

Bear Brook Watershed Study – Physical Setting Characterization Report

January 2025

Prepared for:



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Summary of Findings

Glaciation and post-glacial deposition largely account for the current landscape in the Bear Brook Watershed and significantly influence land use patterns.

The Bear Brook Watershed is comprised of 6 major subwatersheds that are generally formed around the significant tributaries of the Bear Brook River. These subwatersheds each have their own unique characteristics and form a critical sub-unit of analysis for understanding the health of the Bear Brook Watershed.

The current report provides an analysis and presentation of the past and current physical setting of the Bear Brook Watershed. Main findings include:

- Leda clay, a potentially unstable type of clay, is present in areas of the watershed once covered by the Champlain Sea.
- The Vars-Winchester Esker is a defining landform in the Bear Brook Watershed and influences water quality and quantity.
- Clay soils present in the Bear Brook Watershed exhibit poor natural drainage and seasonal flooding, but when drained, are rich in minerals and highly productive.
- Sandy soils present in the Bear Brook Watershed drain swiftly but feature low nutrient levels and are easily eroded by wind, rain and water flow.
- Climate projections suggest that the National Capital Region will become warmer and wetter. The timing of seasons will shift, and periods of extreme heat will become more common.
- Rainfall is expected to increase, both in volume and intensity. Annually, less snowfall and a shorter snow season are projected. Conditions favorable for extreme events such as freezing rain, tornadoes and wildfires are projected to become more common.
- Existing landcover in the Bear Brook Watershed is dominated by lands in agricultural use (35.91%), woodlands (25.27%), wetlands (22.06%), and settlement areas (8.43%).

Table of Contents

Summary of Findings	2
Table of Contents.....	3
List of Figures	4
List of Tables	5
Appendices	6
Disclaimer	7
Physical Setting of the Bear Brook Watershed	8
1. Major Subwatersheds.....	9
2. Geology	12
3. Bedrock Geology	12
4. Physiographic Units.....	18
5. Surficial Geography	20
6. Hydrologic Soil Group.....	26
7. Climate	29
8. Land Cover in the Bear Brook Watershed	32
9. References	38
Appendix A: Land Cover Update Methodology	40

List of Figures

Figure 1. The study area of the Bear Brook Watershed Study and the six major subwatersheds. Main towns and villages are shown.	11
Figure 2. The underlying bedrock geology of the Bear Brook Watershed.	15
Figure 3. The historic location and extent of the Champlain Sea (taken from Russell et al., 2011).	16
Figure 4: Elevations resulting from geologic activity over time (taken from Russell et al., 2011).	16
Figure 5. The location of the paleochannels left behind after the Champlain Sea receded and the Ottawa River settled into its modern location and extent.	17
Figure 6. The physiographic regions in the Bear Brook Watershed.	19
Figure 7. Surficial geology in the Bear Brook Watershed.	25
Figure 8. Hydrologic Soil Groups in the Bear Brook Watershed.	28
Figure 9. 30-year temperature normals from 1951-2020 recorded at the Ottawa International Airport.	31
Figure 10. Land cover in the Bear Brook Watershed as of the 2024 SNC Land Cover Update Project.	35
Figure 11. The Bourget Desert near the Village of Bourget as a result of forest clearing and subsequent wind and rain erosion.	36

List of Tables

Table 1. The six major subwatersheds of the Bear Brook Watershed are described and a general description of each along with their size is provided.	9
Table 2. The percentage of each physiographic region in the Bear Brook Watershed.....	18
Table 3. Surficial soil types in the Bear Brook Watershed and percent composition by each major subwatershed.....	22
Table 4. Hydrologic Soil Groups (HSG) in the Bear Brook Watershed.	27
Table 5. Temperature and precipitation normals (1991-2020) based on data collected from the Ottawa International Airport, Environment and Climate Change Canada climate station.....	30
Table 6. Land cover types and the percentage of each in the Bear Brook Watershed.....	34

Appendices

Appendix A: Land Cover Update Methodology

Disclaimer

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Physical Setting of the Bear Brook Watershed

The physical description of a watershed contributes to the understanding of surface and groundwater systems, natural hazards, natural heritage, human settlement patterns and the resulting socio-economic systems that exist today. Several factors play a critical role in shaping a watershed's systems, including geology, climate, land cover and land ownership.

Glaciation and post-glacial deposition largely account for the current landscape in the Bear Brook Watershed. Deposits laid down by glacial lakes and rivers have strongly influenced soil development and the composition of the landscape and drainage patterns.

Climate influences everything, from physical and environmental systems to socio-economic systems, including basic habitability, agriculture, energy, tourism and recreation. Climate dictates the amount, type, and timing of precipitation received, as well as the rates of evaporation and transpiration. In wetter seasons, there is generally more consistent surface flow in rivers and streams in the Bear Brook Watershed. Drier seasons have the potential to experience intermittent flows or water shortages.

Temperature fluctuations affect the watershed's water balance. Winter seasons lead to snowmelt-driven runoff in spring, and the summer season experiences warmer, drier conditions that are characterized by baseflow-dominated levels and flows in rivers. This report looks at climate normals from a long-term Environment and Climate Change Canada climate station in the Bear Brook Watershed and characterizes both the existing normals and long-term trends in climate.

Geology and climate are closely linked factors that significantly influence the type and distribution of land cover and surface water within the Bear Brook Watershed. Their interaction affects key aspects such as water availability, soil structure, vegetation growth, and land use. Geological features and temperature determine how precipitation is absorbed, stored, or runs off the landscape, influencing soil moisture and water flow within the watershed. Together, they shape vegetation patterns and ecosystems, as well as human activities by determining the suitability of land for agriculture, forestry, or development (Shuguang et al., 2017).

Natural vegetation such as forests and wetlands play a crucial role in slowing water movement, promoting infiltration, reducing surface runoff, and filtering pollutants before they enter streams and rivers (Cotrone, 2022). Urbanized areas with impervious surfaces like roads and buildings prevent infiltration, leading to faster runoff, increased erosion, and higher risks of flooding (Cappiella, 2012). Agricultural practices can also impact the watershed, contributing to faster water movement off the landscape through land and tile drainage practices.

Understanding the relationship between geology, precipitation and land cover will be an important aspect of the Bear Brook Watershed Study, as it helps to predict water flow, soil stability, and ecosystem dynamics, all of which are crucial for sustainable land management (Shuguang et al., 2017).

1. Major Subwatersheds

The Bear Brook Watershed is comprised of 6 major subwatersheds that are generally formed around the significant tributaries of the Bear Brook. These subwatersheds each have their own unique characteristics and form a critical sub-unit of analysis for understanding the Bear Brook Watershed as a whole. A geospatial desktop exercise was performed to update watercourses to ensure accuracy in location and direction of flow, which is further discussed in the Water Resources Section of the characterization report. This update helped determine subwatershed boundaries. Table 1 summarizes the extents and unique characteristics of these subwatersheds, along with the major communities found within them, and are shown spatially in Figure 1.

Table 1. Overview of the six major subwatersheds of the Bear Brook Watershed, including geographic location and extent, general description, and size (km²).

Subwatershed	Geographic Location and Extent	General Description	Size (km ²)
South Bear Brook River	Headwaters and most westerly extent of the Bear Brook Watershed. Located entirely within the City of Ottawa. It begins north of Findlay Creek and continues in an easterly direction until it crosses the 417 and joins the Bear Brook Main reach and subwatershed near Carlsbad Springs.	Mainly agricultural with significant areas of natural cover. Includes the community of Carlsbad Springs, portions of Leitrim / Findlay Creek, and the urban expansion area for the future Tewin community.	60.94
Main Bear Brook River	Forms the largest portion of the Bear Brook Watershed and includes the main reach of the Bear Brook River. It begins near Carlsbad Springs and flows in an easterly direction heading through the City of Ottawa to its eventual outflow where it joins the South Nation River in the United Counties of Prescott & Russell (UCPR).	Mainly agricultural with significant areas of natural cover including the northern portions of Larose Forest. Major communities include Navan, Sarsfield, Cheney and Bourget.	176.10
Mer Bleue	Located entirely within the City of Ottawa, the Mer Bleue subwatershed is comprised of 3 significant tributaries of the Bear Brook, including	Comprised of diverse land uses. A third of the catchment is comprised of Mer Bleue bog in the southwest. Significant	46.75

Subwatershed	Geographic Location and Extent	General Description	Size (km ²)
	McKinnons Creek, McFadden Municipal Drain and East Savage Creek, as well as a significant portion of the Mer Bleue bog.	Agricultural land use is found in the southeast and northern sections. Settlement areas in the north comprised of the southern portions of Orleans and the east-west corridor of Navan Road, centrally located within the catchment. Includes an urban expansion area in South Orleans.	
Shaws Creek	A major tributary of the Bear Brook, Shaws Creek is located within the City of Ottawa with some headwater drainage areas located within the UCPR. It flows in a northerly direction, crossing the 417 and joining the Bear Brook just east of Milton Road in the City of Ottawa.	Agricultural with significant areas of forested natural cover. Includes portions of the community of Vars in the east.	35.31
South Indian Creek	Located primarily within the UCPR, the South Indian Creek is another major tributary of the Bear Brook, which flows in a northerly direction from just south of the 417. It continues east of the town of Limoges until it reaches the Bear Brook near the town of Cheney.	Mainly comprised of forested areas of natural cover, including the western portions of Larose Forest. Significant agricultural areas in the southern extents of the catchment. The community of Limoges is centrally located.	96.29
North Indian Creek	The North Indian Creek is a northern tributary of the Bear Brook. Its headwaters are located within the UCPR in the area of Du Golf and Joannis Roads. It flows in a southeasterly direction north of the community of Hammond until it reaches the Bear Brook west of Bourget.	Mainly agricultural with significant areas of natural cover including the Hammond Swamp, a Provincially Significant wetland in the eastern section. The community of Hammond is located in the southern section.	65.20

