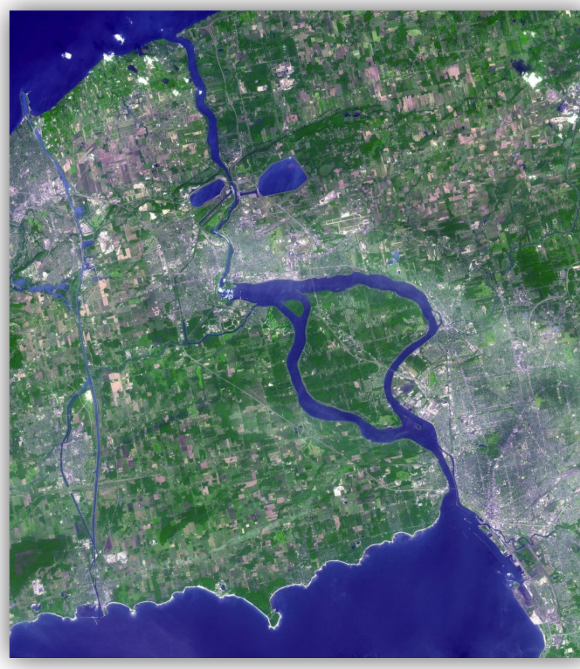
Chapter 2: Watershed Characterization



Aerial of the Niagara River (NASA)

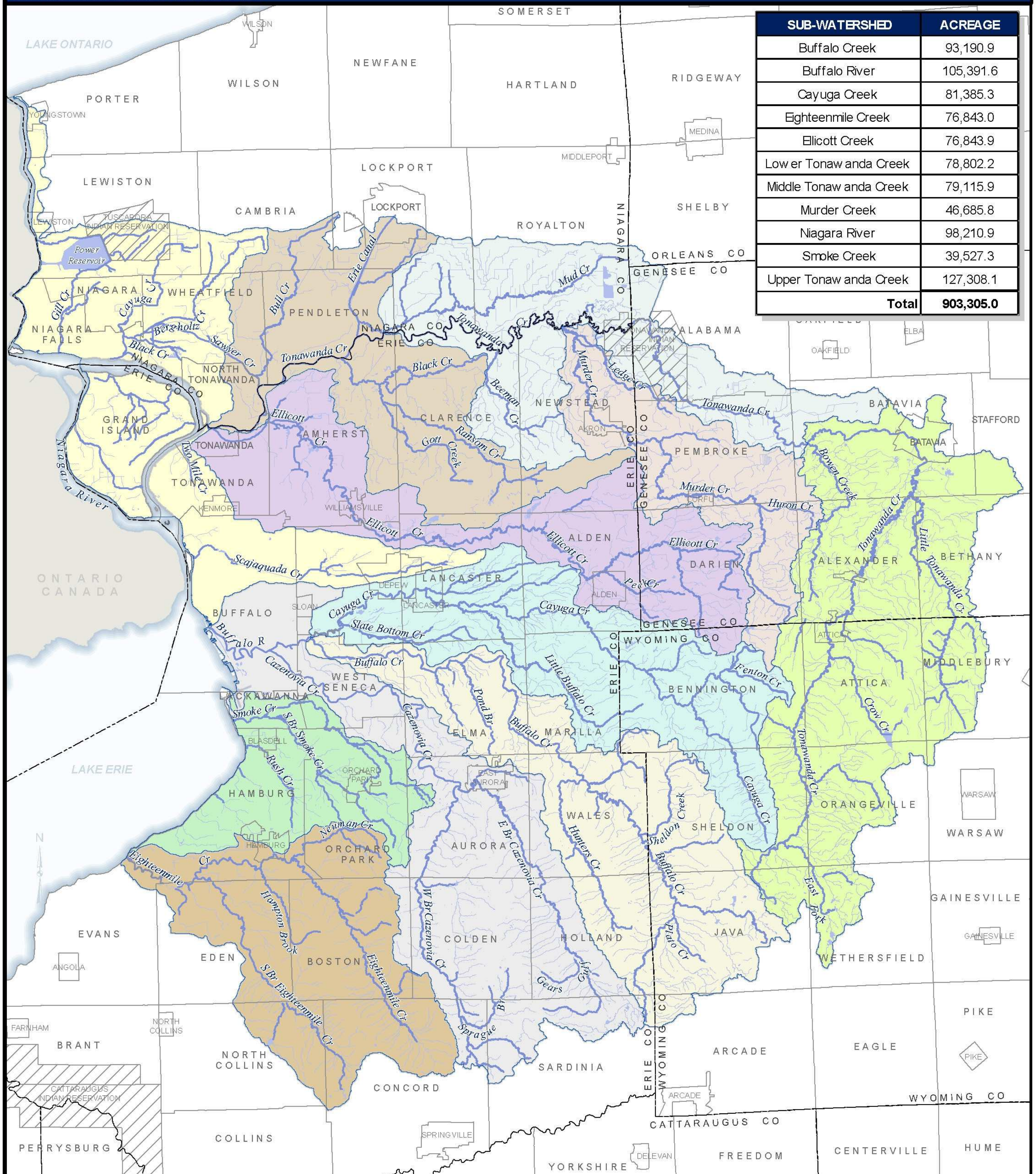
The Niagara River Watershed is located along the western most portion of New York State and drains into the Niagara River, the channel that connects two Great Lakes - Erie and Ontario – and divides the U.S. from Canada. New York State has a total of 17 major drainage basins. The Niagara River Watershed is included within the larger Lake Erie/Niagara River Drainage Basin. Lake Erie and the two principal rivers of the watershed, Buffalo and Niagara, receive waters from over 19 smaller tributaries within the watershed. In total, the watershed encompasses 903,305 acres of land, 3,193 miles of watercourses, and several small lakes and ponds within the Counties of Erie, Niagara, Genesee, Orleans and Wyoming.

Watershed Boundary & Sub-watersheds

Within New York State, the Niagara River Watershed is largely made up of eleven smaller sub-watersheds (See Niagara River Watershed Map on following page), each of which has defined boundaries based upon a 10-digit Hydrological Unit Code (HUC). The U.S. Geological Survey established the hydrological unit system as a basis for watershed planning on science-based hydrologic principles, rather than favoring administrative boundaries or a particular agency. The codes are structured in a hierarchy system to identify smaller sub-watersheds nested within larger watersheds. Table 2.1 below lists the eleven sub-watersheds that are part of the Niagara River Watershed, their 10-digit HUC, and total acreage.

Niagara River Watershed and Sub-Watersheds

WESTERN NEW YORK



SUB-WATERSHED	ACREAGE
Buffalo Creek	93,190.9
Buffalo River	105,391.6
Cayuga Creek	81,385.3
Eighteenmile Creek	76,843.0
Ellicott Creek	76,843.9
Low er Tonaw anda Creek	78,802.2
Middle Tonaw anda Creek	79,115.9
Murder Creek	46,685.8
Niagara River	98,210.9
Smoke Creek	39,527.3
Upper Tonaw anda Creek	127,308.1
Total	**903,305.0**

County
Municipality

Sub-Watershed

Buffalo Creek
Buffalo River
Cayuga Creek
Eighteenmile Creek
Ellicott Creek
Lower Tonawanda Creek
Middle Tonawanda Creek
Murder Creek
Niagara River
Smoke Creek
Upper Tonawanda Creek

0 2.5 5 10
Miles

Data Sources:
Sub-Watersheds : USGS 10-Digit Hydrologic Units;
Waterways: NYS CSCIC Linear & Area Hydrography;
NYS DOT Civil Boundaries.
All data obtained from NYS GIS Clearinghouse.

Prepared by Lisa Matthies-Wiza, Sept 2010.

Table 2.1 Subwatersheds of the Niagara River Watershed

Subwatershed	Hydrological Unit Code	Acreage
Niagara River	0412010406	98,210.90
Lower Tonawanda Creek	0412010405	78,802.20
Middle Tonawanda Creek	0412010403	79,115.90
Upper Tonawanda Creek	0412010401	127,308.10
Ellicott Creek	0412010404	76,843.90
Murder Creek	0412010402	46,685.80
Buffalo River	0412010303	105,391.60
Buffalo Creek	0412010302	93,190.90
Cayuga Creek	0412010301	81,385.30
Smokes Creek	0412010304	39,527.30
Eighteenmile Creek	0412010305	76,843.10
Niagara River Watershed		**903,305.00**

Source: USGS Hydrologic Unit Codes (HUC) , 2010.

USGS's hydrological units were utilized to characterize the watershed because a watershed's boundary does not follow municipal boundaries. However there are 48 towns, 16 villages, and 7 cities located completely or partially within the Niagara River Watershed's Boundary, including the Cities of Niagara Falls and Buffalo. These 71 municipalities include:

City of Batavia
City of Buffalo
City of Lackawanna
City of Lockport
City of Niagara Falls
City of North Tonawanda
City of Tonawanda

Town of Alabama
Town of Alden
Town of Alexander
Town of Amherst
Town of Arcade
Town of Attica
Town of Aurora
Town of Batavia
Town of Bennington
Town of Bethany
Town of Boston
Town of Cambria
Town of Cheektowaga
Town of Clarence
Town of Colden
Town of Concord
Town of Darien
Town of Eden
Town of Elma
Town of Evans
Town of Grand Island
Town of Hamburg
Town of Holland
Town of Java
Town of Lancaster
Town of Lewiston
Town of Lockport
Town of Marilla
Town of Middlebury
Town of Newstead
Town of Niagara
Town of North Collins
Town of Orangeville
Town of Orchard Park
Town of Pembroke
Town of Pendleton
Town of Porter
Town of Royalton
Town of Sardinia
Town of Shelby
Town of Sheldon
Town of Stafford
Town of Tonawanda

Town of Wales
Town of Warsaw
Town of West Seneca
Town of Wethersfield
Town of Wheatfield

Village of Akron
Village of Alexander
Village of Alden
Village of Attica
Village of Blasdell
Village of Corfu
Village of Depew
Village of East Aurora
Village of Hamburg
Village of Kenmore
Village of Lancaster
Village of Lewiston
Village of Orchard Park
Village of Sloan
Village of Williamsville
Village of Youngstown

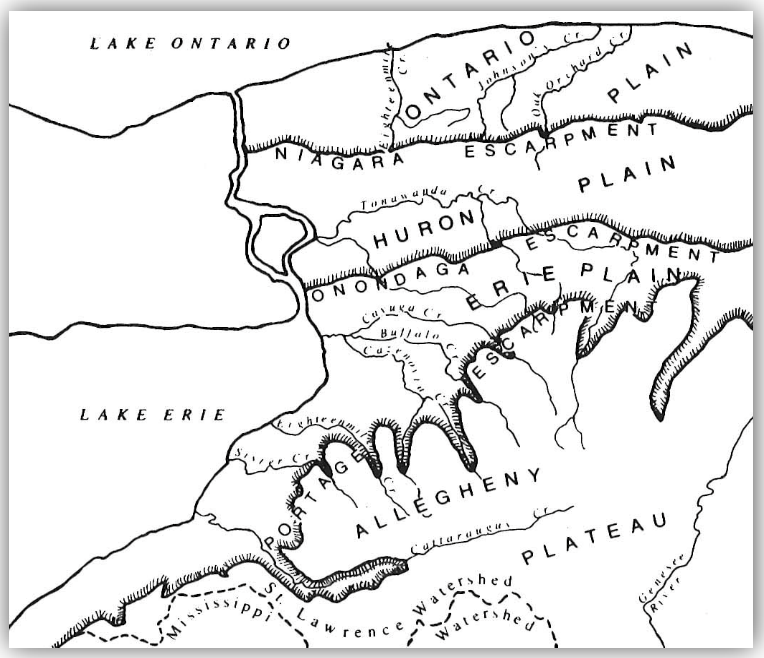
Geology & Topography

In describing physical conditions of the Niagara River Watershed it is useful to traverse from the headlands in the southeast in a northwest direction toward the mouth of the Niagara where it meets Lake Ontario. Refer to the Niagara River Watershed and Sub-Watershed Map included on a previous page for orientation with the following geology and topography descriptions of the watershed.

Geology

In terms of bedrock geology, the Niagara River watershed descends through three levels, or plains, from the Allegheny Plateau at over 2,000 feet above sea level in southwestern New York to the Lake Ontario Plain at 246 feet above sea level in the north (Figure 2.1[1]). An east-west trending escarpment marks each step down. Southernmost and highest is the Portage Escarpment, the dissected northern border of the Allegheny Plateau. The fast flowing headwaters of Niagara's main tributaries—Tonawanda, Cayuga, Buffalo and Cazenovia Creeks—originate here, flowing north and west across the Lake Erie Plain.

