



Evaluating Climate Impacts on Closed Contaminated Sites

→ A Review of Associated Risk

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The Concept and The Outcome

Assess potential impacts of climate change on select closed federally – managed sites by completing the following deliverables:

- 1) Confirm if the site was closed through risk management.
- 2) Where risk management was used (ie. contamination is still present at the site), identify climate hazards / impacts that could have impacted the site conditions.
- 3) Make recommendations of how likely an impact to the site has occurred since closure.

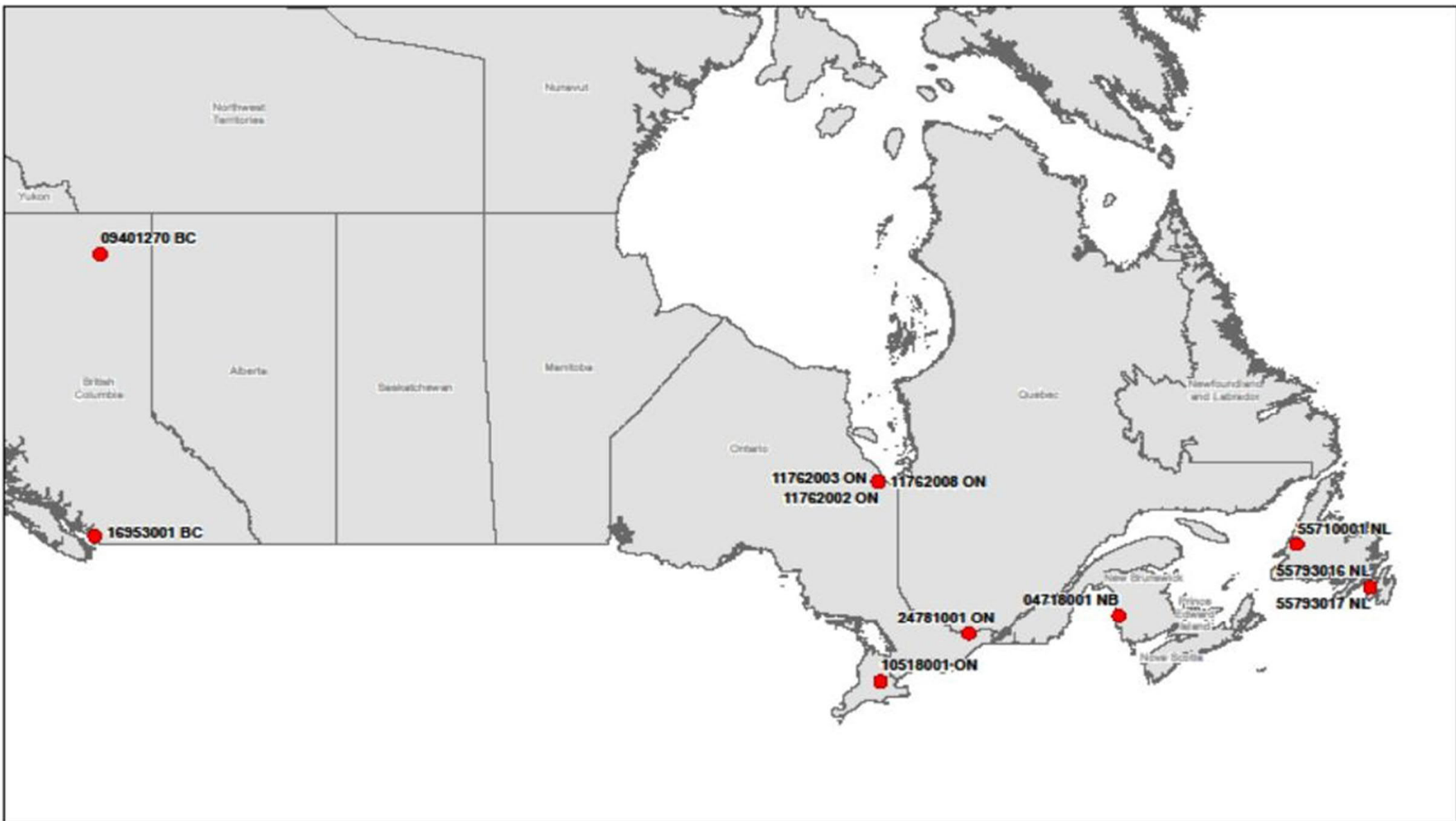
A scalable risk evaluation matrix which incorporates basic site condition review including:

