II. Natural Cycle

"My favourite definition of a watershed?
– Communities connected by water."
–Stephen Born

A. Peel's Hydrogeologic History

The history of Peel, like all of planet Earth, is a long geological history spanning billions of years. Evidence of the earliest signs of life in this area was trapped 1.3 billion years ago in the mud of a tropical sea, totally blanketing Peel's current watersheds. That mud hardened into limestone, which was later eroded by water to eventually become part of the soil in which plants gradually took root. Approximately one billion years ago, the forces that built our continent created mountains in Ontario that were higher and harder than the Rocky Mountains. Water, ice, and wind wore these mountains away just like sandpaper wears wood into dust. The rock dust is the sand of today's Lake Ontario beaches. Later, from the east, rivers of red and grey muddy water flowed out of the Appalachians and covered southern Peel with sediment that gradually filtered down to the bottom of the sea. When the seas were here, the land was probably desolate, stark, and inhospitable to life as we know it.

Geological data suggests the land masses of the Earth (known as "tectonic plates") collided for a period of time (350 to 250 million years ago) and created one enormous continent - Pangaea. As the Atlantic Ocean began to form 210 million years ago, Pangaea split to form the continents we recognize today, separated by immense oceans.

1. Tropical Peel

There's a big rock ridge that took hundreds of millions of years to form, which passes right through Peel. It's called the Niagara Escarpment, and today it is recognized as a World Biosphere Reserve by UNESCO (the United Nations Educational, Scientific and Cultural Organization). This ridge of rock stretches 725 kilometres across Ontario from Queenston on the Niagara River to Tobermory at the tip of the Bruce Peninsula. In Peel, the escarpment runs from Terra Cotta through Cheltenham, Inglewood, the Forks of the Credit, Belfountain and Cataract. In some places the escarpment achieves heights of several hundred meters. In other places it is buried under sand, gravel and soil, like at Caledon Village, en route to Mono Mills. It is also a source of some of southern Ontario's prime rivers and streams, and contains some significant heritage features, rare plants, and significant habitats.[11]

a. The Niagara Escarpment

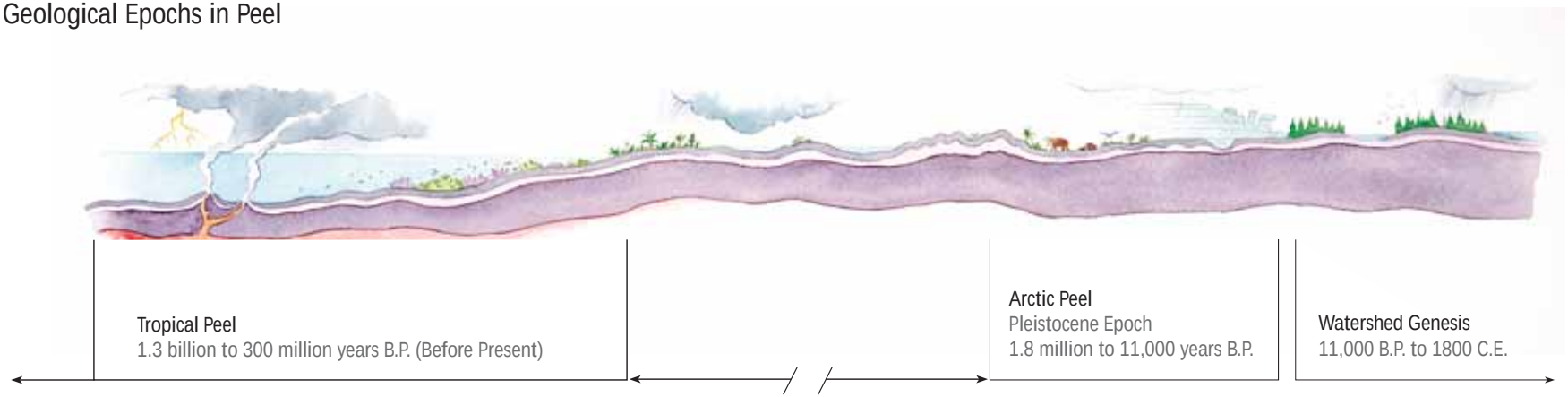
The Niagara Escarpment is an important watershed landform whose origins date back some 430 to 500 million years to a time when Peel still lay under a shallow, tropical sea complete with coral reefs. Over time, elements of sea life became compressed and transformed into rock. Silt turned to shale, sand to sandstone, shells, coral, skeletons, and lime mud to limestone. Erosion of these deposits formed the cliffs we now call the Niagara Escarpment.[12] Today, fossils are exposed throughout Peel, which provide tantalizing clues about creatures from our tropical past. For example, embedded in the shale stones that we skip on the water at Rattray Marsh, one can find the fossilized remains of ancient life, like trilobites and sea lilies that thrived in the sea 400 million years ago.

But where did the seas go? They withdrew 300 million years ago as the Earth got cooler. No one is really sure what happened. The land was raised and the Great Lakes Basin was exposed as a flat monotonous plain with streams and rivers rather than deep lakes. Erosion continued and movements of the Earth made hollows that filled with rain, becoming freshwater lakes much larger than the Great Lakes today.

2. Arctic Peel

Climate has – and will continue to be – a dominant factor influencing the major changes of our watersheds. The expanses of time addressed here can hardly be grasped as we fast-forward from the end of Peel's tropical sea period (300 million years ago) to the relatively recent Ice Age (otherwise

Geological Epochs in Peel



known as the Pleistocene epoch) of Earth's history (approximately 1.8 million years ago until 11,000 years Before the Present time [BP]). About one million years ago, as the climate cooled drastically, huge glaciers began to form and slowly spread southward across present day Canada. Imagine ice covering the Region of Peel to a thickness of three kilometres. At times during the Pleistocene Epoch, ice sheets covered most of Canada, large parts of Europe, and small areas in Asia. But the glaciation of the long Pleistocene epoch was not continuous; it consisted of several glacial advances and retreats, as climate continually changed.

