Chapter 6: Upper Tonawanda Creek

The Upper Tonawanda Creek Sub-watershed (UT) is located in the eastern edge of the Niagara River Watershed. It has an area of 127,308.6 acres, or 198.9 square miles, and includes 589.2 miles of waterways. Located in portions of Genesee and Wyoming Counties, UT includes 14 municipalities: Alexander, Attica, the Town of Batavia, the City of Batavia, Bennington, Bethany, Darien, Java, Middlebury, Orangeville, Sheldon, Stafford, Warsaw, and Wethersfield. Also located within the sub-watershed are the villages of Alexander and Attica. The sub-watershed is shown in Map 6.1.

UT's main tributaries, Tonawanda Creek and Little Tonawanda Creek, originate on the Allegheny Plateau and flow northeast through steep wooded ravines to the village of Attica. Both creeks then meander through wetlands and farmed mucklands. Just south of the City of Batavia, the two branches join on the Onondaga Escarpment and take a sharp left turn, flowing west into the Middle Tonawanda Creek Sub-watershed.

Land Use/Land Cover

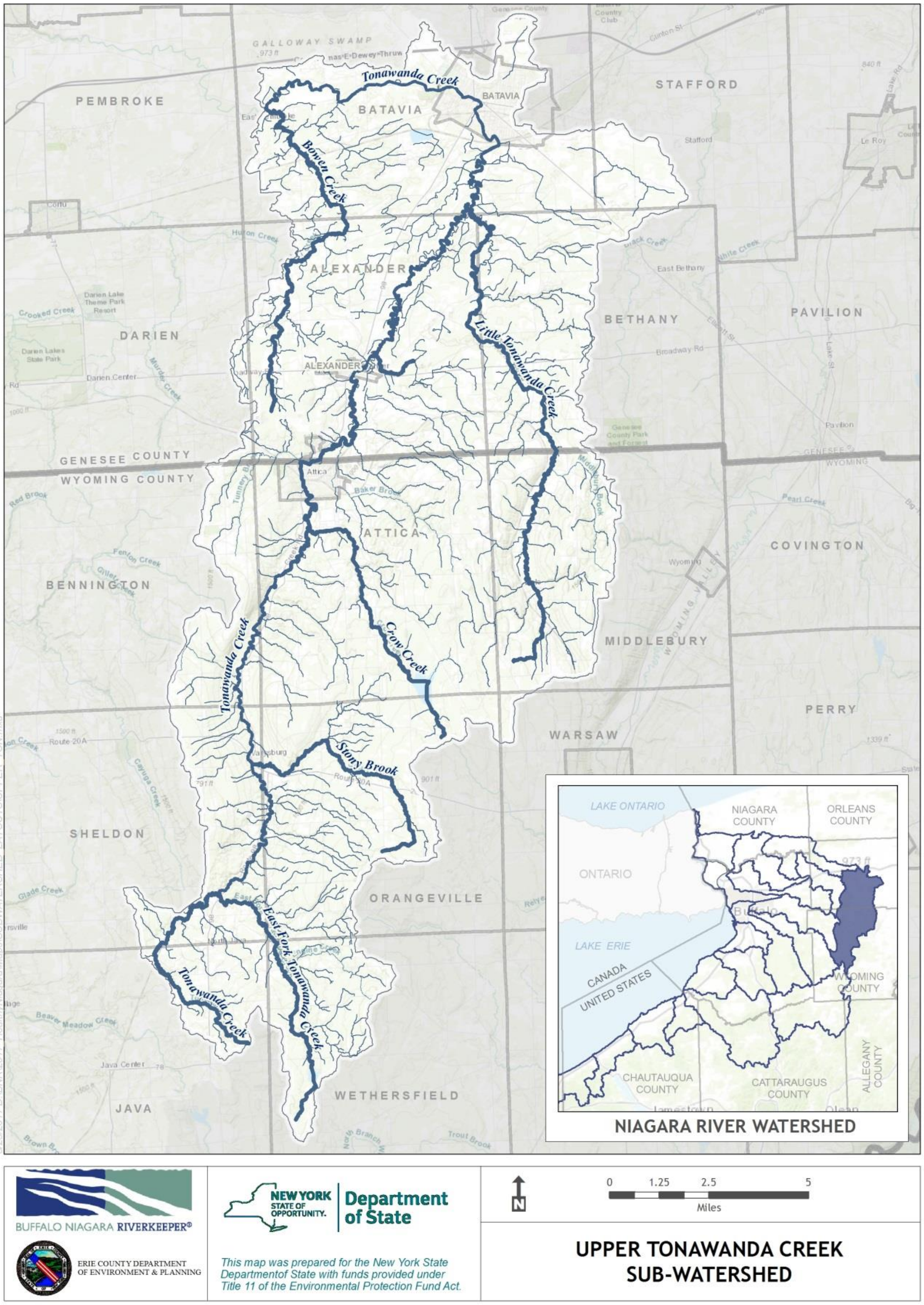
Land Use/Land Cover (LULC) classifications for UT were derived from 2010 National Oceanic Atmospheric Administration (NOAA) LULC data, and like classifications were consolidated into groups that reflect the overall LULC classification.[22] The LULC groups can be seen in Table 6.1.

Table 6.1: LULC Groups and percentages

LULC Class	% by general LULC
Developed, High Intensity	Developed: 4.23%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 49.05%
Pasture/Hay	
Deciduous Forest	Forest: 31.80%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 9.95%
Palustrine Scrub/Shrub Wetland	
Palustrine Emergent Wetland	
Open Water	Water: 0.59%
Palustrine Aquatic Bed	
Grassland/Herbaceous	
Scrub/Shrub	
Unconsolidated Shore	
Bare Land	Other: 4.38%

Characterized by high concentrations of agricultural activities, the most dominant land cover in the sub-watershed is agriculture (41.9%) followed by forest (25.1%), wetland (22.7%), developed land (6.1%), other (3%), and water (1.2%).

Shown in Map 6.2, large amounts of agriculture LULC exist throughout the watershed, with the northern region of the sub-watershed near Batavia becoming increasingly urbanized and developed, while the southern region remains predominately agriculture and forested land.



Map 6.1: Upper Tonawanda Creek Sub-watershed

Active River Area

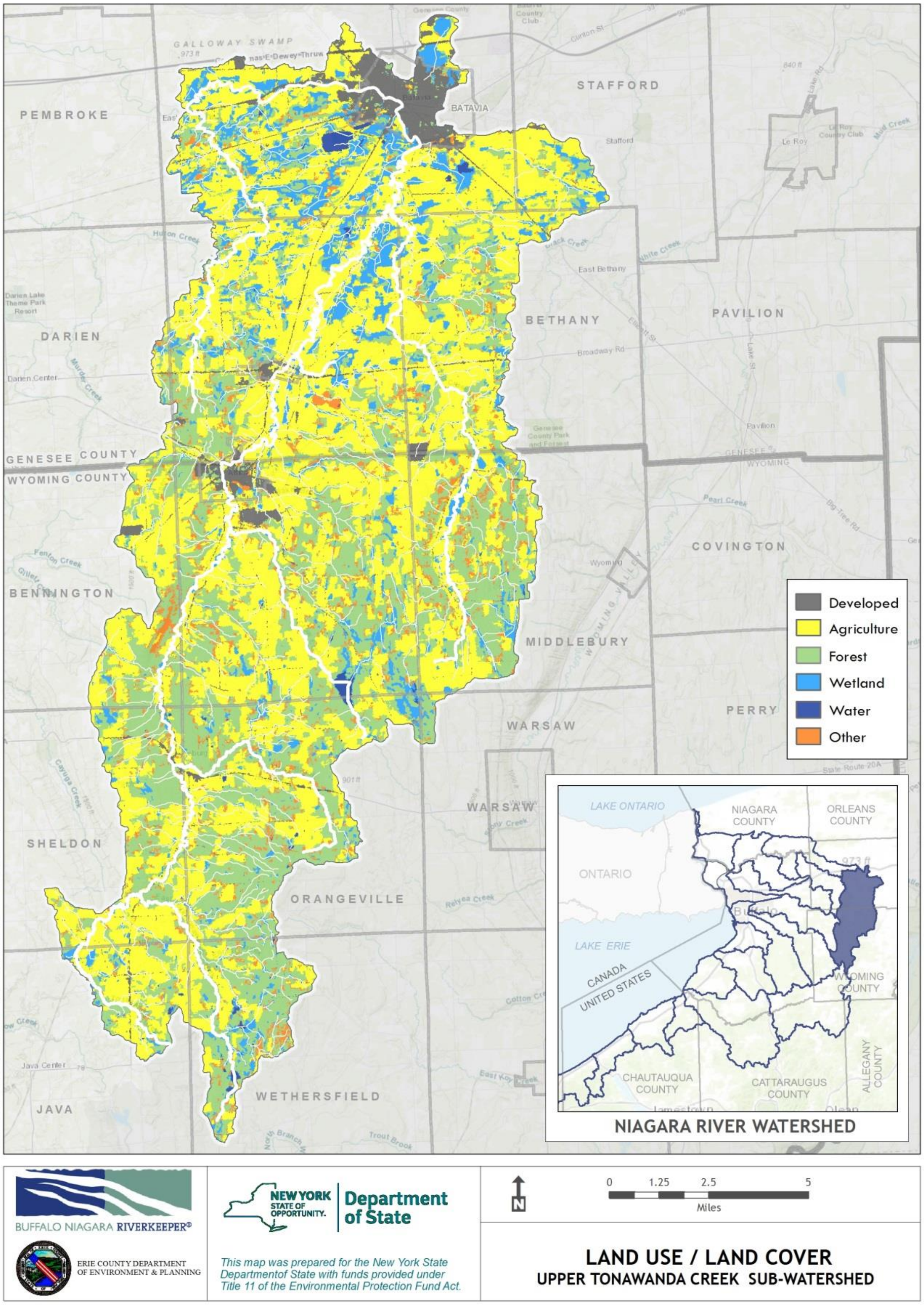
The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of the ARA and focus area for this project. The ARA within UT is generally more constrained in the headwaters, becoming more expansive as the waterbodies approach the Town and City of Batavia.

