FINAL

January 2020

St. Lawrence River Watershed Characterization Report

Prepared for Franklin County Soil & Water Conservation District

This plan was prepared with funding provided by the New York State Department of State under Title 11 of the Environmental Protection Fund.

EcoLogic

ANCHOR QEA

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ABBREVIATIONS

APA	Adirondack Park Agency
APIPP	Adirondack Park Invasive Plant Program
CAFO	Concentrated Animal Feeding Operation
CAIR	Clean Air Interstate Rule
CCE	Cornell Cooperative Extension
CEC	Contaminant of Emerging Concern
CSO	Combined sewer overflow
DANC	Development Authority of the North Country
FEMA	Federal Emergency Management Agency
FCSWCD	Franklin County Soil & Water Conservation District
GLAM	Great Lakes-St. Lawrence River Adaptive Management
HUC	Hydrologic Unit Code
IJC	International Joint Commission
LCLGRPB	Lake Champlain-Lake George Regional Planning Board
MGD	Million Gallons per Day
NASS	National Agricultural Statistics Service
NFHP	National Fish Habitat Partnership
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NYSDAM	New York State Department of Agriculture & Markets
NYSDEC	New York State Department of Environmental Conservation
NYNHP	New York Natural Heritage Program
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Labor
NYPA	New York Power Authority
NYSDOS	New York State Department of State
NYSDOT	New York State Department of Transportation
OPRHP	Office of Parks, Recreation, & Historic Preservation
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works
PRISM	Partnership for Regional Invasive Species Management
PWL	Priority Waterbodies List
REDI	Resiliency & Economic Development Initiative
SLELO	St. Lawrence-Eastern Lake Ontario
SLRWP	St. Lawrence River Watershed Project, Inc.
SO_2	Sulfur Dioxide
SRMT	St. Regis Mohawk Tribe
SPDES	State Pollution Discharge Elimination System
SUNY	State University of New York
SWCD	Soil and Water Conservation District

TMDL	Total Maximum Daily Load
USACOE	US Army Corp of Engineers
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFWS	US Fish & Wildlife Service
USGS	US Geological Survey
VOCs	Volatile Organic Carbons
WAC	Watershed Advisory Committee
WI	Waterbody Inventory
WRP	Watershed Revitalization Plan
WWTP	Wastewater Treatment Plant

1 Introduction

The St. Lawrence River watershed is the largest drainage basin in New York State, encompassing 5,600 square miles in northern New York (**Map 1**). In 2018, the St. Lawrence River Watershed Project (SLRWP) Inc. and the Franklin County Soil & Water Conservation District (FCSWCD) launched a watershed planning effort with funds from the New York State Department of State (NYSDOS) Local Waterfront Revitalization Program. This Watershed Characterization Report has been developed as a component of the St. Lawrence River Watershed Revitalization Plan (WRP), scheduled for completion in 2020.

The St. Lawrence River Watershed Revitalization Plan will address a series of questions:

1. *Where are we now?* That is, what is the current status of the natural, cultural, and political environment within the watershed? What are the assets, existing problems, and emerging threats and opportunities?
2. *Where are we going?* What processes and programs are in place that will affect the future of the watershed?
3. *Where do we want to be?* What is the community's vision for the future of the watershed? What desirable conditions or attributes of the watershed should be enhanced, and what undesirable conditions should be minimized or eliminated?
4. *How do we get there?* What strategic actions will enable the community to achieve the goals and vision? What specific practices and projects will help restore and protect the watershed and how can funds be leveraged?
5. *When will we get there?* When will the recommended projects be advanced, and how will the priority actions be decided?
6. *How do we measure progress?* What is the plan for tracking improvement and deciding what else needs to be done?

This Watershed Characterization Report documents current conditions and trends in the watershed, providing data and information needed to address the first two questions above. Water quality is linked to conditions throughout the watershed, including its landscape (geography, soils, hydrology, habitat, and climate), land use (settlement patterns, impervious surfaces, industry and agriculture centers, and waste management practices), and conditions that alter the natural state of the land. This characterization of the environmental conditions and human activities that affect the St. Lawrence River watershed will provide a basis for recommending long-term protection and restoration strategies for the watershed.

2 Overview of the Watershed

A watershed is the land that drains, or sheds, its water to a defined receiving water, such as a wetland, river, lake, coastal embayment, or ocean. The St. Lawrence River serves as the natural outlet for the Great Lakes to the Atlantic Ocean via the St. Lawrence River and Seaway. The St. Lawrence River ultimately receives runoff that originated across nearly 300,000 square miles; the watershed encompasses all the lands draining to the Great Lakes and flowing from Lake Ontario as well as the northern and western Adirondack Mountains. The river is part of the international boundary between the United States and Canada, and its shoreline abuts the Canadian provinces of Ontario and Quebec as well as northern New York.

The focus of this report is the portion of the St. Lawrence River watershed that lies within northern New York State. This study area encompasses 5,600 square miles within the state's borders and spans eight counties, including all of St. Lawrence County, most of Franklin County, much of northern Jefferson, Lewis, Herkimer, and Hamilton counties, and small areas of western Essex and Clinton Counties. In addition to 185 miles of St. Lawrence River shoreline, New York’s St. Lawrence River watershed includes 12,030 miles of freshwater rivers and streams.

Land cover in the basin is comprised of densely forested woodlands with large peatland complexes in the southern portion of the basin along the slopes of the Adirondack Mountains; and more flat, agricultural plains along the St. Lawrence at the northern side of the basin. Developed and industrial areas include Massena, Malone, Ogdensburg, Canton, Gouverneur, Clayton, and Alexandria Bay.

Much of the southern and eastern portions of the watershed lie within the Adirondack Park, designated by the blue dotted line in Map 1. The Adirondack Park Agency oversees this area to ”insure optimum overall conservation, protection, preservation, development and use of the unique scenic, aesthetic, wildlife, recreational, open space, historic, ecological and natural resources of the Adirondack Park” (APA Act, 2018).

2.1 Evolution and Current Configuration of the Basin

Melting ice, glacial debris, and changing glacial topography contributed to the formation of the St. Lawrence River basin. A quarter of a million years ago, a glacier advanced southward into the Adirondack region, creeping over hills and scraping up soil and rock from the land. Ice dams formed in river valleys due to the glacial debris, dotting the landscape with hundreds of lakes and ponds as the glacier began to melt and recede. Taking the path of least resistance, northwestern Adirondack waters drained into the St. Lawrence River, which developed approximately 10,000 years ago as a result of the rebounding continent from the Last Glacial Maximum, the Wisconsin Glaciation. The Wisconsin ice reached a thickness of more than 2 miles at its maximum extent. The glacier scoured the land depositing various thicknesses of till, significantly modifying the surface hydrology, slope, and terrain. During its final retreat, ice blocked the St. Lawrence valley causing water to flood the

Lake Ontario basin at its southeastern outlet creating Glacial Lake Iroquois, about 18 miles northeast of present-day Albany. As the 2 km of ice over the St. Lawrence Valley retreated, present day Lake Ontario drained into the St. Lawrence River on its course to the Atlantic Ocean. The eastern end of Lake Ontario and the St. Lawrence Valley continue their slow rebound (currently at a rate of 12 inches per century) from the weight of the massive ice sheet (Manninen and Gauthier, 1999). The gradual change in topography is altering the landscape and changing the slope of the river channel.

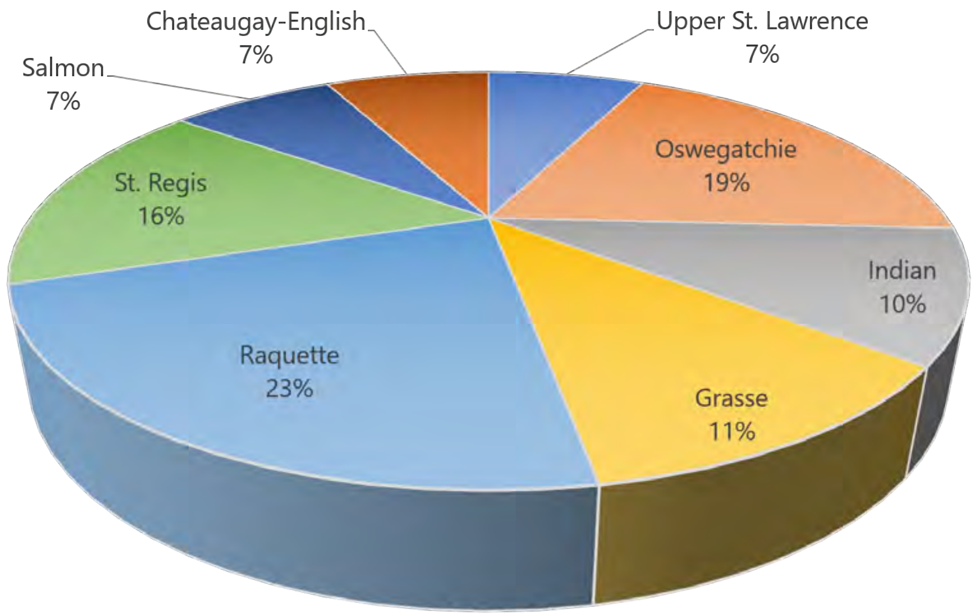
Today, New York's St. Lawrence River watershed extends from the northern and western slopes of the Adirondack Mountains at the southern end of the basin, to the plains along the St. Lawrence at the northern end of the basin. The river's headwaters are as far west as the northeast edge of Lake Ontario (cutting southeast between Watertown and Fort Drum) and as far east as Clinton and Essex Counties.

2.2 Subwatersheds

Watersheds are subdivided into smaller units that collectively contribute groundwater and surface water to larger watersheds or subbasins. Hydrologic units are used to create a baseline drainage boundary framework to account for all land and surface areas. Water basins in the United States are divided into hydrologic units identified by a unique hydrologic unit code (HUC) consisting of four to twelve digits based on six levels of classification: region (2-digit, HUC2), subregion (4-digit, or HUC4), accounting unit (6-digit, HUC6), cataloguing unit (8-digit, or HUC8), watershed (10-digit, or HUC10), and subwatershed (12-digit, or HUC12).

The St. Lawrence River is comprised of nine HUC8s, 43 HUC10 watersheds, and 180 HUC12 subwatersheds. In 2016, the US Geological Survey's (USGS) Watershed Boundary Dataset (WBD) retired the Upper St. Lawrence cataloguing unit (04150301) and subdivided it into the Headwaters St. Lawrence (04150309) and Raisin River-St. Lawrence River (04150310) (**Map 2**). However, much of the data cited and presented here was collected prior to this update and will be referenced as the Upper St. Lawrence subbasin (04150301). HUC8 codes were used to characterize and assess the areas within the St. Lawrence River watershed to better address the various environments, limitations, and needs of its respective area. **Figure 1** displays the percent of land area of the entire watershed contributed by each of the HUC8 watersheds. **Table 1** lists the HUC12 codes, waterbody names, and land areas, as well as the percent contribution of each HUC12 to their associated HUC8 subregion. Each individual HUC8 watershed and the contributing HUC12 subwatersheds are mapped. Progressing from east to west, **Map 3** displays the Upper St. Lawrence River; **Map 4** displays the Oswegatchie River; **Map 5** displays the Indian River; **Map 6** displays the Grasse River; **Map 7** displays the Raquette River; **Map 8** displays the St. Regis River; **Map 9** displays the Salmon River; and **Map 10** displays the Chateaugay-English River.

Figure 1
HUC8 Areas, St. Lawrence River Watershed



Source: 2011 CDL-NLCD Hybrid Land Cover dataset.

Table 1
Hydrologic Units and Area within the St. Lawrence River Watershed

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
Upper St. Lawrence (04150301)	041503010101	French Creek	28.1	7.2
	041503010102	Wheeler Creek-Frontal Saint Lawrence River	35.9	9.2
	041503010103	Mullet Creek	26.1	6.7
	041503010104	Cranberry Creek-Frontal Saint Lawrence River	35.2	9.0
	041503010105	Crooked Creek-Cranberry Creek-Frontal Saint Lawrence River	20.1	5.1
	041503010106	Chippewa Creek	38.6	9.9
	041503010107	City of Morristown-Frontal Saint Lawrence River	31.1	7.9
	041503010201	Tibbits Creek	17.7	4.5
	041503010202	Whitehouse Bay-Frontal Saint Lawrence River	29.0	7.4

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
	041503010203	Little Sucker Brook-Sucker Brook	46.2	11.8
	041503010204	Brandy Brook	36.3	9.3
	041503010205	Coles Creek-Frontal Saint Lawrence River	22.1	5.6
	041503010301	Dodge Creek-Frontal Saint Lawrence River	23.2	5.9
	041503010302	Raquette Creek-Frontal Saint Lawrence River	2.3	0.6
		SUBTOTAL- Upper St. Lawrence	**391.9**	
Oswegatchie (04150302)	041503020101	Robinson River-Oswegatchie River	48.3	4.6
	041503020102	Buck Brook-Oswegatchie River	26.5	2.5
	041503020103	Cranberry Lake-Oswegatchie River	67.6	6.4
	041503020201	Tamarack Creek	14.5	1.4
	041503020202	Upper Little River	31.9	3.0
	041503020203	Lower Little River	27.5	2.6
	041503020301	Sand Lake Outlet-Middle Branch Oswegatchie River	26.2	2.5
	041503020302	Wolf Creek-Middle Branch Oswegatchie River	48.7	4.6
	041503020303	Fish Creek	17.4	1.7
	041503020304	Browns Creek-Middle Branch Oswegatchie River	23.3	2.2
	041503020401	Headwaters West Branch Oswegatchie River	25.8	2.5
	041503020402	Blanchard Creek-West Branch Oswegatchie River	41.2	3.9
	041503020501	Jenny Creek	17.2	1.6
	041503020502	Big Creek	35.3	3.4
	041503020503	Meadow Brook-West Branch Oswegatchie River	21.2	2.0
	041503020504	West Branch Oswegatchie River	37.5	3.6
	041503020601	Peavine Creek-Oswegatchie River	46.7	4.5
	041503020602	Stammer Creek	21.5	2.0
	041503020603	Welch Creek-Oswegatchie River	30.5	2.9
	041503020604	Pork Creek-Oswegatchie River	16.2	1.5
	041503020701	Sawyer Creek	31.5	3.0
	041503020702	Hawkins Creek-Matoon Creek	32.3	3.1
	041503020801	Turnpike Creek-Oswegatchie River	29.0	2.8

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
	041503020802	Malterna Creek-Oswegatchie River	33.7	3.2
	041503020803	Boland Creek	33.9	3.2
	041503020804	Vrooman Creek-Oswegatchie River	45.0	4.3
	041503020901	Anderson Creek-Oswegatchie River	31.1	3.0
	041503020902	Indian Creek	38.6	3.7
	041503020903	Beaver Creek	47.3	4.5
	041503020904	Barter Creek-Oswegatchie River	29.8	2.8
	041503021001	Town of Flackville-Lisbon Creek	23.9	2.3
	041503021002	Village of Heuvelton-Oswegatchie River	17.9	1.7
	041503021003	Oswegatchie River	30.8	2.9
		SUBTOTAL- Oswegatchie	**1050.1**	
Indian (04150303)	041503030101	Weatherhead Creek-Indian River	37.9	6.7
	041503030102	Bonaparte Creek	23.0	4.1
	041503030103	Blanchard Creek-Indian River	34.0	6.0
	041503030201	Rockwell Creek-Indian River	51.3	9.1
	041503030202	West Branch Black Creek	23.4	4.2
	041503030203	Buck Creek-Black Creek	22.8	4.1
	041503030204	Beaver Meadows Creek-Black Creek	16.1	2.9
	041503030205	Hunter Creek-Indian River	21.6	3.8
	041503030301	West Creek	31.8	5.7
	041503030302	Otter Creek	24.4	4.3
	041503030303	Trout Brook-Indian River	28.9	5.1
	041503030401	Soapstone Creek-Indian River	19.7	3.5
	041503030402	Muskellunge Lake-Indian River	23.9	4.2
	041503030403	Bostwick Creek-Indian River	30.9	5.5
	041503030501	Jewett Creek	19.1	3.4
	041503030502	Butterfield Lake-Black Creek	17.9	3.2
	041503030503	Birch Creek	24.8	4.4
	041503030504	Fish Creek	36.1	6.4
	041503030505	Black Creek-Black Lake	74.9	13.3
		SUBTOTAL-Indian	**562.5**	
Grasse (04150304)	041503040101	Dead Creek	24.4	3.9
	041503040102	Massawepie Lake-South Branch Grasse River	52.7	8.3

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
	041503040201	Pleasant Lake Stream-Middle Branch Grasse River	31.9	5.0
	041503040202	South Branch Grasse River	62.6	9.9
	041503040203	North Branch Grasse River	61.2	9.7
	041503040204	Deerskin Creek-Middle Branch Grasse River	40.3	6.4
	041503040301	Grannis Brook	35.3	5.6
	041503040302	Van Rensselaer Creek-Little River	46.7	7.4
	041503040303	Tracy Brook-Little River	17.7	2.8
	041503040401	Tanner Creek	38.1	6.0
	041503040402	Elm Creek	41.1	6.5
	041503040403	Plumb Brook-Grasse River	60.9	9.6
	041503040404	Nettle Creek	16.4	2.6
	041503040405	Line Creek	17.6	2.8
	041503040406	Harrison Creek-Grasse River	29.1	4.6
	041503040501	Town of Madrid-Grasse River	27.8	4.4
	041503040502	McConnell Creek-Grasse River	29.2	4.6
		SUBTOTAL-Grasse	**633.0**	
Raquette (04150305)	041503050101	South Inlet	32.6	2.6
	041503050102	Marion River	33.3	2.6
	041503050103	Raquette Lake	61.8	4.9
	041503050104	Moose Pond	26.5	2.1
	041503050105	Forked Lake-Raquette River	37.6	3.0
	041503050201	Upper Cold River	40.2	3.2
	041503050202	Ermine Brook-Moose Creek	15.3	1.2
	041503050203	Lower Cold River	30.1	2.4
	041503050301	Salmon River	21.8	1.7
	041503050302	Big Brook	40.4	3.2
	041503050303	Raquette River-Long Lake	53.6	4.3
	041503050401	Moose Creek	19.0	1.5
	041503050402	Stony Creek	31.5	2.5
	041503050403	Palmer Brook-Raquette River	17.6	1.4
	041503050404	Follensby Pond-Raquette River	38.3	3.0
	041503050405	Bog Stream	19.9	1.6
	041503050406	Round Lake Stream	56.1	4.5
	041503050407	Bog River	56.9	4.5

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
	041503050408	Wolf Pond	20.6	1.6
	041503050409	Jenkins Brook-Tupper Lake	58.5	4.6
	041503050501	Dead Creek	22.1	1.8
	041503050502	Mountain Brook-Raquette River	35.1	2.8
	041503050503	Willis Brook-Jordan River	19.9	1.6
	041503050504	Potter Brook-Jordan River	28.0	2.2
	041503050505	Ellis Brook-Raquette River	33.8	2.7
	041503050506	Joe Indian Inlet	21.3	1.7
	041503050507	Cold Brook-Raquette River	33.7	2.7
	041503050601	Cold Brook	20.2	1.6
	041503050602	Dead Creek-Raquette River	37.3	3.0
	041503050603	Parkhurst Brook	17.3	1.4
	041503050604	Stafford Brook-Raquette River	47.1	3.7
	041503050701	Upper Trout Brook	30.0	2.4
	041503050702	Lower Trout Brook	36.8	2.9
	041503050703	Village of Potsdam-Raquette River	34.4	2.7
	041503050704	Plum Brook	43.3	3.4
	041503050705	Squeak Brook	38.1	3.0
	041503050706	Hutchins Creek-Raquette River	49.8	4.0
		SUBTOTAL-Raquette	**1259.6**	
St. Regis (04150306)	041503060101	Hays Brook	16.1	1.9
	041503060102	Osgood River	28.2	3.3
	041503060103	Pleasant Brook-East Branch Saint Regis River	55.7	6.5
	041503060201	Windfall Brook-West Branch Saint Regis River	52.7	6.1
	041503060202	Long Pond Outlet	42.7	5.0
	041503060203	Black Brook-West Branch Saint Regis River	24.3	2.8
	041503060204	Stony Brook	26.4	3.1
	041503060205	Alder Meadow Brook-West Branch Saint Regis River	53.5	6.2
	041503060206	Dan Wright Brook-Trout Brook	43.9	5.1
	041503060207	Tucker Brook-West Branch Saint Regis River	26.2	3.0
	041503060301	Mile Brook-Deer River	37.1	4.3
	041503060302	Trout Brook	37.3	4.3

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
	041503060303	Kingston Brook-Deer River	58.3	6.8
	041503060304	Lawrence Brook	35.2	4.1
	041503060305	Redwater Brook-Deer River	29.0	3.4
	041503060401	Headwaters Saint Regis River	35.0	4.1
	041503060402	Quebec Brook-Saint Regis River	32.8	3.8
	041503060403	Goose Pond Brook-Saint Regis River	55.1	6.4
	041503060404	Lake Ozonia Outlet	29.0	3.4
	041503060405	Long Pond-Saint Regis River	19.8	2.3
	041503060406	Hopkinton Brook	20.5	2.4
	041503060407	Miller Brook-Saint Regis River	38.1	4.4
	041503060408	Bell Brook-Saint Regis River	30.6	3.5
	041503060409	Town of Hogansburg-Saint Regis River	35.5	4.1
		SUBTOTAL-St. Regis	**863.2**	
Salmon (04150307)	041503070101	Hatch Brook	39.9	9.8
	041503070102	Ingraham Stream-Salmon River	62.4	15.4
	041503070103	Duane Stream	21.9	5.4
	041503070104	Winslow Brook-Salmon River	36.2	8.9
	041503070201	Headwaters Little Salmon River	15.4	3.8
	041503070202	East Branch Little Salmon River	16.6	4.1
	041503070203	Develin Brook-Little Salmon River	24.1	5.9
	041503070204	Farrington Brook	24.0	5.9
	041503070205	Town of Bombay-Little Salmon River	20.2	5.0
	041503070301	Branch Brook	19.1	4.7
	041503070302	Plum Brook-Salmon River	30.3	7.5
	041503070303	East Branch Deer Creek	24.7	6.1
	041503070304	West Branch Deer Creek	33.4	8.2
	041503070305	Pike Creek	28.0	6.9
	041503070306	Town of Fort Covington-Salmon River	9.4	2.3
		SUBTOTAL-Salmon	**405.6**	
Chateaugay-English (04150308)	041503080101	Middle Kiln Brook	30.1	7.3
	041503080102	Separator Brook	15.0	3.6
	041503080103	Mountain Pond Stream-Upper Chateaugay Lake	36.1	8.8
	041503080104	Bailey Brook-Chateaugay River	37.2	9.0
	041503080201	Marble River	33.3	8.1

HUC8	HUC12	Name HUC12 Watershed	Area (square miles)	% of HUC8
	041503080202	Hinchinbrook Brook	19.9	4.8
	041503080203	Collins Brook	8.3	2.0
	041503080204	Allen Brook-Chateaugay River	15.4	3.7
	041503080205	Beaver Pond Brook-Chateaugay River	19.2	4.7
	041503080301	Collins Brook-Trout River	57.6	14.0
	041503080302	Little Trout River	40.0	9.7
	041503080303	Briggs Creek	14.7	3.6
	041503080304	Town of Trout River-Trout River	8.9	2.2
	041503080401	Crystal Creek	14.5	3.5
	041503080402	Taylor Brook-English River	26.8	6.5
	041503080403	Allen Brook	5.5	1.3
	041503080404	Kellas Creek-English River	9.9	2.4
	041503080406	Ruisseau Norton	2.7	0.7
	041503080501	Ruisseau Noir	11.2	2.7
	041503080502	Riviere aux Outardes Est	3.2	0.8
	041503080503	Riviere aux Outardes	2.0	0.5
		SUBTOTAL- Chateaugay-English	**411.6**	
		GRAND TOTAL- St. Lawrence River Watershed Study Area	**5,577.7**	

SOURCE: 2011 CDL-NLCD Hybrid Land Cover dataset.

2.3 Settlement and Development in the Watershed

The St. Lawrence River basin is home to the Mohawks of the Iroquois Confederation, who call the river *Kaniatarowanenneh*, meaning "big waterway." Original Mohawk territory extended from Schoharie Creek upriver to East Canada Creek. Today, the St. Regis Mohawk Reservation at Akwesasne covers 19,000 acres on the southern side of US-Canada border in Franklin and St. Lawrence Counties at the confluence of the St. Regis, St. Lawrence, and Raquette rivers. Their territory extends from Massena to Malone and across the St. Lawrence River from Cornwall, Ontario. As of 2016, there are approximately 15,900 members in the Saint Regis Mohawk Tribe (SRMT) (Saint Regis Mohawk Tribe, 2016). The SRMT is the only Mohawk community officially recognized by the United States; the Tribe administers its own environmental, social, policing, economic, health, and educational programs, policies, laws, and regulations. Today, Mohawk people have integrated historical culture, practices, and knowledge from centuries-old ways of living into their everyday lives. Traditional ecological knowledge, a term to describe Indigenous knowledge that has been passed down through generations to explain their place in the natural world, is important to the development and understanding of SRMT environmental management. Due to the Tribe's historical reliance on natural resources, it is imperative that the environment remains healthy and safe for continued cultural practices. This knowledge and appreciation for the St. Lawrence River and its connecting water systems is an important element in local and regional management decisions.

The St. Lawrence River valley became a popular settlement location driven by its access to Lake Ontario and its tributaries which provided fishing and hunting opportunities, as well as efficient travel for trade, diplomatic, and military purposes. Settlers of European descent began to flock to upstate New York after the War of 1812, drawn by the "curative" properties of sulfur mineral springs located on the Raquette River, which became the basis of the local economy. During the late 19th century, the Irish and French Canadians built settlements southeast of Massena and along the Franklin and St. Lawrence County border, respectively. Wealth in this region was primarily derived from mining, farming, and logging. Lead, iron, tremolite, zinc, feldspar, talc, and marble were mined from the land, leaving disturbed ground cover, open pits, and ruins. Today, marble, zinc, and tremolite mining is still integral to the towns of Fowler, Pierrepont, and Ogdensburg.

In 1902, the Massena Power Canal was constructed, allowing for an abundant hydroelectric energy supply in the area, which in turn drew more industry to the region (e.g., Pittsburgh Reduction Company, an aluminum producer). In the late 1950s, FDR's Power Project brought additional low-cost electricity to the area followed by new industries in Massena, such as Reynolds Metals Company and General Motors.

The St. Lawrence Seaway opened in April 1959, allowing transatlantic trade and access for ocean vessels as well as commercial and recreational boaters to the Great Lakes. The Seaway System has been integral not only to local economies but to the US economy as a whole, generating more than $4.3 billion in personal income, $3.4 billion in transportation-related business revenue, and $1.3 billion in federal, state, and local taxes (IJC 2014). In addition to commercial goods, dominant commodities shipped along the St. Lawrence Seaway include iron ore for the steel industry, coal for power generation, and limestone for construction and steel industries.

The waters of the St. Lawrence River watershed have various designated use dependent on their water quality. Some waters are used as a source of drinking water, while others are primarily for recreation and aquatic life. The watershed's mix of abundant surface water, rugged peaks, rolling hills, expansive wetlands, and flat plains makes it a major destination for scenic viewing, hiking, fishing, kayaking, boating, snowmobiling and other recreational pursuits. Fifty percent of lakes have been identified as having poor water quality (NYSDEC 2016a). This is in part due to atmospheric deposition of pollutants (acid and mercury) originating outside the basin. In addition, the growth of agriculture and industry in the region since the 19th century has also had a lasting adverse impact on water quality in the watershed. In the late 1900s and early 2000s, The Great Lakes Area of Concern at Massena/Akwesasne and Superfund sites were established at Grasse River in Massena, NY (Alcoa, Inc.), the St. Lawrence River in Massena, NY (General Motors), and at Sealand Restoration, Inc. (disposal facility) in Lisbon, NY, where industrial activity had contaminated sediments and groundwater with polychlorinated biphenyls (PCBs), volatile organic carbons (VOCs), and polycyclic aromatic hydrocarbons (PAHs). Owners of the facilities have taken responsibility for the contamination and are collaborating with Federal and State organizations to remediate legacy pollutants and restore impaired habitats.

Today, citizens of the St. Lawrence River watershed are proactively working toward reducing pollution and revitalizing their community by partnering with organizations and agencies to protect and restore valuable water resources. Taking action to improve and protect water quality will allow communities and economies to thrive and enjoy a sustainable future for years to come.

2.4 Existing Plans and Initiatives Related to Water Resources in the Study Area

Appendix A provides an overview of the institutional framework for local laws, programs, and practices affecting water quality in the watershed, as well as an assessment of the ability of local laws and programs to implement best management practices that would protect water quality.

Several federal and state regulatory and advisory programs are already in place to advance watershed planning within the St. Lawrence River watershed. Examples include:

- Great Lakes Focus
  - Lake Ontario Lakewide Action and Management Plan (2018-2022)
  - Great Lakes St. Lawrence Seaway Study (2007)
  - New York's Great Lakes Basin: Interim Action Agenda (Ongoing effort)
  - Great Lakes Water Quality Agreement (1972, 1983, 1987, 2012)
  - Great Lakes Restoration Initiative (2010) and Action Plans (2010, 2014, 2019)
  - Healthy Fishing Communities Project: Great Lakes Biomonitoring
  - Resiliency & Economic Development Initiative (2019)
- NY Statewide Plans of Interest
  - New York State Riparian Opportunity Assessment (January 2018)
  - New York State Invasive Species Comprehensive Management Plan (Nov 2018)
  - New York State Wildlife Action Plan (September 2015)
  - New York State Hazard Mitigation Plan (2018)
- IJC Climate-Related Plans and Guidance
  - Lake Ontario – St. Lawrence River Plan (2014)
  - Climate Change Guidance Framework for IJC Boards, A Highlights Report (2018)
- Akwesasne Climate Change Adaptation Plan (2013)
- Subwatershed Research
  - Watershed Protection of the St. Lawrence – Raquette River Watershed with Special Consideration to Large Wetlands and Large Landownership; Part One: The St. Regis River Basin

- St. Regis Chain Limnology and Water Quality Report (2017)
- Blue Mountain Lake Watershed Monitoring Program (2016)
- Salmon River Watershed Management Plan, Phase I (2016)
- Adirondack Lake Assessment Program (ALAP)

- Local Watershed Plans and Initiatives
  - Town and Village of Alexandria Bay LWRP (Draft, 2019)
  - Town of Cape Vincent (1988, Update in Progress)
  - Town and Village of Clayton (July 2013)
  - Town of Essex (2003)
  - Town and Village of Malone (2012)
  - Town and Village of Morristown LWRP (1991)
  - City of Ogdensburg LWRP (1987)
  - Town and Village of Waddington LWRP (1991)
  - Canton-Grasse River Waterfront Revitalization Plan (March 2018)
  - Tupper Lake Local Waterfront Revitalization Strategy
  - Tupper Lake LWRP (In Progress)
  - Grasse River Blueway Trail Plan (Draft, 2018)
  - Town of Indian Lake – Waterfront Access Strategy (Awarded 2018)
  - Massena Brownfield Opportunity Area Revitalization Plan (2017)
  - Village of Massena Local Waterfront Revitalization Plan (In Progress)
- Adirondack Forest Preserve Unit Management Plans
  - St. Lawrence Foothills (2015)
  - Cranberry Lake Wild Forest (1984)
  - Debar Mountain Wild Forest (2017)

The monitoring programs and watershed management plans provide key data and insights to inform the analysis of water quality and the environmental setting. The local watershed management plans, although specific to their locality, also address similar critical issues facing the St. Lawrence River watershed.

In response to an extended pattern of flooding along the shores of Lake Ontario and the St. Lawrence River, in 2019 Governor Andrew Cuomo commissioned the Resiliency & Economic Development Initiative (REDI) to address the immediate and long-term resiliency needs of these areas while also enhancing economic development opportunities and health of the lake. This multiagency task force is charged with developing a plan to harden infrastructure in flood prone regions along Lake Ontario's waterfront while strengthening the region's local economies, which are heavily dependent on summer tourism. The Commission pledged $300 million toward projects.

The REDI region encompassed eight counties along shorelines of Lake Ontario and the St. Lawrence River including Jefferson and St. Lawrence counties. Most of the river's shoreline lies within these two counties. While each region has a unique strategic plan and set of goals, there are common themes that relate directly to the priorities and approach of the watershed planning process currently underway:

- commitment to a regional approach to identifying challenges and finding solutions;
- recognition of the need to invest in infrastructure;
- an embrace of smart growth concepts;
- reclamation of waterfront assets for community and economic development;
- recognition of the need to strengthen the effectiveness of government and civic institutions in order to improve the quality of life for all.

In October 2019, Governor Cuomo announced that St. Lawrence and Jefferson Counties would be allotted $50 million for 38 projects to advance REDI. The REDI Commission allocated $20 million for homeowner assistance, $30 million to improve the resiliency of businesses, and $15 million toward a regional dredging effort to maintain navigation channels in harbors and bays along Lake Ontario and the St. Lawrence River. The remaining balance of $235 million was allocated across the other six shoreline counties within the REDI region (Oswego, Cayuga, Wayne, Monroe, Niagara, and Orleans) towards local and regional projects that target at-risk assets such as critical water and wastewater infrastructure, public health and safety, and marinas and harbors. Selected projects emphasize incorporating nature-based features and green infrastructure. Projects selected by the REDI commission can be found at https://www.ny.gov/lake-ontario-flooding/regional-projects-selected-redi-commission#jefferson-and-st-lawrence-counties.

3 Environmental Setting

3.1 Water Resources

Water resources within the St. Lawrence River watershed support multiple human uses, including recreation, shipping, transportation, infrastructure, tourism, agriculture, and hydroelectric power generation. In addition, the watershed supports many critical ecosystem functions including habitat, carbon sequestration, and moderating the hydrologic cycle.

Fishing in Franklin County
Photo source: saratogaphotographer.com

3.1.1 Surface Water

Nineteen percent (19%) of the area in New York's St. Lawrence River watershed is surface water (**Map 11**). In addition to 185 miles of St. Lawrence River shoreline, this includes 12,030 miles of freshwater rivers and streams. Major tributaries include the Oswegatchie River (3,590 miles), Raquette River (2,016 miles), St. Regis River (1,734), Grasse River (1,607 miles), and Indian River (1,222 miles), which drain the northwestern Adirondack Mountains and together comprise 89% of total stream and river miles in the watershed. There are 376 significant freshwater lakes, ponds, and reservoirs covering 104,125 acres, the largest being Black Lake (7,754 acres), Cranberry Lake (6,795 acres), Raquette Lake (5,194 acres), Tupper Lake (4,858 acres), and Long Lake (4,094 acres), which together account for 33% of lake acres in the watershed.

Many of the streams originate as cold headwaters in the hills of the northern Adirondack region (Oswegatchie and Raquette Rivers) and flow to the St. Lawrence River across broad flat plains of lacustrine sands, clays, and peat deposits. Waterfalls and rapids are typical features of the major tributaries as these rivers pass through the mountains along steep gradients. In many places, the potential energy of the water flow is captured by operation of hydroelectric dams.

Fifty percent of lakes in the watershed are assessed as having poor water quality (NYSDEC 2016a), 18% as good or satisfactory, and 32% lack sufficient data for assessment (NYSDEC 2018). Of the river miles, 60% remain largely unassessed; of those rivers that have been assessed, 36% are classified as exhibiting good or satisfactory water quality and 5% as exhibiting poor water quality. Details of existing water quality conditions are presented in Section 5.

3.1.2 Groundwater

The water stored underground in the cracks and spaces in soil, sand, and rock constitutes a large unseen reservoir of water. In addition to human use, groundwater helps maintain flows in streams and wetlands during dry periods, supporting significant ecosystem functions. The Chateaugay Transboundary Aquifer, a semi-confined aquifer, is located along the St. Lawrence Lowlands and the Adirondack Mountains. This system is composed mainly of a sedimentary rock overlain by till and clay. Aquifer recharge occurs primarily in a north-northeast direction with a storage capacity of 37.5 km^3 in the U.S. and 1,250 km^3 in Canada.

Groundwater is an important source of drinking water, especially for the rural populations typical of the St. Lawrence River Basin. Primary aquifers are illustrated in **Map 11**. The 305(b) Ambient Groundwater Quality Monitoring project is an ongoing cooperation between USGS and NYSDEC DOW to characterize naturally occurring, or background, conditions, and identify long-term trends in groundwater quality. Two or three of the 14 major hydrologic basins of NYS are evaluated each year. The St. Lawrence River Basin was most recently evaluated in 2010 and 2015 (Nystrom, 2012; Scott, Nystrom, & Reddy, 2019).

Recent results indicate that groundwater in the St. Lawrence River Basin is generally of good quality, although some constituents sometimes approached or exceeded primary, secondary, or proposed drinking-water standards. Groundwater is typically hard and neutral to slightly basic. Bicarbonate, sulfate, and calcium are the major ions and exhibit the highest median concentrations; the dominant nutrient is nitrate. Trace elements strontium, iron, barium, and boron are present at the highest median concentrations. Radon-222 was detected in concentrations exceeding drinking-water standards in 14 of 21 samples (Scott, Nystrom, & Reddy, 2019), samples with the greatest radon activities originated from bedrock wells. Five of twenty samples exceeded NYS drinking-water standards for bacteria (Nystrom, 2012). Trace levels of six herbicides and one pesticide were detected in over 50% of sampled wells (Nystrom, 2012).

3.1.3 Wetlands

Wetlands are sensitive, productive ecosystems that provide important ecosystem functions including flood storage, filtration, and shoreline erosion protection as well as providing habitat for fish and wildlife. Hydrology varies seasonally and episodically in wetlands due to periodic inundation and saturation of soils. These unique areas support distinctive vegetation adapted to absorb the forces of flooding and erosion. Freshwater Wetlands are protected under Article 24 of the Environmental Conservation Law of NYS. NYSDEC maps and regulates all freshwater wetlands greater than 12.4 acres and requires permits for certain activities within 100 ft of their boundary.

Indian Creek Nature Center, Rensselaer Falls. Photo Source: https://indiancreeknaturecenter.us/

Wetlands are delineated in **Map 12**. The St. Regis watershed has 84,000 acres classified as wetlands representing15% of the total land area. Other areas with significant wetlands include the Oswegatchie (81,000 acres, 12%), and the Raquette (71,000 acres, 9%). Wetlands are threatened by encroachment for residential use, pollution, eutrophication, and alterations in hydrology that can convert them to uplands. Water level management and its effects on wetland soil characteristics plays an important role in contaminant bioavailability and transport. A recent study by Brahmstedt *et al.* (2019) suggests that new water level management plans of the Great Lakes-St. Lawrence River could result in greater transformation and bioavailability of methylmercury in wetland soils of the Upper St. Lawrence River watershed.

3.1.4 Precipitation Patterns and Flooding

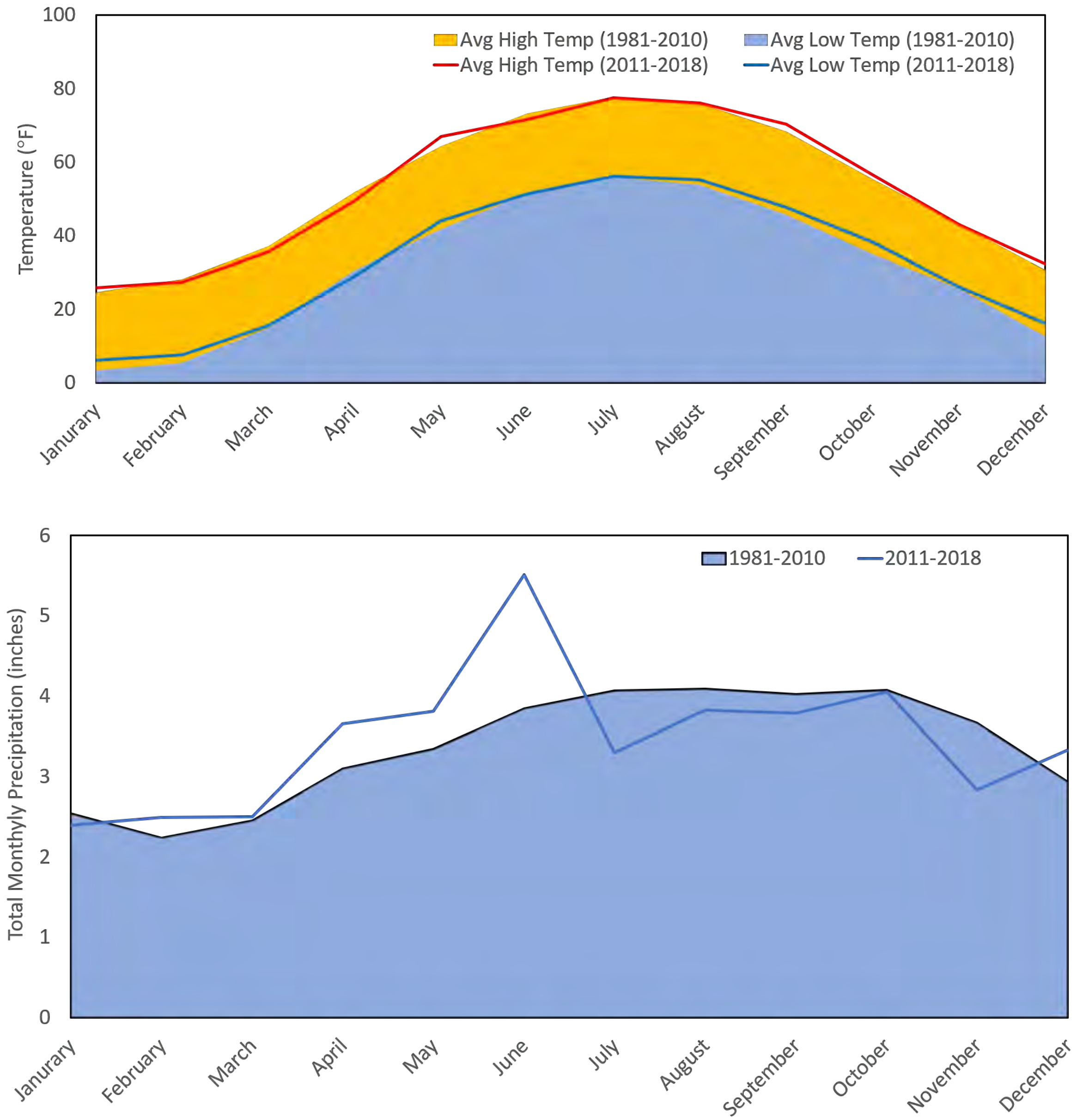
The St. Lawrence River watershed is characterized by long, frigid winters and short, relatively cool summers. Precipitation averages around 35 inches per year in the valley and lowlands and around 45 inches per year in the uplands (National Climatic Data Center, data from 1981-2010, Arguez *et al.*, 2010) (**Map 13**), largely dependent on elevation (**Map 14**). This rate is among the highest annual precipitation rates in New York State. The most precipitation occurs at the southeastern edges of the Raquette subbasin and southern edge of the Oswegatchie subbasin, with the lowest precipitation rates concentrated on areas adjacent to the St. Lawrence River. At the subwatershed level, the mean annual precipitation varies from a low of 37.6 inches in the Upper St. Lawrence to 43.9 inches in the Raquette (US EPA, Average Annual Precipitation 1981–2010). The National Oceanic and Atmospheric Administration (NOAA) calculates climate 'normals' by averaging over a recent 30-year period. The most recent averages are reported for the period from 1981-2010. NOAA operates seven climate monitoring stations throughout NY portion of the St. Lawrence watershed to continuously measure temperature and precipitation. Annual and seasonal normals collected by these stations are listed in **Table 2**. The watershed has a fairly consistent distribution of precipitation throughout the year, although most areas experience slightly higher precipitation rates (approximately 3.5–4.5 inches/month) in autumn and lower rates in the winter (approximately 2–3 inches/month) according to NOAA climatic normals from 1981–2010 (Arguez *et al*. 2010). Snowfall averages increase with elevation; highlands see upward of 100 inches of snowfall annually. It is typical for snowpack to persist in the Adirondacks well into March. The additional snowpack can be rapidly melted by warm spring rains, contributing to the potential for flooding and episodes of significant runoff.

Table 2
Climate Normals, 1981-2010

Climate Monitoring Station	Elevation	Average Temperature (°F)		Precipitation (inches)	
		Winter	Summer	Annual Average	Annual Average Snowfall
Wanakena Ranger School	460.2	19.8	66	44.18	114.2
Malone, NY	268.2	17.2	65.4	38.86	95.3
Canton 4SE, NY	136.6	19.4	66.6	37.34	79.6
Colton 2 N, NY	176.8			42.45	
Gouverneur 3 NW, NY	128	18.2	65.6	37.61	85.2
Tupper Lake Sunmount, NY	512.1	17.1	63.2	44.82	
Massena International Airport, NY	65.2	18.1	66.6	34.96	69.4

SOURCE: Annual/Seasonal Normals, 1981-2010, NOAA Climatic Data

Figure 2
Climate Patterns, Past and Present



Source: Annual/Seasonal Normals, 1981-2010, NOAA Climatic Data; U.S. Climate Data, 2011-2018, usclimatedata.com
Note: Data averaged from Malone, Tupper Lake, and Gouverneur NOAA climatic stations based on available monthly data.

Figure 2 compares monthly temperature and precipitation averages from monthly averages from years 1981-2010 (filled in area) and 2011-2018 (lines). The most recent years following the last 30-year climate normal assessments (1981-2010) have similar temperature patterns, with little variation in average high and low monthly temperatures. In contrast, precipitation differences between 1981-2010 and 2011-2018 precipitation totals are evident; most notably in increased rainfall during spring and early summer. The 4th National Climate Assessment projects that precipitation in the Northeast will increase 5-20%, with much of that increased precipitation delivered through heavy rain events. In addition, the frequency, intensity, and duration of heat waves is expected to increase making the northeast more susceptible to drought (Melillo *et al.*, 2014).

