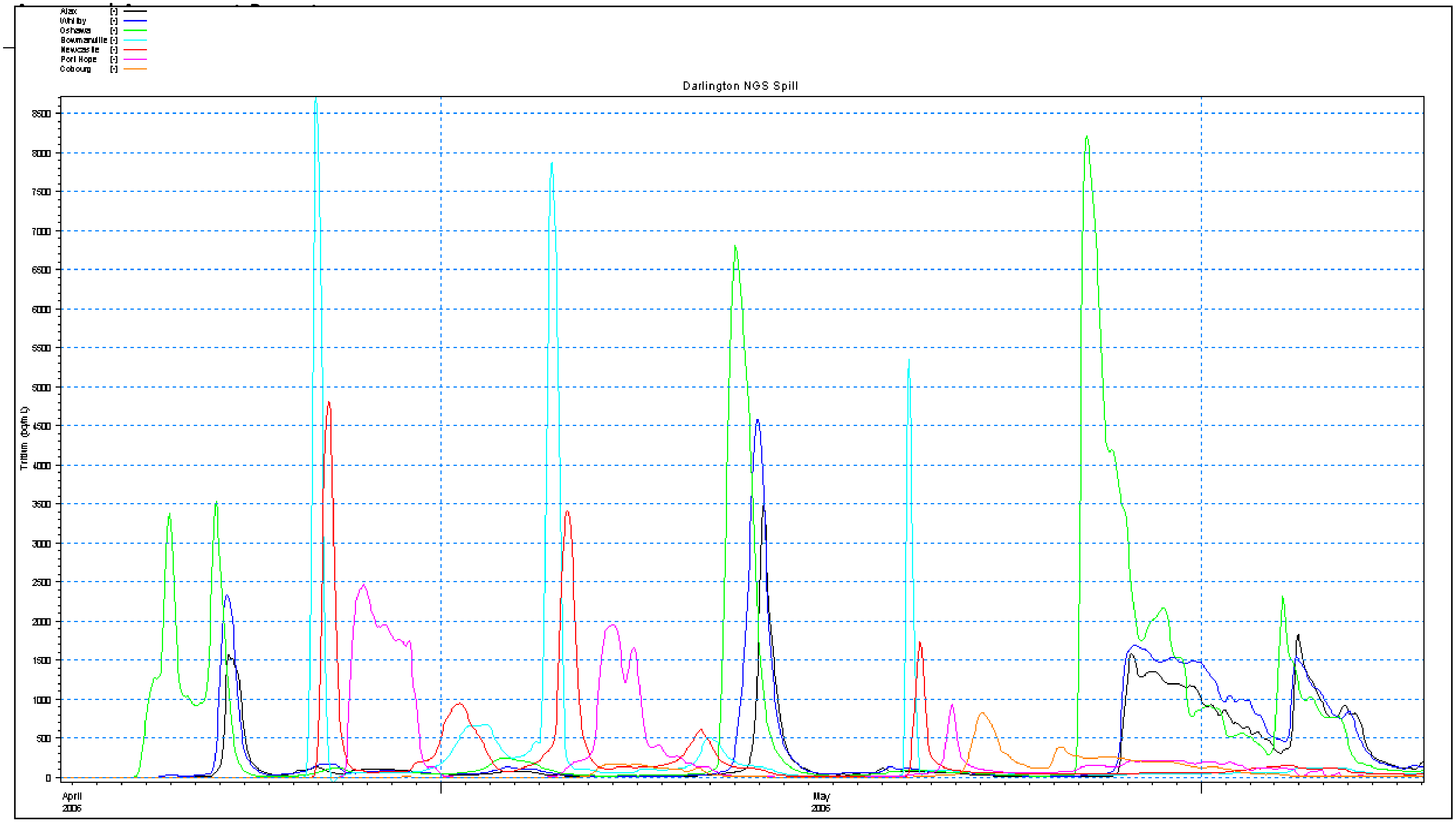


Figure E2.26: Tritium Time Series at Intakes (Ajax to Cobourg) for Release from Darlington Outfall

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.

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)

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

The contaminant map showing the predicted tritium contours of 150 Bq/L from the Pickering spill scenario is provided on **Figure E2.27.** This illustrates the extent of contamination in the coastal zone that could occur.