The ARA within UT encompasses 33% of its total area, as seen in Map 6.3.

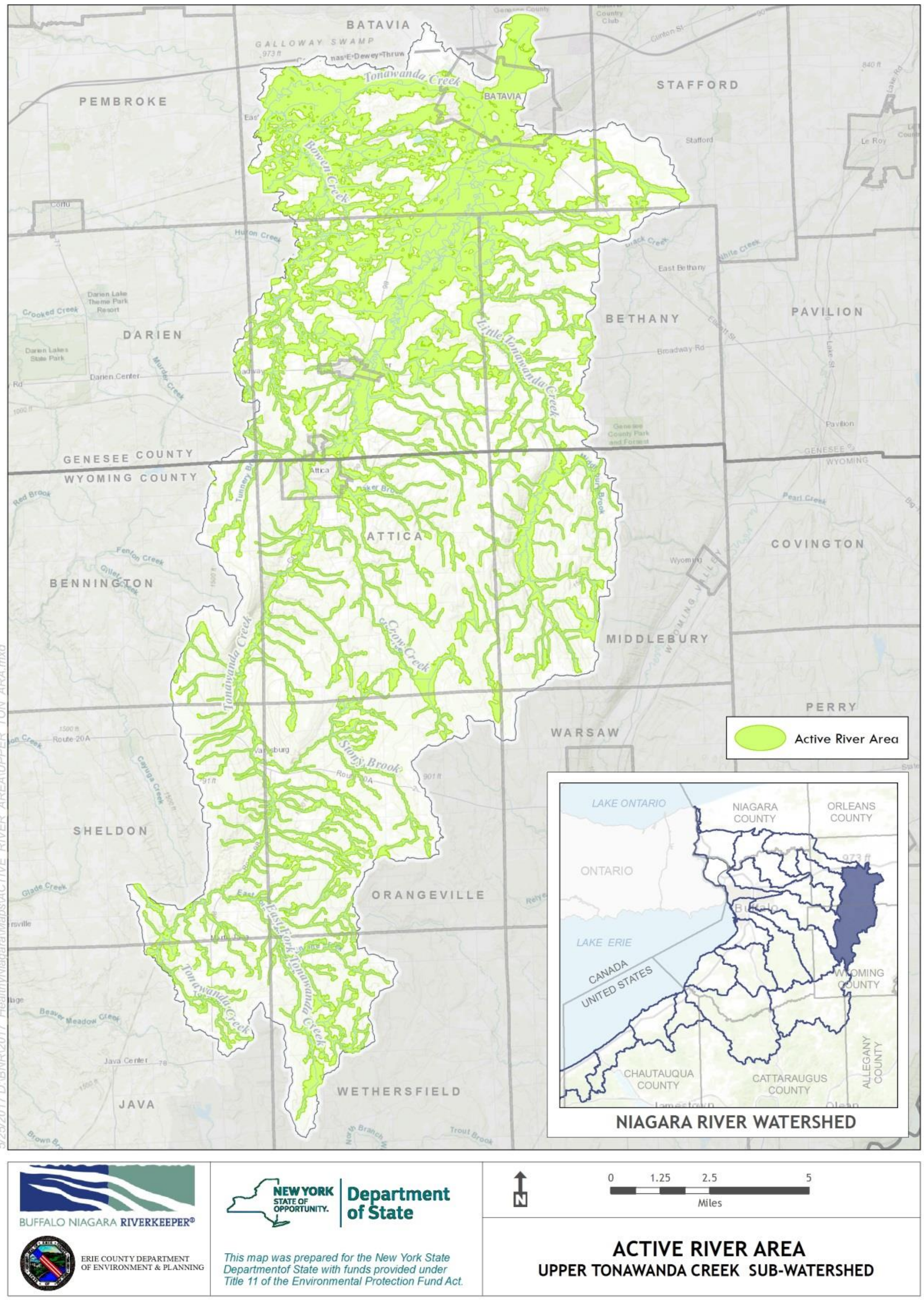
Land Use/Land Cover in the Active River Area

Potential sources of contaminants entering waterways from surrounding lands were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through natural hydrologic mechanisms. Map 6.4 displays LULC limited to the bounds of the ARA, indicating where contaminants on land may have direct interaction with stream waters.

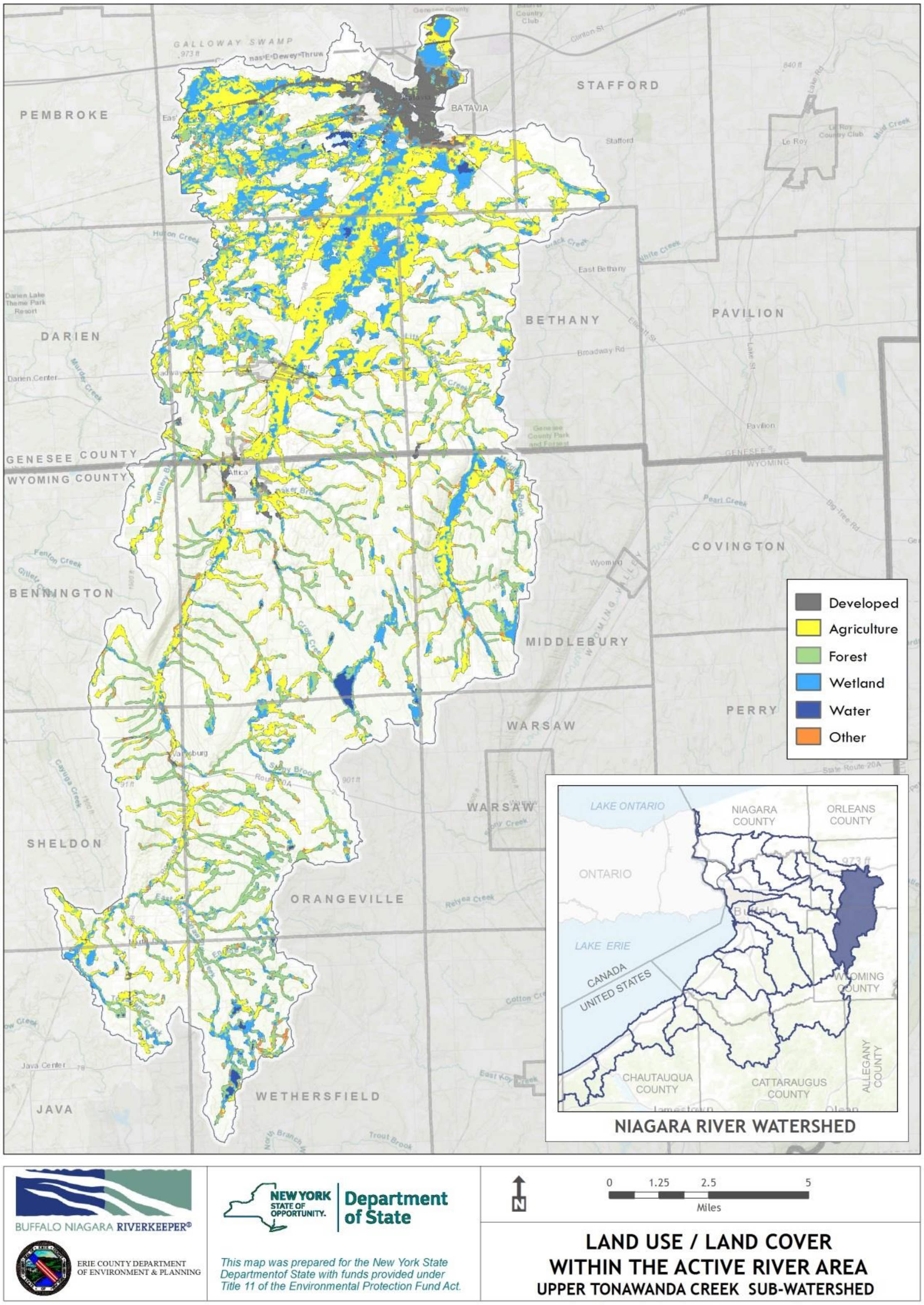
Sections within the ARA in the headwaters of UT interact hydrologically with a variety of land uses such as forest, wetland/palustrine aquatic bed, and agriculture. As the ARA widens flowing downstream, the land-to-stream interaction becomes increasingly dominated by agricultural land use, suggesting that runoff occurs from more homogenous plots of land. Additionally, in the lower reaches of UT, as Tonawanda Creek enters Batavia, land use gives way to urbanized development, where inputs into the creek, such as road runoff and industrial effluent, reflect developed land use and urban environments.