The uptick in spring precipitation and resultant snowmelt has affected flooding within the St. Lawrence River watershed, which has become more devastating in recent years. Flooding occurs when intense or continuous rainfall exceeds the soil's absorptive capacity and channel capacity of local rivers and streams. Flooding along the St. Lawrence River is difficult to address as the Great Lakes-St. Lawrence Watershed receives inflow from a vast area that includes multiple jurisdictions and encompasses transboundary waters (**Figure 3**). Flooding and water-level management are discussed further in **Section 7.2**.

Figure 3
Great Lakes-St. Lawrence Watershed

Source: IJC, International Lake Ontario-St. Lawrence River Board (2019), https://ijc.org/en/loslrb.

Floodplains are mapped as low elevation areas adjacent to streams, rivers, and lakes that are prone to periodic flooding. In natural areas, floodplains typically support diverse a diverse assemblage of upland and wetland biota and provide groundwater recharge. Flood Insurance Rate Maps were sourced from the Federal Emergency Management Agency (FEMA) to determine the locations of floodplains within the watershed (**Map 15**). However, floodplain maps are not available across much of the St. Lawrence River watershed. Other factors such as slopes, soil types, and hydrologic characteristics must be used to delineate areas at risk of flooding.

3.2 Topography and Geology

In general, topography can be described as mountainous terrain in the southwestern area with lowland, agricultural plains lying inland from the St. Lawrence River within the eastern and northern region of the watershed. Defining ridgelines of the western Adirondack mountains have the highest elevation, exceeding 4,000 ft above mean sea level, with the highest elevations found along the southeastern edge of the basin the Adirondacks. The lowest elevations are found in the northern St. Lawrence River valley.

The surficial material throughout the basin was deposited during the Last Glacial Maximum, approximately 26,500 years ago (**Map 16).** Till and kame deposits within the Adirondack region is sand-rich and of metamorphic origin. It has poorly sorted, variable texture, from boulders to silt; permeability varies with thickness and compaction of the material due to deposition from a melting ice sheet. The Upper St. Lawrence, Indian, and western portion of the Oswegatchie subbasins are dominated by lacustrine silt and clay deposits that are generally calcareous and of low permeability. Surficial deposits within the northern central and western areas of the watershed primarily consist of till, marine and lacustrine silt and clay, and sands; these materials are generally of intermediate permeability.

Bedrock geology of the St. Lawrence River watershed predominantly consists of carbonate, sandstone, crystalline and metamorphosed rocks (**Map 17)**. A large band of carbonates extends from the west to east along the St. Lawrence River shoreline adjacent to a thinner band of sandstone. The plains of the Upper St. Lawrence, Indian, and Oswegatchie subbasins are a conglomerate of glacial/alluvial deposits, carbonates, crystalline and sandstone. Crystalline rocks are the most dominant bedrock within the Adirondack region with some glacial deposits, metamorphosed clastic and crystalline, and shale and carbonate bedrock spreading throughout the range.

3.3 Soils

Soils are involved in many critical functions affecting the environment and water quality; they provide habitat to plants, animals, fungi, and microbes that contribute to nutrient and carbon cycling, filter water seeping into aquifers, and moderate the supply of essential nutrients for agricultural production. Soils differ spatially based on parent material, climate, organisms present, topography, and age. Chemical, physical, and biological properties of soil directly affect contaminant fate and transport as well as erosion potential; these factors have a major influence on water quality.

The Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic soil groups (A, B, C, D) based on the soil's runoff potential. Runoff potential generally increases from Group A to D. Group A soils are typically sand, loamy sand, or sandy loam soils with high infiltration rates. Group B soils are usually silt loam or loam soils with a fine to moderately coarse texture; these soils exhibit a moderate infiltration rate when thoroughly wetted. Sandy clay loams are representative of Group C soils, which have a low infiltration rate and a moderately fine to fine structure. Group D soils are typically clay loam, silty clay loam, sandy clay, silty clay, or clay having a high runoff potential and very low infiltration rates due to high swelling potential. The hydrologic soil groups throughout the basin are shown in **Map 18**.

The western areas of the watershed along the St. Lawrence River, including the Upper St. Lawrence, Indian, and Oswegatchie subbasins, are dominated by Groups C and D soils with high runoff potential and low infiltration rates. Land areas dominated by these soil types are at greater risk of flooding. Other Group C and D soils lie along the St. Lawrence River across the northern portions of the Raisin, Raquette, St. Regis, and Salmon River subbasins. The mountainous regions within the mid-southern area of the watershed are characterized by more variable hydrologic soil classes likely due to changing topography and abundant water resources in this area.

The potential for soil erosion by runoff and raindrop impact is measured by the soil erodibility k-factor. The NRCS developed this factor to estimate soil losses based on a soil's physical and chemical characteristics; values range from 0.02-0.69. A higher k-value represents greater susceptibility of the soil to rill and sheet erosion by rainfall. Typically, soils with higher permeability are less susceptible to erosion and are classified with a lower k-value. The erosion potential for the St. Lawrence River watershed is shown in **Map 19**, with erosion potential increasing as colors darken to deeper red. The watershed has an average k-factor of 0.29 with the highest average k-factor of the subbasins in the Upper St. Lawrence. However, areas with the highest k-factor locally lie within the mountainous areas of the Adirondack State Park with steep slopes and high annual precipitation.

3.4 Habitat

Habitat condition is directly affected to landscape position, vegetative cover, and land use, as well as hydrologic and biogeochemical processes. The St. Lawrence River watershed is within the most rural area of New York State. The diverse vegetation, unique geology, and numerous waterbodies within the St. Lawrence River watershed provide habitat to terrestrial, wetland, and aquatic assemblages. The landcover map, **Map 20**, illustrates the diversity of habitats throughout the watershed. A habitat condition index was developed by the National Fish Habitat Partnership (NFHP, 2015 National Assessment) to score habitats on their likelihood of aquatic habitat degradation with a score range of 1 for high likelihood of aquatic habitat degradation, to 5 for low likelihood of aquatic habitat degradation. This score is dependent on land use, population density, roads, dams, mines, and point-source pollution sites. The habitat condition index for the entire watershed was calculated as 4.4, suggesting that there is a low likelihood of aquatic habitat degradation.

The St. Lawrence River is home to a wide variety of warm water fish species including small- and largemouth bass, northern pike, walleye, yellow perch, bullhead, and various panfish. Streams, rivers, and lakes of the Adirondack region support both warm- and cold-water fisheries due to their diverse habitats from deep, clear waters to rushing rapids and swirling pools. Species such as Lake, Brown, Brook, and Rainbow Trout, large- and smallmouth bass, land-locked salmon, walleye, perch, northern pike, and chain pickerel can be found in these waters.

Northern Harrier
Photo Source: National Audubon Society

NY's State Wildlife Action Plan (2015) identifies endangered, threatened, and species of conservation need within the region. Some important species include the endangered blandings turtle, threatened northern harrier, threatened pugnose shiner, and northern pike. The New York Natural Heritage Program (NYNHP) aims to facilitate conservation and biodiversity by providing information and expertise on rare species and natural ecosystems within NYS. The Upper St. Lawrence has the highest total count of at-risk species at 53, followed by the Raquette River at 48. The majority of these counts are characterized as flowering plant species; the second highest at-risk group is birds. A full list of rare, threatened, and endangered species of the St. Lawrence River watershed can be found at New York Nature Explorer (NYSDEC 2014). Invasive species are discussed in **Section 6.2**.

3.4.1 Ecological Zones

A wide range of terrestrial habitats such as forests in the Adirondack region, wetlands, and agricultural lands provide refuge for important bird, reptile, amphibian and mammal populations. These regional differences have been characterized into distinct ecological zones. Each zone, mapped in **Map 21,** represents an assemblage of interacting plant and animal populations that share a common environment. A description of the major zones follows.

Central Adirondacks. Most of this zone is within the southern half of the Raquette River subwatershed. It is characterized by boreal heath barrens, or shrubland that occurs at the outwash plains of the Adirondacks. Soils are sandy, dry, and poor in nutrients and may become seasonally flooded due to a discontinuous subsurface layer of podzolized soil that restricts infiltration rate. The area is characterized by various coniferous communities at higher elevations and mixed forests at lower elevations. A large proportion of this area is within the Forest Preserve and managed by the Adirondack Park Agency.

Champlain Transition. This zone is confined to the Chateaugay-English subbasin at its eastern end along the St. Lawrence River within Clinton County. It is characterized by a mix of perched bogs of acidic, shallow peat, heath shrubland with well-drained, sandy soils, and open canopy woodlands with very shallow acidic soils over sandstone bedrock. Jack pine and pitch pine are the dominant tree species in this zone.

Eastern Ontario Plains. This zone extends from the southwestern portions of the Upper St. Lawrence and Indian subwatersheds approximately to the St. Lawrence County line. This area consists of low elevation plains with shallow loam soils over limestone or dolostone bedrock. The natural biome supports wetlands, grasslands and shrub communities; these have now been largely replaced by agricultural pastures supporting the dairy industry. This area also exhibits alvar communities, a globally rare group of prairie-like plants found on thin mineral soils over limestone.

St. Lawrence Plains. The Upper St. Lawrence, Oswegatchie, and northern tips of the Raquette, St. Regis, and Salmon River subwatersheds fall within the St. Lawrence Plains ecozone. This area is characterized by riverside meadows with gently sloping cobble shores, sparse or patchy vegetation dominated by scrub oak or heath shrubs, and small wetland areas rich in organic matter or clay. Water levels and soil saturation fluctuate seasonally and ice from the St. Lawrence River scours the meadow, cutting back woody plants along its shoreline. The area has a cool microclimate. The forested areas are dominated by pitch pine, chestnut and red oak, red maple, American elm, and green and white ash. Grazing and other agricultural practices have altered the ecological zone.

Western Adirondack Foothills. The Western Adirondack Foothills is the dominant ecological zone of the St. Lawrence River watershed. The band extends from the southwestern edge of the Oswegatchie and stretches diagonally to the southern half of the Chateaugay-English subwatershed, traversing the bulk of the Grasse, the narrow, middle stretch of the Raquette, the southern half of the St. Regis, and the central Salmon River subwatersheds. Sandy, low fertility soils derived from glacial outwash deposits cover the foothills. The area contains many seasonally fluctuating, groundwater-fed ponds and associated wetlands typical of pine barrens. Peatlands and bogs occur along the gentle slopes of the foothills. The landscape is covered with extensive hardwood forests and supports similar communities to those found at the higher elevations of the Adirondacks.

3.4.2 Significant Habitats and Protected Areas

NYSDEC is responsible for approximately 4.5 million acres of public land, including 2.6 million acres in the Adirondack Park. After growing concerns regarding clear cutting of trees, the Adirondack Park was established and recognized in 1892 as a constitutionally protected Forever Wild area. In 1971, the Adirondack Park Agency was created to develop long-range public and private land use plans for the area. State lands fall under four classifications that determine management actions; forest preserve, state forests, wildlife management areas, and conservation easements. The Adirondack Park has 2.6 million acres in forest preserve, 15,000 acres in state forests, 4,000 acres in wildlife management areas, and 780,000 acres under conservation easement.

The Great Lakes and St. Lawrence River host many Significant Coastal Fish and Wildlife Habitats (SCFWH). SCFWHs are areas critical to the populations of fish and wildlife; they contain a unique combination of environmental and biological conditions which fish and wildlife need for survival either seasonally or year-round. Areas typically include coastal wetlands, breeding grounds, nursery areas, migratory routes, and areas of high human use of the fish and wildlife resource (Ozard, 1984). SCFWHs in the St. Lawrence River watershed are catalogued at the NYSDOS site; https://www.dos.ny.gov/opd/programs/consistency/scfwhabitats.html#greatlakes.

New York State and NYNHP are working to protect select areas that are more vulnerable to ecological degradation and poor management. As a result, some areas are designated Critical Environmental Areas (CEA) or are managed by the NYNHP to enhance community resiliency and ecological integrity through restoration and protection. The Great South Woods of the Wilderness located in Colton was designated a CEA in 2003 because of its mature forests and its cultural, recreational, and educational value. CEAs are designated if they provide a significant benefit to public health, represent a natural setting or habitat, serve important agricultural, social, cultural, or historic values, or are inherently sensitive to ecological, geological, or hydrological changes.

The National Audubon Society's mission is to protect birds and the habitats they need to survive. To accomplish this, Important Bird Areas (IBA) that are critical habitats to the success of bird populations have been identified, monitored, and protected. Important Bird Areas must meet one of three criteria: an area where birds gather in large numbers at one time; a habitat for at-risk species; or an area that supports diverse habitat and bird species. The Upper St. Lawrence/Thousand Islands, Adirondack Forest Tract, Moose River Plains/Blue Ridge Area, Adirondack Loon Complex, Brasher Falls and Bombay Forests, Indian River/Black Lakes, Perch River Complex, Spring Pond Bog, Massawepee Mire, Fort Drum, Lisbon Grasslands, and Lower St. Lawrence River areas are designated IBAs. More information on these areas can be found at the National Audubon Society website; https://www.audubon.org/important-bird-areas/state/new-york.

Modeled after the National Audubon Society's IBA Program, New York State's Bird Conservation Area (BCA) Program was established in 1997 to safeguard and enhance bird populations and their habitats on state lands and waters. An area of 8,700 acres in St. Lawrence County in the Towns of

Canton and DeKalb was identified as a BCA. The area is a large complex of open water surrounded by marsh, shrub, swamp, and upland forests

3.5 Land Cover

Both land cover and land use can impact water quality in a watershed. Land cover refers to how much of a region is covered by forests, wetlands, agriculture, open water, and other natural features. Land use refers to how the landscape is utilized by humans, such as for farming, conservation, residential, or commercial purposes. Land cover can function as a buffer against environmental impacts; for example, wetlands provide a buffer against flooding, woodlands buffer waterbodies from runoff, and vegetation can stabilize steep slopes prone to erosion. Land use information helps determine which types of pollutants may be present and how much could potentially be released.

Land cover within the S. Lawrence River watershed (refer to Map 20 and Table 3) is dominated by forested woodlands, encompassing roughly 59% of the total area. The Raquette River subbasin has the most acreage dedicated to forests at 619,000 acres comprising 77% of the area. The region lost about 14,000 acres of its forests from 2001 to 2011 while areas classified as wetlands increased by 350 acres during this period. Agriculture occupies about 17% (616,000 acres) of the watersheds' landscape with the remainder in wetlands (14%), open water (3%), urban development (3%), shrub/scrub (2%), and grasslands (1%).

Farming in St. Lawrence County
Photo Source: northcountrypublicradio.org

Table 3
Land Cover, St. Lawrence River Watershed

HUC8	Forest (acres)	Scrubland (acres)	Grassland (acres)	Wetlands (acres)	Urban (acres)	Agriculture (acres)
Upper St. Lawrence	89166	7145	4758	37537	18116	86806
Oswegatchie	446827	10064	4245	81473	12560	93025
Indian	177609	11313	7714	53231	15768	77481
Grasse	260231	6824	2590	48455	12460	65046
Raquette	619203	17890	3712	70860	13269	27824
St. Regis	389709	16222	3104	83969	7628	34845
Salmon	145666	4884	2194	35512	8212	59140
Chateaugay-English	140762	7355	2443	52096	5158	51759
Watershed	2108346	84789	36167	496538	110193	616731
	% Forest	**% Scrubland**	**% Grassland**	**% Wetlands**	**% Urban**	**% Agriculture**
Upper St. Lawrence	36	3	2	15	7	35
Oswegatchie	66	1	1	12	2	14
Indian	49	3	2	15	4	22
Grasse	64	2	1	12	3	16
Raquette	77	2	0	9	2	3
St. Regis	71	3	1	15	1	6
Salmon	56	2	1	14	3	23
Chateaugay-English	53	3	1	20	2	20
Watershed	59	2	1	14	3	17

SOURCE: 2011 CDL-NLCD Hybrid Land Cover dataset.

The riparian zone of a landscape influences the water quality within, and downstream from, surrounding waterbodies. Identifying riparian zones in need of improvement and maintenance will enhance retainment of excess nutrients and sediments and perform other critical hydrologic, geomorphic, and biological functions that improve a watershed's health. NYS Riparian Opportunity Assessment identifies riparian areas needing improvement at the subwatershed and catchment level using indicators of ecological health and stress. In general, the region has ample natural riparian cover with a higher density in the mountainous areas of the Adirondacks and approximately 50-85% riparian cover on the agricultural plains. Low cover areas are concentrated in the Indian and Oswegatchie River watersheds. Wheeler Creek (Upper St. Lawrence River watershed), encompassing urban areas such as Cape Vincent and Clayton along the St. Lawrence River shoreline, has the least natural riparian cover.

Agriculture is a leading industry and use of land in the area, as the northern skirt of the St. Lawrence River water basin is host to rich soils and flat plains suitable for farming (see Maps 14 and 18).

Agricultural districts are outlined in **Map 22**. According to the 2017 Census of Agriculture from the USDA National Agricultural Statistics Service (NASS), land dedicated to farming has decreased by approximately 7% since 2012 within the watershed. In 2017, 620,714 acres were dedicated to farming, hosting 2,344 farms, a decrease of 144 farms since the 2012 census. In 2017, cropland, pasture/grazing land, and woodlands occupied 333,350, 14,523, and 163,308 acres, respectively. Approximately 18,000 acres of cropland were idle or used for cover crops or soil-improvement but not harvested and not pastured or grazed. No-till practices are used on 191 farms occupying 21,377 acres (up from 173 farms holding 13,032 acres in 2012), and reduced tillage is practiced on 182 farms covering 33,508 acres (up from the 92 farms covering 15,543 acres). Manure is spread across 104,000 acres in the watershed, and 129,000 acres are treated with commercial fertilizers, lime, or soil conditioners. **Table 4** lists the harvested crops and livestock and poultry counts for the watershed. Agriculture census data can also be found for each county within the watershed.

Table 4
Crops and Livestock, St. Lawrence River Watershed

Selected Crop	Farms	Acres	% Harvested Cropland	Change in # of Farms since 2012	Change in Farmed Acres since 2012
Corn	398	74178	26.49	-54	-2615
Soybeans	62	8284	2.96	-11	1054
Small grains (wheat, oats, barley, rye)	117	4109	1.47	-10	625
Vegetables	170	1128	0.40	-33	-473
Orchards	91	296	0.11	-18	-265
Nursery, greenhouse, floriculture, and sod	71	77	0.03	-18	-68
All other crops	1710	191949	68.55	-93	-11897
Total	**2619**	**280021**	**100**	**-237**	**-13639**
Livestock/Poultry	**Farms (2017)**	**Acres (2017)**	**% of Livestock Acres**	**Change in Farms since 2012**	**Change in Farmed Acres since 2012**
Cattle and calves	1173	135567	55.64	-142	-1137
Hogs and pigs	148	1045	0.43	-42	-964
Sheep and lambs	120	3369	1.38	5	-1685
Horses and ponies	622	3753	1.54	-43	-728
Goats	125	1153	0.47	-12	151
Chickens	441	98758	40.53	-8	76936
Total	**2629**	**243645**	**100**	**-242**	**72573**

SOURCE: 2017 Agriculture Census, USDA, National Agricultural Statistics Service.

The Upper St. Lawrence is the most agriculturally intensive subbasin, dedicating 35% of its land to agricultural activities (87,000 acres). The Oswegatchie and Indian subbasins farm an additional 93,000 and 77,000 acres each, constituting 14% and 22% of their total area, respectively. The Oswegatchie and Indian subbasins have the highest count of surface water segments listed as impaired due to nutrients and requiring a TMDL under Section 303(d) of the Clean Water Act (CWA). The counts include state-assigned pollutants/causes identified as nutrients, organic enrichment/oxygen depletion, algal growth, or noxious aquatic plants. These IDs are associated with excess nutrients and sediment transport via agricultural runoff. From 2001 to 2011, the St. Lawrence River watershed increased its agricultural lands by 1,100 acres; approximately 70% were in hydrologically connected zones that are comprised of wet areas with high runoff potential, causing concern for future impairment of adjacent waterbodies.

Only 3% of the St. Lawrence watershed area is classified as urban; this region is among the least populated areas of NYS. With the low population density, impervious cover occupies a low 0.7% of the area (**Map 23**). The highest percentage of impervious surfaces (2%) is within the Upper St. Lawrence subbasin.

Dairy farm in the St. Lawrence River watershed.
Photo Source: Empire State Development; https://esd.ny.gov/industries/agribusiness

4 Community Characteristics

4.1 Municipalities and Population

In all, one Native American territory (Saint Regis Mohawk Indian Territory), one city (Ogdensburg), 22 villages, and 76 towns are wholly or partially within New York's St. Lawrence River watershed (**Table 5**). **Map 24** displays municipalities within the watershed and delineates major population centers. Population density within the St. Lawrence River watershed is displayed in **Map 25**. The total watershed population in 2010 was 196,503, the most populous areas were Potsdam (16,075), Malone (14,799), Fort Drum (12,955), and Massena (12,245) (US Census Bureau 2010). The Upper St. Lawrence subbasin has the highest population density (approximately 37 individuals/km^2), and the Raquette subbasin is home to the largest population of 37,413 (WSIO Indicator Data, EPA EnviroAtlas "Dasymetric Population for the Conterminous United States", February 2015). The upcoming 2020 census will provide valuable information on population trends in this region of northern NY.

Table 5
Municipalities within the St. Lawrence River Watershed

Civil Boundary Type	Primary HUC8	Name	Population*	County
Tribal	St. Regis (04150306)	St. Regis Mohawk Tribe	3,398	Franklin
City	Upper St. Lawrence (04150301)	Ogdensburg	11,128	St. Lawrence
Village	Upper St. Lawrence (04150301)	Cape Vincent	726	Jefferson
		Clayton	1978	Jefferson
		Alexandria Bay	1,078	Jefferson
		Morristown	395	St. Lawrence
		Waddington	972	St. Lawrence
	Oswegatchie (04150302)	Antwerp	686	Jefferson
		Harrisville	612	Lewis
		Gouverneur	3,949	St. Lawrence
		Richville	323	St. Lawrence
		Rensselaer Falls	332	St. Lawrence
		Huevelton	714	St. Lawrence
	Indian (04150303)	Philadelphia	1,252	Jefferson
		Evans Mills	621	Jefferson
		Theresa	863	Jefferson
		Hammond	280	St. Lawrence
	Grasse (04150304)	Canton	6,314	St. Lawrence
		Massena	10,936	St. Lawrence

Civil Boundary Type	Primary HUC8	Name	Population*	County
	Raquette (04150305)	Speculator	324	Hamilton
		Tupper Lake	3,667	Franklin
		Norwood	1,657	St. Lawrence
		Potsdam	9,428	St. Lawrence
	Salmon (04150307)	Brushton	474	Franklin
		Malone	5,911	Franklin
	Chateaugay-English (04150308)	Chateaugay	833	Franklin
		Burke	211	Franklin
Town	Upper St. Lawrence (04150301)	Cape Vincent	2,777	Jefferson
		Orleans	2,789	Jefferson
		Alexandria	4,061	Jefferson
		Hammond	1,191	St. Lawrence
		Morristown	1,974	St. Lawrence
		Clayton	5,153	Jefferson
		Lisbon	4,102	St. Lawrence
		Waddington	2,266	St. Lawrence
	Oswegatchie (04150302)	Fine	1,512	St. Lawrence
		Clifton	751	St. Lawrence
		Pitcairn	846	St. Lawrence
		Edwards	1,156	St. Lawrence
		Fowler	2,202	St. Lawrence
		Gouverneur	7,085	St. Lawrence
		De Kalb	2,434	St. Lawrence
		Oswegatchie	4,397	St. Lawrence
	Indian (04150303)	Theresa	2,905	Jefferson
		Antwerp	1,846	Jefferson
		Philadelphia	1,947	Jefferson
		Le Ray	21,782	Jefferson
		Wilna	6,427	Jefferson
		Croghan	3,093	Lewis
		Diana	1,709	Lewis
		Rossie	877	St. Lawrence
		Macomb	906	St. Lawrence
		De Peyster	998	St. Lawrence
	Grasse (04150304)	Colton	1,451	St. Lawrence
		Hermon	1,108	St. Lawrence
		Canton	10,995	St. Lawrence

Civil Boundary Type	Primary HUC8	Name	Population*	County
		Russell	1,856	St. Lawrence
		Clare	105	St. Lawrence
		Pierrepont	2,589	St. Lawrence
		Madrid	1,735	St. Lawrence
		Louisville	3,145	St. Lawrence
	Raquette (04150305)	Webb	1,807	Herkimer
		Lake Pleasant	724	Hamilton
		Long Lake	711	Hamilton
		Arietta	304	Hamilton
		Inlet	333	Hamilton
		Indian Lake	1,342	Hamilton
		Newcomb	436	Essex
		North Elba	8,957	Essex
		Harrietstown	5,709	Franklin
		Tupper Lake	5,971	Franklin
		Piercefield	310	St. Lawrence
		Parishville	2,153	St. Lawrence
		Potsdam	16,041	St. Lawrence
		Norfolk	4,668	St. Lawrence
		Massena	12,883	St. Lawrence
	St. Regis (04150306)	Santa Clara	345	Franklin
		Hopkinton	1,077	St. Lawrence
		Waverly	1,022	Franklin
		Brighton	1,435	Franklin
		Duane	174	Franklin
		Brandon	577	Franklin
		Dickinson	823	Franklin
		Lawrence	1,826	St. Lawrence
		Moira	2,934	Franklin
		Brasher	2,512	St. Lawrence
		Stockholm	3,665	St. Lawrence
	Salmon (04150307)	Franklin	1,140	Franklin
		Malone	14,545	Franklin
		Bangor	2,224	Franklin
		Bombay	1,357	Franklin
		Fort Covington	1,676	Franklin
		Westville	1,819	Franklin

Civil Boundary Type	Primary HUC8	Name	Population*	County
	Chateaugay-English (04150308)	Bellmont	1,434	Franklin
		Dannemora	4,898	Clinton
		Ellenburg	1,743	Clinton
		Constable	1,566	Franklin
		Burke	1,465	Franklin
		Chateaugay	2,155	Franklin
		Clinton	737	Clinton
		Mooers	3,592	Clinton

SOURCE: New York State Civil Boundaries, NYS GIS Clearing House (June 2019).

Note: In some cases, only a portion of villages and towns lie within the watershed, so populations shown in the table cannot be summed to give the watershed population.

4.2 Regulatory and Programmatic Environment

The St. Lawrence River watershed is affected by regulations, plans, and programs at the federal, state, regional, county, and local level, as well as by collaborations involving nonprofit organizations and academic institutions, designed to help protect and maintain water quality and aquatic habitat. The Project Team worked with a consultant (Rootz) to compile and review the local laws of the watershed municipalities and evaluate their effectiveness in protecting water quality and habitat from point- and nonpoint-source pollution.

4.2.1 Approach to Reviewing Local Laws, Plans, and Programs

The inventory and assessment of municipal measures to protect water resources in the St. Lawrence River watershed were based on a modified version of the process outlined by the Genesee/Finger Lakes Regional Planning Council (2006). Due to the extensive size of the watershed, a rigorous assessment of individual municipalities was not feasible, and therefore the regulatory environment was assessed at the County level. Existing local laws and tools that guide land use were identified by municipal nonpoint assessment forms completed by County Department of Planning and/or SWCD professional staff. The review of existing documents included:

- Comprehensive Plans/Land Use Plans/Rural Development Plans/Waterfront Revitalization Plans;
- Zoning, Site Plan Review and Subdivision Regulations; and
- Water Quality Protection Programs/Measures
- Waterbody/Shore Protection
- Floodplain Protection
- Waste Management
- Wastewater/On-site Septic

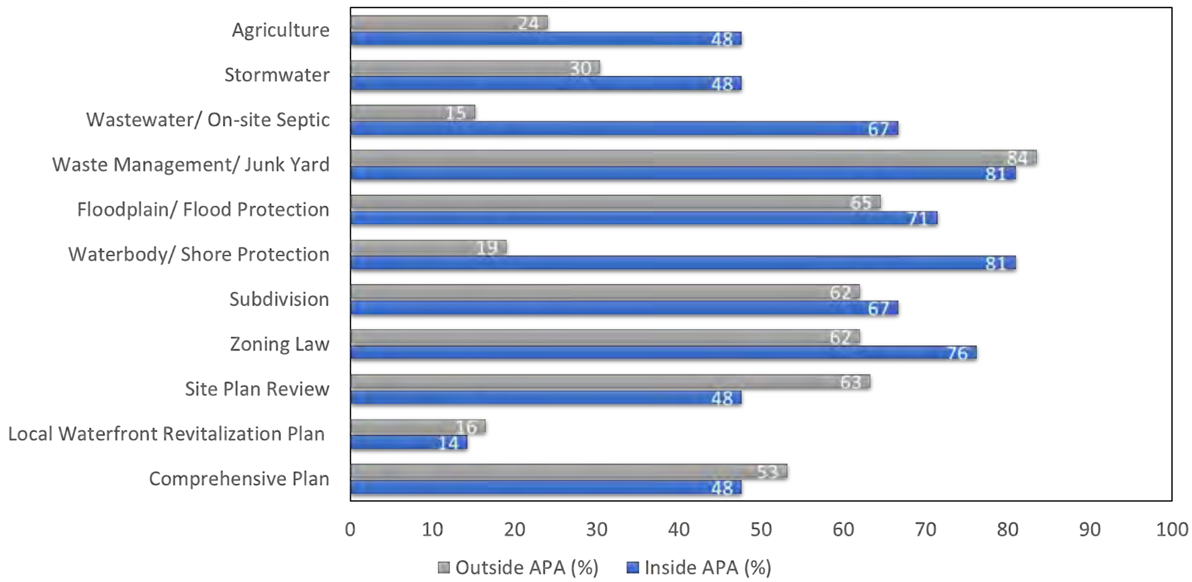
- Stormwater
- Agriculture

The resulting product is the **St. Lawrence River Watershed Local Laws and Programs Affecting Water Quality**. This document evaluates the current regulatory environment with respect to water quality and identifies improvements to local codes that would address water quality impacts from developmental activities more effectively. The St. Lawrence River Watershed Revitalization Plan will improve coordination amongst municipalities, organizations, and agencies to advance our shared understanding of the watershed and build upon the identified regulatory and programmatic gaps in local laws and programs to recommend laws and practices that could enhance sustainable land use and natural resource protection and future livelihood of the watershed.

4.2.2 Gap Assessment as Related to the Desired State

Within the St. Lawrence River watershed, multiple municipalities with several regulatory entities exist, which results in significant variation in regulatory tools and laws that address watershed resource protection. Some municipalities have greater resources available to them, regarding staffing, resources, and regulatory tools, while others are more vulnerable offering few local laws to manage water quality challenges. This variation is, in part, influenced by location within the Adirondack Park boundary. The APA is an important regulatory body, encompassing 44% of the watershed, and is responsible for maintaining protection of the forest preserve and regulating development on privately owned lands. This involves shoreline restrictions, tree removal, and protection of river systems and adjoining land.

Figure 4
Local Laws Assessment



Note: Percentage based on percentage of municipalities adopting practice/plan.

Based on the results of the evaluation, most municipalities do not adequately address the comprehensive protection and preservation of water quality in their regulatory programs. Due to the influence of the Adirondack Park on land use regulation and practices, it was useful to evaluate the adoption of local regulations or plans that influence water quality inside and outside the boundaries of the Adirondack State Park, shown in **Figure 4**. The largest discrepancies between inside and outside the park are with regards to on-site septic/wastewater and waterbody/shoreline regulation and practices. At the time of local law assessment inventory, only 32%, 26%, and 29% of municipalities utilize land use planning tools and regulations to target waterbody/shoreline protection, on-site septic systems, and agriculture, throughout the watershed, respectively. On the contrary, waste and junkyard management (83%) and floodplain protection measures (66%) are most consistently addressed within the watershed.

4.3 Water Use

Waters of the St. Lawrence River Watershed are diversely utilized by its community, providing navigation and commercial shipping channels, recreation, drinking water supplies, energy, and habitat.

4.3.1 Water Withdrawals

Water withdrawals in the St. Lawrence River watershed is divided among four predominant sectors: thermoelectric (59%, 25 million gallons per day MGD), domestic (42%, 14 MGD), industrial (7%, 3 MGD), and agricultural (<1%, 0.013 MGD) (USEPA, Watershed Index Online, 2019; USEPA EnviroAtlas, 2015). **Map 26** shows the locations of water withdrawals throughout the watershed and the sector associated with the withdrawal. NYS has the highest thermoelectric power water withdrawals in the northeastern United States (USGS 2015). Water for thermoelectric power is used to cool power-producing equipment. **Map 27** depicts hydroelectric, thermoelectric, solar, and biomass energy generation plants within the watershed.

4.3.2 Drinking Water Sources

The St. Lawrence River provides drinking water to approximately four million people in the United States and Canada; in New York State, the river serves as public water supply for the City of Ogdensburg, Town of Louisville, and Villages of Massena, Clayton, and Alexandria Bay. The Oswegatchie River serves 3,949 residents in the town of Gouverneur. The Raquette River provides municipal water for the Village of Potsdam with 1,624 water service connections. Canton primarily uses groundwater drawn from the Upland System which consists of a million-gallon reservoir, caisson, and groundwater extraction wells. Malone supplies groundwater drawn from two drilled wells to approximately 13,000 individuals via 2,819 village and town service connections. The Village of Tupper Lake is drilling wells to replace Tupper Lake as their primary source of drinking water. **Table 6** identifies waterbodies and municipalities served, if any, within the description column.

Groundwater aquifers are the main source of drinking water in the region. Groundwater availability is dependent on climatic and hydrogeologic factors. When pumped, changes in water levels of confined aquifers are manifested rapidly; in contrast, the effects of pumping unconfined or semi-confined aquifer systems are slowly made evident. Sand and gravel deposits generally produce the highest yields in the St. Lawrence study area, the sandstone and carbonate aquifers along the northern edge of the basin produce more moderate yields. The crystalline bedrock in the Adirondacks generally produces the lowest yields of the aquifers in the basin. Public water works utilize groundwater and surface water to serve 65% (128,897 individuals, 2014 SWDIS data) and 44% (86,011 individuals, 2014 SWDIS data) of the watershed's population, respectively. Rural residents obtain potable water from deep wells drilled into bedrock. The NYSDEC Water Well Program mapped 973 water wells within the St. Lawrence River watershed, as depicted in the Water Wells map from the NYS GIS Clearinghouse (NYSDEC Division of Water 2016). Note that this data set encompasses only about 20% of private wells in NYS with records beginning post-2000.

Municipal water supplies from major aquifers, lakes and reservoirs, and wellheads are depicted in **Map 26**. The purple/maroon dots on **Map 26** refer to withdrawals for public water via publicly owned water utilities. The mapped water wells, shown as X's, are designated community water systems—those that either serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents, such as local town and village water districts. A comprehensive list of Public Water Systems by county is maintained by the NYS Department of Health (NYSDOH, 2018).

The NYSDEC Water Quality Standards Program classifies surface waters for their best use, including water supply. Class A and AA waters are waterbodies classified as suitable for drinking and culinary purposes, as well as primary and secondary contact recreation and fishing. **Table 6** summarizes Class A and AA surface waters of the St. Lawrence River watershed. Class A waters are drinking waters that require filtration and some treatment, and class AA waters are drinking waters with minimal treatment needed and no filtration. A full list of assigned classifications to fresh surface waters within the St. Lawrence River watershed can be found in the New York Codes, Rules, and Regulations, Division of Water (6 CRR-NY 910.6).[1]

Table 6
Class A and AA Waterbodies

HUC8	Name	Description	Class	Standards
Upper St. Lawrence (04150301)	St. Lawrence River	The portion of river confined between the United States shore line and a line starting at Tibbetts Point Lighthouse, running directly north to the International Boundary Line, thence downstream along the International Boundary Line, terminating at the point of landfall of the International Boundary Line on St. Regis Point approximately 0.5 mile west of St. Regis Hamlet. For classification purposes, this includes all arms and bays in this included section and also includes all streams on islands in this section of the river, except the bay area described in item no. 1b below.	A	A
Oswegatchie (04150302)	Oswegatchie River	From 0.4 mile upstream from N.Y.C. railroad bridge over stream at Gouverneur to bridge over stream at Talcville.	A	A
	Oswegatchie River	From dam at Newton Falls to dam at Cranberry Lake.	A	A(T)
	Oswegatchie River (Cranberry Lake)	From Cranberry Lake outlet to footbridge at Wanakena. Cross reference item 1589. Parts not in forest preserve.	A	A(T)
	South Creek	From Village of Harrisville water supply dam at 0.35 mile upstream from mouth to trib. 5.	A	A(T)
	Cranberry Lake	Parts not in forest preserve.	A	A(T)
	Sylvia Lake		AA	AA
	Star Lake	Star Lake water supply.	AA	AA(T)

[1] NYSDEC intends to reclassify some surface waters within the St. Lawrence River basin: "The Division of Water expects to propose upgrades to the classifications of certain surface waters in 6 NYCRR Part 910 (St. Lawrence River drainage basin). These reclassifications are necessary to meet federal Clean Water Act (CWA) goals for water quality and, if adopted, would result in higher classifications (and thus more stringent water quality standards) for some waters in this drainage basin. Numerous Class D surface waters, which only provide protection for fish survival, would be proposed to be upgraded to higher classifications (Class C or higher)" (NYSDEC 2019a).

HUC8	Name	Description	Class	Standards
Indian (04150303)	Indian River	From old N.Y.S. Route 26 bridge over stream at Antwerp to trib. 42.	A	A
	Indian River Carthage Reservoir	From outlet of P 50 (Carthage Reservoir) to source of Indian River.	A	A(T)
	West Creek	From U.S. Route 11 bridge over stream to source. Evans Mills water supply.	A	A(T)
	Subtrib. of Black Creek	Military Reservation Reservoir.	A	A
Grasse River (04150304)	Grass River	From dam at Madrid to bridge at Morley.	A	A
	Grass River	From trib. 22 to Route 68 bridge at Canton.	A	A
	Little River	From trib. 16 to source.	AA	AA
	Tribs. of Little River and subtribs.	Trib. of Canton water supply.	AA	AA
	Van Rensselaer Creek	From mouth to 0.5 mile above trib. 5.	AA	AA(T)
	Van Rensselaer Creek	From 0.5 mile above trib. 5 to source.	AA	AA
	Dean Brook and tribs. and subtribs.	Trib. of Canton water supply.	AA	AA(T)
	Trib. of Dean Brook	Trib. of Canton water supply.	AA	AA
	Trib. of Van Rensselaer Creek and subtribs.	Trib. of Canton water supply.	AA	AA
	Taylor Creek	From mouth to trib. 3.	AA	AA(T)
	Taylor Creek tribs. and subtribs.	From trib. 3 to source.	AA	AA
	Trib. of Van Rensselaer Creek	Trib. of Canton water supply.	AA	AA
Raquette River (04150305)	Raquette River	From N.Y.S. Route 3 bridge over stream at Piercefield to railroad bridge at Raquette Pond (P 89 outlet).	A	A
	Eagle Crag Lake		A	A(T)
	Subtribs. of Dead Creek. Mt. Arab Lake		A	A
	Piercefield Flow	Used as water source by Hamlet of Piercefield.	A	A
	Tupper Lake	Water supply for Village of Tupper Lake.	A	A
	Blue Mountain Lake		A	A(T)
	Raquette River	From dams at Village of Potsdam north of U.S. Route 11 to bridge over stream at Hannawa Falls.	AA	AA

HUC8	Name	Description	Class	Standards
	Clear Pond	St. Regis Falls water supply.	AA	AA
	Black Pond Black Pond Outlet	St. Regis Falls water supply.	AA	AA
	Trib. of Dead Creek	From mouth to 0.25 mile above trib. 1. Used as water supply by Conifer.	AA	AA(T)
	Trib. of Dead Creek	From 0.25 mile above trib. 1 to source. Used as water supply by Conifer.	AA	AA
	Subtrib. of Dead Creek	Used as water supply by Conifer.	AA	AA
	Subtrib. of Dead Creek	Used as water supply by Conifer.	AA	AA
	Trib. of Tupper Lake and subtrib.	From P 110 outlet to source P 110 is water supply for Village of Tupper Lake.	AA	AA
	Little Simon Pond	Water supply for Village of Tupper Lake.	AA	AA(T)
	Trib. of Shaw Pond	Parts not in forest preserve. Used as auxiliary water supply for Town of Long Lake.	AA	AA(T)
	Trib. of Long Lake	Used as emergency water supply by Town of Long Lake.	AA	AA
	Lake Eaton	Future potential water supply for Long Lake. Parts not bordering forest preserve.	AA	AA(T)
	Raquette Lake	Used as water supply. Parts not bordering forest preserve.	AA	AA
St. Regis River (04150306)	Trib. of Trout Brook	Philadelphia Reservoir.	A	A
	Osgood Pond	Parts not in forest preserve.	AA	AA
	(Spitfire Lake) Subtrib. of Lower St. Regis Lake (Upper St. Regis Lake)		AA	AA
Salmon River (04150307)	Roaring Brook and tribs. and subtribs.	From mouth to source including Fishpole Pond (P 28a)	AA	AA(T)
	Tribs. of Roaring Brook		AA	AA
	Trib. of Salmon River and subtrib.		AA	AA
Chateaugay-English (04150308)	Separator Brook	From dam at Lion Mountain water supply to source.	AA	AA
	Standish Brook	From Standish Water Supply Dam to source.	AA	AA(T)
	Tribs. of Standish Brook and subtribs.		AA	AA

SOURCE: 6 CRR-NY 910.6

Although public utilities treat water used for human consumption, protecting source water from contamination can greatly reduce treatment costs and the risk to public health. NYSDOH manages a Drinking Water Protection Program dedicated to providing safe, quality drinking water. Under this program, NYSDOH (along with other agencies including county health departments and SWCDs) assists private homeowners with testing private water supplies to ensure that they meet public health standards. NYSDOH requires public utilities and water purveyors to test their water quality and inform consumers through an Annual Water Quality Report. These reports include information about the water system, source water, contaminant levels in finished water, and any violations of the national primary drinking water regulations. Typically, these reports can be found on the municipality's public utilities website or acquired by contacting managers or the utility or its respective local health department. NYSDOH operates a Source Water Assessment Program (SWAP) that provides water utilities with information to help them identify potential sources of contamination and implement management measures to prevent, reduce, or eliminate risks to the drinking water supply. Source water assessments have identified 503,000 acres in the watershed as Source Water Protection Areas, defined as areas with increased susceptibility to contamination (EPA Safe Drinking Water Information Systems, SDWIS, 2014 geospatial data).

4.3.3 Commercial Shipping – The St. Lawrence Seaway

The St. Lawrence River has been altered to facilitate transportation. Modifications began in 1680 when Dollier de Casson of the Sulpician Seminary in Montreal built a 1.5 m (5 ft) deep canal to bypass the Lachine Rapids between Lake St. Louis and Montreal. Today it is known as the Great Lakes - St. Lawrence Seaway, a deep draft waterway extending 2,340 miles from the Atlantic Ocean to the Great Lakes. The system serves mariners, farmers, and factory workers by moving a diverse array of commodities. The dominant commodities include iron ore for the steel industry, coal for power generation, limestone, grain for overseas markets, and cements, salt and stone aggregates for agriculture and industry.

The first joint U.S.-Canadian Deep Waterways Commission was formed in 1895 to investigate the feasibility of a Seaway, followed by establishment of the International Joint Commission (IJC) in 1909 and the signing of the Great Lakes – St. Lawrence Deep Waterway Treaty in 1932. Delayed by two world wars and other factors, the project began in 1954 when the St. Lawrence Seaway Authority mandated acquisition of lands for construction, operation, and maintenance of a deep draft waterway between the port of Montreal and Lake Erie, along with international bridges that cross it. The Seaway was completed in 1959 allowing navigation and access to global markets from the Great Lakes region. In 1993 and again in 2004, the Seaway's draft was increased by 3 inches from its original 26 feet, enabling ships to carry more cargo per voyage.

In 2017, the Montreal/Lake Ontario section of the seaway established a new record, remaining open from March 20 to January 11, a total of 298 days. The possibility of winter navigation and shipping on the Seaway are of great concern to shoreline communities. The U.S. Army Corps of Engineers conducted a study investigating the extension of the navigational season identifying probable impacts:

- erosion of shorelines and structural damage due to pressure waves induced by ship passage;
- damage to wetlands, benthic communities, and aquatic vegetation from high velocity water currents and ice scouring;
- re-suspension of sediments in spawning areas resulting in decreased egg and larvae vitality;
- degradation of water quality from resuspended sediment in the water column;
- decreased habitat connectivity, restricting normal migration patterns of native animals and fish; and
- potential loss of winter recreational activities such as ice fishing in small harbor areas due to unstable ice conditions resulting from ship passage.

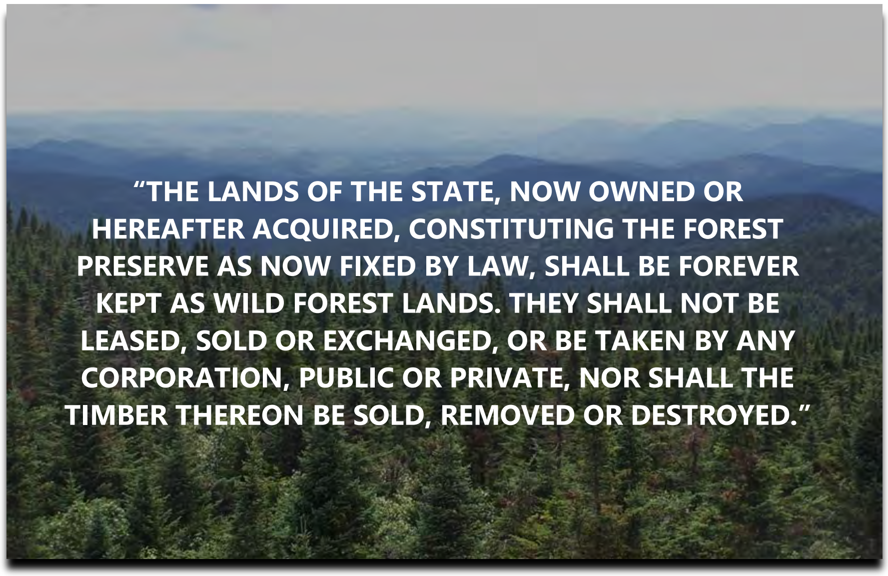
4.4 Public Access and Recreation

Residents of, and visitors to, the St. Lawrence River watershed have diverse opportunities to enjoy water-related recreational activities including boating, swimming, hunting, fishing, and nature observation. Public lands within the Adirondack Park are managed by the Adirondack Park Agency, which is part of NYSDEC. **Map 28** depicts NYSDEC recreational public access points supporting activities such as boating, camping, canoeing, fishing, hiking, and nature observation. A full list of NYS recreational areas is available at https://www.dec.ny.gov/outdoor/. In addition, many counties, cities, towns, and villages also offer boat launches for recreational access. Late spring and summer months are typically when recreational demand is along the St. Lawrence is at its peak.