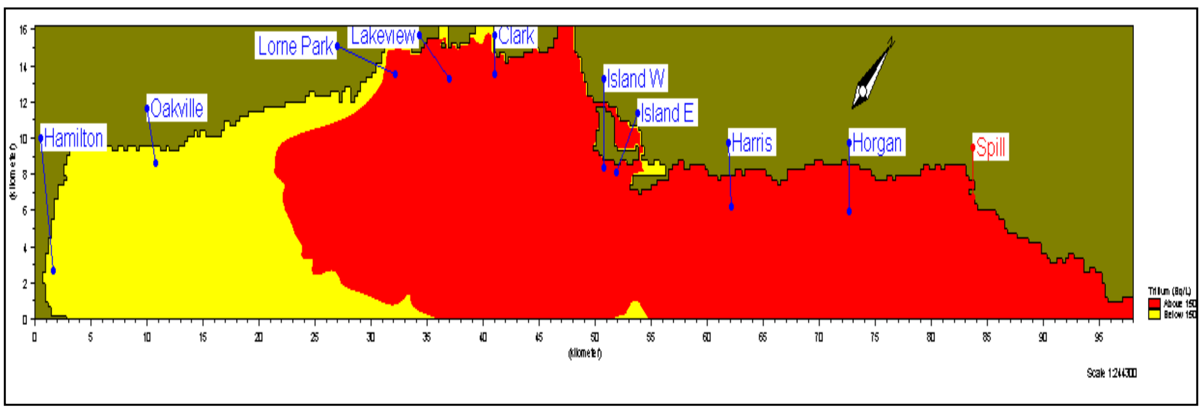


Figure E2.27: Extent of Contamination for Tritium, using a 150 Bq/L Contour (*Lakeview intake has been renamed Arthur P. Kennedy)

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

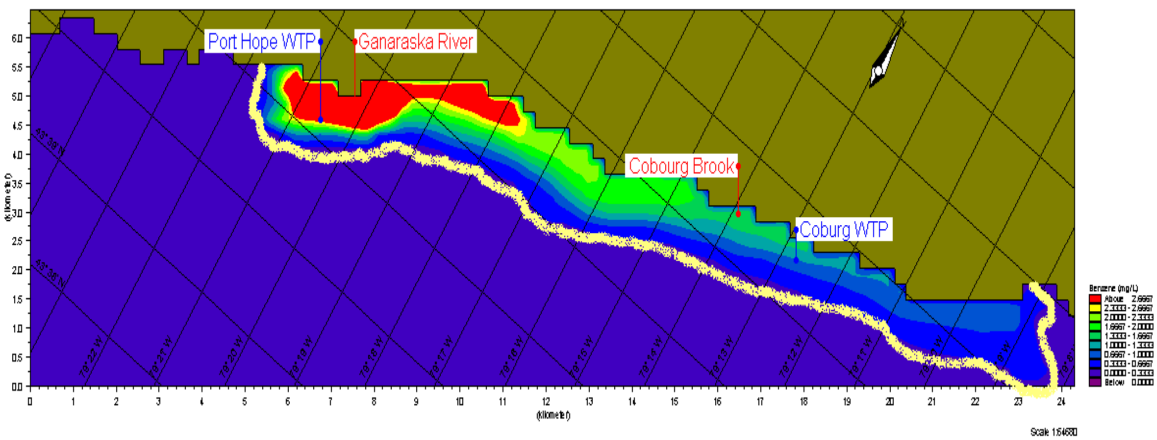
- A series of events.

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 E2.28**.



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

Figure E2.28: 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 E2.29** (time series for Arthur P. Kennedy intake) and **Figure E2.30** (Spatial Extent). This method, therefore, may underestimate the area to which a spill might extend.

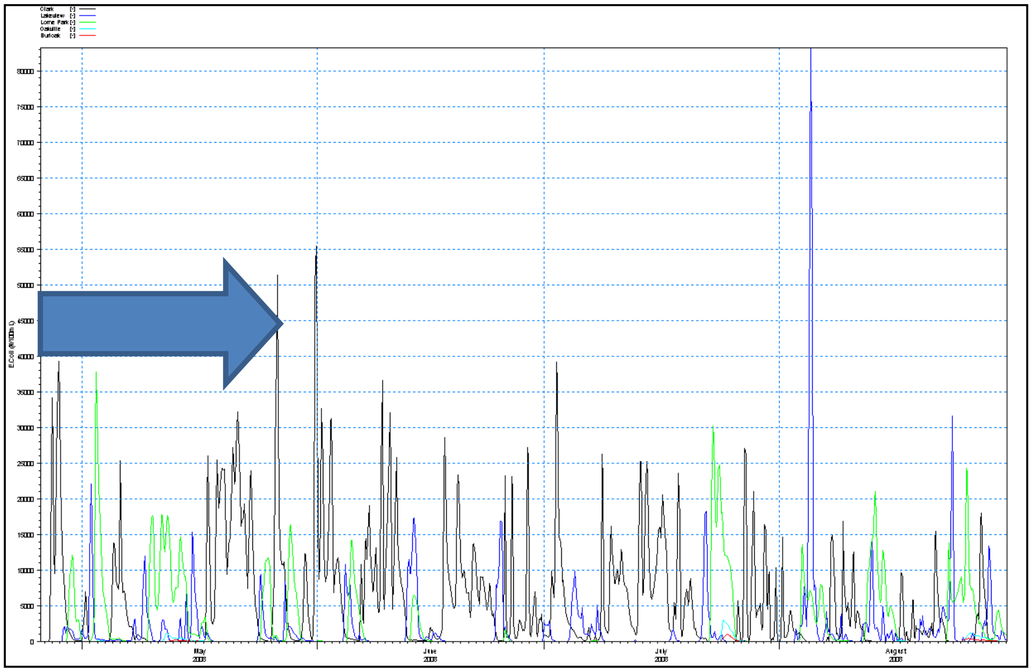


Figure E2.29: Arthur P. Kennedy Time Series (*Lakeview intake has been renamed Arthur P.Kennedy)