Map 6.1: Upper Tonawanda Creek Sub-watershed Land Use/Land Cover



Map 6.2: Upper Tonawanda Sub-watershed Active River Area



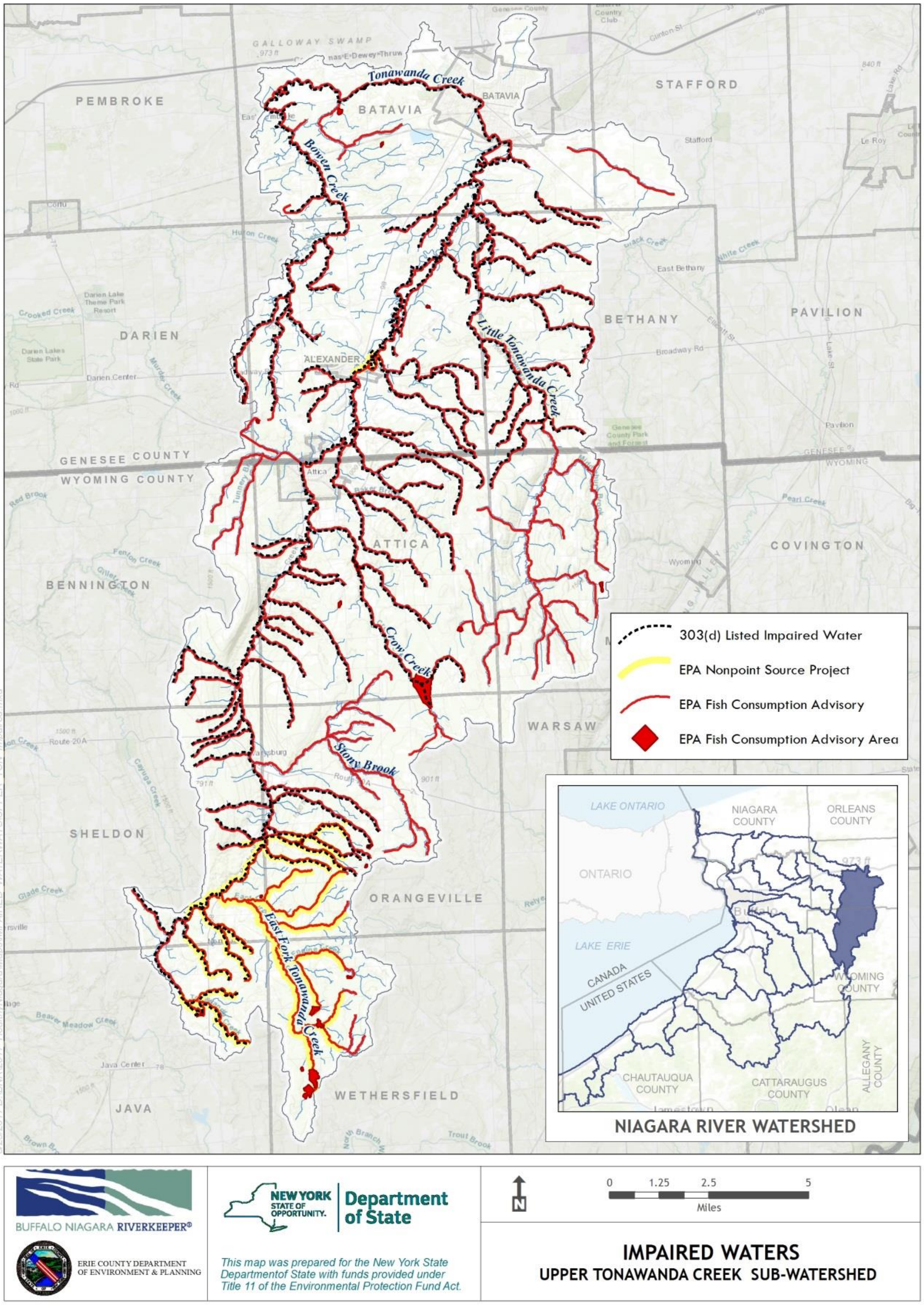
Map 6.4: LULC and ARA Interaction

Impaired Waters

The NYSDEC WI/PWL catalogs several waterbody segments within UT, encompassing 83.5 miles, or 14.2%, as impaired. These segments include East Fork Tonawanda Creek, Little Tonawanda Creek, Stony Brook, Crow Creek, Bowen Creek, Tonawanda Creek and its respective tributaries.

As depicted in Map 6.5, much of the sub-watershed's main streams, Tonawanda Creek, Little Tonawanda Creek, Bowen Creek, and Crow Creek, are listed on the 303(d) list, indicating impaired waterways, while a majority of streams are listed as being under EPA Fish Advisories, including some waterbodies throughout the sub-watershed, such as the Attica Reservoir. The southern tip of the sub-watershed, including the East Fork of Tonawanda Creek, is listed as an area under the EPA Nonpoint Source Project, a program established under Section 319 of the Clean Water Act, and administered by the NYS DEC to "control pollution from nonpoint sources to the waters of the state and to protect, maintain and restore waters of the state that are vulnerable to, or are impaired by nonpoint source pollution"[6].

NYS DEC classifies waterways according to a class system related to uses.[9] Stream classifications for waterways assessed in this project are listed below in Table 6.2. Streams with AA or A classifications are suitable for use as drinking water sources, while streams classified as B, C, or D support descending numbers of uses. The addition of a (T) to a stream classification indicates that the stream may support trout populations, while a (TS) waterway may support trout spawning populations.



Map 6.5: Upper Tonawanda Creek Sub-watershed Impaired Waterways

Table 6.2: NYSDEC Priority Waterbody Classifications

		Designated Use(s) Not Supported by the Waterbody			Pollutant(s) of Concern		Source(s) of Pollution	
Priority Waterbody	Stream Class	Use(s) Impacted	Severity of Impact	Documentation	Type of Pollutant	Documentation	Source	Documentation
Tonawanda Creek, Lower, Main Stem	C	Fish Consumption Aquatic Life Recreation	Impaired Stressed Stressed	Known Suspected Suspected	Priority Organics- PCBs Nutrients Silt/Sediment	Known Suspected Suspected	Toxic/Contaminated Sediment Urban Runoff Sanitary Discharge Streambank Erosion Landfill/Land Disposal Municipal	Known Known Suspected Suspected Possible Possible
Tonawanda Creek, Middle, Main Stem	C	Aquatic Life Recreation Aesthetics	Impaired Impaired Stressed	Known Known Suspected	Nutrients- phosphorus Dissolved Oxygen Silt/Sediment Metals Pathogens	Known Suspected Suspected Possible Possible	Sanitary Discharges Urban Runoff Streambank Erosion Agriculture Municipal-Batavia WWTP On-site/ Septic Systems Landfill/Land Disposal	Known Known Known Suspected Suspected Suspected Possible
Tonawanda Creek, Upper, and minor tributaries	A; Tribs primarily A, A(T), A(TS)	Water Suppy Aquatic Life Recreation	Stressed Stressed Stressed	Known Known Known	Silt/Sediment Nutrients Dissolved Oxygen Thermal Changes Pathogens	Known Known Suspected Suspected Possible	Agriculture Streambank Erosion Hydro Modification Municipal (Attica WWTP) Other Sanitary Disharge On-site/ Septic Systems	Known Known Suspected Suspected Suspected Possible
Bowen Brook & tributaries	C; Tribs primarily C, some B	Aquatic Life Recreation	Impaired	Known	Dissolved Oxygen Nutrients Pathogens	Suspected	On-site Septic Systems	Possible
Crow Creek & tributaries	A	Water Supply	Threatened	Suspected	Pathogens	Suspected	Agriculture	Suspected
Little Tonawanda Creek, Lower & tributaries	A, A(T); Tribs-A	Water Supply Public Bathing Recreation	Stressed Stressed Stressed	Known Known Known	Silt/Sediment Nutrients Dissolved Oxygen Pathogens Salts	Known Known Suspected Possible Possible	Agriculture Streambank Erosion On-site/ Septic Systems	Known Known Possible
Little Tonawanda Creek, Upper & tributaries	A(T); Tribs-A, A(T)	No Use Impairment	---	---	---	---	---	---
Stony Brook & tributaries	A	No Use Impairment	---	---	---	---	---	---
Tannery Brook & tributaries	A	No Use Impairment	---	---	---	---	---	---

Stream Visual Assessment & Water Quality Data Collection

In order to supplement existing data and fill in data gaps, Buffalo Niagara Riverkeeper (BNR) conducted water sampling and stream assessments throughout the sub-watershed. Sampling took place in seven stream bodies in UT during the 2016 field season.

