

# Bear Brook Watershed Study – Natural Hazards Characterization Report

January 2025

Prepared for:



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## Summary of Findings

Ontario's Provincial Policy Statement aims to achieve long-term economic prosperity, environmental health, and social well-being while reducing public cost and risk by directing development away from areas where there is risk of property damage or risk to public safety. One of South Nation Conservation's (SNC) legislated mandates is protecting life and minimizing property damage from flooding and erosion. As such, SNC works with partner municipalities to ensure the identification and delineation of these hazards following provincial and federal guidelines through responsibility under the *Conservation Authorities Act* and corresponding Ontario Regulation 41/24.

Hazard mapping studies across the Bear Brook Watershed have identified that the combination of sandy soils with rapid water infiltration and clay-rich soils with high surface runoff creates conditions that make the landscape vulnerable to flood and erosion hazards.

Riverine flood mapping, including the regulated 100-year floodplain, has been updated or newly developed for several watercourses in the Bear Brook Watershed by SNC. Additional storm analysis provides information on flood risk through mapping different return periods, as well as mapping vulnerable structures exposed to these flood hazards.

Vulnerability assessments in areas where flood hazards have been studied have identified that no critical buildings are impacted by any flood events, while 121 buildings (homes, business or outbuildings) could be impacted within a 350-year flood extent in the Bear Brook Watershed. These assessments also identified that many driveways and roads are vulnerable to different sized flood extents, from a 2-year event up to a 350-year event.

A large floodplain exists between Carlsbad Lane and McNeely Road in one of the paleochannels of the Ottawa River. Here, flow spills out of the main channel of Bear Brook River even during high-frequency storm events. Flooding along this section of river has been well documented over time, especially during the spring freshet when flows are expected to be higher due to melting snow combined with rainfall. This area was studied through a 2D flood modelling project in 2021 and will form an important component of land use decision making and future flood mitigation planning.

Erosion hazard was also delineated along several watercourses in the Bear Brook Watershed. This includes the study of setbacks required for unstable slopes, toe erosion, watercourse meanders, and erosion access allowance. Unstable soils were also investigated. Findings from the current characterization report underscore landslides and erosion as potential hazards within the Bear Brook Watershed. Landslides are especially concerning given the watershed's sensitive clay soils and the potential for retrogressive slides in areas near river valleys and slopes. Potential landslide areas have been screened across the full Bear Brook Watershed by SLR Consulting (Canada) Ltd.

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## Natural Hazards in the Bear Brook Watershed

The Provincial Planning Statement issued under the *Planning Act* provides policy direction on matters related to land use planning and development. To achieve long-term economic prosperity, environmental health, and social well-being, a reduction of public cost and risk to Ontario's residents is required. This is done by directing development away from areas where there is risk of property damage, or more importantly, risk to public safety. The Province of Ontario sets minimum standards to ensure these risks and costs to society are reduced and has empowered municipalities to assume responsibilities for the management of natural hazards, as well as the associated liability and risk relative to planning for new land uses in and around these areas.

One of South Nation Conservation's (SNC) legislated mandates is protecting life and minimizing property damage from flooding and erosion. SNC undertakes flood and erosion hazard mapping through responsibility under the *Conservation Authorities Act* and corresponding Ontario Regulation 41/24. As such SNC works with partner municipalities to ensure the delineation of hazard lands following provincial and federal guidelines.

### 1. Flood Hazard

#### Key Findings:

- Flood hazards are extensive across the Bear Brook Watershed as a result of expansive clay plains and poor drainage. Flooding has historically occurred in this area.
- Flood mapping has been completed across many tributaries and rivers in the Bear Brook Watershed for different annual exceedance probabilities (i.e., 2-year, 5-year, 10-year, 20-year, 50-year, 100-year, 350-year events, etc.).
- Vulnerability assessments in areas where flood hazards have been studied have identified that no critical buildings are impacted by any flood events, while 121 buildings (homes, business or outbuildings) could be impacted within a 350-year flood extent in the Bear Brook Watershed. Many driveways and roads are vulnerable to different sized flood extents, from a 2-year event up to a 350-year event.
- A large floodplain exists between Carlsbad Lane and McNeely Road, within the ancient Ottawa River paleochannel, where flow spills out of the channel even during high-frequency storm events. Flooding along this section of Bear Brook has been well documented over time, especially during the spring freshet when flows are expected to be higher due to melting snow combined with rainfall. This area was studied through a 2D flood modeling project in 2021; the model will form an important component of future land use decisions and flood mitigation planning.



Riverine flooding occurs when rivers or streams overtop their banks due to an excess of water, typically after heavy rainfall or snowmelt. This excess water flows onto the surrounding land, known as the floodplain. Floods are a natural phenomenon, but they can be destructive when they are more intense than anticipated and they affect people's homes, infrastructure, or agriculture. SNC aims to understand flood risk and contribute to the resiliency of communities through undertaking flood mapping studies. This work also helps to develop the regulatory floodplain, which is a provincially approved standard that is used to direct development and site alteration away from flood hazard through local municipal land use planning decisions.

Within SNC's jurisdiction, the Regulatory Floodplain is based on the 100-year flood event. This corresponds to a flood that statistically has a 1% annual exceedance probability (AEP; i.e. a 1% chance of occurring in any given year). Municipalities have the authority to apply additional regulations to minimize risk. For example, the City of Ottawa's Official Plan (2021) defines a climate change flood vulnerable area as the area between the regulatory 1 in 100-year floodplain and the 1 in 350-year floodplain. In the climate change flood vulnerable area, the Official Plan will require new development applications in these areas to assess riverine flood risks and include mitigation measures to reduce or avoid identified flood risks.

### **1.1. Flood Mapping in the Bear Brook Watershed**

Flood mapping, including the 1 in 100-year floodplain, has been updated or newly developed for several watercourses in the Bear Brook Watershed through flood hazard mapping exercises undertaken by SNC, and supported by the City of Ottawa, United Counties of Prescott and Russell, and federal funding initiatives following provincial and federal guidelines.

Additional storm analysis conducted by SNC staff provides information on flood risk through mapping flood extents associated with different return periods. Vulnerable structures exposed to these flood hazards were also delineated.

All flood mapping products were developed in accordance with the Technical Guidelines for Flood Hazard Mapping in Ontario (Ministry of Natural Resources, 2002), while also conforming to Conservation Ontario Guidelines Pertaining to Flood Hazard Mapping (2005). A flood extent with a 1% AEP (1 in 100-year floodplain) was delineated for use in SNC's regulation limits mapping, as per Ontario Regulation 41/24. This mapping also supports municipal land use planning and development approval processes under the *Planning Act*.