Figure 2.1: Western New York Geography



Ten to twenty miles north of the Portage Escarpment, the Onondaga Escarpment marks a decrease in elevation across the watershed to the level of the Lake

[1] Figure from Marian E. White, *Iroquois Culture History in the Niagara Frontier Area of NYS.*

Huron Plain. The Onondaga Escarpment creates barriers and waterfalls on several Niagara tributaries including Indian Falls on Tonawanda Creek near Akron, Serenity Falls on Scajaquada Creek in Buffalo, and Glen Falls on Ellicott Creek in the Village of Williamsville. Vernal pools at the base of these escarpments provide critical habitat for amphibians like spotted salamanders (NYS DEC, 2006). The Onondaga Escarpment also marks the rapids between Lake Erie and the upper Niagara River. Northernmost is the Niagara Escarpment - a defining feature of the Great Lakes basin. The escarpment determines the northern boundary of the watershed. It creates Niagara Falls and divides the river into two separate aquatic ecosystems.

Serenity Falls, Scajaquada Creek (M. Wooster)

The three escarpments can be identified in the watershed's Elevation Map included on the following page. Bedrock throughout the entire watershed is shale with dolomite and limestone intrusions visible at the escarpments.

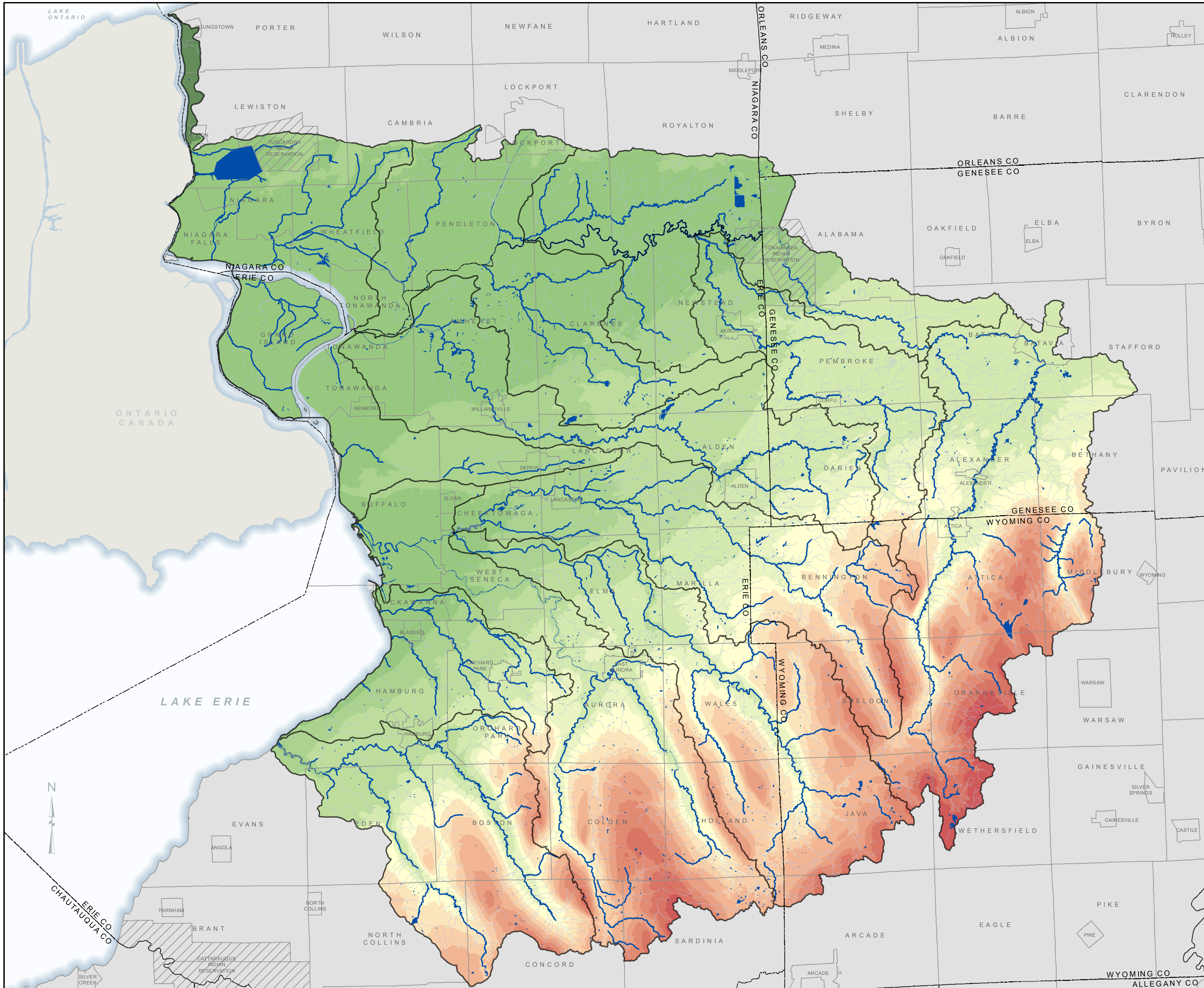
Landforms

The landforms also change across the watershed. The southern portion consists of uplands and dissected plateau with rolling hills and plateau toe slopes consisting of deposited materials at the bottoms of steep slopes. The focus of the watershed, the Niagara River sub-basin to the west, sits on the flat lake plain bounded inland by Pleistocene beach ridges. The north and northeast portion is a lowland area and the home of the Tonawanda Floodplain which spans the Middle and Lower Tonawanda sub-basins.

Soils

There are three main soil types found in the watershed. Alfisols are very fertile soils that formed underneath old forests. They are moderately well drained, giving the soil a good balance of moisture. Alfisols have a layer of clay underneath the surface of the soil. Many of them are used for growing new forests or for agricultural purposes. Alfisols are primarily found in western and central New York.

The northern and western regions of the state are home to histosols. These soils have a very dark layer directly underneath the surface. They have a large amount of organic material. They form in



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Niagara River Watershed Management Plan

ELEVATION

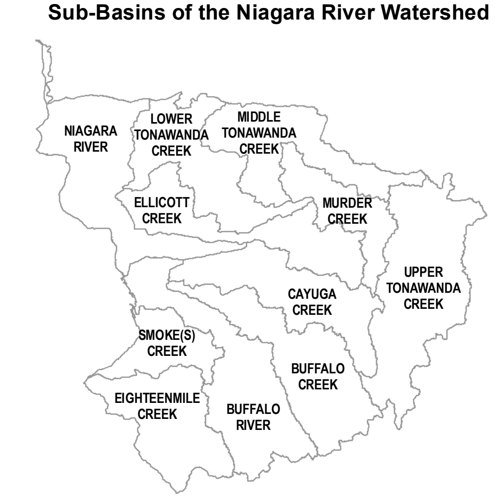
Elevation (in Meters)

72.9 - 110.5
110.6 - 154.7
154.8 - 192.3
192.4 - 221
221.1 - 254.2
254.3 - 289.6
289.7 - 329.4
329.5 - 367
367.1 - 402.4
402.5 - 435.5
435.6 - 466.5
466.6 - 495.3
495.4 - 526.2
526.3 - 563.8
563.9 - 636.8

Sub-Basin Boundary
County
Municipality

5 2.5 0 5
Miles
5 2.5 0 5
Kilometers

Sub-Basins of the Niagara River Watershed



National Elevation Data (NED) obtained through USDA NRCS Geospatial Data Gateway, 30m resolution.

Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

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wetlands of all types, including swamps and marshes, anywhere that is poorly drained. Organic material in these places decays very slowly. Histosols are commonly called "peats," and are often mined and burned as fuel.

Inceptisols are found everywhere in the southern half of New York State. They have vaguely defined layers under the surface, and are found in all types of environments. These soils support approximately one fifth of the earth's population, more than any other type of soil.

Hydric soils are formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions and support the growth and regeneration of hydrophytic vegetation. The northern portion of the watershed, where historic Lake Tonawanda once existed hosts the largest swath of hydric soils. A map of the watershed's hydric soils is provided on the following page.

Erosion/ Slope

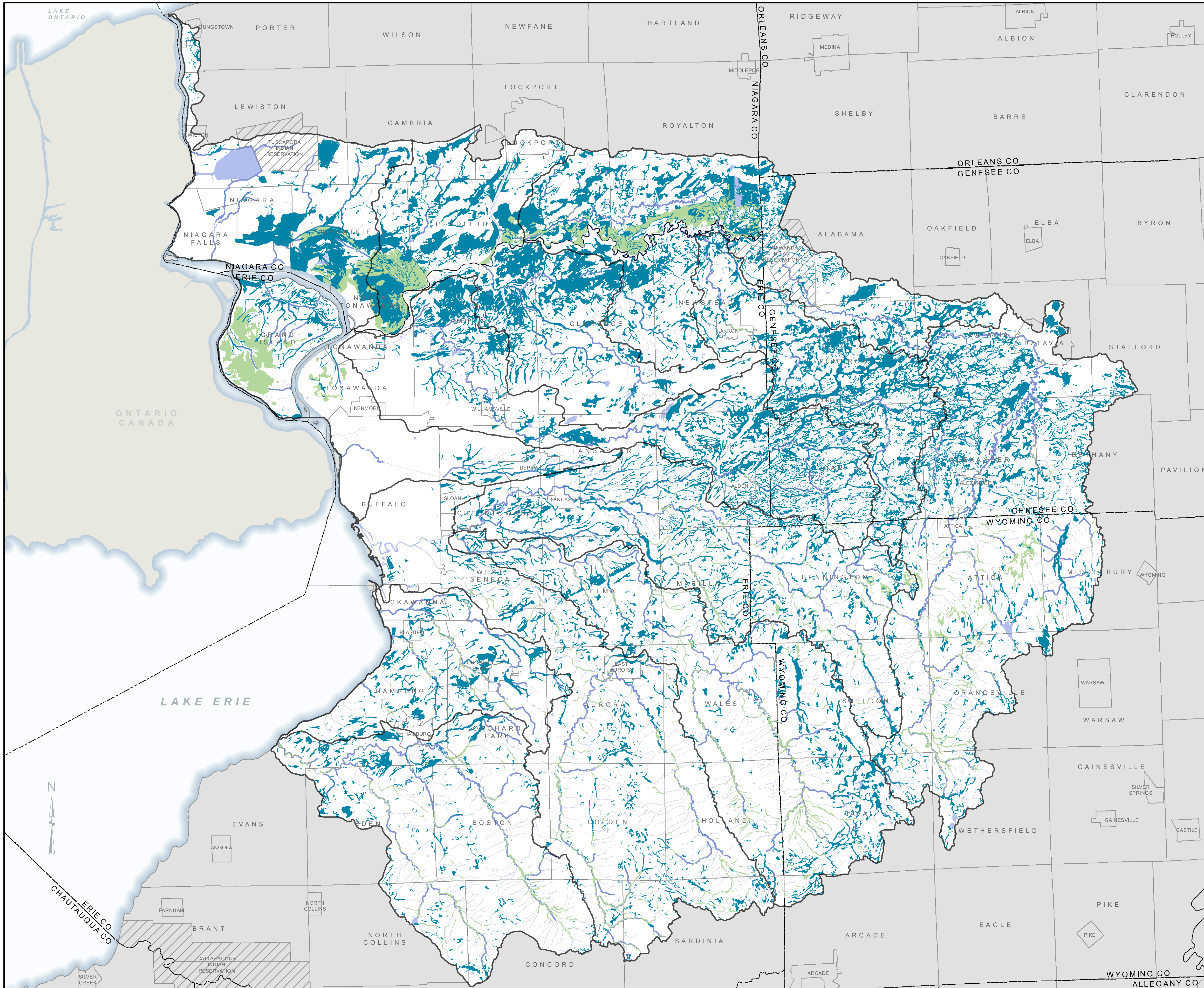
Steep slopes can affect water quality with the erosive force that increases as grade increases, allowing run-off to pick up and move more sediment, increasing downstream turbidity and further eroding upstream channels. In the watershed, the percentage of areas with steep slopes decreases as you move northwest across the watershed into the flatter Huron Plain. However, the uplands in the southeast, where many of the watersheds' headwaters originate, have a large amount of steep slopes, some being very steep or over 35% (See Slopes Map). In the lowlands and lake plains in the north and west of the watershed all slopes are nearly level (0 – 2%).

Hydrography

Surface Hydrology

Surface water is the water that collects on the ground, in a stream, river, lake or wetland. This water naturally increases with precipitation and is lost through evaporation, evapotranspiration, infiltration and run-off. The Niagara River Watershed is primarily home to rivers, creeks and streams, with a few water bodies, including some smaller ponds, the Great Lake Erie and the Tuscarora Reservoir. All of the surface water located in the Niagara River Watershed naturally drains into the Niagara River. The watershed covers an area of 903,305 acres drained across approximately 3,193 total miles[2] of waterways. The general direction of surface movement is from the highlands in the southeast, north and west to the floodplains and lowlands.

[2] Based on the USGS National Hydrography Dataset.