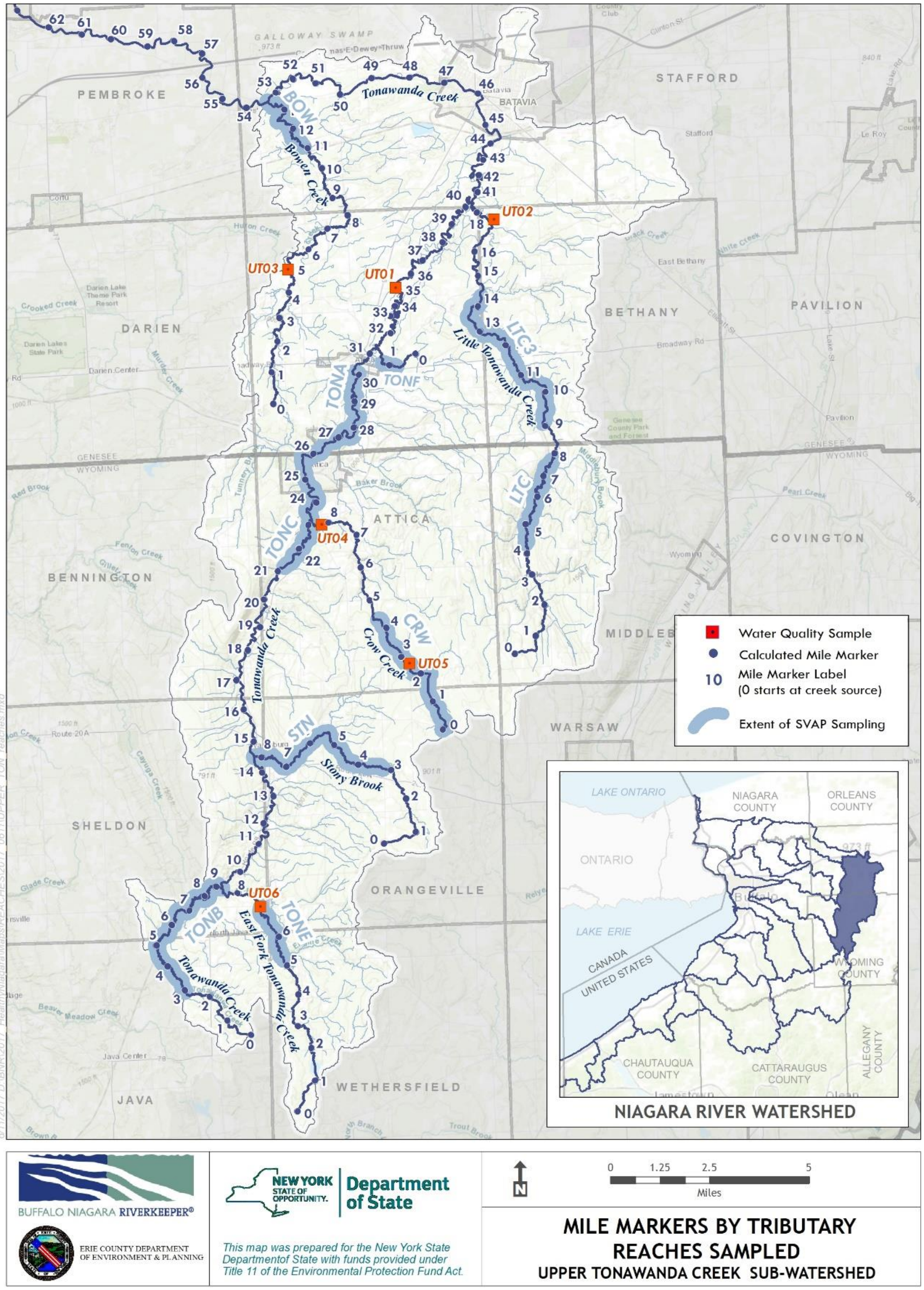
Waterways within UT were assessed from May 23, 2016 to August 3, 2016. Within seven stream bodies, 784 reaches were assessed. Reaches refer to a length of stream 200 feet in length. The streams assessed were Tonawanda Creek, East Fork Tonawanda Creek, Little Tonawanda Creek, Stony Brook, Bowen Creek, Crow Creek, and one unnamed minor tributary. Each stream was broken up into segments and assigned a unique identifier based on location (BOW, CRW, LTC, LTC3, STN, TONA, TONB, TONC, TONE, and TONF).

Table 6.3: Streams Assessed in Upper Tonawanda Creek Sub-watershed

Stream Assessed	Stream Class	Miles Assessed
Tonawanda Creek - Upper and minor tributaries	A	10.9
East Fork Tonawanda Creek	A	1.9
Little Tonawanda Creek	A, A(T)	7.9
Stony Brook	A	4.6
Bowen Creek	C	2.1
Crow Creek	A	2.3

Within UT, 29.75 of the total 589.2 miles (5%) of waterways were assessed using a modified version of the Stream Visual Assessment Protocol (SVAP).[15] Table 6.3 presents the segments assessed.

Stream miles were calculated using ArcGIS software so that stream segments and sample sites could be assigned a unique "mile marker" within the waterways for reference. Mapped segments with mile markers can be seen below in Map 6.6.



Map 6.6: Stream Segments Assessed

Physical Properties

As seen in Table 6.4, UT recorded an average depth of 8.7 inches for the seven streams assessed. The sub-watershed recorded an average bankfull width of 34.0 feet and an average baseflow width of 19.3 feet.

Table 6.4: Upper Tonawanda Creek Sub-watershed Physical Properties

Stream	Average Depth (in.)	Average Bankfull Width (ft.)	Average Baseflow Width (ft.)
Tonawanda Creek	14.3	50.0	33.4
East Fork Tonawanda Creek	8.2	46.8	25.4
Little Tonawanda Creek	10.3	38.4	23.3
Stony Brook	6.8	39.4	18.2
Bowen Creek	9.7	28.8	12.3
Crow Creek	6.7	23.8	13.5
TONF (minor tributary)	4.6	11.1	8.8
Sub-watershed Average	**8.7**	**34.0**	**19.3**

Stream Visual Assessment and Water Quality Findings

During the Phase 1 process, UT was chosen based on a priority to preserve and protect conditions leading to high water quality and healthy habitat. Throughout the fieldwork process, it became apparent that while many stream segments were indeed in good overall health, many others were in poor condition, exhibiting impairments. Overall SVAP findings from the seven assessed waterbodies within the sub-watershed resulted in an average score of 'fair' (7.0). Within the sub-watershed, the STN stream segment in Stony Brook had the highest average SVAP score, 'good' (7.8). The stream segment with the lowest average SVAP score was the TONA segment in Tonawanda Creek, which recorded an average of 'poor' (5.6).

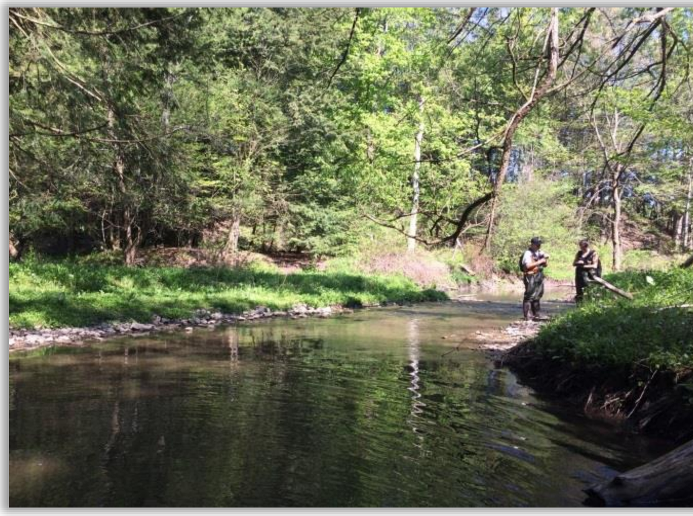
Table 6.5 presents an SVAP score summary for UT, and a full SVAP summary is available in Appendix D.

Table 6.5: Upper Tonawanda Creek Sub-Watershed SVAP Element Summary

	Channel Conditions	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance	Nutrient Enrichment
# of scores	784	784	784	784	784	784	784
average	9.4	8.5	8.4	7.3	7.5	7.5	6.7
	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	
# of scores	784	784	784	784	88	527	
average	4.9	4.5	7.2	5.3	4.5	6.6	

Substrate in UT is predominantly cobble, with 45% of assessed reaches having a cobble substrate. Silt/clay was observed to account for 22% of the sub-watershed's assessed substrate. Gravel comprised 20%, bedrock 8%, boulder 4%, and sand 2% of the sub-watershed's assessed substrate.

Figure 6.1: Stream visual assessment in Tonawanda Creek (BNR)



All assessed stretches within the sub-watershed received 'good' or 'excellent' average channel condition scores (8.7+). Stream channels are generally unaltered with limited channelization or use of rip-rap. These natural stream conditions have a positive impact on wildlife and overall stream health. Areas of channel alteration were concentrated around more urban areas, such as the town of Attica. This stretch of stream received the lowest average SVAP score within Tonawanda Creek of 'poor' (2.2), partly due to the level of channelization.

