Updated Assessment Report

Sault Ste. Marie Region

Source Protection Area

CHAPTER 4

SURFACE WATER VULNERABILITY ANALYSIS

With Support Provided By

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ASSESSMENT REPORT
SURFACE WATER VULNERABILITY ANALYSIS

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EXECUTIVE SUMMARY

The *Clean Water Act, 2006* (CWA, 2006) requires the mapping and assessment of the natural vulnerability specific to vulnerable areas located within the Sault Ste. Marie Source Protection Area - highly vulnerable aquifers (HVAs), wellhead protection areas (WHPAs) intake protection zones (IPZs) and significant groundwater recharge areas (SGRAs). The natural vulnerability of these areas is assessed and scored on a high, medium, or low scale using approved provincial methodologies. The vulnerability scoring is required as a first step in determining threats to drinking water sources from different land-uses and activities both current and future. Threats are determined using the vulnerability score multiplied by the hazard score assigned to the different activities and their associated chemicals and pathogens, as outlined in Chapter 5.

Intake protection zones (IPZs) for the intake at Gros Cap in Lake Superior have been delineated. The IPZ-1 was delineated based on a 1 kilometre radius from the intake crib. IPZ-2 was delineated using hydrodynamic models to estimate the distance that a contaminant could travel in three hours. The models include such factors as wind direction and speed, stream loadings, and lake currents. There was no consideration of the time required for a contaminant to move from the surface of the water to the intake.

The existing data was assembled for the IPZ-2 investigation: bathymetry, recorded and modeled wind data, modeled currents, tributary flows, water quality information, sediment samples, turbidity information, and shipping records for the St. Marys River and Lake Superior. In addition, the following datasets were collected specifically by the study team: current measurements throughout the water column adjacent to the intake, surface and composite water samples, sediment samples from the lakebed and local tributaries, and stream flow measurements from five local tributaries.

The vulnerability score for IPZ-1 and IPZ-2 determined based on factors set out in the Technical Rules (2009). The IPZ-1 scored a vulnerability of 5 (low). The vulnerability score for IPZ-2 was 4 (low).

The IPZ-3 was determined based on two event-based scenarios within the international shipping lane located on the IPZ-2 boundary. The event-based scenarios have been modelled to determine if a contaminant released from a spill in the shipping channel could be transported to the intake and result in the deterioration of the water for use as a source of drinking water. The results showed that a large volume spill of either Potassic Fertilizer or Fuel Oil from a commercial ship in the shipping lanes would result in an exceedance of drinking water standards at the intake under a simulated westerly wind event.

The assessment report was originally developed under the 2008, 2009 and 2013 versions of the Technical Rules and where updates were made, they were carried out under amendments to the 2017 Rules and 2018 addition of pipelines circumstances to the Table of Drinking Water Threats.

1.0 SURFACE WATER VULNERABILITY

Vulnerable areas for surface water are referred to as Intake Protection Zones (IPZs). For municipalities to protect the area around their intake, they must protect the surrounding water and, in most cases, the land area nearest the intake. Under the CWA, 2006 these areas of water and land are known as Intake Protection Zones (IPZs).

The focus of the CWA, 2006 is the protection of municipal drinking water supplies. A major source of drinking water for the population of the residents of Sault Ste. Marie is drawn from Lake Superior at Gros Cap.

The surface water vulnerability analysis for the Gros Cap Intake located at Lake Superior was undertaken by Baird Associates (Gros Cap Intake Protection Study - *Surface Water Vulnerability Assessment, Phase 1 and 2, 2010 by Baird Associates*). This report contains the foundation technical data and information upon which the summary below has been based. Both reports are presented in **Appendix 1**.

The vulnerability analysis included the characterization of the intake and near shore areas, delineation of IPZ-1 and IPZ-2 zones, and vulnerability scoring to potential contamination. The IPZ-1 is based on a circular area that extends to a 1 kilometre radius from the intake. The IPZ-2 for the intake was delineated using complex *hydrodynamic* models. These computer-based models were constructed using data inputs such as water current direction and speed, wind direction and speed and water temperature profiles.