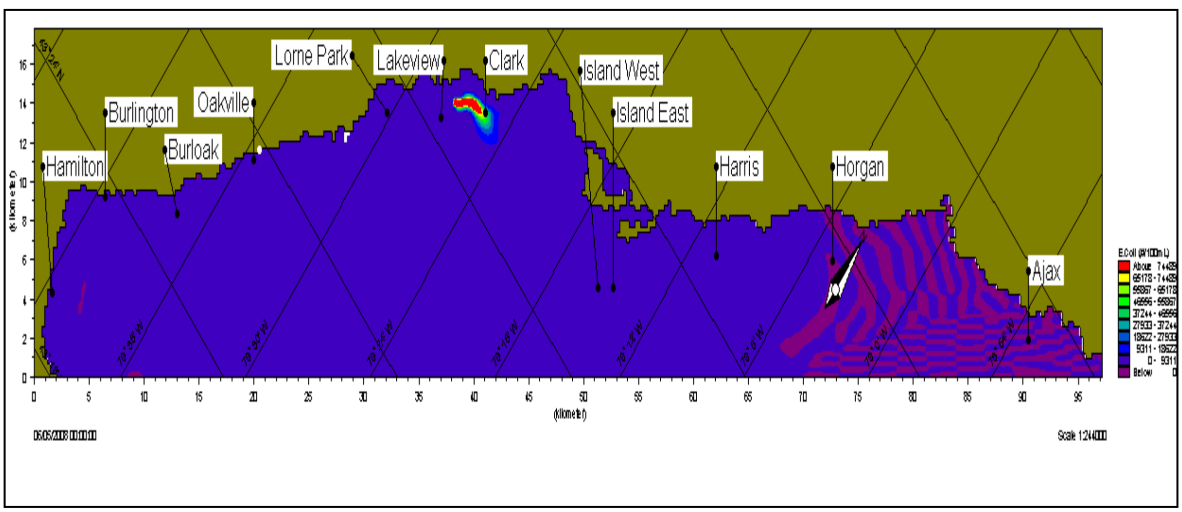


Figure E2.30: Spatial Extent of Impact from Spill occurring August 5 (*Lakeview intake has been renamed Arthur P. Kennedy)

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 E2.31**.

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.

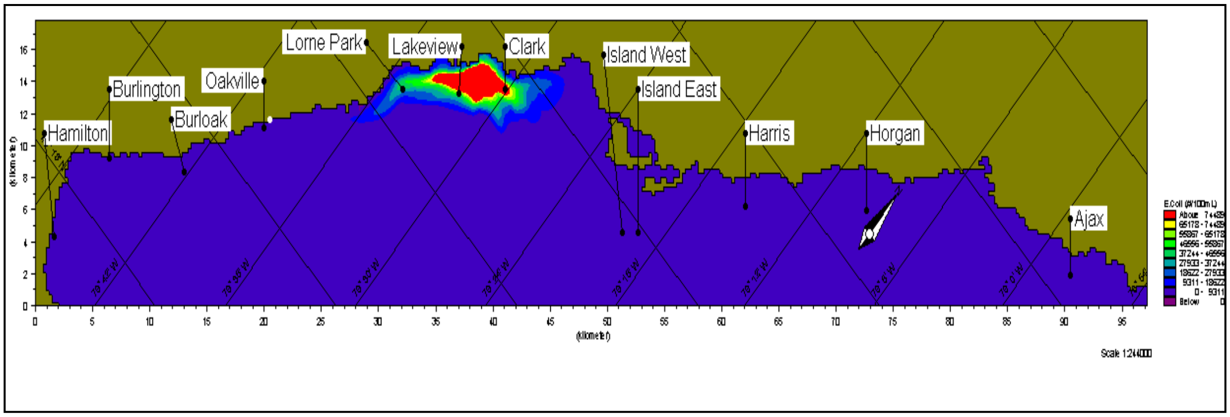


Figure E2.31: Spatial Extent of Impact from Spills starting April 4 for a Four–week period (*Lakeview intake has been renamed Arthur P. Kennedy)

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 E2.32** to **Figure E2.36**. 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