Overall SVAP scores draw attention to Tonawanda Creek, which recorded the lowest average score in UT. Recording an average score of 'poor' (6.0), Tonawanda Creek runs the full expanse of UT from the southern end of the sub-watershed near the town of Java, through the towns of Attica and Alexander, and reaches the city of Batavia in the northernmost section. The creek passes through a variety of different land uses including agricultural, residential, and conservation lands. In contrast, Stony Brook recorded the highest average SVAP score in UT of 'good' (7.8). Stony Brook is a tributary of Tonawanda Creek, and cuts predominately through forested LULC.

Figure 6.2: Altered Stream Channel in Attica - Tonawanda Creek (BNR)

Japanese Knotweed was observed in 9% of assessed stream reaches in UT. Hydrilla was observed in 3%, Phragmites was observed in 2%, and Purple Loosestrife was observed in 1% of all assessed reaches.

In addition to being performed during SVAP, water quality sampling at stationary sites was performed monthly at six sites within the sub-watershed at locations in Bowen Creek, Tonawanda Creek, Little Tonawanda Creek, and Crow Creek from April 25, 2016 to November 15, 2016. It must be noted however, that as discussed above, 2016 sampling took place during drought conditions, and fewer storm events would have contributed to runoff bringing nutrients into waterways.

Table 6.6 displays water quality parameters measured, including the number of measurements performed, high and low values measured, and the average value recorded for each parameter. Full water quality parameter results can be found in Appendix C and D.

Table 6.6: Upper Tonawanda Creek Sub-watershed Water Quality Element Summary

	Temperature ºC	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
# of scores	187	187	187	186	186
low value	8.6	6.57	66.9	193.8	166.4
high value	27.5	17.05	193.2	854	617.5
average	17.1	11.3	119.3	409.5	311.9
	pH	**Turbidity (NTU)**	**Phosphorus (µg/L)**	**Nitrate (µg/L)**	
# of scores	187	182	181	183	
low value	7.48	0.7	0	400	
high value	8.81	94.2	214.5	34,600	
average	8.1	8.1	33	10,000	

Baseline Indicators

Through the fieldwork portion of this project, parameters that either indicated pervasive impairments throughout the sub-watershed, or had high numbers of water quality parameters exceeding relevant standards or guidance values were isolated for further discussion. These baseline indicators begin to give us a picture of the sub-watershed's health or impairment status during normal, baseline conditions.

Baseline indicators for Upper Tonawanda Sub-watershed are identified as:

- Land Use/Land Cover
    - LULC in UT directly affects water quality throughout the sub-watershed, and stormwater and agricultural runoff is a major vector transporting contaminants from

surrounding land into waterways. LULC also affects suggested management actions, as those actions that are able to be performed on agricultural or forested land may not be appropriate for more developed land.

- Turbidity
  - Turbidity as measured throughout the sub-watershed is consistently high. 51% of water quality samples performed during stream assessments had levels over the NYS DEC standard of 5 NTU.
- Riparian Zone
  - The riparian zone, which measures the expanse of a natural vegetated strip along a waterway, was rated as 'good', but many individual reaches recorded fair and poor scores. A poor riparian zone places stream banks at risk for erosion, and increases the likelihood of contaminant runoff to enter a waterbody. Bank stability is grouped with riparian zone, as a poor riparian zone generally coincides with poor bank stability. While some reaches scored very high, erosion issues were prevalent throughout the sub-watershed, and 'poor' bank stability scores were recorded in every stream segment SVAP assessments occurred in.
- *E. coli*
  - *E. coli* measurements performed in the sub-watershed had levels greatly exceeding recommended levels for recreational use, but as many of the waterways in the sub-watershed are class A, with drinking water uses, *E. coli* inputs must be addressed.
- Nutrient Load
  - Phosphorus and nitrate within the sub-watershed are consistently high, indicating that elevated levels of these parameters are entering waterways.

Baseline Indicators Discussion

Land Use/Land Cover

In relation to the high amount of agricultural land in the sub-watershed, UT features an abundance of farmland of statewide importance[14], a classification established by the NRCS Farmland Protection Policy Act as land "that is of statewide or local importance for the production of food feed, fiber, forage, or oilseed crops."[11] Additionally, the sub-watershed contains nearly 20,000 acres (15.5% of total land) of protected land, the second most in the Niagara River Watershed falling second to only Middle Tonawanda Creek. Land protection and conservation, including easements and regulatory protections (such as state parks, forests, etc.) are critical tools in preserving water quality. If protected these areas will not succumb to urban sprawl or development and will help to preserve the water quality of nearby rivers and streams. This is especially important in such areas where drinking water supplies stem from surface water (Town and City of Batavia), reservoirs (Attica) or underlying aquifers (Alexander).

Turbidity

Figure 6.3: Tonawanda Creek Bank Erosion (BNR)

Tonawanda Creek recorded an average bank stability score of ‘fair’ (6.1), the lowest of all waterbody segments assessed. All other assessed waterbody segments recorded ‘good’ average bank stability scores (7.9-8.8). The low bank stability scores along Tonawanda Creek indicate that reaches have a higher existence of, or potential for bank erosion. Several sites with significant stream bank erosion were observed as seen in Figure 6.3. Stream banks with limited riparian vegetation have a greater potential to erode and would receive a poor SVAP score.

A total of 182 water samples from assessed stream segments were collected and analyzed for turbidity. Turbidity refers to the clarity of a liquid. Suspended solids stemming from stream bank erosion, stormwater runoff, and/or other pollutants contribute to turbidity. Cloudy water containing an abundance of suspended solids would record ‘high’ turbidity. Turbidity readings over the NYSDEC standard of 5.0 NTU were common within UT. Of the 182 samples collected, 92 read over the standard. The assessed segment in Bowen Creek recorded an average turbidity reading of 45.8 NTU, the highest in the sub-watershed.

Riparian Zone and Bank Stability

The riparian zone, or area of natural vegetation bordering waterbodies, along assessed stretches of Tonawanda Creek recorded an average score of ‘fair’ (6.5), the lowest of all waterbody segments assessed. Poor scores indicate a lack of riparian zone or a narrow riparian zone width in comparison to the stream’s active channel. This zone is a vital component to a healthy waterbody, as the roots of riparian vegetation naturally stabilize banks and control erosion. This zone of vegetation also functions as a surface water filter, slowing and absorbing storm water runoff and the various pollutants it may be transporting as well as provides natural shade helping to regulate water temperature.[17]

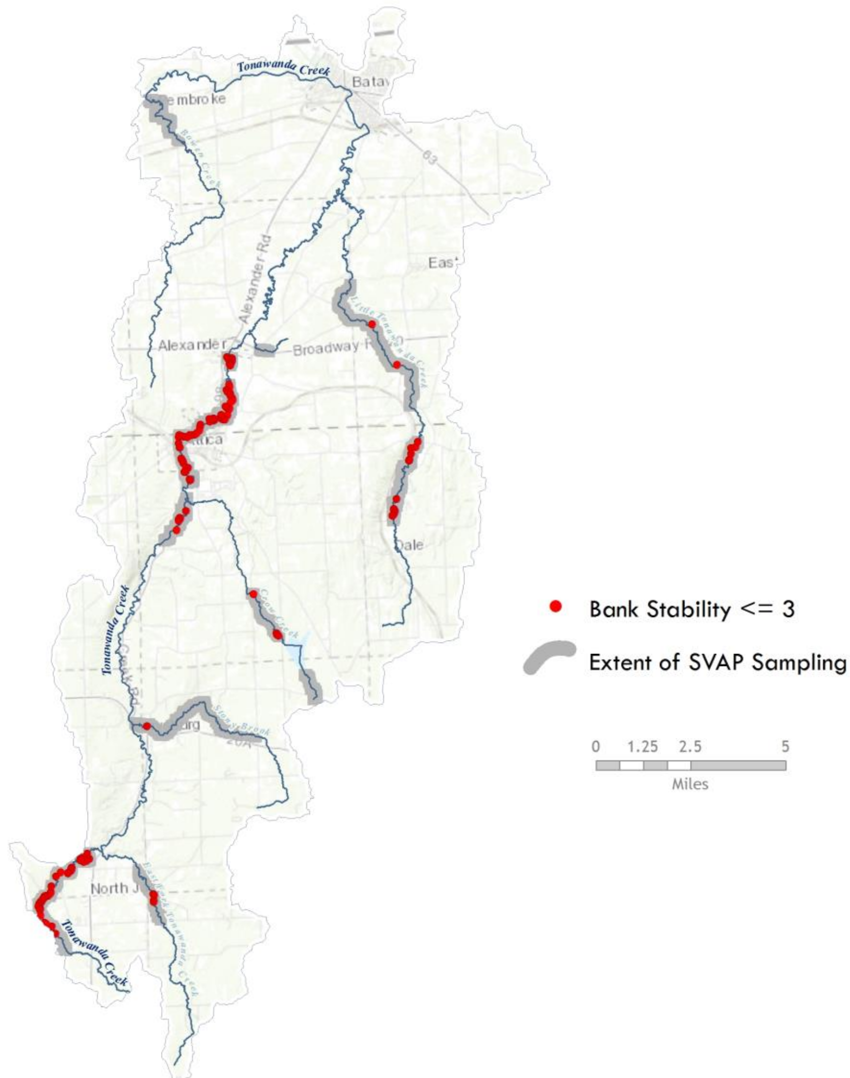
Figure 6.4: Riparian Zone -Tonawanda Creek (Google Maps)

Several sites, many occurring in agricultural areas, were observed along Tonawanda Creek that lacked a riparian zone. The location depicted in Figure 6.4, in particular received poor scores for bank stability and riparian zone (one side), as the stream bank's natural vegetation had been completely removed. The bank was actively eroding, and heightened levels of turbidity and phosphorus were recorded just downstream.

