Chapter 1: Introduction and Methodologies

This report is part of a multi-phased watershed planning process, and has been prepared to directly supplement previous work conducted by Buffalo Niagara Riverkeeper in Phase I of the Niagara River Watershed Management Plan (Healthy Niagara), and ongoing work by project partners Erie County Department of Environment and Planning, and the Lake Erie Watershed Protection Alliance. This project was prepared for the New York State Department of State with funds provided under Title 11 of the Environmental Protection Fund Act.

Phase I began the watershed planning process through assessment of current conditions, trends, and major contributors to regional water quality at a watershed-wide scale. This document builds on the priorities identified through the Phase I planning process, aims to provide a "snapshot in time" of water quality conditions throughout the Niagara River Watershed, and develop implementation plans to address specific concerns identified in five priority sub-watersheds.

For the purpose of this report, we collectively refer to four sub-basins (USGS HUC 8 level) as the Erie/Niagara Watershed: Chautauqua-Conneaut, Cattaraugus, Buffalo-Eighteenmile and Niagara River sub-basins. The first three sub-basins drain into eastern Lake Erie and the fourth is the connecting channel which drains Lake Erie into Lake Ontario. It is important to note that although the Chautauqua-Conneaut sub-basin spans both New York and Pennsylvania jurisdictions, we only describe NYS lands. Additionally, Canada is an equally important contributor to the Erie/Niagara Watershed; however, it is beyond the scope of this report.

Priority Sub-watersheds and Methodologies

Many rural, suburban, and urban settlements exist throughout the watershed, with each setting presenting its own unique set of impairments to ecological integrity. Although some deteriorations cause site-specific changes to water quality (such as livestock grazing eroding a streambank), it is imperative to note that these issues also influence the ecosystem at a much larger scale. Thus, a successful watershed management plan must carefully consider degradation at both small and large scales as well as across an urban to rural gradient. The approach taken is to identify priority areas to address impairments, conduct a thorough inventory of the most serious threats to water quality (through both modeling and data collection), and finally to highlight specific strategies which will have greatest potential for watershed-scale improvements. In this report we provide both short-term solutions for time-sensitive impairments, as well as long-term goals which have the greatest propensity to ensure long-term sustainability of healthy watershed conditions.