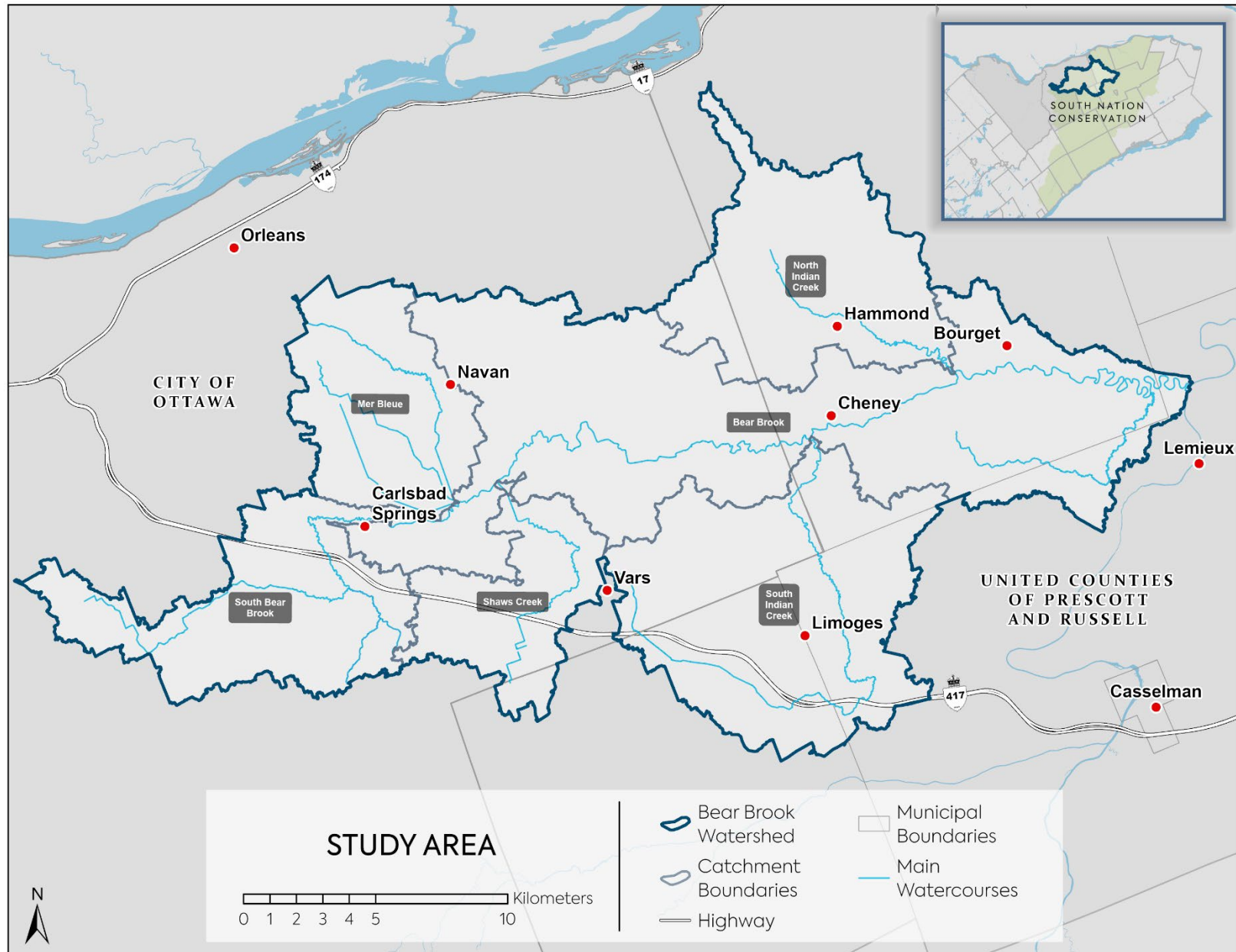


Figure 1. The study area of the Bear Brook Watershed Study and the six major subwatersheds. Main towns and villages are shown.

2. Geology

The underlying geology, including rock and soil formations, affects water infiltration, runoff, and stream flow. Sandy or clay-rich soils, both present in large quantities in the Bear Brook Watershed, have varying drainage capacities. For instance, sandy soils facilitate rapid water infiltration, leading to reduced surface runoff in the ice-free months, while clay soils can lead to increased runoff due to their low permeability. The geological features of Bear Brook, such as the ridges and valleys associated with the ancient Ottawa River, combined with soil permeability, influence how water flows across the watershed. These features contribute to the delineation of several subwatersheds in the greater Bear Brook Watershed and determine drainage patterns and direction of surface runoff within these areas.

Several data sets were referenced to identify geological features and soil properties in the Bear Brook Watershed. The Ontario Geological Survey (OGS) is the steward of Ontario's public geoscience data. Several geospatial datasets were referenced to characterize the bedrock geology (OGS, 2011), physiography (Chapman and Putnam, 2007), and surficial geology (OGS, 2010) of the study area. Additional materials were used to better understand the significance of the Ottawa River paleochannels and the presence of Leda clay in the watershed (Schut, 1987).

Hydrologic Soil Groups are related to geology and have been mapped in Ontario to aid in the determination of run-off potential (Ontario Ministry of Agriculture, Food and Rural Affairs, 2019). This information has many applications including flood mapping, stormwater studies and farm field investigations for nutrient application. Data was obtained from Ontario Ministry of Agriculture, Food and Rural Affairs, and the Percent Hydrologic Soil Group was calculated for each subwatershed, as well as for the Bear Brook Watershed as a whole.

3. Bedrock Geology

Bedrock is the solid, un-weathered rock that underlies soils. While largely unseen, the bedrock across the study area plays a formative role in the characteristics of the Bear Brook Watershed. Bedrock geology across the catchment is depicted in Figure 2.

Precambrian Era

The area surrounding the Ottawa River Valley is underlain by the Canadian Shield, composed of ancient Precambrian rocks that are over a billion years old. These rocks were formed when sedimentary and igneous rocks were thrust up to form a mountain chain (Bélanger & Harrison 1980). Within the core of this mountain system, heat and pressure changed limestone to marble and sandstone to quartzite. 500 million years of erosion exposed these altered rocks. They form the stable geological foundation on which more recent geological activities occurred over time.

Paleozoic Era

During the Paleozoic Era, approximately 500 million years ago, eastern Ontario was inundated with a shallow ocean that advanced from the east. The nearly flat exposed core of the former mountain chain was slowly inundated (Bélanger & Harrison 1980), depositing eroded sediment from the Precambrian landmass along its shorelines. During the next 70 to 80 million years, the sea withdrew and advanced several times over the area. The sand and gravel deposits formed from wave action against rock were laid down and lithified (transformed under pressure) becoming layers of sandstone, conglomerate, limestone, and shale, leading to the deposition of sedimentary rocks like limestone and sandstone on top of the older Precambrian bedrock. These flat layers of rock are evident today and are broken by faults.

Mesozoic Era

The Mesozoic Era, approximately 252 to 66 million years ago, was marked by significant erosion and tectonic activity. The Appalachian Mountains to the east influenced regional topography through uplift and erosion, though the direct impact on the Ottawa Valley was limited compared to later glacial processes (Rogers, 1985).

Cenozoic Era

The Cenozoic Era, 66 million years ago to present day, is a critical period for understanding the development of the landscape that shaped the Bear Brook Watershed. During the Paleogene Period (66 million to approximately 2.6 million years ago), the region experienced significant erosion due to a warm and humid climate. This erosion shaped the landscape, removing sedimentary layers and exposing the underlying bedrock. Although tectonic activity in the region was relatively stable during the later period of this era, ongoing isostatic adjustments and slight tectonic movements contributed to minor landscape changes.

The Quaternary Period of the Cenozoic Era (2.6 million years ago to present) observed multiple glaciation events. The Laurentide Ice Sheet repeatedly advanced and retreated over the Ottawa Valley, dramatically altering the landscape. The immense weight of the glaciers caused the Earth's crust to depress approximately 180 m below present sea levels.

Following the last ice age, rising temperatures caused the Laurentide Ice Sheet to melt and retreat. Huge spillways, which looked like massive rivers, carried the melting glacial waters away, sometimes creating lakes. In the region now known as the Ottawa Valley, this process created numerous channels and depressions in the landscape (Dyke & Prest, 1987) and led to the formation of a vast inland arm of the Atlantic Ocean known as the Champlain Sea (Figure 3, Figure 4). The sea existed from about 12 000 to 10 000 years ago (Fulton and Richard, 1987), its water level decreasing continuously as the earth's crust rebounded once freed from the weight of a 1- to 3-kilometre-deep glacier.