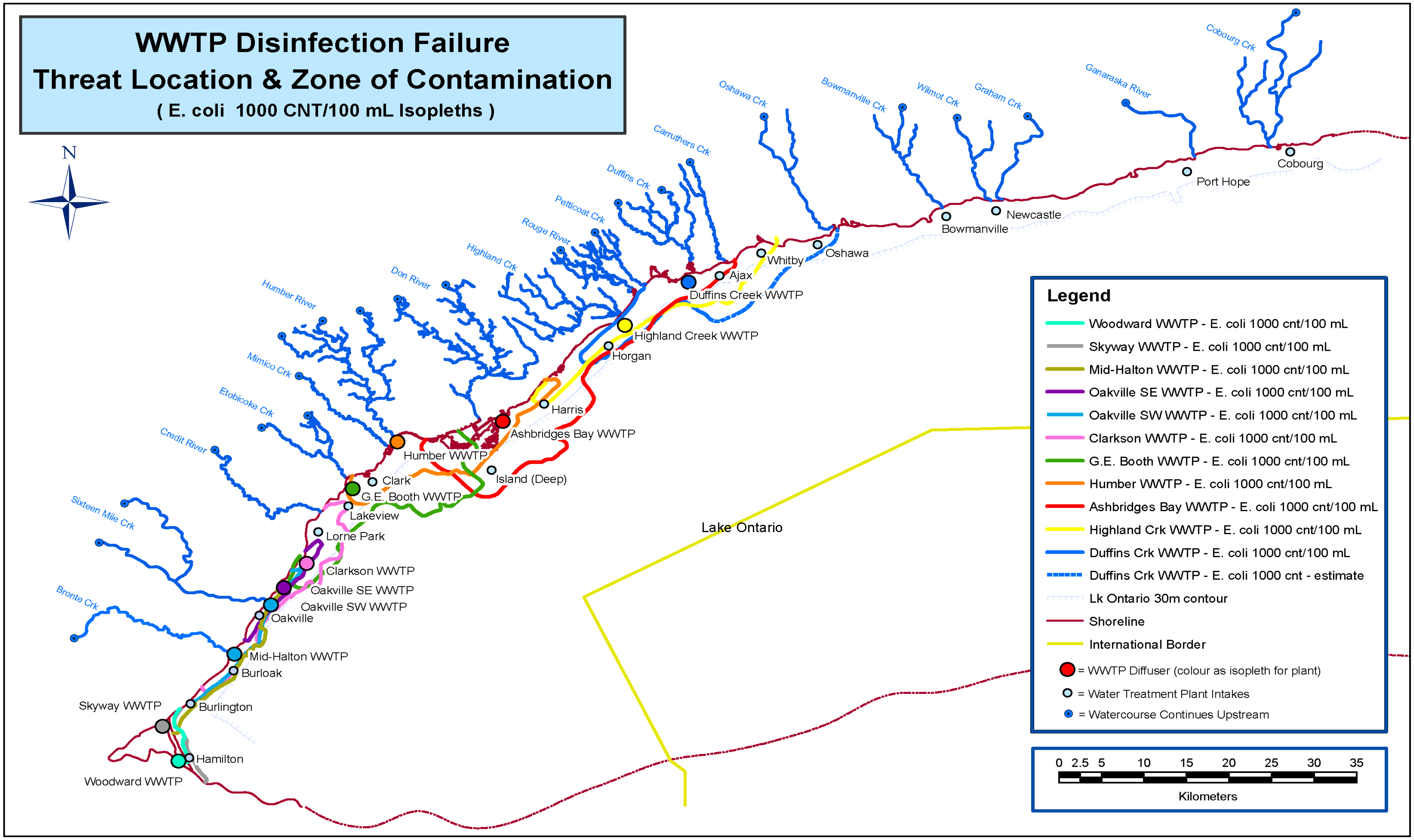


Figure E2.32: WWTP Disinfection Failure Threat Location and Zone of Contamination (*E. coli* 1000 CFU/100 ml Isopleths)
(*Lakeview intake has been renamed, Arthur P. Kennedy)