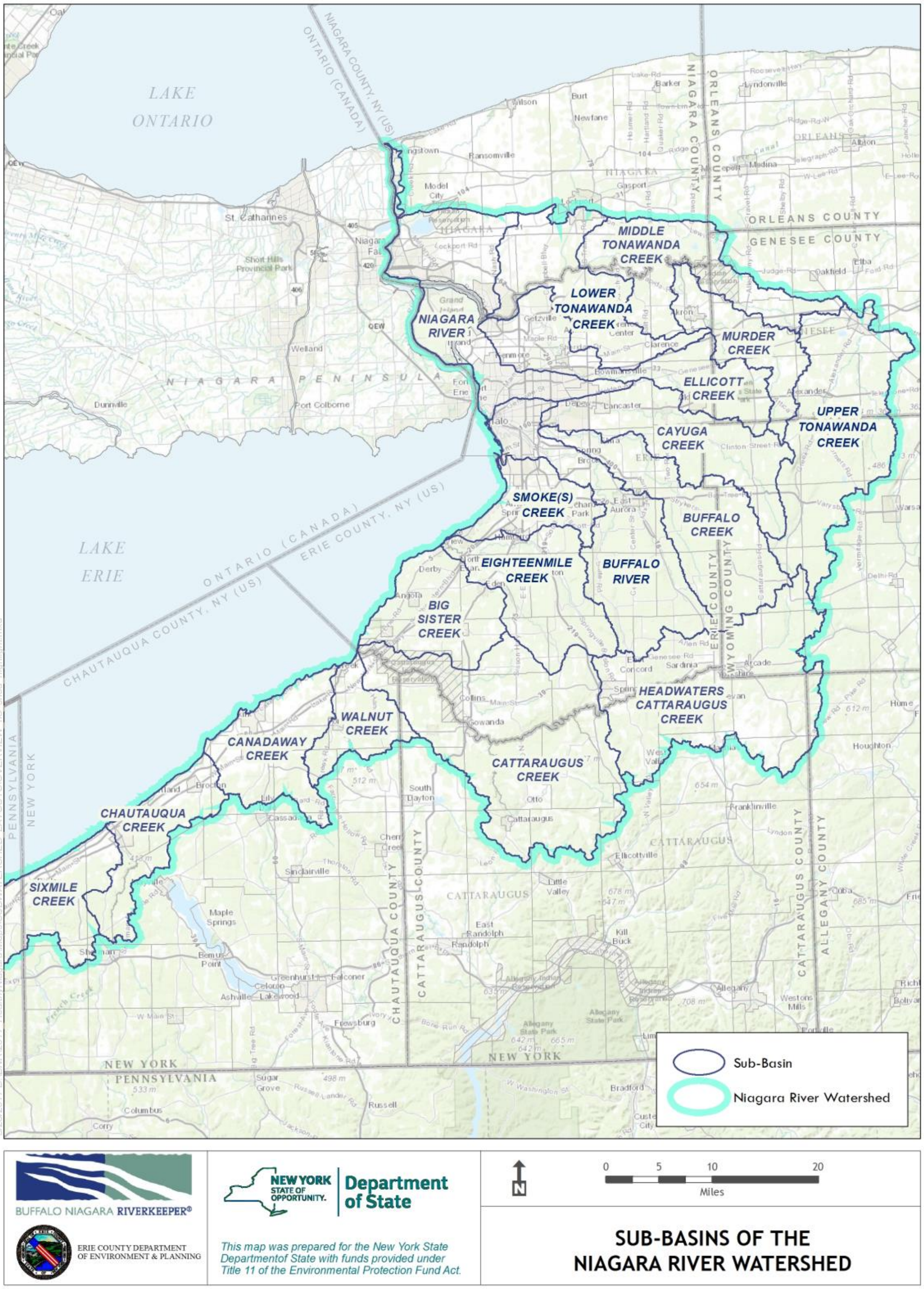
The Niagara River/Lake Erie Watershed is located in Western New York, which has a rich history and legacy of industrial pollution. Currently the Niagara and Buffalo Rivers are designated as Areas of Concern (AOCs) under the Great Lakes Water Quality Act, an agreement between the US and Canada to protect and restore the waters of the Great Lakes. Lake Erie is the shallowest and most ecologically productive of the Great Lakes, and also has the shortest water retention time of all five lakes. The Niagara River is the connecting channel between Lakes Erie and Ontario; essentially the mode of transportation for water from all of the other lakes into Lake Ontario. The Niagara River is a globally recognized Important Bird Area, the same designation given to areas such as the Galapagos Islands, which are able to support incredible populations and communities of migrating birds. The Lake Erie walleye fishery is unmatched elsewhere in the country and recreational fishing brings in considerable revenue to the region, as does tourism at Niagara Falls. Additionally, the Niagara River also supports one of two of the only self-sustaining, native musky populations in the Great Lakes, with the other location being in the St. Lawrence River.

The Niagara River/Lake Erie Watershed spans eight counties: all of Erie County, and portions of Allegheny, Cattaraugus, Chautauqua, Niagara, Orleans, Genesee, and Wyoming counties. The watershed also spans across a transect of rural to urban land use, with generally more rural regions in the upper reaches of the watershed, becoming increasingly urbanized downstream towards Lake Erie and the Niagara River. The three largest municipalities in this watershed are Buffalo, Niagara Falls, and Amherst. Sub-watersheds are shown in spatial context below in Map 1.1.

The Niagara River/Lake Erie Watershed is comprised of 18 sub-watersheds (USGS HUC 10 level) that cover 1,523,515.3 acres (2,380.5 square miles) of the eastern end of Lake Erie, including the full extent of the Eastern (US) side of the Niagara River Channel. The total area of each individual sub-watershed is listed above in Table 1.1.