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Niagara River Watershed Management Plan

HYDRIC SOILS

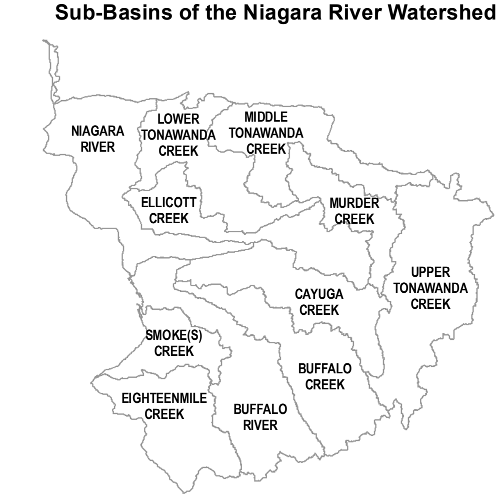
Hydric Soil Class

- All hydric
- Partially hydric

Sub-Basin Boundary — County — Municipality

Scale: 5 2.5 0 5 Miles; 5 2.5 0 5 Kilometers

Sub-Basins of the Niagara River Watershed



Soils based on SSURGO detailed soil data obtained through USDA NRCS Soil Data Mart.

Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

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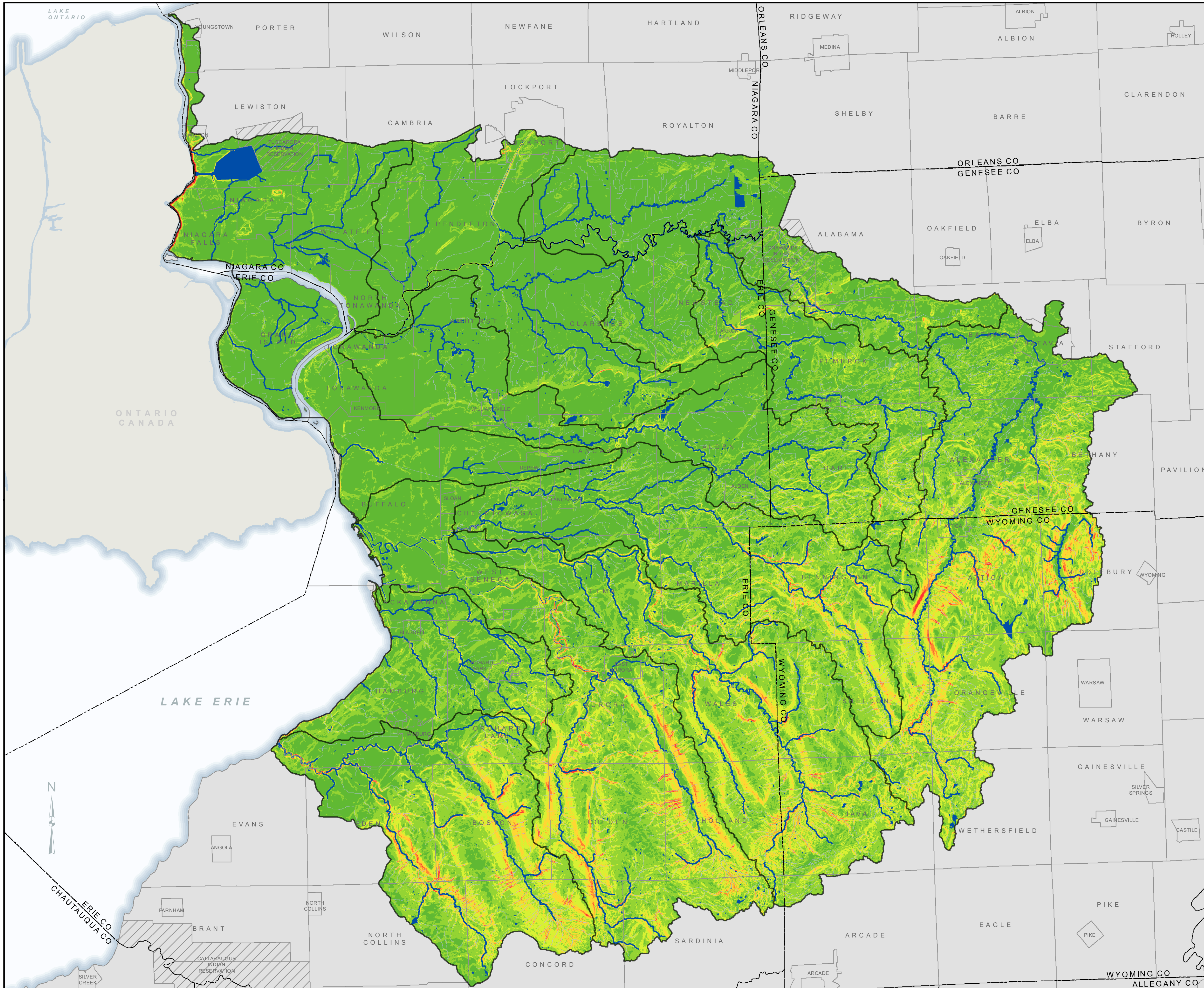
Niagara River Watershed Management Plan

SLOPE



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Slope Class

- Nearly Level (0% - 2%)
- Gently Sloping (3% - 7%)
- Strongly Sloping (8% - 14%)
- Moderately Steep (15% - 24%)
- Steep (25% - 34%)
- Very Steep (35% and greater)

Sub-Basin Boundary

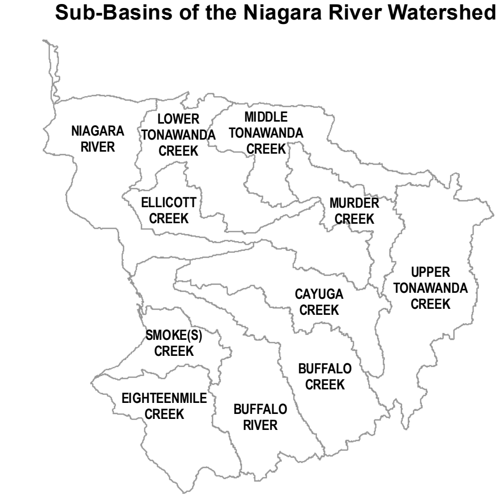
County

Municipality

5 2.5 0 5
Miles

5 2.5 0 5
Kilometers

Sub-Basins of the Niagara River Watershed



National Elevation Data (NED) obtained through USDA NRCS Geospatial Data Gateway, 30m resolution. Slope derived using ArcGIS Spatial Analyst.

Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

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In the uplands, streams and creeks are much more clustered due to the slopes they traverse. Tributaries follow a parallel pattern down the steep slopes into their larger streams. In the lowland areas the waterways meander and run further apart in a dendric pattern. Many of the waterways have been channelized when they flow through the industrialized areas of the Tonawandas, Buffalo and Niagara Falls.

Sub-watershed Descriptions

The **Upper Tonawanda Creek** Sub-watershed and its main tributary, Little Tonawanda, start on the Allegheny Plateau and flow northeast through steep wooded ravines as far as the village of Attica. After which both creeks meander through wetlands and farmed mucklands. Just south of the City of Batavia the two branches join on the Onondaga Escarpment and take a sharp turn left, flowing west into the Middle Tonawanda Creek Sub-watershed.

The **Middle Tonawanda Creek** Sub-watershed is located between the Lower and Upper Tonawanda Creek Sub-watersheds. The Middle portion covers Tonawanda Creek's 20 mile stretch from Tonawanda Creek's confluence with Bowen Creek in the Town of Batavia west to the Town of Pendleton. In this section it travels through a broad floodplain and many wetlands which are the remaining imprint of the ancestral, 50 mile long, glacial Lake Tonawanda. Mud Creek and Beeman Creek are the major tributaries of this portion of Tonawanda Creek.

In the **Lower Tonawanda Creek** Sub-watershed the last 11.6 miles of the Tonawanda Creek was historically deep slack water but is now channelized and dredged to a width of 75 feet and a depth of 12 feet to accommodate the Erie-Barge Canal. A lock in Pendleton controls the flow, and is also where the Creek diverges from the Erie Canal. Ransom Creek, Gott and Black Creeks are the major tributaries running north-northwest from the Clarence and Newstead Townships to the Canal section in the Creek in Pendleton. Bull Creek is the other primary tributary running southwest from the Niagara Escarpment through low-lying hydric soils to the Canal in the Town of Wheatfield.

Ellicott Creek, 47 miles long, flows northwest from its headwater wetlands in Genesee County to join Tonawanda Creek about a half mile above its mouth at the Niagara River, in the Town of Tonawanda. Many of the natural tributaries of Ellicott Creek have been channelized into stormwater conveyance systems in the urban and suburban areas of the Ellicott Creek Sub-watershed, and no longer include natural hydrologic features.

Murder Creek is its own sub-watershed but also the major tributary to Tonawanda Creek in the Middle Tonawanda Creek Sub-watershed. Located primarily in the southwestern portion of the Genesee County, Murder Creek also includes many low-lying areas and meanders through the Towns of Pembroke and Newstead.

The **Cayuga Creek** (in Erie County) Sub-waterhshed includes Little Buffalo, Slate Bottom and Plum Bottom Creeks as tributaries for a total of 356 stream miles. It begins in primarily farmland/wooded areas in higher elevation Wyoming County and passes through several residential areas before its confluence with Buffalo Creek near Cheektowaga.

The 43-mile-long **Buffalo Creek** originates in the southeastern portion of the watershed, in the Towns of Arcade, Java and Sheldon in Wyoming County, where higher elevations create a multitude of smaller feeder streams and tributaries, such as Plato Creek, Beaver Meadow Creek, Glade Creek, Sheldon Creek, Stoney Bottom Creek, Bender Creek, and Hunter Creek. Buffalo Creek itself flows northwest towards the City of Buffalo and drains 149 square miles, joining Cayuga Creek 8 miles above Lake Erie in the Town of West Seneca, shortly after which Cayuga Creek flows into the Buffalo River.

The headwaters of the **Buffalo River** include the east and west branches of Cazenovia Creek and flow north-northwest to the lake plain. Cazenovia Creek drains 138 square miles of southern Erie County, joining the Buffalo River about 6 miles above Lake Erie. Its two major branches, 18 mile long West Branch and 24 mile long East Branch, join in the Village of East Aurora, 17 miles upstream from the confluence with the Buffalo River. At 1820 feet above sea level, the source of the East Branch is the Buffalo River Sub-watershed's highest elevation. The lower Buffalo River meanders across the flat Lake Erie Plain within the City of Buffalo before draining into Lake Erie. Within the City of Buffalo, a portion of the Buffalo River is a federally-designated navigation channel and dredged to maintain a 22 foot depth. The average daily flow of the Buffalo River is about 355.5 mgd or about half the amount of precipitation in the watershed.

The **Smokes Creek** Sub-watershed is the smallest sub-watershed of the eleven and includes several small tributaries draining directly to Lake Erie in the Town of Hamburg and City of Lackawanna. Smokes Creek begins in the Town of Orchard Park and flows west-northwest to its mouth on Lake Erie. The creek's one principal tributary is South Branch.

The southernmost sub-watershed of the Niagara River Watershed is **Eighteen Mile Creek**, which technically drains into the eastern end of Lake Erie in the Town of Evans. Its principal tributary is the South Branch. Middle reaches of the Creek flow through steep sided gorges in the Towns of Hamburg and Eden. At its lower end it is a large meandering stream where the lower half mile is low gradient with a broad floodplain.

Most of the waterways in the **Niagara River** Sub-watershed drain directly to the upper Niagara River. Many, like Two Mile Creek, have been channelized and turned into drainage ditches receiving runoff from industries, landfills and storm sewer systems. While others, have had their historic hydrology significantly altered from urban development. Several of the tributaries located on Grand Island are the last remaining un-altered waterways of this sub-watershed.

Historically fifteen-mile Scajaquada Creek, a primary tributary of the Niagara River sub-watershed, rose in spring fed wetlands in the present Town of Lancaster and flowed almost due west to its mouth on the Black Rock Canal on the Niagara River. Its course was generally level except for a small falls over the Onondaga Escarpment in present day Forest Lawn Cemetery in North Buffalo. Originally the creek was wide, shallow and meandering. Much of the creek has been channelized and tunneled underground. Portions receive overflows from the City of Buffalo's combined sewer system and Town of Cheektowaga's sanitary sewer system. Springs recharge the creek not only at its source, but also downstream in Forest Lawn Cemetery. These springs are now a major component of the base flow of lower Scajaquada Creek.

Another major tributary of the Niagara River Sub-watershed, 7.6 mile long Gill Creek originates in the wetlands of the Tuscarora Nation and flows south to its mouth on the Little Niagara River approximately 1,000 feet above the upper Niagara River. The watershed is mainly flat and underlain with Lockport Dolomite covered by lake clays and silts. Today, the Lewiston reservoir occupies over half the upper watershed on Tuscarora Nation Land, with a discharge channel to Gill Creek to supplement low flows in the summer. The creek is ditched around the reservoir's southern end until it reaches the original stream bed and turns south. A dam about 1.2 miles upstream of the creek's mouth creates 30 acre Hyde Park Lake.