Detailed methodologies can be consulted in Flood Hazard Mapping final reports. The following steps were generally taken:

- A base terrain model was generated using a Light Detection and Ranging (LiDAR) data derived Digital Elevation Model (DEM) and bathymetry data gathered through field survey;
- Design storm rainfall data from Environment Canada's Intensity Duration Curve Data for the Ottawa Airport was used;
- Stream flows were modelled using either SWMHYMO software, developed by JFSA or HEC-HMS software, developed by the US Army Corps of Engineers;
- River hydraulics were modelled using GeoHECRAS, developed by CivilGeo Inc., which utilizes HEC-RAS software developed by the US Army Corps of Engineers to determine flood elevations;
- The flood lines were mapped through spatial analysis of the terrain data and flood elevations; and
- Analysis and results were subject to internal technical reviews and peer reviewed by a third party. Final results are approved by the SNC Engineering Department.

Methods of analysis, results and hazard mapping products can be consulted in flood mapping final reports (available upon request). Table 1 identifies projects and completion dates.

Several different storm scenarios were analyzed, and the worst-case scenario (most conservative) was chosen for input into regulation products. The 10-day rain on snow scenario is the worst-case scenario in the Bear Brook Watershed, so was deemed the most appropriate for regulation products with the overarching goal of protecting people and property.

The 1% AEP using the 10-Day rain on snow scenario flood hazard for all projects mapped in the Bear Brook Watershed is depicted in Figure 1.

Table 1. Flood Hazard Mapping studies conducted in the Bear Brook Watershed and the year of completion.

| Study                                                                                       | Municipality                            | Year Completed |
|---------------------------------------------------------------------------------------------|-----------------------------------------|----------------|
| Bear Brook Watershed Floodplain Mapping Report                                              | United Counties of Prescott and Russell | 2024           |
| Bear Brook and Tributaries Flood Hazard Mapping Report                                      | City of Ottawa                          | 2022           |
| South Indian Creek and Tributaries Flood Hazard Mapping Report                              | United Counties of Prescott and Russell | 2020           |
| Shaw's Creek Flood Hazard Mapping Report                                                    | City of Ottawa                          | 2020           |
| South Bear Brook Flood Risk Mapping                                                         | City of Ottawa                          | 2019           |
| Devine Creek Flood Risk Mapping                                                             | City of Ottawa                          | 2018           |
| McKinnons Creek Subwatershed Flood Risk Mapping Report - McKinnon, McFadden and East Savage | City of Ottawa                          | 2018           |
| Nelson Charlebois Creek Flood Risk Mapping Report                                           | City of Ottawa                          | 2018           |

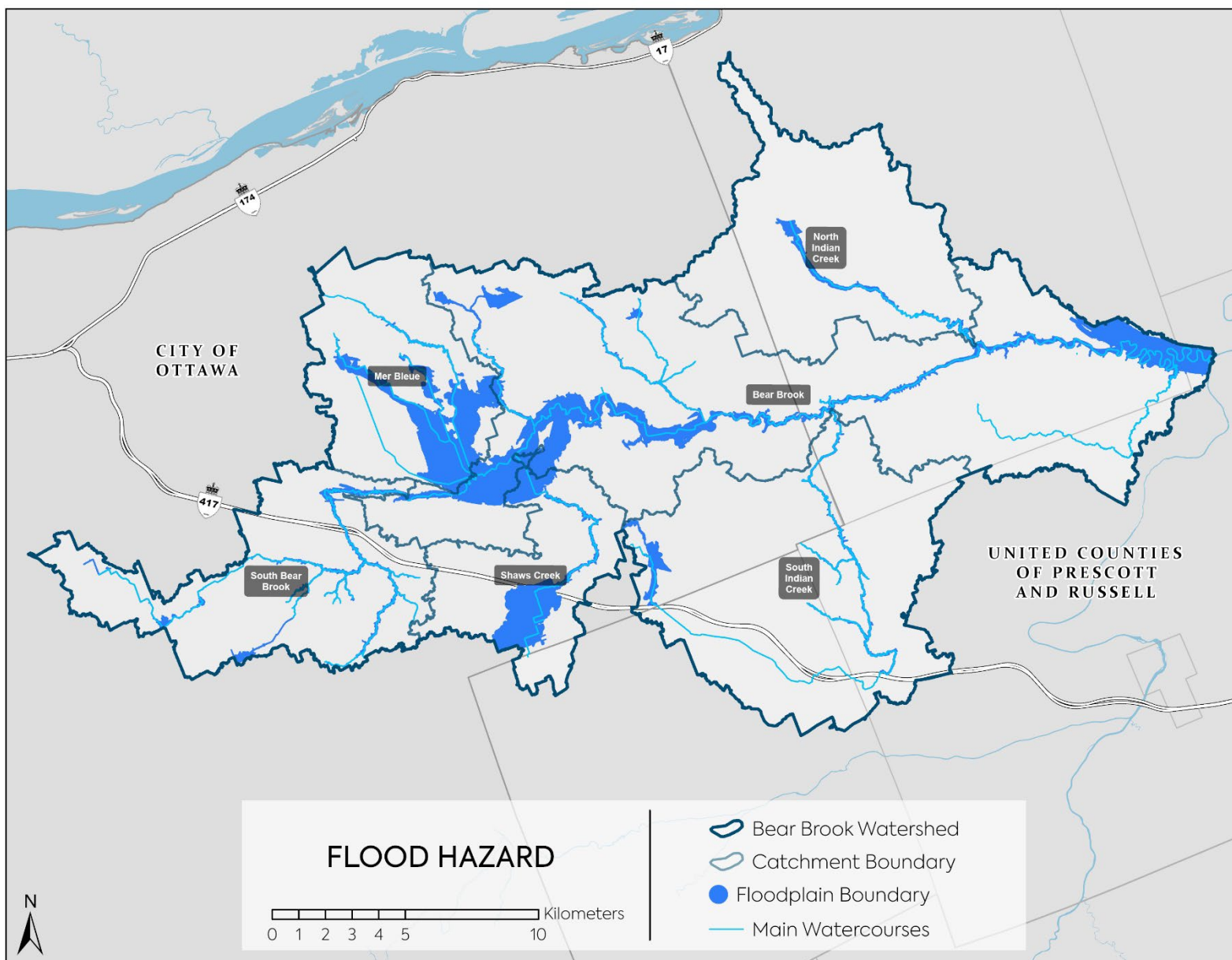


Figure 1. Flood Hazard with 1% Annual Exceedance Probability (100-year event) using 10 Day Rain on Snow Scenario developed through Bear Brook Floodplain Mapping Project (SNC, 2024).