Table 1.1: Sub-watershed Areas

10-Digit Hydrologic Unit	Acres	Square Miles
Big Sister Creek	62,363.00	97.4
Buffalo Creek	93,158.50	145.6
Buffalo River	105,367.80	164.6
Canadaway Creek	64,538.80	100.8
Cattaraugus Creek	197,523.20	308.6
Cayuga Creek	81,358.20	127.1
Chautauqua Creek	51,266.30	80.1
Eighteenmile Creek	76,834.00	120.1
Ellicott Creek	76,824.30	120
Headwaters Cattaraugus Creek	160,605.70	250.9
Lower Tonawanda Creek	78,788.80	123.1
Middle Tonawanda Creek	79,090.00	123.6
Murder Creek	46,666.40	72.9
Niagara River	102,812.10	160.6
Sixmile Creek	43,537.60	68
Smokes Creek	39,522.80	61.8
Upper Tonawanda Creek	127,237.90	198.8
Walnut Creek	36,019.90	56.3
Total	1,523,515.30	2,380.50



Map 1.1: Niagara River/Lake Erie Watershed

It is important to note that Phase I of this project, and the selection of priority sub-watersheds for Phase II considered only the 11 sub-watersheds of the Niagara River Watershed, the area referred to hereafter in this document as the "New Phase II Territory" is comprised of seven additional sub-watersheds, Big Sister Creek, Canadaway Creek, Chautauqua Creek, Cattaraugus Creek, Headwaters Cattaraugus Creek, Sixmile Creek, and Walnut Creek, that were outside of the scope of the previously completed Phase I work. These areas are included in this report as expanded territory of the Lake Erie Watershed, but, because this phase builds off of Phase I work, they were not selected for consideration as priority sub-watersheds for on-the-ground assessment. It should also be noted that roughly half of all inputs into this region of Lake Erie and the Niagara River are not included in this project, as they are part of the Niagara River Watershed in Canada.

As Phase II of the watershed management process was developed, it became increasingly clear that due to the size and scale of the Niagara River Watershed, a single study spanning only two to three years in total would not be able to effectively investigate and assess the 18 sub-watersheds individually. Because of this, a matrix was developed to rank and prioritize for further study, sub-watersheds as either a sub-watershed with high water quality and healthy habitat to be protected and preserved, or a sub-watershed with impaired water quality and habitat quality. The matrix assessment used to assess watershed prioritization in Phase I is shown below in Table 1.2.

Table 1.2: Watershed Prioritization Matrix

Sub-watershed Prioritizing Data Sets	Good Indication	Poor Indication
% of Impervious Cover	Low	High
% of Natural Areas	High	Low
% of Woodland Cover	High	Low
Predicted Biologic Assessment Profile Scores	High	Low
% Riparian Woodland (tracts greater than 50 Acres)	High	Low
Density of Stream Miles	High	Low
% of Industrial Use	Low	High
Urban Density	Low	High
# of Road/Bridge Crossings	Low	High
# of Hazardous Waste Sites	Low	High

Through this process, five sub-watersheds, Eighteenmile Creek, Buffalo River, Lower Tonawanda, Smokes Creek, and Upper Tonawanda, were identified as priorities for further investigation of water quality and physical characteristics in order to develop appropriate management actions for improving and protecting healthy conditions.

Priority Sub-watersheds to Protect & Preserve (Good Conditions):

- Buffalo River Sub-watershed
- Eighteenmile Creek Sub-watershed
- Upper Tonawanda Creek Sub-watershed

The three sub-watersheds above were chosen based on the priority to preserve and protect conditions leading to high water quality and healthy habitat. These watersheds are characterized by a large amount of forest cover, much of it in connected riparian corridors. They have low levels of urbanization and impervious cover. They are also currently found to have the best water quality characteristics in the Niagara River Watershed. By focusing on these sub-watersheds, tools can be developed and outcomes measured which will be most effective in protecting the health of sub-watersheds from common impairments moving forward. A summary of the Protect & Preserve assessment is provided in Table 1.3 below, with Phase II priority sub-watersheds highlighted in green.