Most of the shoreline along the St. Lawrence is privately owned with a few state parks managed by the Office of Parks, Recreation, and Historic Preservation (OPRHP). Surface water access to the St. Lawrence River is mostly provided by privately owned sites such as recreational clubs, marinas, restaurants, motels, and residential properties. However, demand for improving and enhancing opportunities for public access to swimming, fishing, and boating has increased throughout the watershed. Recreational freshwater fishing demand is highest for the Raquette (81,600 fishing day trips/year), Oswegatchie (69,300 fishing day trips/year), and St. Regis (55,900 fishing day trips/year) subbasins.

A recent study by the Trust for Public Lands researched the economic benefits of open space, conserved lands, public access and trails within the Thousand Islands region of Jefferson and St. Lawrence Counties. The study found that these amenities attract visitors and tourists, generating $164 million in labor income and 6,100 jobs each year, as well as $25.8 million in local taxes and $21.0 million in state taxes annually (The Trust for Public Land, 2018, https://tilandtrust.org/about-tilt/value-land-conservation).

4.5 Protected Lands



Article 14 of the 1984 New York Constitution
Photo Source: Stephen Williams, The Daily Gazette

In response to growing concerns regarding clear cutting of trees, NYS established the Adirondack Park in 1892 as a constitutionally protected Forever Wild area. Approximately 44% of the St. Lawrence River watershed lies within the Adirondack Park boundary. The Adirondack Park is a six-million-acre patchwork of public and private lands in northeastern New York. It cuts northeast from the southwestern corner of the Oswegatchie subbasin up to the middle of the Chateaugay-English subbasin. A significant proportion of this land is part of the Adirondack Forest Preserve, afforded constitutional protections under Article 14 of the 1894 NYS Constitution, that prevent the removal of timber and guides management and land use within the park. These lands are rich in both recreational opportunity and ecological significance.

In 1971, the Adirondack Park Agency was created to oversee regulation that envelops the long-range public and private land use plans for the area. State lands fall under four classifications that determine management actions; forest preserve, state forests, wildlife management areas, and conservation easements. Public lands managed by NYSDEC and their classifications are shown in **Map 28**. The NYNHP has created the New York Protected Areas Database (https://www.nypad.org/) that collects and shares spatial information on lands protected, designated, or functioning as open space, natural areas, conservation lands, or recreational areas. In addition, the USGS maintains a Protected Areas Database and publicly available interactive map at https://maps.usgs.gov/padus/. It is important to note that these interactive mapping tools use the word "protected" somewhat loosely; lands can be public or private, open or closed to public use, permanently protected from development, or subject to future changes in management.

4.6 Infrastructure

4.6.1 Dams

Dams serve many purposes within the St. Lawrence River watershed including recreation, flood control and storm management, navigation, water supply, and hydroelectric power generation. There is a total of 190 dams in the St. Lawrence River watershed with the most being in the Raquette and Oswegatchie subbasins (**Map 29**). **Table 7** lists the number of dams within each HUC8 of the St. Lawrence River watershed.

The Federal Energy and Regulatory Commission works with dam owners, local municipalities, and regulatory agencies to provide licensing for dams throughout the watershed. NYSDEC's DOW operates a NYS Dam Inventory which assigns a hazard classification to each dam structure based on the height of the dam, maximum capacity, physical characteristics, and downstream land use. A dam would be considered a high hazard dam (Class C) when in the case that it was to fail, loss of life and significant damage to homes, commercial buildings, public utilities, highways and roads would be expected to occur. Moderate hazard dams (Class B) would result in some damage to homes, buildings, infrastructure, and public utilities in the circumstance of a dam failure. Low hazard (Class A) dams would be expected to only damage isolated buildings, vacant lands, or rural roads in the event of failure. **Table 8** lists the 21 high hazard dams, designated Class C by NYSDEC and their respective subwatershed.

Table 7
New York State Dam Classifications, St. Lawrence River Watershed

HUC8	Low Hazard (A)	Moderate Hazard (B)	High Hazard (C)	Total Dams
Upper St. Lawrence	0	0	4	4
Oswegatchie	21	10	6	37
Indian	24	2	0	26
Grasse	12	0	0	12
Raquette	44	6	10	60
St. Regis	23	1	1	25
Salmon	13	3	0	16
Chateaugay-English	8	2	0	10
St. Lawrence River Watershed	**145**	**24**	**21**	**190**

SOURCE: NYS Dam Inventory, http://www.dec.ny.gov/maps/nysdams.kmz.

Table 8
High Hazard (Class C) Dams in the St. Lawrence River Watershed

Dam Name	Length (ft)	Height (ft)	Max Discharge (cubic ft/s)	Max Storage (acre-ft)	Basin
Long Sault Dam	2960	132	873000	2000000	Upper St. Lawrence
Robert Moses/Robert H Saunders Dam	3200	167	873000	2000000	Upper St. Lawrence
Massena Intake Dam	4000	75	0	5000	Upper St. Lawrence
Iroquois Dam	1980	72	310000	50	Upper St. Lawrence

Dam Name	Length (ft)	Height (ft)	Max Discharge (cubic ft/s)	Max Storage (acre-ft)	Basin
Cranberry Lake Dam	360	24	14220	57400	Oswegatchie
Newton Falls Dam	640	40	1331	16000	Oswegatchie
Flat Rock Dam	680	80	10500	5020	Oswegatchie
Ogdensburg Water-Power Company Dam	400	19	26600	4175	Oswegatchie
Browns Falls Dam	870	70	8900	3593	Oswegatchie
Eel Weir Dam	1020	30	52120	810	Oswegatchie
Carry Falls Dam	623	66	31800	117595	Raquette
Blake Falls Dam	1593	70	50000	37800	Raquette
Rainbow Falls Dam	2420	91	62800	25800	Raquette
Higley Falls Power Dam	435	50	16540	13960	Raquette
South Colton Dam	877	50	50300	4500	Raquette
Norwood Dam	910	30	17800	4080	Raquette
Five Falls Dam	1655	60	45400	3090	Raquette
Colton Dam	465	27	31770	2310	Raquette
Norfolk Dam	500	29	22030	108	Raquette
East Norfolk Dam	423	20	16530	94	Raquette
Allen Falls Development Dam	766	40	25400	1780	St. Regis

SOURCE: NYS Dam Inventory, http://www.dec.ny.gov/maps/nysdams.kmz.

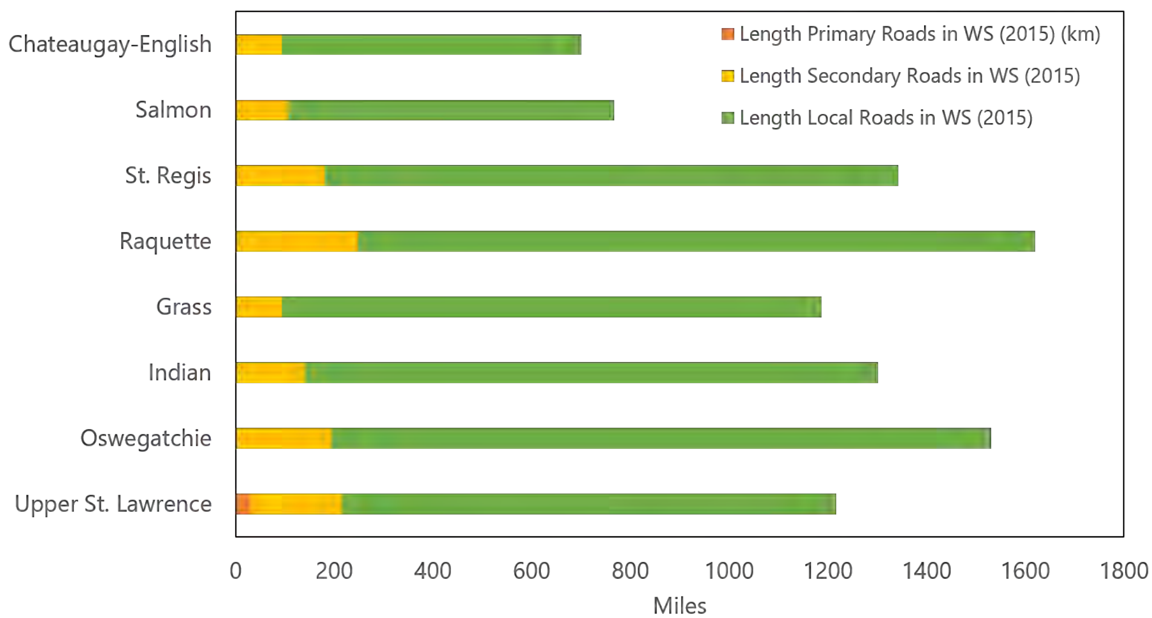
Dams serve as a major component of the watersheds' energy supply. Hydroelectric plants are reliable, cost-effective and support less-flexible sources of renewable energy. The Robert Moses-Robert H. Saunders Power dam first generated power in 1958 as part of the St. Lawrence-FDR project. It has 32 turbine-generators divided equally by the international border between the New York Power Authority (NYPA) and Canada's Ontario Hydro. The NYPA's 16 generating units can produce 800,000 kilowatts of electricity, more than enough energy to light a city the size of Washington, D.C. The Long Sault and Iroquois dams were also built as part of the St. Lawrence-FDR project.

4.6.2 Roads, Highways, and Railways

Roads, highways, and railways are shown on **Map 29**. The primary east-west highways are State Routes 11 and 37, which run parallel to the St. Lawrence River, and Highway 30, which runs north to south through Malone. The watershed includes over 450 miles of railways with track CSXT crossing through Gouverneur to Massena and track ADCX traversing through the Adirondacks passing through Tupper Lake.

Roads, highways, and related infrastructure such as parking lots contribute to the amount of impervious area in a watershed. The St. Lawrence River watershed contains a small amount of impervious cover at 0.67%, covering a total area of approximately 24,000 acres (see Map 23). The greatest concentration of impervious cover lies within the Upper St. Lawrence and Indian River subbasins due to developed centers of Ogdensburg and Le Ray/Fort Drum. **Figure 6** illustrates the length of road miles in each watershed, categorized by primary, secondary, and local roads.

Figure 5
Road Miles in Watershed



Source: WSIO Indicator Data, 2018.

Notes: Primary roads refer to divided highways within the interstate highway system or under state management and are distinguished by the presence of interchanges and raps for entrance/exit. Secondary roads are main arteries with one or more lanes of traffic in each direction that may be divided, and are usually in the US Highway, State Highway or County Highway system. Local roads are paved non-arterial street, road, or byway that usually has a single lane of traffic in each direction and may be privately or publicly maintained.

4.7 Industries and Employment

The watershed developed centered around manufacturing and aluminum smelting along the St. Lawrence River with agricultural and forestry-related industries set more in-land. With time, a significant shift in the primary economic center of the watershed has occurred. With economical centers shifting to incorporate areas such as Canton and Potsdam, which host three of the five hospitals in the watershed and four colleges/universities. Colleges and Universities, including St. Lawrence University, SUNY Potsdam, SUY Canton, Clarkson University, Paul Smith's College, and

SUNY ESF Ranger school, are important employers and economic drivers within these communities. Agriculture utilizes much of the land in the St. Lawrence River watershed and continues to be a prominent contributing economy although it has experienced a 6% decrease in amount of farm and farmland from 2012 to 2017 (US Agricultural Census, 2017).

Significant industries within the counties of the St. Lawrence River watershed include manufacturing, educational services, health care, leisure and hospitality, public administration/government, transportation, and utilities (NYSDOL, 2015). The public sector employs nearly 20,000 people with an average annual wage of $53,300, making it the largest employment sector of the North Country. The educational services sector, carrying 19,000 jobs and an average annual wage of $43,400 in 2015, lost hundreds of jobs between 2009 and 2014 due to declines in primary and secondary schools. The hospitality sector employs the third most workers of any sector in the North Country economy with more than 11,400 workers and average annual wages of $14,500. The North Country region has an average annual unemployment rate of 5.3%, ranging from 4-7.5% throughout the year due to seasonal employment (NYSDOL, 2018).

5 Existing Water Quality Conditions

The NYSDEC Division of Water conducts regular, periodic assessments of waterbodies in the state to fulfill certain requirements of the Federal Clean Water Act (CWA). Waters are assessed according to their designated best use such as drinking water, recreation, and aquatic life, as defined by 6 CRR-NY 910.6.

- Class A, AA indicate a best usage for a source of drinking water, swimming, contact recreation, and fishing
- Class B indicates a best usage for swimming, contact recreation, and fishing
- Class C indicates a best usage for fishing and non-contact activities
- Class D indicates a best usage of fishing, but these waters will not support fish propagation

Waters with AA, A, B, and C classifications may also have "T" or "TS" classifications or standards, meaning that they support trout (T) populations or trout spawning (TS).

These assessments are compiled in an inventory database called the Waterbody Inventory/Priority Waterbodies List (WI/PWL). For waters classified as impaired, the Clean Water Act also requires states to consider a strategy, such as the development of a Total Maximum Daily Load (TMDL), to reduce the input of specific pollutant(s) restricting waterbody use. Impaired waterbodies are listed on the Section 303(d) list.

5.1 Waterbody Inventory and Priority Waterbodies

The Division of Water's WI/PWL database compiles current water quality information, characterizes known or suspected water quality problems, and tracks progress toward their resolution. The documents can be found at https://www.dec.ny.gov/chemical/36735.html. The NYSDEC's Rotating Integrated Basin Studies (RIBS), which sample water quality and macroinvertebrates in various regions on a five-year rotating basis, is a primary source of information. NYSDEC engages volunteers in water quality monitoring through citizen science programs, including the Citizen Statewide Lake Assessment Program (CSLAP) and the Water Assessments by Volunteer Evaluators (WAVE) program, which helps to provide additional water quality information and screening to determine where additional assessments are needed. According to NYSDEC staff, the WI/PWL assessments for the St. Lawrence River watershed reflect data collected through the 2014 NYSDEC sampling season, although the date of last assessment varies by waterbody.

The PWL identifies seven assessment classifications:

- *Impaired:* Waterbodies with well documented water quality problems that result in precluded or impaired uses

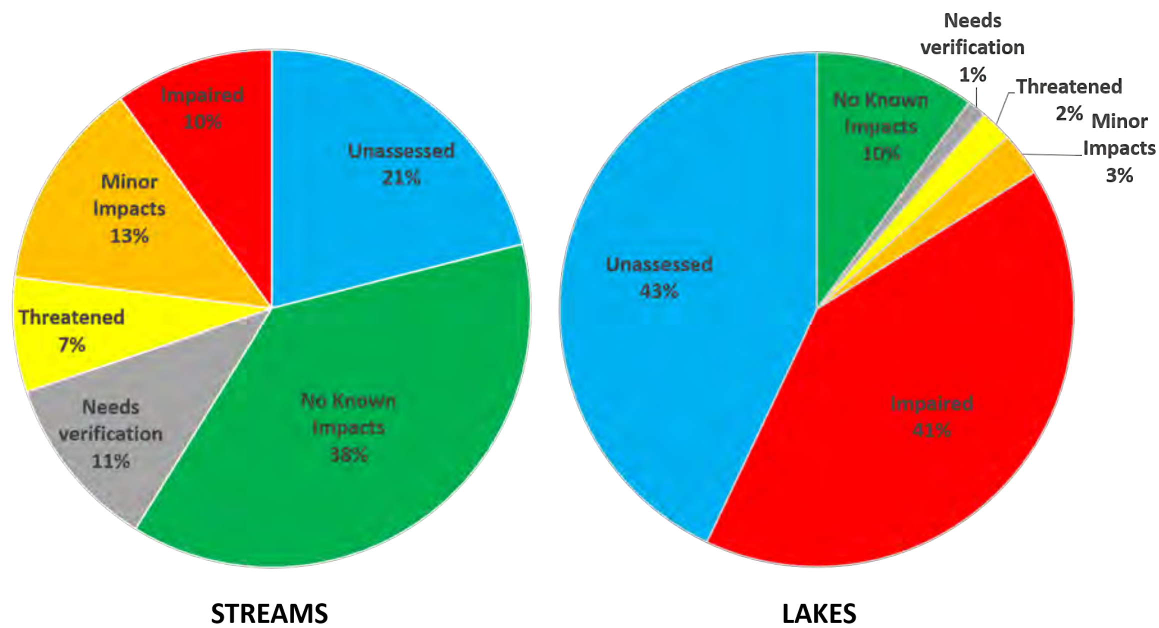
- *Minor impacts:* Waterbodies where less severe water quality impacts are apparent but uses are still considered fully supported
- *Needs verification:* Segments that are thought to have water quality problems or impact but for which there is not sufficient of definitive documentation
- *Threatened:* Waterbodies for which uses are not restricted and no water quality problems currently exist, but where specific land use or other changes in the surrounding watershed are known or strongly suspected of threatening water quality
- *Threatened (possible):* Waterbodies for which uses are not restricted and no water quality problems currently exist, but where waterbody classification, distinct uses, or other considerations make the water more susceptible to threats and additional protection efforts are warranted
- *No known impact:* Segments where monitoring data and information indicate that there are no use restrictions or other water quality impacts/issues
- *Unassessed:* Segments where there is no available water quality information to assess the support of designated uses

An overview of the PWL status for waterbodies in the St. Lawrence River watershed is presented in **Figure 6**. The WI/PWL assessed 52% (6,212 miles) of the total 12,030 miles of streams and rivers within the St. Lawrence River drainage basin. About 38% of the assessed stream miles are characterized as impaired, minorly impacted, or threatened. Thirteen (13%, 781 miles) of assessed stream miles were classified as impaired, signifying that the waters do not fully support their designated uses.

The 2016 WI/PWL assessed 57% of total lake acres within the watershed. Eighty percent (80%, 47,654 lake acres) of assessed (59,386) lake acres within the St. Lawrence River watershed were found to be impaired, minorly impacted, or threatened. About 72% of lake acres were found to be impaired and not supporting their designated use.

WI/PWL characterizations of lakes and streams in specific subwatersheds are shown in **Table 9** and **Map 30.**

Figure 6
WI/PWL Status of St. Lawrence River Watershed Waterbodies



SOURCE: NYSDEC, WI/PWL 2016

Table 9
Priority Waterbodies Assessment of St. Lawrence River Streams and Lakes

Streams (miles)						
HUC8	**Impaired**	**Minor Impacts**	**Threatened**	**No Known Impacts**	**Unassessed**	**Assessed Impacted (%)**
Upper St. Lawrence	254	204	--	--	166	100
Oswegatchie	298	181	265	157	1266	57
Indian	56	182	--	115	683	50
Grasse	30	175	--	707	548	19
Raquette	142	48	--	539	1677	26
St. Regis	--	58	--	841	722	5
Salmon	--	102	264	218	332	63
Chateaugay-English	--	84	32	398	423	22
Watershed	**781**	**1034**	**560**	**2974**	**5818**	**38**
Lakes (acres)						
HUC8	**Impaired**	**Minor Impacts**	**Threatened**	**No Known Impacts**	**Unassessed**	**Assessed Impacted (%)**
Upper St. Lawrence	--	--	--	--	1736	--
Oswegatchie	8581	--	--	638	8457	92

Indian	8487	2263	474	292	4998	97
Grasse	56	--	--	1294	2248	4
Raquette	21157	225	--	6220	21167	76
St. Regis	1782	356	1656	850	4568	82
Salmon	54	--	--	667	1174	4
Chateaugay-English	2564	--	--	543	390	83
Watershed	**42681**	**2843**	**2129**	**10505**	**44739**	**80**

SOURCE: NYSDEC WI/PWL 2016a

5.2 Section 303(d) List

Forty-three waterbodies in the St. Lawrence River watershed are classified as impaired and are therefore included on the Final NYS 2016 303(d) list. These waterbodies are listed in **Table 10**, which also indicates the specific pollutants causing impairment and their sources. Data reported in this document is from NYS's Final 2016 Section 303(d) List (NYSDEC 2016b).

The St. Lawrence River drainage basin lists four waterbodies under Section 303(d) Part 1, classifying them as waters with impairment requiring development of a total maximum daily load allocation. A TMDL quantifies the maximum amount of a pollutant that a waterbody can receive and maintain its designated uses and defines the magnitude of source reductions. Waterbodies in need of a TMDL include the Lower Raquette River and minor tributaries (pathogens from onsite waste treatment systems), Black Lake Outlet - Black Lake (phosphorus from agricultural runoff), Fish Creek and minor tributaries (phosphorus from on-site waste treatment systems), and Little River and tributaries (priority organics from industrial waste disposal).

Twenty-six waterbodies in the watershed are listed under Section 303(d) Part 2a, which means they are impaired by atmospheric deposition, or acid rain. In 2006, NYSDEC completed TMDLs for 143 acid-impaired lakes within the New York's Forest Preserve, the majority of which were listed as impaired on the inaugural 303(d) list in 1998. The Forest Preserve has expanded in recent years, and the current TMDL is focused on the remaining acid-affected lakes.

Thirteen of the St. Lawrence River drainage basin's waterbodies are listed under Part 2b, meaning they are subject to fish consumption advisories due to contamination with dioxin, pesticides, PCBs, and mercury. Note that Stark Fall Reservoir (0903-0073) and Willis Pond (0903-0105) have been added to the Draft 2018 303(d) List under Part 2b. A TMDL was developed to target mercury pollution in the Northeast Region in 2007.

In addition to the classifications shown in Table 10, Appendix A of Section 303(d) lists thirty-four waterbodies in the watershed that are classified as smaller lakes impaired by atmospheric deposition of acid rain.

Table 10
NYS 303(d) Listed Waterbodies in the St. Lawrence River Watershed

HUC8	Waterbody Name	Type	Class	Cause/Pollutant	Source
Part 1—Requiring TMDL Development					
Raquette	Raquette River, Lower, and minor tribs (0903-0059)	River	B	Pathogens	Onsite WTS
Indian	Black Lake Outlet, Black Lake (0906-0001)	Lake	B	Nutrients (P)	Agriculture
	Fish Creek and minor tribs (0906-0026)	River	C	Nutrients (P)	Onsite WTS
Oswegatchie	Little River and tribs (0905-0090)	River	C(T)	Priority Organics	Industry/Landfill
Part 2a—Impaired due to atmospheric deposition					
Grasse	Len, Wolf, Beaver Ponds (0904-0002)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
Salmon	Wolf Pond (0902-0006)	Lake	B	Acid/Base (pH)	Atmospheric Deposition
	Catamount Pond (0902-0092)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
St. Regis	Lower, Upper Twin Ponds, more (0902-0045)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Duck Pond, Benz Pond (0902-0021)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Diamond Lake (0902-0011)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
Raquette	Rock Pond (0903-0001)	Lake	B(T)	Acid/Base (pH)	Atmospheric Deposition
	High Pond (0903-0001)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Little Pine Pond (0903-0028)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Spruce Crouse, Spring, Graves Ponds (0903-0041)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Halfmoon Pond (0903-0032)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	South Pond (0903-0005)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Salmon Pond (0903-0004)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Pilgrim Pond (0903-0043)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Haymarsh Ponds, Lone Pond (0903-0017)	Lake	D	Acid/Base (pH)	Atmospheric Deposition

HUC8	Waterbody Name	Type	Class	Cause/Pollutant	Source
	Lost Pond (0903-0057)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
Oswegatchie	W. Br. Oswegatchie (0905-0003)	River	FP	Acid/Base (pH)	Atmospheric Deposition
	Dry Timber Lake	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Gregg Lake, Green, Twin, Loon Hollow Ponds (0905-0035)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Muskrat Pond (0905-0062)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Bear Pond, Diana Pond (0905-0062)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Lower, Middle, Upper South Pond (0905-0012)	Lake	D	Acid/Base (pH)	Atmospheric Deposition
	Desert, Jakes, Buck, Hog Ponds (0905-0038)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Crystal Lake (0905-0030)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Minor Lake Trib to Upper Oswegatchie (0905-0005)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
	Gull Lake (0905-0072)	Lake	C(T)	Acid/Base (pH)	Atmospheric Deposition
Part 2b—Impaired with respect to fish consumption					
Upper St. Lawrence	St Lawrence River (0901-0001)	River	A	Dioxin	Contaminated Sediment
				Mirex	Contaminated Sediment
				PCBs	Contaminated Sediment
	St Lawrence River (0901-0002)	River	A	Dioxin	Contaminated Sediment
				Mirex	Contaminated Sediment
				PCBs	Contaminated Sediment
	St Lawrence River (0901-0015)	River	A	Dioxin	Contaminated Sediment
				Mirex	Contaminated Sediment
				PCBs	Contaminated Sediment
	St Lawrence River (0901-0004)	River	A	Dioxin	Contaminated Sediment

HUC8	Waterbody Name	Type	Class	Cause/Pollutant	Source
				Mirex	Contaminated Sediment
				PCBs	Industr, Contam Sed
	Massena Power Canal (0904-0012)	River	D	PCBs	Industr, Contam Sed
Grasse	Grasse River (0904-0009)	River	B	PCBs	Industr, Contam Sed

SOURCE: NYS 303(d) list (2016)

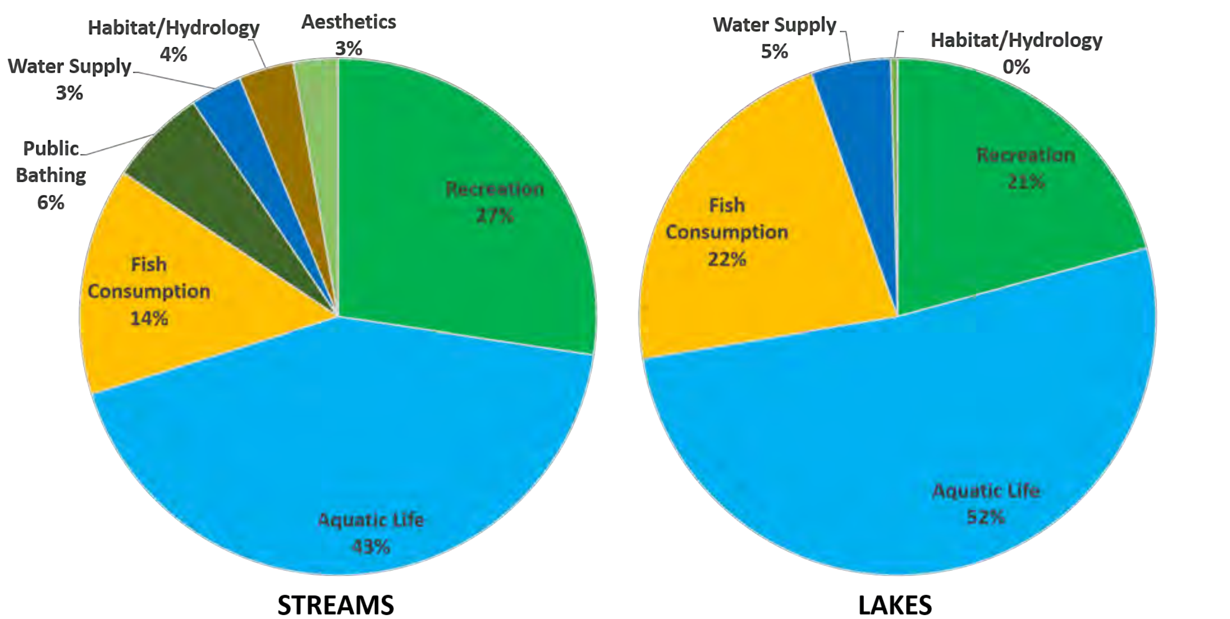
6 Waterbody Impairments and Potential Sources of Pollution

This section begins with an overview of known impairments and stresses to waterbodies in the St. Lawrence River watershed, and then summarizes potential sources of pollution that may contribute to those impairments and stresses.

6.1 Impairments to Designated Best Use

NYSDEC assesses impacts to waterbodies based on their designated best use and characterizes them as impaired or stressed if their best use is not being met, as was discussed in section 5. Waters of the St. Lawrence River watershed are best used for fishing, recreation, swimming, and potable water. **Figure 7** summarizes the percentage of streams and lakes in the watershed that do not meet their designated best use (including waterbodies found to be impaired, displaying minor impacts, threatened, and/or needing verification).

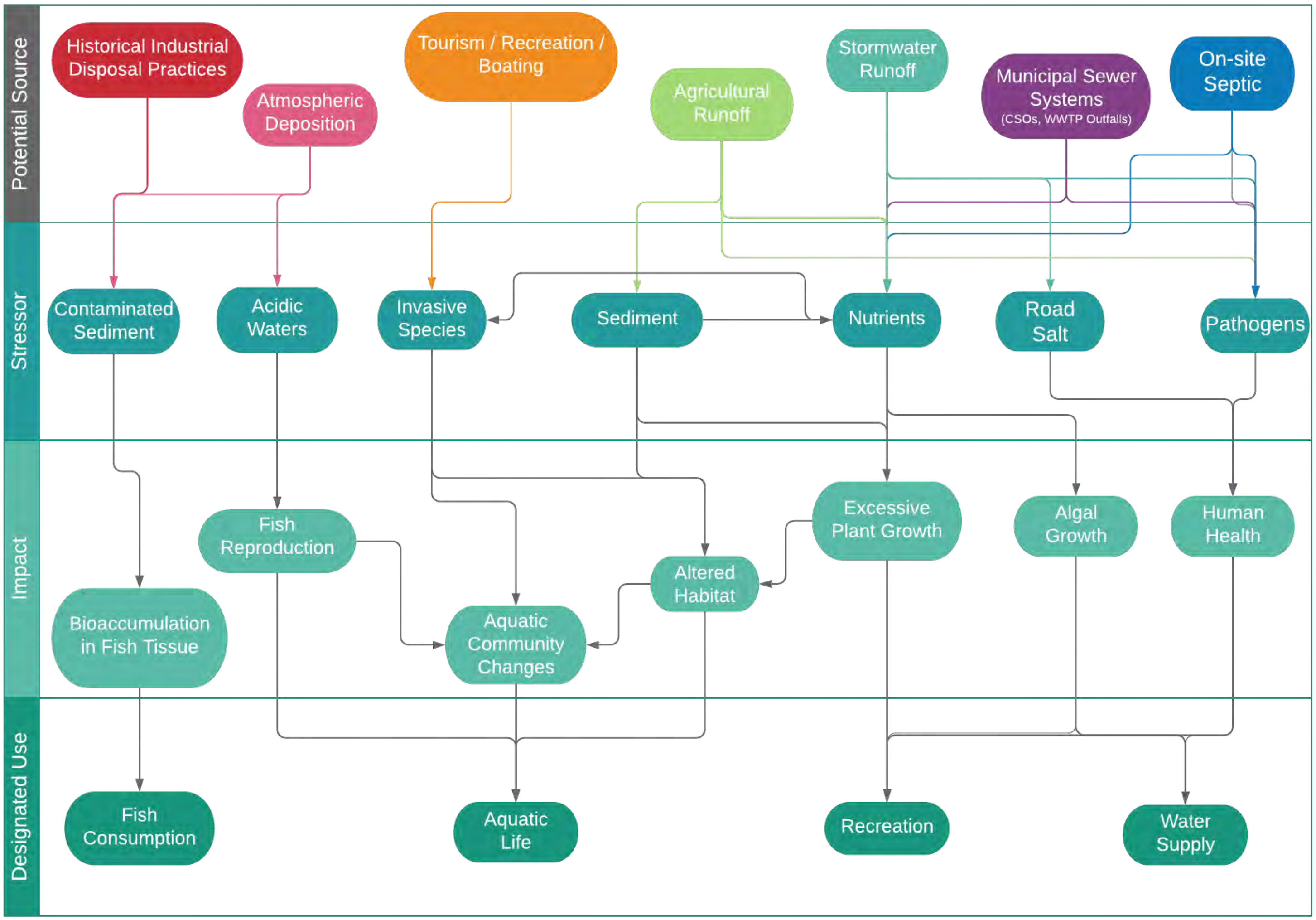
Figure 7
Impairments or Stresses Impacting the Designated Best Use of Streams and Lakes



SOURCE: NYSDEC, WI/PWL (2016)

Aquatic life is "stressed" in 43% and 52% of impacted streams and lakes, respectively. The mountain and wilderness areas are host to cold-water fisheries, while lakes and streams in the open and wooded lowlands support warmwater fisheries. Fish consumption is affected in 14% of streams and 22% of lakes in the watershed. Use of 33% of streams and 21% of lakes are impacted in ways that affect recreation and swimming. A conceptual model linking sources, stressors, and their impact on a designated use of a waterbody in the St. Lawrence River watershed are shown in **Figure 8**.

Figure 8
Conceptual Model - Linking Sources, Stressors, Impacts, and Designated Use in the St. Lawrence River Watershed



6.1.1 Fish Consumption Advisories

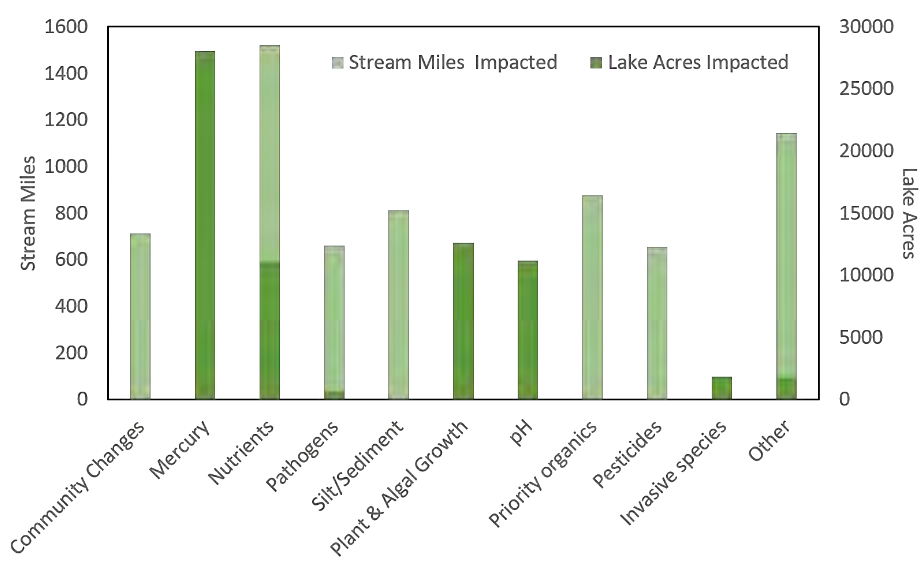
NYS has issued blanket and regional advisories for all waters in the St. Lawrence Valley and Adirondack region concerning consumption of specific species. The NYSDOH provides advisories for individual waterbodies and sportfish species and maintains a web site noting current status at https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/.

6.2 Impacts and Stressors Preventing Waterbodies from Meeting Their Designated Uses

The St. Lawrence River watershed has experienced numerous ecological impacts associated with the stresses brought on by such human activities as industry, commercial and recreational navigation, agriculture, and development. **Figure 9** characterizes the most frequently cited pollutants and stressors affecting water quality according to the 2016 NYSDEC WI/PWL and 303(d) List.

Pollutants and sources affecting water quality in the basin differ in streams and lakes. Nutrients (25% of assessed stream miles, 1,500 miles), priority organics such as PCBs, dioxins and PAHs (14%, 875 miles), and sediment (13%, 810 miles) are the most common pollutants of streams. Lakes in the watershed are primarily impacted by mercury (47%, 28,000 acres), excessive algal and plant growth (21%, 12,600 acres), and acidic waters (19%, 11,200 acres). Other threats to water quality in the watershed include community composition changes and invasive species, silt/sediment transport, salinization, and pathogens.

Figure 9
Pollutants and Stressors of Waterbodies



SOURCE: NYS WI/PWL & 303(d) List, (2016) The subsections below discuss causes for impairment in lakes and streams that are not meeting their designated best uses of fish consumption, aquatic life, recreation, and water supply.

6.2.1 Mercury

Impaired Use: Fish Consumption

Approximately 47% of assessed lake acres in the watershed are threatened, stressed, or impaired due to mercury found in sediments, waters, and fish. Fish consumption advisories have been issued due to elevated levels of mercury in certain fish species and sediments of the St. Lawrence River watershed. In the aquatic environment, microbial processes can metabolize mercury into its organic form, methylmercury. Acidic lake conditions have been shown to enhance this transformation. Methylmercury is a potent neurotoxin that bioaccumulates in fish and aquatic organisms. Human exposure to mercury is largely through consumption of contaminated fish, where developing fetuses and young children are the most sensitive populations.

6.2.2 Contaminated Sediment

Impaired Use: Fish Consumption

As a result of historical industrial practices and improper waste disposal, stream bottom sediments in portions of the St. Lawrence River watershed have been contaminated by priority organics (14% of assessed streams, 876 miles) and pesticides (11%, 656 miles). The Upper St. Lawrence subbasin at the St. Lawrence River and Massena Power Canal, the Oswegatchie subbasin at Little River and tributaries, and the Grasse River at the mouth of the Power Canal within the Grasse River subbasin are on the 2016 state and federal list of impaired waters due to sediment contamination by organic chemicals. The pollutants are dioxins, PCBs, and Mirex (an organochlorine insecticide); all are known to be bioaccumulative and carcinogenic. Benthic organisms exposed to contaminated sediment can accumulate these compounds through oral and dermal exposure. These compounds biomagnify to increased concentrations along the food chain, making some species of fish unsuitable for human consumption.

6.2.3 Acidic Waters

Impaired Use: Aquatic Life

Acidic waters are the third leading pollutant of lakes of the St. Lawrence River watershed, affecting 19% (11,167 lake acres) of assessed lake acres and an additional 400 stream miles (WI/PWL, 2016). Acidified waters have many ecological effects, especially on aquatic life. These waters leach nutrients and metals (e.g., calcium, aluminum) from soil clay minerals, which then flow across the surface as runoff water into streams and lakes or sink into the soil. Aluminum is toxic to vegetation at high levels and impairs a plant’s ability to take up water and withstand environmental stressors, while the loss of soil nutrients can stunt plant growth and productivity. Leached aluminum can interfere with ion regulation in aquatic animals and can accumulate on the surface of fish gills, leading to respiratory dysfunction. In addition, low pH and increased aluminum levels have been shown to cause chronic stress to fish, resulting in lower body weight and size that makes them less capable of competing for food and habitat. Fish reproduction is adversely impacted by acidic waters; calcium levels in female fish become lower to the point where egg production or pass is not viable, or larvae development is abnormal. Aquatic community composition changes and biodiversity decreases as lakes and streams become more acidic and viable only for fish and plant species that can tolerate lower pH levels. Even fish species that are more tolerant of acidic waters may suffer population impacts due to decreased food supply.

NYSDEC has conducted a liming program of acidic waters since 1959 with the purpose of restoring or protecting fish communities. These efforts, in addition to reductions resulting from implementation of the Clean Air Act, have contributed to the trend of increasing pH across several lakes. Analysis of historical data reveals that 25% of lakes included in the Adirondack Lake Assessment Program (ALAP) with long-term data have exhibited an increasing trend in pH (Laxson *et al.*, 2018).

6.2.4 Invasive Species

Impaired Uses: Aquatic Life, Recreation

Native aquatic species in the St. Lawrence River watershed are vulnerable to the presence of invasive species—nonnative organisms, such as rooted, aquatic plants, algae, animals, bacteria, viruses, and insects, that can harm humans or the environment. Invasive species pose a threat to aquatic habitat, nutrient cycling, and a lake or stream's capacity to fully support its designated uses. **Table 11** lists known invasive species and "watch" or "prevention" species referenced by the Partnerships for Regional Invasive Species Management (PRISMs), which coordinate invasive species management and monitoring efforts. Although the 2016 WI/PWL (2016) listed only three St. Lawrence River watershed waterbodies as impacted by invasive species (1,767 acres, 3%), research by the St. Lawrence-Eastern Lake Ontario (SLELO) Partnership, and Adirondack Park Invasive Plant Program (APIPP), and the Adirondack Watershed Institute has documented the widespread scale of invasives.

Typically, invasives grow and reproduce quickly and spread aggressively due to a lack of predators in the invaded environment. Their presence can quickly alter community dynamics, decrease biodiversity, and threaten native wildlife. For example, zebra and quagga mussels blanket the bottoms of waterbodies, filtering water and increasing water clarity as they consume plankton that serve as a food source for native populations. Increased clarity allows more sunlight to penetrate the water column, which creates ideal conditions for algae to grow and thus can contribute to algal blooms. Zebra and quagga mussels also impact recreation; beach areas colonized by the mussels provide a rough and sharp blanket on the bottom creating a hazard and unpleasant experience for swimmers. Pipes, boats, and water intake structures often become coated with zebra and quagga mussels causing severe impacts on the functionality of the pipes or structure. Zebra mussels have been confirmed in Black Lake, the Grasse River downstream of the Power Canal, and in the St. Lawrence River near Ogdensburg and at its confluence with the Grasse River.

Two especially significant invasive species have been the target of management efforts in the watershed. Water chestnut (*Trapa natans*) has clogged waterways by forming dense mats that limit light penetration into the water and impact native aquatic plants beneath the canopy. The reduced plant growth underneath, combined with the dieback and decomposition of water chestnut each year, can lead to reduced dissolved oxygen levels that affect aquatic life and can potentially lead to fish kills. Boaters and other recreationists also consider water chestnut as a nuisance and potential hazard. Eurasian milfoil (*Myriophyllum spicatum)* competes aggressively with native aquatic plants, growing in dense mats that interfere with fishing, swimming, and recreational access. This plant can grow in a variety of environments and sediment types, contributing to its widespread distribution. The Adirondack Park Agency and many lake associations are actively working to reduce its presence, but once established it is very difficult to eliminate. Terrestrial invasive species, such as Japanese Knotweed, and forest pests, such as the Emerald Ash Borer and Hemlock Wooly Adelgid, can impact water quality by threatening riparian health and cold-water stream habitat. APIPP maintains an interactive Invasive Species Distribution Map documenting the distribution and management status of target aquatic and terrestrial invasive species within the Adirondack region (http://adkinvasives.com/Invasive-Web-Map/index.html). NYNHP also operates an invasive species database and mapping tool, iMapInvasives, https://www.nyimapinvasives.org/.

Additional impacts related to invasive species are discussed in **Section 6.2.6** in the context of aquatic plants (macrophytes) and adverse impacts on recreation.

Table 11
Invasive Species Targeted for Prevention, Early Detection, and Control

Species	Scientific Name	PRISM
Target/General Invasive Species		
Asian Clam	*Corbicula fluminea*	APIPP
Autumn Olive	*Elaeagnus umbellata*	APIPP
Bale & Pale Swallow-wort	*Cyanchum spp.*	SLELO
Buckthorns	*Rhamnus cathartica, Frangula alnus*	APIPP
Bush Honeysuckles	*Lonicera spp.*	APIPP
Chinese Mystery Snail	*Cipangopaludina chinensis*	APIPP
Common Reed Grass	*Phragmites australis*	APIPP
Cup Plant	*Silphium perfoliatum*	APIPP
Curly-leaf Pondweed	*Potamogeton crispus*	APIPP
Emerald Ash Borer	*Agrilus planipennis*	APIPP, SLELO

Species	Scientific Name	PRISM
Eurasian Watermilfoil	*Myriophyllum spicatum*	APIPP, SLELO
European Frog-bit	*Hydrocharis morsus-ranae*	APIPP, SLELO
Fishhook Waterflea	*Cercopais pengoi*	APIPP
Garlic Mustard	*Alliaria petiolata*	APIPP
Giant Hogweed	*Heracleum mantegazzianum*	APIPP, SLELO
Glossy Buckthorn	*Frangula alnus*	SLELO
Hemimysis	*Hemimysis anomala*	SLELO
Hemlock Woolly Adelgid	*Adelges tsugae*	APIPP
Japanese Barberry	*Berberis thunbergii*	APIPP
Japanese Honeysuckle	***Lonicera japonica***	**SLELO**
Japanese Knotweed	*Polygonum cuspidatum*	SLELO
Japanese Stilt Grass	*Microstegium vimeneum*	SLELO
Knotweeds	*Reynoutria spp.*	APIPP
Leafy Spurge	*Euphorbia esula L.*	SLELO
Leek Moth	***Acrolepiopsis assectella***	**SLELO**
Lesser Celandine	*Ficaria verna*	APIPP
Multiflora Rose	*Rosa multiflora*	APIPP
Norway Maple	*Acer platanoides*	APIPP
Oriental Bittersweet	*Celastrus orbiculatus*	APIPP
Phragmites	*Phragmites australis*	SLELO
Purple Loosestrife	*Lythrum salicaria*	APIPP, SLELO
Quagga Mussel	***Dreissena rostriformis bugensis***	**SLELO**
Round Goby	***Neogobius melanostomus***	**SLELO**
Scotch Broom	*Cytisus scoparius*	APIPP
Sirex (European) Woodwasp	***Sirex noctilio***	**APIPP, SLELO**
Spiny Waterflea	***Bythotrephes longimanus***	**APIPP, SLELO**
Spotted Knapweed	***Centaurea maculosa***	**SLELO**
Spring Viraemia		**SLELO**
Swallow-worts	*Cynanchum louiseae*	APIPP
Tree of Heaven	*Ailanthus altissima*	APIPP
Variable-leaf Watermilfoil	*Myriophyllum heterophyllum*	APIPP
Viral Hemmorhagic Septicemia		**SLELO**
Water Chestnut	*Trapa natans*	APIPP, SLELO
White Nose Syndrome		**SLELO**
Wild Chervil	*Anthriscus sylvestris*	SLELO
Winged Burning Bush	*Euonymus alatus*	APIPP
Yellow Iris	*Iris pseudacorus*	APIPP
Zebra Mussel	***Dreissena polymorpha***	**APIPP**
Prevention Watch-List Species		
Asian Longhorned Beetle	*Anoplophora glabripennis*	APIPP, SLELO
Asian Carp	*Cyprinus carpio*	SLELO

Species	Scientific Name	PRISM
Asian Clam	*Corbicula fluminea*	SLELO
Asian Jumping Worm	*Amynthas spp.*	SLELO
Eurasian Boar	*Sus scrofa*	APIPP
Fanwort	*Cabomba caroliniana*	SLELO
Feral Swine	*Sus scrofa Linnaeus*	SLELO
Hemlock Woolly Adelgid	*Adelges tsugae*	SLELO
Hydrilla	*Hydrilla verticillata*	APIPP, SLELO
Japanese Angelica Tree	*Aralia elata*	APIPP
Japanese Stiltgrass	*Microstegium vimeneum*	APIPP
Kudzu (Vine)	*Pueraria lobata*	SLELO
Mile-A-Minute	*Polygonum perfoliatum*	APIPP, SLELO
New Zealand Mud Snail	*Potamopyrgus antipodarum*	SLELO
Porcelain Berry	*Ampelopsis brevipedunculata*	APIPP, SLELO
Quagga Mussel	*Dreissena rostriformis bugensis*	APIPP
Rock Snot (didymo)	*Didymosphenia geminate*	SLELO
Rusty Crayfish	*Orconectes rusticus*	APIPP/SLELO
Slender False Brome	*Brachypodium sylvaticum*	APIPP
Tench	*Tinca tinca*	SLELO
Water Soldier	*Stratiotes aloides*	SLELO
Wineberry	*Rubus phoenicolasius*	APIPP

SOURCE: SLELO and APIPP PRISMS, retrieved December 6, 2019.
Note: Bold rows refer to species on SLELO's General Invasive Species List.