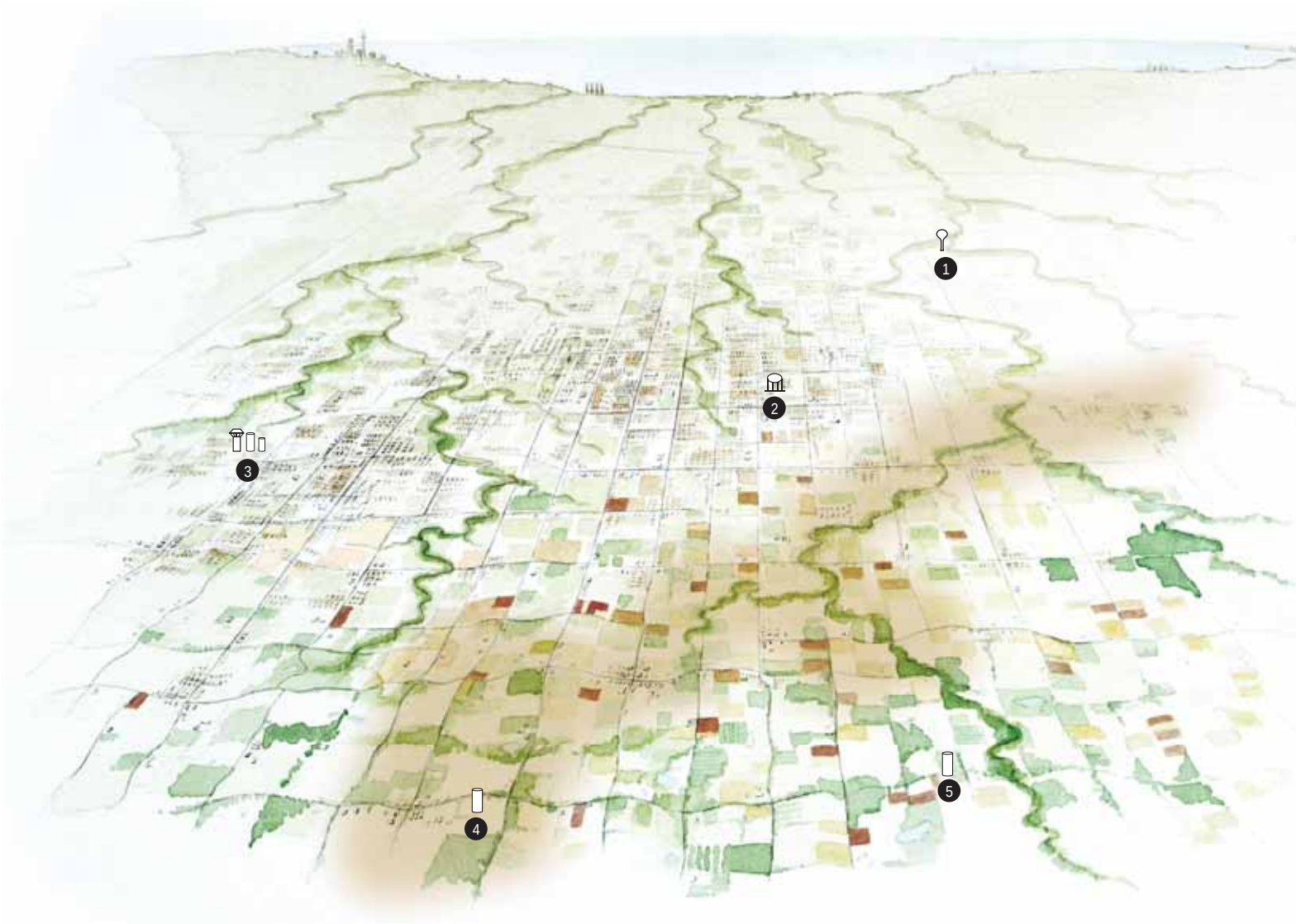
Previous to the Pleistocene epoch, and during successive glacial retreats, plant life blanketed the Peel landscape and strange animals, now extinct, roamed Peel. Giant beavers the size of bears chewed through whole forests. There were wild horses, huge mastodons, and long-tusked mammoths lumbering across the Peel landscape. As the continent-wide sheets of ice advanced each time, spruce forests were ground to powder and the animals migrated south before Caledon, Brampton, and Mississauga became locked under ice.

The most recent of the four major glacial stages is called the Wisconsin Glaciation Period, which occurred between 70,000 and 11,000 years BP. During this period, the Laurentide Ice Sheet moved down through Southern Ontario. Eleven thousand years ago, the climate changed yet again and the Wisconsin glacier retreated. Parts of that glacier, called the Foxe-Baffin Glacier Complex, still exist to this day in the Canadian arctic, perhaps awaiting another ice age, or waiting to melt due to global warming - a relatively quick climatic change, partly induced by human activity. Ecosystems and life connections in Peel were different then, as were their relationships to the watersheds, which changed dramatically over that relatively short period of time.

3. Watershed Genesis

The retreating Wisconsin glacier of 11,000 years ago formed Peel's watersheds as we know them today. It was at this time that local moraines were formed when the meltwater of glacial ice, super-saturated with eroded sediments, deposited these sediments in a large trough between two melting ice lobes (between the Simcoe and Ontario Ice Lobes in the case of the Oak Ridges Moraine)

Gulliver's View of Peel Region from the headwaters looking south to Lake Ontario on the horizon.



"Gulliver's View"

1. Streetsville Elevated Tank

2. Snelgrove Elevated Tank

3. Bolton Elevated Tank and Stand Pipes

4. Mono Mills Stand Pipe

5. Alton Stand Pipe

The sediment in the trough has formed a ridge, and the resulting Oak Ridges Moraine is the thickest and most extensive deposit of glacially-derived sediment in Ontario, measuring over 200 meters thick in some places.[13]

a. The Oak Ridges Moraine

SEE "I AM AN ACQUIFER" ACTIVITY

The Oak Ridges Moraine is a provincially significant, prominent upland area that runs east to west through south central Ontario, intersecting Peel. In order to effectively visualize the Oak Ridges Moraine (ORM), imagine yourself a giant-like Gulliver in the land of the Lilliputians. There you stand on the moraine, at the height of the land in the northern most reaches of Peel Region, overlooking the vista of your home ground. The political boundaries aren't visible, but the valleys of Peel's four major water courses are, as are the water towers of Snelgrove, Bolton, and Streetsville.[14] Under your feet are the headwaters for all the major watersheds within the Regions of Peel, Halton, Dufferin, and Toronto. The ORM can be thought of as an enormous, natural rain barrel for much of the area that is the present day Greater Toronto Area (GTA). At its westerly end, the moraine spills into the jumble of Caledon Hills country and over the buried limestone edge of the Niagara Escarpment. When looking eastward, the ORM extends further than the eye can see; past Caledon East and Palgrave, it passes north of Bolton as it leaves Peel. The hills of the Oak Ridges Moraine appear to leapfrog over one another in a broad band that reaches east almost to Peterborough, where, over 200 kilometers from Caledon, the gravel hills become less distinct and the Moraine reaches its edge.