Figure 6.5: Stony Brook Riparian Zone (BNR)

Bank stability scores under 3 for the sub-watershed are shown in Map 6.7 below. A score of 3 indicates that "banks are moderately unstable, typically high, actively eroding at bends; ~50% rip-rap; excessive erosion" while a score of 1 represents "Unstable high banks, actively eroding at bends throughout; dominated by rip-rap."

All other assessed segments within UT recorded 'good' or 'excellent' (8.8+) average riparian zone scores. Excellent scores refer to a riparian zone extending at least two times the width of the stream's active channel. Stony Brook received the highest average score for riparian zone of 'excellent' (9.87). This waterbody was characterized by extensive riparian vegetation as seen in Figure 6.5. This vegetation provides ample shade, which helps maintain cool water temperatures.



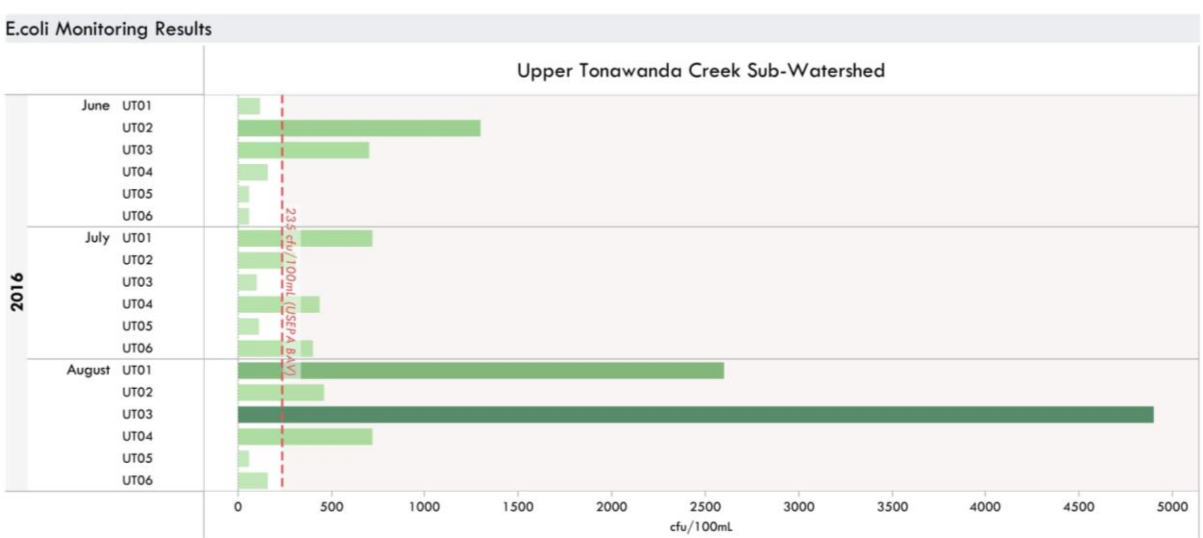
Map 6.7: Bank Stability Scores 1-3

E. coli

Concentrations of livestock activity were observed along Tonawanda Creek as seen in Figure 6.6 (a) and (b). Along some streams, livestock appeared to have unlimited access. Livestock activity can degrade riparian vegetation and escalate bank erosion, and the presence of manure in streams can increase nutrient and bacteria levels. *E. coli* samples collected at 6 various sites within UT frequently exceeded the United States Environmental Protection Agency (USEPA) Beach Action Value (BAV) of 235 cfu/100mL as seen in Figure 6.7. The BAV is a tool often used to assist in making beach notifications and closures.[29]

Figure 6.6 (a) and (b): In-stream Cattle Crossing (BNR)

Figure 6.7: *Escherichia coli* Monitoring Results 2016



Nutrient Load

Samples to assess nutrient levels (phosphorus and nitrate) were also collected and processed. With the sub-watershed having a dominant percentage of agricultural land cover, there is a higher potential for non-point source pollution with high concentrations of nutrients from fertilizers, pathogens, and pesticide chemicals. Phosphorus readings for the sub-watershed recorded an average of 34.64 µg/L, well above the NYSDEC guidance value of 10 µg/L for Lake Erie Eastern basins.[8] Bowen Creek recorded the highest average phosphorus readings in comparison to other assessed stream segments at 72.6 µg/L. Tonawanda Creek recorded the highest average nitrate readings at 13,115.49 µg/L, falling above the NYSDEC standard value of 10,000 µg/L.[6]

Figure 6.8: Abundant growth of aquatic vegetation within Bowen Creek (BNR)

Nitrogen and phosphorus are natural constituents of the environment, but can also be introduced into the system via fertilizers and sewage inputs. Most traditional fertilizers, used both for agricultural or residential purposes, contain nitrogen, phosphorus, and potassium (or potash). Animal manure and commercial fertilizer, used as a crop fertilizer, are primary sources of nitrogen and phosphorus to surface and groundwater via runoff or infiltration.[26]

While nitrogen and phosphorus are vital for a healthy stream, the correct balance is critical to sustain aquatic life.[18] High nutrient levels can fuel growth of aquatic vegetation and algae which can congest streams, restricting water flow and fish movement as seen in Figure 6.8. With elevated plant respiration and decomposition, dissolved oxygen levels become depleted. These oxygen-depleted environments can stress and have detrimental impacts on aquatic life. At times, algae will grow in large, expansive colonies often referred to as an algal bloom. Under the right conditions, some algal blooms will produce toxins that can be dangerous to wildlife and human health.[14]

During monthly sampling phosphorus levels measured at the same stationary sites ranged from 0 µg/L measured in June, to a high level 148.5 µg/L measured in August. While the high value recorded at UT02 is well above the range of other measurements within the sub-watershed, it is in line with observations made in other sub-watersheds where agricultural land use is prevalent. UT02 is located between active farm fields, and is also directly downstream of a registered medium Consolidated Agricultural Feeding Operation (CAFO), so high levels of pollutants related to agriculture and livestock operations are to be expected.

Nitrate samples collected at the six sites generally fell below the NYS DEC standard value of 10,000 μg/L, but some high values were recorded, especially in the spring. Agricultural fertilizers, often applied in the early spring before planting occurs, are susceptible to runoff. This may explain the nitrate spikes observed in at UT01, UT02, UT03, and UT05 in April during monthly water quality sampling.

Eighteenmile Creek Critical Source Areas

CSAs in UT are depicted in Map 6.8, and displays CSAs using the methodology described on page 1-9.

"Critical" source areas are those land uses known to contribute to impairments, and are designated as priority areas for intervention. "Non-Critical" sources are those passive land uses such as forested lands that do not actively contribute impairments.