## 1.2. Vulnerable Structures

Flood mapping exercises provided the opportunity to generate additional mapping products that improve asset management programs and guide the delivery of emergency management services, including the Flood Forecasting and Warning Program, during flood events less than and greater than the 100-year flood event. Several scenarios were chosen to provide a range of flood conditions from nuisance flood events to extreme flood events:

- The 2-year, 5-year, and 10-year, events have a 50%, 20%, and 10% chance of occurring in any given year, respectively. These events occur more frequently and identify flood prone areas that encounter ongoing nuisance flooding.
- The 20-year and 50-year flood events have a 5% and 2% chance of occurring in any given year, and are significant events that are used in the design of bridges and culverts based on functional road classification by the Ontario Ministry of Transportation (MTO, 2008)
- The 100-year flood event has a 1% chance of occurring and is used in floodplain regulation and land-use planning (Ontario Regulation 41/24).
- The 200-year, 350-year, 500-year, and 1000-year flood events represent extreme events that may cause impacts in a larger exposure area and have been used by municipalities as a proxy for climate change impacts.

Flood extents for the 2-year, 5-year, 10-year, 20-year, 25-year, 50-year, 100-year, 350-year, 500-year (2024 study only), and 1000-year (2024 study only) storm events were delineated. Examples of flood hazard mapping products are provided in Figure 12 for the Bear Brook River in the City of Ottawa and Figure 2 for North Indian Creek in United Counties of Prescott and Russell. A vulnerability analysis was performed to identify buildings, roads, and driveways within these flood extents. Geospatial products generated through this process are presented in Table 2 and generally include:

- Compilation of georeferenced digital map layers including flood lines and flood depths for all storm scenarios; and
- Inventory of flood vulnerable buildings, roads, and driveways for all scenarios.

Table 2. Geospatial products generated through flood mapping exercises for the Bear Brook Watershed.

| GIS Layer                             | Description                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Floodplain Polygon                    | A polygon feature class that includes a consolidated layer of modelled floodplain areas.                                                                                                                                                                                                                                                                                     |
| Floodplain Depth Raster               | A raster mosaic that includes a consolidated layer of modelled floodplain depths.                                                                                                                                                                                                                                                                                            |
| Building Points                       | <p>A point feature class that consists of a building located within the floodplain boundary. Buildings were categorized as critical or non-critical.</p> <ul style="list-style-type: none"> <li>• Critical Building: hospital, school, retirement building.</li> <li>• Non-critical Building: residential dwelling, residential outbuilding, commercial building.</li> </ul> |
| Private Driveways and Roads Polylines | <p>A polyline feature class that includes driveways, private roads, and roads within the floodplain.</p> <p>Roads/driveways with unsafe access (greater than 0.3m water depth) were identified.</p>                                                                                                                                                                          |

Table 3 presents a summary of the number of buildings and the length of roads and driveways with unsafe access contained within the floodplains of different storm events, as outlined through the flood mapping studies in Table 1. Additional details, such as building type, location address, and postal code are available upon request, along with digital mapping.

**No critical buildings were identified within any flood extent studied.**

Table 3. Flood vulnerable buildings, roads and driveways identified as part of various flood mapping and vulnerability projects at SNC.

| Projects                                      | Event Return Period | Non - Critical Buildings in floodplain | Length of Flooded Driveways and Private Roads that are <u>Unsafe</u> for travel (m) | Length of Flooded Roads (m) | Length of Flooded Roads that are Unsafe for Travel (m) |
|-----------------------------------------------|---------------------|----------------------------------------|-------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------|
| Bear Brook and North Indian Rivers (2024)     | 2-year              | 1                                      | 1507.4                                                                              | 1904.5                      | 71.8                                                   |
|                                               | 5-year              | 1                                      | 1742.2                                                                              | 2344.5                      | 121.0                                                  |
|                                               | 10-year             | 2                                      | 2024.1                                                                              | 3149.5                      | 245.4                                                  |
|                                               | 20-year             | 3                                      | 2229.8                                                                              | 3440.6                      | 362.3                                                  |
|                                               | 25-year             | 4                                      | 2302.5                                                                              | 3571.6                      | 429.0                                                  |
|                                               | 50-year             | 5                                      | 3186.4                                                                              | 4084.6                      | 548.4                                                  |
|                                               | 100-year            | 7                                      | 3637.1                                                                              | 4476.0                      | 759.6                                                  |
|                                               | 200-year            | 19                                     | 5281.3                                                                              | 6400.7                      | 1154.5                                                 |
|                                               | 350-year            | 24                                     | 5978.3                                                                              | 6870.5                      | 1292.5                                                 |
| South Bear Brook and Bear Brook Rivers (2022) | 2-year              | 2                                      | 0.0                                                                                 | 53.9                        | 52.6                                                   |
|                                               | 5-year              | 7                                      | 54.6                                                                                | 57.0                        | 54.8                                                   |
|                                               | 10-year             | 14                                     | 321.3                                                                               | 191.4                       | 57.2                                                   |
|                                               | 20-year             | 19                                     | 388.8                                                                               | 334.8                       | 169.5                                                  |
|                                               | 25-year             | 28                                     | 527.2                                                                               | 423.1                       | 258.2                                                  |
|                                               | 50-year             | 32                                     | 656.2                                                                               | 856.4                       | 348.1                                                  |
|                                               | 100-year            | 46                                     | 1031.2                                                                              | 1711.5                      | 411.5                                                  |
|                                               | 350-year            | 69                                     | 1359.2                                                                              | 4341.1                      | 1986.3                                                 |
| Shaws Creek (2020)                            | 2-year              | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 5-year              | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 10-year             | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 25-year             | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 50-year             | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 100-year            | 13                                     | 1.3                                                                                 | 167.0                       | 0.0                                                    |
|                                               | 350-year            | 17                                     | 1.3                                                                                 | 175.1                       | 31.6                                                   |
| South Indian Creek (2020)                     | 2-year              | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 5-year              | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 10-year             | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 25-year             | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 50-year             | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 100-year            | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 350-year            | 0                                      | 0.0                                                                                 | 0.0                         | 0.0                                                    |
|                                               | 5-year              | 0                                      | N/A                                                                                 | 130.0                       | 0.0                                                    |