Like much of northern Peel, the ORM was a huge dumping ground for glacial debris scraped up from other parts of the countryside. This hummocky terrain has numerous wetlands and kettle lakes, like Heart Lake, in Brampton. These depressed areas were formed by the melting out of large entrapped blocks of glacial ice. During the early post-glacial era, the young watercourses of the Credit, Humber, Etobicoke and Mimico excavated their own channels. With the continued erosion of the landscape, these water corridors came into being under the direction of gravity, widening and lengthening from their ORM headwaters all the way south to Lake Ontario.[15]

The Oak Ridges Moraine is an environmental treasure that "discharges" clean water as baseflow for more than thirty rivers and streams that drain into Lake Ontario, the source of drinking water for most of Peel's 1.1 million residents. ORM's porous sands and gravels soak up water from rain and melting snow, which then percolates down and replenishes or "recharges" groundwater – a source of drinking water for the remaining Peel residents in the Town of Caledon. "Groundwater plays an important role in the hydrologic cycle of the water resource system in Peel. The identification, maintenance and protection of groundwater recharge and discharge features…such as woodlands, topographic depressions, wetlands, ponds, lakes, rivers and streams are important to sustaining groundwater quality and quantity. Groundwater, accumulated and stored in aquifers, is an important source of drinking water for individual households (via private wells) and communities (via municipal wells) in Peel."[16]

At the base of the moraine, clean water bubbles up in artesian wells and springs; near the Village of Cataract, the Crystal Springs Beverage Company daily extracts between 136,000 and 227,000 litres of pure water from two wells.[17] By way of absorption and storage, the moraine also protects the rivers, roads, and properties from excessive storm water run off and flood damage.

The Moraine has a unique combination of geological, hydrological, topographical, and biotic attributes. It performs several essential functions providing significant natural habitat, surface water resources, groundwater resources and landform character. Its significant natural features make its protection and long-term management important to the residents of Ontario. It is presently regulated by provincially approved guidelines.[18] As you stand on the moraine, overlooking the Peel landscape, realize that the moraine is vital to the ecological health of our local watersheds.

The Iroquois Plain:
an ancient lake bed.

● = intersection of Dundas Street and Mavis Road

b. Ancient Lake Iroquois - Shoreline and Plain

Lake Ontario is one of the Great Lakes. The word Ontario comes from the Iroquoian languages and means "beautiful/ sparkling lake." Lake Ontario forms Peel's southern boundary and is a very prominent feature within the natural heritage system of Peel. The fish and wildlife habitat associated with this aquatic ecosystem has undergone significant physical change through shoreline and stream channel alteration, land clearance and drainage, and other urban activities. It is therefore important that water resource initiatives along the river valley and stream corridors and the upland headwater areas of Peel be complemented by efforts to sustain and create fish and wildlife habitat along the Lake Ontario Waterfront."[19]

SEE "NO WATER OFF A DUCK'S BACK" ACTIVITY

In their present form, the five Great Lakes came into being about 3,000 years ago. Previously, there existed larger "ancestral Great Lakes" including:

1. Lake Iroquois (ancestor of present day Lake Ontario, which drained to the Atlantic Ocean);

2. Lake Chicago (now Lake Erie and southern Lake Michigan, which drained via the Mississippi River into the Gulf of Mexico);

3. Lake Duluth (now Lake Superior, which also drained via the Mississippi River into the Gulf of Mexico);

4. Lake Algonquin (today's northern Lake Michigan, Lake Huron, and Georgian Bay, which drained through the French and Mattawa River valleys directly into the Atlantic Ocean).

Reassume the perspective of Gulliver the Giant, and imagine travelling south along Hurontario Street, in Mississauga. Beneath the railway bridge near Cooksville's four corners, there is an irregular line of elevation that runs more or less east and west and roughly parallels Dundas Street. Approximately five kilometres north of Lake Ontario, the land here drops several metres at what is known as the shoreline of ancient Lake Iroquois. As you continue south and quickly descend the hill, imagine yourself travelling off an ancient beach and going under the waters of Lake Iroquois, which were here a mere five thousand years ago. Since that time, the waters of the ancient lake have receded to the point of Lake Ontario today, leaving in their wake a sandy plain—the "Iroquois Plain"—which can easily be spied looking south from atop the steep hill, the ancient beach, at the intersection of Dundas Street and Mavis Road.

B. Peel's Life Zones - Climate and Biodiversity

Humans weren't the first to make Peel their home. Before the English settlers crossed the ocean; before the French Voyageurs paddled the rivers to peddle their wares; even before the Mississauga (Anishinabeg) or Iroquoian (On,gwehon,we) nations harvested these rich watersheds, there were other colonizers moving in and out of this territory. Plant species of Peel's current Carolinian and Mixed Forest Life Zones first appeared in their present locations approximately 7,000 years ago, due in large part to climate. Following the Wisconsin glacier's last retreat, opportunities dawned for plants and animals to migrate north. As the climate changed over the next 3,000 years, south-western Ontario

Curriculum Connections 1

"The history of Peel, like all of Planet Earth is a long geological history over billions of years."

Water is necessary to sustain all life.

The natural water cycle affects and is affected by all life forms within local watersheds.

• Kindergarten

Sci/Tech: Exploration and Experimentation

Personal and Social Development: Awareness of Surroundings

• Gr.1

Sci/Tech: Life Systems: Characteristics and Needs of Living Things

• Gr.2

Sci/Tech: Life Systems: Growth & Changes in Living Things

Sci/Tech: Earth & Space Systems: Air & Water in the Environment

Sci/Tech: Energy & Control: Energy from Wind & Moving Water

• Gr.3

Sci/Tech: Life Systems: Diversity of Living Things

Sci/Tech: Earth & Space Systems: Soils in the Environment

• Gr.4

Sci/Tech: Life Systems: Habitats and Communities

Sci/Tech: Earth& Space Systems: Rocks, Minerals, & Erosion

Social Studies: Canada & World Connections: Canada's Provinces, Territories & Regions

• Gr.5

Sci/Tech: Matter & Materials: Properties of & Changes in Matter

Sci/Tech: Earth & Space Systems: Weather

• Gr.6

Sci/Tech: Life Systems: Diversity of Living Things

• Gr.7

Sci/Tech: Earth and Space Systems: The Earth's Crust

Sci/Tech: Life Systems: Interactions Within Ecosystems

Geography: Patterns in Physical Geography

• Gr.8

Sci/Tech: Life Systems: Cells, Tissues, Organs, and Systems

Sci/Tech: Earth and Space Systems: Water Systems

Geography: Patterns in Human Geography

• Gr.9

CWS: Geography: Geography of Canada

• Gr.10

Science: Biology: Earth and Space Science

• Gr.11

Geography: Physical Geography

• Gr.12

Science: Earth and Space Science

experienced an evolving series of life zones. After the Ice Age, the Region of Peel was first tundra, then boreal forest, and then a mixed forest zone. Plants and their respective life zones would actually migrate by a repeated process of relocating generations. Today, much of Peel's undeveloped area is Mixed Forest, as it has been for the past 7 000 years due to a relatively stable climate.