6.2.5 Nutrients

Impaired Uses: Aquatic Life, Recreation

Although nutrients are required to support healthy ecosystems, excessive nutrients can harm water supplies, recreational uses, and aquatic life. Nutrient contamination of surface waters, primarily attributed to nitrogen and phosphorus, has been a longstanding issue that is not unique to the St. Lawrence River watershed. The WI/PWL cited nutrients as the primary pollutant of streams in the St. Lawrence River watershed, affecting 1,520 miles (24% of the assessed 6,212 miles). Nutrients affect the fourth greatest amount of assessed lake area (11,074 lake acres, 19%) in the watershed.

In freshwater systems, phosphorus is typically the limiting element on growth and productivity. Excessive levels of nutrients stimulate the growth of algae and aquatic plants, which upon dieback are decomposed by bacteria that consume oxygen on the water floor. This can result in hypoxia (low oxygen conditions), which is detrimental to aquatic life and habitat. Other impacts related to excessive plant and algal growth are discussed below.

6.2.6 Excessive Plant and Algal Growth

Impaired Uses: Aquatic Life, Recreation, Water Supply

Twenty-one percent of lakes (12,630 acres) and an additional 156 miles of streams in the watershed are impacted by excessive plant and algal growth. Excessive plant growth diminishes the recreational value of the waterbody by inhibiting swimming and boating, which in turn impacts local economies that are largely dependent on tourism and recreation. Excessive plant growth can also decrease habitat for fish and spawning beds. Often, the excessive growth is due to the introduction of invasive species that form dense beds on the lakebed and outcompete native species for habitat. In particular, invasives such as Eurasian milfoil and curly leaf pondweed can inhabit various sediments, depths, and light conditions, altering conditions that were previously good conditions for spawning habitat.

Algae is a fundamental component of any aquatic food web, as it produces oxygen, provides food for many organisms, and removes nutrients from the water column. However, when a significant influx of nutrients occurs, algae can grow excessively, creating an unpleasant and unaesthetic atmosphere for swimmers and recreationists. Algal growth can contribute to taste and odor issues and clog intake pipes impacting drinking water sources. Large mats of algal growth block sunlight necessary for aquatic plants below the surface, altering habitat and reducing oxygen levels. In the dieback season, algae fall to the water floor where it is microbially decomposed in a process that reduces dissolved oxygen levels. Reduced oxygen levels significantly affect organisms in the benthic zone and cause changes in community dynamics and potential migration of organisms to areas with more suitable conditions.

Some algal species can produce toxins. Harmful algal blooms (HABs) are kept in check partly by native nontoxic algae that readily take up excess nutrients from the water column. However, HABs can proliferate in suitable environmental conditions, which include excess nutrients, increased precipitation, sufficient sunlight, low-flow conditions, warm temperature, and calm waters (low wind). Lake dynamics such as native algal species and presence of invasive species contribute to their presence. Lake associations and organizations such as the Adirondack Watershed Institute are actively involved in training the public and lake residents on how to identify and report HABs in the watershed. NYSDEC encourages lake users to "know it, avoid it, and report it" when a suspected HAB is observed and operates a NYHABS online notification and reporting system for HABs.

6.2.7 Sedimentation

Impaired Use: Aquatic Life, Recreation

Sedimentation affects 13% (812 miles) of assessed stream miles in the St. Lawrence River watershed (WI/PWL, 2016). Sedimentation occurs when loose sand, clay, silt, and other soil particles enter and fill catch and flood basins, structures that are important for mitigating flooding and increasing volumetric capacity during times of increased precipitation and snowmelt. When these structures are instead filled with excess sediment, their functionality is inhibited.

Sediment deposits in rivers can alter the natural flow of water and reduce water depth, affecting recreational use and navigation. In addition, soft sediment deposits can increase turbidity and make swimming undesirable. Aquatic life is also affected by the transport of sediment and associated nutrients; turbid conditions can prevent fish from finding prey, and sediment can clog fish gills, lowering growth rates and reducing resistance to disease.

6.2.8 Salt

Impaired Use: Aquatic Life, Water Supply

Salts from de-icing and residential water softeners can enter lakes and streams, and groundwater that supply drinking water. Just one teaspoon of salt can permanently pollute five gallons of water. Once in the water, treatment becomes difficult and expensive. The St. Lawrence River watershed has a growing salt contamination problem that threatens drinking water supplies and aquatic life. Lakes in watersheds with paved roads have a median sodium concentration four times greater than those in watersheds without paved roads (Kelting, Laxson, and Yerger 2012). Dissolved salts can leach into aquifers and ground water when exposed to rain, snow, and wind. Road salt that enters roadside soils can also displace other cations within the soil, leaching them from the soil for offsite transport and depleting soil fertility. This cation loss from soils demonstrates a flux that may have a significant impact on soil and waterbody biogeochemistry and ecosystem health by reducing water retaining capacity and increasing erosion potential. Deicing compounds are known to be nontoxic at lower concentrations, but at higher concentrations they can place stress on fish and insect community structure, diversity, and productivity. Ultimately, salt intolerant species are outcompeted by salt-tolerant species, which often include invasive species. In addition, chloride corrodes road surfaces, bridges, and other elements of infrastructure, increasing maintenance and repair costs.

The Adirondack Watershed Institute at Paul Smith's College collected data showing that wells in the Adirondacks were contaminated by road salt at unhealthy levels. Two-thirds (2/3) of the wells tested downslope from state roads contained concentrations of sodium beyond the federally recommended health limit of 20 parts per million (ppm). The natural salinity of water in the Adirondacks is 0.3-0.5 ppm. Sodium has been strongly linked with hypertension, a condition that affects 12–30% of the population. Chloride levels exceeded 250 ppm, the recommended NYSDOH guideline for chloride, in nearly one-third of the 157 wells downslope of state roads. Some wells contained around 1,000 ppm of chloride, a level deemed not potable or drinkable (Virtanen, 2019).

6.2.9 Pathogens

Impaired Use: Water Supply

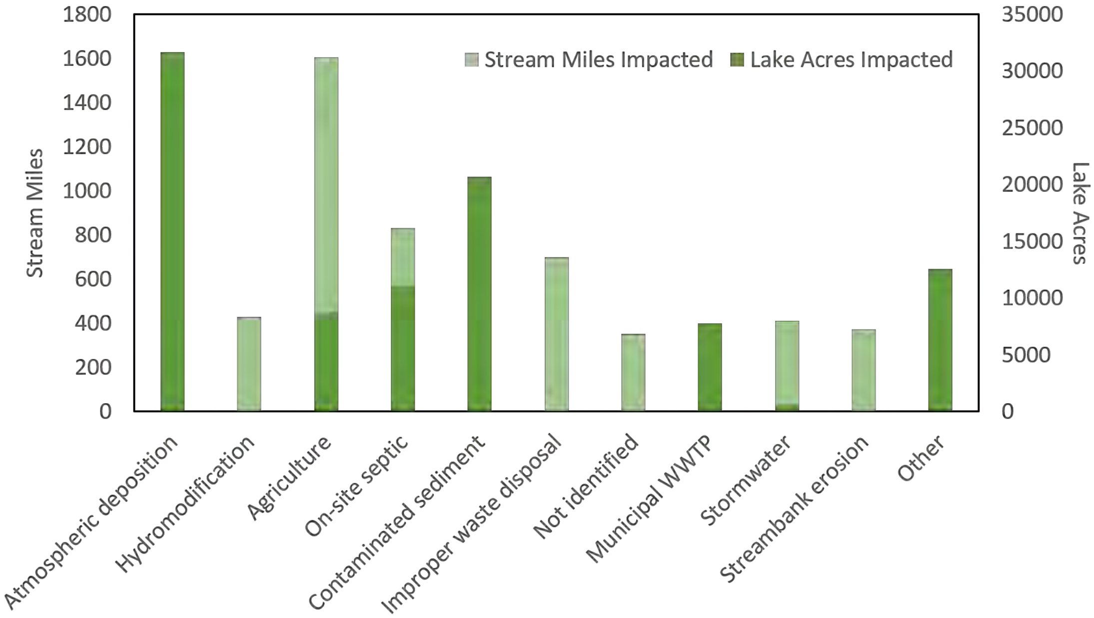
Pathogens affect 11% of assessed stream miles (661 miles) and 1% of lake acres (727 lake acres) (WI/PWL, 2016). Swimming in and drinking contaminated waters can make people ill, resulting in beach closures and an unsafe drinking water source. EPA has developed criteria to protect people from bacteria and their associated toxins in water bodies.

6.3 Potential Sources of Stressors

Lakes and streams in the St. Lawrence River watershed are affected by a combination of local and regional sources of pollution, which presents a challenge for those developing strategies to combat stresses and impairments to waterbodies. These sources include atmospheric deposition of pollutants originating outside the basin (regional), as well as local point and nonpoint sources related to industry, agriculture, hydromodification, municipal infrastructure, development, and commercial and recreational navigation. Point sources refer to discharges that originate from a single, identifiable source such as a pipe or outfall from a sewage treatment plant, whereas nonpoint sources represent diffuse combinations of pollutants from a large area, such as stormwater runoff that accumulates contaminants from several sources and then flows into streams.

Figure 10 shows the potential pollutant sources affecting the St. Lawrence River watershed and the magnitude of their impact. **Maps 31** and **32** display pollution sources within the St. Lawrence River watershed, such as sites permitted under the National Pollution Discharge Elimination System (NPDES), Superfund, Brownfield, and Environmental Restoration sites, landfills, sites undergoing voluntary cleanup programs, and mines. Regional sources contributing to pollution, nonpoint local sources, and local point sources affecting the St. Lawrence River watershed are discussed in the subsections that follow.

Figure 10
Potential Sources of Pollutants and Stressors



SOURCE: NYS WI/PWL & 303(d) List, (2016)

6.3.1 Regional Nonpoint Sources

Atmospheric deposition of acid rain and mercury is the primary source of lake pollutants in the watershed, affecting 53% (31,680 lake acres) and 400 miles of streams. Atmospheric deposition is the process by which pollutants in the form of particulates, aerosols, and gases are transported by wind currents and released through precipitation to the earth's surface. For the St. Lawrence River watershed, the pollutants released through this process are inorganic acids (known as acid rain) and mercury. These pollutants represent historical sources that still affect the system due to the recycling of contaminants in the environment and the atmosphere; they are addressed by federal and state regulations, including the Clean Air Act and Clean Water Act.

Coal-fired plant in Monroe, Michigan
Photo source: crainsdetroit.com

6.3.1.1 Acid Rain

Acid rain is formed when sulfur dioxide (SO_2) and nitrogen oxides (NO_x) combine with moisture in the atmosphere to produce sulfuric and nitric acids. Sulfur dioxide and nitrogen oxides are largely produced through the combustion of fossil fuels and emitted by motor vehicles, power plants, and industries. Higher elevation areas of the St. Lawrence River watershed, including the Adirondacks, are highly susceptible to the impacts of acid rain due to their thin soils, which are largely devoid of limestone (calcium carbonate). This severely limits the soil's buffering capacity to counteract the impacts of acid rain, making lakes more vulnerable to its effects. Acid rain has affected 19% of lake acres (11,167 acres) in the watershed.

Federal and state programs including the Clean Air Act (1990), Clean Air Interstate Rule (CAIR), and NYS Acid Deposition Control Act have reduced emissions of nitrogen oxide and sulfur dioxide. Environmental improvements in the region have been documented recently in response to these air pollutant control strategies (Waller, 2012).

6.3.1.2 Atmospheric Deposition of Mercury

Mercury is emitted into the air through human activities such as mining and fossil fuel combustion and through natural processes such as volcanic eruptions. It is then deposited via atmospheric deposition onto land and water, where microbial processes can metabolize it into an organic form, methylmercury. Approximately 47% of the St. Lawrence River watershed lake acres are threatened, stressed, or impaired due to mercury found in sediments, waters, and fish. New York State has issued blanket and regional advisories for all waters in the Adirondack region concerning consumption of specific species. The advisories include additional limits on fish consumption for women of child-bearing age and all children.

6.3.1.3 Recreation and Commercial Transport

Aquatic invasive species typically enter waterbodies via transport by boats and recreational users. The St. Lawrence River watershed is particularly susceptible to aquatic invaders due to international commerce from Eurasia across the Atlantic. Invasive plants and animals in ballast water enter the watershed through the St. Lawrence Seaway and rivers flowing from the Great Lakes. In addition, recreational boating, particularly in the Adirondack's region, can hasten the spread of invasive species. The NYSDEC coordinates efforts to combat invasive species through its Partnerships for Regional Invasive Species Management (PRISM).

6.3.2 Local Nonpoint Sources

6.3.2.1 Runoff from Agricultural Areas

Water flows off a farm following a storm.
Photo Source: Tim McCabe/NRCS

Agricultural activities and associated runoff contribute nutrients, sediments, and pesticides to receiving waters, which can have adverse effects on aquatic life and water quality. Twenty six percent (26%) of assessed stream miles (1,604 miles) and 15% of assessed lake acres (8,800 acres) in the watershed are threatened, stressed, or impaired due to agricultural activities (WI/PWL, 2016). There are 2,344 farms in the watershed occupying 620,000 acres of land, and agricultural districts (**Map 22**) are concentrated primarily in the northern skirt of the basin, which is host to flat plains and rich soils (**Maps 14** and **18**). **Table 4** lists the farmed crops and livestock of the St. Lawrence River watershed and the associated amount of land used for the activity.

The Oswegatchie and Indian subbasins dedicate 14% and 22% of their total area, respectively, to agriculture and have the highest count of surface water segments listed as impaired due to nutrients. The counts include state-assigned pollutants/causes identified as nutrients, organic enrichment/oxygen depletion, algal growth, or noxious aquatic plants. These IDs are associated with excess nutrients and sediment transport via agricultural runoff.

Fifteen percent (15%) of croplands and pasture in the watershed are contiguous to water, and 3% are on hydric soils. The Upper St. Lawrence has the highest percentage of agriculture contiguous to water at 31%. 70% of newly converted agricultural lands (1,100 acres) from 2001-2012 are within hydrologically connected zones, land that is comprised of wet areas with high runoff potential.

Impacts to local waterways can result from poor agricultural management, such as improper manure application on fields, intense cultivation of lands with little riparian buffer, and unrestricted access of livestock to streams. The St. Lawrence River watershed fertilizes 104,254 acres of farmland via manure application (USDA-NASS, 2018). An average of approximately 380 and 390 kg N/ha/year of manure and synthetic nitrogen, respectively, are applied to lands for fertilization purposes (WSIO Indicator Data, 2018).

6.3.2.2 On-Site Water Treatment Systems (Septics)

On-site septic systems are considered to threaten, stress, or impair 19% (11,100 acres) of lake acres and 13% (830 miles) of stream miles in the NY portion of the St. Lawrence River basin. Pathogens associated with sewage effluent can impair the use of a waterbody for contact recreation and as a source of potable water. Nutrients in wastewater can exacerbate algal growth, threatening aquatic life, recreation, and swimming access. The NYS Department of Health has established minimum standards for domestic septic systems. Other agencies, including the APA or local health departments may establish more stringent standards. Local municipalities can adopt local laws related to maintenance and inspection of septic systems that consider distance to waterways or critical environmental areas.

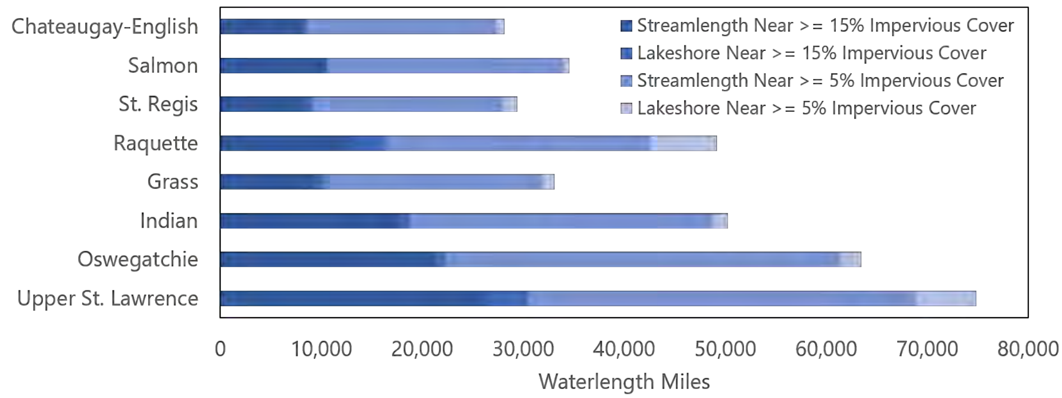
Historically, the St. Lawrence River watershed and the broader Adirondack region hosted many seasonal visitors from late spring to fall. Recent years have seen a rise in conversion of lakefront properties from seasonal cottages into year-round residences. If homes fail to upgrade their septic systems to accommodate this transition, they risk sewage effluents reaching nearby waterbodies. Depending on the age of the septic system, its distance from waterways, and the biogeochemical properties of the leach field (e.g., mineral composition and bulk density of soils, slope, depth to groundwater), even a well-maintained system may contribute nutrients to nearby waters and increase the risk of eutrophication.

6.3.2.3 Road Deicing

Deicing compounds are effective and necessary for maintaining safe travel conditions for motorists throughout the winter months. The NYSDOT relies on sodium chloride (salt) as the primary de-icing chemical due to its low cost and availability. About 50% of salt applied to roads runs off to surface waters; the remainder accumulates in soils and eventually reaches groundwater (Kelting & Laxson 2017). Road salt runoff tends to be a problem in areas with increased impervious surfaces. **Figure 11** shows the stream and lakeshore length in each HUC12 within 30 meters of areas with greater than or equal to 15% and 5% impervious surfaces.

Road-deicing.
Photo Source: Paul Smith's College, Adirondack Watershed Institute, Road Salt Research

Figure 11
Waterbodies Near Impervious Cover



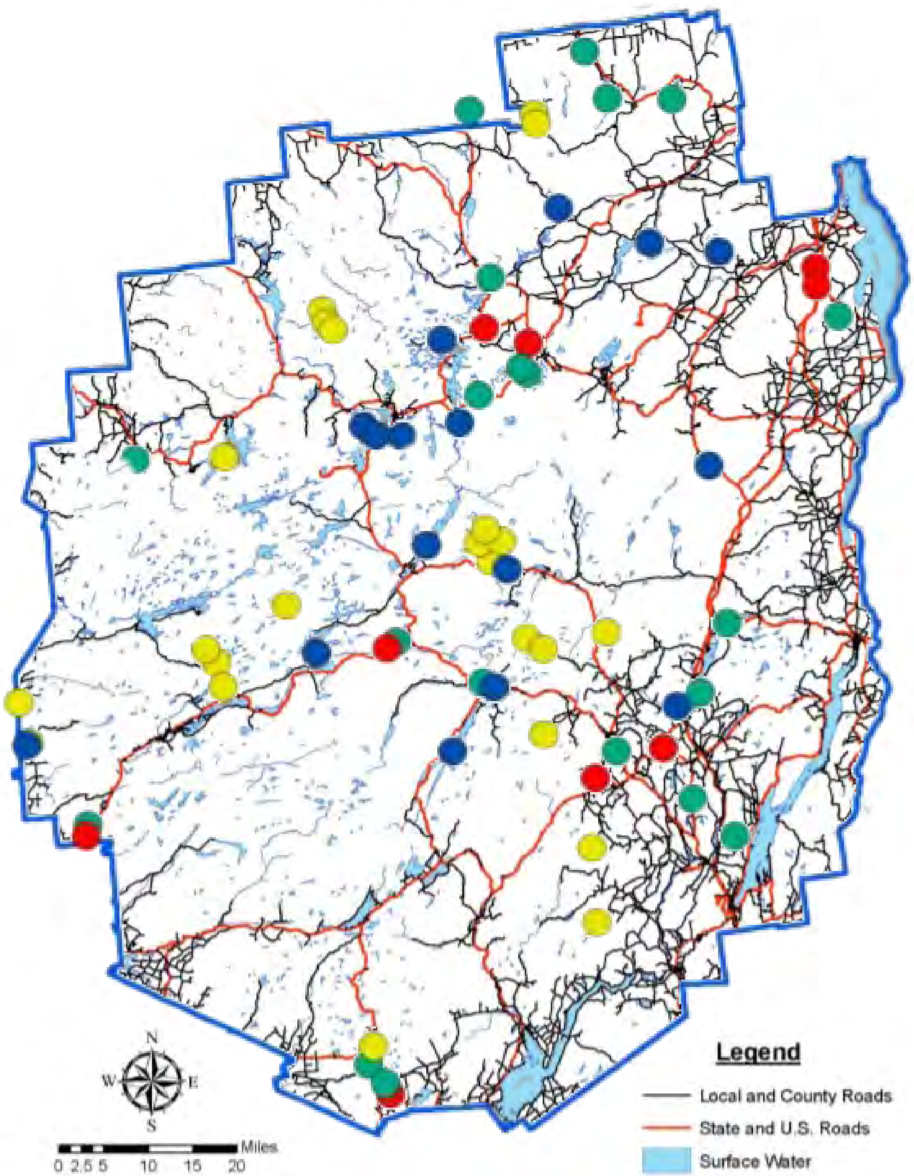
Source: WSIO Indicator Data, 2018; Based on analysis of the proximity of impervious cover to water features done by EPA using NLCD 2011 Percent Developed Imperviousness dataset (October 2014 version) and NHDPlus2 NHD Snapshot (June 2014).

The Upper St. Lawrence watershed has the greatest percentage of waters near impervious surface, primarily due to developed areas around Ogdensburg, Waddington, Alexandria Bay, Clayton, and Cape Vincent along the St. Lawrence River. The Oswegatchie, Indian, and Raquette watersheds have between 12-20 thousand miles of waterbody length within 30 m of areas with 15% impervious cover.

Studies found a high correlation between road density and sodium and chloride concentrations, pointing to road salt as the primary source of salt loadings to lakes (Kelting, Laxson, & Yerger 2012). This same study found that roads maintained following NYSDOT deicing protocols (state roads) are the greatest contributors to salinization of lakes in the Adirondack Park. **Figure 12** illustrates the proximity of road networks to waterbodies of the Adirondack Park. About 208,000 metric tons of road salt (NaCl) is applied to roads in the Adirondack Park every year, this equals an average application rate of 23 tons per lane kilometer of state roads (Laxson *et al.*, 2019). In addition, coarse texture glacial till and soils of granitic origin have high infiltration rates and low retention within the soil matrix, contributing to the rapid and increased migration of salts to aquifers and groundwater.

Salted roads are hydrologically connected to 77% of the surface water in the Adirondack Park (Regalado and Kelting, 2015). Roughly 72% of lakes assessed as part of the Adirondack Lake Assessment Program (ALAP) by the Adirondack Watershed Institute are influenced by road salt, with many of those lakes containing anywhere from 10-170 times the background concentration of chloride of 0.3-0.5 mg L^{-1} (Laxson *et al.*, 2019).

Figure 12
Surface Water and Road Network in the Adirondack Park



SOURCE: Laxson *et al.*, 2018 for the road salt condition status of lakes. Laxson & Kelting, 2010 for the proximity of Adirondack Lakes to roads. Colored dots indicate road salt influence; blue, low influence (1-5 ppm chloride); green, moderate influence (5-20 ppm chloride); red, high influence (20-50 ppm chloride); and yellow, not significant (less than 1 ppm chloride).

The storage of deicing compounds is currently unregulated, and many municipalities have inadequate storage facilities, leaving deicing compounds exposed to the elements and increasing the potential for offsite transport. NYS updated its guidelines for snow and ice control in 2006 with revisions in 2012 (NYSDOT, 2012). The guidelines are maintained and updated by the Cornell Local Roads Program (CLRP) and form the basis for operator training conducted by the CLRP for NYSDOT.

These guidelines incorporate documents from the American Association of State Highway and Transportation Officials.

6.3.2.4 Hydromodification

Hydromodification is the alteration of the natural flow of water through a landscape that results from changes in land cover or channel modification. Road and streambank erosion, shoreline erosion, development, and the building of dams are examples of hydromodification. Seven percent (7%) of assessed stream miles in the St. Lawrence River watershed are impacted by hydromodification (WI/PWL, 2016).

Streambank and shoreline erosion. Sediment carried by rivers and streams draining large watersheds is primarily attributed to bank and channel erosion. When a stream is straightened or widened, whether via human manipulation or fast-flowing waters, its banks and shoreline can erode as the stream reestablishes a stable size and pattern. Vegetation removal and land use changes can contribute to more erosion. As sediments are released downstream, they can potentially settle in low-flow areas, altering stream flow and filling in areas that previously mitigated flooding. Banks and shorelines that are unvegetated, high sloped, and experience large flow rates during times of increased precipitation are more susceptible to erosion. The NY Riparian Opportunity Assessment assesses erosion potential and provides the data in a publicly available map at https://www.arcgis.com/home/webmap/viewer.html?webmap=a914e62f4ffc497ea05cbeaf203fb819. The heat map highlights HUC12s that receive runoff waters from steep, upslope areas that have a greater risk for erosion adjacent to the stream bank. McConnell Creek (Grasse River watershed) and Vrooman Creek (Oswegatchie River watershed) are ranked most vulnerable to erosion, with slopes of the Adirondacks also displaying some vulnerability.

Dams. Dams can alter hydrology, surface water quality, and aquatic habitat in the stream or river where they are located. There are 190 dams in the St. Lawrence River Watershed, shown on **Map 29**. Dams trap sediment and inhibit its transport downstream, altering both upstream and downstream habitat. Disrupting water flow and sediment transport by changing the quantity and timing of water flow affects the ecological web of a river system. For example, increased flow conditions are an important environmental cue for initiating the salmon run of Chinook salmon in the Salmon River. In recreational reservoirs impounded by dams, sedimentation is cited as a nuisance for swimmers and lakeshore residents, who experience difficulty navigating due to buildup of sediment and increased plant growth.

In some cases, a dam wall can block fish migrations or separate spawning habitats from rearing habitats. Barriers to stream connectivity have been mapped by the Northeast Aquatic Connectivity Project (https://maps.freshwaternetwork.org/northeast/#), depicting barriers such as road crossings and dams. In 2016, the Saint Regis Mohawk Tribe (SRMT) oversaw the removal of the Hogansburg

Dam at the mouth of the St. Lawrence River. The removal resulted in the connection of 441 km (274 miles) of river and stream migration routes to upstream spawning and nursery habitat, benefiting Walleye, Muskellunge, Atlantic Salmon, Lake Sturgeon, American Eel, and other species. This project marked the first removal of a hydropower dam in NYS. The North Atlantic Aquatic Connectivity Collaborative developed protocols for assessing road stream crossings for the Northeast, and maintains a map illustrating prioritized areas by HUC12 (found at TNC HUC12 Prioritization Tool under the Tools Tab at http://streamcontinuity.org/). However, it is important to note, barriers such as dams can play a beneficial role in preventing Sea Lamprey from accessing thousands of miles of additional spawning habitat and preventing the spread of other invasive species including Round Goby. The Great Lakes Fishery Commission has developed a Sea Lamprey control map that assesses barriers importance in preventing Sea Lamprey introductions (http://data.glfc.org/).

Development. Development, of urban and rural areas, or "back-country sprawl," is an emerging threat to aquatic ecosystems and water quality in the St. Lawrence River watershed. New development brings new roads, driveways, power and water lines, leach fields, invasive species, and other disruptions to the natural hydrography of the landscape. Culverts at road stream crossings can obstruct the passage of fish through tributaries, reducing aquatic habitat connectivity. Development also increases impervious surfaces in the watershed that can disrupt the natural flow of water. Studies have shown that water quality can be harmed when as little as 2% of a watershed is converted from natural vegetation to artificial hard surfaces (Adirondack Council, 2008).

Town of Clayton, NY
Photo Source: townofclayton.com

The Massena Power Canal was constructed in the early 1900s to provide hydroelectric power to the local community and Alcoa Inc., an aluminum smelting facility. The Canal connects the St. Lawrence Seaway to the lower Grasse River. The Grasse River was widened and deepened to accommodate the additional source of streamflow from the Canal and St. Lawrence Seaway. The river was altered to have steep banks that extend from shallow areas along the shorelines to a relatively deep and flat river bottom, spanning about 400 to 600 feet wide. The Power Canal was closed in 1958 upon completion of the Moses-Saunders Power Dam and Eisenhower locks system. In addition to widening the river and altering flows, the closing of the Massena Power Canal significantly reduced the volume of water transported through the Grasse River channel, resulting in low flow conditions throughout the river. Even under spring flows, velocities are still relatively low and difficult to measure with conventional equipment. The low flow velocities offer favorable conditions for the settling of solids entering from upstream, with one to three centimeters of solids deposited in the river bottom each year.

6.3.3 Point Sources

The Clean Water Act regulates point sources that discharge pollutants into a waterbody by requiring the discharger to have a National Pollutant Discharge Elimination Systems (NPDES) permit. The permit identifies the pollutant(s) of concern, the discharge allowance, and monitoring and reporting requirements. This system protects water quality by ensuring that the state's water standards are met and specifying acceptable levels of a pollutant, or pollutant indicator, in a discharge. NPDES sites in the St. Lawrence River watershed include publicly owned treatment works (39), combined sewer overflows (33), municipal separate storm sewer systems (2), stormwater constructs (8), industrial wastewater discharges (56), and concentrated animal feeding operations (72). NYSDEC's Info Locator map provides information about permitted facilities including links to permits. **Map 31** locates sources of pollution such as landfills, publicly owned treatment works, and industrial wastewater discharges.

6.3.3.1 Publicly Owned Treatment Works

Publicly owned treatment works (POTWs) are tasked with collecting municipal wastewater and treating it to meet discharge requirements before the effluent can be released into adjacent waters. Wastewater can contain pathogens, metals, suspended solids, residual chlorine, and trace contaminants that can threaten drinking water and recreational activity. Wastewater treatment plants (WWTPs) are cited as the suspected source of pollutants of 13% (3,130 lake acres) of assessed lake acres and 6% (410 miles) of assessed streams (WI/PWL, 2016). Sewage pollution discharge information is publicly accessible under the Sewage Pollution Right to Know Law (2013). **Table 12** lists POTWs within the St. Lawrence River watershed.

The Clean Water Act, passed in 1972, provided funding to support the construction and upgrade of wastewater treatment facilities, which led to a significant improvement in water quality. However, funding for maintaining and upgrading these systems has been greatly reduced, which coincides with the end of these systems' 30- to 40-year design lives. Many sewage treatment systems in small towns and villages are aging, inadequate, or operating beyond their capacity.

Table 12
Publicly Owned Treatment Works Permitted under NPDES

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
Upper St. Lawrence	041503010102	**Clayton (V) STP**	**NY0027545** **NYL027545**	
	041503010104	Alexandria Bay WWTP	NY0022501	St. Lawrence River
		Orleans/Alexandria Joint WWTP	NY0258059	St. Lawrence River
		Thousand Island Park STP	NY0030686	
		Us Coast Property At Wellesley Island	NY0022284	St. Lawrence River
	041503010107	Morristown (V) WWTF	NY0206997	
	041503010202	**Ogdensburg Secondary WWTP**	**NY0029831**	**St. Lawrence River**
		Waddington (V) WWTF	NY0030180	
	041503010203	Lisbon STF	NY0257559	St. Lawrence River
Oswegatchie	041503020102	Fine - T Wanakena Sewer District	NY0034533	
	041503020604	Edwards (V) WWTP	NY0023809	Oswegatchie River
	041503020802	***Gouverneur (V) WWTF**	**NY0020117** **NYR00E780**	**Oswegatchie River**
	041503020902	Dekalb Junction STP	NY0034762	Gulf Creek
	041503020904	Rensselaer Falls WWTP	NY0257613	Oswegatchie River
	041503021002	Heuvelton (V) WPCP	NY0027146	Oswegatchie River
Indian	041503030205	Antwerp (V) WWTP	NY0235890	Indian River
	041503030301	Evans Mills (V) WWTP	NY0024660	
	041503030303	Philadelphia (V) WWTP	NY0033022	Indian River
	041503030401	Theresa (V) WWTP	NY0207004	Indian River
	041503030501	Redwood SD	NY0215911	
	041503030505	Hammond (V) STP	NY0033561	
Grasse	041503040402	Hermon (V) WWTP	NY0257532	Elm Creek
	041503040404	***Canton (V) WWTP**	**NY0236586** **NYR00E591**	**Grasse River**
	041503040501	Madrid WPCP	NY0024635	Grasse River
	041503040502	***Massena (V) WWTP**	**NY0031194** **NYR00E618**	**Grasse River**
Raquette	041503050409	**Tupper Lake (V) WPCP**	**NY0029939**	**Raquette River**
	041503050604	Colton STP	NY0022012	Raquette River
	041503050703	Norfolk (T) SD#1	NY0023604	Raquette River
	041503050703	**Norwood (V) WWTP**	**NY0021369**	**Raquette River**
		Potsdam (V) WPCP	**NY0020818**	**Raquette River**

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
			NYR00E695	
	041503050703	Potsdam Sewer District #1 STP	NY0023337	Raquette River
St. Regis	041503060303	N. Lawrence & Nicholville STP	NY0110116	Saint Regis River
	041503060405	St Regis Falls WWTP	NY0255858	Saint Regis River
	041503060408	Brasher Falls SD#1 STP	NY0030732	
Salmon	041503070302	**Malone (V) WWTP**	**NY0030376**	**Salmon River**
	041503070306	High Street WWTP	NY0027863	Salmon River
Chateaugay-English	041503080102	Lyon Mountain SD WWTP	NY0239577	Separator Brook
	041503080104	Brainardsville SD#1 WWTP	NY0255726	
	041503080201	**Chateaugay (V) STP**	**NY0024830**	

SOURCE: Enforcement and Compliance History Online (ECHO), USEPA
NOTE: Bold rows are "major" permit types; Asterisks (*) denote facilities that receive industrial stormwater.

6.3.3.2 Stormwater Collection Systems

Stormwater Collection
Photo Source: Capitol Region Watershed District

Stormwater runoff is generated when water from rain and snowmelt events flows over land or impervious surfaces and does not seep into the ground. If runoff is not captured or treated, it can accumulate and transport nutrients, chemicals, sediment, and other pollutants that adversely affect water quality in receiving waters. Urban and developed areas with a higher concentration of impervious surfaces are more vulnerable to the impacts of stormwater runoff. Stormwater impacts seven percent of assessed streams (410 miles) and one percent of assessed lakes (634 acres) in the St. Lawrence River watershed (WI/PWL, 2016). The CWA regulates combined sewer overflows (CSOs), municipal separate storm sewer systems (MS4s), industrial facilities, and construction sites to prevent and monitor discharges of pollutants in stormwater runoff.

Combined Sewer Overflows. Combined sewer systems collect water from domestic sewers and wastewater, industrial wastewater, and stormwater runoff. These systems are designed with relief points to mitigate periods of high flow. A CSO occurs when stormwater runoff from precipitation or snowmelt exceeds the sewer's capacity and excess waters are discharged directly to its receiving waterbody through the built-in relief points. CSO discharges may contain mixtures of domestic sewage, high levels of suspended solids, toxic chemicals, floatable material, and other pollutants. In the event of an overflow, receiving waterbodies may be hazardous for human and animal health and have significant water quality impacts such as bacterial contamination, algae growth, and reduced oxygen levels in the water. As permittees, municipalities are required to comply with long-term control plans that present mechanisms to reduce the frequency and volume of CSO discharges. Popular methods include separating stormwater and sewer lines, expanding wastewater treatment capacity, creating retention basins to hold overflow during storm evens, and using green infrastructure to reduce stormwater flows.

There are 33 permitted CSOs in the St. Lawrence River watershed (**Table 13)**. CSOs are concentrated in the City of Ogdensburg, and Villages of Massena, Clayton, Tupper Lake, Gouverneur, and Potsdam. The highest number of CSOs exist within the City of Ogdensburg, with 17 overflows monitored and owned by the City of Ogdensburg WWTP. The Village of Massena monitors ten CSOs operated by the Massena WWTP. The NYSDEC website presents a mapping tool showing the locations of CSOs within the state.

Table 13
Permitted CSOs

HUC8	HUC12	Receiving Waterbody	Permit ID	Facility Owner	Operating CSOs
Grasse	041503040502	Grasse River	NY0031194	Village of Massena, WWTP	5
Raquette	041503050706	Raquette River	NY0031194	Village of Massena, WWTP	5
	041503050409	Raquette Pond	NY0029939	Village of Tupper Lake, WPCP	2
	041503050703	Raquette River	NY0020818	Village of Potsdam, WPCP	1
Oswegatchie	041503020802	Oswegatchie River	NY0020117	Village of Gouverneur, WWTF	1
	041503021003	Oswegatchie River	NY0029831	City of Ogdensburg, WWTP	10
Upper St. Lawrence	041503010202	St. Lawrence River	NY0029831	City of Ogdensburg, WWTP	7
	041503010102	St. Lawrence River	NY0027545	Village of Clayton, STP	2

SOURCE: CSO Outfalls Google Earth Map, NYSDEC; Enforcement and Compliance History Online (ECHO), USEPA.

Municipal Separate Storm Sewer Systems. The St. Lawrence River watershed hosts two MS4s, serving areas within the Indian River subwatershed at Fort Drum and the adjacent town, LeRay (**Table 14**). These systems utilize a collection of structures, including retention basins, ditches, roadside inlets, and underground pipes, to gather stormwater from flooded areas and discharge it into local streams and rivers without treatment. Many rural developments use similar stormwater management structures, but only communities that the US Census Bureau classifies as "urbanized areas" (based on population density) are required to become part of the MS4 program and retain a permit. Urbanized areas contain more impervious surfaces and development that leads to increased stormwater runoff. In conjunction with retaining an NPDES permit for these systems, communities are required to develop a stormwater management plan and six minimum control measures.

Table 14
Permitted MS4s

HUC8	HUC12	Receiving Waterbody	Permit ID	Facility Name	Operating MS4s
Indian	041503030301	West Creek	NYR20A556	Fort Drum	Base-wide, Fort Drum
			NYR20A557	LeRay	Town-wide, Evan Mills

SOURCE: Enforcement and Compliance History Online (ECHO), USEPA.

Jefferson County established a Stormwater Coalition in 2014 in order to comply with federal stormwater regulations and improve water quality in a cost-effective manner (https://jcnystormwater.com/coalition/). Public participation is a key element of the MS4 Permit requiring that certain documents be made available to the public including an annual report and stormwater management program goals and implementation documents.

Industrial Wastewater and Stormwater. Industrial wastewater may contain pollutants at levels that have adverse impacts on water quality. Effluents may contain components that interfere with POTWs that receive their wastewater. Industry and construction are often exposed to the weather, where runoff from rainfall or snowmelt can potentially transport pollutants to stormwater catchments or adjacent waterbodies. The NPDES permitting program establishes discharge limits and conditions for industrial sources with specific standards relevant to the type of industrial activity. Relevant subjects to regulation in the St. Lawrence watershed subject include sand and gravel storage sites, mines, manufacturing and solid waste management facilities. **Table 15** lists industrial facilities subject to the NPDES permitting system.

Table 15
Industrial Wastewater and Stormwater Sites Permitted under NPDES

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
Upper St. Lawrence	041503010101	French Creek Marina	NYR00A10F	St. Lawrence River
	041503010102	Northern Marine Inc	NYR00A494	St. Lawrence River

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
	041503010106	Stout's Ready Mix Ltd.	NYR00F161	Chippewa Creek
	041503010107	Acco Brands USA LLC	NYR00E721	St. Lawrence River
	041503010201	Acco Brands	NYR00G008	
		Maxam Us, LLC	NYR00F749	
		Ogdensburg Distribution And Manufacturing Facility	NYR00F496	
		Ogdensburg Power Plant	NYR00D126	
	041503010202	Port of Ogdensburg	NYR00A860	St. Lawrence River
Oswegatchie	041503020503	Viking Cives Inc USA	NYR00B403	West Branch Oswegatchie River
	041503020702	Bestway of New York	NYR00F489	
	041503020801	Gouverneur Division, #1 Mill And #2 Mine	NYR00A595	
		Gouverneur Division, #3 Mill	NYR00A894	
	041503020802	Cargill Feed and Nutrition Gouverneur	NYR00C212	Oswegatchie River
		Cives Steel Company	NYR00B413	
		Dunn Paper - Natural Dam Inc	NYR00F629	Oswegatchie River
	041503020804	Seavey Road Quarry	NYR00B614	Oswegatchie River
	041503020902	Stiles Used Auto Parts	NYR00G028	
		Losurdo Foods Inc	NYR00D375	Oswegatchie River
		Sunopta Aseptic Inc	NYR00E518	Oswegatchie River
	041503021003	Ogdensburg International Airport	NYR00A859	
Indian	041503030102	Gouverneur Division, #4 Mine	NYR00B205	Clark Creek
	041503030301	Building 2084 - Jp-8 Storage Tanks	NYR00F375	Black River
		Building 21510 Central Vehicle Wash Facility	NYR00F376	Black River
		Fort Drum Military Installation	NYR00E835	
Grasse	041503040303	Poulin Grain Inc	NYR00F610	Tracy Brook
	041503040406	Canton Usarc	NYR00C438	Grasse River
		St Lawrence County Manufacturing & Properties LLC	NYR00A798	Grasse River
		Witherbee And Whalen Inc	NYR00B829	Grasse River
	041503040502	Massena Energy Facility	NYR00E893	Robinson Creek
Raquette	041503050603	UPS-Potsdam	NYR00C046	Plum Brook
	041503050604	Potsdam Quarry And Concrete	NYR00F954	Stafford Brook
		Waste-Stream Inc	NYR00D032	Stafford Brook
	041503050703	Knapps Station Facility	NYR00B231	
		Norwood Facility	NYR00B658	Raquette River
	041503050704	Potters Industries, LLC	NYR00D568	Raquette River
	041503050706	Massena Ready Mix Plant	NYR00G151	
		Massena Terminal Railroad Company	NYR00D761	Raquette River

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
Salmon	041503070204	Malone Quarry	NYR00F957	Farrington Brook
	041503070302	Malone Ready Mix Plant	NYR00G126	Salmon River
		Westville Facility	NYR00B660	
	041503070303	Malone Distribution Warehouse	NYR00G146	
Chateaugay-English	041503080102	Wi Ore Sand	NYR00F865	Separator Brook
	041503080103	Lyon Mountain Convenience Sta	NYR00E340	
	041503080201	McAdam Plant Chateaugay	NYR00D497	Marble River
	041503080202	Clinton Quarry	NYR00F955	
	041503080203	Grasslands	NYR00D031	
	041503080301	Waste Stream Management Transfer Station	NYR00D595	
	041503080303	County of Franklin Solid Waste Management Authority	NYR00D523	
	041503080406	Mooers Transfer Station	NYR00D597	English River
	041503080501	Churubusco Convenience Station	NYR00E548	Hinchinbrook Brook

SOURCE: Enforcement and Compliance History Online (ECHO), USEPA.

6.3.3.3 Concentrated Animal Feeding Operations

Animal feeding operations and their associated manure and wastewater contribute nutrients, pathogens, organic matter, hormones, and antibiotics to the environment. Agricultural animal feeding operations are defined by the following conditions:

- Animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and
- Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility

Animal feeding operations that meet the regulatory definition of a *concentrated* animal feeding operation (CAFO) are considered point sources, as defined by the CWA [Section 502(14)] and regulated under the NPDES permitting program. CAFOs are classified by the type and number of animals they contain, and the way they discharge waste into a waterbody. A CAFO is defined as a "large" when 1,000 or more head cattle are present (including heifers, steers, bulls, and cow/calf pairs). A "medium" CAFO" has 300-999 head and meets one of the criteria below:

- Pollutants are discharged into waters through a manmade ditch, flushing system, or other similar manmade device, or
- Pollutants are discharged directly into waters that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation (122.23(b)(2)).