The Champlain Sea was a significant phenomenon, and the deposition of marine sediments from this sea (including Leda clay) greatly influenced the region's topography and hydrology

(Parent & Occhietti, 1999). As isostatic rebound continued, the Champlain Sea receded, and the Ottawa River began establishing its current course. This dynamic process led to the abandonment of certain channels, forming the paleochannels seen today (Barnett, 1992). These paleochannels are observed as depressions or ridges filled with sediments (Figure 5).

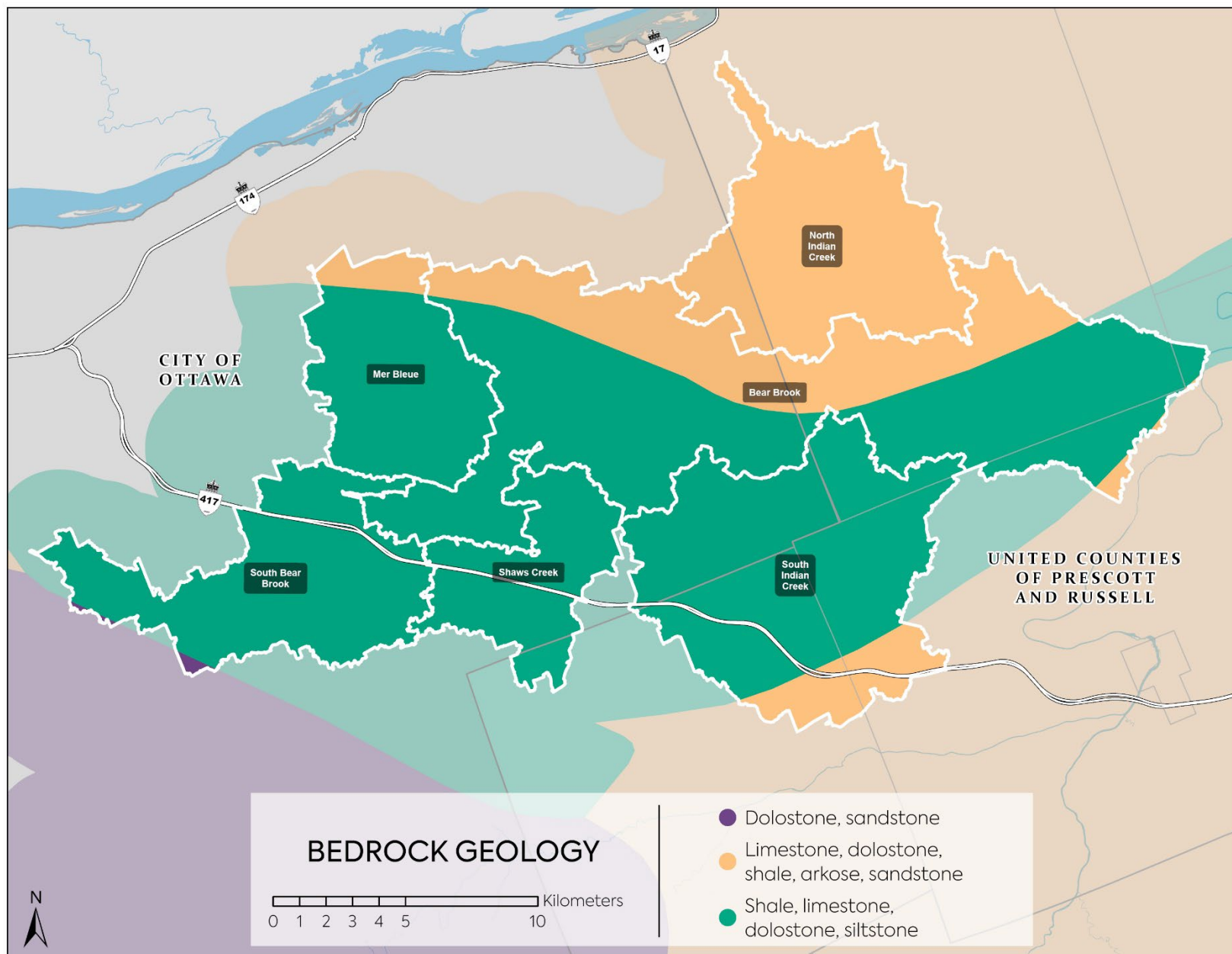


Figure 2. The underlying bedrock geology of the Bear Brook Watershed.

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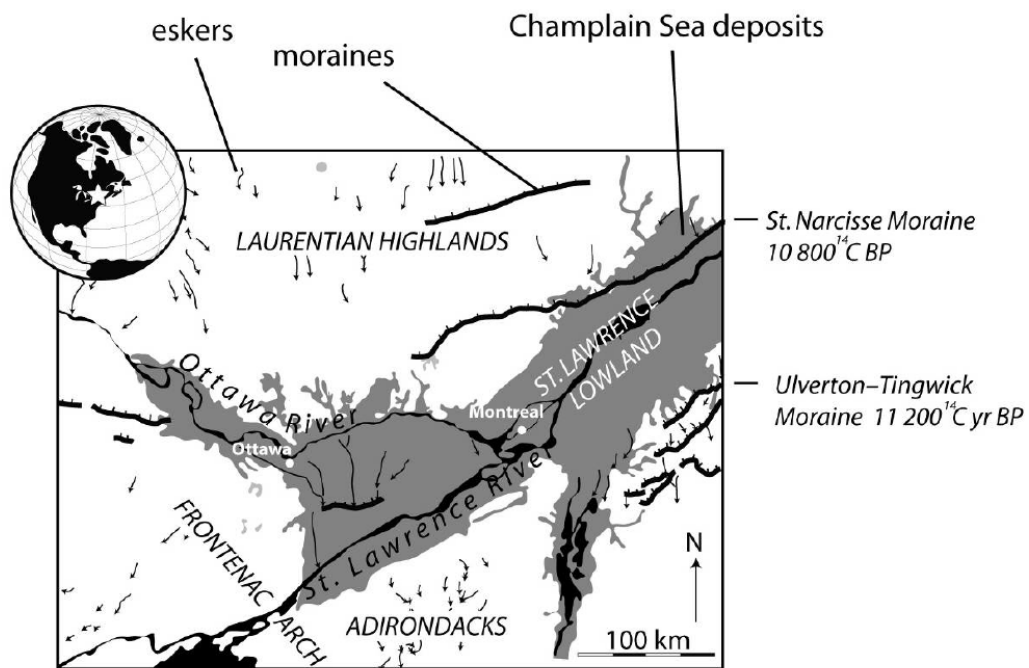


Figure 4. The historic location and extent of the Champlain Sea (taken from Russell et al., 2011).

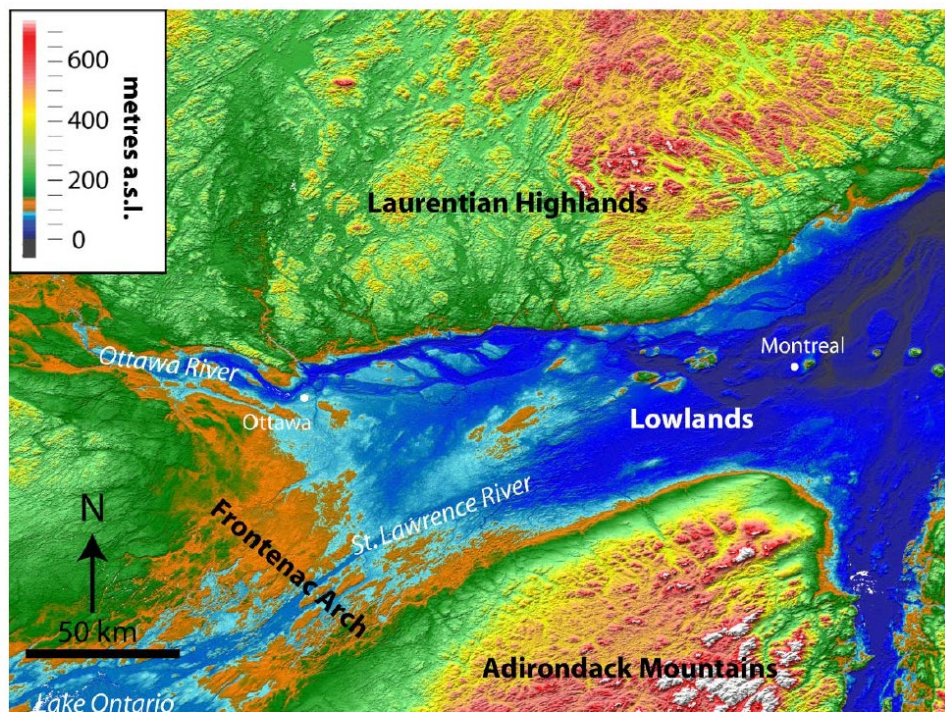


Figure 3: Elevations resulting from geologic activity over time (taken from Russell et al., 2011).