1. The Butterfly Effect

Of course, vegetation is the foundation of all animal life, including human life. Southern Ontario has the greatest number of plant species in Canada, and while most of Peel is within the Mixed Forest Zone, it is our Carolinian Zone in southern Peel that is the most biodiverse. Some animals here require specific plants in order to survive. For example, the larvae of the Spicebush Swallowtail Butterfly feed exclusively on spicebush and sassafras plants, both of which are found only in the Carolinian Zone. Other varieties of plants found only or extensively in this zone include oaks, hazelnuts, beech, and maples, which are valuable food sources for wild turkeys, blue jays, squirrels and chipmunks, to name a few.[20] Throughout the Carolinian zone, gradations of habitat are comprised of different plants (and therefore different animals)—from meadows to shrubs to thickets to forests.

As a prerequisite for life, water is an inseparable part of Peel's life zones and biological communities. One example of the connections between water and life systems is seen with the moderating effect of the Great Lakes, which create a milder climate and in turn extend the breeding ranges for birds such as the Orchard oriole, Carolina wren, and Hooded warbler.[21] The health of these biological communities influences, and is influenced by, the quality of the water in the soil, brooks, streams, rivers, and lakes as well as the organisms that live in them, including insects, crustaceans, amphibians, fish and numerous other life forms. Biodiversity is in jeopardy in both Peel's southern Carolinian and northern Mixed Forest zones. Species loss and the decline of health in our local biological communities are due in part to the loss of habitat. This interconnectedness of the natural world is described by "the butterfly effect."[22]

Climate also continues to have a major and complex influence on biodiversity within these life zones. Today, the effects of water, wind, plants, animals and people change the face of Peel's watersheds, just as glaciers did thousands of years ago. Streams continue to cut valleys. Kettle lakes—such as Heart Lake—are slowly evolving into wetlands, which through natural succession will eventually become dry land, or climax wooded land. These sorts of changes occur naturally over thousands of years, but the human impact of urban development makes these and other changes occur much more quickly.

C. The Hydrologic Cycle… and Beyond

1. Water Cycle Thinking

Also known simply as the Water Cycle, the hydrologic cycle is a fundamental ecological concept that describes in stages how water cycles seamlessly through our physical world. Every elementary student is familiar with the basic idea, where water "rains up" through evaporation and transpiration to form clouds, which eventually rain down and return water to earth as precipitation. Amongst the truly remarkable properties of water is its ability to endlessly change states in this way, between liquid, solid, and gas. It is the heat generated by our sun, or the lack thereof that instigates these changes, causing water to evaporate (liquid to a gas), for example, as the vapour rises to form clouds. As a part of photosynthesis, plants transpire, releasing water vapour into the environment, which also eventually becomes a cloud. When the air temperature cools enough, this water vapour eventually condenses (gas to a liquid). As the clouds get heavy, gravity causes the liquid water, and all that is dissolved within it, to fall back to earth as some form of precipitation. Depending on the

atmospheric temperature, precipitation can change states and fall not as liquid rain, but as solid sleet, snow, or hail (liquid to solid).

It is by way of these sun-induced physical changes in state that water moves through the hydrologic cycle. When in a solid state, water may move slowly, remaining frozen for millennia, as in the case of the glaciers that once covered Peel. As a liquid, water can move rapidly in rivers and creeks, like the Credit or the Etobicoke during spring runoff. Take a walk outside during a rain or snow storm to witness the rushing creeks and rivers of our watersheds, as they rush downhill towards Lake Ontario. This Great Lake can at times be placid, or quickly conjure up powerful waves that crash onto the shores of Mississauga.

SEE "TOAST TO WATER" ACTIVITY

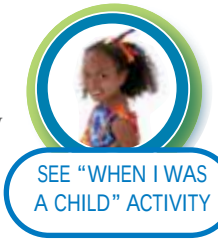
2. Water Cycle Sensing

To experience the water cycle with all of our senses, in its many natural forms, is to truly know the water cycle. This is imperative for children especially, who make meaning through experiences and who only gradually connect abstract knowledge with their collection of personal experiences. All of our senses can enjoy the rain, mist, snow or sleet. Feel comfortable in the outdoors. It's a must. If you're not there, you'll miss something very important. Go on a safari in the rain and sniff the air; it smells fresh and clean. Does it? Catch snowflakes on your tongue. Walk into the mist that rises from the land early in the morning. Step bare foot onto the dew of the grass as the sun rises. This is the "Lilliputian view" of the world. This is the child's take on things.

Watch the clouds drift by and notice the variety; your imagination can wonder at the mystery. Why do clouds look so white anyway? What causes them to look like horse tails or cotton balls? Why do storm clouds look so dark? Why do they sometimes drift leisurely by and at other times rush past? Why does the air feel/smell differently just before it snows or rains? Does it? How does it? What are the connections between water and air? Teachers connect ideas to children through metaphor and children can do the same for the teacher. Children understand metaphor at a very young age. They are the owner of the knowledge they experience about the world, from nature.

On a hot day, go to a forest. What do you notice there? Is it good? Why or why not? What else do you notice as you experience the relationships between water and the rest of nature? Feeling the rain, the snow flakes, the dew, the coolness of the riverside, or warm treated water from the bathtub faucet; tasting cold, clean water from a spring or well –these are all sensory experiences that help make water more than just two hydrogen molecules stuck to one oxygen molecule.

In Peel, there are still some diverse, natural ecosystems. At the Rattray Marsh, Heart Lake, Albion Hills or a nearby woodlot, children can *sense* changes within the ecosystems brought on by the rain or snowfall. Where does the water seem to disappear to? Why is it so much cooler as you get closer to a woodlot, river, or lake? Is it cooler? What do you begin to realize that is special? What life forms choose to live in the water, or near the edge of the river, in the marsh, in the meadows, in the woodlot? Do you affect their lives? Do they affect yours? Are you connected at all? What does water have to do with it? Anything? What is the air cycle? What is the soil cycle? Can you see how the air and soil cycles are connected to the water cycle? There is much more to these systems (which you are a part of) than meets the eye, or the written page. Have children tell their stories about water, sketch them, or write them expressively in a journey book. They will do so prodigiously. "Tell us *your* story."