- Contaminants of concern
- Site conditions
- Closure mechanisms

With review of climate data:



- Historical climate events and data
- Climate change projection models

To establish a risk factor for previously closed contaminated sites based on climate change.



Step 1

→ Site Conditions and Closure Review

<p>Area C: Auto Shop Building, Mooseonee, Ontario</p> <p>Site Location</p> <p>51.2865930103526, -80.6257249294005</p> <p>Coordinates</p>	<p>Google Maps View</p> 	<p>Site Description</p> <p>The former radar base is located approximately 250 m west of the Moose River, towards the northern edge of the community of Mooseonee, Ontario. The radar base was approximately 45 hectares in size and was divided into military and residential areas. Originally, the military component of the site was occupied by over 30 buildings, including radar towers, a central heating building, soldiers' barracks, officer's houses, a water treatment plant, mess halls and other buildings. Currently there are less than 20 of the original buildings remaining. The Town of Mooseonee currently owns a number of the properties within the former military base. Current land uses include a vehicle maintenance shop, scrap metal storage, concrete production, secondary schooling, and other small businesses. The residential area of the radar base is owned by the Town of Mooseonee and is not included in the current study.</p>	<p>Report Findings</p> <p>Executive Summary - Results</p> <p>Current and historical laboratory data was first compared to generic CCME Tier I criteria. Exceedances were then compared against site specific CCME Tier II criteria. Based on the Tier II assessment, no exceedances of any CCME Tier II human health related criteria were found within the area of concern at the site and therefore a human health SRA is not required. Exceedances of Tier II environmental health criteria for the Eco Soil contact pathway were observed at the Auto Shop / Scrap Metal Yard (CS 003). The estimated volume of impacted soil exceeding the CCME Tier II Eco Soil contact CS003 - 1710 m³. As groundwater in the area is not used for drinking water, comparison to MOE drinking water criteria is appropriate, since CCME does not have water criteria. No exceedances of MOE drinking water criteria were identified in groundwater.</p>
<p>Photo 2: Contaminated Site CS005-PAOC 17 & 16, looking south (July 24 2006)</p>		<p>A Phase I ESA conducted by CH2MHill in 2000 identified 26 Potential Areas of Concern (PAOC) within the former radar base which were grouped into 10 areas A through J. The current investigation is focused on 5 of the 10 areas, all located within the west half of the radar base. Each of the 5 areas has been assigned a Contaminated Site (CS) number by PROS for all future reference. The areas, with corresponding contaminated site numbers and potential areas of concern include:</p>	<p>Summary of Contaminated Site 003</p> <p>All groundwater concentrations within Contaminated Site 003 were below MOE non-potable criteria. An estimated volume of impacted soil exceeding CCME Tier II criteria identified at Contaminated Site 003 (Figure 5) includes 110 m³ at Building 82 (PAOC 16), 108 m³ at Building 23 (PAOC 15), 30 m³ at PAOC 17, 1,170 m³ at PAOC 18, and 400 m³ within the access road area for a total of 1818 m³. Application of CCME Tier II site specific criteria to data collected by KGS Group in 2004 and CH2MHill in 2002 and 2001 has revealed all identified surface and subsurface impacts are below Tier II criteria for applicable human health related pathways. Thus a human health related SRA is not required for Contaminated Site 003. As criterion for the Eco Soil contact pathway (environmental health) was exceeded, Contaminated site 003 is included in the</p>