"Small" CAFOs—those with fewer than 300 animal units—are designated CAFOs on a case by case basis, depending on factors such as size, manure production, location relative to waters, slope, vegetation, rainfall, and other factors that affect the likelihood and frequency of discharge to waters.

There are 69 CAFOs permitted under the NPDES program in the St. Lawrence River watershed (**Table 16**). CAFOs with effective coverage under the general permit also submit CAFO-specific nutrient management plans, which provide information on production and land application areas, best management practices, an implementation schedule, and an emergency action plan. These plans and permits are essential to reducing the risk of nutrient and pathogen transport to surface and groundwaters from agricultural activities.

Table 16
CAFOs Permitted under NPDES

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
Upper St. Lawrence	041503010102	Bourcy Farm Property	NYA001542	
		Wood Farms LLC	NYA000351	
	041503010106	Pitcher Farms	NYA000579	
	041503010107	Beamish Farm	NYA000547	
	041503010202	Woodcrest Dairy LLC	NYA000561	
	041503010203	Five Mile Farms	NYA000071	
		Flack Farms	NYA000628	
		Harvest Dairy Farm	NYA000267	
		Keystone Dairy	NYA001385	Squaw Creek
		Lisbon Centre Farms, LLC	NYA000565	
	041503010204	Brandy Brook Haven Farms, LLC	NYA001374	Brandy Brook
		Brandy View Farms	NYA000615	Brandy Brook
		Ceda-Meadow Farm	NYA000448	
	041503010205	Fobare Lake Farm	NYA001380	Coles Creek
		River-Breeze Farm	NYA000083	Grasse River
		Corscadden Family Farm	NYA000207	
Oswegatchie	041503020902	Mclean Farms	NYA001432	Line Creek

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
	041503020903	Martin Farm	NYA000076	Merrill Creek
	041503020904	Kelly Farm	NYA000573	Beaver Creek
		Rainbow Acres	NYA001386	
	041503021002	Chambers Farms LLC	NYA000013	Oswegatchie River
	041503021003	Bruce Nichols	NYA000569	
		Fishel Farms LLC	NYA000498	
		Royal-J-Acres LLC	NYA000090	
		Virgil Valley Farms	NYA000480	
		Pominvilles Farm	NYA001556	Indian River
Indian	041503030303	Leuze Farms	NYA000354	Indian River
		Thompson Farm Property	NYA001538	
	041503030504	Dori B S Farm	NYA000461	
		Shady Brook Farm	NYA001578	Mud Lake Outlet
	041503030505	White Acre Farms	NYA000560	
Grasse	041503040401	Gebarten Acres	NYA001325	
	041503040402	Gotham Family Farm, LLC	NYA000162	
	041503040404	Greenwood Dairy Farm, LLC	NYA000067	Nettle Creek
		Lloyd T. Smith & Sons	NYA001394	Grasse River
	041503040406	Jordan Farms	NYA000206	Grasse River
		Kingston Brothers Farm	NYA000515	Grasse River
		Teriele Family Dairy, LLC	NYA000428	
	041503040501	Mapleview Dairy LLC	NYA000059	
		Paradise Valley Farm	NYA000020	Grasse River
Raquette	041503050603	Snell Farm	NYA001369	
	041503050604	Adon Farms	NYA000092	
		Chambers Dairy	NYA001424	
St. Regis	041503060302	Durant Farms	NYA000581	Allen Brook
		Dutch Pride Farm	NYA001357	
		New Beginnings	NYA000073	
		Roberts Dairy Farm LLC	NYA001329	

HUC8	HUC12	Facility Name	NPDES ID	Receiving Waterbody
	041503060303	Stauffer Farms	NYA000489	Deer River
	041503060305	Tri Oak Lea Farm	NYA001519	
	041503060406	Norco Farms	NYA000068	Hopkinton Brook
	041503060407	Adirondack Heifer Management, Inc.	NYA000082	
Salmon	041503070203	Jimali Holsteins	NYA001320	
	041503070302	A. Miller	NYA001431	
		Dan's Dairy LLC	NYA001458	Salmon River
	041503070303	Carsada Farms	NYA001292	East Branch Deer Creek
		Clearview Dairy	NYA001355	
		Ellsworth Farms	NYA001339	
		Monica Farms	NYA001321	East Branch Deer Creek
		Papas Dairy, LLC	NYA001315	
		White's Dairy Farm LLC	NYA001316	West Branch Deer Creek
	041503070305	Brockway Hilltop Farm	NYA001289	Pike Creek
Chateaugay-English	041503080201	Brior Farm	NYA001537	Marble River
	041503080203	Trainer Farm, LLC	NYA001310	
	041503080204	Sunset Lake Farm #2 LLC	NYA00C010	Allen Brook
		Swanston Farms, Inc.	NYA001313	Allen Brook
	041503080205	Shipman Farm LLC	NYA001452	Flynn Brook
	041503080303	Metcalf Farms	NYA001317	
	041503080402	Lamberton Farms	NYA000542	English River

SOURCE: Enforcement and Compliance History Online (ECHO), USEPA

6.3.3.4 Legacy Industrial Waste Disposal Practices

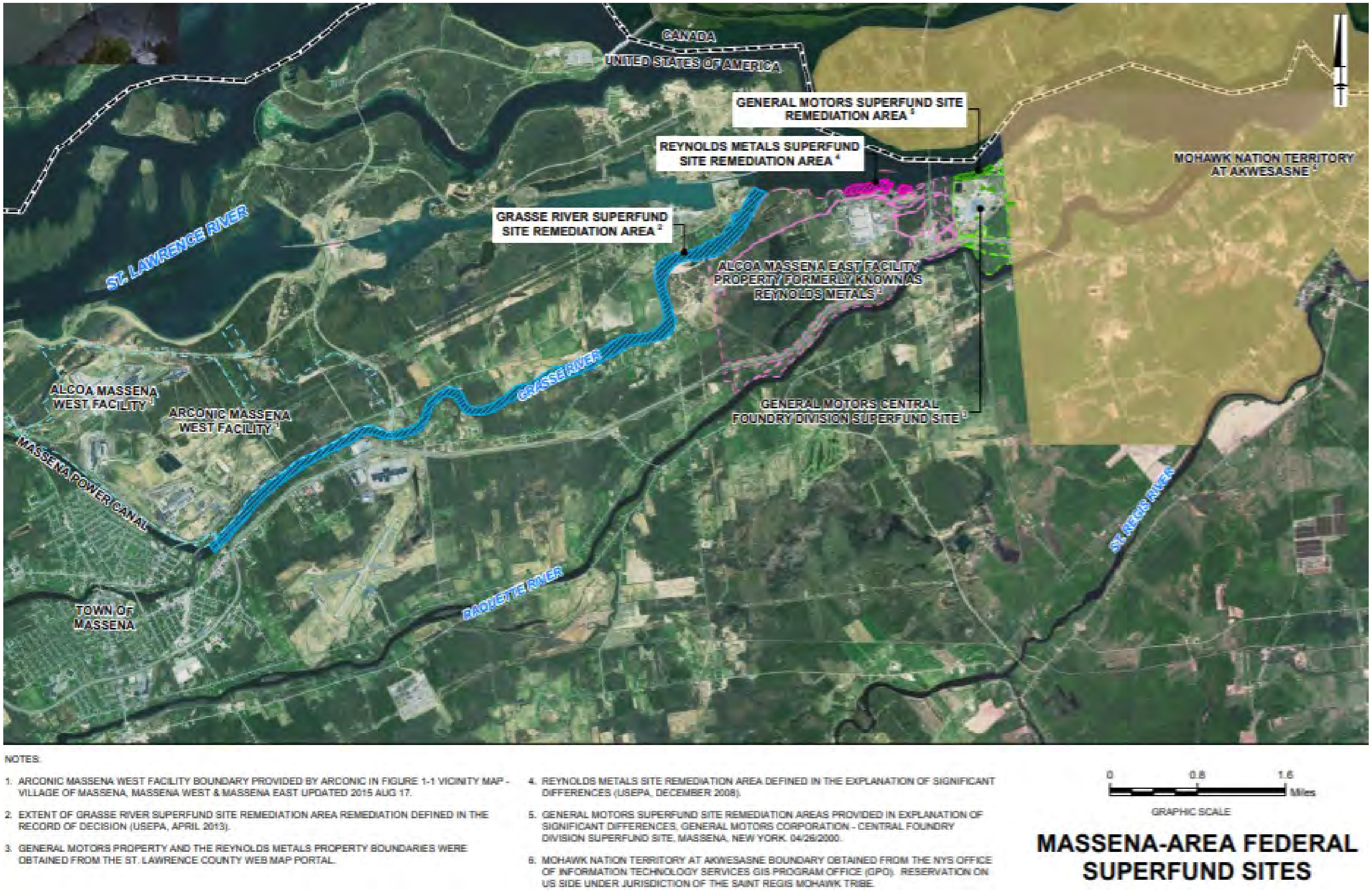
The St. Lawrence River watershed has been affected by industrial production and improper waste disposal practices that resulted in contamination of sediments and waterways. The Massena area in northeastern St. Lawrence County, once an industrial powerhouse, is now addressing pollution resulting from past waste management practices. Priority organics (PAHs, PCBs) and pesticides have contaminated 875 stream miles (14% of assessed miles), and 700 miles are suspected to be contaminated due to improper industrial waste disposal practices. The threat to human health from consumption of contaminated fish resulted in designation of the St. Lawrence River at Massena as a Great Lakes Area of Concern, inclusion on the National Priority List, and implementation of Federal and State Superfund restoration activities at the sites (**Figure 13**).

The boundaries of the Area of Concern (AOC) are mapped in **Figure 14**. The area includes waters of the St. Lawrence River upstream of the Canadian boundary to the Massena public water supply intake, the Grasse River from its mouth upstream to the breached dam in the village of Massena, the Raquette River from its mouth upstream to the NYS Route 420 bridge, and the St. Regis River from its mouth upstream to the dam at Hogansburg. Remediation and restoration actions are outlined in the Remedial Action Plan (RAP). RAPs are developed in three stages.

- Stage 1: identifies specific problems, called Beneficial Use Impairments, and sources of pollution. The Massena Stage I RAP was completed in November 1990.
- Stage 2: proposes restoration actions and implementation plan. The Stage II RAP was completed in August 1991.
- Stage 3: provides documentation that all Beneficial Use Impairments in an AOC have been addressed and that the AOC is ready to be delisted. Stage III remains in progress. Currently, water, sediment, and biota within St. Lawrence River AOC are being tested to evaluate whether the Massena area cleanup efforts have improved the local ecosystem to a point where specific Beneficial Use Impairments have been restored. NYSDEC and the SRMT recently collaborated on an assessment of fish tissue contamination from fish sampled from waters in proximity to the AOC on the St. Lawrence River and its adjoining tributaries. The report provided data necessary to update fish advisories and examine impairments. Fish sampled inside the AOC were found to have significantly more contamination than fish sampled outside the AOC, with the greatest risk to fish consumers driven by PCB concentrations (Skinner, David, & Ritcher, 2018).

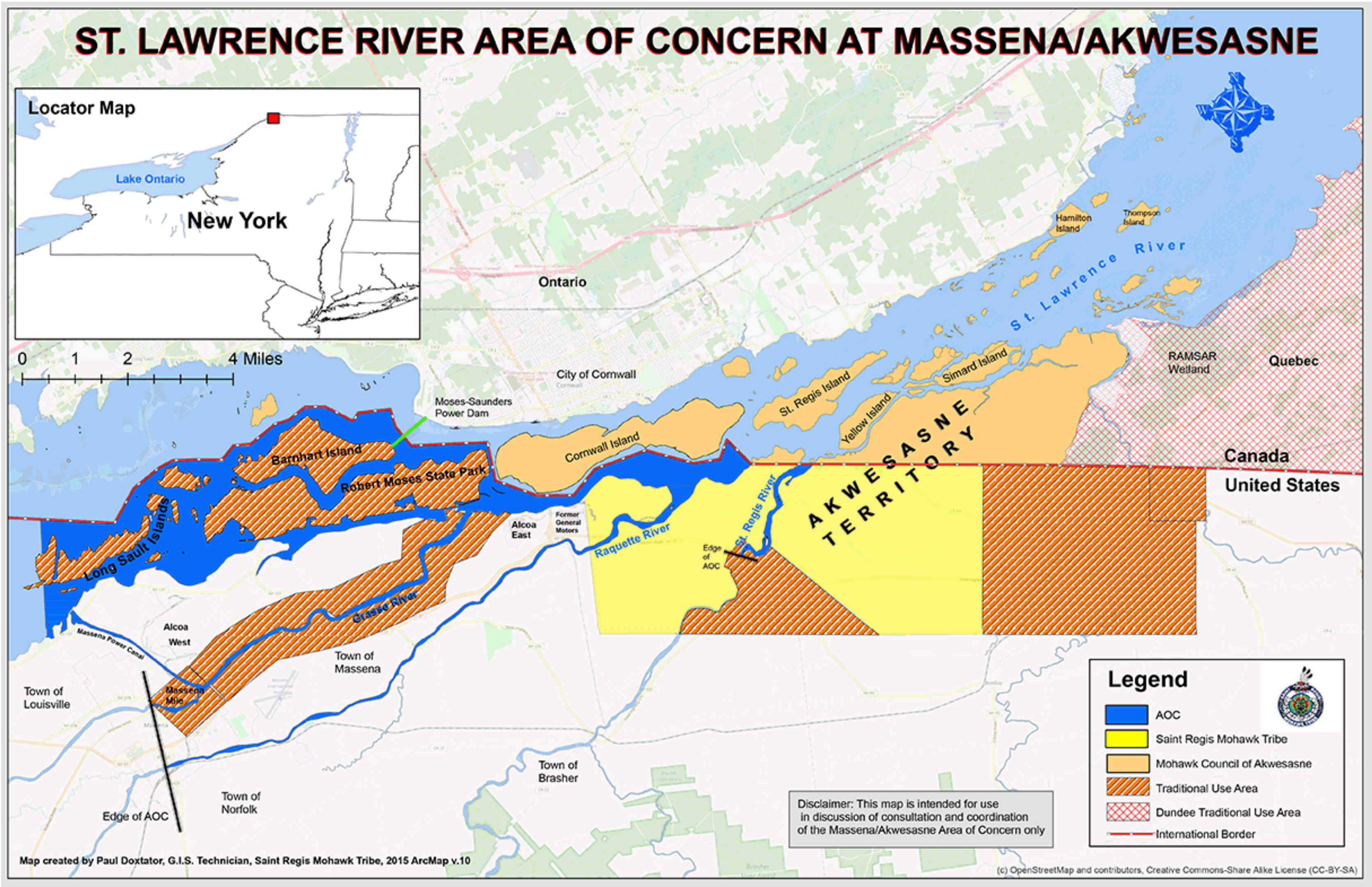
Remedial Action Plans and other relevant information are available at the St. Lawrence River at Massena Area of Concern website maintained by NYSDEC https://www.dec.ny.gov/lands/98794.html.

Figure 13
St. Lawrence River Area of Concern at Massena/Akwesasne



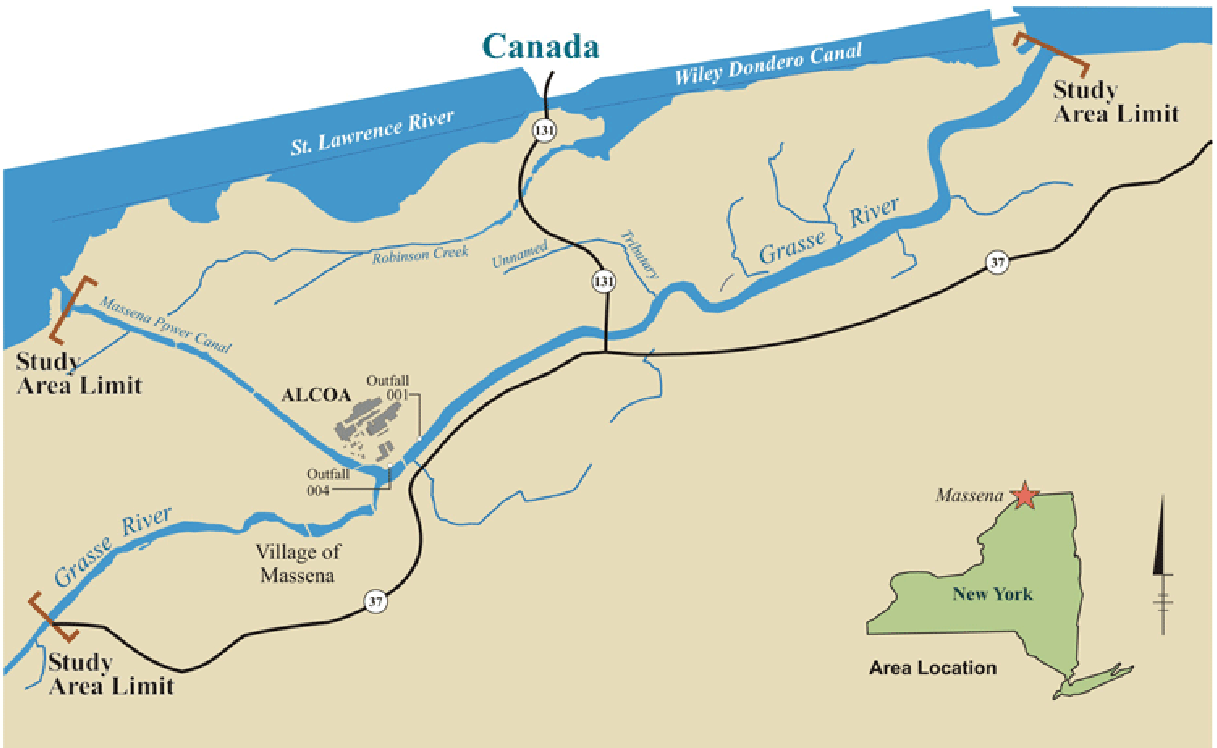
SOURCE: USEPA, Site Area Map, 2017.

Figure 14
St. Lawrence River Area of Concern Boundary Map



SOURCE: USEPA, St. Lawrence River AOC Boundary Map, Great Lakes AOCs, 2015.

Figure 15
Grasse River Project Study Area

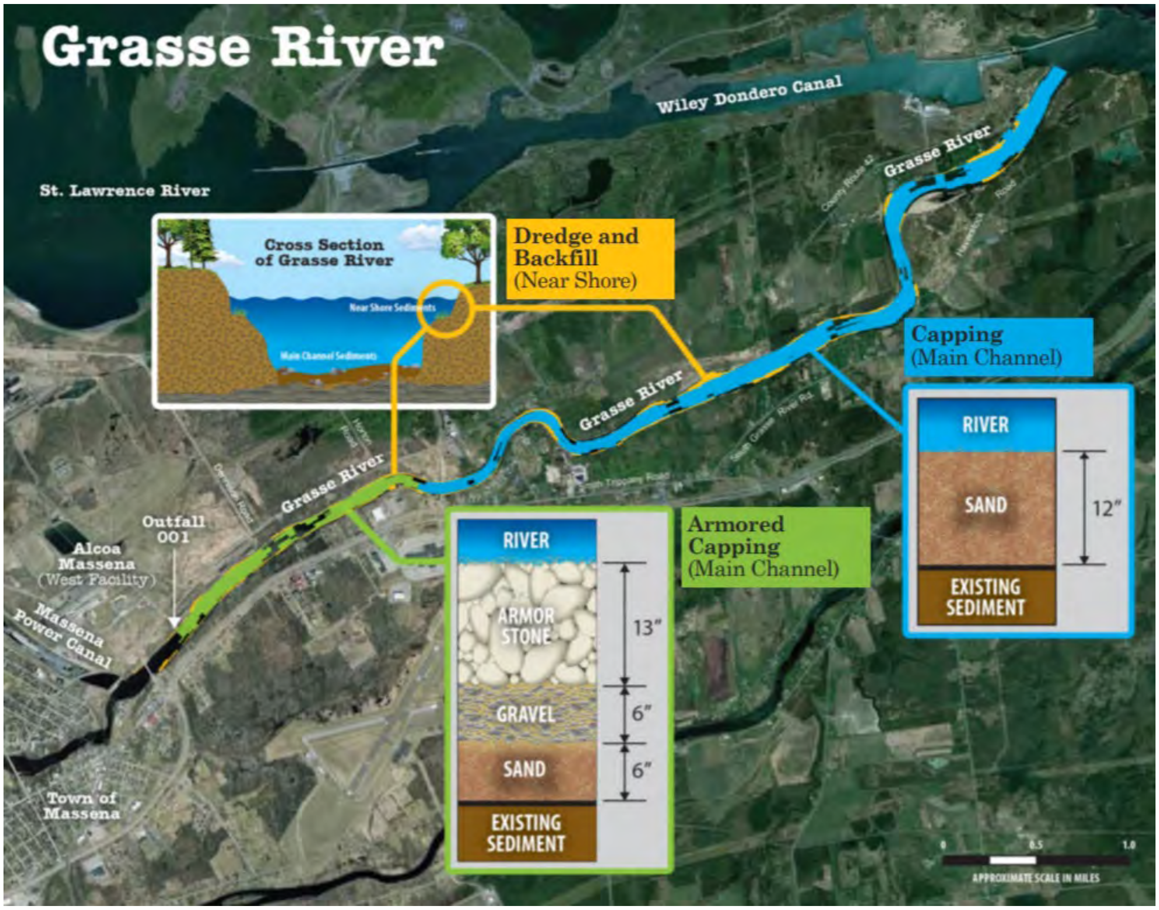


Not to Scale

SOURCE: [Grasse River Project, http://www.thegrasseriver.com/about.html](http://www.thegrasseriver.com/about.html)

Grasse River Superfund Site In 1990, the NYSDOH advised the public to not eat any fish from the mouth of the Grasse River to the Massena Power Canal. From 1995 to 2001, Alcoa completed some dredging and capping of the contaminated site, but a severe ice jam event in the Grasse River damaged a portion of the capping, so subsequent monitoring and remediation is needed. In 2013, the USEPA issued a record of decision (ROD) which selected a final cleanup plan for the Grasse River Superfund site. As shown in **Figure 16**, the cleanup consists of some near-shore dredging, capping and armored capping in a 7.2 mile stretch of the lower Grasse River and the St. Lawrence River (USEPA, 2013). The plan also requires monitoring of fish, water and habitat, along with long-term monitoring of the capped areas to ensure that the caps remain intact. In November 2016, Alcoa separated into two companies – Alcoa Corp. and Arconic. Upon separation, Arconic assumed responsibility for the Grasse River remediation project. Arconic continues to work with the EPA, NYSDEC, and the SRMT to implement the EPA Record of Decision for the Grasse River remediation project. More information and updates can be found at the Grasse River Project website, http://www.thegrasseriver.com/.

Figure 16
Grasse River Project Remediation Strategy



SOURCE: Grasse River Project, http://www.thegrasseriver.com/

Reynolds Metals Superfund Site, (EPA ID: NYD091972554)**.** The Reynolds Metals Company operated a 1,600-acre facility on the St. Lawrence River, approximately eight miles east of the village of Massena. The facility is now owned and operated by Alcoa Corp. Industrial wastes contaminated with PCBs and PAHs were discharged into river through four permitted outfalls. The USEPA issued a Unilateral Administrative Order ordering investigation and cleanup of the site to address contamination of river sediments. An excavation program was implemented in 2001 which removed 20,200 pounds of PCBs from the St. Lawrence riverbed (USEPA, 1993). Dredging and capping of remaining contamination was completed in 2009 with ongoing cap and erosion monitoring. The Superfund program conducts assessments every five years to evaluate the continued effectiveness of remediation. The last site assessment occurred in 2016 and USEPA concluded that the remedial measures remain protective of human health and the environment.

General Motors, Central Foundry Division Superfund Site, (EPA ID: NYD091972554). In 1984, a 270-acre site in Massena was added to the Superfund National Priorities List. General Motors produced aluminum cylinder heads and operated as an aluminum die-casting plant from 1959 to 2009. This site lies between the St. Lawrence River to the north, the SRMT to the east, and the Raquette River to the south. Various industrial wastes were deposited on-site resulting in contamination of two disposal areas, an industrial landfill, and four industrial lagoons. PCB contamination of groundwater, on-site and off-site soils, and sediment in the St. Lawrence and Raquette Rivers, Turtle Cove, and Turtle Creek have been documented. Cleanup work is carried out by the current owner of the site, RACER Trust, which was created through the GM bankruptcy in 2011, and overseen by the EPA, SRMT Environmental Division, and NYSDEC. In 1987, the industrial landfill was capped to prevent migration of contaminants. Dredging and excavation of contaminated materials, followed by on-site treatment and disposal of residual contamination, and groundwater extraction and treatment were selected remediation strategies outlined in the USEPA's 1992 ROD (USEPA, 1992). This site is still undergoing cleanup, including construction of a groundwater collection and treatment system and dredging of a ten million-gallon lagoon. Cleanup work is expected to be completed in 2020.

J&L Steel/Benson Mine (NYSDEC Site Code: E645029). The former J&L site is in the northwestern corner of the Adirondack Park along the border of the Towns of Clifton and Fine. The 54-acre site mined iron ore from 1889 through the late 1970s. The US Defense Plant Corporation built a processing plant on site to expand US production capabilities of military equipment. In the 1950s, this site was the largest open pit magnetite mine in the world, employing up to 1,000 people.

Processing operations led to soil and groundwater contamination by substances including friable asbestos, polychlorinated biphenyls (PCBs), metals, and petroleum. In 1988, NYSDEC was notified of an oil spill in the Little River, a tributary to the Oswegatchie River adjacent to the mine. A polyvinyl curtain measuring 1,000 ft. by 15 ft. was installed to separate the contamination area from the Little River. The curtain has lost its effectiveness allowing oil to seep into the river. Cleanup funded by the Oil Pollution Act of 1990/Oil Spill Liability Trust Fund began in 2013.

St. Lawrence County applied to NYSDEC's Environmental Restoration Program (ERP) to complete site investigations and define remedial measures. The oil plume was found to extend over large portions of the lowlands south of the Little River and portions of the adjacent uplands. Eight PCB hot spots were identified, and sediment along the bank of the Little River was found to be saturated with petroleum, noting periodic releases of petroleum to a depth of at least eight feet. A Record of Decision (ROD) was issued in 2013 to remediate areas affected by the oil spill and PCBs under the NYSDEC's State Superfund Program (https://www.dec.ny.gov/docs/remediation_hudson_pdf/e645029rod.pdf).

6.4 Sensitive Areas

The St. Lawrence River watershed encompasses many sensitive areas, including lakes and streams, steep slopes, wetlands and hydric soils, floodplains, and primary aquifers (**Map 33)**. These areas provide multiple essential ecosystem services. For example, wetlands provide a buffer against flooding; woodlands and natural land cover of riparian areas buffer waterbodies from runoff; and intact vegetation stabilizes steep slopes prone to erosion. The St. Lawrence River watershed includes a large area within the Adirondack region exhibiting slopes greater than or equal to 15%; these are associated with a high risk of soil erosion. The plains of the northern region traversing the St. Lawrence River shoreline are dominated by emergent and forested wetlands, which are threatened by encroaching agricultural practices and changing land use patterns.

7 Emerging Issues

In addition to the previously mentioned stressors, climate change and water-level management are significant issues. Solutions to these problems require knowledge and a collaborative effort that transcends watershed boundaries. An ecosystem-based management approach, formalizing watershed planning as a continual process that engages stakeholders, is a viable path to solving such long-term, complex challenges.

7.1 Climate Change

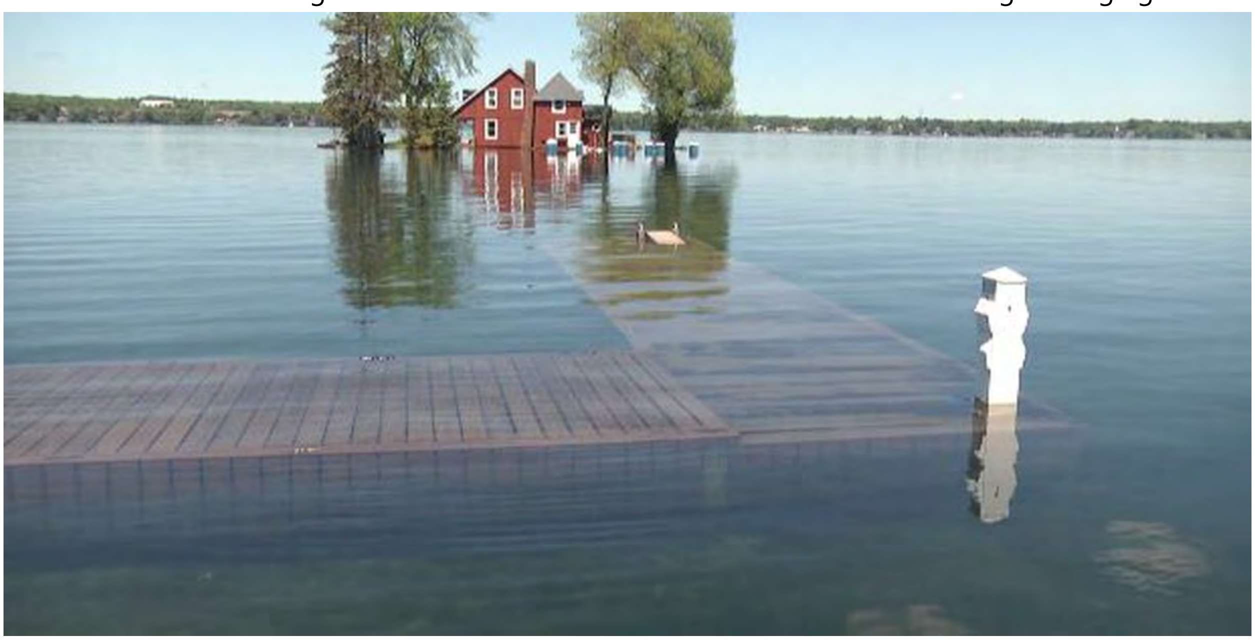
Seasonal differences in Northeast temperatures have decreased in recent years as winters have warmed three times faster than summers (Giroux *et a*l., 2018). The 4th National Climate Assessment for the Northeast and Great Lakes Regions predicts a 20% increase in precipitation delivered in heavy rainfall events, an increase in drought events, reduced ice over on the Great Lakes, and increased invasive species threats and vulnerability (Dupigny-Giroux *et al.,* 2018). A decrease in early winter snowfall and earlier snowmelt will lead to a shorter snow season. Winters are seeing a shift in the proportion of precipitation falling as rain or snow, with fewer days without temperatures below freezing resulting in decreased snow depth, fewer days without snow on the ground, and multiple snowmelt events each year. Changes in seasonal precipitation and frequency have been noted in recent years, with increases in heavy rainfall events in the spring and fall, and periods of low precipitation and drought during the summer months.

Climate change affects the severity of numerous water quality issues. Water resources are influenced by factors such as temperature, amount and duration of snowfall and snow cover, rainfall, and evaporation. Climate change has the potential to shrink water supplies for human desired uses and degrade the quality of remaining supplies. Warmer weather and more variable precipitation complicate efforts to manage both the natural and built environments. Heavy rains create hazardous runoff conditions and increase vulnerability to flooding. Higher temperatures, changing precipitation and wind patterns, and increased nutrient-rich runoff exacerbate the risk of eutrophication. Changing precipitation patterns and a warming climate also threaten fish populations by decreasing the levels of dissolved oxygen, increasing water temperature and turbidity, and altering water flow. As these impacts are not due to local or point sources, adaptation strategies should incorporate resiliency and "smart growth" principles to help mitigate stress on waterbodies and prepare for the future.

The winter recreation industry is an important economic resource for rural areas and the Adirondacks and is strongly influenced by weather and climate, making it particularly vulnerable to climate change. Agriculture, a leading industry in the watershed, is expected to benefit from a changing climate over the next half-century due to greater productivity and a longer growing season. However, excess moisture is already a leading cause of crop loss in the Northeast (Dupigny-Giroux *et* *al.,* 2018) and intense precipitation can increase soil compaction and reduce the number of workable field days.

7.2 Floodplain and Water-Level Management

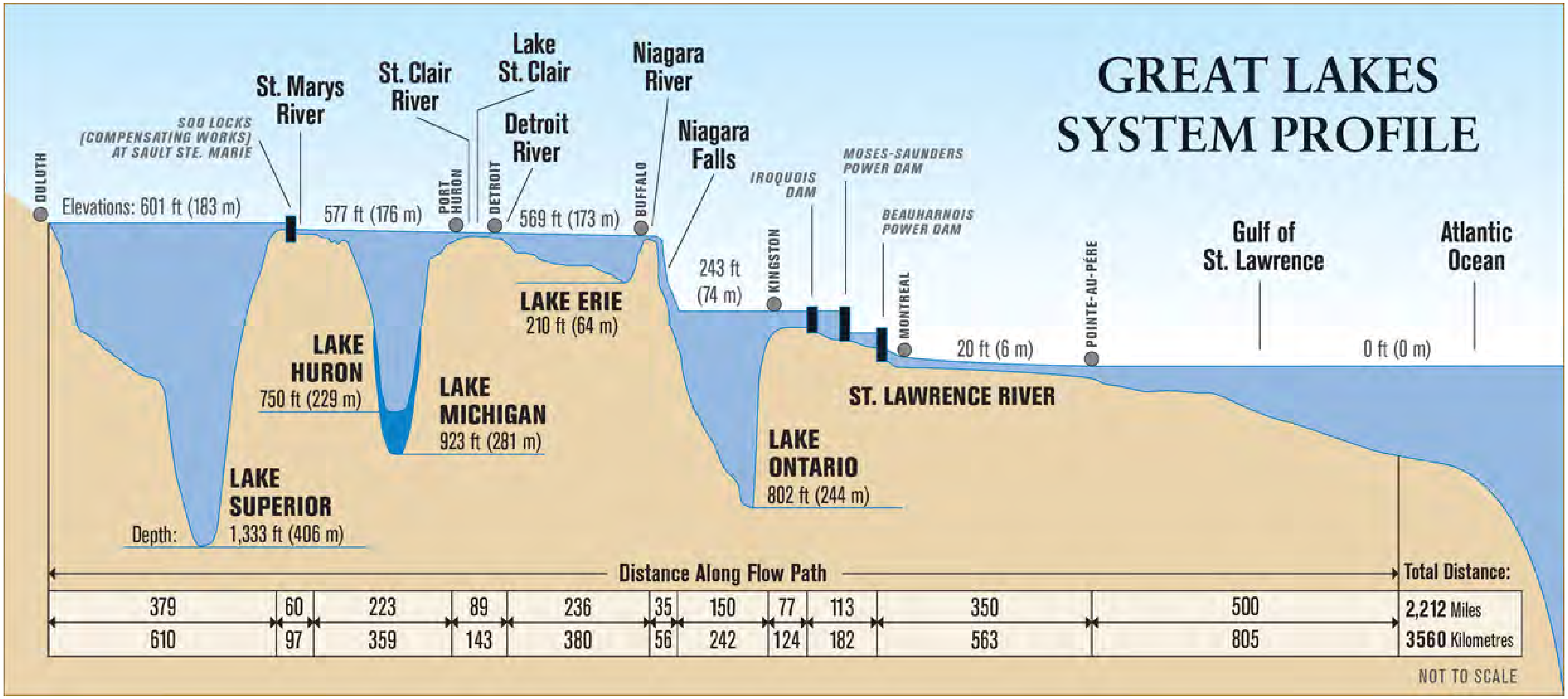
Many communities along the St. Lawrence River watershed and shoreline of Lake Ontario experienced extreme high water and flooding conditions in 2017 and 2019. Historically high rainfall across the Great Lakes Basin caused high water levels in upstream lakes and rivers, which flowed into Lake Ontario and out the St. Lawrence River. Water levels in the St. Lawrence River are primarily affected by Lake Ontario outflow. The Moses-Saunders and Long Sault Dams are the primary means of regulating Lake Ontario outflow. According to the IJC, changing the outflow by 323 cubic meters per second (m^3/s) for one week will change the level of Lake Ontario by only 1 cm; in contrast, this change in outflow modifies the St. Lawrence River level by 16 cm (IJC, 2014). If Lake Ontario's outflow rate is too low, shoreline communities will flood. At the same time, too little water released to the river will threaten river navigation and increase the risk of ship groundings. Large releases may reduce the risk of flooding Lake Ontario shoreline areas but increase river flooding. Managing this



Docks are submerged along the flooded St. Lawrence River
Photo Source: wwnytv.com

water system and balancing the risks to human uses along with the natural and built environment is complex and difficult. **Figure 17** illustrates the Great Lakes system profile, including depths and widths of waterbodies and important water-level control sites.

Figure 17
Great Lakes System Profile



Source: The Great Lakes Basin, map/poster, NOAA-Great Lakes Environmental Research Laboratory, Coastwatch

Widespread and record-setting precipitation in 2017 and 2019 brought significant water volumes and flooding to both Lake Ontario and the St. Lawrence River, affecting residents, business owners, and municipalities. Impacts from the flooding affect local economies due to expensive remediation and infrastructure repairs, decreased tourism, and damage to residential and business properties. Rapid runoff resulting from increased precipitation is expected to affect sediment and contaminant transport, impairing waterways and eroding shorelines. Alterations in flow patterns and consequential sedimentation of low-flow areas can decrease fish spawning and egg viability, biodiversity, and habitat. Adaptation strategies to flooding should focus on projects that contribute to the resiliency of shorelines and infrastructure to high volumes of water. These should involve infrastructure that enhances natural hydrologic processes (soil infiltration, groundwater recharge, evaporation) and slows the movement of water instead of rapidly conveying it to waterbodies.

The International Joint Commission (IJC) was established to resolve issues between the US and Canada under the 1909 Boundary Waters Treaty. As a committee within the IJC, the Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee undertakes monitoring, modeling, and assessment needed to support ongoing evaluation of the regulation of water levels and flows. In addition, IJC's International Lake Ontario-St. Lawrence River Board works alongside GLAM to ensure that outflows from Lake Ontario meet the requirements of the IJC order and communicate with the public about water levels and flow regulation. The International Lake Ontario-St. Lawrence River Board implemented Plan 2014 which sets the flow rate of the Moses-Saunders Dam, effective in January 2017. Plan 2014 generally works to:

- increase Lake Ontario outflows as water levels rise,
- reduce flows when the Ottawa River peaks,
- increase flows when downstream conditions improve, and
- prevent peak levels on both Lake Ontario and St. Lawrence River.

Major flooding has occurred in recent years (2017 and 2019) resulting in millions of dollars in damages. From January to June 2017, inflows to Lake Ontario were above average but did not set records. From January to March, inflows from Lake Erie combined with heavy rainfall and snowmelt caused Lake Ontario to rise 60 cm (2 ft), twice the normal rise for this time of year. In addition, unusual weather caused the St. Lawrence River to experience five freeze/thaw cycles during January to March. When ice is forming, the flow of water must be reduced to prevent ice jams that can potentially block the flow of water and cause localized flooding. April and May 2017 were two of the wettest months on record with historic precipitation records. Record flows from the Ottawa River, the outflow from Lake Ontario were adjusted nearly every day in an attempt to balance water flows. St. Lawrence County, in partnership with the City of Ogdensburg, and the Town and Village of Morristown is conducting an assessment of ecosystem vulnerability to determine how resiliency measure can be incorporated into local planning. Ongoing efforts and programs such as REDI aim to

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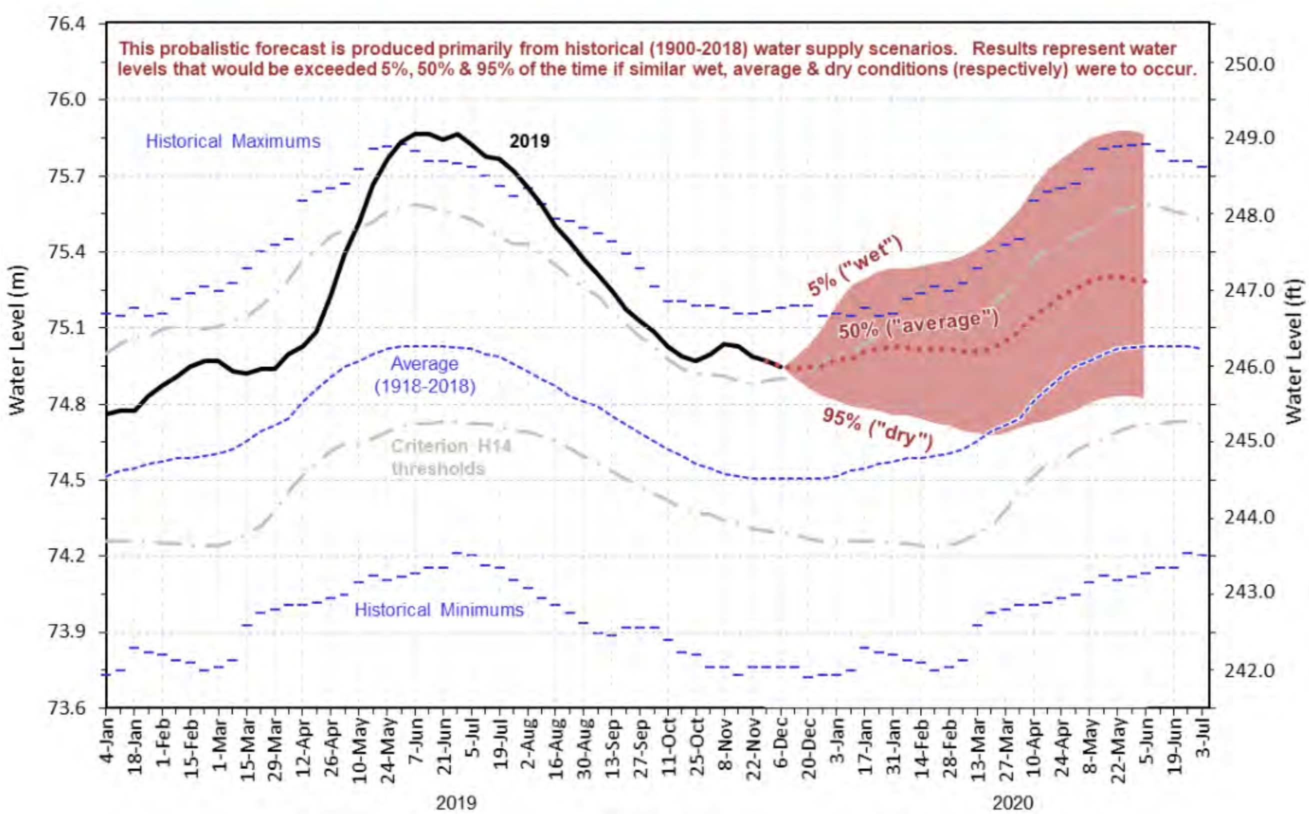
help communities adapt to this new pattern of flooding in the area through hardening key infrastructure and smart growth principles. Resiliency guidelines and resources to reduce the risk of future damage and minimize habitat impacts have been compiled by NYSDEC at https://www.dec.ny.gov/lands/117819.html, FEMA's Community Rating System also offers planning support and incentives to communities who work to mitigate their risks to flooding under increased precipitation.

The IJC maintains historic records on lake levels, flows, and precipitation and provides forecasts for upcoming years at https://ijc.org/en/loslrb/watershed/forecasts. **Figure 18** shows the most recent weekly forecast of Lake Ontario through June 2020. The forecast illustrates the projected range of water levels and flows that are expected to occur under potentially wet, average, and dry conditions. It is important to note that actual future water levels and flows are dependent on precipitation, weather, and existing water supplies.

Figure 18
Lake Ontario Water Level Forecast



Source: IJC, International Lake Ontario-St. Lawrence River Board (Dec 2019)

7.3 Contaminants of Emerging Concern (CECs)

Historically, chemical pollution and toxicity has been focused on “priority” pollutants that are persistent in the environment and commonly used in industry. However, a new a diverse group of chemicals known collectively as “emerging contaminants” or “contaminants of emerging concern” (CECs) are gaining attention. Captured under the umbrella of CECs are compounds such as pharmaceuticals, personal care products, pesticides, herbicides, endocrine disruptors, flame retardants, and microplastics. With advanced analytical instrumentation and technology, CECs have been detected in trace amounts in surface waters and wastewater treatment effluents (Glassmeyer *et al.,* 2017).

These compounds and their bioactive metabolites are continually released into the aquatic environment as complex mixtures primarily through sewage treatment systems and wet weather runoff. This group of chemicals is unique in that many of these compounds were designed to be biologically active at trace levels and therefore can elicit a biological response at environmentally relevant levels. Although biochemical actions and mechanisms of many of these compounds in humans is known, the known pathways of actions are not always the only mechanisms at work. Understanding of the complex biochemical signaling pathways and their targets is limited making possible effects on nontarget organisms largely unknown (Daughton and Ternes, 1999). Knowledge of the effects of these compounds in the aquatic and terrestrial environment is lacking, especially with respect to low-dose, cumulative, and multi-generational exposure of complex mixtures. This is particularly troublesome for aquatic organisms who are captive to continual life-cycle, multigenerational exposure. Cumulative exposure over time can potentially manifest into changes that are not observed with current toxicity-directed screening methods.