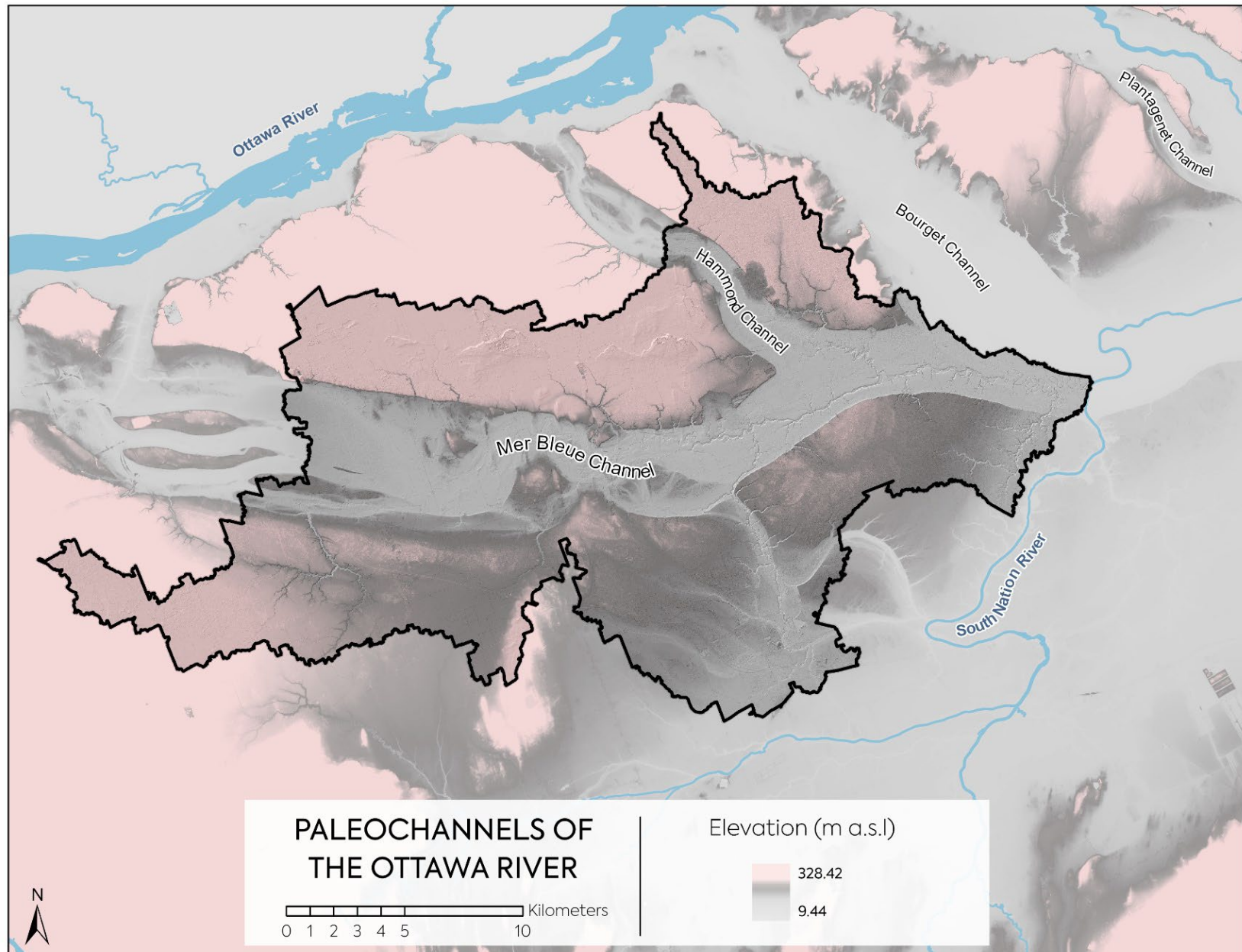


Figure 5. The location of the paleochannels left behind after the Champlain Sea receded and the Ottawa River settled into its modern location and extent.

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4. Physiographic Units

Physiographic units, as defined by Chapman and Putnam, (2007), refer to the large geographic regions characterized by similar landform characteristics, geological structures, and topography. As mentioned above, the catchment was originally inundated by the Champlain Sea, later forming a delta of the early Ottawa River. Over time, the delta was incised, and the Ottawa River's water and flows were rerouted during the isostatic rebound when glaciers retreated, and the land mass rose.

The resulting physiographic regions include the Ottawa Valley Clay Plains which are large, flat areas of clay, present in the ancient paleochannels. The Russell and Prescott Sand Plains are also found, bound by high bluffs. The upper portions of the bluffs are composed of sand underlain by clay, usually at a depth greater than 3 meters. In other places, the only traces of delta and channels are clay plains showing evidence of erosion and numerous sand deposits (Schut, 1987). Physiographic regions are useful for understanding broad patterns in the landscape for purposes like land use planning, agriculture, and ecology. Table 2 identifies the percentage physiographic area by subwatershed, and Figure 6 illustrates the areas.

Table 2. The percentage of each physiographic region in the Bear Brook Watershed.

Subwatershed	% Ottawa Valley Clay Plain	% Prescott and Russell Sand Plain
South Bear Brook	13.26	86.74
Shaw's Creek	19.80	80.20
Mer Bleue	100	0
South Indian Creek	9.74	90.26
North Indian Creek	50.51	49.49
Main Bear Brook	75.26	24.74
Bear Brook Watershed (Total)	49.24	50.76

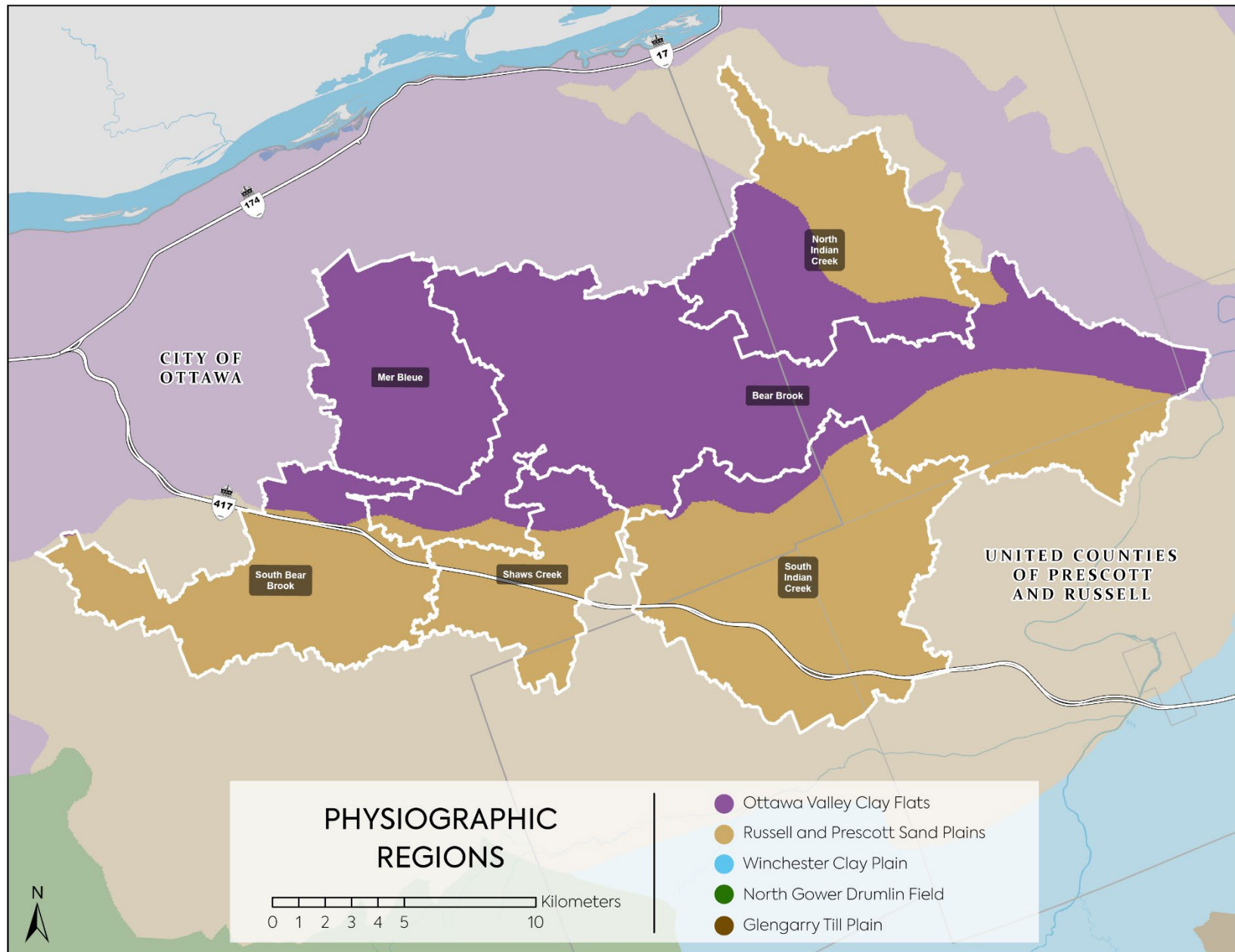


Figure 6. The physiographic regions in the Bear Brook Watershed.

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5. Surficial Geography

Surficial geology refers to the study of unconsolidated sediments and materials found on the Earth's surface. In eastern Ontario, surficial soils are the result of glacial deposits left behind from retreating glaciers, sediments deposited by rivers and streams, and organic deposits formed from peat and other soils rich in organic material found in wetlands.

Surficial soils within the Bear Brook Watershed are diverse and the relative permeability of soils are variable. The predominant surficial materials are sandy deltaic deposits and marine clay deposits, the remainder largely being distributed between older alluvial deposits, till, organic deposits and bedrock. Understanding the location of different types of surficial soils offers insights into drainage patterns, and natural resources, affecting water management. Table 3 describes each surficial soil type found in the Bear Brook Watershed and provides the percent composition by subwatershed, while Figure 7 provides a depiction of surficial soil type across the watershed.