<p>Additional Subsurface Investigation, Historical Data Review and Screening Level Risk Assessment, former DND Radar Base, Mooseonee, Ontario, KGS Group, March 28, 2005</p>	<p>Climate Change Impacts</p> <p>Precipitation: Total precipitation has increased by approximately 1 mm between the pre-closure (2002-2021) and closure to present day (2022-2021) periods. Annual precipitation is projected to increase by an additional 17mm within the (2023-2040) period. Comparison of historic and future IDF curves show an increase in intensity of precipitation events over the historic and future (2021-2050) time horizons.</p> <p>Temperature: Minor increases to average and maximum temperature have been observed in the pre-closure (2002-2011) and present day (2012-2021) periods. Mean temperature is projected to increase by 1.27C relative to the baseline within the projected (2023-2040) period.</p> <p>Sea Level Rise: Recent SLR data (2020) indicates that local sea levels have decreased by approximately 14.48 cm relative to 1990 baseline. SLR is projected to continue to decrease to 25.75 cm by 2042.</p> <p>All data sourced from: https://climate.data.ca</p>	<p>Site Closure Plan</p> <p>Remediation involved excavation of soils with PHC and BTEX impacts and removal off-site to a former closed landfill in west Mooseonee. Contamination remains beneath the auto shop foundation. It was recommended to be removed however, will require partial demolition of the building or supporting the building while excavating beneath it. The extent of the impact not known. Further investigation of impact associated with the building location would also involve interior inspection for sump/floor drainage/water separator, placement of interior borings and exterior test pits. Additionally, the limit of the PHC/BTEX contamination beyond the eastern limit of excavation EX2 is currently unconfirmed. There are two options to address this issue which include the completion of a limited test-pitting program in the area immediately east of the former recreation eastern side wall) to evaluate the volume of impacted soil remaining in this area. This would include the removal of metal debris in this area to access the soil. The second option includes the completion of a risk assessment to evaluate the risk associated with the remaining impacted soil in the immediate area within the southeast portion of PAOC 18. Closure was based on confirmatory samples from 16 borings and four other excavation which met applicable MOE and CCME Tier II industrial use and site specific values.</p>	<p>Flooding</p> <p>There have been no recorded flooding events directly impacting the site.</p> <p>Government of Canada Flood Archive, 2021 https://open.canada.ca/data/en/dataset/144824-2068-4cea-9f89-72915a128189</p> <p>Fire</p> <p>There have been no wild fire events directly impacting or in close proximity of the site since closure.</p> <p>Canadian National Fire Database (CNFD), 2023. https://ovfils.fds.nrcan.gc.ca/haz/0/</p> <p>Climate</p> <p>Since closure, the site has not been impacted from drought conditions.</p> <p>Canadian Drought Monitor (CDM), 2023. https://open.canada.ca/data/en/dataset/47292466d-619f-4200-af1-8b2c3199442</p> <p>The drought areas are classified as follows:</p> <p>D0 (Abnormally Dry) -- represents an event that occurs once every 5-5 years;</p> <p>D1 (Moderate Drought) -- represents an event that occurs every 5-10 years;</p> <p>D2 (Severe Drought) -- represents an event that occurs every 10-20 years;</p> <p>D3 (Extreme Drought) -- represents an event that occurs every 20-25 years; and</p> <p>D4 (Exceptional Drought) -- represents an event that occurs every 50 years.</p> <p>Extreme Weather Events</p> <p>Since closure there has been 19 recorded days with strong wind gusts:</p> <p>2013: 9 2014: 2 2015: 3 2016: 3 2017: 2 2018: 2 2020: 2 2022: 2</p> <p>Strong wind categorized by being Greater than level 6 on the Beaufort Wind Scale, which is the wind speed (75km/h) where structural damage is likely.</p> <p>Government of Canada Historical Weather Database, 2023. https://climate.weather.gc.ca/historical_data/search_historic_data_e.html</p>
<p>Potential Impacts of Climate Change on Closure</p>	<p>Google search showed that spring flooding is common in Mooseonee, ON (May 2013 and May 2014 articles indicating flooding and evacuation of Mooseonee residents due to flooding conditions). PHC impacted soil is still present on site and both the extent of impact and concentration of PHC are unknown. Further investigation and remediation for this site was recommended. While the likelihood of climate change hazards occurring is very low, seasonal flooding events may impact the closure plan. The unknown.</p>		