Table 2.2 Watershed Waterway Miles

Sub-basin	Miles	% of Total
Buffalo Creek Sub-watershed	353.72	11.1%
Buffalo River Sub-watershed	311.96	9.8%
Cayuga Creek Sub-watershed	356.19	11.2%
Eighteenmile Creek Sub-watershed	273.81	8.6%
Ellicott Creek Sub-watershed	244.02	7.6%
Lower Tonawanda Creek Sub-watershed	216.63	6.8%
Middle Tonawanda Creek Sub-watershed	331.05	10.4%
Murder Creek Sub-watershed	222.21	7.0%
Niagara River Sub-watershed	185.01	5.8%
Smoke Creek Sub-watershed	109.06	3.4%
Upper Tonawanda Creek Sub-watershed	589.19	18.5%
Total Watershed	**3,192.85**	**100.0%**

Source: USGS National Hydrography Dataset

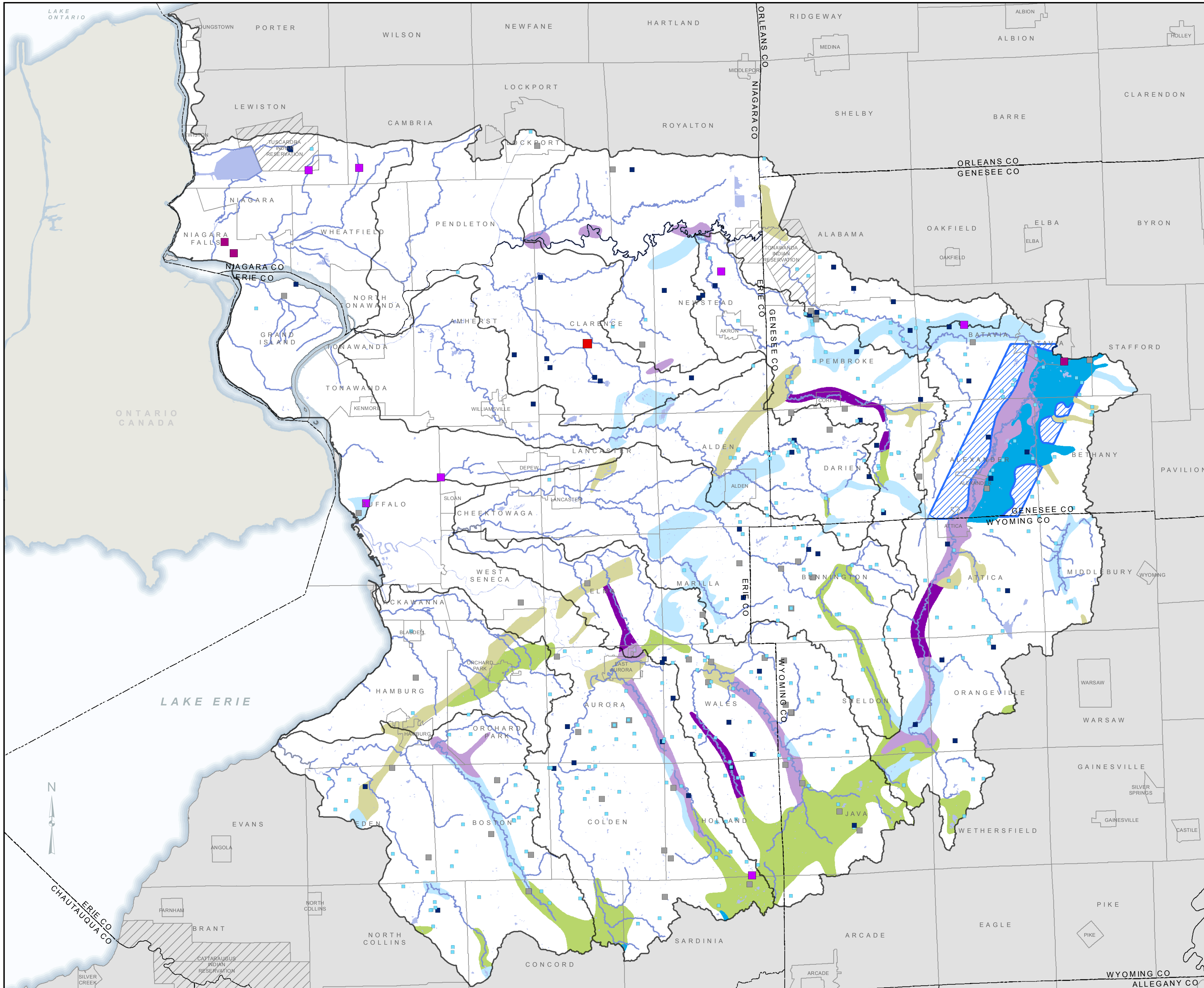
Groundwater flow

Groundwater is the water located beneath the ground within the soil, or fractures of rock formations. This water eventually comes to surface via springs and can even form wetlands. Groundwater is stored in and moves through moderately to highly permeable rocks called aquifers. These aquifers can be sand and/or gravel, glacial tills, or layers of sandstone or cavernous limestone bedrock.

New York State has mapped and identified aquifers throughout the Niagara River Watershed with most of them being in the east and south of the watershed (See Aquifer Map on the following page). The uplands in the southeast sub-watersheds have large moraine aquifers. Gaging stations on Buffalo, Cayuga and Cazenovia Creeks show the average groundwater component of stream flow in these tributaries is between 41% and 45%. At the foot of the Portage Escarpment lies a line of kame or alluvium aquifers. The Upper Tonawanda creek sub-basin contains a primary aquifer region with high yield unconfined aquifers. The Onondaga Aquifer is important for supplying water to households and farms in the Towns of Clarence and Newstead.

Wetlands

Wetlands occur where land and water meet for extended periods of time. They occur along water bodies, lakes, rivers, streams, etc., in low lying areas where water ponds, and even on hillsides where groundwater seeps to the surface. They provide natural open space and help to provide food and homes to fish, amphibians, shellfish, insects, birds, and other animals. Wetlands also clean our water



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Niagara River Watershed Management Plan

WATER WELLS AND UNCONSOLIDATED AQUIFERS

Water Well Discharge Rate (Gallons per Minute)

- 0-19
- 20-75
- 100-300
- 600-1000
- 10000
- N/A

Unconsolidated Aquifer

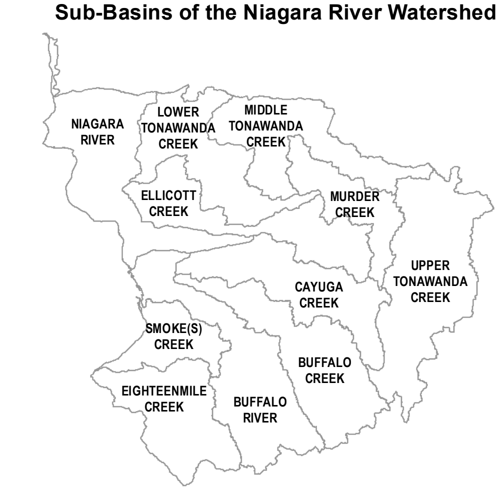
- Primary Aquifer Region
- Unconfined, High Yield
- Unconfined, Mid Yield
- Confined, No Overlying Surfical Aquifer
- Confined, Unknown Depth and Thickness
- Kame, Outwash or Alluvium
- Moraine

- Sub-Basin Boundary
- County
- Municipality

5 2.5 0 5
Miles

5 2.5 0 5
Kilometers

Sub-Basins of the Niagara River Watershed



Water well data is developed from well completion reports submitted to NYS DEC and is not always verified.The aquifers represent an effort by NYS DEC to facilitate the identification of the location and extent of significant unconsolidated aquifers; those that consist of sand and gravel and yield large supplies of water to wells. Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

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Tifft Nature Preserve Wetland

by filtering pollution and recharging aquifers. They maintain dry season stream flows and stabilize shorelines from erosion.

Wetlands are particularly important for flood protection. They act as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater and flood waters. The holding capacity of wetlands helps to control floods and prevent water logging of crops. Trees, root mats, and other wetland vegetation also slow the speed of flood waters and distributes them more slowly over the floodplain, reducing flash flooding and downstream inundation. This combined water storage and braking action lowers flood heights and reduces erosion. Wetlands within and downstream of urban areas are particularly valuable, counteracting the greatly increased rate and volume of surface water runoff from pavement and buildings (impervious cover).

Wetlands are characterized as having a water table that stands at or near the land surface for a long enough period each year to support aquatic plants. These lands have hydric soils that are often saturated with water permanently or part of the year. Most importantly they have plants and animals that can withstand this flooding.

Wetlands are threatened by a whole host of human and environmental influences. Urbanization brings new roads, schools, and housing developments which are often built on or near wetlands, which may cause shifts in vegetation types and drainage of soils and wetlands thus disturbing the flow of water into and out of the wetlands. Wetlands in poor health filter fewer pollutants, capture less carbon and provide less storm protection. Preserving and restoring wetlands, together with other water retention, provide natural flood control and healthier waters.

The amount and character of the wetlands in the Niagara watershed change as you transit from the southeast to the northwest. A map of the watershed's wetlands and floodplains is provided on the following page. The headwater areas in the southeastern portion of the watershed have steeper slopes, better drainage and deeper riverbeds and thus contain only small pockets of wetlands. The floodplains are very narrow in this area as well. In general only 3-4% of the land area in the south-southeastern watershed is wetlands. As you pass north over the Portage escarpment the waterways start to meander more and the amount of wetlands increases. Table 2.3 below outlines the amount of wetlands located within each sub-watershed, as well as the percentage protected as NYS DEC listed wetlands. To illustrate this point, the Cayuga Sub-watershed has 8% of its land cover area classified as wetlands[3] but only 23 percent protected, while the Murder Creek Sub-watershed contains 7,190 acres of wetlands, 50 percent of which are protected as NYS DEC listed wetlands.

Table 2.3 Wetlands by Sub-watershed

Subwatershed	Acres*	% of Total Acreage	% Protected (DEC Listed)
Niagara River	5,149	8%	24.7%
Lower Tonawanda Creek	7,698	12%	37%
Middle Tonawanda Creek	11,978	20%	56%
Upper Tonawanda Creek	4,813	12%	47%
Ellicott Creek	6,729	15%	35%
Murder Creek	7,190	26%	50%
Buffalo River	2,036	8.61%	41%
Buffalo Creek	2,329	10%	34%
Cayuga Creek	2,545	8%	23%
Smokes Creek	1,306	8%	30%
Eighteenmile Creek	1,596	9%	26%
Niagara River Watershed	**52,979**	**12.8%**	33%

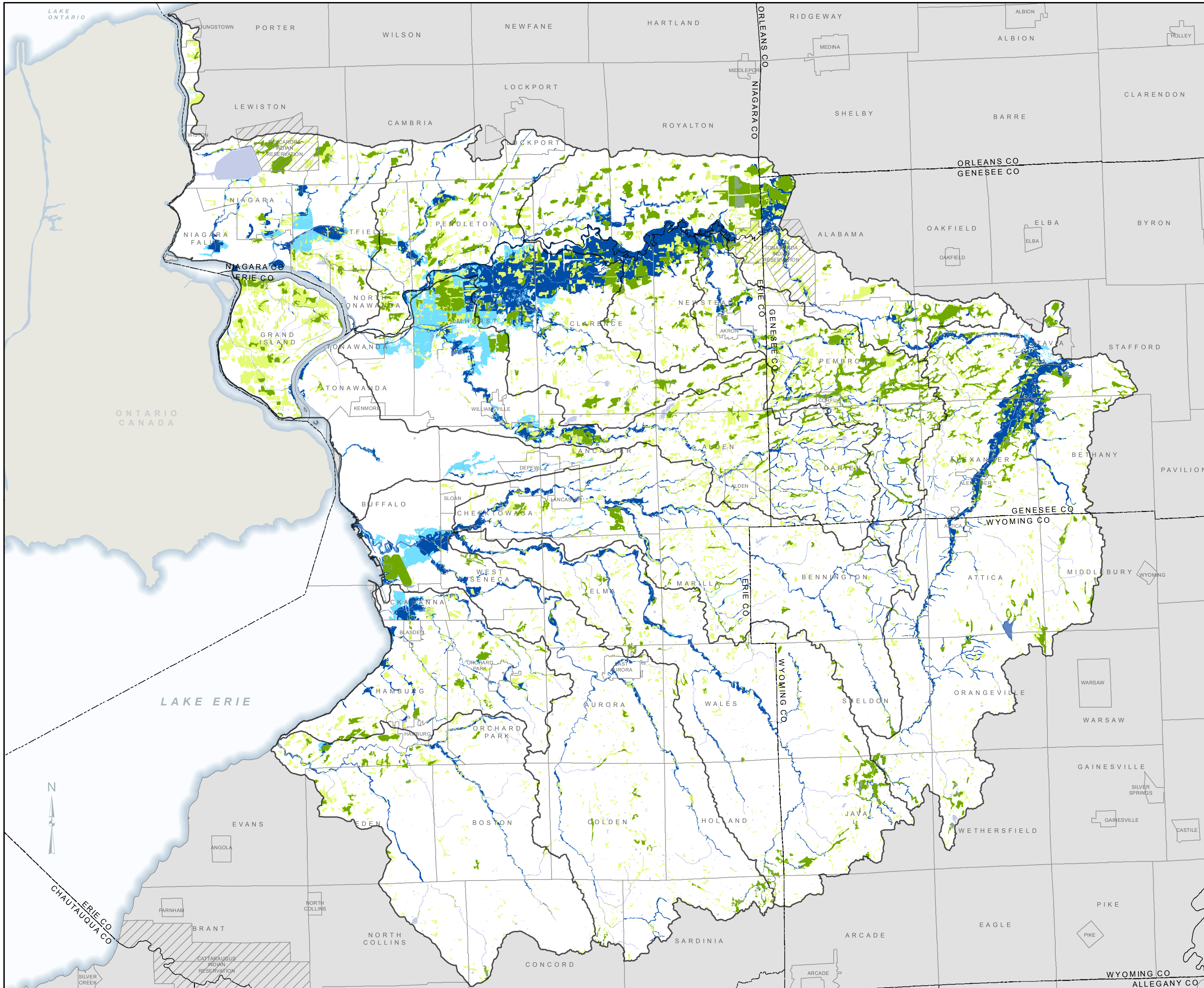
*includes State listed (DEC) and Federally listed (National Wetlands Inventory). Figures are based on the Active River Area as defined by the Niagara River Habitat Conservation Strategy (Source).