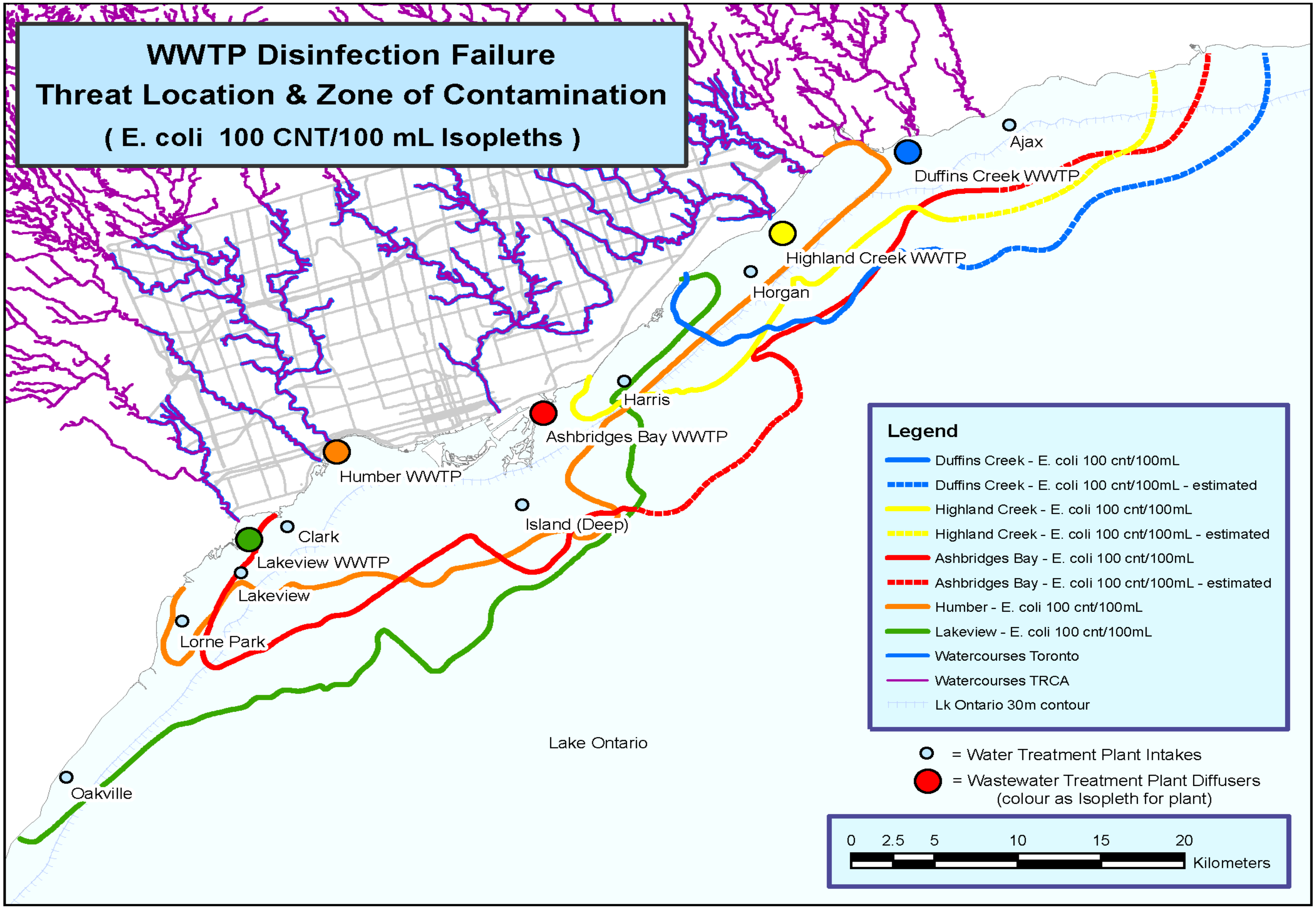


Figure E2.33: WWTP Disinfection Failure Threat Location and Zone of Contamination (E. coli 100 CFU/100 ml Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