Metrics which were evaluated as part of Step 1 were:

- Site description and location
- DFRP and FCSI #
- Site plans and figures
- Report findings
- Site closure plan
- Year site closure was obtained

Think high-level conceptual site model review and understanding ...

This involved an extensive review of environmental site assessment reports and site closure documentation on a site-by-site basis.

Step 2

→ Evaluate Climate Data

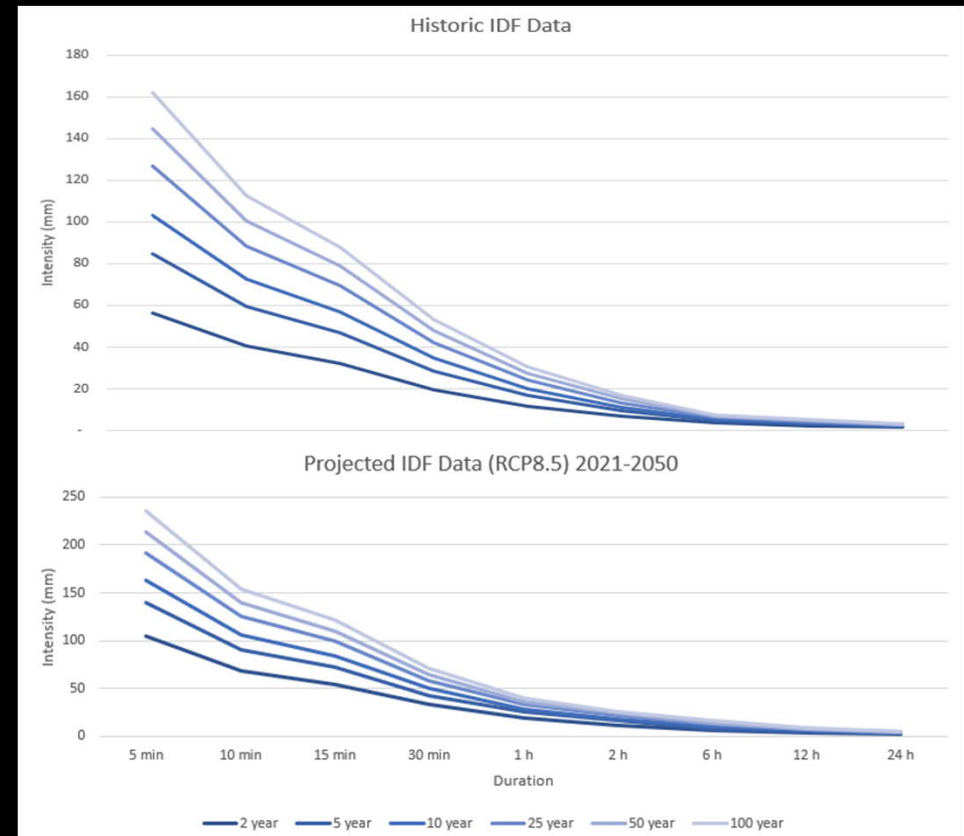
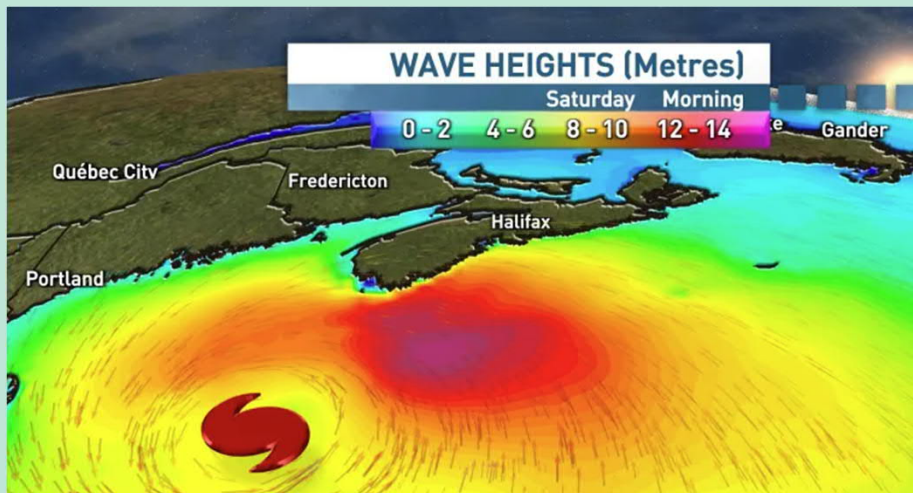