SEE "WHEN I WAS A CHILD" ACTIVITY

D. Peel's Watersheds

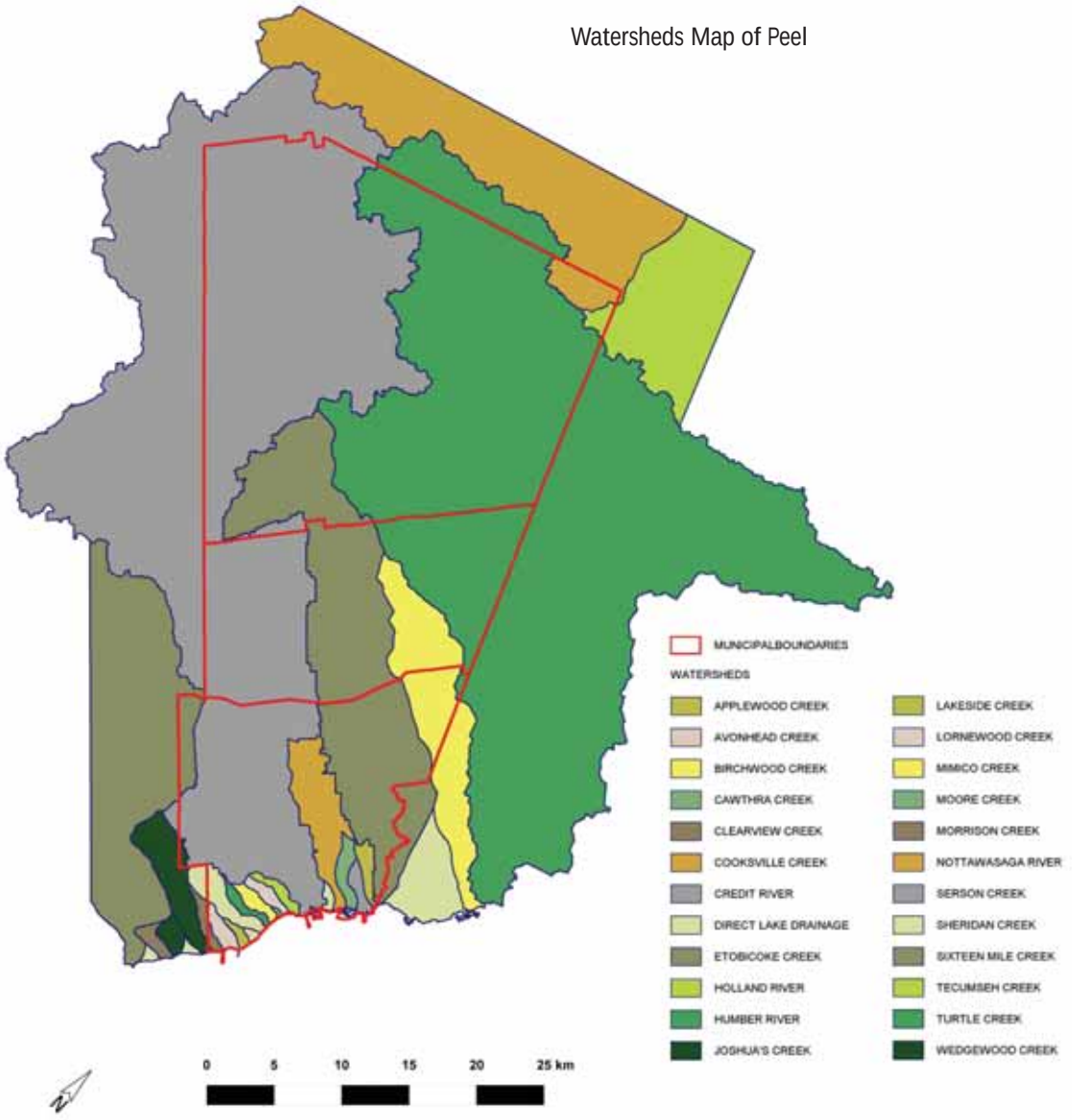
Let us further explore the water cycle as it functions here in Peel. First of all: *watersheds*. A watershed is the entire area of land whose water (rain and snow),

sediments, and dissolved materials (nutrients and contaminants) drain into a water body, like a marsh, lake, river, stream, creek, or aquifer. Its boundary can be identified on the ground by connecting all the highest points of the land around the receiving body of water. It is not human-made, and it does not relate to political boundaries. Homes, farms, cottages, forests, small towns, and big cities can make up watersheds. They come in all shapes and sizes and can vary from millions of acres, like the land that drains into the Great Lakes, to a few acres that drain into a pond. In Peel, the major watersheds are defined by the Credit River, Humber River, Etobicoke Creek, Mimico Creek and their tributaries.[23] The stream bed for each of these watercourses is the lowest ground of a valley into which drains surface water from the surrounding lands.

SEE "CONSTRUCT A WATERSHED" ACTIVITY

Such is predominantly the case in an area like the Peel Plain where soils are less permeable and very little water infiltrates the ground. Instead, most of the surface water travels overland and downhill, draining into streams and rivers, which empty into Lake Ontario. As Gulliver, walking south through Caledon, you would notice the northern extent of the Peel Plain (about 40 kilometers north of Lake Ontario), where rich agricultural lands persist (and are provincially protected until

Watersheds Map of Peel



the year 2021). This immense plain almost spans the width of the Region, and includes part of an area once covered by the vast Lake Peel at the time of the last glacier's retreat.[24] As you continue your giant's march downhill along Hurontario Street, farm land gives way to suburban and industrial development, which covers a full two-thirds of the Peel Plain (about 750 square kilometers). The plain dominates the landscape until you reach its southern limit at the four corners in Cooksville (just five kilometers north of Lake Ontario). As Gulliver travels south from there, Hurontario Street descends a gentle slope from the Peel Plain's southerly rim before it drops down from the ancient shoreline of Lake Iroquois, described above. Today, the Peel Plain is home to 95% of Peel's population and industry. How would this affect the watersheds?