| Projects                                     | Event Return Period | Non - Critical Buildings in floodplain | Length of Flooded Driveways and Private Roads that are <u>Unsafe</u> for travel (m) | Length of Flooded Roads (m) | Length of Flooded Roads that are Unsafe for Travel (m) |
|----------------------------------------------|---------------------|----------------------------------------|-------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------|
| McKinnon, East Savage, McFadden Creek (2018) | 25-year             | 1                                      | N/A                                                                                 | 200.0                       | 0.0                                                    |
|                                              | 50-year             | 1                                      | N/A                                                                                 | 730.0                       | 0.0                                                    |
|                                              | 100-year            | 2                                      | N/A                                                                                 | 810.0                       | 590.0                                                  |
|                                              | 350-year            | 2                                      | N/A                                                                                 | 1080.0                      | 620.0                                                  |
| Devine Creek (2020)                          | 2-year              | 0                                      | 0.1                                                                                 | 0.0                         | 0.0                                                    |
|                                              | 5-year              | 0                                      | 167.8                                                                               | 80.4                        | 0.0                                                    |
|                                              | 10-year             | 0                                      | 258.3                                                                               | 261.4                       | 166.2                                                  |
|                                              | 25-year             | 0                                      | 269.3                                                                               | 292.6                       | 177.0                                                  |
|                                              | 50-year             | 0                                      | 275.6                                                                               | 313.1                       | 209.3                                                  |
|                                              | 100-year            | 0                                      | 282.4                                                                               | 322.8                       | 231.0                                                  |
|                                              | 350-year            | 7                                      | 339.1                                                                               | 1208.9                      | 673.4                                                  |
| Nelson Charlebois Creek (2020)               | 2-year              | 0                                      | 0.0                                                                                 | N/A                         | 0                                                      |
|                                              | 5-year              | 0                                      | 0.0                                                                                 | N/A                         | 0                                                      |
|                                              | 10-year             | 0                                      | 0.0                                                                                 | N/A                         | 0                                                      |
|                                              | 25-year             | 0                                      | 0.0                                                                                 | 173.1                       | 0.0                                                    |
|                                              | 50-year             | 0                                      | 0.0                                                                                 | 181.6                       | 0.0                                                    |
|                                              | 100-year            | 0                                      | 0.0                                                                                 | 217.0                       | 0.0                                                    |
|                                              | 350-year            | 2                                      | 0.0                                                                                 | 353.5                       | 0.0                                                    |



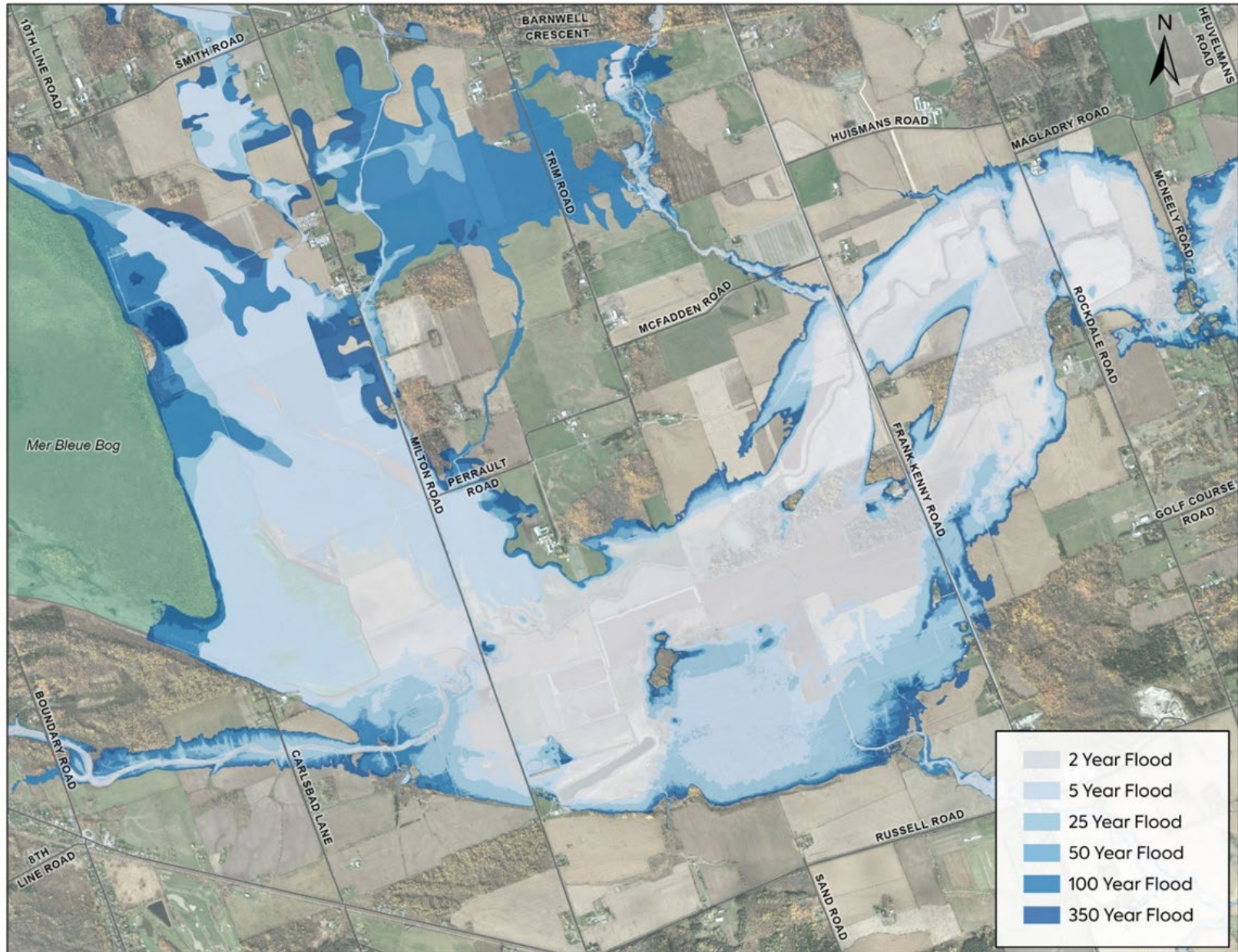


Figure 2. An example of flood extents with different annual exceedance probabilities generated through the Bear Brook Floodplain Mapping Project (SNC, 2024).





Figure 3. An example of flood extents with different annual exceedance probabilities in North Indian Creek generated through the Bear Brook Floodplain Mapping Project (SNC, 2024).

### 1.3. 2D Flood Modelling in the Bear Brook Watershed

A flood mapping update was completed on the South Bear Brook River and Main Bear Brook River within the City of Ottawa in 2021 with funds from the National Disaster Mitigation Program, City of Ottawa and South Nation Conservation (SNC, 2021). For this project, a hydrology model was developed to estimate flood hydrographs with different return periods. These hydrographs were then imported into a 1-dimensional hydraulic model to assess river network hydraulics for various events. HEC-HMS software (version 4.9) and GeoHECRAS software packages were used to create hydrology and hydraulic models (CivilGeo, 2019).

The 2021 study included Smith-Gooding Municipal Drain, Johnston Municipal Drain, Bear River Drain, Rochon Municipal Drain, Bear Brook Municipal Drain, McWilliams Municipal Drain, Dutrisac Municipal Drain, Scott Extension Municipal Drain, and Elian Reginbald Municipal Drain. Flows through the study area are mostly contained within watercourse channels. However, there is a portion of the Main Bear Brook River from Carlsbad Lane downstream to Dunning Road where flow spills out of the channel even during high-frequency storm events. Flooding along this section of the Bear Brook River has been well documented over time and is a known area of historic and current flooding. Flooding here is especially extensive during the spring freshet when flows are expected to be higher due to melting snow combined with rainfall and low infiltration.