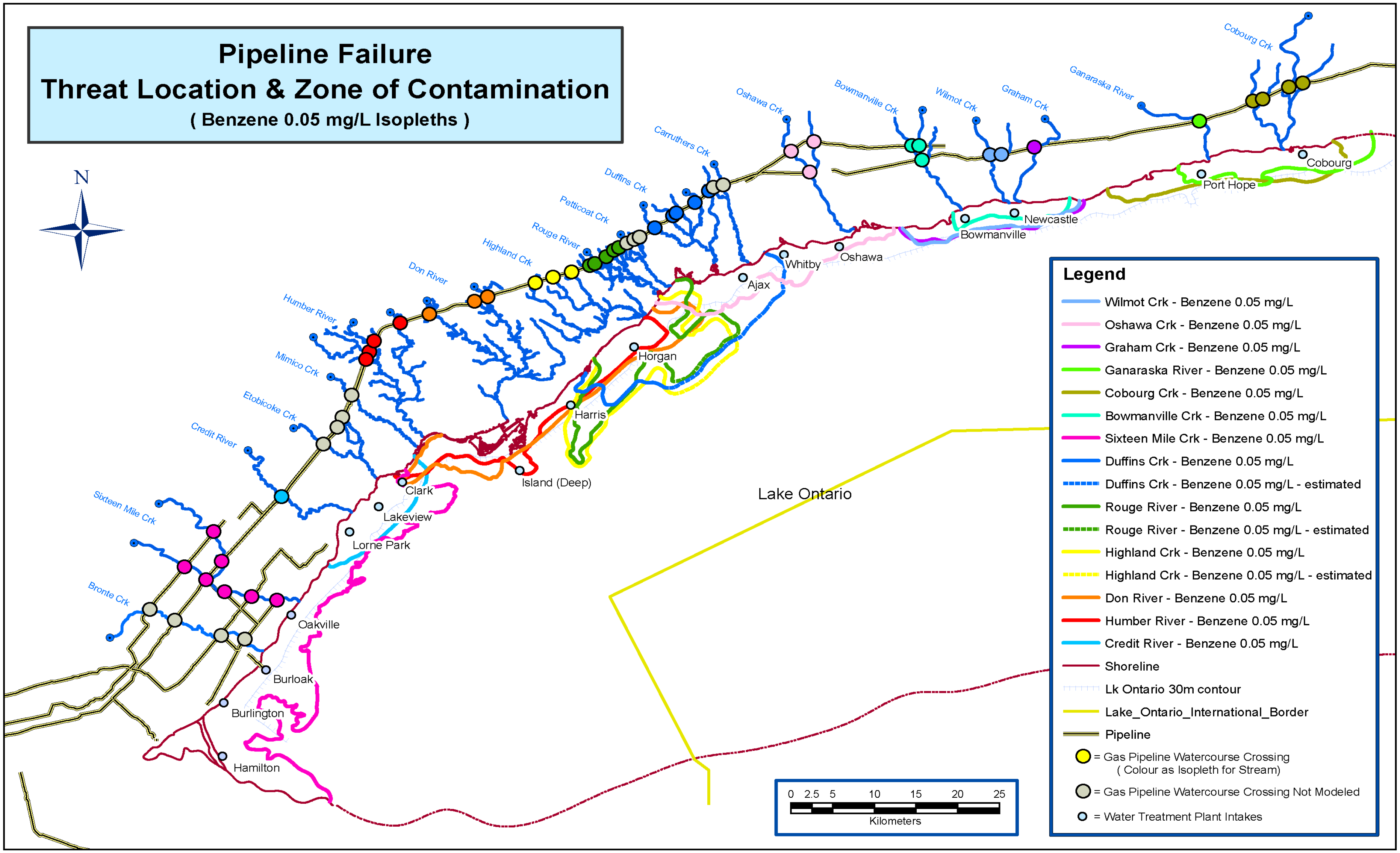


Figure E2.34: Pipeline Failure Threat Location and Zone of Contamination (Benzene 0.05 mg/L Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