“What does climate change look like to you?”

Two-factor authentication?

Take real-world, measurable data...

- Data collected since site closure, pre-site closure.
- Precipitation (min, max, totals)
- Temperature (mean, high, lows)
- Sea level rise and flood events
- Droughts and forest fires
- Hurricanes, tropical storms, high wind events



... and pair it with climate modelling and projections of future climate trends

- IDF curves (using various RCP models)

Step 3

- Evaluate Potential Climate Impact on Site Closure Mechanisms

Factors to Consider

- What was the media impacted at the subject site?
- Was the site closed via remediation and source removal of contamination?
- Was the site closed via a risk management approach?

11	Sites across Canada reviewed during the program lifecycle
8	Total sites were closed via risk assessment / management
5	Sites posed negligible risk to climate change impacts
6	Sites exhibited low to high risk for climate change impacts



From the site review and through discussion with PSPC, the risk matrix was established based on two conditions:

Likelihood of Occurrence of Climate Change Hazard
and
Consequence of Climate Change Hazard

Consequence of Climate Change Hazard

Very High	Moderate Risk	High Risk	High Risk	Extreme Risk	Extreme Risk
High	Low Risk	Moderate Risk	High Risk	High Risk	Extreme Risk
Moderate	Low Risk	Low Risk	Moderate Risk	High Risk	High Risk
Low	Negligible Risk	Low Risk	Low Risk	Moderate Risk	Moderate Risk
Very Low	Negligible Risk	Negligible Risk	Low Risk	Low Risk	Low Risk
	Very Low	Low	Moderate	High	Very High