Table 1.3: Sub-watershed Assessment by Potential to Protect and Preserve

Data/Indicator	Niagara	Lower Tonawanda	Middle Tonawanda	Upper Tonawanda	Ellicott	Murder	Cayuga	Buffalo Creek	Buffalo River	Smokes	Eighteenmile
Low Impervious Cover	1	3	5	5	2	5	4	5	3	2	5
Natural Areas	1	1	2	4	2	3	3	4	5	3	5
Woodland Cover	1	2	2	3	2	2	4	4	4	3	5
Water Quality – BAP	2	3	4	5	3	2	4	5	5	1	3
Riparian Woodland	3	1	2	3	2	4	4	4	5	3	4
Stream Miles	2	2	4	5	3	3	4	4	3	1	3
	10	**12**	**19**	**25**	**14**	**19**	**23**	**26**	**25**	**13**	**25**

It is important to note, that although Buffalo Creek Sub-watershed ranked highest on this scale, it was not chosen for further investigation through this project, as the Buffalo River Sub-watershed contains an EPA Area of Concern, has been previously studied, and is therefore already deemed a high priority for implementation of identified management actions.

Priority Sub-watersheds to Address Impairments (Poor Conditions):

- Smoke's Creek Sub-watershed
- Lower Tonawanda Creek Sub-watershed

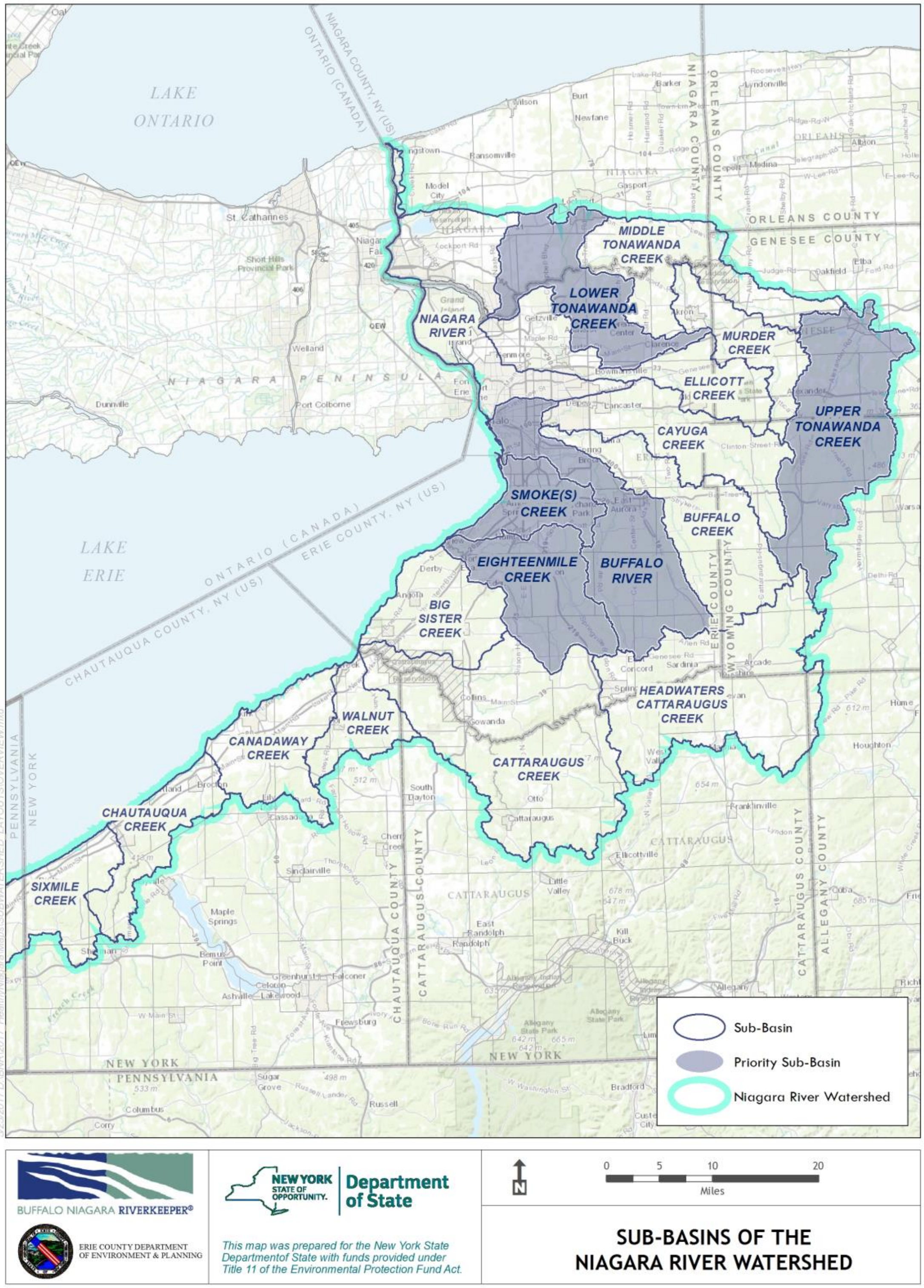
The two sub-watersheds were chosen the based on the potential to affect factors that currently contribute to the impairment of water quality and habitat conditions. These watersheds are characterized by high density urban development in the cities of Buffalo, Lackawanna, and the Tonawandas, along with high percentages of impervious cover. There are also high amounts of land and water impaired by legacy contamination within these sub-watersheds. Table 1.4 below summarizes the assessment, with Phase II priority sub-watersheds highlighted in yellow. While Ellicott Creek Sub-watershed ranks slightly higher on the matrix assessment for potential to address impairments, Lower Tonawanda was selected for further investigation due to higher regional interest in the waterbodies as expressed by stakeholders.