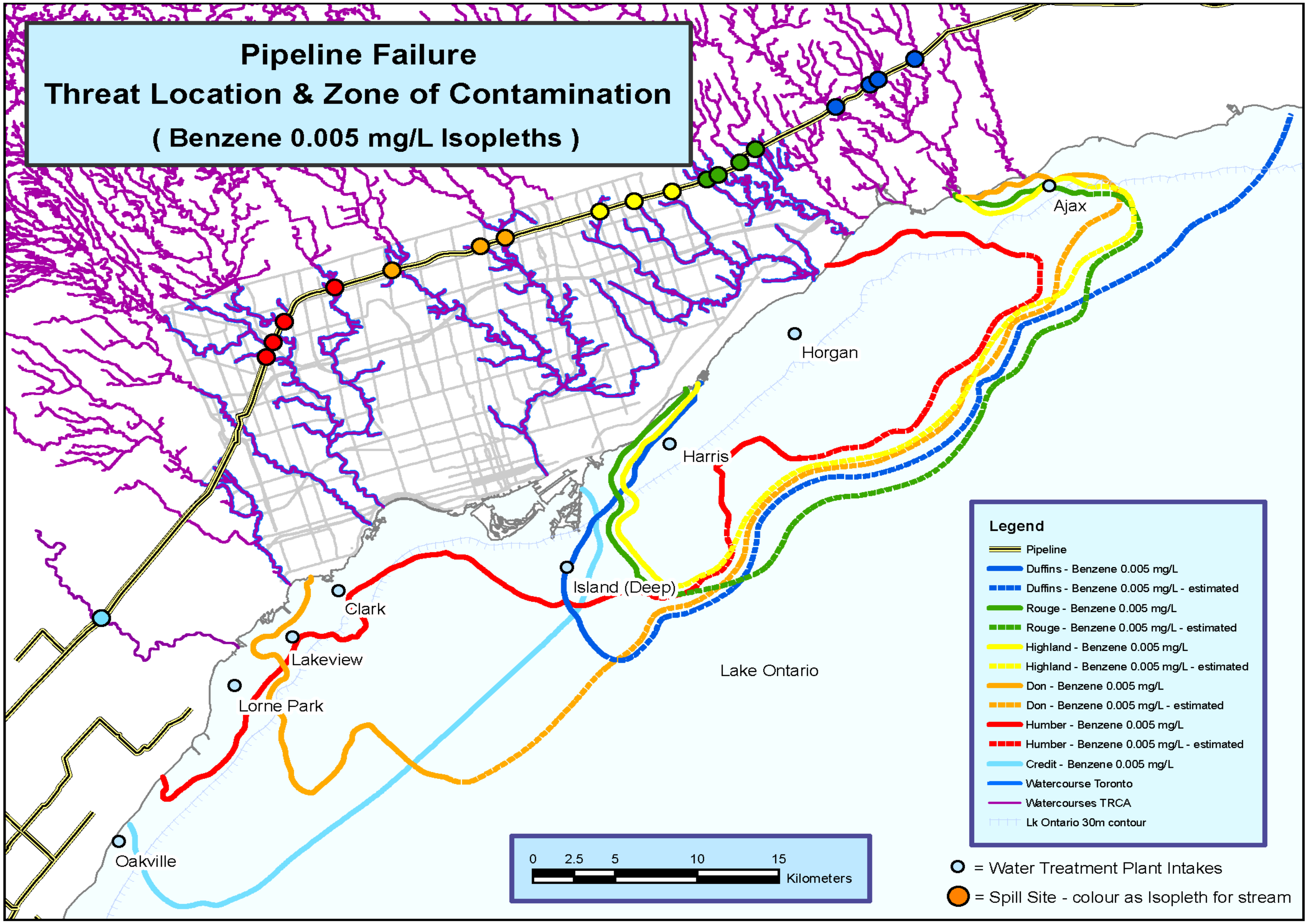


Figure E2.35: Pipeline Failure Threat Location and Zone of Contamination (Benzene 0.005 mg/L Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

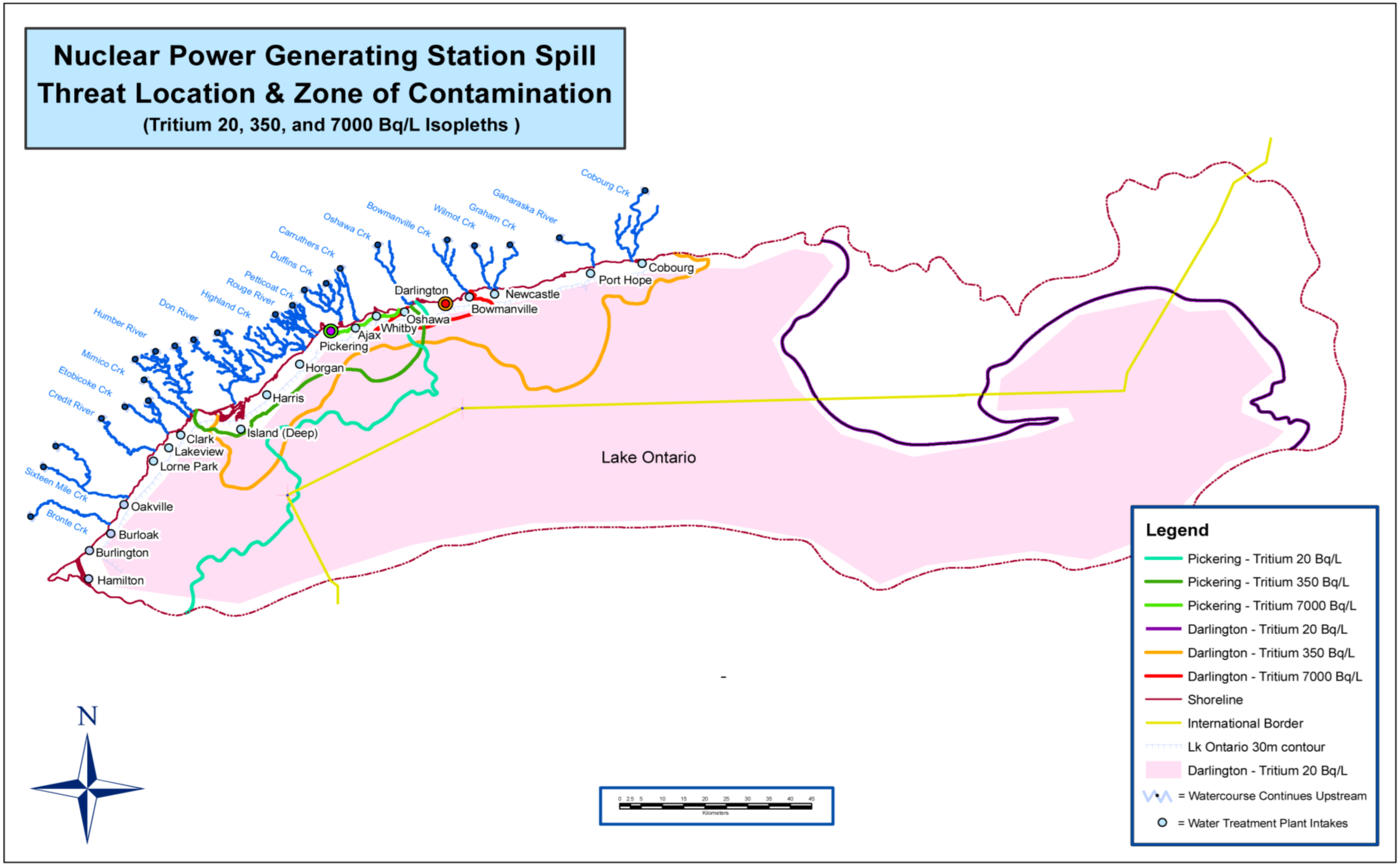


Figure E2.36: Nuclear Power Generating Station Spill Threat Location and Zone of Contamination (Tritium 20, 350 and 7000 Bq/L Isopleths) (*Lakeview intake has been renamed, Arthur P. Kennedy)

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 E2.37** 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** E2-18 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.