The Vulnerability analysis includes:
- Characterization of the intake and adjacent land and water;
- Delineation of vulnerable areas around the intake;
- Assessment of vulnerability around intake, and the assignment of vulnerability scores
- Simulation of Spill scenarios in the shipping lane located within IPZ-2

The study also assessed storm-sewer systems (per Technical Rule 65 (2)) and transport pathways (per Technical Rule 72) within the IPZ s, that could potentially allow contaminants to reach an intake.

2.0 INTAKE PROTECTION ZONES DELINEATION

The Gros Cap Intake is located in Lake Superior, about 830 m from shore with a depth of approximately 15 m. The intake screen openings are approximately 2.0 m above the lake bottom. The Intake is classified as Type A Intake under the Technical Rules (2009), as it is associated with an existing municipal drinking water system and is located in a Great Lake.

Under the CWA, 2006 the Province of Ontario requires that three IPZ areas be identified. The size of each area varies depending on circumstances such as where the intake is located, bathymetry, currents, contributing area and loadings. Great Lake intakes are designated type A under the Technical Rules with the associated technical requirements outlined. The following short descriptions clarify the zones around intakes.

Great Lake IPZs associated with the Great Lakes intakes include:

- IPZ-1: This zone represents the area immediately adjacent to the drinking water intake. According to the Technical Rules 61 (1 & 2), it is a circle with a radius of 1 km around the intake crib. It is generally considered the most vulnerable zone because it is close to the intake, and because contaminants discharged within this area are presumably undiluted (**SW Map 1**).

- IPZ-2: This zone represents the area where a spill of a contaminant might reach the intake and the time required for the plant operator to respond. The IPZ-2 for the source protection area is projected to the regulated 120 m zone inward from the shoreline and based on estimating distance a contaminant might move in three hours along the water surface (Rule 65 and 66), calculated from the water intake crib outwards under ten-year storm wind conditions (**SW Map 2**).

- IPZ-3: In the Great Lakes, this zone was calculated as the area that may contribute contaminants to the intake, based on modelling potential spills or releases from a specific facility on the shore, or from rivers or creeks during extreme storm event conditions, such as a 100-year storm event. A 100-year storm is a rainfall event that statistically has a 1% chance of occurring in any given year. The main objective of the Sault Ste. Marie (SSM) IPZ-3 delineation was to determine if a contaminant released from a spill in the shipping channel could be transported to the intake and result in the deterioration of the water for use as a source of drinking water (**SW Map 4**).

The IPZ-1 (1 km buffer) for Gros Cap intake is extended to the shore. For the delineation of IPZ-2 for Gros Cap Intake, the average 10-year wind speed was used to drive the hydrodynamic models. The delineated IPZ-2 for the Gros Cap municipal intake in the Source Protection Area is based on a three-hour time of travel distance from the intake, which is the minimum time needed by a water treatment plant operator to shut down the water treatment plant intake should a problem be identified.

Details on the modelling analysis used to delineate IPZ-2 is summarized in **Appendix 2**, and fully presented in the foundation report referenced above. The model results show that a review of the Y-component (north-south) of the surface currents showed currents to be predominately to the south. A stronger relationship was evident between the measured data and modelled results in the north-south direction compared to the east-west direction (X-component) as the correlation coefficients were determined to be 0.54 and 0.04, respectively. The intake is located at a sufficient distance offshore so it is not influenced by shoreline structures. Adjacent tributaries did not influence current patterns around the intake under analyzed two-year flow events.

The results from the numerical modeling activities indicate that current patterns are most strongly influenced by wind conditions. The analysis indicates that the most severe events are from the west, northwest and southwest. The upstream limit of the IPZ-2 for each tributary is calculated using the residual time of the 3-hour Time of Travel (TOT) at the watercourse mouth and a standard “full bank” high flow event.

The *Clean Water Act, 2006* requires that Assessment Reports list activities that are or would be drinking water threats. Although transportation corridors are not included in the list of activities (Ontario Regulation 287/07), the regulations and Technical Rules (MOE, 2009) provide a mechanism through which Source Protection Committees can identify specific activities such as transportation of specific substances, that are taking place within a transportation corridor. IPZ-3 threats can be considered as per Technical Rule 68. The IPZ-3 study modelled that “contaminants released during an extreme event may be transported to a type A surface water intake”. Extreme event modelling based scenarios of two spills were selected for model simulation.