Table 1.4: Sub-watershed Assessment by Potential to Address Impairments

Data/Indicator	Niagara	Lower Tonawanda	Middle Tonawanda	Upper Tonawanda	Ellicott	Murder	Cayuga	Buffalo Creek	Buffalo River	Smokes	Eighteenmile
High Impervious Cover	5	3	1	1	4	1	2	1	3	4	1
Natural Areas – lack of	5	5	4	2	4	3	3	2	1	3	1
Woodland Cover – lack of	5	4	4	3	4	4	2	2	2	3	1
Water Quality - BAP	4	3	2	1	3	4	2	1	1	5	3
Industrial Use	4	3	0	2	2	1	1	1	1	5	0
High Density Urban	5	1	0	0	2	0	1	0	3	4	0
Road Crossings	4	2	1	4	3	3	3	2	1	5	1
Hazardous Waste Sites	5	3	1	1	3	1	2	4	1	3	1
	37	**24**	**13**	**14**	**25**	**11**	**16**	**14**	**13**	**32**	**8**

To identify these impairments on-the-ground stream visual assessments, water quality sampling, and nutrient and bacterial loading measurements were taken throughout the five priority sub-watersheds. Using the data collected, critical source areas, defined as those lands which serve as impairments sources within the sub-watershed, were identified by performing a combination of mathematical and GIS analysis.

Priority Sub-watersheds are shown as shaded sections Map 1.2.



Map 2.2: Prioritized Sub-Watersheds

EPA Nine Element Watershed Management Plan and TMDL

The long-term goal for the Regional Niagara River/Lake Erie Watershed Management Plan is to contribute to the drafting and implementation of a US EPA Nine Element Watershed Management Plan. While Phases 1 and 2 of the planning processes have contributed towards progress on a Nine Element Plan for the region, the complete process is expected to take another three to four phases of watershed planning efforts over the next several years. A complete and implemented nine element plan outlines strategies for restoration that are based on quantifiable metrics to enable ongoing tracking of watershed health and the effectiveness of restoration initiatives.

A related yet ancillary study completed through this effort was to analyze the feasibility of implementing a Total Maximum Daily Load (TMDL) for those waterbodies listed on the New York State List of Impaired water bodies, and is available as Appendix A. A summary chart comparing nine-element Plans and TMDLs is presented below in Table 1.5.