8 Data Gaps

This watershed characterization process uses available data to evaluate current metrics of watershed health and define effective strategies for restoration and protection. Ultimately, this information and analysis will inform the revitalization plan and help define milestones to assess progress in response to recommended actions. Several important data gaps are noted:

- Only 48% of stream miles and 43% of lake acres have been assessed for water quality, meaning that nearly 50% of the waters within the watershed were not characterized or monitored for impairment. Of the assessed waters, 38% of stream miles and 80% of lake acres were found to be threatened, stressed, or impaired. Given that high percentage, it is likely that many of the unassessed waters are also impacted.
- The North Country of New York State is largely unmapped by FEMA for identification of high-risk flood areas. Consequently, parameters such as slope, soil type, storage capacity, and incoming flow were used to evaluate which areas are more vulnerable to flooding.
- Citizen science is a major source of data for detecting invasive species and cyanobacterial blooms and assessing water quality and benthic macroinvertebrate communities. While citizen data are essential for stakeholder engagement and expanding capacity of resource management agencies, selective sampling can introduce bias if there are major disparities in sampling frequency and spatial coverage.
- The land use characterization does not include a detailed analysis of local codes for each municipality, due to the complexity and level of effort required to collect these data across such a large study area. However, since 44% of the watershed is within the Adirondack Park and a substantial percentage of the remainder is currently in agricultural use, analysis of local land use laws affecting nonpoint sources of pollution are less significant in this rural area. Moreover, the characterization demonstrates that water quality impairments are primarily the result of regional (atmospheric) sources and/or legacy contaminants; neither source is subject to local control. Despite this finding, improvements to local codes for water resource management is an important recommendation for long-term protection as this rural area undergoes development.

Despite these data gaps, the findings of the Characterization Report support development of recommended actions and priorities.

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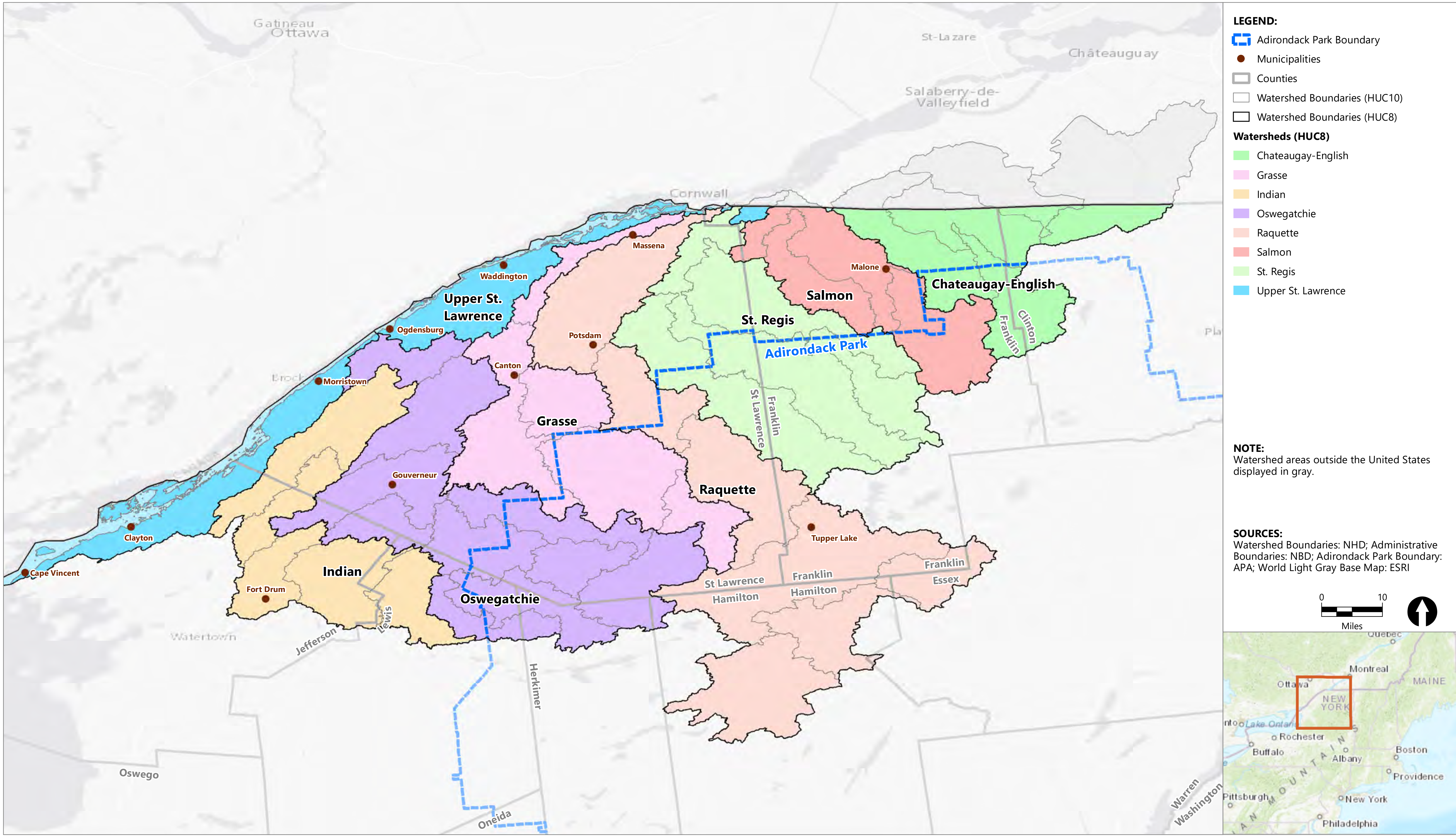
Maps



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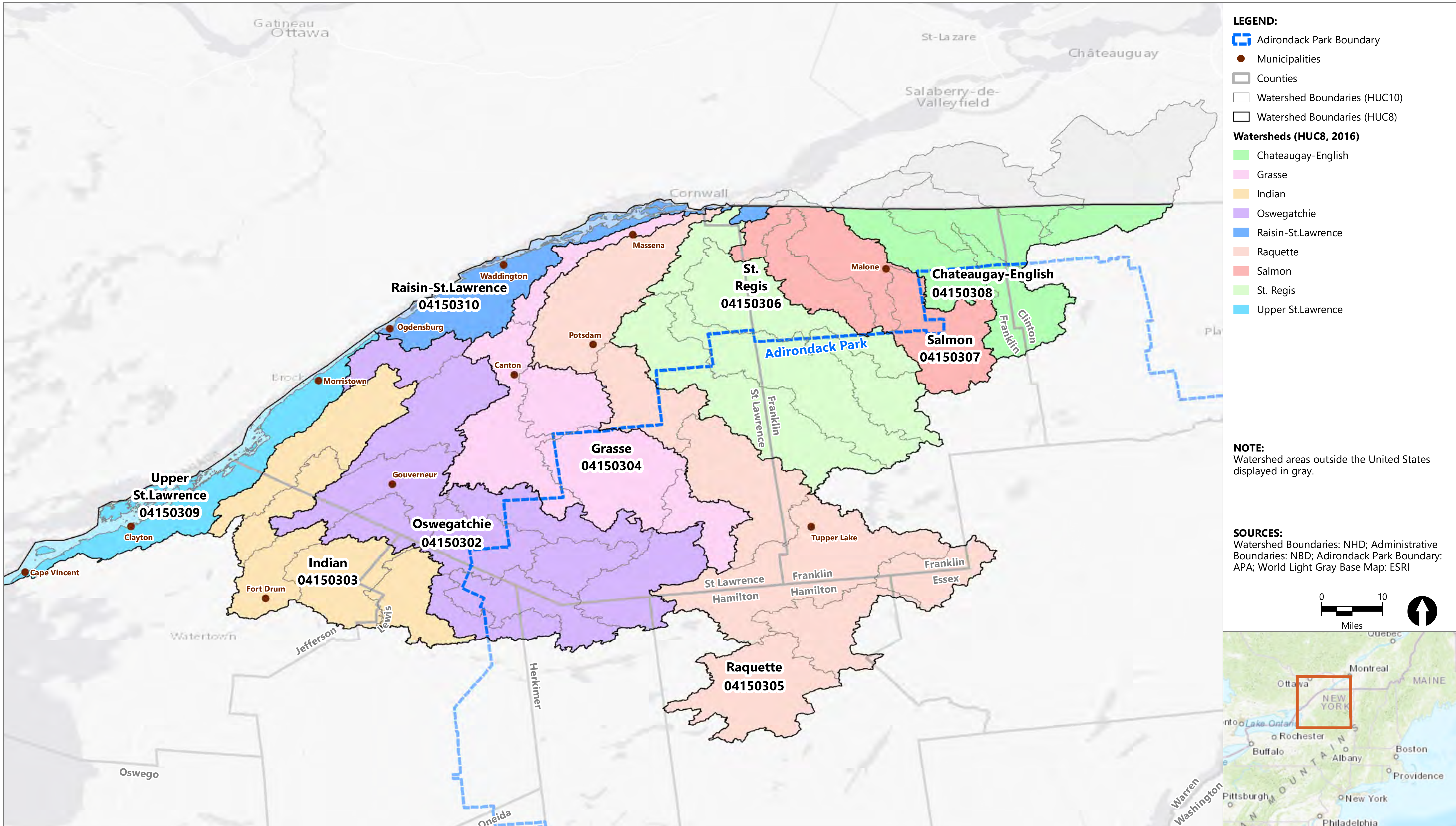
ANCHOR QEA
EcoLogic
St. Lawrence River Watershed Project
NEW YORK STATE OF OPPORTUNITY. Department of State

Map 1
St. Lawrence River Watersheds (HUC8) in New York State
St. Lawrence River Watershed Revitalization Plan



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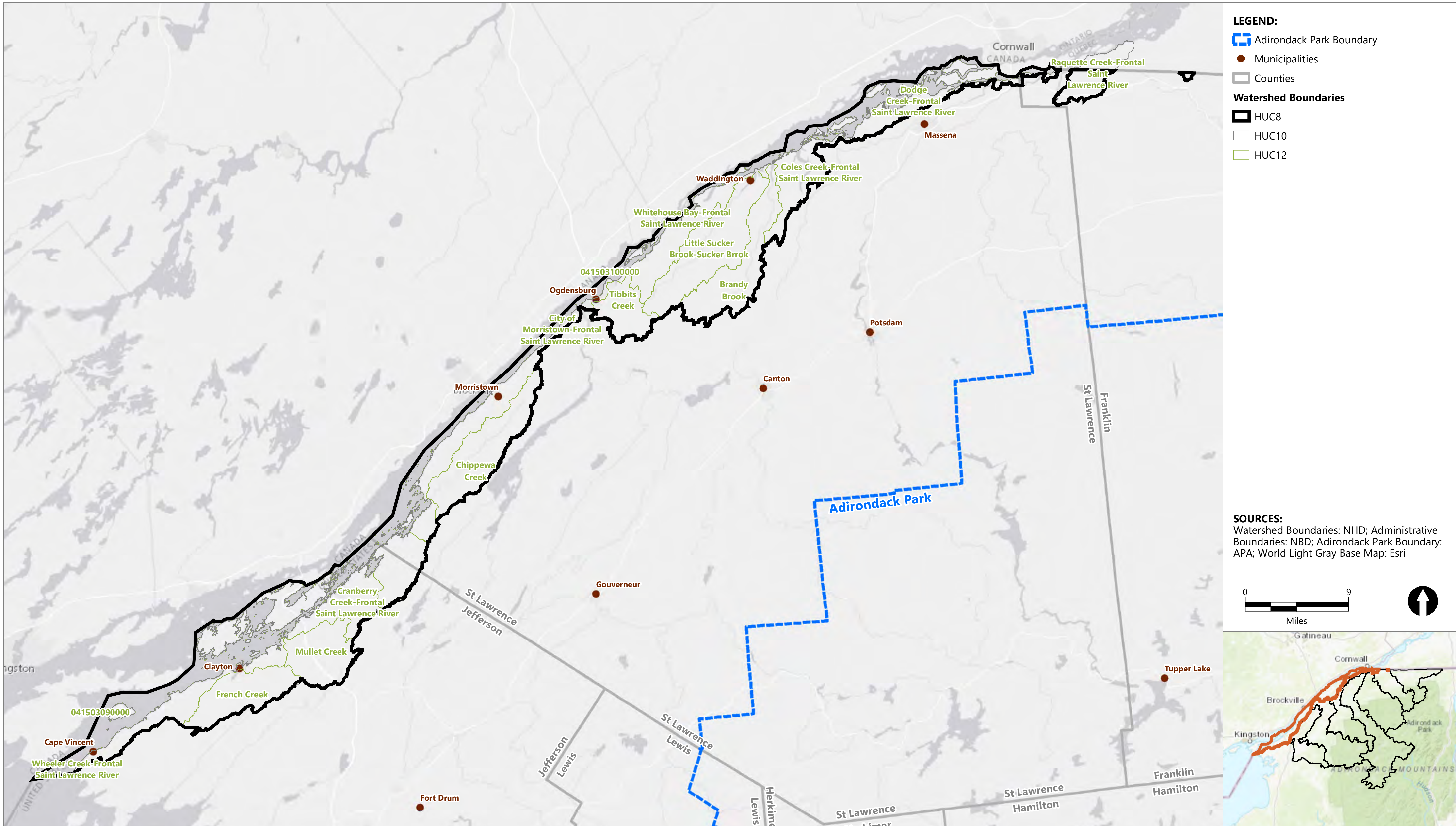
Map 2
St. Lawrence River Watersheds (HUC8, 2016) in New York State
St. Lawrence River Watershed Revitalization Plan



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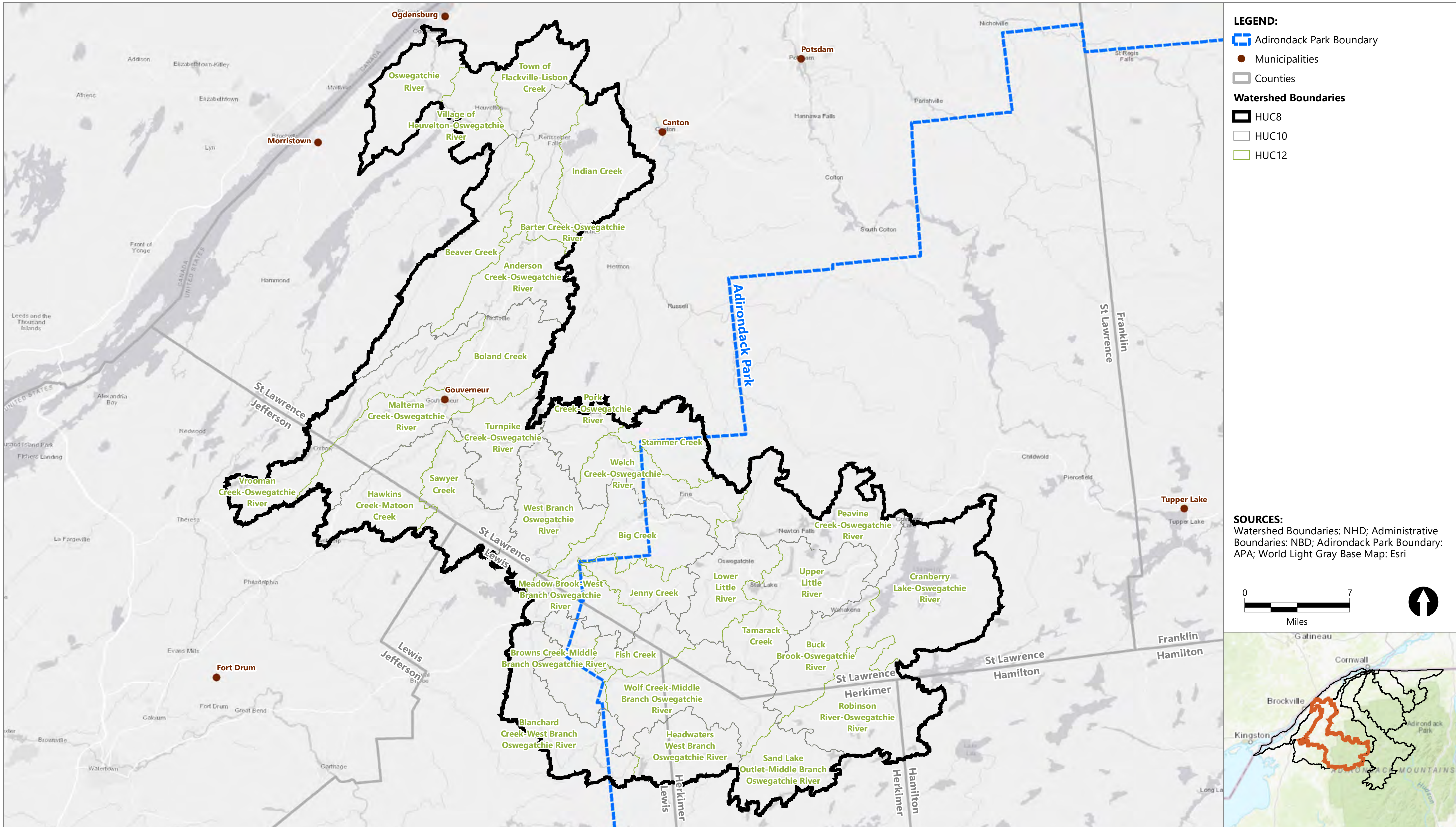
Map 3
Upper St. Lawrence River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan



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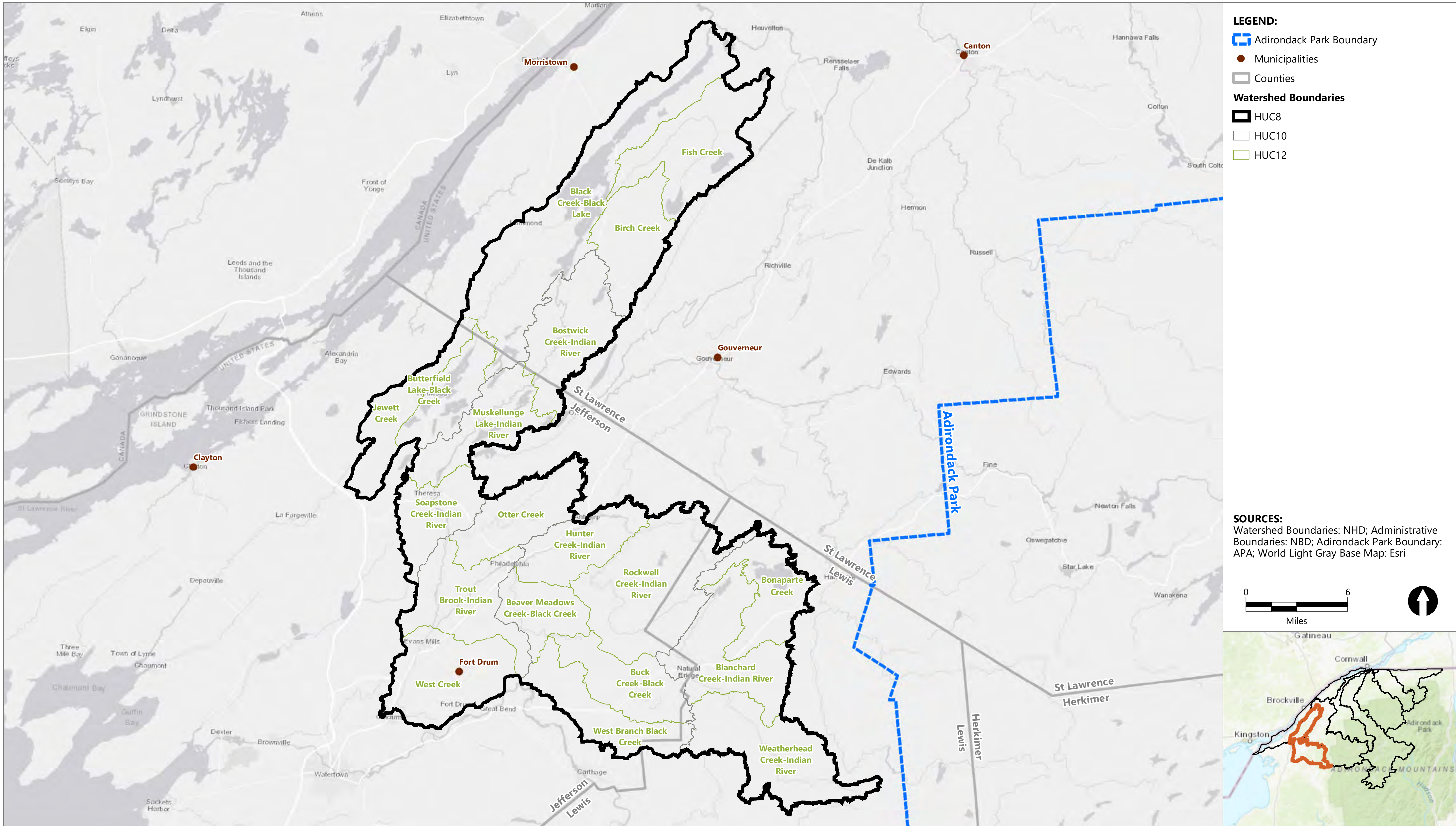
Map 4
Oswegatchie River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan



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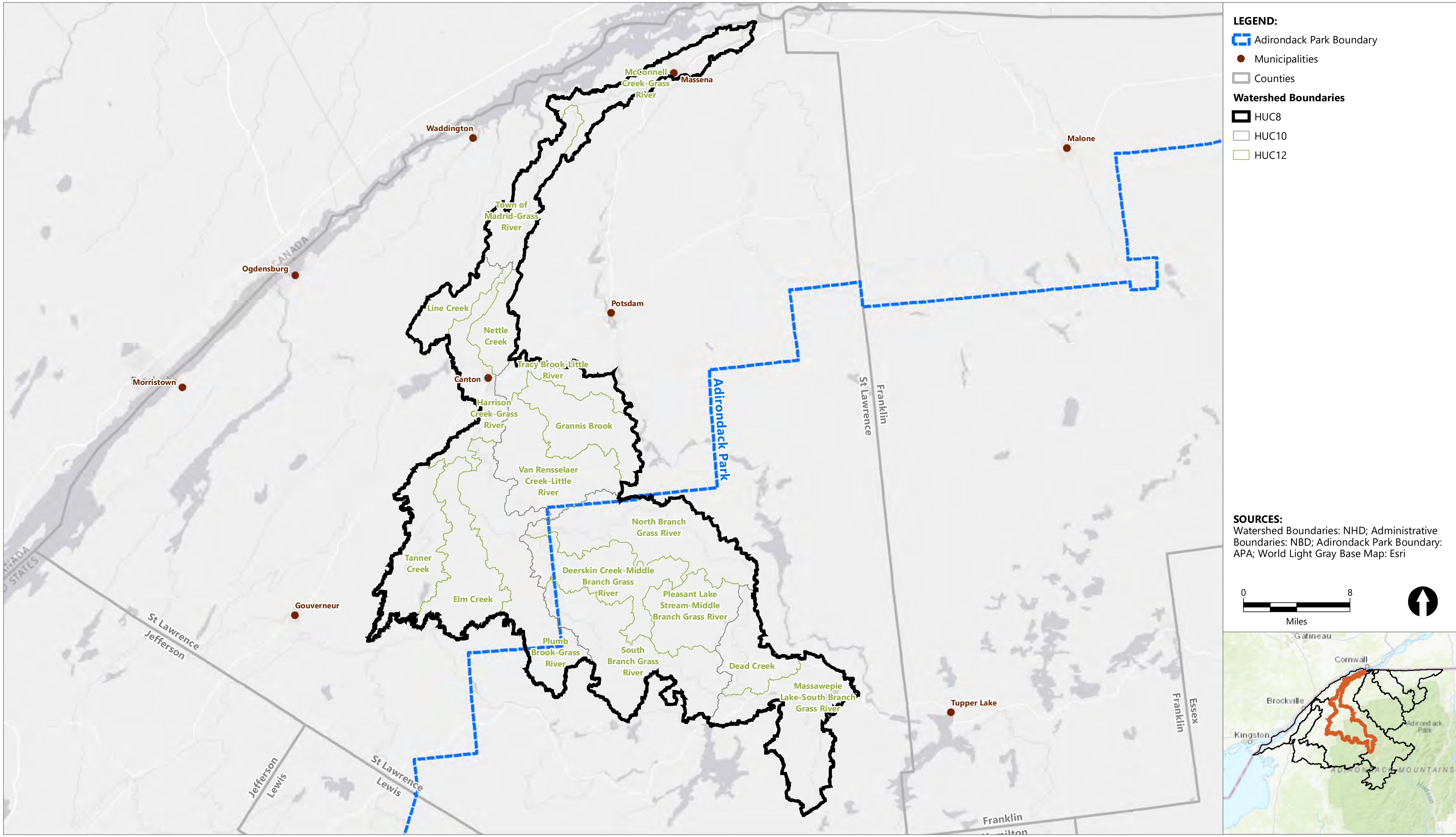
Map 5
Indian River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan



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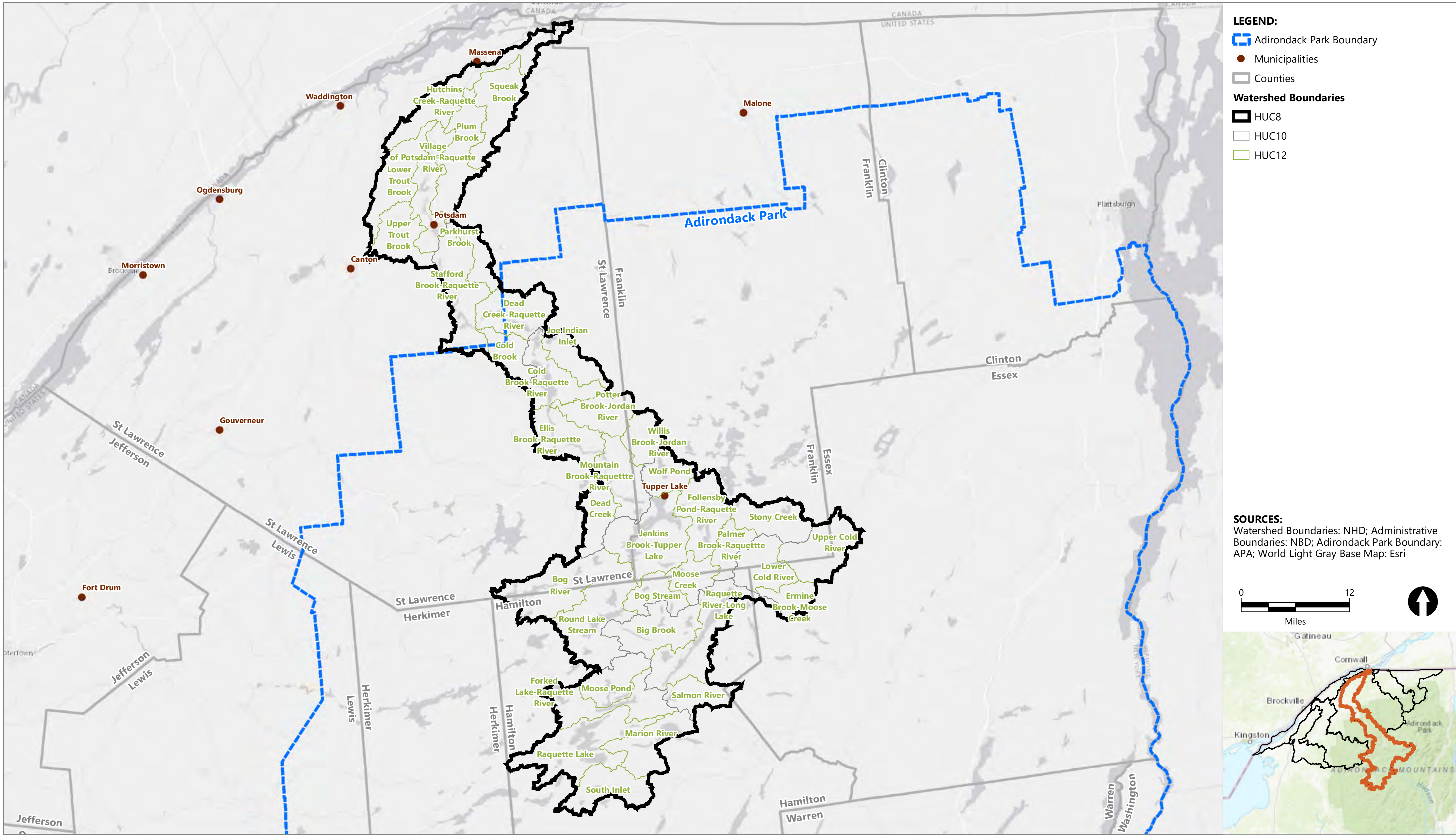
Map 6

Grasse River Watershed (HUC8)

St. Lawrence River Watershed Revitalization Plan



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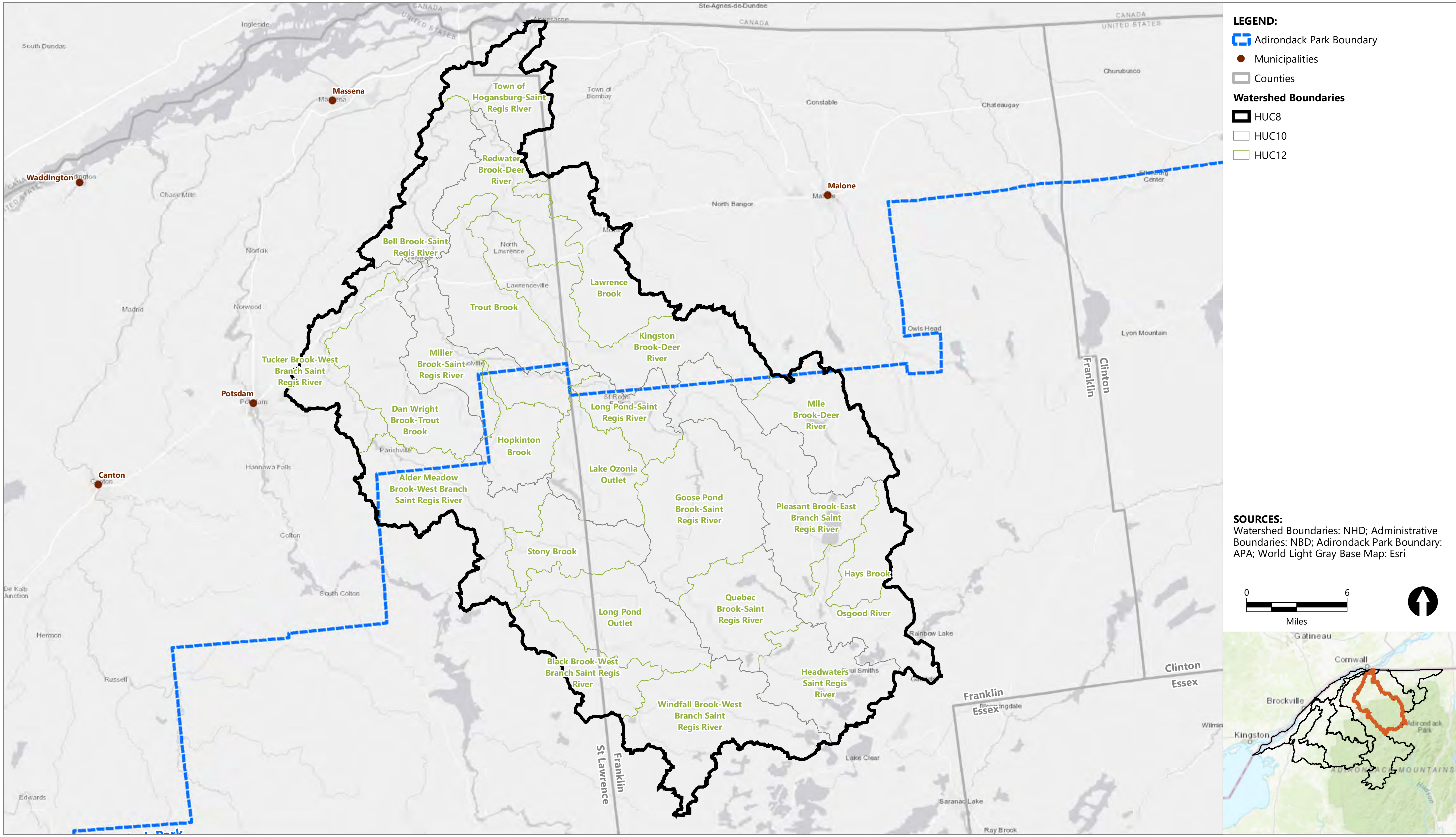
Map 7
Raquette River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan



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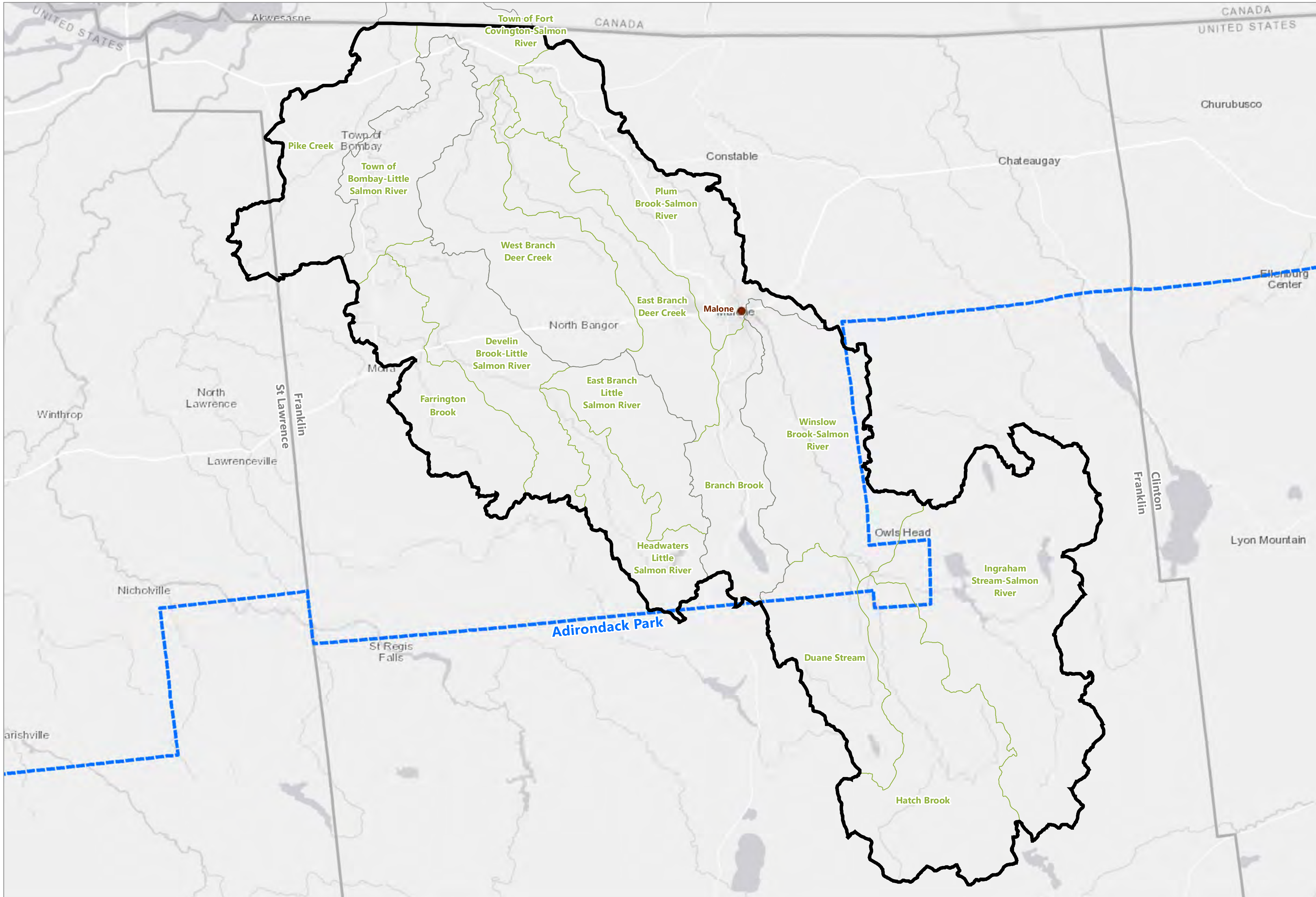
Map 8
St. Regis River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan



LEGEND:

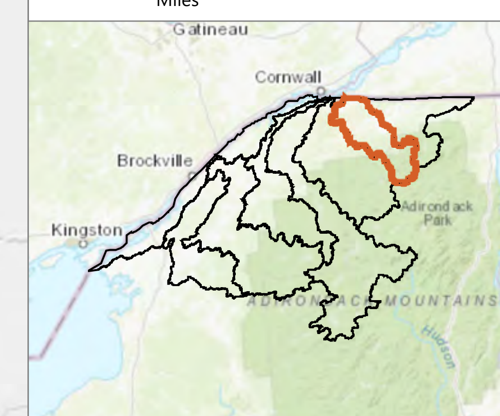
- Adirondack Park Boundary
- Municipalities
- Counties

Watershed Boundaries

- HUC8
- HUC10
- HUC12

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: Esri

0 4
Miles



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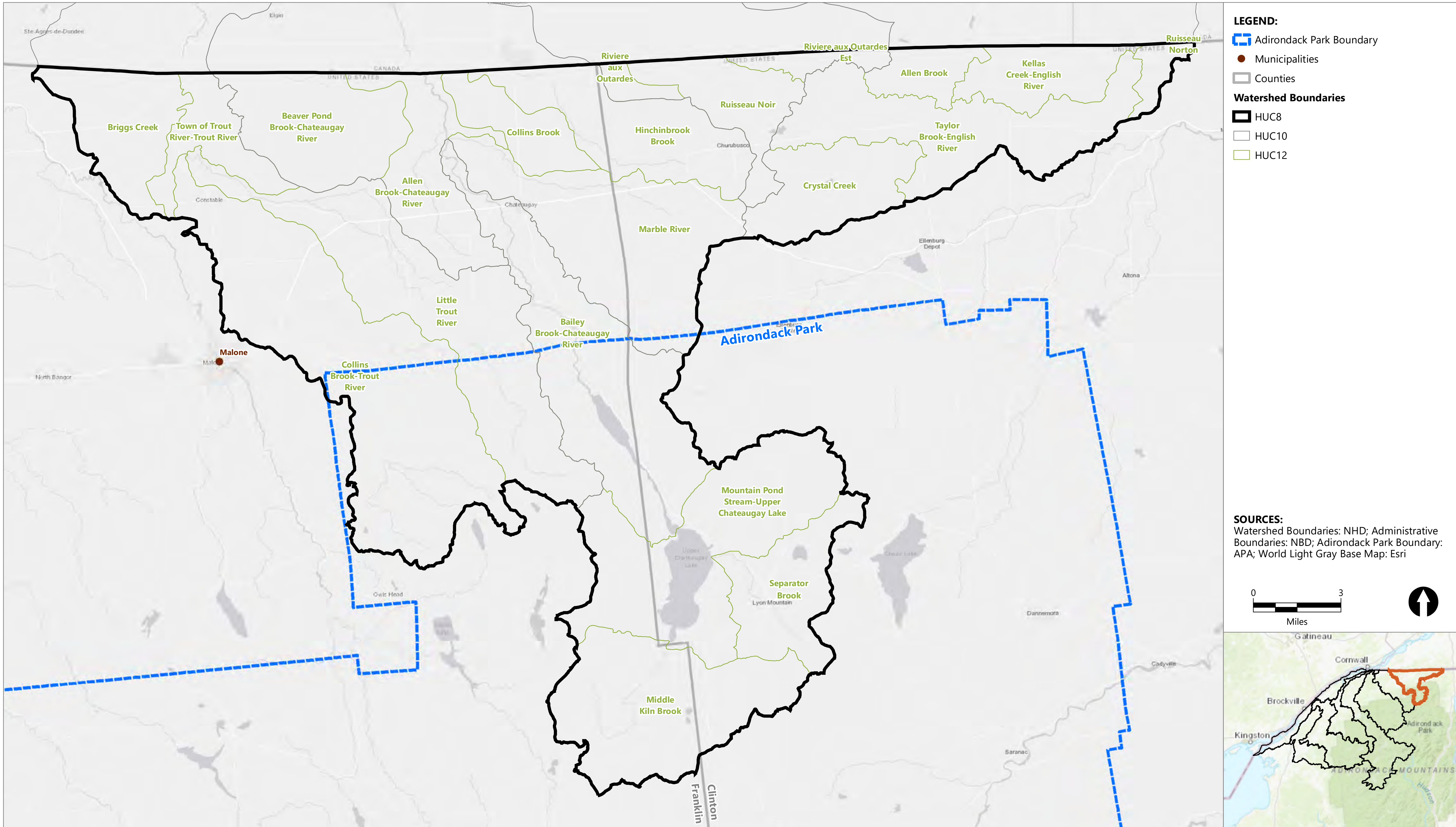
Map 9
Salmon River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan



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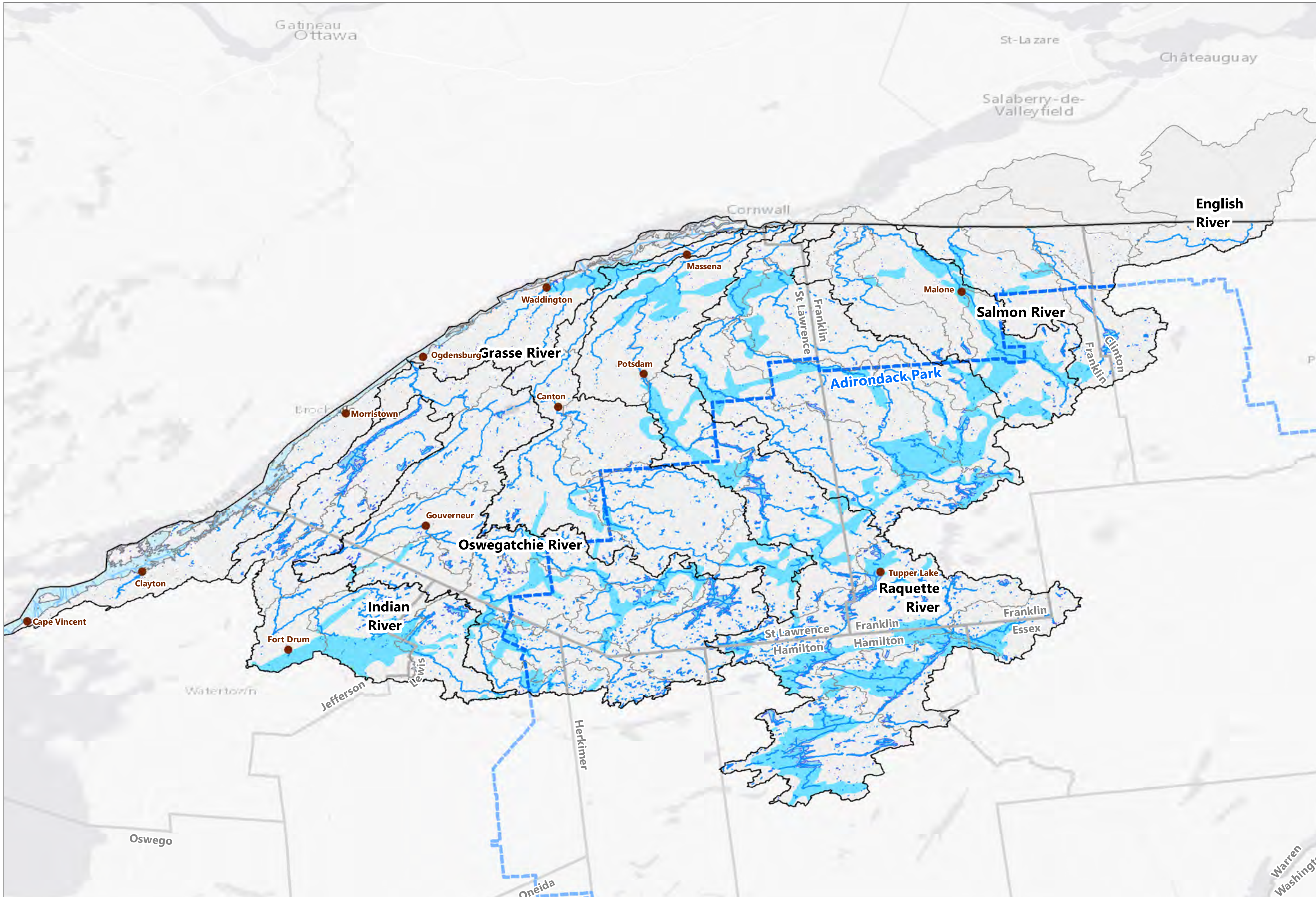
Map 10
Chateaugay-English River Watershed (HUC8)
St. Lawrence River Watershed Revitalization Plan

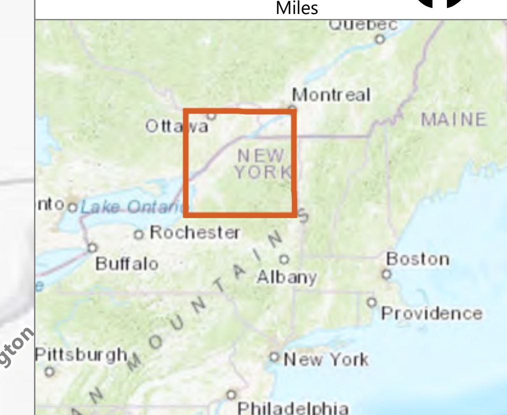


LEGEND:
- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)
- NHD Streams
- NHD Waterbody
- Primary Aquifer

NOTES:
Watershed areas outside the United States displayed in gray. NHD = National Hydrography Dataset.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Hydrography: NHD