In other places in Peel, permeable landscapes absorb water. When rain falls on the Niagara Escarpment or the Oak Ridges Moraine, it infiltrates through the fractured bedrock and percolates through gravel soils to recharge the groundwater found in underground aquifers. Some of this groundwater moves laterally and resurfaces as springs, which may in turn flow into streams, rivers, wetlands, and lakes. This feeding of surface watercourses by underground sources is known as *baseflow*. Some groundwater remains underground for eons. Communities like Caledon East, Mono Mills, and Palgrave continue to depend on groundwater, as do many of Peel's rural residents who have private wells. At any one time, vast and finite stores of water are found within our watersheds' moraines, aquifers, ponds, and wetlands. Further below, these environments are explored as an integral part of the larger water cycle, whose numerous functions include erosion prevention, habitat provision, and of course, water purification and retention.

Key to maintaining and restoring watershed health is the acknowledgement that all life forms and processes are interconnected with water. Like all living beings, people too are a part of this system that endlessly cycles in various forms as clouds, ice, dew, tears, lakes, slush, rain, saliva, snow, fog, mist, urine, sleet, ponds, rivers, sweat, puddles, wetlands, et cetera. In fact, every life form is mostly comprised of water, and some form of exchange is always happening. Whether living or dead, plants, animals and all other species eventually give their water back for other uses; all life is part of this cycle. The water cycle is dynamic *within* living systems - both ecosystems and life forms.

The many branches of the Credit and Humber Rivers, the Etobicoke and Mimico Creeks have sustained humans and "more-than-humans" in this region for at least 12,000 years. Over the last two centuries, the water cycle in Peel has been significantly altered, as is described in the "Human Cycle" below. Deforestation and growing demands for groundwater to supply agricultural and residential needs has reduced the baseflow of many streams. Many tributaries have been "channelized" or buried in pipes underground.

Staggering numbers of wetlands–nature's holding areas for stormwater—have been drained or filled. Groundwater recharge has been significantly reduced because once permeable earth has been replaced with hectares of impermeable roads and roofs in our modern cities and towns. Throughout much of Peel Region the watersheds are heavily populated and highly urbanized.

In Caledon, where the headwaters are located, the present land use is primarily agricultural; agriculture has also contributed to the decline in these watersheds. The environmental and economic costs of these alterations are enormous, and we all stand to benefit from a strategic return to a more natural hydrologic cycle.[25]

How should children understand the hydrologic cycle? Help them to consciously and meaningfully participate in important ecological relationships within the local watersheds that we all are a part of.

1. Credit River Watershed

The Credit River watershed includes the entire land area drained by the Credit River and its tributaries, including groundwater flows. The main axis of the watershed lies in a north-westerly, south-easterly direction and is adjacent to the Etobicoke and Humber watersheds to the east, the Nottawasaga watershed to the north, the Grand watershed to the west, and the Oakville Creek watershed on its south-westerly limit.[26] Most of the watershed's 1,070 square kilometres falls within the political boundaries of the Region of Peel.

The Credit River itself originates at a cedar swamp in the hills of Mono Township, northeast of Alton. It flows approximately 105.8 kilometres from its northerly headwaters at the Orangeville Reservoir's "Island Lake" all the way south to Lake Ontario.[27] The present course of the Credit was shaped 10,000 to 15,000 years ago, making it part of the remnants of the last Ice Age.

Described above, the Oak Ridges Moraine is found partially in the upper eastern part of the Credit watershed where it acts like a large storage tank absorbing precipitation and delivering this water to underground aquifers. These aquifers filter and store fresh, clean water accessed via wells; they also slowly release clean water into rivers like the Credit and its northern tributaries: Shaw's Creek, the West Credit, Caledon Creek, the East Credit, and Silver Creek. Located in the Mixed Forest Life Zone, 60% of the upper watershed is covered with deciduous forests and white cedar swamps.[28] This northern portion of the watershed is rugged, with moderate lateral slopes. As you follow the Credit River south, just upstream of the Forks of the Credit, the river is at 527 meters above sea level, and then it suddenly drops more than 100 metres. Between the villages of Cataract and Inglewood the incline is marked. Southward from the Forks, the land undulates for at least five kilometres through a valley of scrub forest and wetlands. One must marvel at the beauty of the Credit Valley as the land then flattens out all the way south to Brampton Airport, creating a landscape that sustains horse and dairy farms within the shadow of the influential Niagara Escarpment.

To the southwest, the Credit River crooks near the *University of Toronto at Mississauga* before meandering in a south-easterly direction, passing through the Mississauga Golf Course and then ending in a beautiful harbour overlooked by a lighthouse. Today the river is approximately 15 feet at its deepest, near the mouth, at Port Credit. But before major deforestation (discussed below) and the resultant erosion and evaporation which occurred, the Credit was "a much deeper, wider stream, a proud stream with numerous picturesque falls and rapids, a river compared to which the Don, Humber and Etobicoke were puny streams indeed."[29] Large ships at that time were able to get upstream as far as the present day Mississauga Golf Course.

Being located in the Carolinian Zone, the lower Credit watershed once boasted much more biodiversity. As the shores of the ancient Lake Iroquois receded south to the point of today's Lake Ontario, the exposed soils of the Iroquois plain were colonized by maple, oak, hickory, and white pine. There were also areas of swamp, savannah, prairie, and wetlands, some of which are being restored by the Credit Valley Conservation Authority at Jack Darling Park.

As with Peel's other watersheds, the effects of urbanization have severed the Credit's ecological connections that once supported teeming life zones. Today, that past biodiversity can only be glimpsed through historical and archaeological records, including this Peel Water Story. The primeval forests that once covered this region remained intact and were not considered in need of protection until as late as 1850. In 1836, for example, the Credit River was described as "winding its silent way through a sea of trackless forest, on each side the very finest pine in that or any other day." The effects of deforestation are addressed below, however, one can appreciate

how fauna (animal life) disappeared, after flora (plant life) did.

Few of the original inhabitants of Peel's watersheds such as beaver, fox, moose, weasel, and porcupine have been seen here for centuries. One early resident of Streetsville recounted how "in 1835, the last bear to be seen in these parts was killed."[30] By the time of Confederation in 1867, every part of the Credit watershed was occupied by settlers. As described below, these major alterations to the local ecosystems brought serious economic and cultural challenges to the First Nations peoples of this area, since their livelihood depended directly upon sustainable natural systems and practices.

Today, a few species are making a comeback in the Credit watershed. Through stocking activities, Atlantic salmon have returned to the river. Wild turkeys have also been seen in the watershed thanks to reintroduction efforts throughout Southern Ontario. Most of the remaining natural ecosystems, however, are located in the upper watershed. To the south, some areas such as Rattray Marsh, Eldorado Park, the Creditview Wetland, and Eden Woods Park Woodlot give a good composite of what the Carolinian Zone looked like before European settlement, and demonstrate some healthy ecological relationships.