Likelihood of Occurrence of Climate Change Hazard

<p>11762002</p> <p>Remediation involved excavation of soils with PHC and BTEX impacts and removal off-site. Lateral excavation at the northern wall was limited by a building foundation and no sampling was conducted under building to delineate extent of contamination. Closure was based on confirmatory samples from sidewalls and floor after excavation which met applicable MOE and CCME Tier II industrial use and site specific values.</p>	<p>Recent SLR data (2020) indicates that local sea levels have decreased by approximately 14.44 cm relative to 1990 baseline. SLR is projected to continue to decrease to 25.75 cm by 2040.</p> <p>Total precipitation has increased by approximately 21mm between the pre-closure (2010-2019) and closure to present day (2020-2022) periods.</p> <p>Minor increases to average and maximum temperature have been observed in the pre-closure (2010-2019) and present day (2020-2022) periods. Mean temperature is projected to increase by 1.09°C relative to the baseline within the projected (2023-2040) period.</p> <p>There have been no recorded flooding events directly impacting the site, however, there have been previous spring flooding events within close proximity to the site.</p> <p>There have been no wild fire events or drought conditions directly impacting or in close proximity of the site since closure.</p> <p>Since closure there has been 4 recorded days with strong wind gusts.</p> <p>The likelihood of a climate change hazard occurring on site is low and the risk of impact on site closure is negligible as the impacts to soil in this area were relatively shallow (15 - 25 m) and the area has been remediated.</p>	<p>Negligible Risk</p>	<p>Low - Likelihood of Occurrence of Climate Change Hazard</p> <p>Very Low - Consequence of Climate Change Hazard</p>	<p>024010270</p>	<p>Arsenic and selenium were in exceedance in soil but determined to indicate background soil concentrations. Toluene and naphthalene were also in exceedance in soil.</p> <p>Dissolved magnesium, sodium, and uranium were in exceedance in groundwater but determined to be from background sources. Benzene, ethylbenzene and toluene also exceedances were present in the western extent of the excavation area on site, but concentrations were determined to be either stable or decreasing.</p> <p>The soil vapour and indoor air samples were analysed for BTEX, VPH and VOCs and no exceedances were noted.</p> <p>Within the ERA, it was previously determined that the presence of styrene posed a risk to the dusty shrew, however the concentration was not above CCME guidelines so the risk was determined to be acceptable. Based on the assumptions and scenarios employed in the H-FRA, previously identified risks of naphthalene exposure for recreation centre workers was considered acceptable as no exceedances were found in further assessments of soil vapour. Previously identified risk of benzene exposure for construction workers in a trench setting were considered acceptable after updates to BC MOE Guidance.</p>	<p>Changes to sea level were determined to not be relevant for the site.</p> <p>Total precipitation has increased by approximately 14 mm between the pre-closure (2010-2019) and closure to present day (2020-2022) periods. Annual precipitation is projected to increase by an additional 14 mm within the 2023-2040 period.</p> <p>Minor increases to average and maximum temperature have been observed in the pre-closure (2010-2019), closure to present day (2020-2022) and projected (2023-2040) periods.</p> <p>There have been no recorded flooding events directly impacting the site, however, there have been previous seasonal flooding events within close proximity to the site.</p> <p>There have been no wild fire events directly impacting or in close proximity of the site since closure.</p> <p>Since closure, the site has been impacted by level D1 and D2 drought events in 2022.</p> <p>Since closure there has been 4 recorded days with strong wind gusts, taking place between 2021 and 2022.</p> <p>Potential climate change hazards, such as increases to precipitation or possible seasonal flooding events, pose a negligible risk to the site closure method. Groundwater, soil and soil vapour levels are acceptable and it is there is a low likelihood of climate change hazards occurring at the site.</p>	<p>Negligible Risk</p>	<p>Low - Likelihood of Occurrence of Climate Change Hazard</p> <p>Very Low - Consequence of Climate Change Hazard</p>