0 10
Miles



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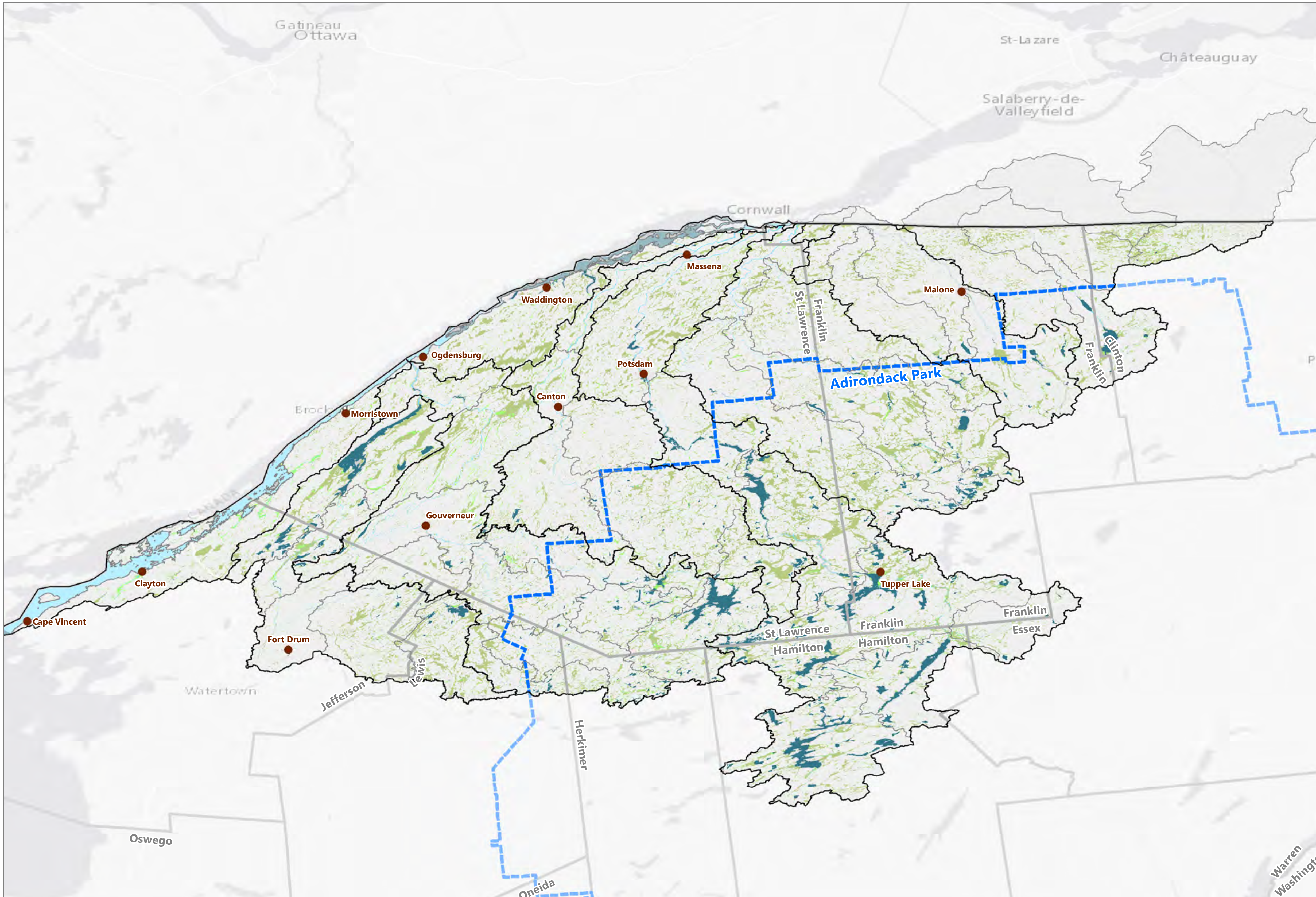
Map 11
Hydrography in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)

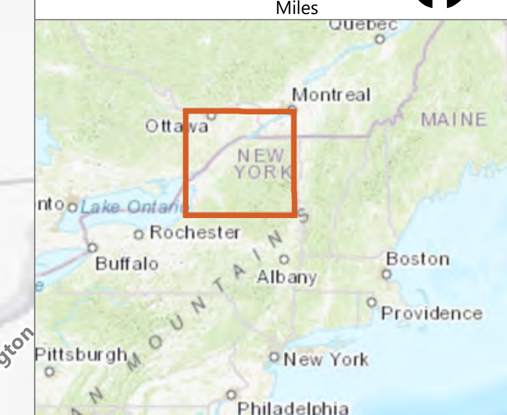
Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

NOTE:
Watershed areas outside the United States displayed in gray.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Wetlands: NYS GIS Clearing House

0 10
Miles



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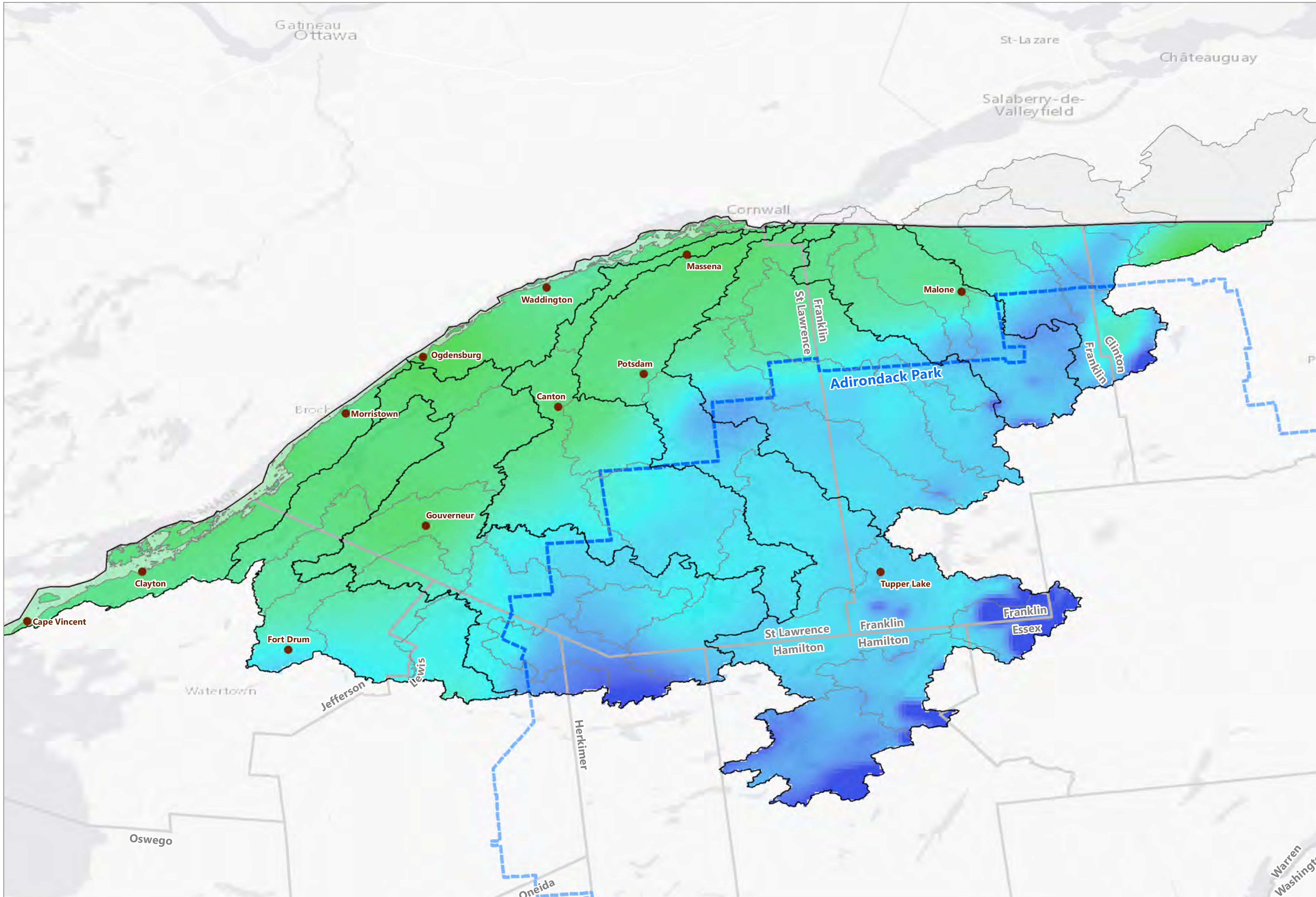
Map 12
Wetlands in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)

Projected Precipitation (inches per year)

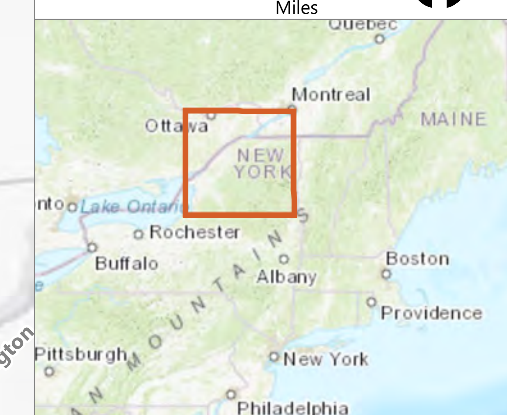
High : 62

Low : 35

NOTE:
Watershed areas outside the United States displayed in gray.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Average Annual Precipitation: NOAA PRISM 1981-2010

0 10
Miles



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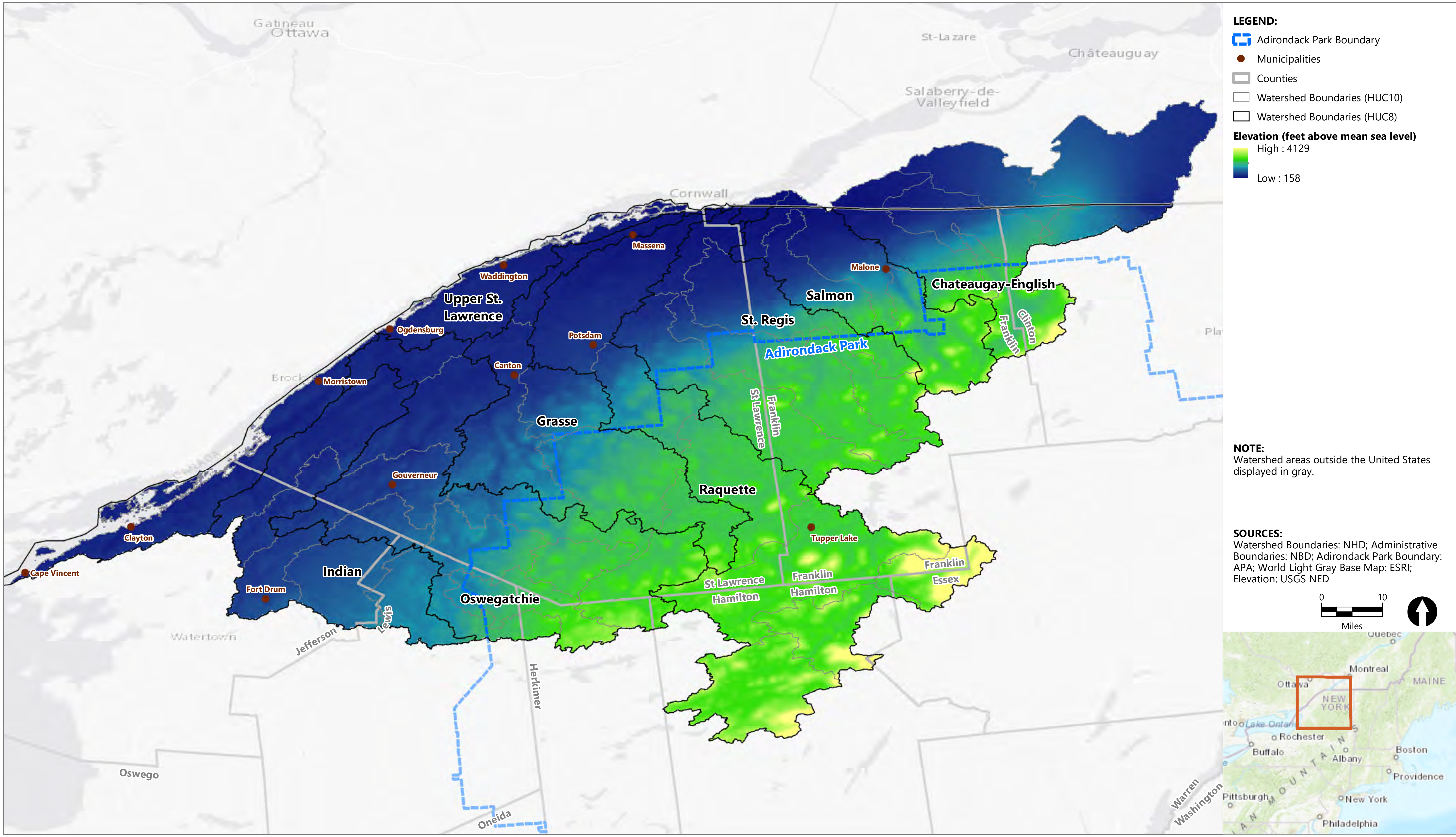
Map 13
Average Annual Precipitation in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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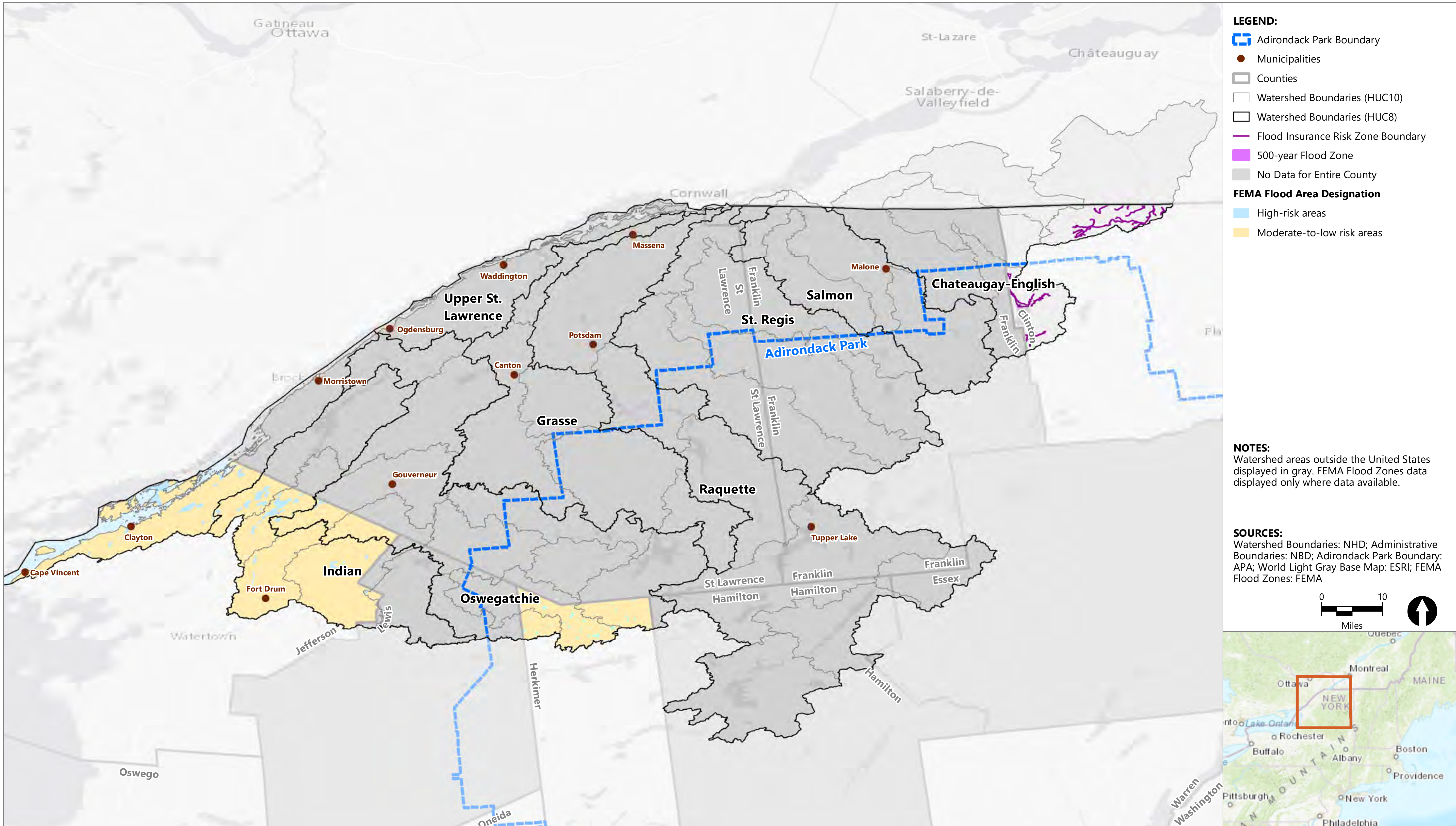
Map 14
Topography/Elevation/Steep Slopes in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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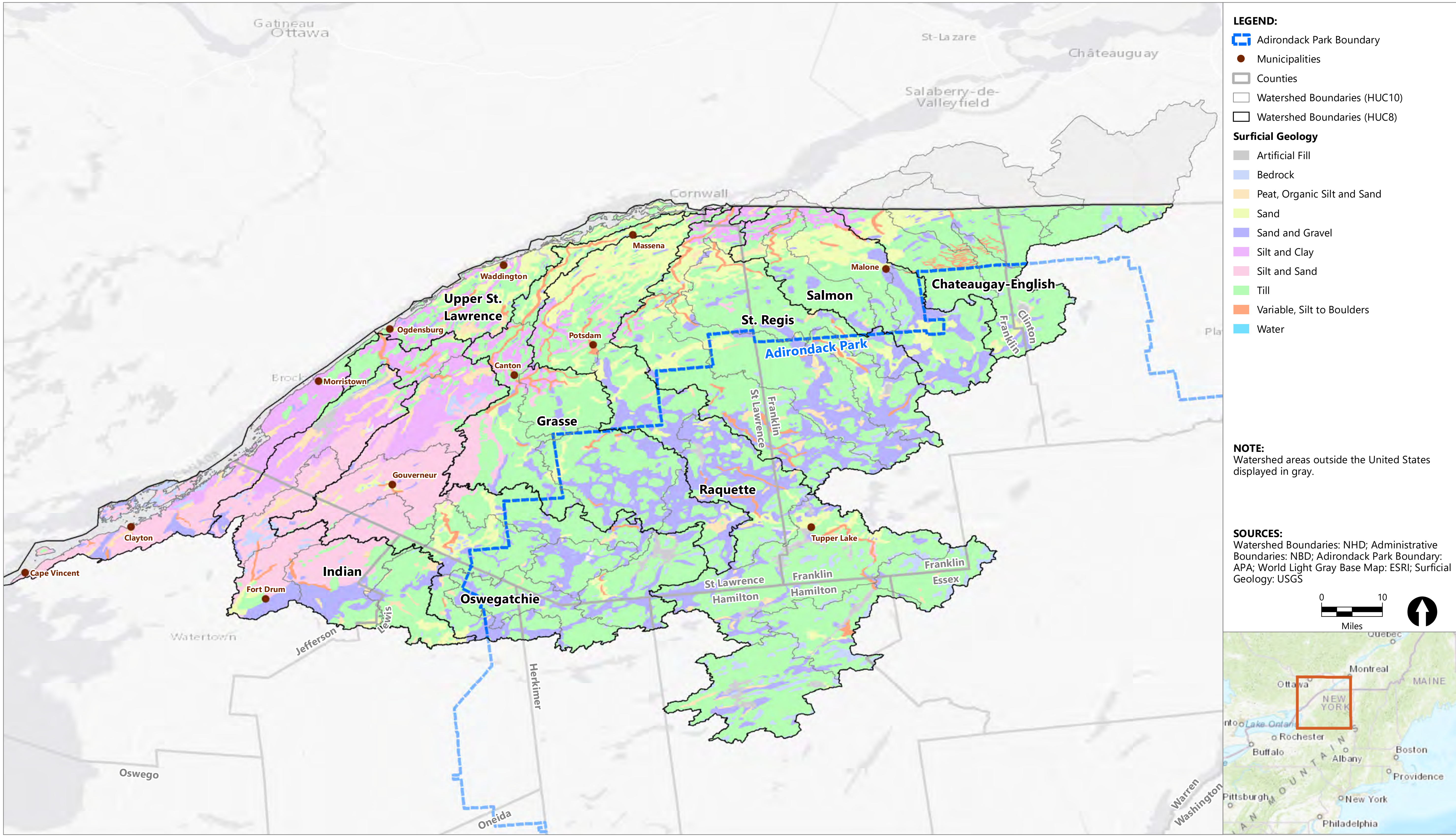
Map 15
FEMA Flood Zones in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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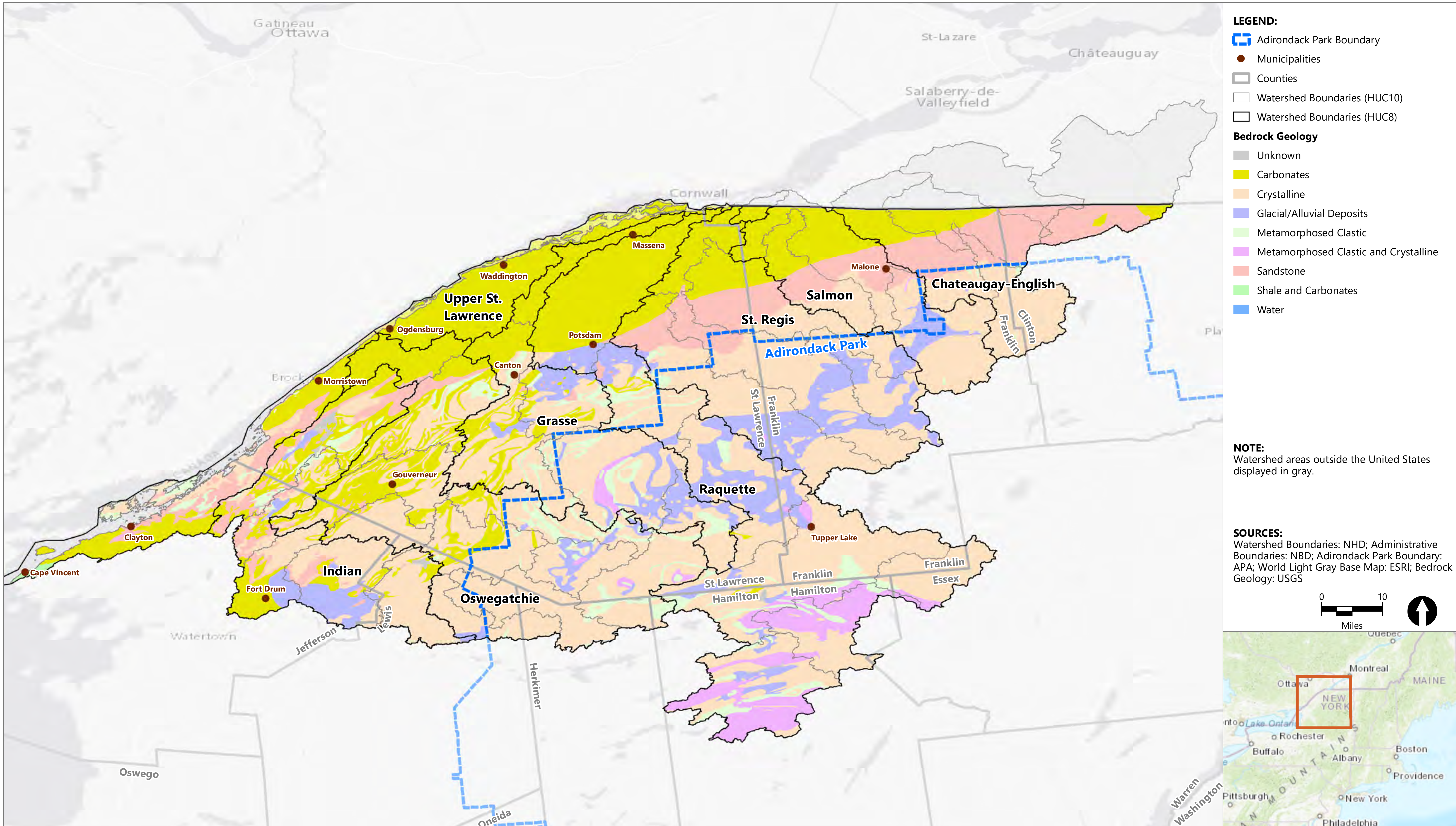
Map 16
Surficial Geology in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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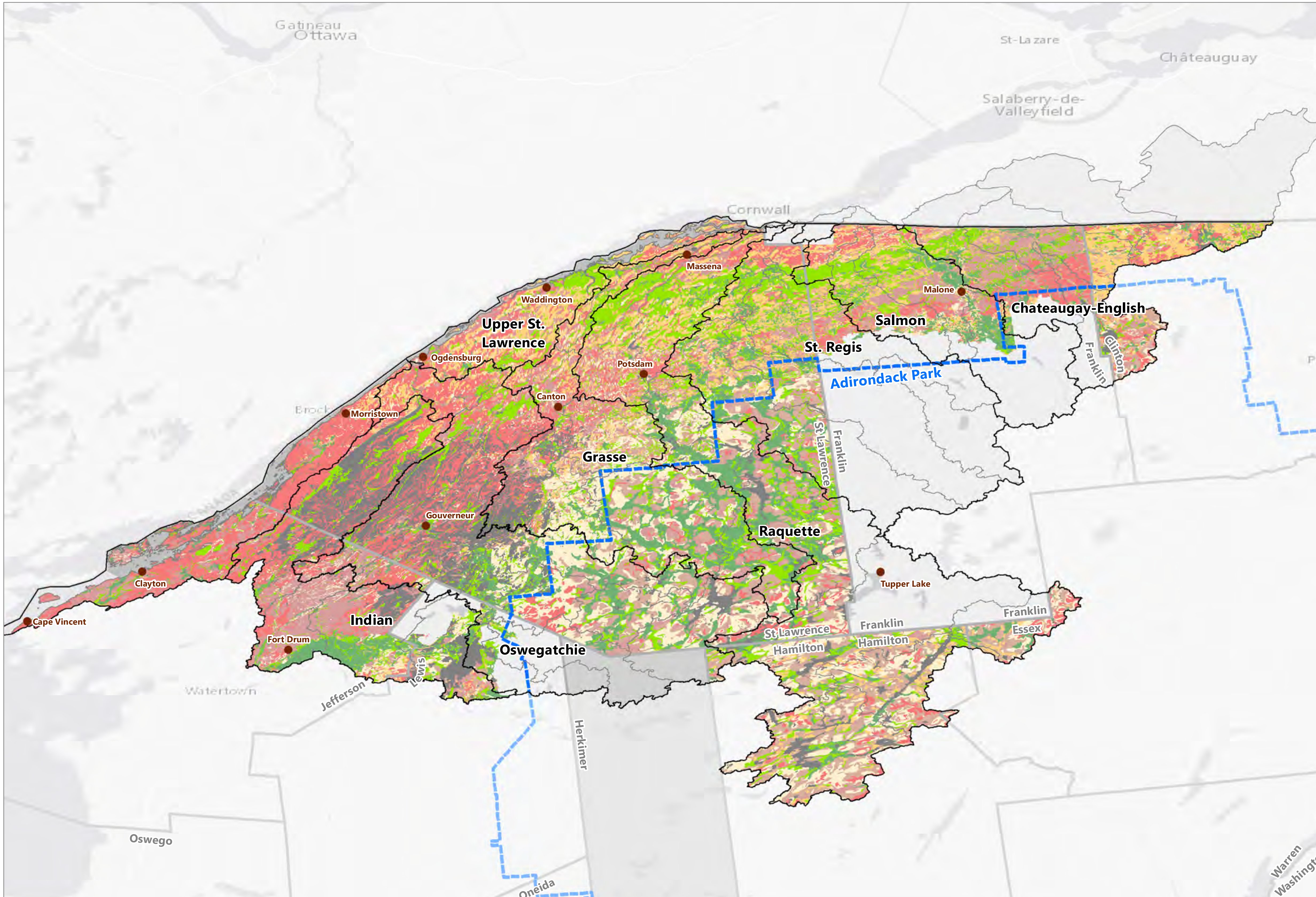
St. Lawrence River Watershed Project
NEW YORK STATE OF OPPORTUNITY Department of State

Map 17
Bedrock Geology in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:
- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)
- No Data for Entire County

Hydrologic Group (SSURGO)
- Unknown
- A
- A/D
- B
- B/D
- C
- C/D
- D

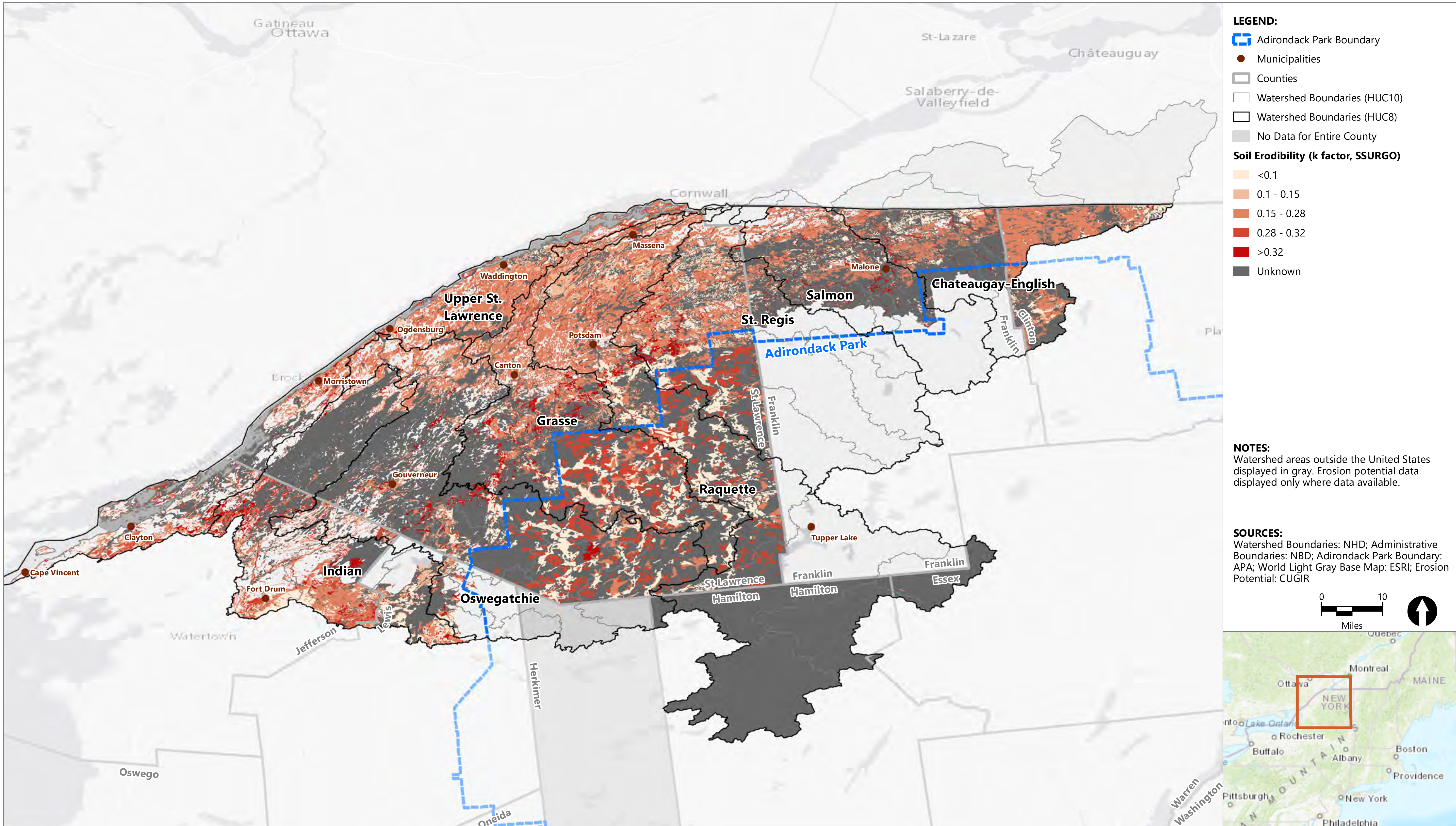
NOTES:
Watershed areas outside the United States displayed in gray. Soils/Prime soils data displayed only where data available.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Hydrologic Soil Groups: SSURGO

0 10
Miles

Publish Date: 2019/12/19, 10:31 AM | User: pkwon
Filepath: \\orcas\gis\Jobs\Franklin_County_SWCD\GIS\ArcMap_Documents\FINAL_VERSION\SLR_Watershed_Characterization_Map.mxd

Map 18
Hydrologic Soil Groups in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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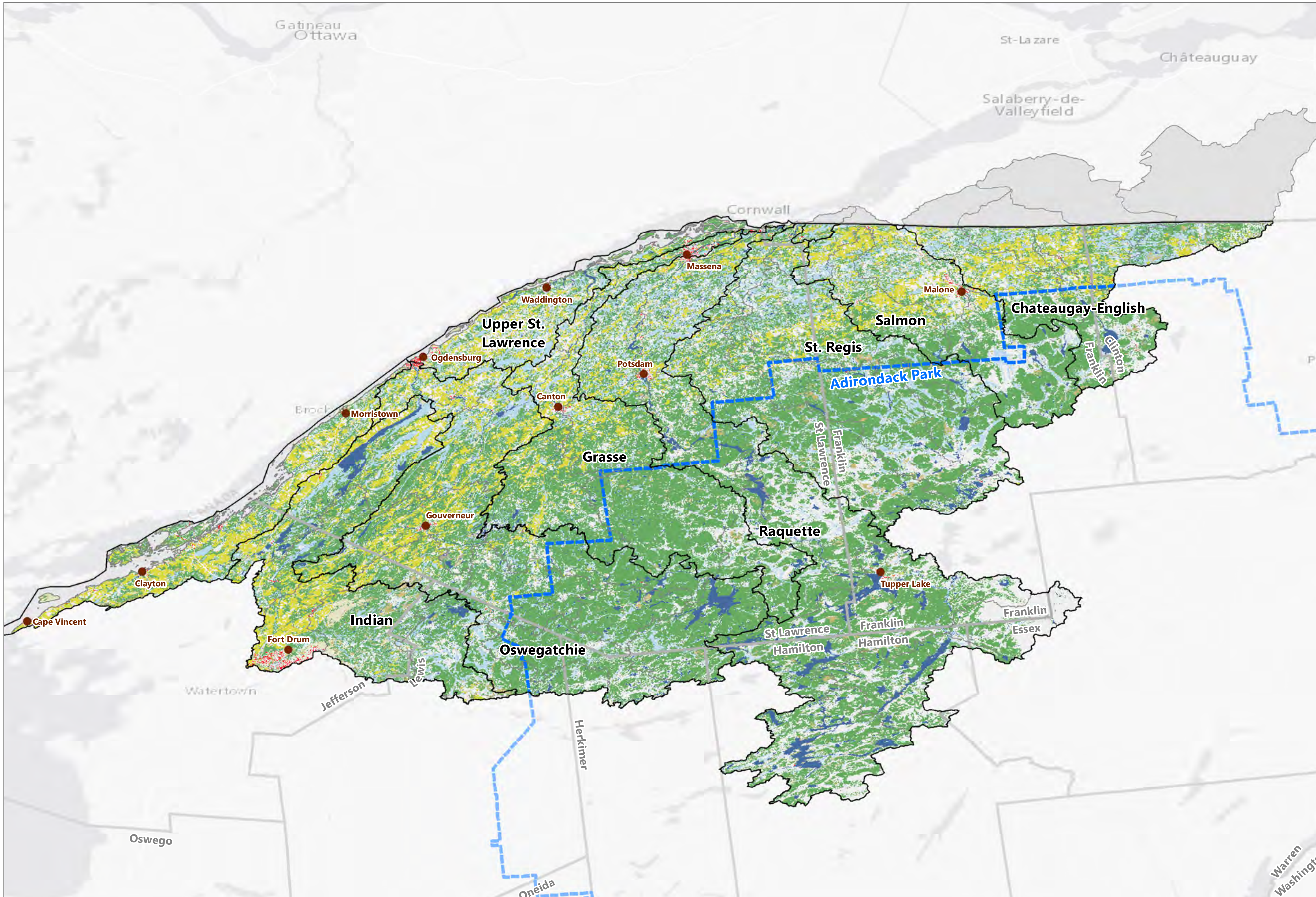
Map 19
Erosion Potential in St. Lawrence River Watershed in New York State



LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)

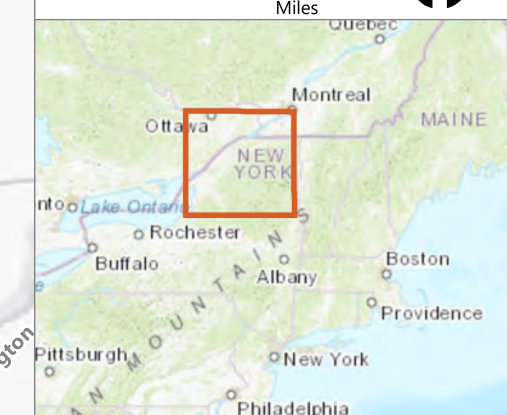
NLCD 2011 Land Cover

- Non-U.S. Lands
- Open Water
- Developed
- Barren
- Forest
- Shrubland
- Herbaceous
- Planted/Cultivated
- Wetlands

NOTE:
Watershed areas outside the United States displayed in gray.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Land Cover: MRLC

0 10
Miles



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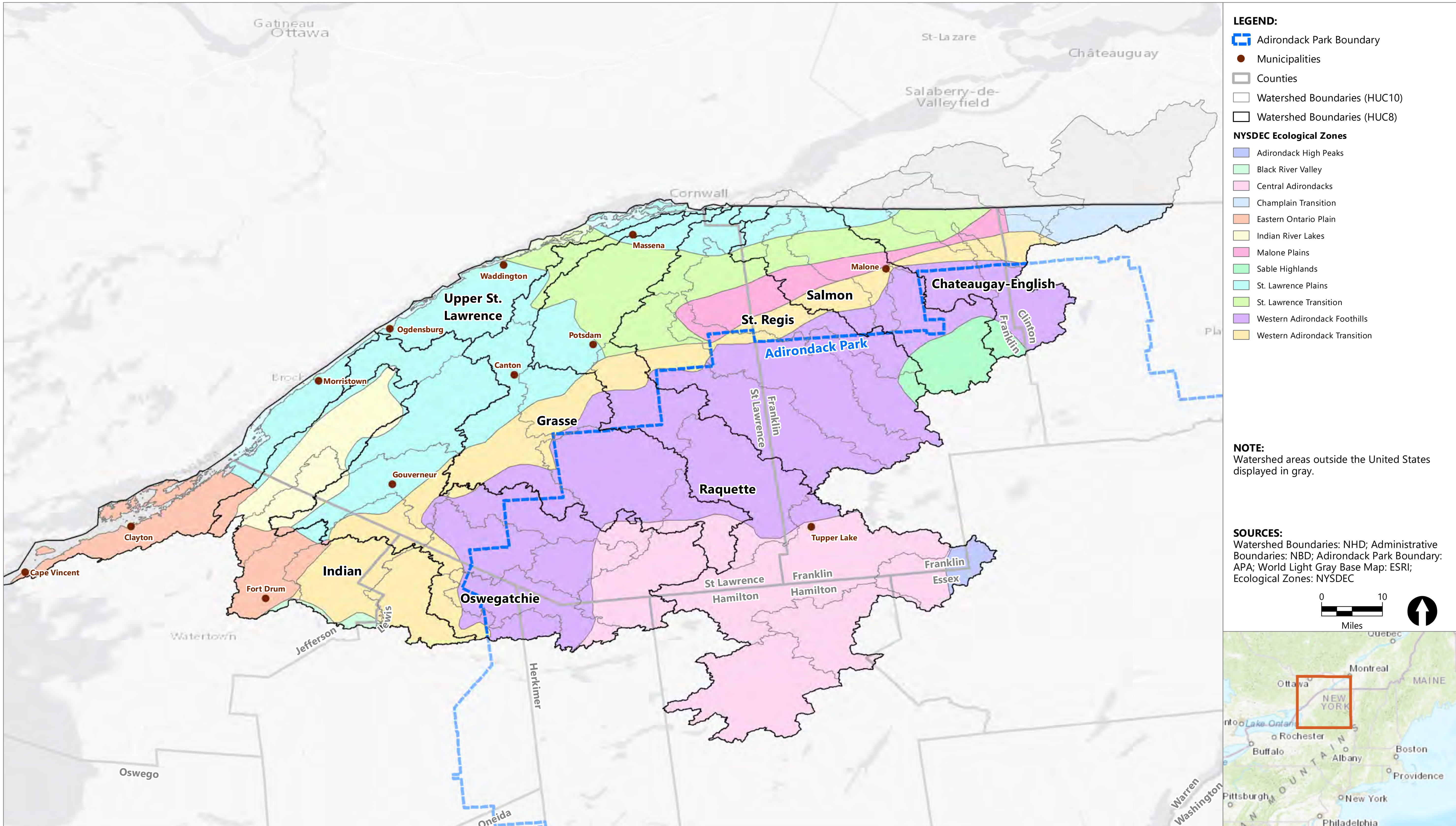
Map 20
Land Cover (NLCD 2011) in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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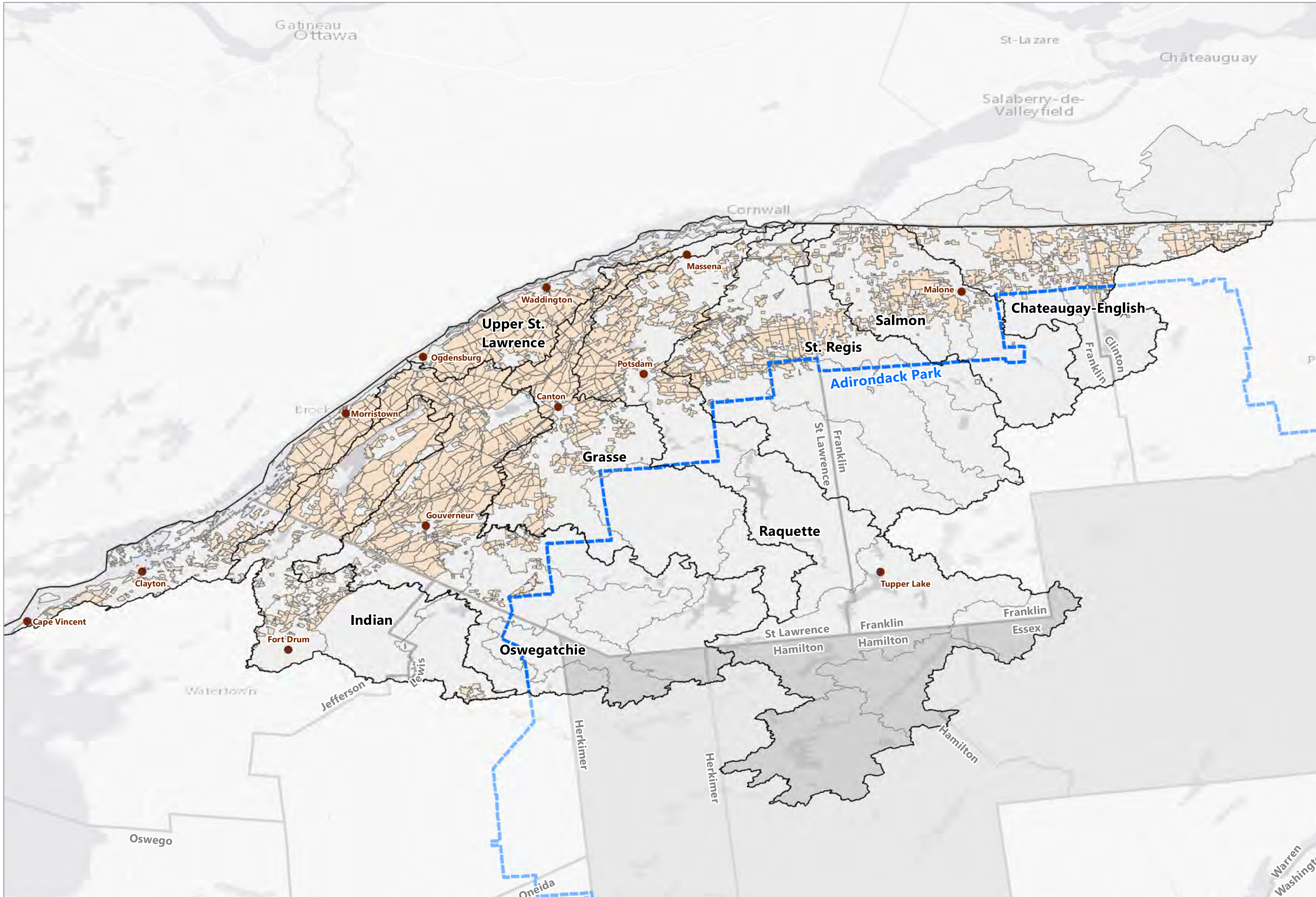
Map 21
Ecological Zones in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



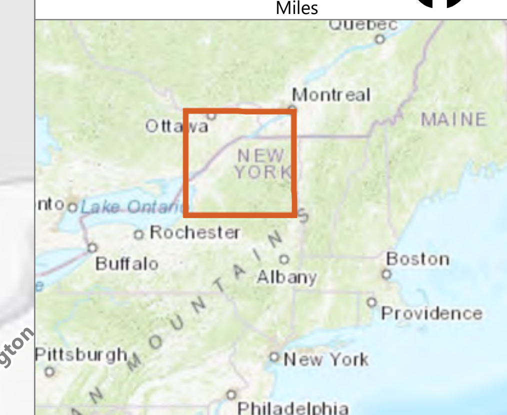
LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)
- No Data for Entire County
- NY Agricultural Districts

NOTE:
Watershed areas outside the United States displayed in gray. Agricultural district data displayed only where data available.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Agricultural Districts: NYS Dept. of Agriculture & Markets