Since the 1954 onset of urban expansion from Toronto into Peel, it is the Humber watershed that has been impacted the most. It was in 1954 that the Ontario Government established the Credit Valley Conservation Authority (CVC), which since that time continues to study many aspects of the watershed. Indeed, as development extends further north into the Region of Peel, the Credit River watershed's ecosystems will come under increasing pressure. Efforts must be made by all stakeholders to find solutions that will restore watershed health, particularly in the areas of storm water management and forest protection.[31]

2. Humber River Watershed

The Humber watershed is the other large watershed within the Region of Peel. Encompassing 908 square kilometres, it is nearly as large as the Credit watershed, and is the largest of the nine watersheds found within the Toronto and Region Conservation Authority's (TRCA) jurisdiction. The main branch of the Humber travels 100 kilometers from its headwaters in the Oak Ridges Moraine all the way south to Lake Ontario, dropping over 350 metres in elevation as it does so. The river system is composed of 750 streams in total, which together form 1,800 kilometers of tributaries. It is the main branch of the Humber River that is found in Peel, where it passes through the communities of Bolton and Palgrave.

The Humber River has been known by other names throughout history. The First Nations Haudenosaunee peoples called the river *Tau-a-hon-ate* meaning "place where they pull up their canoes" in the Seneca language.[32] It was later known by European settlers as St. John 's Creek to commemorate the earliest French settler on its banks, who went by the name *St. Jean Baptiste*. It was the Lieutenant Governor John Graves Simcoe, who, preferring English names over Aboriginal ones, decided to call the river "Humber" in the Township of Albion. He imagined that the first English settlers would feel less homesick coming to a township bearing the romantic name of England, and whose major river was named for one of the largest and most important rivers in that country, (beside which Simcoe had his Devonshire estate).

The memoirs of an early settler in Bolton provide a sense of the Humber watershed's natural wealth: *"In the fall of 1858 we saw the last great flight of the passenger pigeon. Of course the salmon were all gone, but twenty years earlier big catches of these fish were speared in the deep holes of the river. [Other] fish were [still] plentiful: brook trout, red chub and shiners —all good eating fish. It was common to take fifteen to twenty 8 to14 inch trout below the dam in an evening's fishing with rod and line. Saw mill men would hang a*

basket over the mill wheel a little above the water at night and find a good catch of trout in it in the morning –fish that had been trying to jump the little dam but lit in the basket." [33]

The Humber River is a designated Canadian Heritage River. The importance of the Humber River and watershed to Aboriginal and non-Aboriginal peoples is addressed below.

3. Etobicoke & Mimico Creek Watersheds

Situated beside one another and in between the Credit and Humber watersheds are Peel's third and fourth major watersheds, which drain to our two major creeks –the Etobicoke Creek and the Mimico Creek. Throughout most of their lengths, both of these creeks are cut into the glacial deposits that lie on top of the much older bedrock. The creeks came into being because of the geologic features of the landscape, and the force of gravity directed the movement of runoff and groundwater seepage to the lowest elevations.[34]

In comparison to the Mimico, the Etobicoke Creek has a larger watershed and greater stream flows, resulting in valley systems that are more pronounced. The Etobicoke rises close to the Village of Cheltenham, at the Region's northern extreme in Caledon. Here on what is known as the South Slope plain of the ORM, one can leap across the beginnings of the narrow Etobicoke Creek. In the headwaters area, there are several stretches with well-defined valley walls and flood plains. The creek meanders south across the Peel Plain to the place where, on its flood plains in 1853, the village of Brampton was incorporated. Discussed at length further below, the relationship between the Etobicoke Creek (demoted from a "River") and this growing village (that became a town and now a city), is deeply interwoven. South of Brampton, the creek turns east to skirt the edge of Lester B. Pearson International Airport where it meets Spring Creek. It's south of the 401 highway, in the lower part of the watershed, that the Etobicoke's steepest valley walls reach nine to twelve metres in height and where the underlying shale bedrock is exposed.[35] Finally, the Etobicoke turns south again and tumbles down to Lake Ontario, beside the pebble beach of Marie Curtis Park. This southern stretch of the Etobicoke Creek forms the eastern boundary of Peel Region (and the City of Mississauga). The Ojibwa word *Etobicoke* means "the place where alders grow."

The Mimico Creek headwaters are found in Brampton's glacial till, deposited there 22,000 to 13,000 years ago. The entire Creek is 32 kilometers in length with a total drop in elevation of 160 meters. The valley system of Mimico Creek is very shallow upstream of Derry Road, where its two main branches join behind Lincoln Alexander Secondary School in Malton. Students at the school have been involved over the years in a partnership to naturalize the banks of the creek there. The southern part of Mimico Creek, however, flows through a well-formed valley across the Iroquois Sand Plain where the gradient begins to steepen. The creek intersects the ancient shoreline of Lake Iroquois near the junction of Dundas Street and Islington Avenue.[36] The Ojibwa word *Mimico* means "resting place of wild pigeons."

4. Peel's Wetlands

Wetlands are contained within, and are an integral, if undervalued, part of any watershed's ecological systems. Each of Peel's four major watersheds contains wetland areas, as do others. Wetlands include marshes, swamps, bogs, and fens. While wetlands once covered 11% of Peel Region prior to European settlement, today less than 5% of Peel is wetland.

It's important to understand that while rivers help to carry water away relatively quickly, wetlands help to keep it in one place longer. Wetlands hold floodwater, and can protect developed areas against flooding. Because plants use vast quantities of water, vegetation and soils act as great sponges to slow down and reduce the amount of rainwater that enters a river. So the more wetlands we have, the less chance of

an unnaturally large flood.[37] By filling in wetlands, we risk flooding that can result in the loss of rare plants and animals, not to mention property and even human life.

Wetlands are extremely valuable to the diversity of life found in Peel's watersheds. They provide habitat for a large percentage of flora and fauna throughout the four seasons. While stabilizing and protecting lakeshores and banks from erosion, weedy wetland edges of lakes and ponds simultaneously provide protection and spawning grounds for fish and their prey. Marshes are shallow water wetlands with even greater diversity; here we find cattails, bulrushes, arrowheads, reeds, pickerel weed, as well as grasses and sedges. Fish, ducks, frogs, and a variety of insects seek out this habitat to raise their young, and predators follow.