Table 1.5: Comparison of 9E plans and TMDLs

Attribute	9E Plan	TMDL
Pollutant sources	Better for nonpoint sources	Better for point sources
Implementation plan	Required	Optional*
Public comment period	No (public participation is conducted throughout plan development)	Required
Agency approval	NYS DEC	EPA
Funding eligibility	State and federal opportunities	State and federal opportunities

Of the five priority sub-watersheds studied, three contained water bodies or segments of waterbodies listed as impaired. This means they may require the state to set a TMDL for the water body limiting the amount of pollutants that can be discharged into a specific water body each day. This report identifies baseline indicators of pollution as well as best management practices for addressing identified impairments. Together these factors can be used to implement an alternative to a TMDL. TMDLs can be costly and difficult to implement. However, if the goals of the TMDL can be met through alternate means, then the listed water body can be taken off the impaired water body list. This report, through a holistic and science driven approach will identify the major sources and contributors of pollution and present strategies to combat those sources of pollution through mechanisms that include voluntary landowner actions, alternative land management regimes, maintenance, as well as other best management practices, policy and regulatory tools.

Land Use/Land Cover

Land Use/Land Cover (LULC) classifications were derived from 2010 National Oceanic Atmospheric Administration (NOAA) LULC data, and like classifications were consolidated into groups that reflect the overall LULC classification.[22]

Active River Area

This project was developed around measuring conditions in streams to determine impairments, and begin to understand the processes and areas that those impairments stem from during baseline conditions, i.e. not during storm events or extreme weather. Because of this, a need to understand which land the stream channels interact with during these baseline conditions became apparent.

Understanding the connectivity between land and water is crucial for implementing effective conservation, restoration, and management actions. The Active River Area (ARA) model, developed by the Nature Conservancy was utilized to determine the extent that stream channels within the priority sub-watersheds interacts with surrounding land. This model is composed of components that capture the natural processes and key attributes that define a stream's active components and interaction with surrounding land. Table 1.6 below displays an itemized list of features that the ARA model incorportates.

Table 1.6: Active River Area Components

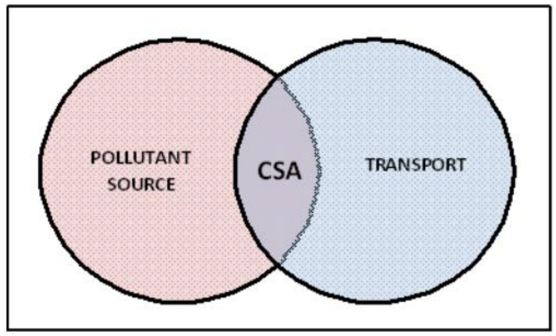
Active River Area Component	Typical Habitat Features
Material contribution areas	Seep or saturated source area
	Spring
	Wetland (forested, meadow, etc.)
	Forest canopy / overhanging vegetation
	Bluff, cliff and steep slopes
Meander belt	Step, riffle, run, pool, glide, dune, ripple
	Sediment & gravel bars (point, mid-channel, etc.)
	Hydraulic refugia from tributaries and oxbows
	Undercut bank
	Beaches and scour areas
	Physical refugia from LWD, debris jam, CPOM
	Forest canopy / overhanging vegetation
Floodplain	Oxbows
	Meander scar
	Floodplain lake
	Wetland
	Backwater swamp
	Island
	Natural levee
	Floodplain forest
	Forest canopy / overhanging vegetation
	Clay plug (filled oxbow)
Terraces	Wet meadow
	Ridges (old natural levee)
	Troughs (dry oxbow)
	Meander scars
	Prairie
	Remnant floodplain forest
Riparian wetlands	Forested, meadow, etc.
	Vernal pool
	Backwater swamp
	Beaver pond flowage

By modeling and identifying the sub-watershed's components, as seen above, which sustain the waterway's physical and ecological processes, the ARA of a stream or sub-watershed can be determined. The ARA model defines the area of land that is hydrologically connected to a waterway, and is an important tool to guide actions to improve water quality.