Significance of the Champlain Sea and Leda Clay

Leda clay is present in areas once covered by the Champlain Sea. The Champlain Sea contained both fresh water from glacial melt and salt water from the ocean. When salt molecules combine with clay molecules, the result is a stable clay. However, if fresh water infiltrates the clay and washes away the salt, the clay becomes very unstable. An unstable clay molecule is prone to liquefaction. Generally, the clay is buried beneath the surface and protected from fresh water, making it stable. However, earth tremors, whether natural (like earthquakes and erosion) or human-made (such as explosions, blasting, and digging), can allow fresh water to seep into the Leda clay, removing the salt molecules. If this clay is located on a hill or at the edge of a winding river, it can lead to landslides.

Vars-Winchester Esker

The Vars-Winchester Esker is an important geological feature in the Bear Brook Watershed. The esker is 50km in length and is comprised of glaciofluvial outwash deposits (permeable sand and gravel) and, except for where it outcrops at the surface, is overlain by fine, low-permeability sediment associated with Champlain Sea deposits (Gorell, 1991). The esker consists of two elements:

- A gravely central-ridge that is highly permeable, ranging from 2-m to 20-m in height and 100-m to 200-m in width; and,
- A sandy-fan carapace that is moderately permeable, ranging from 400-m to 2-km in width.

Groundwater flow is largely in a north-eastern direction towards the Ottawa River, generally along the gravelly core of the esker.

The Vars-Winchester esker is a productive groundwater feature that provides municipal water for seven villages including Vars, Limoges, Russell, Embrun, Marionville, Winchester and Chesterville. Municipal wells have been shown to be very productive, with yields that are >31 L/sec of water. This feature will be highlighted in the water budget for the Bear Brook Watershed.

Hydrostratigraphy and surficial soils found in the Bear Brook Watershed are further summarized by Aquanty Inc. in the Water Resources Section of the Characterization Report in Appendix B: Development of a Fully-Integrated GW-SW Model for the Bear Brook Subwatershed: Preliminary Water Balance Analysis (Aquanty Inc., publication pending).

Table 3. Surficial soil types in the Bear Brook Watershed and percent composition by each major subwatershed.

Surficial Soil Type	General Soil Description	% Surficial Soil Group by Subwatershed						% Bear Brook Watershed
		South Bear Brook	Shaw's Creek	Mer Bleue	Bear Brook	South Indian Creek	North Indian Creek	
Marine Clay (light green)	• Uniform in composition compared to alluvial and deltaic deposits, due to deep water influence of Champlain Sea where slow sedimentation rates allowed fine particles to settle. • Fine-grained, largely composed of clay; can also include biogenic material (e.g., shells, planktonic debris), resulting in nutrient rich soils.	25.45	44.02	44.43	33.13	16.98	19.28	28.94
Deltaic Deposits (blue)	• Formed where rivers meet standing bodies of water, causing the river to lose energy and deposit sediments such as sands and silt. • Located in bluff areas adjacent to the Champlain Sea	25.60	30.87	13.27	28.78	74.39	46.97	38.63
Alluvial Deposits (dark green)	• Formed from sediments transported and deposited by rivers and streams. • Typically found in river valleys, floodplains; well sorted with sediments of similar size deposited together.	4.17	0.46	5.51	14.21	3.36	10.97	8.47
Till (light purple)	• Formed from the abrasion and plucking of bedrock by glaciers, incorporating a wide range of particle sizes.	4.47	9.56	6.42	16.00	1.06	12.44	9.66

Surficial Soil Type	General Soil Description	% Surficial Soil Group by Subwatershed						% Bear Brook Watershed
		South Bear Brook	Shaw's Creek	Mer Bleue	Bear Brook	South Indian Creek	North Indian Creek	
	• May exhibit poor drainage due to fine particles filling pore spaces.							
Organic Deposits (teal)	• Located in Mer Bleue Bog because of plant material building up faster than it can decompose (peat). • High organic carbon content and porosity; acidic soil. • Important for carbon sequestration	1.64	11.38	29.31	1.57	1.63	0.91	4.92
Nearshore Sediments (orange)	• Formed in shallow water areas close to shorelines. • Typically, well sorted sands and gravels due to influence of waves and currents winnowing away finer particles like silt and clay; Well-drained but nutrient poor.	36.90	0.83	0	0.57	0	0	4.95
Dune (yellow)	• Mounds or ridges of sand created by the wind's deposition of sand particles. • Composed of well sorted, fine to medium grained sand.	1.32	2.88	0.01	0.89	2.27	0.31	1.20
Glaciofluvial Deposits (dark brown)	• Formed by meltwater from glaciers, resulting in deposits of gravel and sand • Location of Vars-Winchester Esker, a long winding ridge that is an important groundwater recharge area and aquifer in the Bear Brook Watershed.	0.45	0	0	1.05	0.24	0	0.49

Surficial Soil Type	General Soil Description	% Surficial Soil Group by Subwatershed						% Bear Brook Watershed
		South Bear Brook	Shaw's Creek	Mer Bleue	Bear Brook	South Indian Creek	North Indian Creek	
Bedrock (light brown)	• Residual soils form in place from the weathering of underlying bedrock • Locations of gravel pits and quarries	0	0	0.55	1.95	0.07	4.50	1.39
Landslide (red)	• Retrogressive, sensitive clay landslide features were identified by Brooks (2019). • The larger escarpment near the center of the Bear Brook watershed is located in Cheney, Ontario. • The escarpments located to the west of the Bear Brook watershed are in the Navan area. • The escarpments to the east of the Bear Brook watershed are located near Hammond, Ontario.	0	0	0.50	1.85	0	4.61	1.35

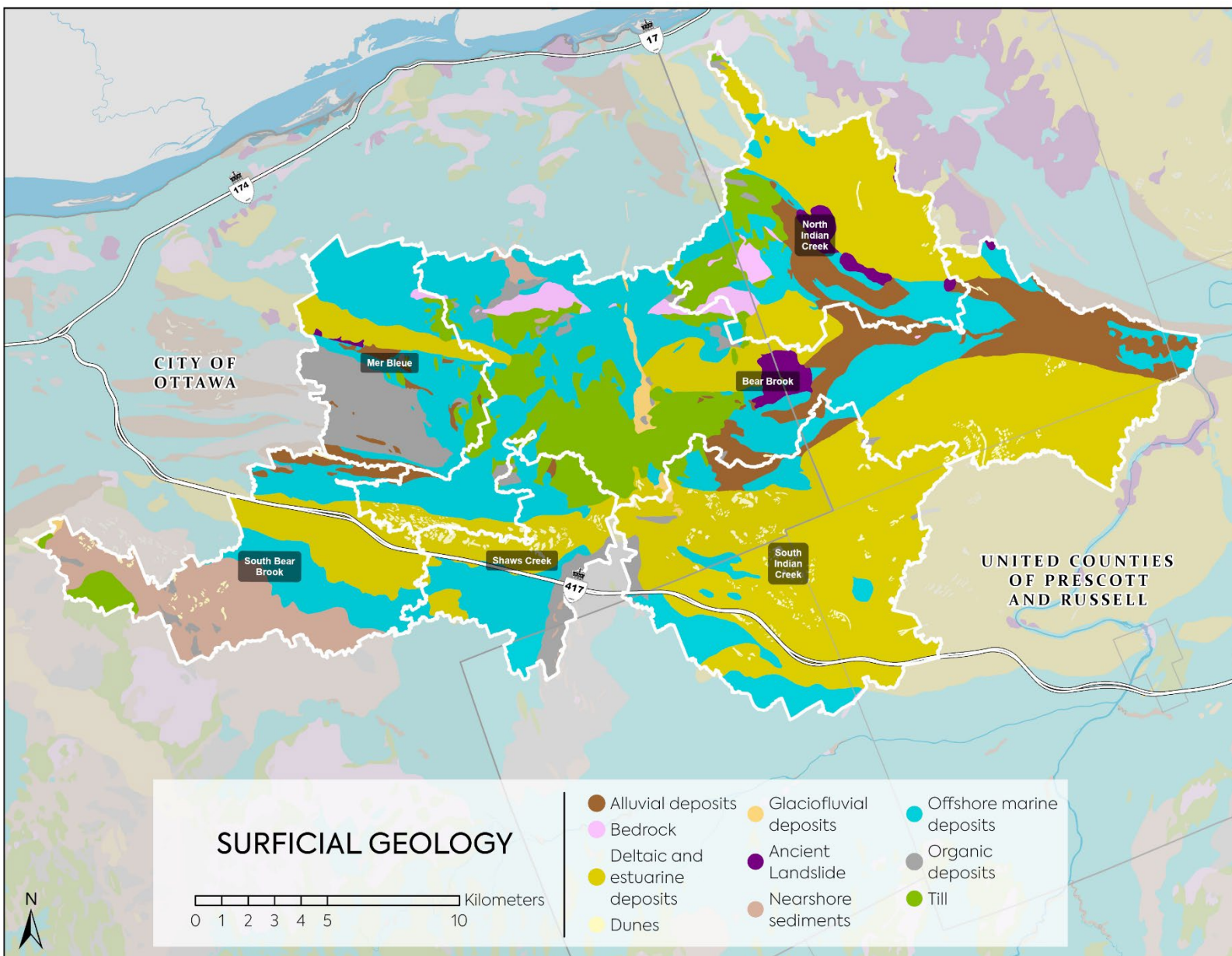


Figure 7. Surficial geology in the Bear Brook Watershed.