The four sub-watersheds north of the Onondaga Escarpment (Lower & Middle Tonawanda, Ellicott Creek and Niagara River Sub-watersheds) have a significant amount of wetland habitat, hydric soils and connection with underlying aquifers including the Onondaga Aquifer (See Aquifer Map). Wetlands constitute an average of 18% of sub-basin habitat within this area. Tonawanda Creek flows through the former lake bed of the prehistoric Glacial Lake Tonawanda, and many of the wetlands in the watershed are remnants of that earlier time. On eastern edge of the watershed, halfway between Lockport and Batavia, the Tonawanda Wetland area is located in the Middle Tonawanda Creek Sub-basin. It is a 5,600-acre wetland tract. From there, a broad floodplain sprinkled with wetlands,

[3] NOAA Land Cover data

Niagara River Watershed Management Plan

WETLANDS AND FLOODPLAINS



State Wetland

Federal Wetland

100-Yr Floodplain

500-Yr Floodplain

Sub-Basin Boundary

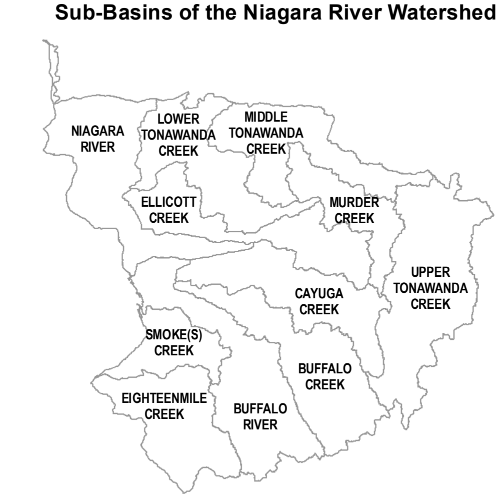
County

Municipality

5 2.5 0 5
Miles

5 2.5 0 5
Kilometers

Sub-Basins of the Niagara River Watershed



State wetland designations by New York Department of Environmental Conservation, current to April 2010.
Federal wetland designations by United States Fish and Wildlife Service National Wetlands Inventory, current to July, 2010. Floodplain data are derived from the Flood Insurance Rate Maps (FIRMs) published by the Federal Emergency Management Agency. Date varies.
Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hydrologic Unit Codes (HUC).

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New York State Department of State

This map was prepared for the New York State Department of State with funds provided under Title 11 of the Environmental Protection Fund Act.

C:\Users\WKS7\Documents\ArcGIS\Packages\11x17_wetlands_and_floodplains\v10\11x17_wetlands_and_floodplains.mxd extends westward across the watershed until it meets and is stopped by the urban development in the City of Buffalo and the Tonawandas.

Floodplains

The Niagara River Watershed has approximately 83,497 acres of floodplain. The Wetlands and Floodplains Map located on the previous page depicts their location. Presently the northern low-lying areas of the watershed host the largest acreage of floodplain (Table 2.4). Former Lake Tonawanda's boundary can be seen from this map as well, spanning from the large 100-year and 500-year floodplain complex sprawled across Tonawanda Creek from northern Amherst to the Tuscarora Reservation. The development occurring in and around this floodplain complex has seen increased high-water events downstream in the Cities of Tonawanda and North Tonawanda several days after a rain event. The other large floodplain complex existing along Tonawanda Creek is located just south of the City of Batavia in Genesee County, where several tributaries converge.

Table 2.4 Acreage of Floodplains by Sub-watershed

Sub-watershed	Acres	% of Total
Lower Tonawanda Creek	16,942.51	22%
Ellicott Creek	13,904.67	18%
Middle Tonawanda Creek	13,295.05	17%
Upper Tonawanda Creek	8,887.11	7%
Murder Creek	6,393.25	14%
Buffalo River	6,242.48	6%
Niagara River	6,173.61	6%
Cayuga Creek	3,689.04	5%
Smokes Creek	3,174.25	8%
Buffalo Creek	3,003.51	3%
Eighteenmile Creek	1,791.67	2%

Source: FEMA FIRM Maps

On the western end of the watershed, Smokes Creek's floodplain expands as it goes through Lackawanna. This is all industrial land with very little wetlands to help mitigate the issues of impervious cover. This area of Smokes Creek also experiences a lot of erosion during high rain events as minimal riparian vegetation exists to stabilize banks.

Just north of that, the lower Buffalo River meanders across the flat Lake Erie plain to the lake with a very wide floodplain extending up Buffalo Creek. The land area susceptible to 100 and 500 year flooding greatly expands as the river reaches the industrialized lower six miles of the Buffalo River in the urban areas of West Seneca and Buffalo. This floodplain is a habitat concern because of the contaminated sediments from the steel and chemical industries that once lined the river. At the mouth are remnants of one of the most extensive and productive coastal marshes on Lake Erie.

Climate & Precipitation

The climate of the Niagara River Watershed is typical humid continental, which is a climate type that exhibits large seasonal temperature contrasts, with cold winters and hot summers. These diverse climatic conditions are influenced by the region's location, the Great Lakes themselves, and air masses from other regions. The Great Lakes central position in North America exposes the region to alternating flows of warm, moist air from the Gulf of Mexico and cold, dry air from the Arctic. The Great Lakes are probably best known for lake effect snow, where cold Artic air masses move across the lakes picking up heat and moisture and depositing it in extreme snowfall events on the downwind side of the lake. Despite this reputation for extreme snowfall events, winters are changeable and often there are periods of bare ground. Summers are warm and sunny, with moderate to low humidity, and are often cooler than inland areas due to breezes off the lake.

A review of 1981-2010 weather station normals shows that while temperatures in the upper 30's can occur as early as October, on average the region experiences its first frost during the month of November (Table 2.5). The region can experience temperatures below 32°F up until April. On average the hottest month of the year is July, and the coldest month is January, though occasionally comparable lows can be found during February.

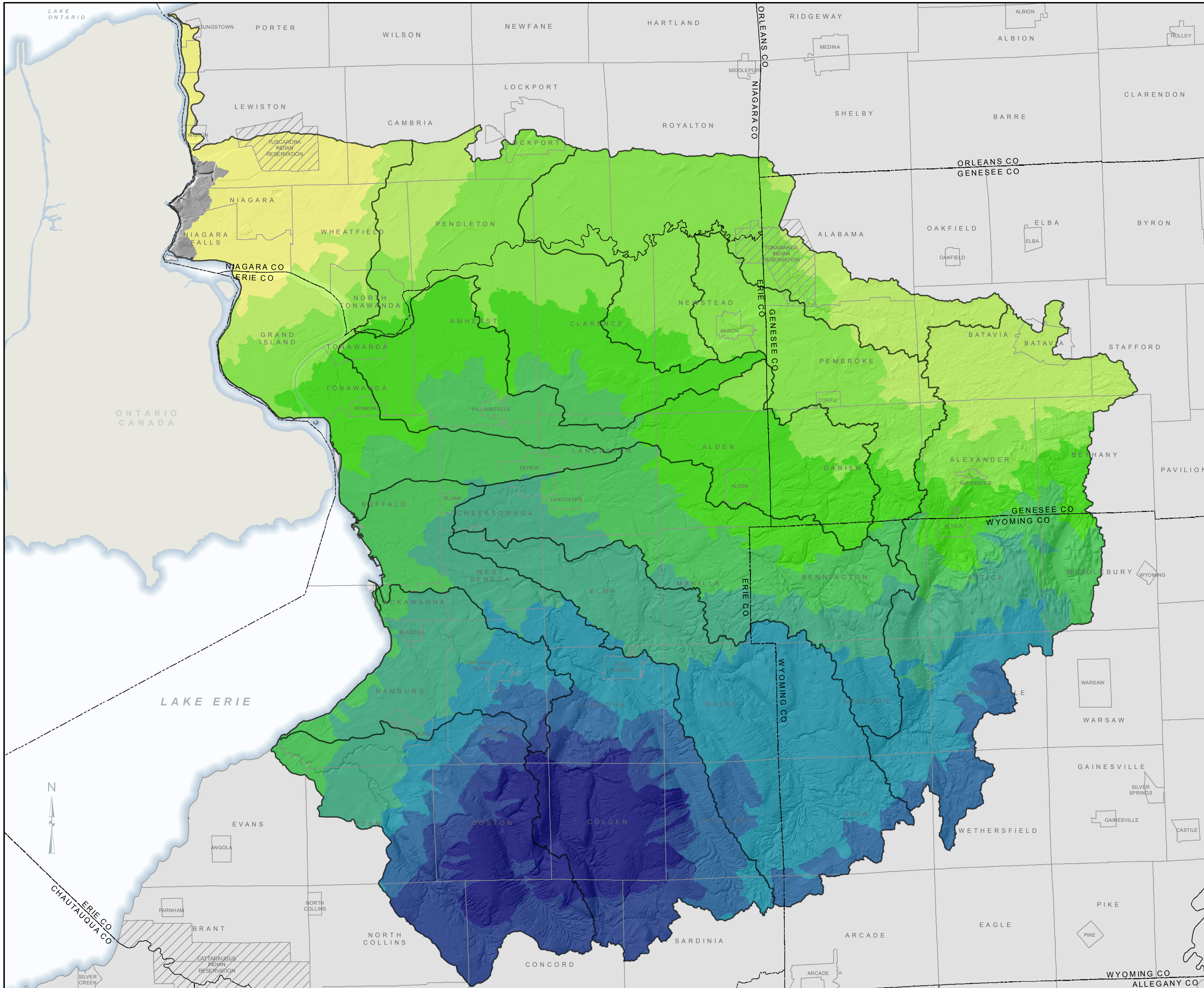
Table 2.5 Average First & Last Frost dates for the Niagara River Watershed (1981-2010)

Measuring Station	Aprox. First Frost	Aprox. Last Frost
Batavia	November 19th	April 2nd
Buffalo	November 21st	April 3rd
Colden	November 7th	April 15th
Lockport	November 21st	April 2nd
Niagara Falls	November 14th	April 6th
Wales	November 11th	April 12th

Source: National Climatic Center Station Normals, 2013

Western New York's climate is strongly driven by the lake. Intense lake effect snow is common from November to January, sometimes resulting in historic storms, but lake effect events taper off after the lake freeze over. The lake also modulates summer climate, resulting in the areas closest to the lake having more sunshine and fewer thunderstorms than inland areas. Variations in local climate are demonstrated in Table 2.6. Based on data provided by the National Climatic Data Center, the average annual temperature for the watershed ranges from 45.5-49.7 °F.

The average annual precipitation for the Niagara River Watershed ranges from 34.97 inches in Niagara Falls to 46.91 inches in Colden. The southern end of the watershed gets considerably more precipitation than the north. Higher precipitation levels are found primarily in the Colden/Boston area, but also extend to some degree to Wales and Orangeville. This can be clearly seen in Watershed Precipitation Map. The middle of the watershed gets moderate levels of precipitation, with the north receiving the least. Similar trends can be seen with snowfall, with the southern tier receiving considerably more snowfall than the northern end of the watershed.



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Niagara River Watershed Management Plan

AVERAGE ANNUAL PRECIPITATION (1971-2000)

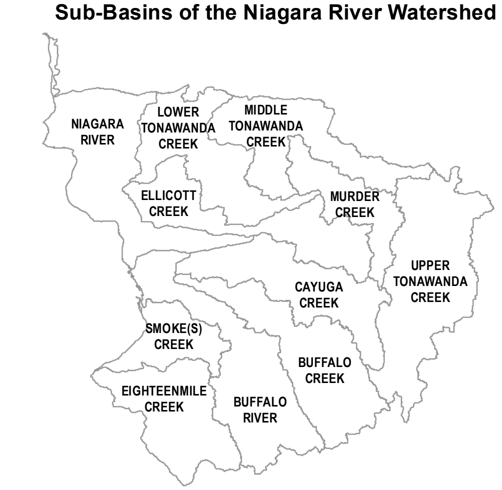
INCHES

32.6 - 35.5
35.6 - 36.8
36.9 - 37.8
37.9 - 38.9
39.0 - 40.1
40.2 - 41.5
41.6 - 42.9
43.0 - 44.7
44.8 - 47.0
47.1 - 50.7

Sub-Basin Boundary
County
Municipality

Miles: 5 2.5 0 5
Kilometers: 5 2.5 0 5

Sub-Basins of the Niagara River Watershed



Climate Divisions obtained from the National Climatic Data Center, published by the U.S. Geological Survey. Sub-Watersheds are based on the U.S. Geological Survey 10-Digit Hyrologic Unit Codes (HUC).