It is widely accepted that 2D models have better performance in representing the channel process when the capacity of the channel has been exceeded and the flow spills out to a larger area (Horritt & Bates, 2002, Cook & Merwade, 2009, Sampson et al., 2015). For this reason, SNC undertook a complementary 2D modeling study on the portion of the Bear Brook River that has a wide floodplain (SNC, 2021). A hydrodynamic model (i.e., HEC-RAS 2D) and an accurate LiDAR map were used to simulate a 100-year storm event from Carlsbad Lane to Dunning Road. Results are depicted in Figure 4. The performance of both models was compared, concluding that results are consistent between the 1D and 2D models, with the 1D model producing more conservative results.

This model will be beneficial in future land use decision making and forming a flood mitigation strategy for the Bear Brook Watershed.



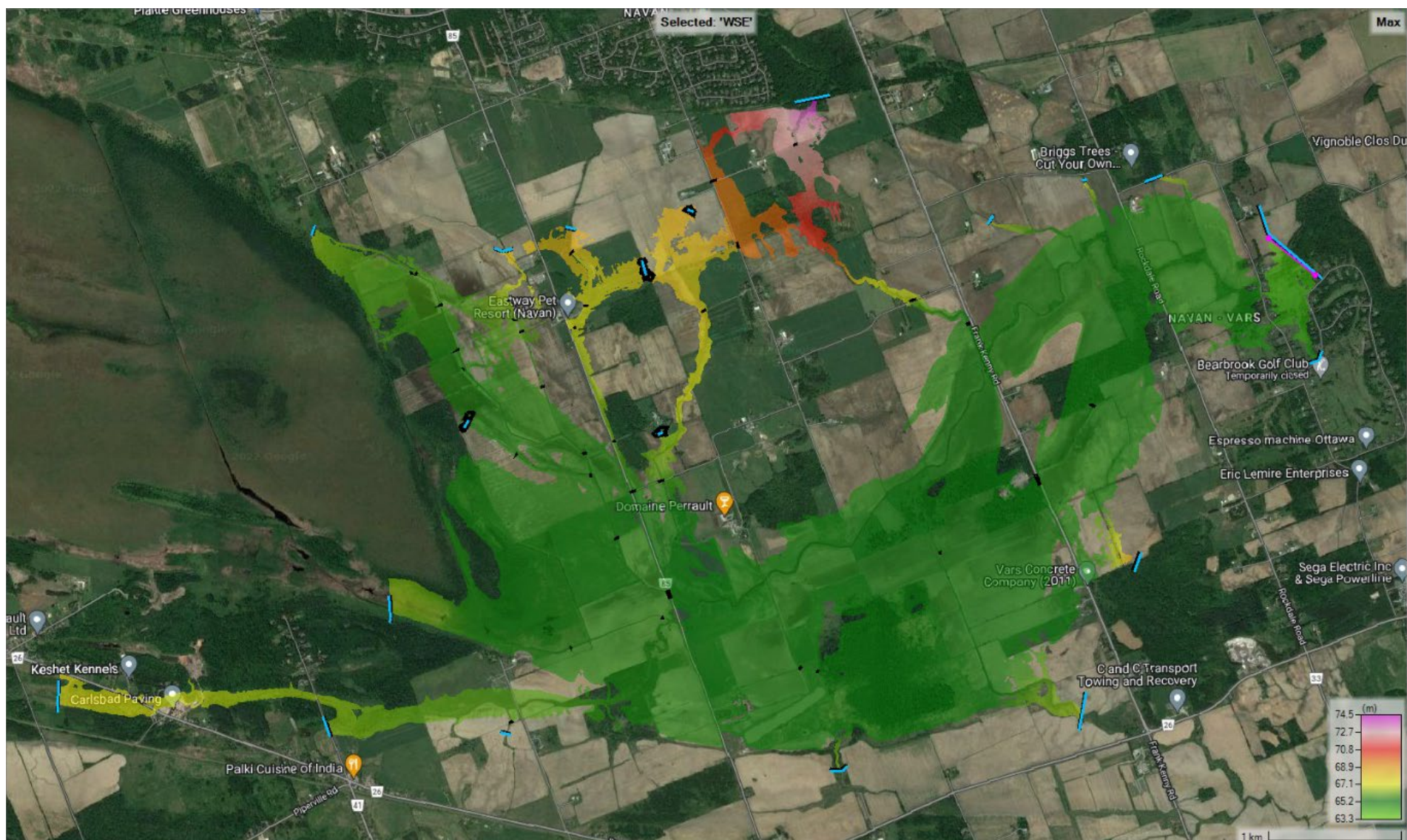


Figure 4. Flood hazard mapping with a 1% Annual Exceedance Probability (100-year event) using a 10 Day Rain on Snow Scenario and HEC-RAS 2D model workflow.

## 2. Erosion Hazard

### Key Findings:

- Unstable soils and erosion have been identified as critical hazards within the Bear Brook Watershed. Unstable soils are of particular interest given the watershed's sensitive clay soils and the potential for retrogressive slides in areas near river valleys and slopes.
- Riverine erosion represents the greatest hazard in approximately 45% of all watercourses studied and is notable in rivers with deep valleys, such as South Indian Creek and North Indian Creek.
- Geospatial locations of possible, probable, and historical unstable soils sites have been identified in the Bear Brook Watershed (SLR, 2024).

Erosion causes a watercourse to change its location over time because it gradually wears away the soil and rock along the banks and bottom of the river or stream. As water flows, it picks up small particles, which are carried downstream. This process slowly reshapes the watercourse, making it wider, deeper, or causing it to shift direction. Over time, this constant wearing away and movement of sediment will cause the river or stream to meander, change its path, or even create new channels in the landscape.

Surficial geology and physiography act as primary controls regarding channel development as they greatly influence the hydrological and sediment characteristics of a given drainage system. Channel morphodynamics are largely governed by the flow regime and the availability and type of sediments within the stream corridor. These processes were explored through an Assessment of Fluvial Geomorphology Project completed by SLR Consulting (Canada) Ltd. in 2024. Results from this study are available in Appendix A of Section 5: Fluvial Geomorphology and Landslide Distribution.

### 2.1. Riverine Erosion Hazard

Erosion poses a risk when a changing watercourse negatively impacts infrastructure or property. Managing the risk associated with the natural hazards of erosion is one of the primary roles of conservation authorities under the *Conservation Authorities Act* and Chapter 5 of the Provincial Planning Statement. This policy outlines the provincial interest and policy direction for land use planning in areas of natural hazards, including erosion hazards, unstable soils, and unstable bedrock. The policies direct development and site alteration away from these hazards through local municipal land use planning decisions.

Erosion hazard was delineated along several watercourses in the Bear Brook Watershed. This includes the study of setbacks required for unstable slopes, watercourse meanders and erosion access allowance. An additional consideration for unstable soils is the risk of landslide due to marine clays, discussed in Section 2.2 of this report. This hazard has been screened through a desktop analysis performed by SLR Consulting (Canada) Ltd. (2024) and results are presented in in Appendix A of Section 4: Fluvial Geomorphology and Landslide Distribution.