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6. Hydrologic Soil Group

Hydrologic Soil Groups have been mapped in Ontario to aid in the determination of run-off potential (Ontario Ministry of Agriculture, Food and Rural Affairs, 2019). This information has many applications including flood mapping, stormwater studies and agricultural investigations when considering nutrient application and drainage.

Table 4 provides general details on the hydrologic soil groups, while Figure 8 displays the hydrologic soil groups found in the Bear Brook Watershed. Most soils within the Bear Brook Watershed have slow infiltration rates with moderate run-off potential.

Table 4. Hydrologic Soil Groups (HSG) in the Bear Brook Watershed.

HSG Drainage Class	General Soil Texture	Infiltration Rate	Run-off Potential	% Hydrologic Soil Group by Subwatershed						% HSG Bear Brook Watershed
				South Bear Brook	Shaw's Creek	Mer Bleue	Bear Brook	South Indian Creek	North Indian Creek	
A	Deep, well-drained sands and gravels	High	Low	5.69	3.89	10.51	15.71	25.18	9.21	14.08
B	Loam, moderately deep, soils with coarse to moderately fine textures	Moderate	Moderate	6.19	11.90	6.90	36.10	43.44	60.24	32.44
C	Clay loams, shallow sandy loams, soils with moderately fine to fine textures	Slow	Moderate	74.27	57.67	11.24	19.80	27.05	4.17	27.99
D	Clay soils, soils with permanently high- water table, shallow soils over nearly impervious material	Very slow	High	6.34	21.81	68.65	25.71	2.87	24.87	22.45
No Data	Areas with no data tend to be aggregate sites or river bottoms	N/A	N/A	7.51	4.73	2.69	2.69	1.46	1.52	3.04

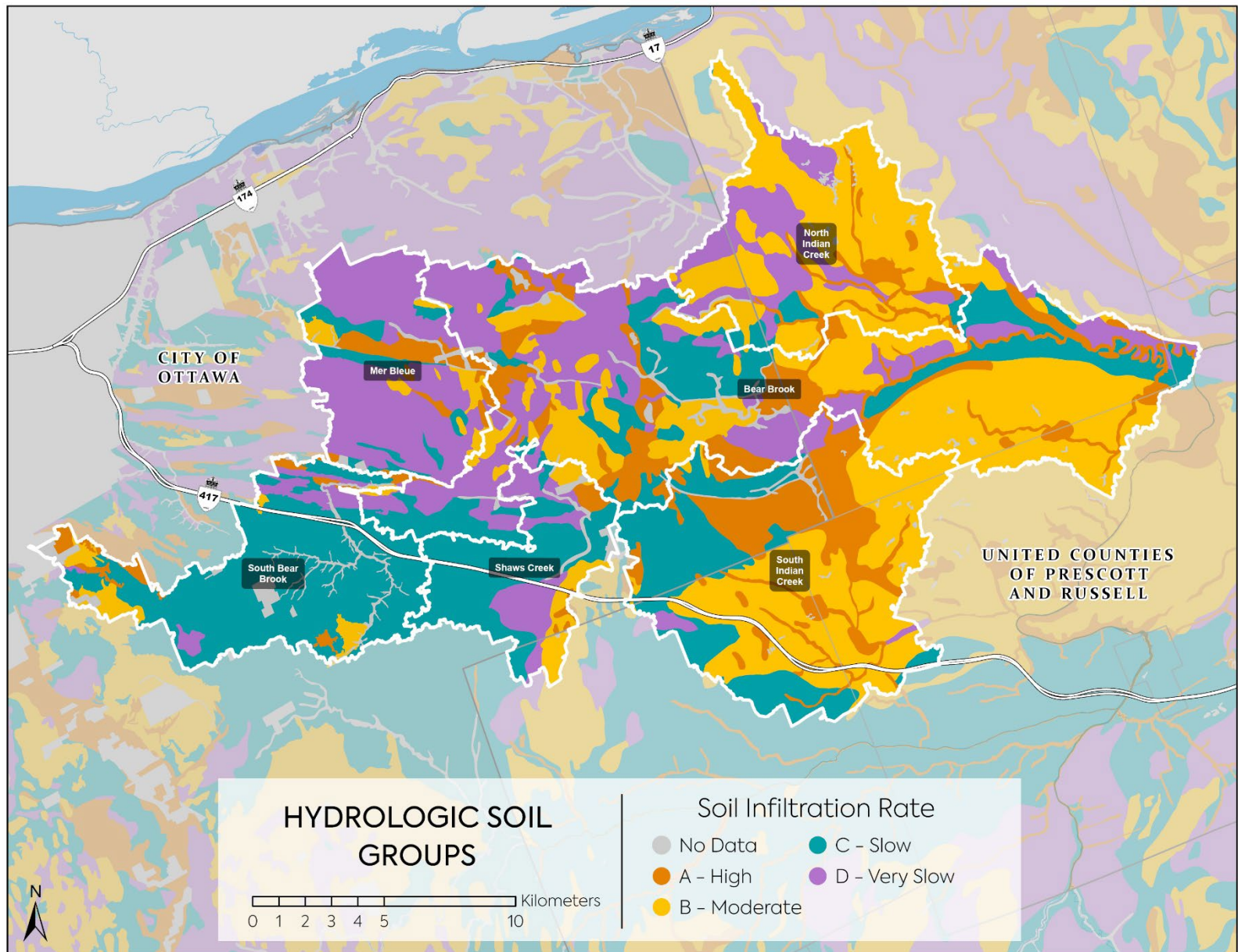


Figure 8. Hydrologic Soil Groups in the Bear Brook Watershed.

7. Climate

The Bear Brook Watershed exhibits a humid continental climate and is characterized by four distinct seasons, cold, snowy winters and warm, humid summers. Mean temperatures vary significantly according to season. Precipitation is evenly distributed through the year, with slightly higher precipitation between April and October. The climate is influenced by several factors including:

- Mid to high-latitude location in the Northern Hemisphere;
- Inland location far from ocean influences;
- Proximity to the Great Lakes and the St. Lawrence River; and,
- Varying topography.

The World Meteorological Organization (WMO) recommends the use of Climate Normals to summarize conditions of a location using data from a full calendar year over a 30-year period to minimize year-to-year variations (WMO, 2017). Climate Normals are used for two main purposes:

1. They form a benchmark or reference against which conditions (especially current or recent conditions) can be compared; and,
2. They are widely used as an indicator of the conditions likely to be experienced in a given location.

Countries, including Canada, update normals every decade with the most recent calculations summarizing the 1991-2020 time period. This report compares data from Ottawa International Airport for several periods including 1951-1980, 1961-1990, 1971-2000, 1981-2010 and 1991-2020 to highlight climate trends and provide insights into the Bear Brook Watershed's changing climate.

Table 5 represents 30-year climate normals obtained from an Environment and Climate Change Canada climate station located at the Ottawa International Airport (1991-2020).

Table 5. Temperature and precipitation normals (1991-2020) based on data collected from the Ottawa International Airport, Environment and Climate Change Canada climate station.

Parameter	Normal
Annual Average Temperature	6.5 °C
Winter Average Temperature	-8.1 °C
Spring Average Temperature	5.7 °C
Summer Average Temperature	20 °C
Fall Average Temperature	8.4 °C
Average Growing Season	118 days
Days with Maximum Temperature >0 °C	288.9 days
Days with Maximum Temperature >30 °C	14.8 days
Average Annual Rainfall	757.2 mm
Average Annual Snowfall	231.9 cm
Average Annual Precipitation	929.8 mm
Average Annual Evapotranspiration	550 mm
Average # of Thunderstorms	23
Average # of Freezing Rain Events	14
Average Length of Frost-Free Period	160 days

Temperatures in the Bear Brook Watershed show long-term warming trends based on 30-year climate normals obtained from the Ottawa International Airport (1951-2020), as depicted in Figure 9. In addition, temperatures are getting warmer through the ice-free months and winters are becoming less cold.