3.0 SUMMARY – IPZS DELINEATION

The IPZ-2 acts as a secondary protective zone around the IPZ-1. In the event of a spill or acute situation, the treatment facility will have minimal time to respond. Contaminants released in this zone have a high chance of reaching the intake quickly and will have limited time to be diluted prior to reaching the intake.

Delineation of the IPZ-2

The IPZ-2 is defined based on the area that may contribute water to the intake where the time of travel to the intake is equal to or less than the time that is sufficient to allow the operator of the system to respond to an adverse condition in the quality of the surface water (Rule 65). The delineation of IPZ 1 and 2 is presented in **SW Map 1** and **SW Map 2**.

Where the time that is sufficient to allow the operator to respond to an adverse condition in the quality of the surface water is less than two hours, the time of travel to the intake shall be deemed to be two hours (Rule 66). A 3-hour response time has been used for this intake based on the operator survey described in Baird (2008). The operator indicated a 1 hour maximum time for the MOE Spills Action Centre (SAC) to inform the PUC operator if a spill is called into their centre, plus an allowance of 2 hours to shut the WTP down upon notification of a spill. The IPZ-2 is comprised of four areas: the area within each surface water body (in this case, the lake which the intake is located in and an extension up tributaries flowing into the IPZ-2); the area within the storm sewershed of each storm sewer that discharges into the surface water body; a setback inland along the abutted land; and an extension to include areas that contribute water to the IPZ-2 through transport pathways (Rules 65 and 72-74).

Delineation of each of the areas that comprise the IPZ-2 is described in this section. Storm sewersheds are not present in the IPZ-2 are and were therefore not included in the IPZ-2 delineation.

The reverse particle tracking model was run with the 10-year return period winds for directions N clockwise through NW (at 45 degree intervals). The model was run until steady state was reached, for each direction (in each case this occurred within 24 hours). This provides a scientifically defensible definition of the hydrodynamic conditions used to delineate the IPZ-2. The limits of the 3-hour travel time used to delineate the IPZ-2 and it crosses into the International Shipping Lane.

There are two tributaries that flow into Lake Superior within the in-lake limits of the IPZ-2: Jackson Creek, and an un-named tributary east of the Gros Cap intake. The IPZ-2 extends 710 m upstream in Jackson Creek, to where it connects with a small water body. With an estimated bank full velocity of 4.27 m/s, the travel time upstream is 2.8 minutes to the lake

Delineation of the IPZ-3

The two spills selected for IPZ-3 modelling included a positively buoyant substance (fuel oil) and a negatively buoyant substance (potassic fertilizer). Fuel oil is less dense than water therefore the plume would tend to remain at the surface. Potassic fertilizer is heavier than water and would tend to sink and mix through the water column. Details on the simulation analysis used to delineate IPZ- 3, is summarized in **Appendix 3.**

The hydrodynamic model was setup to simulate a spill event for three potential scenarios:

1. Fuel oil spill at the surface (Positively Buoyant);
2. Potassic fertilizer spill at the lake bed (Negatively Buoyant);
3. Hypothetical spill, fully mixed through water column (Neutrally Buoyant)

The selected spill volumes were released at a constant rate over a period of one hour. Constant concentrations of 1000 mg/L were assumed for all runs and the impact at the intake was documented in the form of dilution estimates. The concentration represents an arbitrary value used to determine dilution estimates for each scenario. Results of all three scenarios are presented in Appendix 3.

4.0 VULNERABILITY SCORING

The vulnerability score is derived by using an equation as per Technical Rule 87. Area vulnerability factors are assigned to each IPZ according to its susceptibility to becoming contaminated. An IPZ-1 is always assigned a score of 10 (Technical Rule 88), while the area vulnerability factor for IPZ -2 is assigned by a value ranging between 7 and 9 using professional judgement (Technical Rule 89). A source vulnerability factor is assigned, depending upon the type of intake, the depth and length of the intake, and number of past incidences exceeding the water quality guidance/standards. For Great Lakes (Type A) intakes, the source vulnerability factor ranges between 0.5 and 0.7 (Technical Rule 95).