Critical Source Areas

Areas where priority contaminants–those prevalent in large spatial expanses of the sub-watershed or that consistently exceed water quality standards and guidance values are defined as Critical Source Areas (CSAs). These source areas are described in this study as discrete regions within the sub-watershed that contribute a disproportionate amount of pollutants relative to their spatial expanse. For example, a study conducted in Oklahoma by White et al. (2009)[32], found that only 5% of the land in the six watersheds studied contributed 50% of the sediment load and 34% of the measured phosphorus. Additionally, in watersheds with more agricultural land use, large portions of agricultural pollutants were found to enter waterways from an even smaller subset of land area. Figure 1.1 displays the study's definition of a CSA, and how it is developed from overlap between a pollutant source and transport.

Figure 1.1: Concept of Critical Source Areas



CSAs are also not intended to trackdown and pinpoint the exact location of a pollutant's source, but rather identify where pollutants are actively interacting with and influencing a stream. The National Institute of Food and Agriculture Conservation Effects Assessment Project states that, "pollutant sources in the watershed are usually, although not always, a function of land use and management."[17]

This report views CSAs through the lens of ARA and LULC. Critical sources that contribute to water quality impairments identified in this report were separated from noncritical sources that do not actively contribute to the impairments as identified in the sub-watershed. Critical sources were derived from agriculture and developed LULC within the ARA, while forest, wetland, water, and other land covers make up the noncritical sources of impairments to the sub-watershed. It is important however, to note that CSAs as defined in this project refer only to potential nonpoint pollution sources during baseline conditions (i.e. not storm event), and that point source pollution from sources such as CSO and CAFO complexes may be contributing to stream impairments from non CSAs.

Management actions and best management practices to address impairments to waterbodies are intended to be implemented sub-watershed-wide but by focusing these actions on the CSAs identified in each sub-watershed, project implementation may achieve more successful, sustainable, and cost effective results. Targeting management and implementation actions where CSAs indicate potential stream segments or baseline indicator impairment in the ARA can enable practitioners to more quickly address problems.

Field Methodologies

Stream Visual Assessment Protocol

The SVAP was used to conduct field assessments of streams in order to define baseline conditions. This tool, developed by the Natural Resources Conservation Service, allows efficient qualification of a stream's condition by assessing several elements indicative of overall stream health. The result provides a "snapshot in time" of qualitative stream conditions, which are helpful for gauging the apparent health of a stream. The protocol was modified to better reflect conditions within the assessment area. Scoring elements such as salinity were not included in assessment due to freshwater conditions. Many streams and segments of streams were unable to be assessed due to limitations of the SVAP protocol. For example, SVAP requires assessments to be taken from within a stream; therefore a stream must be wadeable, generally no more than a few feet in depth at baseflow conditions. In certain instances, segments of streams were not wadeable and therefore were not assessed.

The SVAP scores select components of a stream's physical attributes on a 1-10 scale. For this study, the SVAP included (if applicable) the following elements:

- Channel Conditions
- Riparian Zone (Left and Right Bank)
- Bank Stability (Left and Right Bank)
- Water Appearance
- Nutrient Enrichment
- Instream Fish Cover
- Pools
- Invertebrate Habitat
- Riffle Embeddedness
- Canopy Cover
- Manure Presence

Stream reaches were located a standard 200 feet apart from each other, and sampling was conducted while moving upstream in the stream segment. Each sub-watershed was broken down into segments, and each segment was then divided into reaches, where individual assessments occurred. Each reach received an SVAP score based on observed elements. Scores of individual elements are averaged to generate overall SVAP scores for different waterbodies. Numerical scores are then calculated and grouped into four different categories as listed below.

- Poor (1.0-6.0)
- Fair (6.1 – 7.4)
- Good (7.5 – 8.9)

- Excellent (9.0-10.0)

Assessment locations were determined by identifying stream segments with impairment thresholds, i.e. stream segments where a marked change in water quality, stream health, land use, or other predictive tools suggest that in-water conditions have changed.