The Bear Brook River and tributaries riverine erosion hazards were delineated in accordance with methodologies proposed by:

- Ministry of Natural Resources in the 2002 Technical Guide – River & Stream systems: Erosion Hazard Limit prepared by Terraprobe Limited and Aqua Solutions for the Ontario Ministry of Natural Resources, Water Resources Section, in support of the Natural Hazard Policies (3.1) of the Provincial Policy Statement of the Planning Act (1997), and;
- Conservation Ontario & Ministry of Natural Resources in the 2005 Conservation Authorities Act, Section 28 – “Generic Regulation” Development, Interference With Wetlands & Alterations to Shorelines and Watercourses Guidelines for Developing Schedules of Regulated Areas prepared by Conservation Ontario – Generic Regulation Technical Standards Committee, in co-operation with the Ontario Ministry of Natural Resources.

The four (4) factors considered when determining the regulation limit for riverine erosion hazards within erosion studies include:

1. Toe Erosion Allowance
2. Stable Slope Allowance
3. Erosion Access Allowance
4. Meander Belt Allowance

Erosion limits are developed according to the provincial guidance listed above. The workflow is depicted in Figure 5.

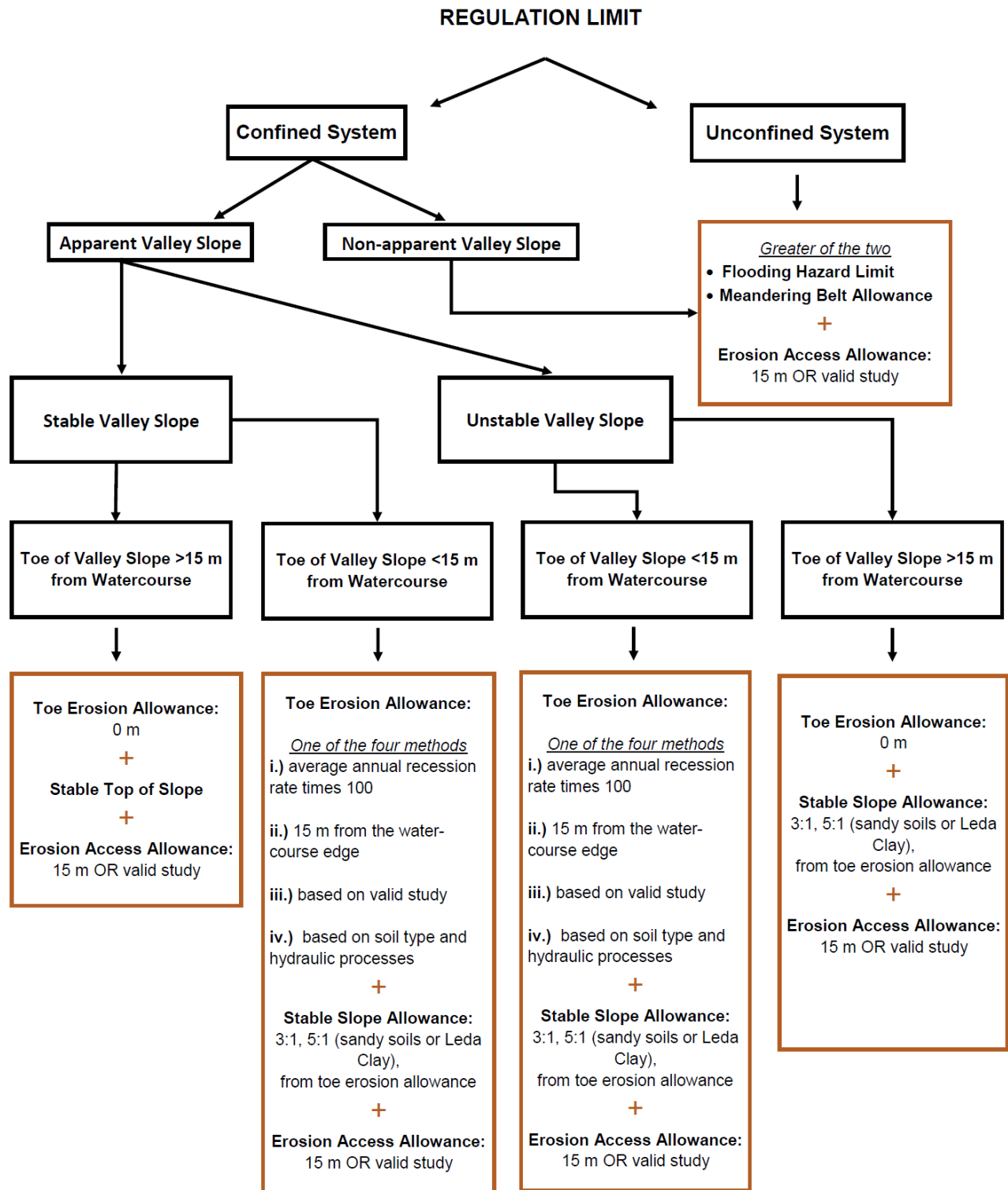


Figure 5. A flowchart summary of the determination of the regulation limit for rivers and streams, excluding hazardous sites (i.e., sensitive marine clays) (CO, 2005; MNR, 2002).



Systems within the Bear Brook Watershed were first analyzed to determine if they had confined or unconfined, and apparent or non-apparent valley lands. SNC has detailed methodologies for specific studies within the Bear Brook Watershed (available upon request). Defining the riverine erosion hazard within the Bear Brook Watershed generally included the following steps:

- Review digital elevation model (DEM), contours, surficial geology, hydrostratigraphy (thickness of main soil units), and historical aerial imagery to identify confined versus unconfined systems;
- Identify valley toe and top of slopes using DEM, contours, GIS tools, and aerial photography;
- Generate slope profiles approximately every 5-m using GIS tools and DEM within confined systems to determine if the slope heights are non-apparent (< 3 m) or apparent (3 m or greater);
- Apply methodology in Section 3 of Ontario Regulation 41/24 once 'confined vs unconfined' and 'apparent vs non-apparent' characteristics have been determined; and
- Results are reviewed and approved by the SNC Engineering Department.

Project specific methodologies and results are available for all studies. Table 4 summarizes the study location and date while Figure 5 identifies erosion mapping across the Bear Brook Watershed.