A summary of the professional judgement considerations, and detailed analysis used in assessing vulnerability for SSMR SPA intake, is provided in Table 4.1 from **Appendix 2** and are presented here in. The resulting vulnerability score for IPZ-1 for Gros Cap Intake is considered low (5). The vulnerability score for IPZ-2 is also considered low (4). The vulnerability scoring is displayed on **SW Map 3**.

Table 4.1: Summary of Vulnerability Scores for Gros Cap Intake

Intake Type	Area Vulnerability Factor (B)		Source Vulnernability Factor (C)	Vulnerability Score (V)	
	IPZ-1	IPZ-2		IPZ-1	IPZ-2
Great Lakes	10	8	0.5	5	4

5.0 UNCERTAINTY ASSESSMENT

An uncertainty assessment was undertaken for the delineation of IPZ-1 and IPZ-2 for the Gros Cap municipal intake (Technical Rules 108 and 109). The uncertainty associated with delineation of IPZ-1 is low as this is a fixed radius of one kilometre around the intake crib. The assessment indicated that the uncertainty for the IPZ-2 delineation is “high” due to the limitations of the hydrodynamic lake modelling process. This is to be expected since constructing a model for a large, complex water body, such as Lake Superior, requires an extensive amount of data and is based on numerous assumptions regarding wind speed, direction, and duration, barometric pressure, temperature, as well as inputs from the tributaries that drain into Lake Superior.

Uncertainty associated with the IPZs delineation and vulnerability score, for Gros Cap Intake is shown in **Table 4.2**. Additional information on modeling limitations and a discussion of the factors influencing the uncertainty is presented in **Appendix 2**.

Table 4.2: Summary of Uncertainty Assessment

Zone	IPZ - 1	IPZ - 2
IPZ Delineation	High	High
Vulnerability Score	Low	Low
Combined Rating	High	High

6.0 SUMMARY

The CWA, 2006 requires the mapping and assessment of the natural vulnerability of intake protection zones. These areas can be vulnerable based on water quantity or water quality considerations, or both. The natural vulnerability of these areas is assessed and scored high, medium, or low, using approved provincial methodologies. The vulnerability scoring is required as a first step in determining the threat to drinking water sources from different land-uses and activities both current and future. Threat is determined using the vulnerability score multiplied by the hazard score assigned to the different activities and their associated chemicals and pathogens, as outlined in Chapter 5.

Intake protection zones (IPZs) of Gros Cap Intake have been delineated. The IPZ-1 is delineated based on a 1 km radius from the intake crib. IPZ-2 was delineated using hydrodynamic models to estimate the distance that a contaminant could travel in three hours. The models include estimating such factors as wind direction and speed, stream loadings, and lake currents. There was no consideration of the time required for a contaminant to move from the surface of the water to the intake (the depth of the intake in SSMR SPA ranged from 10 metres to 18 metres below surface). The vulnerability for IPZ-1 and IPZ-2 areas were scored based on factors set out in the Technical Rules (2009). The IPZ-1 located in the SSMR SPA jurisdiction has been scored 5 (low vulnerability). The vulnerability score for IPZ-2 was 4 (low vulnerability).

Two spills were selected for modeling: a fuel oil spill of 11,519 m^3 and a potassic fertilizer spill of 22,644 m^3. These represent positively and negatively buoyant materials, respectively. In addition, model runs were undertaken using a neutrally buoyant material for comparison. The dilution estimates determined from the numerical models, concentrations at the intake were calculated for those constituents that had a drinking water standard. The results showed that a large volume spill of either potassic fertilizer or fuel oil from a commercial ship in relatively close proximity to the intake (approximately 3.2 km) exceeded the drinking water standards at the intake under the westerly wind event simulated in this study. The IPZ-3 may extend further but that modeling has not been undertaken due to complex bathymetry, difficulty in predicting the currents and the jurisdiction of Source Protection Area.