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

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 E2-16: *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	0.4	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

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)

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.

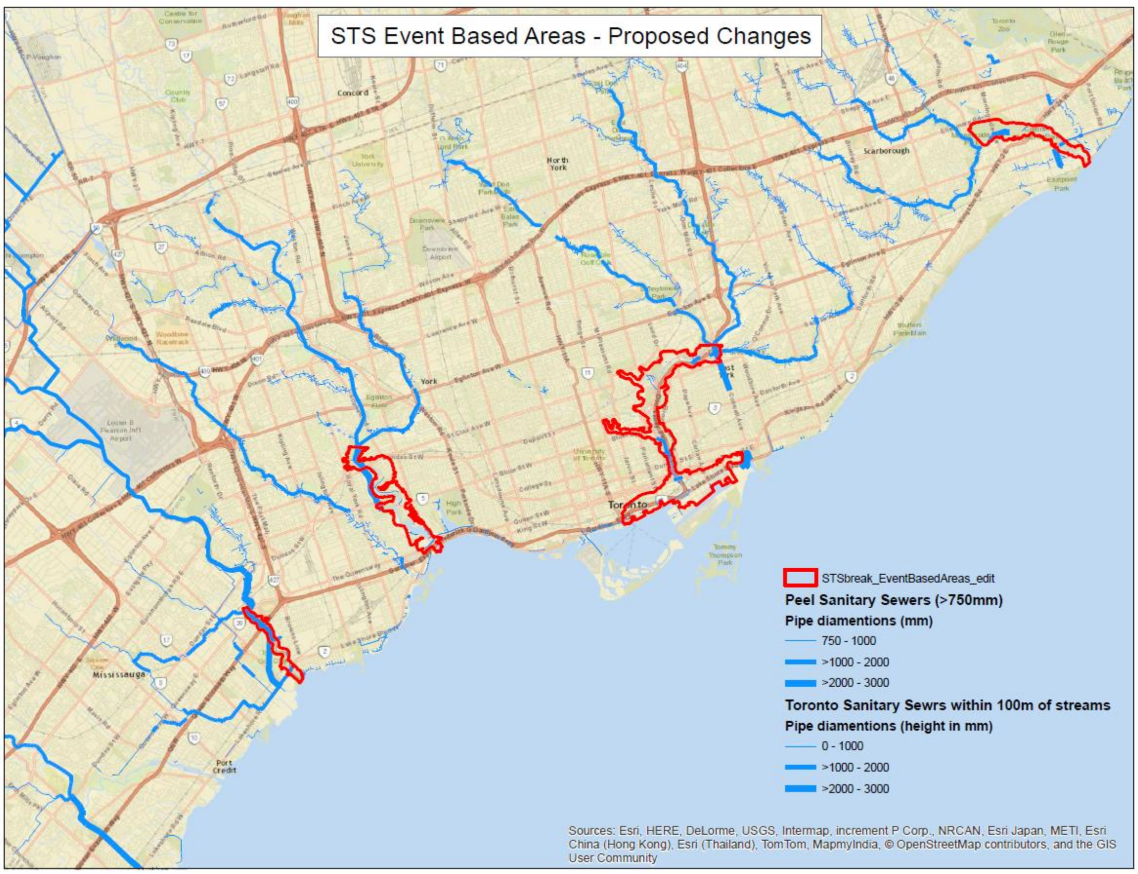


Figure E2.37: Revised STS EBAs for CTC study area (2015)

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.

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

Table E2-18: Uncertainty Assessment

E2.6 REFERENCES

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E2.7 ADDENDUM TO APPENDIX E2

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.

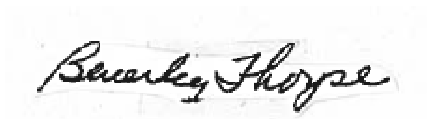
  MODELED CIRCUMSTANCE: The scenario is based on the parameters from the actual tritium spill in 1992 from the Pickering Nuclear Generating Station. The modeled spill scenario resulted in tritium levels exceeding the ODWS at the Whitby and Oshawa intakes. Note a number of other intakes, including all of 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
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
14th Floor
40 St. Clair Ave. West
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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.

1

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
Heather Malcolmson, Manager, Source Protection Planning
Katie Fairman, Supervisor, Source Protection Implementation
John Westlake, Liaison Officer, CTC Source Protection Region
Clara Tucker, Watershed Management Specialist, Source Protection Planning

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

3

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

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