Table 4. Erosion studies completed across the Bear Brook Watershed and the year of completion.

| Study                                                     | Regulation Area                         | Year Completed |
|-----------------------------------------------------------|-----------------------------------------|----------------|
| Bear Brook and Tributaries Riverine Erosion Hazard Report | United Counties of Prescott and Russell | 2024           |
| Bear Brook and Tributaries Riverine Erosion Hazard Report | City of Ottawa                          | 2022           |
| South Indian Creek Riverine Erosion Hazard Report         | United Counties of Prescott and Russell | 2020           |
| Shaw's Creek Riverine Erosion Hazard Report               | City of Ottawa                          | 2020           |



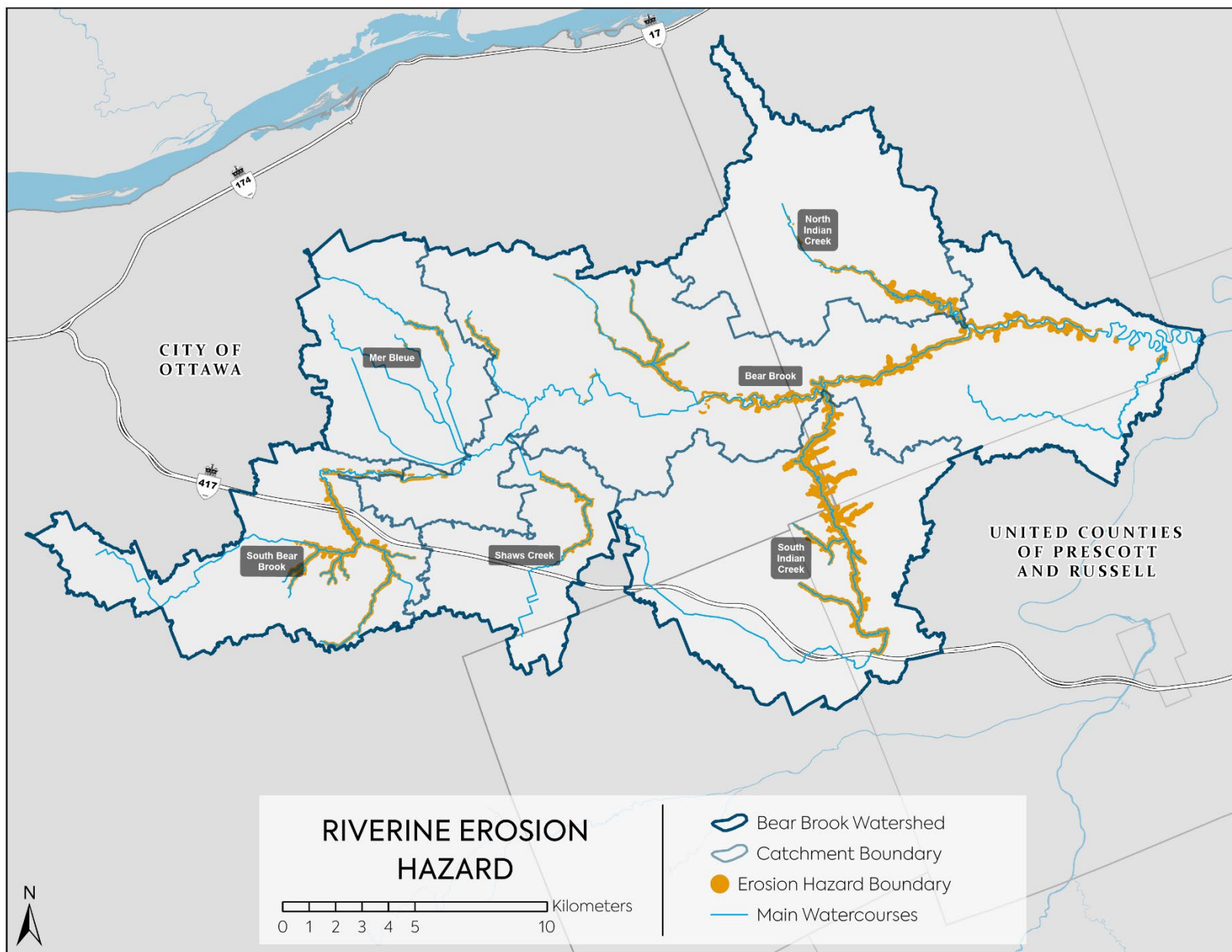


Figure 6. Riverine erosion hazard mapping across the Bear Brook Watershed. The erosion hazard boundary is shown.

## 2.2. Unstable Soils

The Bear Brook Watershed, shaped by glaciation, post-glacial deposits, and the influence of the Champlain Sea, features a unique landscape with varied soil types, including sandy areas and clay-rich soils, particularly glaciomarine clays known as Leda clay. These clay-rich soils, when disturbed by freshwater infiltration or seismic activity, can become highly unstable, increasing the risk of retrogressive landslides. Risk is especially present on slopes over eight meters or near winding river edges.

The combination of sandy soils with rapid water infiltration and clay-rich soils which promote surface runoff creates conditions that make the landscape vulnerable to landslides and erosion. For example, when sandy and clay-rich soils are in proximity, such as on the same slope, water infiltration from sandy areas can flow into lower clay-rich zones, potentially creating a slip-plane along the sand-clay boundary. This interface can be particularly susceptible to landslides if the waterlogged clay is prone to instability (Leda clay).

The Geological Survey of Canada recently developed a sensitive clay landslide inventory map and compiled a database for the area bound approximately by the City of Ottawa (Brooks, 2019). The project was intended to promote or foster additional sensitive clay landslide mapping in the Ottawa Valley. Brooks (2019) identified that there are well-documented, historical examples of sensitive clay landslides in the Ottawa Valley. Recent events that occurred near the Bear Brook Watershed include the 1971 South Nation River landslide (Eden et al., 1971) and the 1993 Lemieux landslide (Evans and Brooks, 1994; Brooks et al., 1994).

The requirement to conduct a screening of potential unstable soils across the full Bear Brook Watershed was identified. SLR Consulting (Canada) Ltd. was hired to conduct the study and results of the study are presented in the characterization report under Section 4: Fluvial Geomorphology and Landslide Screening.

The occurrence of landslide damming, where displaced soil and rock temporarily block watercourses, illustrates the risk for sudden, intense flooding downstream upon dam breach. A notable example is the 1993 Casselman-Lemieux landslide, where dam failure triggered destructive downstream flooding, highlighting the interconnectedness of landslide and flood hazards.

Flood events, particularly those resulting from landslide dam breaches or severe weather, exacerbate erosion in the watershed, contributing to bank destabilization, widening of channels, and sedimentation that impacts water quality, aquatic habitats, and infrastructure. Sediment transport from floods can clog channels, alter stream profiles, and compromise the watershed's resilience, ultimately creating a cycle where destabilization leads to recurrent landslides and erosion. High sediment concentrations from erosion also disrupt aquatic ecosystems, smothering spawning grounds and increasing water turbidity, which limits photosynthesis in aquatic plants.