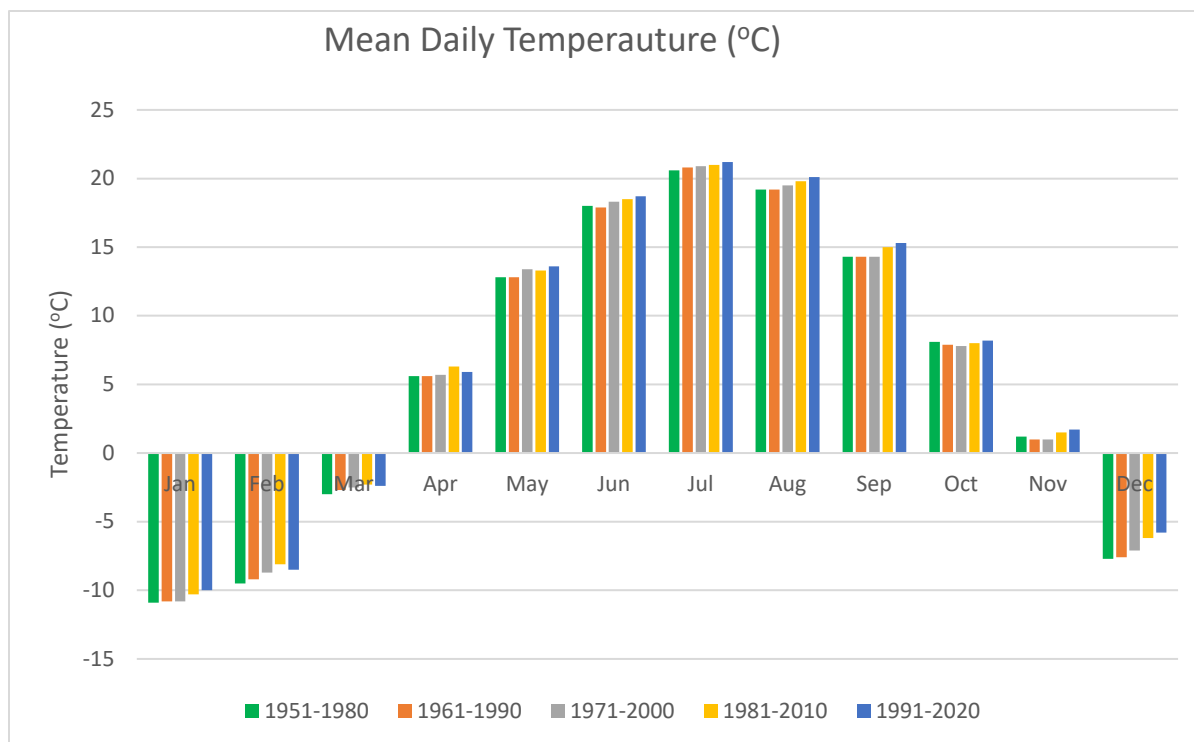


Figure 9. 30-year temperature normals from 1951-2020 recorded at the Ottawa International Airport.

Canada's climate will continue to warm, driven by global greenhouse gas emissions from human activity. Both past and future warming in Canada is, on average, about double the magnitude of warming globally (Bush et al., 2019). A comprehensive climate change projection study was recently completed by the National Capital Commission (NCC) and the City of Ottawa for the National Capital Region (CBCL, 2021).

Climate projections studied under the moderate to high emission scenarios (Representative Concentration Pathway 4.5 and 8.5) determined that the National Capital Region will become warmer and wetter. Like the trend observed above, warming is anticipated in all seasons. An increase in precipitation is anticipated in all seasons, except summer. It is expected that the timing of seasons will shift and that periods of extreme heat will become more common. Rainfall is expected to increase, both in volume and intensity. Annually, less snowfall and a shorter snow season are projected. Conditions favorable for extreme events such as freezing rain, tornadoes and wildfires are projected to become more common (CBCL, 2021).

Temperatures are projected to be warmer under the high emission scenario (RCP 8.5 compared to the moderate scenario (RCP 4.5). Precipitation scenarios are more variable and do not show significant difference between the two scenarios when examined in 30-year time slices (CBCL, 2021).

Assessing impacts from climate change is outside the scope of this report and will be considered in the next phase of the Bear Brook Watershed Study.

8. Land Cover in the Bear Brook Watershed

A comprehensive land cover update was completed by South Nation Conservation on the Bear Brook Watershed in 2024. The purpose of this update was to increase spatial accuracy of different land cover types using the best available data. Several technical specifications were considered by a working group comprising of staff from the City of Ottawa, South Nation Conservation, Rideau Valley Conservation Authority and Mississippi Valley Conservation Authority. The methodology for the development of this product is included in Appendix A. In this report, Percent (%) Land Cover Class is presented for each subwatershed, as well as for the overall Bear Brook Watershed. Results are presented in Table 6.

Geology and climate have greatly contributed to existing landcover across the Bear Brook Watershed (Figure 10). Before European settlement, eastern Ontario presented a vastly different landscape compared to today. These areas were predominantly covered by natural ecosystems consisting of deciduous forests and swamp wetlands that had developed over thousands of years without significant human alteration.

The physical and chemical properties of soils, particularly their texture and composition, play a crucial role in determining the land cover present in the Bear Brook Watershed today. Clay and sandy soils represent two ends of the soil texture spectrum, each with distinct characteristics that contribute to the formation of different ecosystems and land uses. The key characteristics of clays in the Bear Brook Watershed includes:

- Poor Natural Drainage: The fine texture of clay soils leads to slow water infiltration and percolation, resulting in waterlogged conditions; and,
- Seasonal Flooding: Spring snowmelt and seasonal rains often causes extensive surface water accumulation.

Several characteristics of these soils make them beneficial for vegetation productivity:

- The fine soil particles are rich in minerals, and have a high cation exchange capacity, meaning they can hold and exchange positively charged nutrients like potassium, magnesium, and calcium;
- Clay soils retain water effectively due to their small particle size and pore spaces. This ensures that plants have access to moisture during dry periods;
- Nutrients are less likely to be washed away compared to sandy soils, keeping them available for plant uptake; and,
- They accumulate organic matter over time, increasing fertility.

The natural conditions of the clay soils, including high water retention and flat topography, would have created ideal environments for wetlands and hydrophytic vegetation. The arrival of European settlers in the 18th and 19th centuries brought significant changes to the clay plains, as well as increased their expanse. Wetlands with thick peat were drained, dried, and burnt to

reveal the underlying clay soils (Department of Planning and Development, 1948). Trees were cleared for timber and to open land for crops and settlements, and other wetlands were drained using ditches and tile drainage to create arable land.

By addressing the drainage limitations inherent in clay soils, settlers and the present farmers in the Bear Brook Watershed have transformed these lands into highly productive agricultural areas. The combination of nutrient-rich soils and water management elevates their classification to Class 1-3 suitability, supporting a wide range of crops, including corn and soybeans, contributing to the region's agricultural success. Agriculture accounts for 35% of the land cover in the Bear Brook Watershed today, primarily in clay soils. Tile drainage is extensive across these areas, present in approximately 17% of the watershed.

Table 6. Land cover types and the percentage of each in the Bear Brook Watershed.

Land Cover Type	Percent (%) Land Cover by Subwatershed						Bear Brook Watershed Total
	South Bear Brook	Mer Bleue	Shaw's Creek	South Indian Creek	North Indian Creek	Main Bear Brook	
Aggregate	0.63	0.97	0.30	0	1.03	0.80	0.63
Settlement	10.46	12.48	7.89	8.08	7.65	7.24	8.43
Transportation	4.21	4.88	3.76	3.41	2.65	2.94	3.41
Water	0.43	0.27	0.41	0.31	0.29	0.69	0.46
Wetland	27.17	29.00	17.57	30.55	23.56	14.15	22.06
Wooded Area	28.77	12.33	15.73	28.74	27.49	26.68	25.27
Crop/Pasture	22.82	32.47	49.05	24.52	33.03	43.30	34.91
Grassland	6.15	7.61	5.29	3.99	4.31	4.20	4.83
Tile Drained Land	6.55	13.16	31.06	11.12	13.03	22.18	16.52

***Note: Land cover types do not add up to 100% due to overlap between Wetland and Wooded Area land cover types due to the presence of swamps, as well as overlap between Crop/Pasture and Tile Drained Land.*