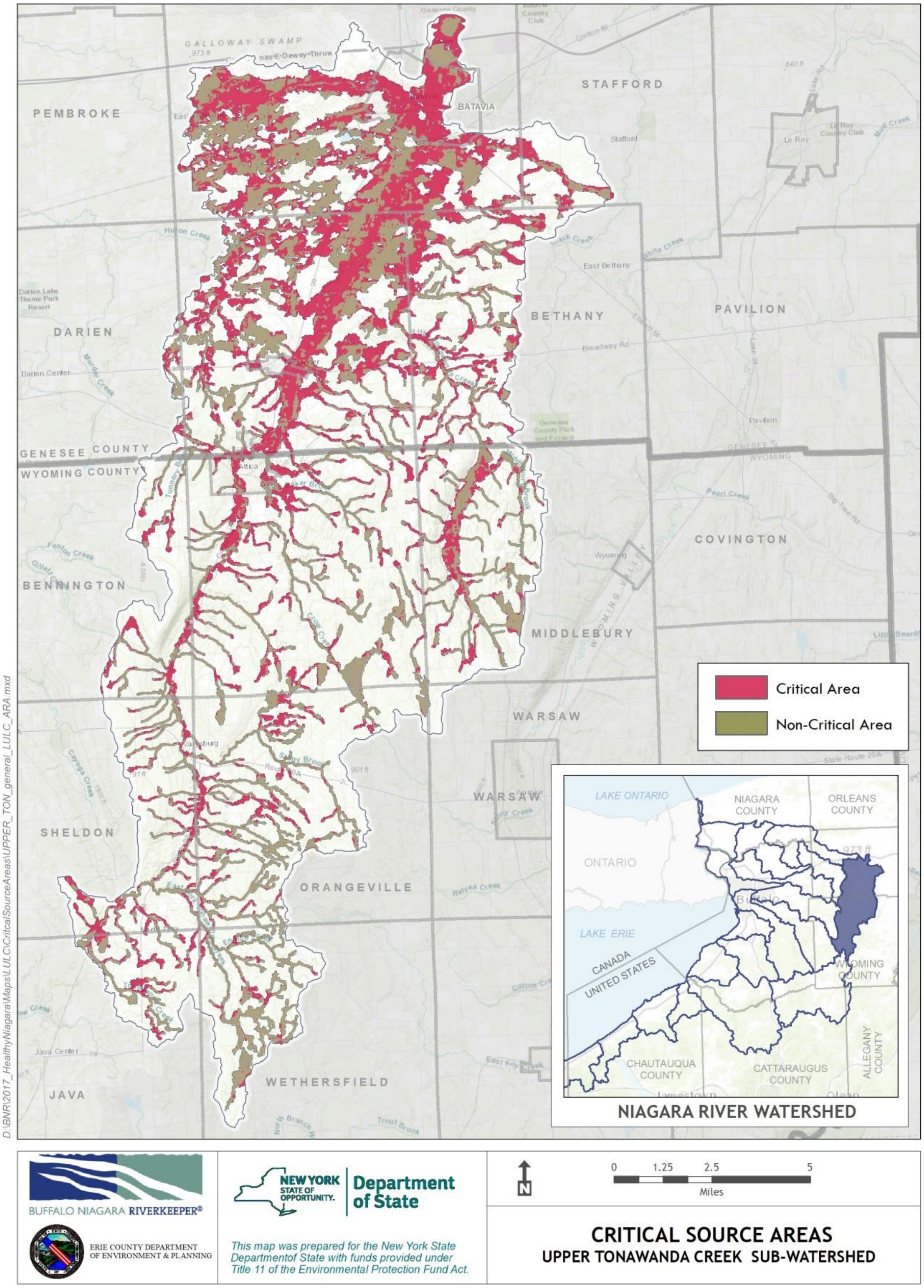
CSA Conservation Priorities

As noted previously, agricultural land use is dominant in the Upper Tonawanda Creek Sub-watershed. High percentage of agricultural land use leads to numerous targeted areas throughout the watershed where agricultural best management practices need to be applied in order to limit impacts to stream health and maintain climate resiliency. Three core forest areas are identified as protection priorities. These areas include riparian forests surrounding Tonawanda Creek near the Village of Attica, the headwater forests of Crow Creek, and headwater forests of the East Fork of Tonawanda Creek at the southernmost end of the sub-watershed.

Three potential, high priority fish barrier removal projects are also located in the southernmost headwaters of Tonawanda Creek. Removal of fish barriers at these locations will increase fish passage and therefore increase the number of stream miles suitable as fish habitat in the sub-watershed. Due to the sub-watershed's agriculturally dominated land use, critical source areas due to impervious cover are not frequent but those that do occur throughout should be addressed.

Several headwater streams of Tonawanda Creek would benefit from re-classification in order to better reflect and protect current conditions. Trout observations have been documented in these locations but current stream classifications do not include the trout habitat (t) and trout spawning (s) designations. Updating stream classifications in locations where data knowingly supports adult and spawning trout habitat would increase protections for sensitive native species like eastern brook trout.

Several projects have been through Buffalo Niagara Riverkeeper's Niagara River Habitat Conservation Strategy, which are seen as priority projects for conservation lands that may directly address impairments in the sub-watershed. These projects are included as Appendix I.



Map 6.8: Critical Source Areas

Target Goals for Baseline Indicators

As specific management actions are carried out, baseline indicators can be used for comparison or to determine the effectiveness of implementation efforts. Suggested management actions are also developed to address baseline indicators, as these indicators can vary regionally and can be tuned to address a sub-watershed's unique characteristics.

Land Cover: Land cover can provide valuable information related to water quality and overall watershed health. With increased development and urbanization, areas with impervious cover will also increase. According to the Center for Watershed Protection, water quality can begin to degrade at 10% impervious cover. [3]

> **Future Goal:** Reduce the amount of impervious cover within the sub-watershed.
>
> **Target:** In data compiled in 2005, UT contains 3.3% Impervious Cover. This percentage should be analyzed in future years with a target of it remaining at or below 3.3%.
>
> **Future Goal:** Conserve and protect undeveloped land in the sub-watershed.
>
> **Target:** Engage communities in the sub-watershed to develop a cross-municipal land conservation strategy.

Turbidity: Erosion of shorelines contributes to turbidity and sedimentation of waterways. High turbidity levels were common throughout UT in the 2016 field season. Turbidity can be used as an indirect indicator of the concentration of suspended matter.

> **Future Goal:** Restore steep and actively eroding shorelines to decrease erosion and sedimentation in streams.
>
> **Target:** Meet NYSDEC water quality standard or set a higher reachable level <25 NTU throughout the sub-watershed.

Riparian Zone and Bank Stability: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for water runoff, and cools water temperatures via shading. The natural riparian zone has been removed or severely altered within the sub-watershed.

> **Future Goal:** To increase the length and width of riparian vegetation along streams within the sub-watershed, and incentivize and encourage riparian buffer ordinances.
>
> **Target:** Increase the width of riparian vegetation to 2 times the active channel or 300ft, whichever is greater.

Future Goal: Work with communities, agencies, and municipalities to implement stream bank stabilization programs at actively eroding sites.

Target: Stream stabilization at reaches scoring 3 and below in SVAP Bank Stability (Map 4.7).

***E. coli*:** As a bacterial indicator, *E. coli* is used to monitor the presence of human/animal waste in waterbodies. Sources may include fertilizer, livestock, sanitary discharges, or compromised septic systems.

Future Goal: Reduce access of livestock to streams and stream banks thereby limiting bacterial inputs.

Future Goal: Provide resources to communities to upgrade outdated and deteriorated septic systems.

Future Goal: Municipalities continue to disconnect sanitary sewer overflows from discharging into waterways.

Target: Samples test at or below USEPA BAV throughout the sub-watershed, or reduce 30-day geometric mean value to meet USEPA recommended value of 126 cfu/100mL.

Nutrient load: Resulting from stormwater runoff, wastewater treatment plants, septic systems, and (possible) fertilizer use, high nutrient levels are commonplace throughout the sub-watershed.

Future Goal: Reduce loadings of nutrients, specifically phosphorus.

Target: Meet NYSDEC guidance values

- Phosphorus NYSDEC guidance value for Lake Erie Eastern basins of 10 μg/L
- Nitrate NYSDEC standard value of 10,000 μg/L

Suggested Management Actions

The work performed during this project, along with the compilation of preceding data collection and inventory of watershed characteristics, is intended to support the development of an action plan consisting of suggested management actions. Actions suggested below are intended to be part of an ongoing, dynamic process, in which management actions are periodically revisited to address changing conditions and management goals with the Lake Erie/Niagara River Watershed.

By implementing the general strategies and recommendations detailed here, the sub-watershed will be on track to meet the previously listed targets for various baseline indicators. These recommendations focus on key issues facing the sub-watershed and are not intended to act as a comprehensive list of everything that could be implemented.

The following management actions and goals are derived from the baseline indicators developed through the field assessments performed for this sub-watershed, including SVAP assessments and WQ monitoring.

These suggested management actions apply to: homeowners, municipalities, volunteer groups, agricultural landowners, organizations and agencies working within the sub-watershed.

Land Use

Goal: Maintain, or reduce, the amount of impervious cover within the Upper Tonawanda sub-watershed below current level of 3.3%

Benefit: According to the Center for Watershed protection, water quality begins to degrade at 10% impervious cover. The Upper Tonawanda sub-watershed has an estimated 3.3% impervious cover. Due to the low amount of impervious cover within the sub-watershed making changes and updates to existing spaces will likely have the greatest impact. Ideas for retrofitting existing spaces include increasing pervious surface by using porous material in constructing roadways and parking lots beyond what may be required by the NYS Stormwater Manual. Similarly, strategically integrating green and living infrastructure such as rain gardens, green roofs and natural or constructed wetlands into existing landscaping can reduce the volume of run-off from impervious surfaces, therefore lessening the frequency of combined sewer overflow (CSO) events which negatively impact waterways. Reducing the frequency and magnitude of CSO events, will in turn improve turbidity, fecal contamination and nutrient loadings, three of the other identified impaired indicators.

Best Management Practices

The actions outlined in the table below are organized into three broad categories: green and living infrastructure, land use policy changes and community engagement.

Implement Green Infrastructure | Living Infrastructure

By incorporating simple living infrastructure practices such as bioswales or rain gardens into small-scale development plans or implementing broader techniques across a larger scale, the resulting effect will be to help to collect rain water before it is able to flow over impervious surfaces, collect pollution and enter bodies of water. In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges.