<p>11762003</p> <p>Remediation involved excavation of soils with PHC and BTEX impacts and removal off-site. Contamination remained beneath the auto shop foundation and it was recommended to be removed however, would require partial demolition of the building or supporting the building while excavating beneath it. The extent of the impact is not known. Further investigation of impact associated with the building location would also involve interior inspection for sumps/floor-drains/roll-water separators, interior boreholes and exterior test pits. Additionally, the extent of impact on the eastern side of the excavation is not known as metal debris in the area prevented further excavation. Closure was based on confirmatory samples from sidewalls and floor after excavation which met applicable MOE and CCME Tier II industrial use and site specific values.</p>	<p>Recent SLR data (2020) indicates that local sea levels have decreased by approximately 14.44 cm relative to 1990 baseline. SLR is projected to continue to decrease to 25.75 cm by 2040.</p> <p>Total precipitation has increased by approximately 1mm between the pre-closure (2002-2011) and closure to present day (2012-2022) periods. Annual precipitation is projected to increase by an additional 17mm within the 2023-2040 period. Comparison of historic and future IEP curves show an increase in intensity of precipitation events over the historic and future (2021-2050) time horizons.</p> <p>Minor increases to average and maximum temperature have been observed in the pre-closure (2002-2011) and present day (2012-2022) periods. Mean temperature is projected to increase by 1.27°C relative to the baseline within the projected (2023-2040) period.</p> <p>There have been no recorded flooding events directly impacting the site, however, there have been previous spring flooding events within close proximity to the site.</p> <p>There have been no wild fire or drought events directly impacting or in close proximity of the site since closure.</p> <p>Since closure there has been 19 recorded days with strong wind gusts, with an average of 2 a year.</p> <p>While the Site was closed due to confirmatory post-remedial sampling of the excavation area, unknown extent of contaminated soil remain on site under the automotive garage building and at the eastern portion of the excavation. While the likelihood of climate change hazards occurring is very low, seasonal flooding events may impact the closure plan. The unknown extent of remaining soil impacts may act as a smear zone during flooding events.</p>	<p>Low Risk</p>	<p>Very Low - Likelihood of Occurrence of Climate Change Hazard</p> <p>Moderate - Consequence of Climate Change Hazard</p>	<p>10193001</p>	<p>There is a shallow (2 m) and fluctuating water table with LEPA and naphthalene impacts remaining in groundwater. It was determined that the contamination plume is generally receding with seasonal contaminant concentration fluctuations. It was suggested that there is residual soil contamination that created a smear zone which led to the seasonal fluctuations, however this has not been investigated and/or delineated.</p> <p>It was concluded that there were no unacceptable ecological or human health risks. Previously noted pathways for contaminant migration to off-site ecological receptors were no longer of concern as it was determined that there was low risk to migration due to mobility characteristics and that the nearest aquatic ecological receptor was far enough away (600m).</p> <p>Report recommended site be closed with additional monitoring if site conditions change in the future.</p>	<p>Recent SLR data (2020) indicates that local sea levels have increased by approximately 5.33cm relative to 1990 baseline. SLR is projected to increase to 12.25cm by 2040.</p> <p>Total precipitation has increased by approximately 20cm between the pre-closure (2003-2012) and closure to present day (2013-2022) periods. Annual precipitation is projected to increase by an additional 10cm within the 2023-2040 period.</p> <p>Minor increases to average and maximum temperature have been observed in the pre-closure (2003-2012), closure to present day (2013-2022) and projected (2023-2040) periods.</p> <p>There have been no recorded flooding events directly impacting the site. However, in 2018 and in 2021 there were recorded flooding events in close proximity to the site. Atmospheric rivers frequently occur in the region.</p> <p>There have been no wild fire events directly impacting or in close proximity of the site since closure.</p> <p>Since closure, the site has been impacted by numerous recorded drought events: D1 - 2012, 2014, 2015, 2016, 2017, 2018, 2019, 2021, 2022; D2 - 2015, 2021, 2022; D3 - 2015.</p> <p>Since closure there has been 116 recorded days with strong wind gusts, taking place between 2012 and 2022.</p> <p>Potential climate change hazards pose high risk to closure method. The likelihood of increases to precipitation, drought events and sea level hazards is high. There is also potential for flooding and atmospheric river events. While it was determined that there were no unacceptable risks to ecological or human health, the risk of impact from climate change hazards is moderate due to the shallow nature of residual groundwater contamination and documented fluctuations in contaminant concentrations. This results in a high risk to impact on site closure.</p>	<p>High Risk</p>	<p>High - Likelihood of Occurrence of Climate Change Hazard</p> <p>Moderate - Consequence of Climate Change Hazard</p>

What does this all mean?



By reviewing site conditions and closure mechanisms in conjunction with climate data and climate projections, a scalable means of evaluating a risk factor associated with climate change is achievable.

Standardized alignment for risk weight / rating would allow for integration of this matrix into many practices and applications.



*** Thank You**

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