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Table 2.6 Average Temperatures and Precipitation for the Niagara River Watershed (1981-2010)

Measuring Station	Temperature (Fahrenheit)			Average Annual Precipitation (Inches)
	Winter Average (Jan)	Summer Average (July)	Annual Average	
Batavia	26.9	69.5	48.9	35.34
Buffalo	27.1	69	48.3	40.48
Colden	24.4	65.6	45.5	46.91
Lockport	28.4	70.2	49.7	37.85
Niagara Falls	26.2	68.8	47.7	34.97
Wales	24.8	65.7	45.8	42.35

Source: National Climatic Center Station Normals, 2013

However, since 1975, the number of days with land snow cover has decreased by 5 days per decade, and the average snow depth has decreased by 1.7 cm per decade. From 1973 to 2010, annual average ice coverage on the Great Lakes declined by 71%.[4] If this trend continues, reduced ice cover will result in increased lake-effect precipitation, which can lead to increased flooding. However, reduced ice cover can also increase evaporation, and decrease water recharge, leading to falling water levels, especially for Lake Erie.

Climate Change

The Earth's atmosphere is warming, and nearly all communities around the Great Lakes will need to adapt to changes in regional climate over the next century. These changes include: warming air temperatures; shifts in the timing, frequency, and severity of precipitation events; declining lake levels; and higher water temperatures and reductions in lake ice cover. Changes to regional climate pose increased risks to the water resources, built environment and infrastructure, ecosystems, and recreation and tourism sectors that already face other pressures.

In the next several years weather patterns are predicted to become more variable, with multiple weather events occurring simultaneously, for instance, droughts followed by heavy rains. This example would have multiple repercussions for water quality, by "negatively affecting turbidity, contaminant concentrations, and organic matter in raw water supplies." [5] Other anticipated climate change impacts include increased heat waves; exacerbated drought; more invasive species; shifts in species range; changes in timing of ecological events; reduced lake ice cover; and, earlier snow melt. Efforts to prepare for these immediate and longer-term impacts are needed. Climate variability and change exacerbate many existing vulnerabilities and add to the complexity of resource management, capital investment and community planning.

[4] Great Lakes Integrated Science Assessments, 2012

[5] ibid

Potential Emerging Climate Change Impacts

1. **Warming Temperatures**

   Recent climatological research indicates that regional temperatures are warming slightly, especially in the winter and spring, with spring showing the strongest warming. Summer and Fall are not as affected by this trend, with the Fall season even showing a slight cooling trend. Winter/spring warming results in shorter frost periods, and reduced ice cover on the lakes, which due to their weather modulating capabilities can significantly impact the region's seasons and climate. This can also explain why annual precipitation is increasing, while the ratio of snow to total precipitation is decreasing.[6]

2. **Heat Waves and Reduced Cold Events**

   Heat waves are expected to become much more common in a region where they have historically been rare. This may have significant impact on the region's agricultural industries, by changing growing conditions for staple crops such as blueberries and apples, and by increasing irrigation demands. Projected warmer temperatures also can negatively impact the dairy industry, which is a significant economic driver in the watershed. Heat stress in cows can dramatically reduce milk production and slow birth rates.[7] Extreme cold events, defined both as the number of days per year with minimum temperature at or below 32°F and those at or below 0°F, are expected to decrease[8].

3. **Increased Rainfall**

   Climate change is expected to increase annual precipitation across the Great Lakes region. Relatively large increases in winter and spring precipitation are projected by the end of the century, with large decreases for summer months. The frequency of heavy rainfall events is expected to continue increasing with longer dry spells in between. Fewer snow cover days and less lake effect snow are projected in the future. Warm winter temperatures can also result in "earlier snowmelt, ice breakup, nutrient input and subsequent algal growth in reservoirs"[9].

   Heavy rainfall can mobilize contaminants from a watershed and disturb sediments. Rainfall events can cause sewers to overflow, releasing contaminants especially during the "first flush" of rainfall after dry periods. If heavy rains occur frequently, reservoirs may have little time to

[6] Alden, M., Mortsch, L., Sheraga, J. *Climate Change & Water Quality in the Great Lakes Region: Risks, Opportunities & Responses.* 2003

[7] US Global Change Research Program, *Global Climate Change Impacts in the United States*, 2009

[8] NYS's Open Space Conservation Plan (2014 Draft)

[9] ibid

recover from increased turbidity, and if those rains occur after a dry spell, organic materials can be flushed downstream all at once.[10]

4. **Increased Flooding**

An increase in flooding is considered one of the most probable impacts of climate change in this region. Factors that could influence flooding include shifts in the intensity and tracks of storms and changes in the type of precipitation. Land conditions such as smaller snow-packs, less soil moisture and frozen soil when large storms take place can also change and influence the intensity of flooding effects. According to the NYS Open Space Conservation Plan, climatologists expect that even if the frequency of storms does not increase, the proportion of storms that become severe is likely to be greater.

The ability to estimate future flood risks and developing effective future flood mitigation strategies will become vital for municipalities. An article published recently by the U.S. Geological Survey did not come up with a clear pattern of how climate change will alter flooding in the future but did indicate that changes in snow packs, frozen ground, soil moisture and storm tracks are all factors that could be altered by greenhouse gas concentrations and possibly alter current flooding patterns. In the study the United States was divided into four large regions and the research showed some regional differences in the way that flooding has varied with CO2 levels over the past century. For the northeastern region that includes New York State, the study shows a tendency towards increases in flooding over this period.

Ultimately, the relationship between greenhouse gas concentrations and floods is complex, demonstrating the need for long-term stream flow data to help guide future flood hazard mitigation and water resources planning.

5. **Changing Lake Levels**

As mentioned previously, warmer air and water temperatures along with reduced snowpack and shorter duration of ice cover may result in greater evaporation and overall lower lake levels. The frequency and duration of low water levels could increase, falling below historic low water levels. However, increase in frequency and intensity of storm events may also raise lake levels. Water level change will not be equal among all lakes. Considerable range in the change in lake levels is due to differences in precipitation patterns and evapotranspiration.

[10] Source: American Water Works Association, *Climate Change: how does weather affect surface water quality?* 2013

The impact of climate change on Great Lakes water levels is a critical question for the region's economy and environment, and for one of the nation's key shipping corridors. Even small drops in lake water levels could create problems for shipping and navigation, recreational boating, hydro-electric production and other uses.

6. **Changing Winter Freeze and Thaw Dates**
   In the Great Lakes Region, later ice-in dates appear to be increasing the frequency of "lake effect" storms, very heavy snowfalls that occur when open water in the lakes is warmer than the surrounding land surface. If the lakes freeze over later in winter (or not at all), more lake-effect events are expected. Reduced ice cover can also increase winter wind and wave erosion of shorelines[11].

Extreme Weather Events

VT Rt 100 - Hurricane Irene (Burlington Free Press)

Studies have indicated that if current trends continue, the region's already variable climate could become increasingly volatile and unpredictable, with increases in both extreme wet and dry events. Extreme weather events can lead to "increased turbidity and organic matter, hypoxia, eutrophication leading to algal and cyanobacteria growth, taste and odor problems, increased presence or risk of pathogens and changes to conductivity, pH and alkalinity."[12] In addition, extreme rainfall events can increase erosion, which can increase sedimentation and turbidity.

Heavy rainfall (over short time periods) produces the most water quality impact, more than any other extreme weather event. With increasing temperatures, and with rainfall making up a greater percentage of annual precipitation, this poses a serious threat for regional water quality.

[11] NYS Open Space Conservation Plan (Draft 2014)

[12] (Source: American Water Works Association, *Climate Change: how does weather affect surface water quality?* 2013)

Existing Infrastructure in the Watershed

Dams

According to the NYS Dam Inventory (2009) there are 317 dams within the watershed, collectively retaining approximately 79,300 billion gallons of water[13]. The oldest dam recorded was built in 1807 (LC Brown Dam) and the most recent was built in 2007 (Denz Pond Dam). The earliest dams were built for irrigation, fire protection, and drinking water supply purposes (between the mid 1800's and early 1900's). There seems to have been a dam-building explosion in the 1950's and 60's, with the vast majority of these dams built for "recreation" purposes. A map of the watershed's dams and their designated purposes is provided on the following page.

NYPA Hydroelectric Dam in Lewiston, NY (WKBW Online)

Most of the dams in the watershed are small earthen dams (74%), with the remaining consisting of timber crib, concrete, masonry, rock fill, and buttress style designs. The Lewiston Pump Generating Plant is the largest dam in the watershed and located in the Niagara River Sub-watershed. It was built by the NY Power Authority in 1960 and stores approximately 22,000 billion gallons of water to feed the Lewiston Hydroelectric generation facility. The other seven hydro-electric dams[14] in the watershed include:

- Sweewaldt Dam on Tonawanda Creek
- Depew & Lancaster Co Dam on Cazenovia Creek
- Haungs Dam on Cayuga Creek
- Burnnen Mill Dam on Eighteen Mile Creek
- Yaws Mill Dam on the West Branch of Cazenovia Creek
- Grays Mill Dam on the West Branch of Cazenovia Creek
- Hyman Brothers Saw Mill Dam on Buffalo Creek

Most of the watershed's dams are in private ownership for irrigation, private stocked ponds, and other recreational purposes. Only 49 of the dams are under public ownership for public water supplies, hydroelectric, recreation or flood control purposes.

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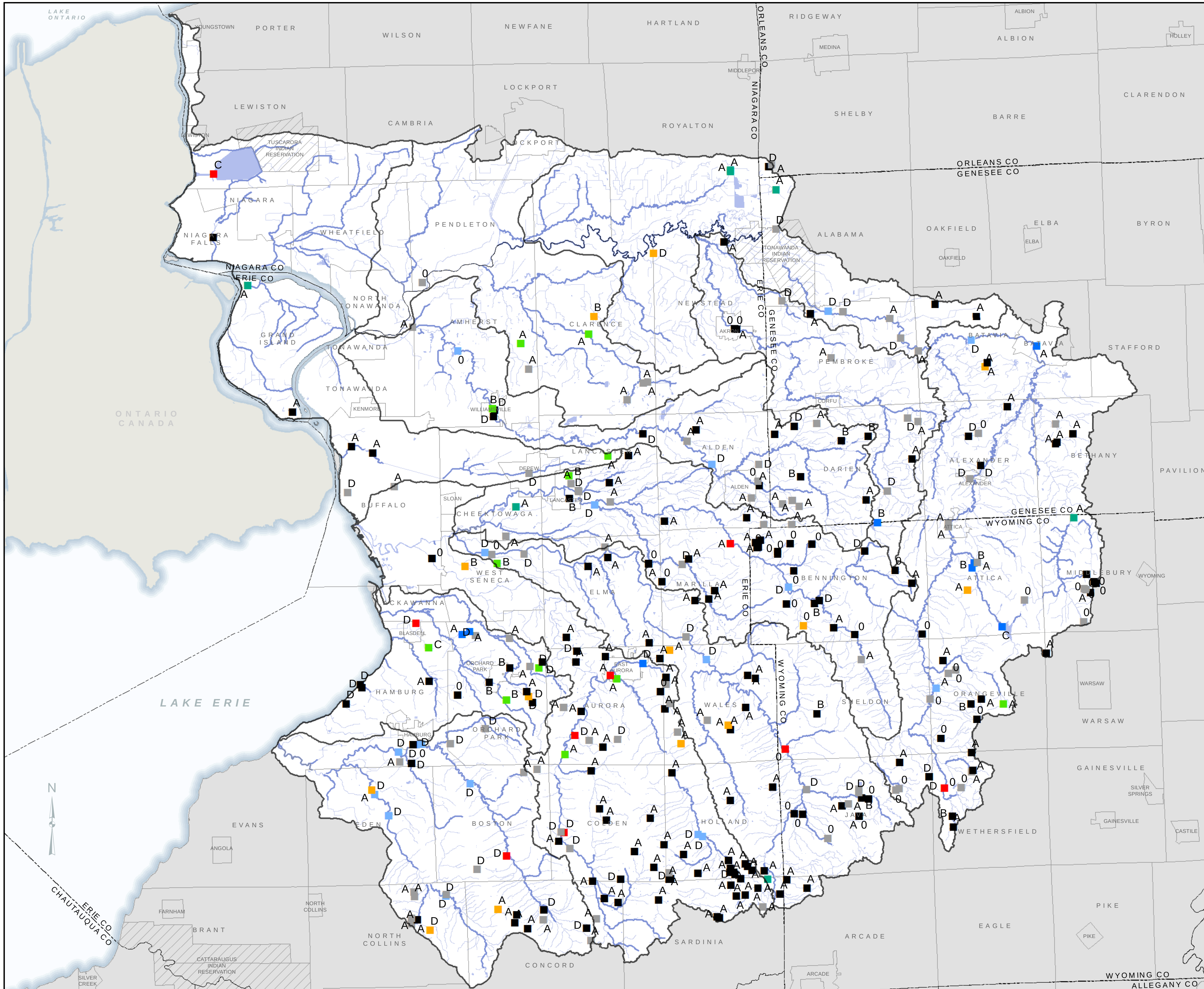
[13] normal storage capacity, NYS DEC Inventory of Dams (2009).