0 10
Miles



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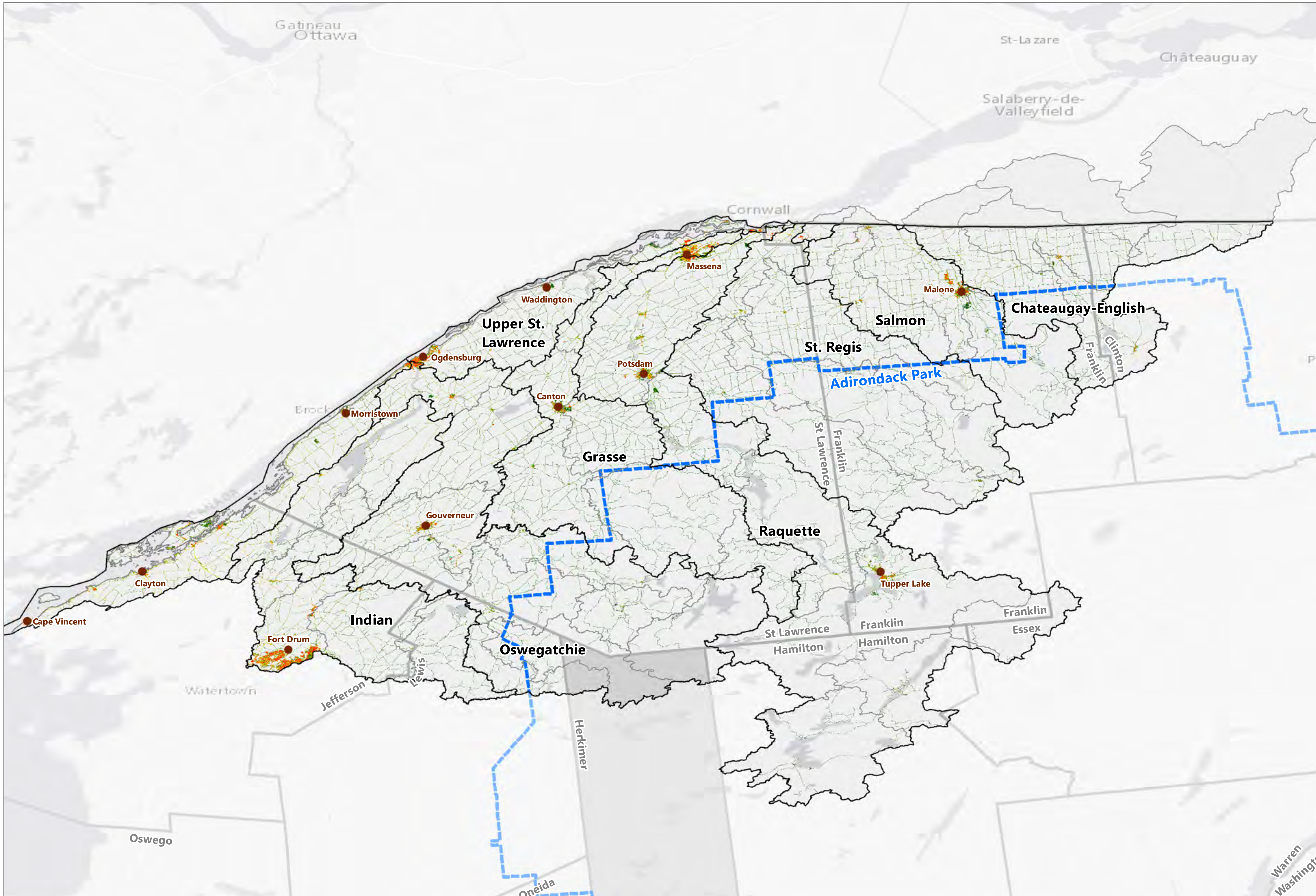
NEW YORK STATE OF OPPORTUNITY. Department of State

Map 22
Agricultural Districts in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)
- No Data for Entire County

Percent Impervious

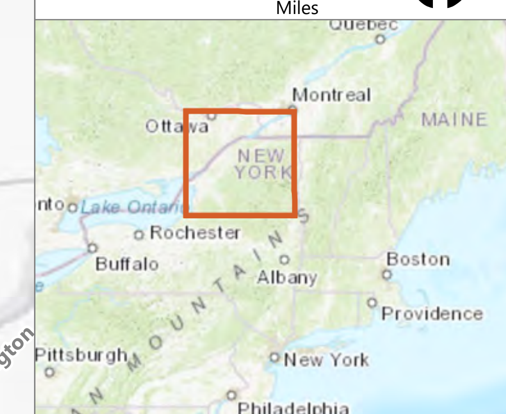
High : 100

Low : 1

NOTE:
Watershed areas outside the United States displayed in gray.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Impervious Surface: MRLC

0 10
Miles



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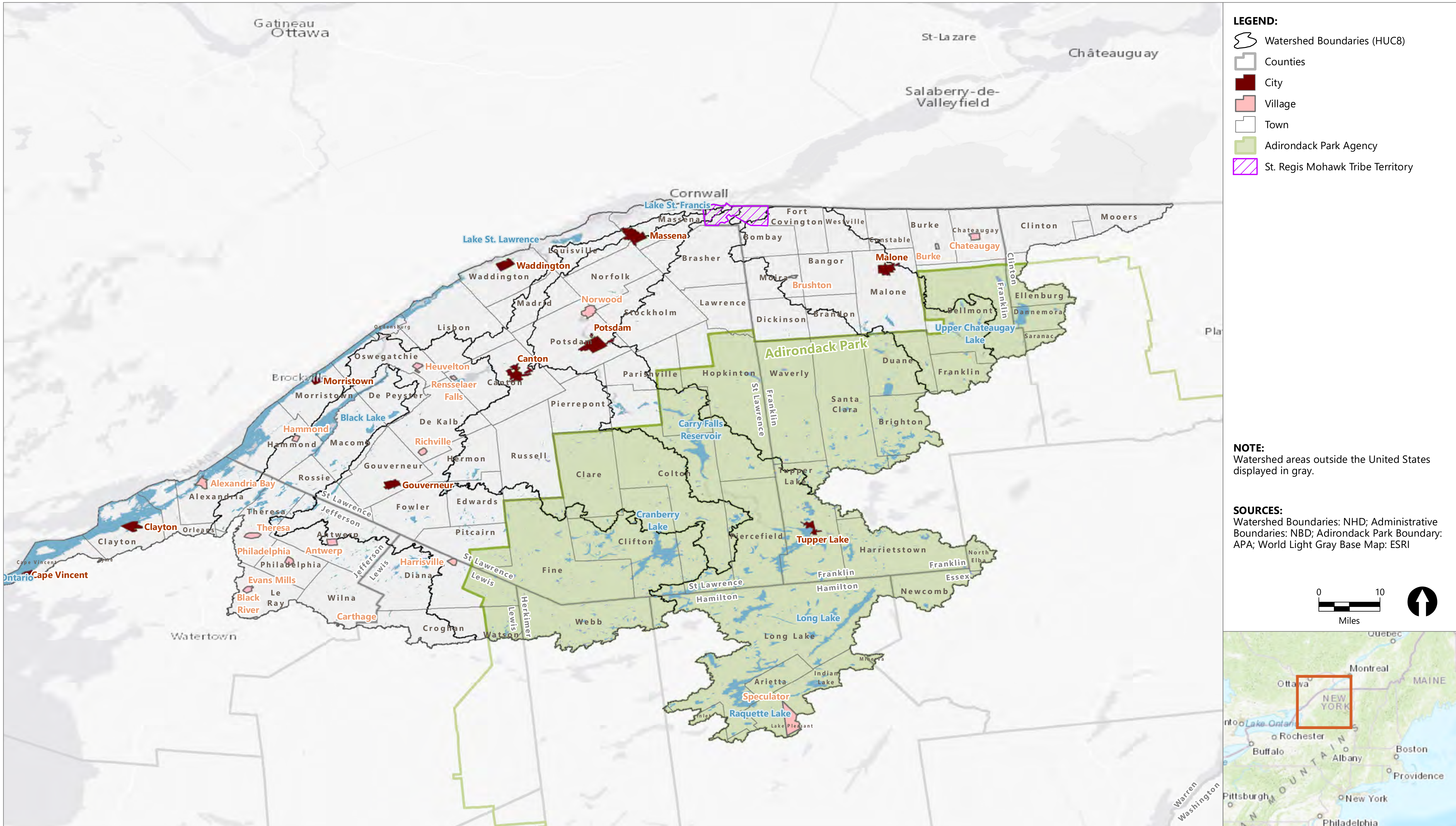
Map 23
Percent Imperviousness in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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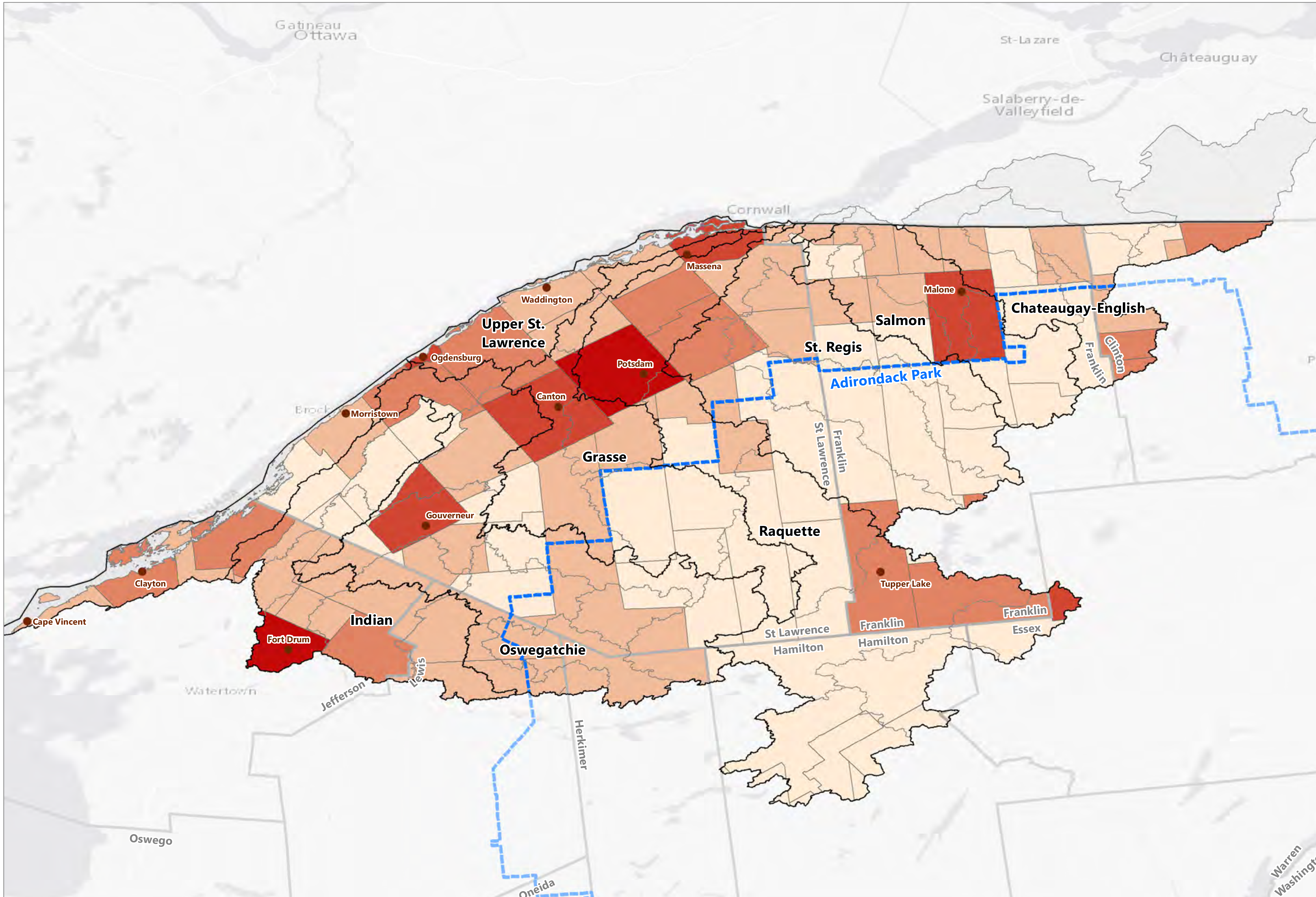
Map 24
Governance in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:

Adirondack Park Boundary

Municipalities

Counties

Watershed Boundaries (HUC10)

Watershed Boundaries (HUC8)

2010 Population Density by County Subdivision

<1500

1501 - 3500

3501 - 7000

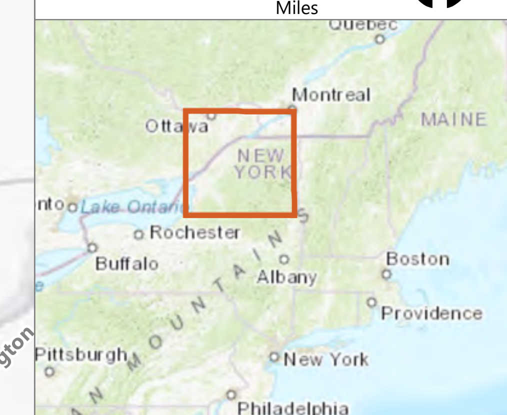
7001 - 16000

>16000

NOTE:
Watershed areas outside the United States displayed in gray.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Population Density: US Census

0 10
Miles



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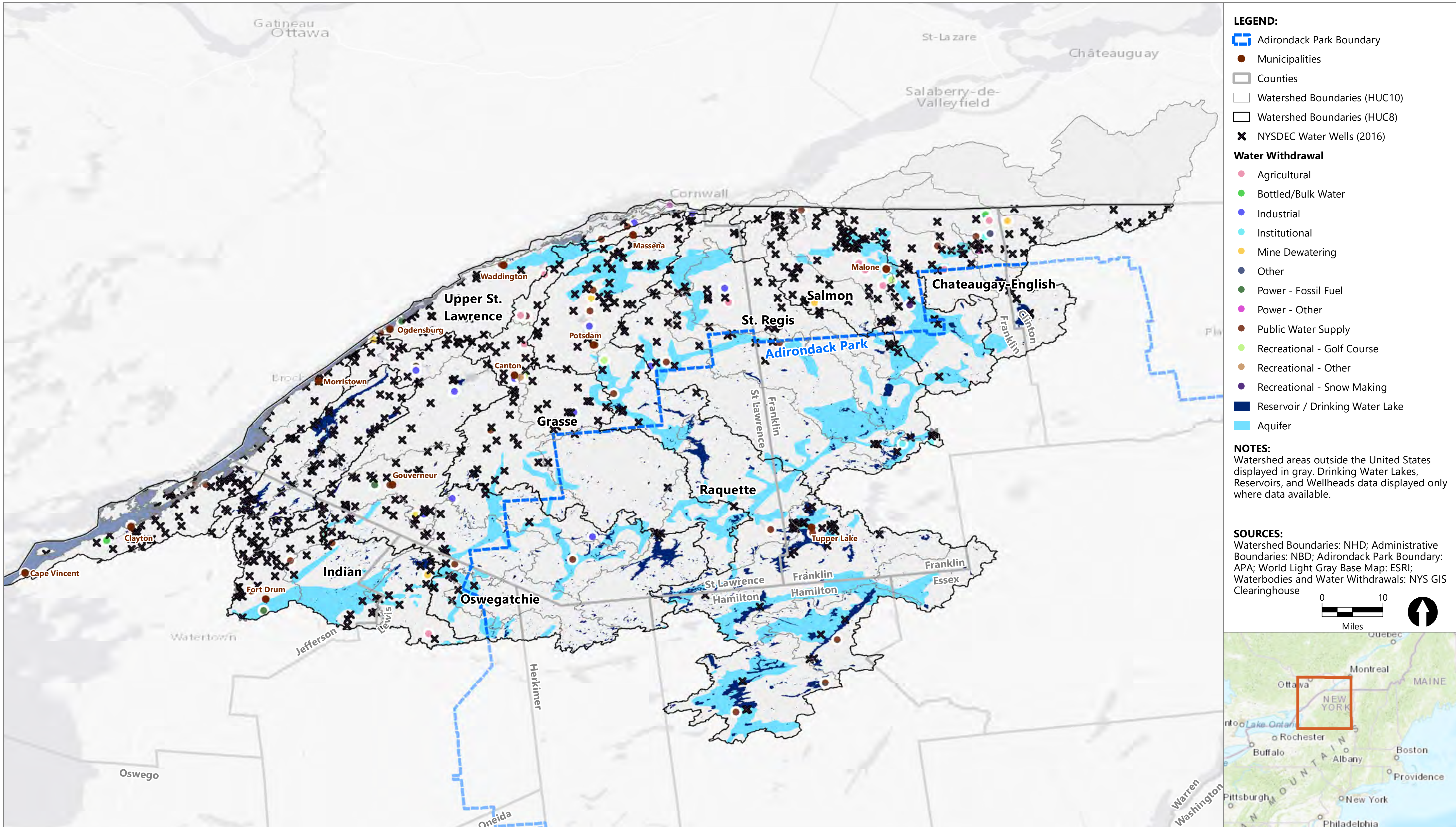
St. Lawrence River Watershed Project
NEW YORK STATE OF OPPORTUNITY Department of State

Map 25
Population Density in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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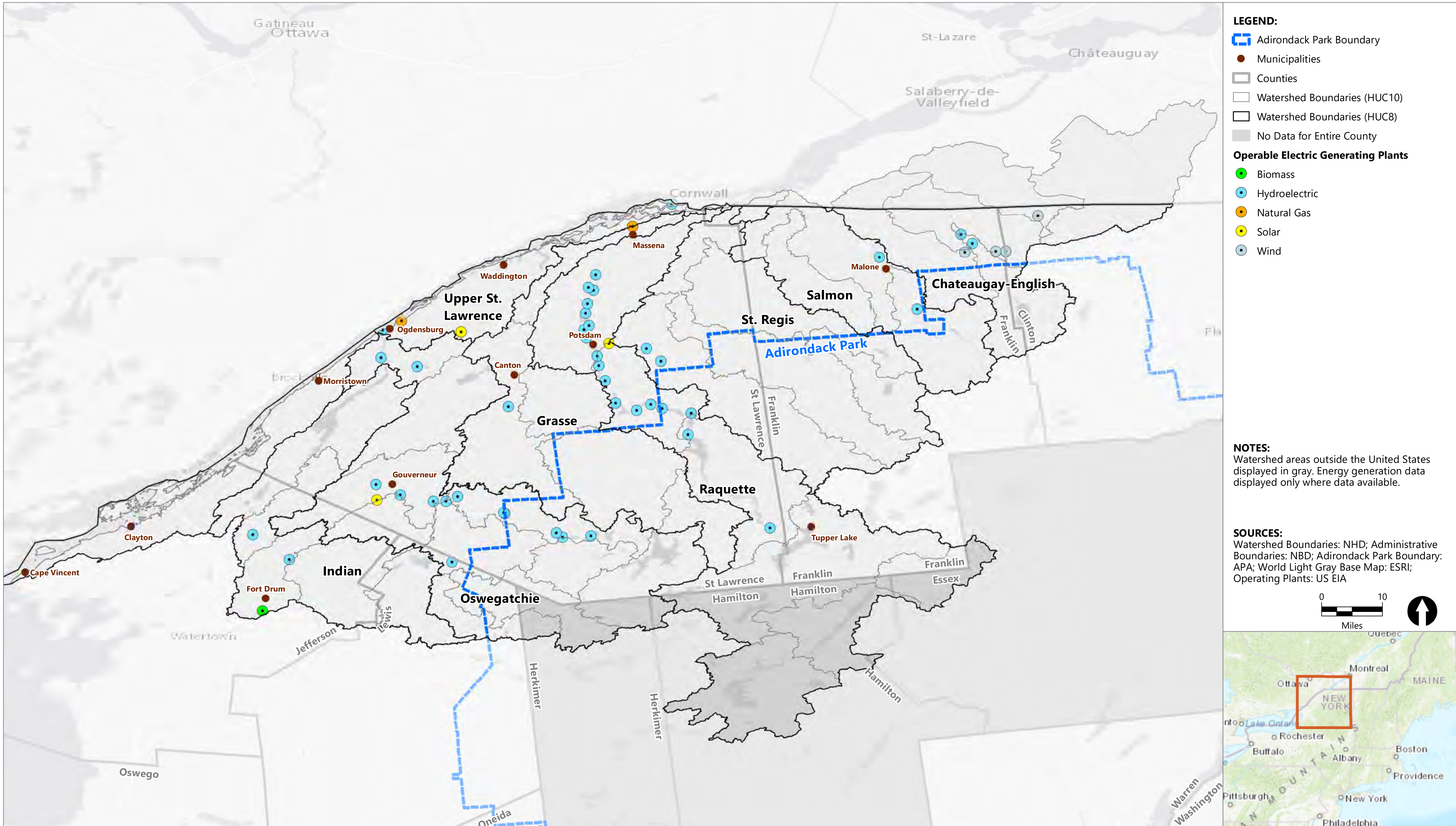
Map 26

Water Withdrawals from Lakes, Reservoirs, and Wellheads in St. Lawrence River Watershed in New York State

St. Lawrence River Watershed Revitalization Plan



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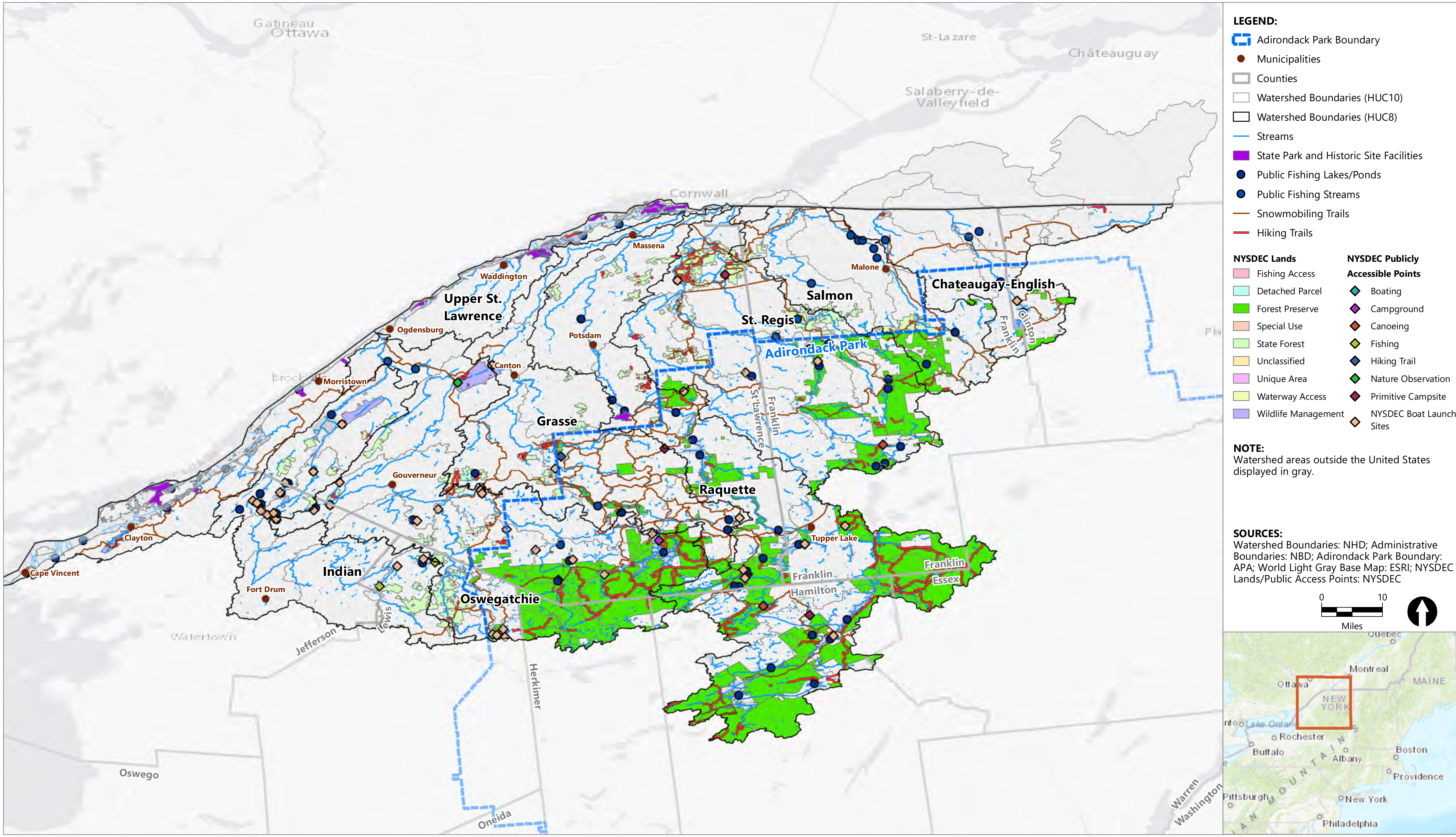
Map 27
Energy Generation in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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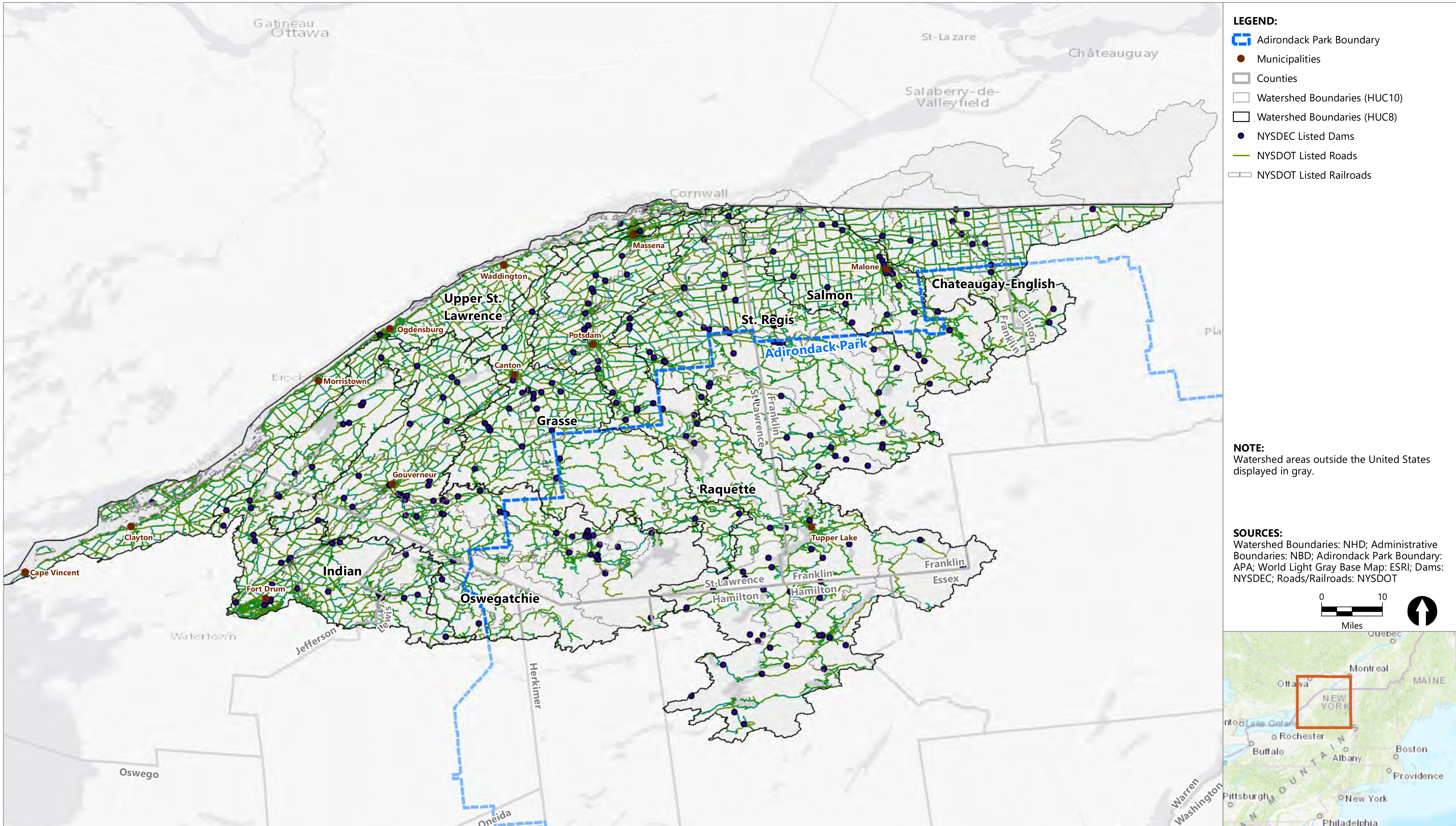
Map 28

NYSDEC Public Access Points in St. Lawrence River Watershed in New York State

St. Lawrence River Watershed Revitalization Plan



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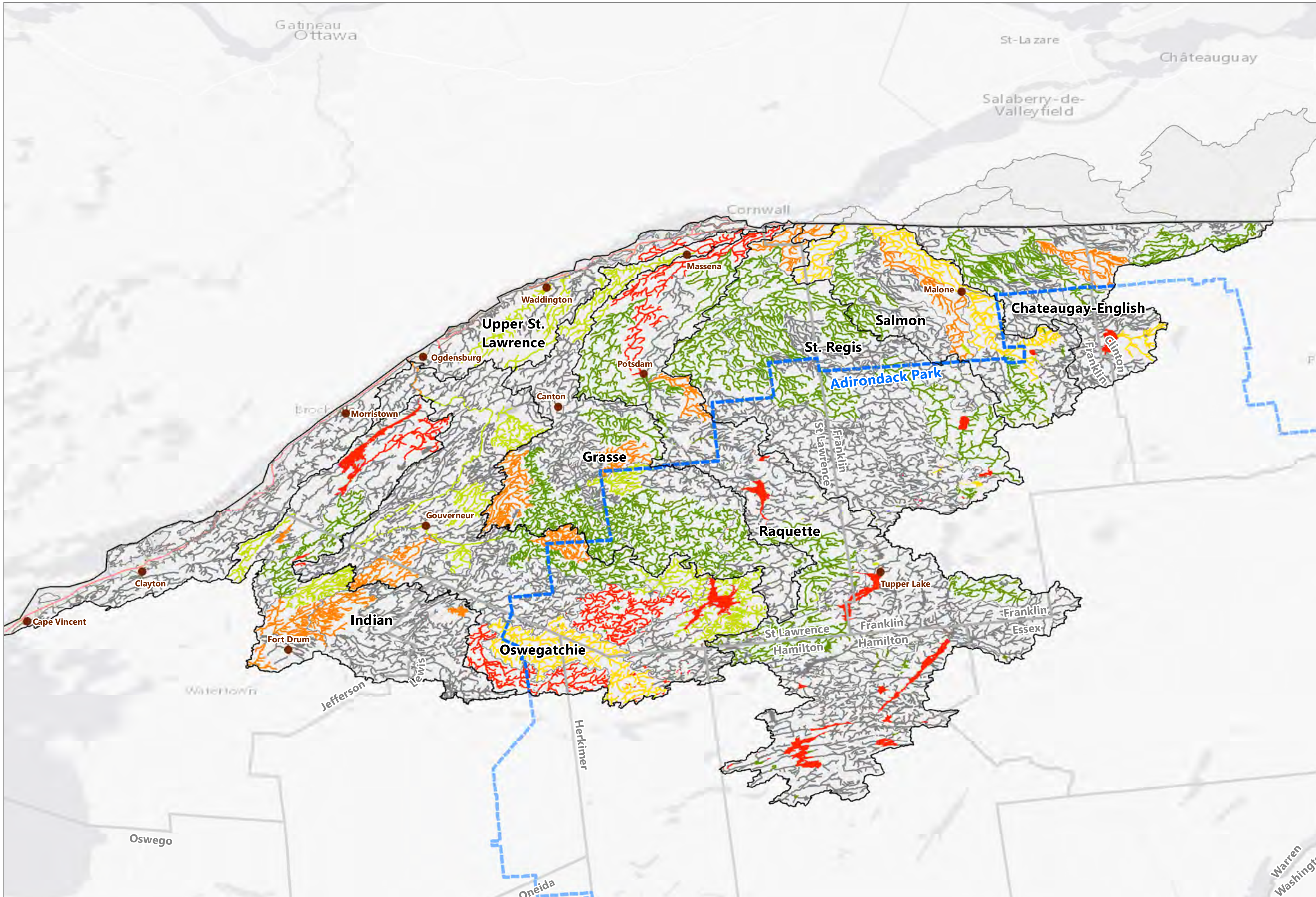
Map 29
Infrastructure in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)

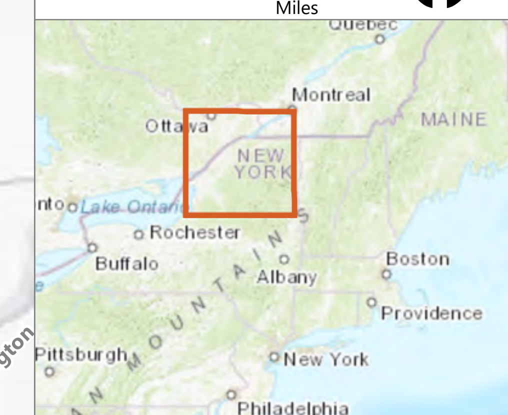
Priority Waters (Streams and Lakes)

- Impaired
- Minor Impacts
- Threatened
- Needs Verification
- No Known Impact
- Unassessed

NOTES:
Watershed areas outside the United States displayed in gray. PWL status categories include Impaired, Minor Impacts, Threatened, Needs Verification, No Known Impacts, and Unassessed in waterbody categories.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; PWL Status: NYSDEC

0 10
Miles



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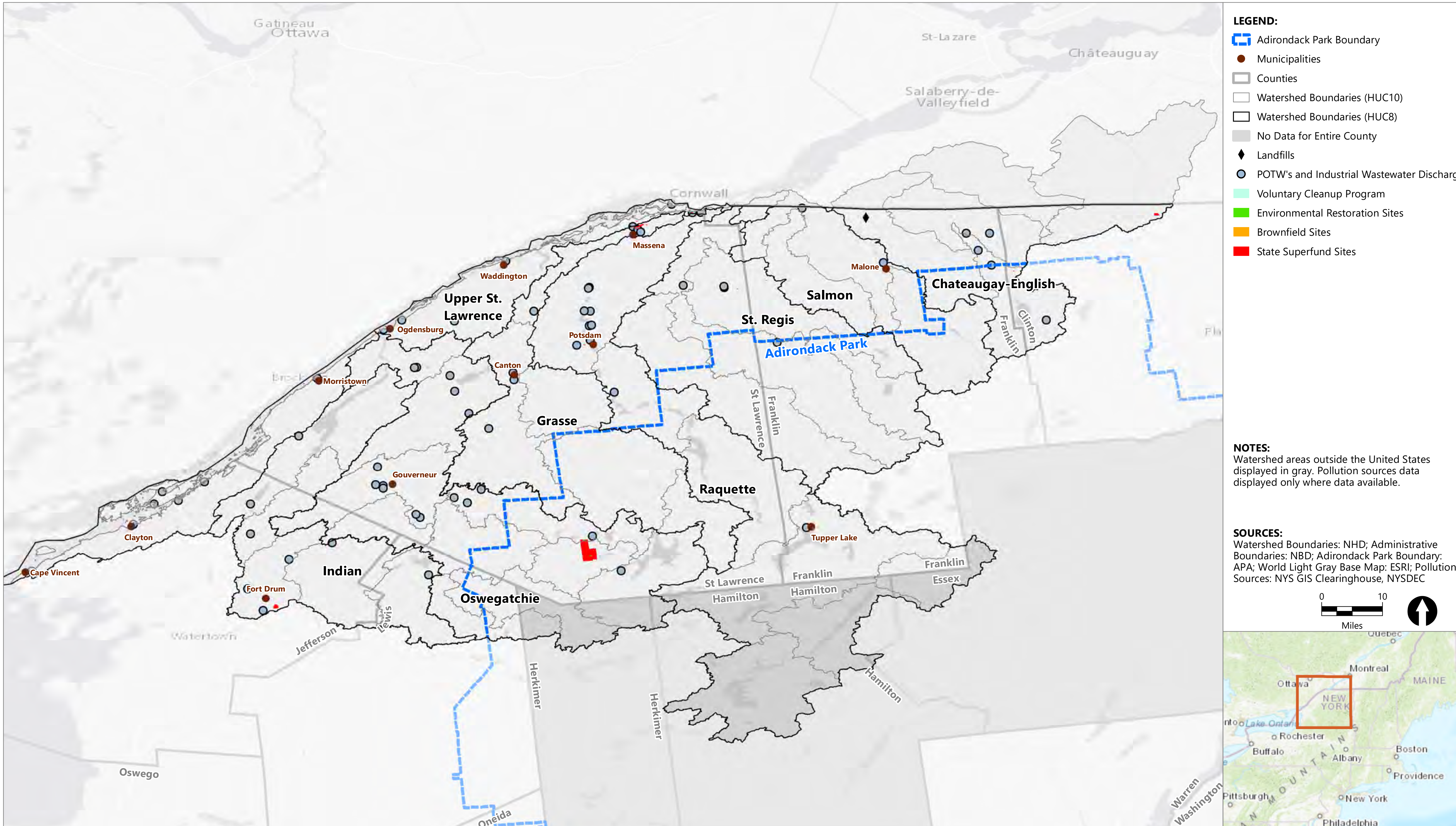
Map 30
Priority Waterbodies List Status for St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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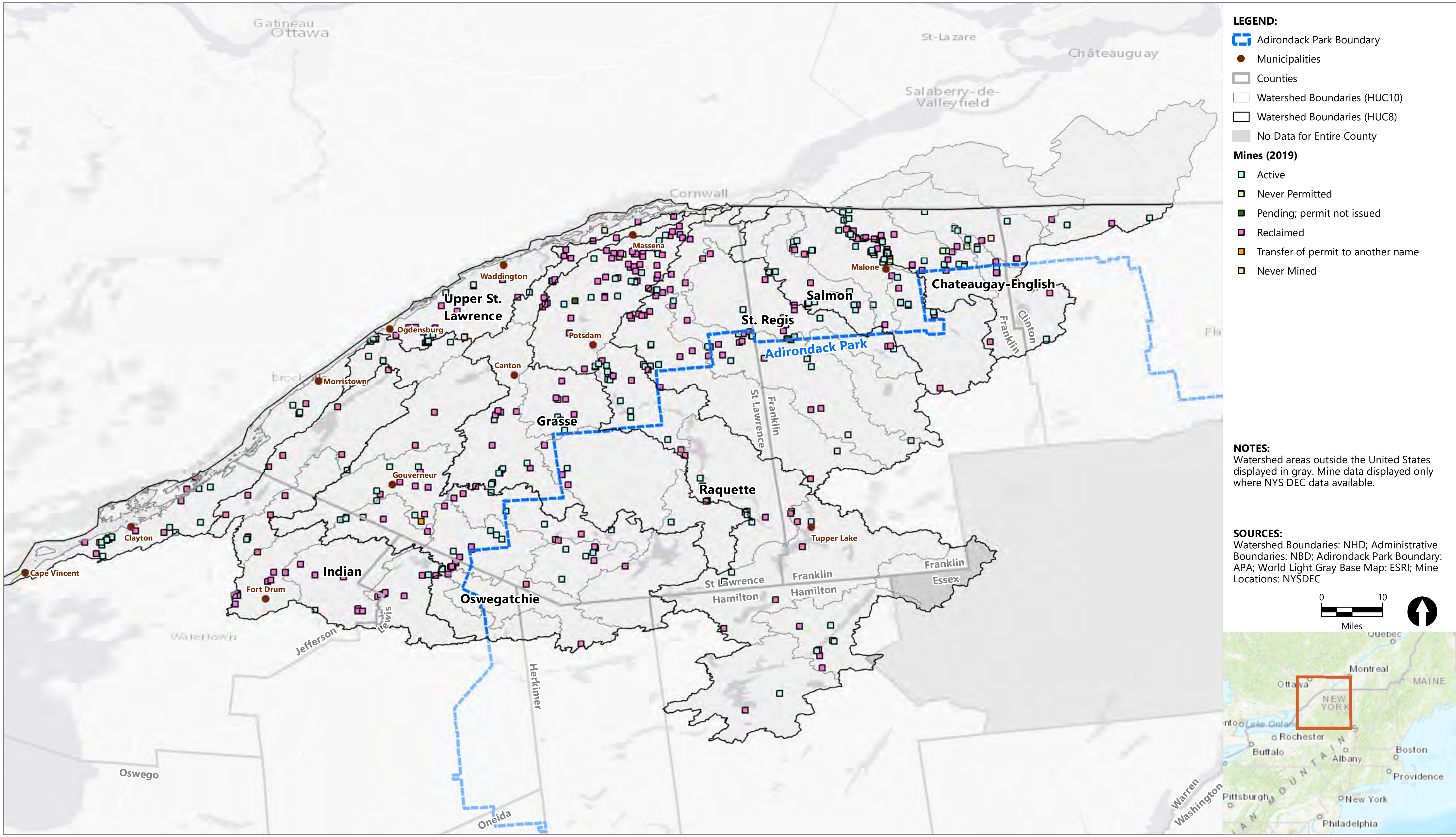
Map 31
Pollution Sources in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



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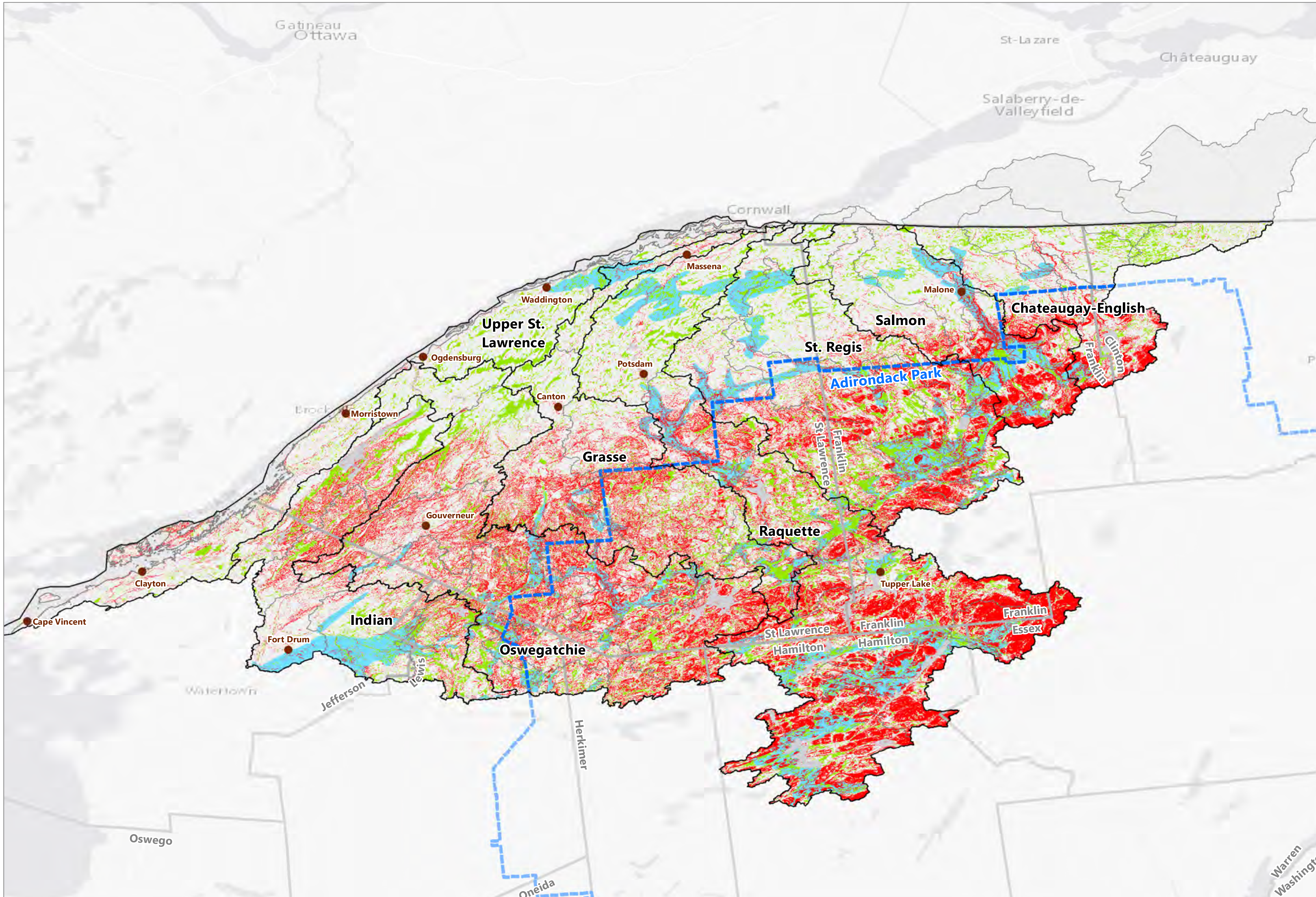
Map 32
Mines in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan



LEGEND:

- Adirondack Park Boundary
- Municipalities
- Counties
- Watershed Boundaries (HUC10)
- Watershed Boundaries (HUC8)
- Principal Aquifer

Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland

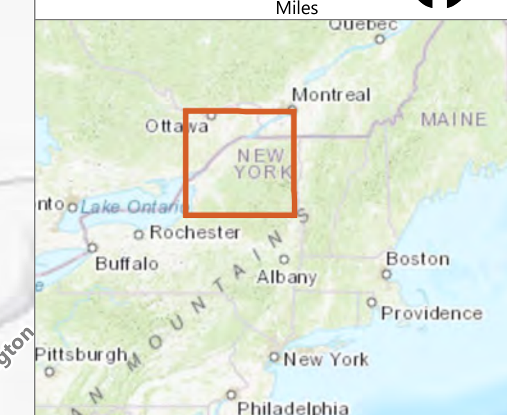
Slope

- <15%
- >15%

NOTE:
Watershed areas outside the United States displayed in gray.

SOURCES:
Watershed Boundaries: NHD; Administrative Boundaries: NBD; Adirondack Park Boundary: APA; World Light Gray Base Map: ESRI; Wetlands: NYS GIS Clearinghouse; Aquifers: NYS GIS Clearinghouse; Slope: NYS GIS Clearinghouse

0 10
Miles



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Map 33
Sensitive Areas in St. Lawrence River Watershed in New York State
St. Lawrence River Watershed Revitalization Plan

Appendix A
Local Laws and Programs Affecting Water Quality