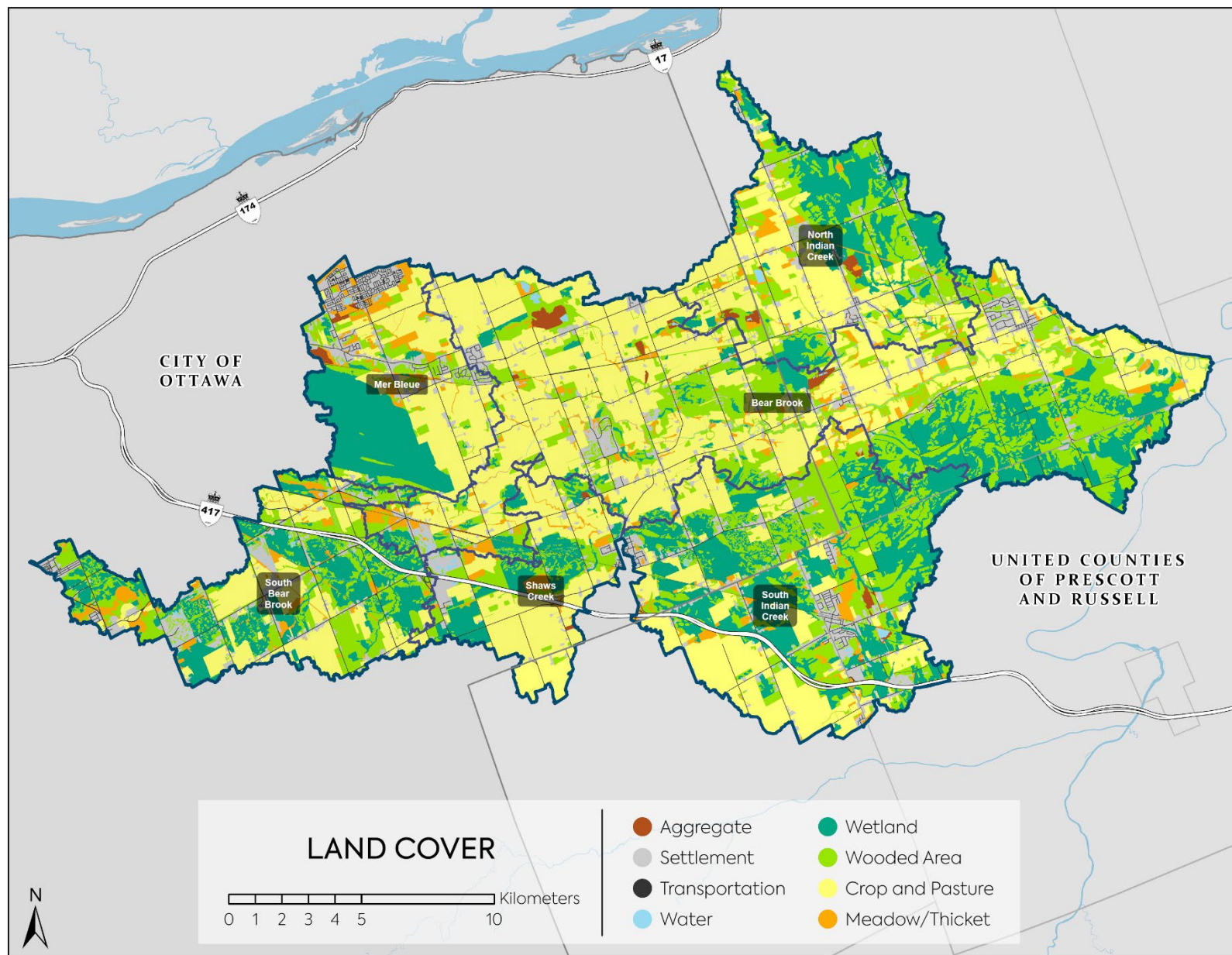


Figure 10. Land cover in the Bear Brook Watershed as of the 2024 SNC Land Cover Update Project.

Sandy soils, characterized by coarse particles, rapid drainage, and low nutrient retention, support ecosystems adapted to drier, nutrient-poor conditions. Extensive forest clearing in the late 18th century and early 19th century was widespread, regardless of soil type. It became evident over time that sandy soils were not conducive to growing crops due to their poor nutrient retention, high permeability and difficulty in retaining moisture. The Bourget Desert was a unique environmental phenomenon that manifested because of poor land use choices in sandy environments. Incompatible land uses (i.e., land clearing, agriculture) in the sandy glaciomarine sands led to erosion and soil loss, resulting in vast expanses of drifting sand dunes and sparse vegetation near the village of Bourget.



Figure 11. The Bourget Desert near the Village of Bourget, a result of forest clearing and subsequent wind and rain erosion.

By the early 20th century, authorities acknowledged the severity of land degradation in the Bourget area, and between 1928 and the 1950s, millions of trees were planted over thousands of hectares, forming the Larose Forest. Larose Forest is now one of the largest human-made forests in North America, spanning over 11,000 hectares in the United Counties of Prescott and Russell, effectively stabilizing the previously eroding sand soils. This impressive legacy is underscored by the reforestation of the lands of two ghost towns, Grant and Gagnon, within Larose Forest. Their residents, who had been dependent on logging and agriculture, abandoned them because of desertification.

Today, these glaciomarine sands are largely covered by upland forests and treed swamps across the Bear Brook Watershed and make up large portions of several subwatersheds including the south east portion of South Bear Brook, large expanses of South Indian Creek, the northeast portion of North Indian Creek and the south east portion of the Main branch of the Bear Brook River.

Additional land cover types also have strong ties to underlying geology. Aggregate extraction is located in areas where there is a presence of bedrock and glaciofluvial deposits. This is found in the northern portion of the Vars-Winchester Esker near the village of Bear Brook and in areas where the esker outcrops are near ground surface.

Mer Bleue Bog is a large wetland located in organic deposits with very slow drainage. Covering approximately 3,500 hectares, it is one of the largest peat bogs in southern Ontario and the second-largest raised bog in the province. Recognized for its ecological importance, Mer Bleue has been designated as a Wetland of International Importance under the Ramsar Convention since 1995.

Finally, the location of the Bear Brook Watershed in proximity to the Ottawa River and the National Capital Region has influenced settlement patterns over the years. During the mid-to-late 19th century, several communities developed within the Bear Brook Watershed with their growth facilitated by the arrival of the railway and historic presence of a booming logging industry. These communities include Carlsbad Springs, Bear Brook, Cheney, Limoges, Navan, Hammond and Bourget.

In more recent history, due to the proximity to the urban boundary of the City of Ottawa and the presence of large transportation corridors such as Highway 417, several large settlements are present in the headwaters of McKinnon's Creek in the Mer Bleue Subwatershed and the headwaters of South Bear Brook River. Additional urbanization and intensification of these areas is expected due to increasing populations within the City of Ottawa.

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Appendix A: Land Cover Update Methodology

Scale of Digitization

Landcover features were digitized at a scale of 1:4000.

Classification Schema

A classification schema was derived for the project through a working group comprising of several partners: Mississippi Valley Conservation Authority (MVCA), Rideau Valley Conservation Authority (RVCA), City of Ottawa, and South Nation Conservation (SNC). The schema was developed largely from historical land cover classification completed by RVCA. Table 1 details the data schema used.

Table 1 Data schema for land cover update in the Bear Brook Watershed.

Main Class	Sub-Class	Description	Minimum Mapping Unit (ha.)
1. Unclassified	N/A	Unclassified land cover	N/A
2. Aggregate	N/A	Pits or quarries; based on ministry typing of authorized sites. Mapping updates based on visual interpretation of DRAPE and may show dynamics in "Water" features (subclass = pond).	0.5
3. Settlement	1. Pervious	Urban recreation areas (i.e., golf courses, playing fields, parks). Manicured open spaces; generally grassed.	0.25
	2. Impervious	Industrial, commercial, and civic areas. Large parking lots and other concrete/asphalt dominated features.	0.25
	3. Pervious Homestead	Farmstead including silo and barn, and other marginal manicured portions of the property.	0.25
	4. Residential	Mix of impervious and pervious land cover, generally in high population density regions; may include larger, more isolated estate properties.	0.25
4. Transportation	1. Rail	Active or inactive - sourced from Ontario Railway Network (ORWN); 10 Meter Buffer.	0.5
	2. Roads	Sourced from Ontario Road Network (ORN); 12 Meter Buffer.	0.5
5. Water	1. Lake		0.5

Main Class	Sub-Class	Description	Minimum Mapping Unit (ha.)
	2. River	No macrophyte vegetation, trees or shrub cover. Stream/River width should be > 8 m at 1:4000. Digitized named lakes at 1:1000.	
	3. Pond		
6. Wetland	Null (Not Categorized)	Open, shrub and treed communities - water table seasonally or permanently at, near, or above substrate surface. Not sub-classified if not open water or treed swamp.	0.5
	1. Open Water		
	2. Swamp		
7. Historical classification not currently used	N/A	N/A	N/A
8. Wooded Area	1. Treed	Tree cover > 60%. Upland tree species > 75% canopy cover and > 2 m in height. Interior openings > 0.5ha and < than 20m wide (often permanent infrastructure is present).	0.25
	2. Plantation	Tree cover > 60% and minimum 2 m in height. Linear organization, uniform tree type, minimum 30 m in width.	0.25
	3. Hedgerow	Tree cover > 60% and minimum 2 m in height. Linear arrangement, minimum 10 m width and maximum 30m width.	0.25
	4. Regenerative	Tree cover < 60% and minimum 2m in height. Area appears to be transitional (tending towards a forested area).	0.25
9. Crop and Pasture	N/A	Managed/cropped agricultural lands such as mixed annual and perennial systems (i.e., row crops, hay, sod). Temporary pasture (primarily hay/crops with pasture rotation). Plantations with shrubs < 2m in height.	0.5

Main Class	Sub-Class	Description	Minimum Mapping Unit (ha.)
10. Meadow/Thicket	N/A	Predominantly herbaceous and < 25% tree or shrub cover (ELC standard). Should not include any manicured vegetation (crop or grass). May have evidence of previous land uses such as agriculture. Indicates marginal or transitional land.	0.25

Reference Data

The March 2024 Land cover product was completed by consulting several different data products:

- 2019 aerial imagery (DRAPE, 2019)
- 2014 aerial imagery (DRAPE, 2014)
- LiDAR derived digital terrain models and hillshades (latest available; 2018 – 2022)

The previous DRAPE 2014 product was also used to help identify wetland areas as much of the imagery was captured during the spring freshet of 2014. The DRAPE 2014 imagery was used only as reference to wetlands and staff ensured that digitized areas were visually and topographically consistent between data sets when referencing DRAPE 2014.

LiDAR (2021) derived hillshade was also a useful tool in determining wetland areas and other topographical features. Due to the temporal variability between datasets, staff reviewed products for any inconsistencies between the aerial imagery and hillshade.

Additionally, an adjustment of the landcover data was conducted using best available historic satellite imagery accessed through Google Earth (GE). Throughout most of the watershed, this imagery was often newer than 2019, allowing for a closer approximation of current conditions within the watershed. The GE imagery used to refine the landcover data ranged from July 2022 to May 2024. Certain areas where the GE imagery was pre-2019 were not adjusted.