[14] The Robert Moses Niagara Power Plant is not included in this list as it's a "river-run" hydroelectric facility, not a dam.



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Niagara River Watershed Management Plan

STATE INVENTORY OF DAMS

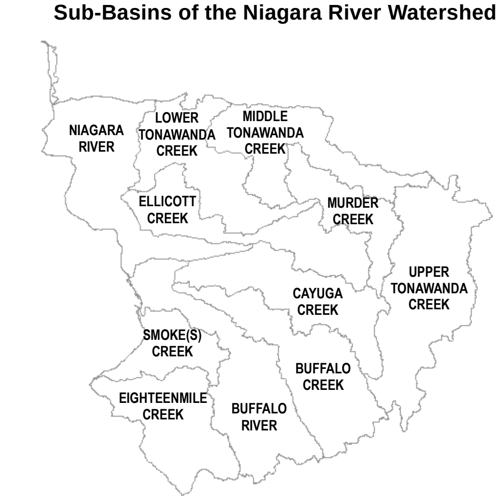
Purpose of Dam

- Fire Protection
- Fish and Wildlife Pond
- Flood Control and Storm Water
- Hydroelectric
- Irrigation
- Water Supply
- Recreation
- Other

Sub-Basin Boundary
County
Municipality

5 2.5 0 5
Miles
5 2.5 0 5
Kilometers

Sub-Basins of the Niagara River Watershed



This dataset is used to show the location of dams in New York State's inventory of dams, and lists selected attributes of each dam, NYS DEC, November 2009.

Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

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New York State Department of State

This map was prepared for the New York State Department of State with funds provided under Title 11 of the Environmental Protection Fund Act.

The NYS Dam Inventory also classifies a dam's hazard class, which indicates the level of hazard the dam poses if it were ever to fail or be breached. Dam's hazard classes range from A-C, with A equaling a low-level hazard (minor damage to property) and C equaling a high-level hazard (causing loss of life, damage to public infrastructure, and property). Dams classified as D, are considered no longer functioning and therefore have no hazard. There are a total of 176 dams classified as Hazard Level A (low-hazard), 20 as level B (moderate-hazard), 3 as level C (high-hazard), and 74 as class D (no-hazard). The State Inventory of Dams Map on the previous page includes labels for each dam's Hazard classification. The three Class C dams include the McKinley Mall Retention Pond Dam on Blasdell Creek, Lewiston Hydroelectric Generation Dam on the Niagara River, and the Attica Dam on Crow Creek. Owners of Class C dams are required to have an Emergency Action Plans and Inspection and Maintenance Plans in place, as well as regularly scheduled safety inspections. Table 2.7 outlines the number of dams located in each sub-watershed.

Table 2.7: Number of Dams by Sub-watershed

Subwatershed	Total Amount
Buffalo Creek	39
Buffalo River	66
Cayuga Creek	44
Eighteenmile Creek	31
Ellicott Creek	23
Lower Tonawanda Creek	8
Middle Tonawanda Creek	15
Upper Tonawanda Creek	53
Murder Creek	11
Niagara River	9
Smoke Creek	18
Total	**317**

source: NYS Dam Inventory

Dams can significantly alter the ecosystem of a waterway. Reservoirs created by dams can block fish migration, increase water temperatures, trap sediments, decrease water speed, reduce dissolved oxygen, increase nitrogen levels, and alter riparian areas. Because these changes to the ecosystem can lead to eutrophication and cause stress on fish populations and riparian habitats, older non-functioning dams in the watershed should be investigated further for possible removal and restoration of waterway hydrology and habitat.

NYPA Niagara Power Project Impacts & Relicensing

Prior to the relicensing of the Lewiston Hydroelectric Generation facility by the NYPA in 2007 the generation facility, its reservoir and other infrastructure were argued to be the cause of significant environmental impacts to the Niagara River. Findings from environmental studies completed as part of the relicensing effort identified major impairments caused by the water diversions necessary for the operations of the plant. Presently water level draw-downs average 1.5 feet/day just above the intakes, up to 12 feet/day in the gorge area above the tailrace, up to 36 feet/day in the Lewiston Reservoir, and .6 feet/day at Lake Ontario (URS 2003). The water fluctuations may destabilize nearshore habitats for many plants and animals including spawning fish, nesting shorebirds, amphibians and reptiles[15]. One NYPA study (Riveredge, 2004) identified 49 rare, threatened or endangered species and three significant natural communities that were likely affected by these fluctuations, including pied-billed grebe, lake sturgeon, and the deep emergent marsh community at Buckhorn State Park.

Due to the environmental impacts and the infrastructure's limitation of public access to the waterfront, relicensing included a settlement to waterfront (Greenway) communities of Western New York of $9 million/year for 50 years. The settlement provides three Standing Committees that oversee disbursement of the funds for environmental and public access projects in the Greenway Communities, plus allocations to Erie and Niagara Counties[16].

Stormwater Infrastructure

The other primary man-made infrastructure impacting how water moves in the watershed is stormwater infrastructure. In the Niagara River Watershed this encompasses both combined and separated storm sewer infrastructure. Combined Sewer Systems (CSS) are conveyance systems that are designed to collect stormwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of the wastewater to a sewage treatment plant, where it is treated before being discharged to a local waterbody. However, during heavy rain events combined systems can be inundated and include overflow release points that discharge untreated sewage into the watershed. Presently the Cities of Buffalo, Niagara Falls, Lockport, and the Village of Perry have Combined Sewer Systems. A full detailed discussion of this infrastructure and the impacts of these combined systems are presented in Chapter 4.

Municipal Separate Storm Sewer Systems, or MS4's for short, are storm water conveyance systems that are completely separate from sanitary sewer systems. MS4 infrastructure can include underground pipes, stormwater retention ponds and roadside ditches, all of which either store or convey water along man-made routes in the watershed. It is important to note that MS4 conveyed waters are not treated prior to entering their final destination, a waterbody or tributary in the watershed. Therefore, stormwater has the potential to contribute pollutants into the watershed, including animal waste, litter, roadway contaminants, yard clippings, plus fertilizers and pesticides. Because of this pollution potential, the US Environmental Protection Agency (US EPA) regulates all municipal, industrial and commercial stormwater discharges as part of the National Pollutant Discharge Elimination System (NPDES) under the Federal Clean Water Act.

All municipalities have some type of MS4 infrastructure; however communities that meet a certain threshold for population density as outlined by the most recent US Census (Urbanized Areas), must

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[15] Buffalo and Niagara Rivers Habitat Assessment and Conservation Framework (Buffalo Niagara RIVERKEEPER, 2008)

[16] A list of projects funded by NYPA Relicensing Greenway Funds is available online at http://niagara.nypa.gov/

meet additional requirements to manage their stormwater discharges in accordance with the NPDES. These municipalities are often referred to as "MS4 communities" because of this designation and include the following municipalities in the Niagara River Watershed:

City of Buffalo	Town of Elma	Town of Wheatfield
City of Lackawanna	Town of Evans	
City of Niagara Falls	Town of Grand Island	Village of Alden
City of North Tonawanda	Town of Hamburg	Village of Blasdell
City of Tonawanda	Town of Lancaster	Village of Depew
	Town of Lewiston	Village of East Aurora
Town of Alden	Town of Marilla	Village of Hamburg
Town of Amherst	Town of Newstead	Village of Kenmore
Town of Aurora	Town of Niagara	Village of Lancaster
Town of Boston	Town of Orchard Park	Village of Lewiston
Town of Cambria	Town of Pendleton	Village of Orchard Park
Town of Cheektowaga	Town of Porter	Village of Sloan
Town of Clarence	Town of Tonawanda	Village of Williamsville
Town of Eden	Town of West Seneca	Village of Youngstown

Presently, all 40 of the designated MS4 communities are located within Erie and Niagara Counties. A major MS4 mapping effort is currently underway to inventory all of MS4 infrastructure routes within these communities to identify the paths by which stormwater is directed in these systems. The latest map of the MS4 outfalls is provided through Erie County's Online GIS mapper[17].

Gas Wells & Fracking

The Medina sandstone rock stratum under the Allegheny plateau contains pockets of natural gas. Even under the best of circumstances, impacts of gas drilling can include heavy truck traffic on local roads, noise and odors emanating from drilling sites, conflicts with outdoor recreation, diminished tourism, reduced biodiversity, and deterioration of air and water[18]. In small drilling operations vertical wells are drilled to depths approximately 2,500 to 3,100 feet to pump the gas from these wells. There are 2,049 such wells in the Watershed. With proper management practices and maintenance the land use impacts associated with this type of well are considered low. However, old wells run the risk of well casing failure and without proper maintenance and testing can become a public risk due to gas leakage into the atmosphere and surrounding water sources.

[17] http://gis1.erie.gov

[18] Gas Drilling in the Town of Colden, 2013

Along with production wells, the area also houses underground vertical and horizontal gas storage wells. Natural gas produced elsewhere is pumped into and stored in these underground wells in the warm months when demand is low and then pumped out in the cold winter months when household demand is high. Potential negative impacts to the surrounding environment can include chemical spills, road damage due to heavy truck traffic and water contamination and drilling noise. Vigilant performance from the well operators is necessary to protect the watershed from these impacts.

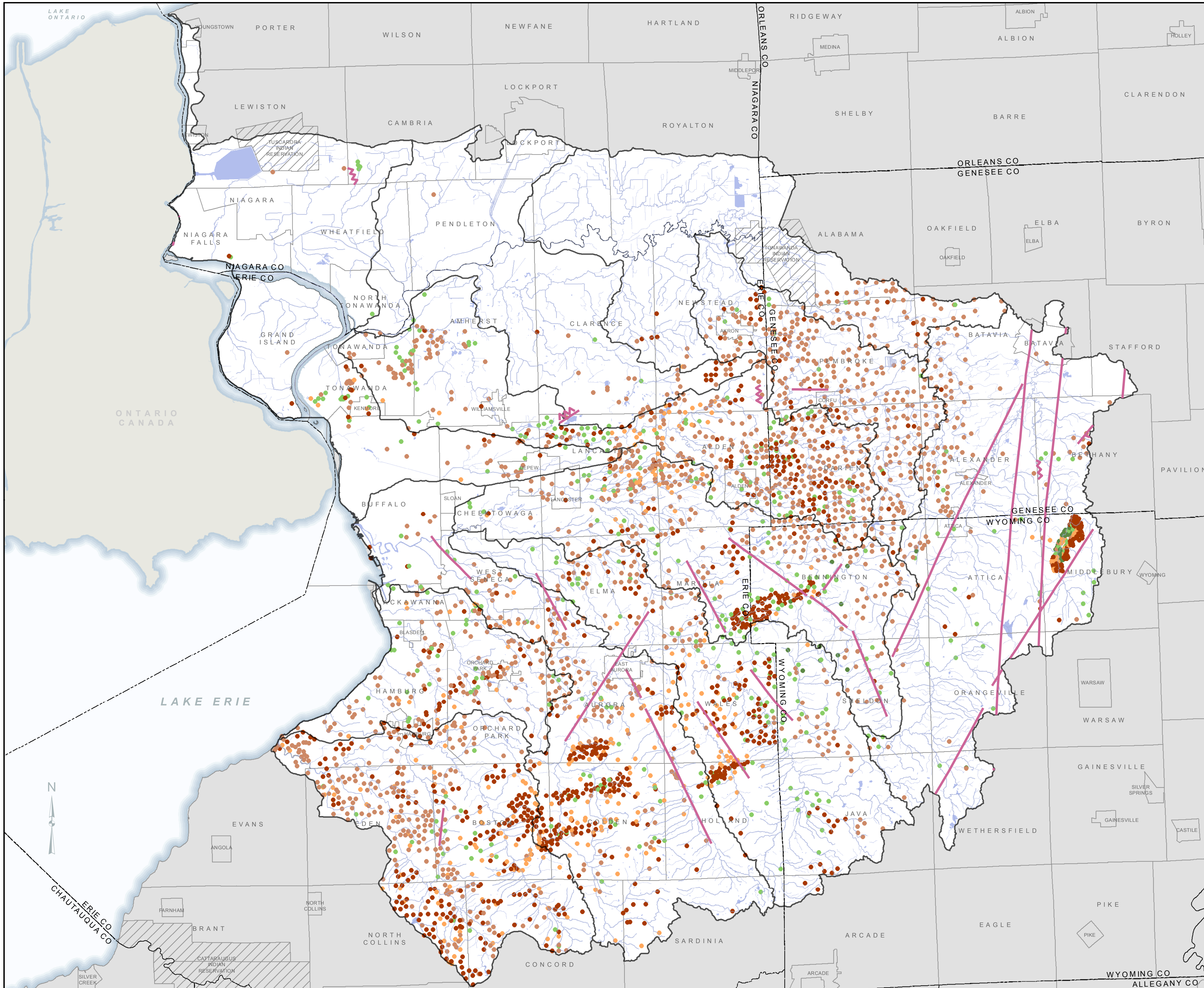
Old gas wells are periodically reworked for performance enhancement. Reworking an existing active storage well consists of cleaning out the wellbore, installing a new casing inside the existing casing and then perforating the new casing and hydro fracking. These small hydraulic fracturing treatments are commonly used to remedy "skin damage", a low-permeability zone that sometimes forms at the rock-borehole interface. In such cases the fracturing may extend only a few feet from the borehole, though still using a considerable amount of fracking and drilling fluids.