Streams to be sampled were selected for assessment based on a rubric assessment, various physical characteristics, and land use types. Digital reconnaissance of the streams was conducted using a Geographic Information System (GIS) and various maps to determine the practicality of SVAP sampling. Ground truthing of the selected streams occurred prior to the field season. The target was to assess and characterize approximately 10% of the total stream miles in the sub-watershed.

In addition to standard SVAP elements, the presence of invasive vegetation, aquatic vegetation, and barriers to fish movement were noted. Photo documentation occurred at the end of each reach, looking downstream. Additional photos and notes were taken to record any stream features that may influence stream condition or health such as pipes, culverts, tributaries, etc.

General parameters (coordinates, stream depth, bankfull width, baseflow width, and dominate substrate type) were recorded at each stream reach.

Water Quality Sampling

General water quality measurements were recorded at every other stream reach where SVAP assessments occurred. Stationary water quality monitoring sites were also utilized to provide measurements over time.

Yellow Springs Instruments (YSI) Pro Plus Multiparameter Instruments were used to measure temperature, conductivity, total dissolved solids, dissolved oxygen, and pH. YSI's were calibrated no longer than 24 hours in advance of sampling, as per manufacture specifications.

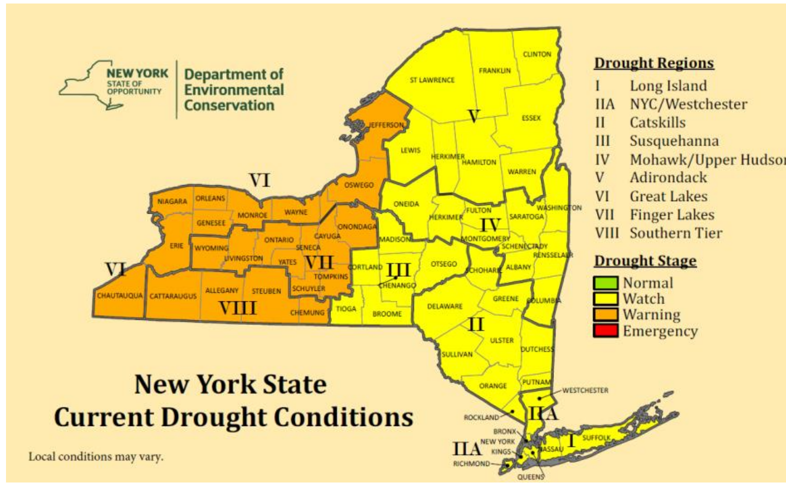
If water quality sampling was unable to be performed, due to equipment malfunction or dangerous conditions, it was noted on the field data sheets.

Grab samples were taken and stored on ice to later to analyze phosphorus, nitrate, and turbidity using a YSI 9500 Photometer and a Hach 2100Q Turbidimeter.

During the months of June to August, grab samples for *Escherichia coli* (*E. coli*) were collected and analyzed at the Erie County Health Department Lab. The sites were sampled regardless of weather or stream flow conditions.

Western New York experienced drought conditions during the spring and summer months of 2016. As of August 3rd, NYSDEC issued a drought warning for most of this region. The extent of the drought conditions can be seen in Figure 1.2. Samples collected during this time may not be representative of normal conditions in the watershed, as samples were still taken in the drought conditions.

Figure 1.2: Drought Conditions in NYS – As of August 3, 2016



Public and Municipal Input

Through the process of identifying impairments to water quality and developing management actions, it became increasingly important to gather input from municipal, agency, and public stakeholders. Riverkeeper held two municipal workshops, one in the northern portion of the Niagara River Watershed, and one in the southern portion, to present findings and recommendations to interested stakeholders, as well as solicit input on the development of the implementation plans. Additionally, a public presentation of the completed project was performed in Buffalo, NY to inform interested parties of the methods, results, and suggestions identified through the watershed planning process.

Additionally, a project advisory committee of technical experts was consulted for feedback and development of recommended management actions.

Figure 1.3: Riverkeeper staff member Elizabeth Robbe presenting to the public in Buffalo, NY