To mitigate these cascading effects, identifying areas with a history or likelihood of landslides within the Bear Brook Watershed is fundamental. The report's identification of probable, possible, and historical landslide sites will inform hazard assessments and prompt action to safeguard infrastructure, property, and ecosystems. The next steps involve conducting further field studies to delineate landslide extents and developing a landslide hazard map database, which would consider slope height, soil type, and proximity to historical sites.

Advances in technology, like LiDAR, play an essential role in this endeavor by offering detailed landscape imagery that enables detection of subtle changes in topography. LiDAR's precision allows for the mapping of potential landslide-prone areas, helping create risk maps and guiding safe development planning. With these insights, SNC can be equipped with tools to inform public planning and emergency response strategies that protect communities and ensure that development is managed away from high-risk areas.

Ultimately, this comprehensive study builds hazard resilience in the Bear Brook Watershed, addressing the long-term stability of both natural and built environments. Identifying and mapping landslide hazards equips decision-makers with data to implement sustainable watershed management, mitigate future hazards, and preserve both human communities and ecosystems against the evolving impacts of landslides, erosion, and flooding in this unique landscape.

### **3. Regulated Hazard Limit in the Bear Brook Watershed**

The regulated hazard limit in the Bear Brook Watershed is presented in Figure 8 and is based on collective results from both flood and erosion hazard studies.

Ontario Regulation 41/24 applies to: i) river or stream valleys; ii) wetlands; iii) areas where development could interfere with the hydrologic function of a wetland; iv) areas adjacent or close to the shoreline of the Great Lakes-St. Lawrence River System or inland lakes; and v) hazardous lands.

Ontario Regulation 97/04: Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation allows conservation authorities to prevent or restrict development in areas where the control of flooding, erosion, dynamic beaches, pollution, or the conservation of land may be affected by development, to prevent the creation of new hazards or the aggravation of existing hazards.

The Minister of Natural Resources approved SNC's specific regulation on May 4, 2006, titled Ontario Regulation 41/24 South Nation River Conservation Authority: Development, Interference with Wetlands and Alteration to Shorelines and Waterways Regulation. Ontario Regulation 41/24 makes SNC permission necessary to undertake development in river or stream valleys, wetlands, shorelines, or hazardous lands; alter a river, creek, stream, or watercourse; or interfere with a wetland. SNC may grant permission for proposed work in a Regulated Area if it is demonstrated to SNC's satisfaction that the proposed work will not affect the control of flooding, erosion, dynamic beaches, pollution, or the conservation of land.

The Regulated Area represents the greatest extent of the combined hazards plus any prescribed allowance as described in Ontario Regulation 41/24. Areas regulated under Ontario Regulation 41/24 are mapped according to the criteria and standards outlined in the Guidelines for Developing Schedules of Regulated Areas (October 2005) as approved by the Ontario Ministry of Natural Resources and Forestry and Conservation Ontario.

SNC Regulation Policies can be viewed at [www.nation.on.ca](http://www.nation.on.ca) or available upon request. Regulated areas can be viewed at [SNC Public Geoportal](#).

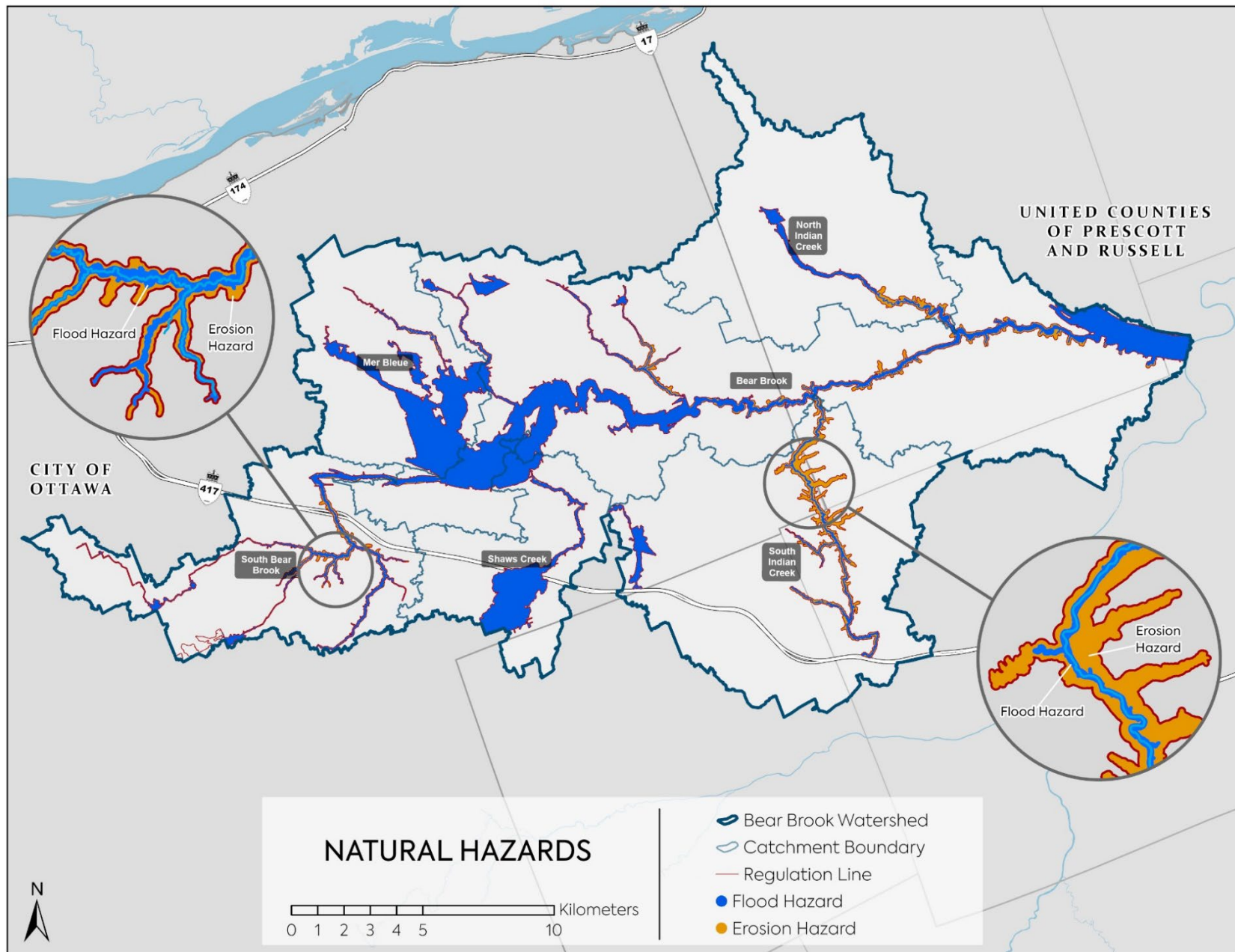


Figure 7 Cumulative Regulated Hazard Limits in the Bear Brook River Watershed.  
 South Nation Conservation Authority  
**Bear Brook Watershed Study – Natural Hazards Characterization Report**



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