Wetlands play a key role in the hydrologic cycle, as groundwater aquifer recharge areas and evaporation areas. Wetlands play a crucial role in helping to ensure safe drinking water. Plants in a healthy wetland improve water quality by processing nutrients and pollutants. They also maintain oxygen levels in the water. Marsh plants are particularly effective at soaking up large quantities of excess nitrogen and phosphorus, thus reducing water pollution downstream.[38] They can absorb heavy metals and other pollutants, thereby purifying the water that eventually reaches our aquifers, rivers and lakes, all sources of drinking water in Peel.

Additionally, wetlands provide food and other necessities for humans and more-than-humans. They help improve air quality by contributing to the cycling of gases such as oxygen, methane, and carbon. And not least of all, wetlands like the Rattray Marsh are a source of rejuvenation, recreation, and education for all.[39]

5. The Bog, the Badlands, and the Big Kettle Lake

Described below are just a few from amongst the numerous and amazing "Places to Go" in Peel. (see GIS resource "Places to Go" at www.peelwaterstory.ca)

THE CREDITVIEW WETLAND (also known as "the bog") forms part of a composite of Peel's primeval past. An area of 4 hectares in the City of Mississauga, the protected wetland is located north of Eglinton Avenue West, and east of Creditview Road. It is situated at the northern end of a shallow, north-south oriented depression created at the time of the last glacial retreat. Indeed, while other places in Peel changed more noticeably over time with natural succession, parts of this place still resemble Peel's tundra landscape of 11,000 years ago when the glaciers first withdrew.

As a rare wetland with bog-elements, located within Canada's Carolinian Zone, this natural heritage feature takes us back thousands of years to the time when the woolly mammoths roamed Peel. The sphagnum peat moss there is the oldest we know of in Ontario. This is a great place to sense wetland biodiversity today, as it is home to 109 wildlife species, as well as 207 plants, (43 of which are rare within the Region of Peel). While the drainage area for the wetland remains relatively self-contained, water quality impacts include nutrient and pesticide runoff from adjacent school and park lands, although the City of Mississauga has undertaken efforts to reduce pesticide and fertilizer use through Integrated Pest Management (IPM) practices.

It is thanks to the efforts of concerned citizens that this valuable ecosystem has been protected through the years and is now owned by the City of Mississauga. This wetland is a sensitive and rare environment and therefore access is strictly controlled. Plans are underway for a future interpretive education area. For more information about the Creditview Wetland and its Conservation Plan, visit the City of Mississauga's website.

The CHELTENHAM BADLANDS (sometimes called the "Caledon Badlands") got their name because they are close to the village of Cheltenham

The Cheltenham Badlands, 1948.

The Badlands today. More than 50 years separates these two photos of the Badlands, a bare landscape caused by deforestation. A comparison of the photos attests to the ongoing effects of erosion there.

in the Town of Caledon, and because the denuded landscape resembles the Badlands of Western Canada. They are found in the shadow of the Niagara Escarpment on the south side of Old Baseline Road, just east of Creditview Road. This feature is a stunning example of the erosive power of water when protective trees are removed. The distinct red colour of the earth at the Badlands is made up of Queenston shale, which appears throughout this area.

Peel's tropical sea of 430 million years ago was teeming with life, although plants and animals were not yet established on land. Southeast of here (roughly where the Appalachian Mountains are now) an enormous mountain range was rising from the collision of the North American and European Continental Plates. The rocks of these mountains were rich in iron, and rivers flowing down these mountains picked up the red, iron-rich sediment and transported it to the sea. When the fast-moving rivers reached the calm sea, the sediment was deposited and eventually compacted into the red Queenston shale. The sea disappeared 300 million years ago, and a long period of erosion began.

Queenston shale is a very soft rock, which erodes rapidly if layers of other rock or vegetation are removed. The Cheltenham Badlands probably began to form in the early 1900s when the trees were cut down to allow for a cattle pasture. With the protective layer of vegetation removed, the shale began to erode. Although farming at the site ended in 1931, erosion of the Badlands continues. The Badlands are part of Ontario's Niagara Escarpment, which was designated a UNESCO (United Nations Educational, Scientific and Cultural Organisation) World Biosphere Reserve in 1990. The Badlands lie within the Inglewood Slope Environmentally Sensitive Area (ESA), which is an important groundwater discharge zone. The coldwater stream on the property at the foot of the badlands is a tributary of the Credit River.

In 1999, the Cheltenham Badlands property was bought for the Bruce Trail Association with funds from the Ontario Ministry of Natural Resources' Natural Areas Protection Program. The property was purchased to secure 2 km of the Bruce Trail Optimum Route, and ensure its long-term

SEE "THE EROSION GAME" ACTIVITY

protection as a natural area. While natural erosion processes cannot be stopped, one of the stewardship goals is to minimize the erosion of the shale by staying on designated trails and preserving the existing vegetation. This will reduce the amount of sediment entering the Credit River, while conserving the rare features of the Badlands. Guided school tours of the Cheltenham Badlands are conducted by the Bruce Trail Association. See their website for more information.

Located at the centre of Peel Region, in the City of Brampton, HEART LAKE is a kettle lake that got its name in the 20th century when aerial photography allowed people to discern its heart-like shape. It was previously known by other names, including Snell's Lake. A kettle lake is a depressed land area that is filled with water, which was formed by the melting out of large, entrapped blocks of glacial ice. Heart Lake itself, and the surrounding Heart Lake Conservation Area, contain several wetlands. This environmental jewel has a long history of human and 'more-than-human' occupation, which continues to this day. Visit Heart Lake and see Peel's largest colony of Great Blue Herons, enjoy the various kinds of water recreation it has to offer: swimming, boating, fishing and sightseeing.

Created by the retreating Lake Iroquois, RATTRAY MARSH occupies 33 hectares at the mouth of the Sheridan Creek in the Credit River watershed. For "the past 10,000 years it has acted as a filter for Sheridan Creek before it empties into Lake Ontario. There are approximately 450 species of flora within the marsh and a diverse bird population that includes the Great Egret and the Black-crowned Night Heron."[40] The Rattray Marsh is a significant wetland in Peel that was saved from development by the intervention of concerned citizens. Embedded in the stones along the shingle bar, which we skip along the water, can be found the fossilized remains of ancient life, like trilobites and sea lilies that thrived in Peel's tropical sea of 400 million years ago. At Rattray Marsh, with a bit of imagination, one can sense the presence of an ancient past. Take a child(ren) there and tell the story. For more information visit Credit Valley Conservation Authority's website.

Looking north from Lake Ontario across the shingle bar that separates the lake from Rattray Marsh, the mouth of Sheridan Creek.