This becomes a bigger environmental issue when dealing with high volume, hydraulically fractured (HVHF) gas wells. This is due to the drastic difference in scale of an HVHF site. A typical HVHF gas drilling permit application may encompass a 640 acre (one square mile) spacing unit. These wells are much deeper and the actual fracturing of the rock extends much further from the borehole. The scale of all potential environmental impacts increases accordingly. For example, reworking a vertical well uses approximately 14,000 gallons of fracking fluid and 10,000 gallons of drilling fluid. In comparison fracking one HVHF well uses 5 – 8 million gallons of water mixed with varying amounts of chemicals, estimated by researchers to range from 30 – 300 tons of chemicals.

HVHF has recently been banned in New York State, but reworking existing wells is still a concern. There are currently 3,329 gas wells in the watershed. Nearly 76% (2,530) of these wells were drilled between the years 2000 and 2011. (See map of State Regulated Gas Wells on the next page.) The gas development industry has been under pressure to reduce its environmental footprint by developing Best Management Practices to maintain the integrity of each well system, isolate the well from the surrounding subsurface environment, and effectively contain the produced gas and other fluids within the well's innermost production conduit so the wastewater that is returned to the surface can be efficiently captured, contained, treated, and ultimately recycled. The American Petroleum Institute (API) has taken the lead in reviewing and evaluating the industry's practices for drilling, completing, and operating oil and natural gas wells and has published an extensive number of documents describing recommended practices for well planning, well design, well construction, well completion, and well decommissioning. These practices can certainly be improved upon, but at a very minimum it should be required for all operators to employ drilling, completion, and environmental

Niagara River Watershed Management Plan

STATE REGULATED GAS WELLS



Fault

YearDrilled

- 1987 - 1990
- 1991 - 1996
- 1997 - 2001
- 2002 - 2006
- 2007 - 2011

Sub-Basin Boundary

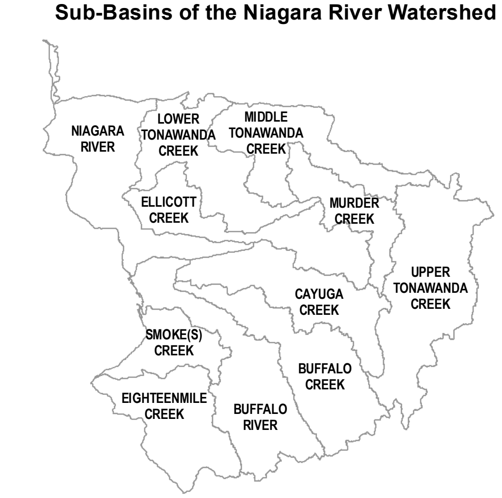
County

Municipality

Miles: 5 2.5 0 5

Kilometers: 5 2.5 0 5

Sub-Basins of the Niagara River Watershed



he 305(b) program system provide assessed water data and assessed water features respectively.
Well dataset contains locations of oil, gas, and other service wells. The Division of Mineral Resources maintains information and data on almost 40,000 wells, categorized under New York State Article 23 Regulated wells.
Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

BUFFALO NIAGARA RIVERKEEPER®

NEW YORK STATE DEPARTMENT OF STATE

This map was prepared for the New York State Department of State with funds provided under Title 11 of the Environmental Protection Fund Act.

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control technologies and practices that fully meet these evolving standards and that are considered up-to-date.

Transportation Infrastructure

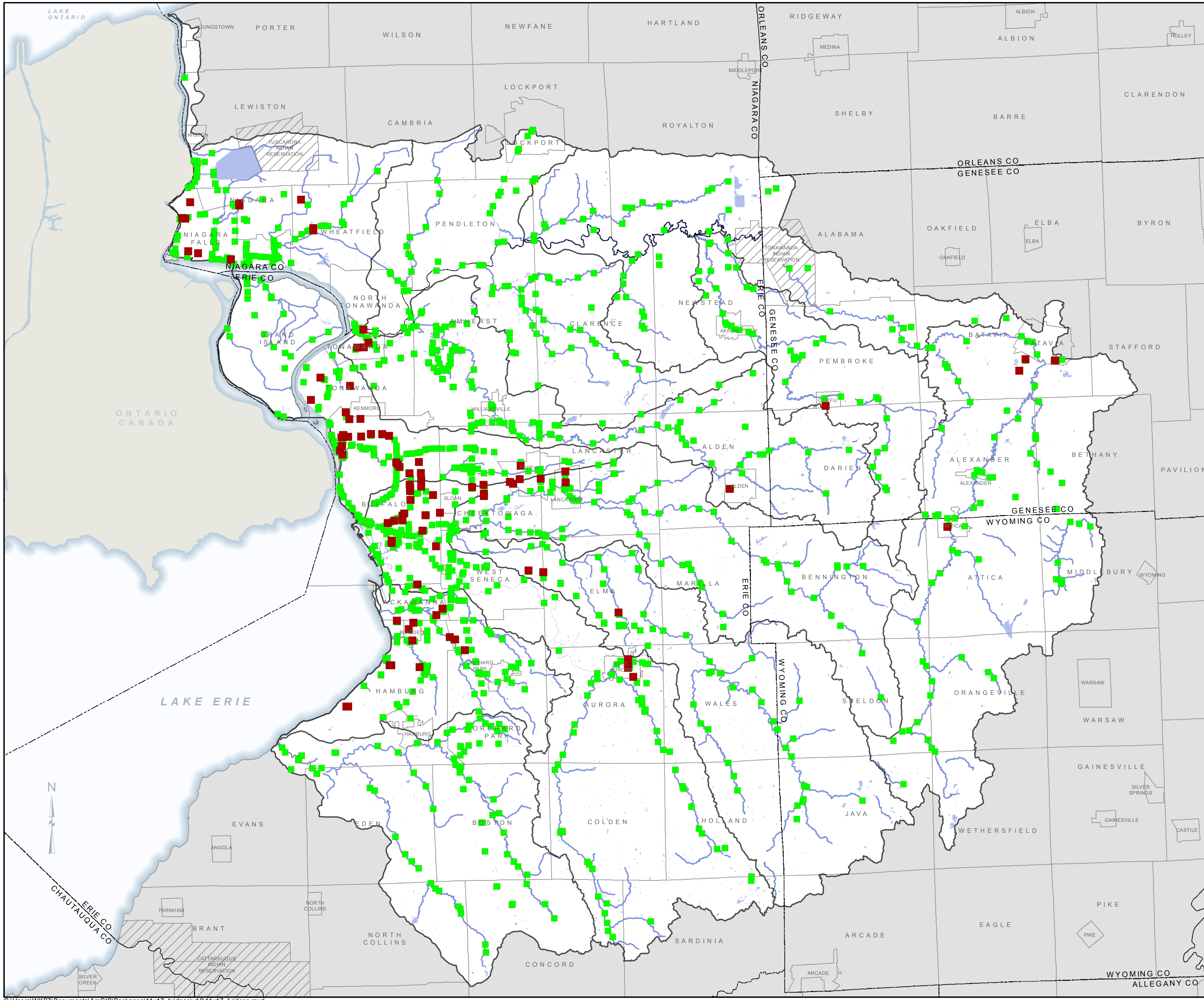
Drainage for transportation infrastructure makes up the vast majority of MS4 infrastructure. Roadways are typically impervious and act as collection systems, collecting surface waters and diverting rainwater to underground stormwater pipes and roadside ditches. Most bridges over waterways also collect and directly convey stormwater into the waterway they cross over, allowing for minimal opportunities to filter and treat roadway runoff prior to its release into area waterways. A map on the following page documents all of the locations where an automobile or railroad bridge exists to cross a waterway, highlighting the extent of direct run-off release points in the watershed.

Design of bridges, roadway and MS4 infrastructure can influence waterway health. Poor design can create channelized stormwater routes, and poor culvert placement can break stream connectivity and strand aquatic life. A crucial area of interference is the intersection of a waterway by a roadway. Without careful design bridge abutments change the geometry of the stream bed and floodplain. They can constrict the channel, increase velocity and cause scour around the abutments weakening the bridge's structural integrity. Well-designed bridges should span the entire waterway without disturbing or altering the waterway bed or banks. Culverts also, if improperly designed or located, can add to erosion, sedimentation issues and act as fish barriers. Roadside maintenance practices have are a potential source of contamination from bridge washing/ painting and can often aid the spread if invasive species as well, when groundcover is disturbed.

Navigational Channels & Shipping Infrastructure

The City of Buffalo's historic growth in the late 19th and early 20th centuries was spurred by the establishment of major shipping routes via the Erie Canal and other Great Lakes connections afforded by its location at the western end of Lake Erie. As a major shipping economy, the city altered much of its natural shorelines to accommodate ship navigation, docking and the transfer of goods. Today, some of those alterations still exist in the landscape. A portion of Buffalo's shipping past is still active in certain sections of the waterfront as well.

Presently the Buffalo River from its mouth at Lake Erie upstream to the Mobile Oil and the Buckeye Terminals is an official navigation channel. Large portions of the Buffalo River in this section have hardened shoreline and docking areas mixed in with the former grain elevators that sit immediately adjacent to the water. The City Ship Canal is another navigational channel that runs off of the Buffalo River along the other side of Kelly Island. The City Ship Canal sees shipping traffic as far south as the Sand Products company located off of Furhmann Boulevard.



Niagara River Watershed Management Plan

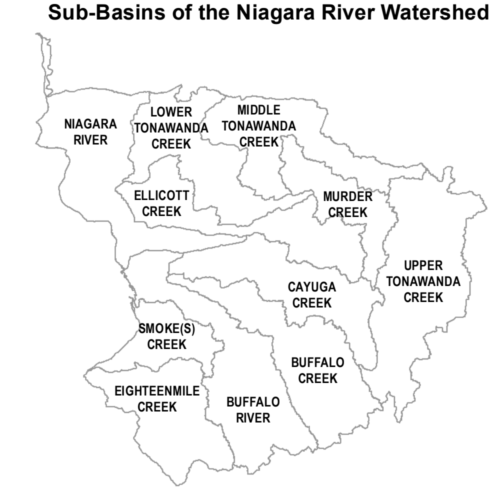
HIGHWAY AND RAILROAD BRIDGES

- Highway Bridge
- Railway Bridge

- Sub-Basin Boundary
- County
- Municipality

5 2.5 0 5
Miles
5 2.5 0 5
Kilometers

Sub-Basins of the Niagara River Watershed



National Bridge Inventory (NBI) database provided by the Federal Highway Administration, Office of Bridge Technology 2007, and NYS Department of Transportation, 2009. Sub-Watersheds are based on the U.S. Geological Survey10-Digit Hyrologic Unit Codes (HUC).

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The Black Rock Canal begins where Lake Erie meets the Niagara River and continues up the City of Buffalo's shoreline and ending at the US Army Corp of Engineers lock located at the northern end of Squaw Island. This navigation channel hosts more recreational boaters than shipping vessels these days.

Outside of the City of Buffalo, there are three other additional navigation channels: Niagara River Channel, Tonawanda Channel and Tonawanda Creek. The Tonawanda Channel continues from where the Black Rock Channel ends and continues north within the East Branch of the Niagara River along the shoreline of the Tonawandas before changing names to the Niagara River Channel near North Tonawanda. The Niagara River navigation channel continues north north-east around the Western side of Grand Island in the East Branch of the Niagara River. Due to dangerous currents near Niagara Falls the Niagara River navigation channel ends at the breakwalls off of Buckhorn Island State Park at the Northern tip of Grand Island. The navigation channel of Tonawanda Creek exists from its mouth at the Niagara River all the way upstream to where it splits off from the Erie Canal in the Town of Pendleton. This portion of the Creek is considered part of the Erie Canal and overseen by the NYS Canal Corporation.

Aside from the main navigation channels there are several areas of the watershed where major shipping infrastructure exists. Buffalo's Outer Harbor hosts four main shipping canals, some of which can be utilized for docking major great lakes shipping freighters and barges. Farther south on Lake Erie, the City of Lackawanna has remediated and is reinvesting in the Lackawanna Canal, a major freighter docking facility. Only a few other opportunities exist for large ship docking in the watershed, including docks at Huntley Power Plant, Riverworld and United Refinery on the Niagara River in the Town of Tonawanda. Major railroad infrastructure in the watershed is often found co-located in with these major port areas as well, specifically along the City of Lackawanna and Town of Tonawanda waterfronts, Buffalo's Inner and Outer Harbor, the City Ship Canal, and along the Buffalo River.