As noted in the NYS DEC Stormwater Management Design Manual, a one-acre parking lot can produce 16 times more stormwater runoff than a one-acre meadow each year."[10] Because of this, in a sub-watershed such as the Buffalo River that extends into a once-industrialized urban area, many additional opportunities exist to increase the amount of green space by reclaiming abandoned buildings or parcels for reuse in green infrastructure designs.

Land Use Policy

Recommended changes in land use policies include actions such as updating a municipality's Comprehensive Plan or amending zoning codes. A Comprehensive Plan allows the municipality to clearly state its long-term goals and priorities for a community. While this document is not law, it does inform the law as a municipality would write zoning codes and ordinances that enable it to meet the goals outlined in the Comprehensive Plan. Conservation updates that can be made to code include: conservation overlay districts, steep slope requirements to limit erosion, minimum setback requirements from waterbodies (sometimes called a "waterfront yard" or "buffer" requirement) on new development, or requirements and standards for vegetated buffers along waterways on all lands.

Community Education and Engagement

While regulation through zoning codes forces those living in a municipality to abide by a certain set of laws, some practices are better implemented through landowner cooperation and collaboration. For example, nearly 20% of the sub-watershed is classified as agricultural land and data analysis suggests that agricultural lands may be contributing to water quality impairments in places across the sub-watershed. Here, encouraging landowners to voluntarily participate in conservation initiatives can greatly benefit a community. These initiatives include landowner stewardship like utilizing a vegetated riparian buffer along a shoreline, even if it isn't mandatory or installing a rain barrel on a property to collect rainwater for reuse. Similarly dedicating open space or hosting local clean-up or invasive species removal days can help people feel more connected to their environment thereby fostering a greater sense of community and stewardship.

Recommended Actions to reduce impervious land cover:

Short Term	• Utilize green and living infrastructure practices; rain barrels; no-mow areas; buffers and rain gardens
	  o Cost: Low
	• Reclaim unused or underutilized impervious spaces and develop into "green" spaces like meadowlands, rain gardens or community gardens
	  o Cost: Low to Medium
	• Host sustainable development workshops for municipalities and private landowners
	  o Cost: Low
	• Promote recreational use of natural areas to increase land protection and awareness
	  o Cost: Low

Long Term	• Improve/incorporate stormwater management on paved and unpaved roads/parking lots
	  o Cost: Medium to High
	• Reduce new parking lot sizes in urban areas
	  o Cost: Medium
	• Use pervious surfaces and materials when constructing new parking lots or updating existing parking lots beyond the percentage required by the New York State Stormwater Management Design Manual
	  o Cost: Medium
	• Develop vegetative buffer standards to protect stream quality
	  o Cost: Low
	• Creative incentive and educational programs for green infrastructure implementation
	  o Cost: Medium
	• Promote the conservation of open spaces through conversation easements and parks.
	  o Cost: Low

Turbidity

Goal: Restore steep and actively eroding shorelines to decrease erosion and sedimentation in streams such that stream quality, at a minimum, meets the NYSDEC water quality standard for turbidity

Benefit: Levels of high turbidity were prevalent in the waters surveyed and tested throughout the Upper Tonawanda sub-watershed. High turbidity in waterways can be an indicator of concentrations of suspended matter. Cloudy or turbid water affects light penetration through increasing light scattering, which typically leads to warmer water temperatures (with lower dissolved oxygen capacity). The effects of turbidity on light penetration also directly affect plant growth, further lowering the dissolved oxygen in water. Typically, lowering turbidity can improve plant growth and benthic communities, which are the basis for the aquatic food chain.

Best Management Practices

Land Use

Any number of actions that limit erosion and lessen sediment loading into waterways will help to combat turbidity. For example, instituting steep slope ordinances, where appropriate, into zoning codes can limit the amount of sediment that enters into waterways from highly erodible banks. Specifically, in the Upper Tonawanda this would be useful tool for Town of Orangeville. The town of Cortlandt, downstate in Westchester County, provides a good example of a steep slope ordinance. The ordinance states the following as one of the reasons for the protection of steep slopes:

> "The Town's experience with past development has shown that the improperly managed disturbance of steep slopes can aggravate erosion and sedimentation beyond rates experienced in natural geomorphological processes. Erosion and sedimentation often include the loss of topsoil, a valuable natural resource, and can result in the disturbance of habitats, degradation of the quality of surface water, the silting of wetlands, alteration of drainage patterns…"

Similarly requiring setbacks and requiring or encouraging vegetated buffers can help to anchor soil to the banks. Installing a Living Shoreline or vegetated buffer of either shrubs and grasses or tall trees can all help sediment remain in place.

Recommended Actions to combat turbidity:

Short Term	• Landowners should replant and reshape failing streambanks with stabilizing vegetation to reduce erosion and sediment deposition ○ Cost: Low to High

Long Term	• Develop restoration plans for severely failing waterways such as Tonawanda Creek and Bowen Creek.
	  ○ Cost: Medium
	• Develop vegetated buffer standards for all waterfront development that ensure a protected, stabilized shoreline.
	  ○ Cost: Low
	• Identify and mitigate or replace improperly installed road/stream crossings and stream barriers
	  ○ Cost: Medium to High

Riparian Zone and Bank Stability

Goal: Increase the length and width of riparian vegetated buffers along stream banks within the sub-watershed

Benefit: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for pollutants and cools water temperature by providing a shade over the water. The natural riparian zones in the lower portions of the Buffalo River sub-watershed have been affected by development and upstream, are subject to agricultural stressors. Increasing the width of vegetated riparian zones to twice the width of the stream channel or 300 feet, whichever is greater, would provide the greatest improvement to the health of the waterway.

Best Management Practices

Stream Stabilization

Stabilization of actively eroding shorelines using living and natural infrastructure is recommended where appropriate. Other engineered stabilization techniques should be used only in extreme cases.

Add Vegetation

Hosting community tree planting days in a municipality can provide great benefit to the riparian corridor and improve waterway health with limited costs borne by the municipality. Trees can even be obtained at no cost through the NYSDEC "Trees for Tribs" Program.[5] Similarly installing appropriately sized vegetated buffers in the more open and agricultural areas on the sub-watershed would be very beneficial.

Develop Ordinances

As noted above, including vegetated buffer or setback requirements into a municipality's zoning code is one regulatory mechanism to ensure measures are taken to protect water health. Not all land can be regulated through laws so in some instances encouraging best management practices or utilizing incentive programs may be a more effective approach. Located in the Lower Tonawanda sub-watershed, the Towns of Amherst and Pendleton both include language in their zoning codes for vegetated buffers. For example, Goal 4-4 of The Bicentennial Comprehensive Plan for the Town of Amherst (amended Feb 2011) sets a goal, "To establish buffer/setback standards for new development to help protect streams of significance." This goal is then applied in the town's zoning code in Chap. 204, Part 3 §3-5-6, "Lots abutting a watercourse." This sections requires that lots abutting a watercourse install a 50-foot-wide riparian buffer on either side of a watercourse and further, any building be an additional 10 feet from the buffer.

Recommended Actions to increase the length and width of riparian zones:

Short Term	• Host tree plantings with volunteers
	  ○ Cost: Low
	• Develop programs to encourage the installation of riparian buffer and cover crops
	  ○ Cost: Low to Medium
	• Implement stream and bank stability projects to stop erosion
	  ○ Cost: High

Long Term	• Develop vegetated buffer requirements for development in riparian areas
	  ○ Cost: Low
	• Develop setback ordinances for new development in riparian areas
	  ○ Cost: Medium
	• Encourage collaboration amongst municipalities and agencies to develop zoning codes to encourage conservation and best management practices across waterways that span municipalities
	  ○ Cost: Low

E. coli

Goal: Reduce bacterial inputs into streams

<u>Benefit:</u> *E. coli* is a fecal indicator bacteria used to monitor the presence of human/animal waste in waterbodies. Because few strains of *E. coli* naturalize in the environment, the presence of *E. coli* almost certainly suggests that fecal matter is contaminating a body of water. Sources may include fertilizer, livestock, sanitary sewer discharges, or compromised septic systems. Waterbodies with high levels of *E.coli* are not suitable for consumption or recreating and can result in a chain-reaction of negative human health and economic effects. Reducing *E. coli* levels to meet USEPA's recommended value of 126 cfu/100ml (30 day geometric mean) would greatly improve water quality. Combating *E. coli* requires that the sources inputting the bacteria into waterways be mitigated, such as CSO/SSO outfall mitigation and livestock exclusion.

Best Management Practices

<u>Livestock</u>

When livestock is able to freely roam in and across streams, they can produce a number of undesirable effects such as trampling banks, increasing erosion, and directly inputting sources of bacteria such as *E. coli* into water bodies through excrement. In addition, livestock fecal contamination releases a large amount of antibiotics into waterways, contributing to widespread naturalized antibiotic resistance. If livestock cannot be completely excluded from streams, then at a minimum, limit access by creating a designated crossing. Similarly, some lands have seen success by placing water troughs near the water body so that the cows can easily get to the stream water they may use for drinking but are not directly standing in the stream.

<u>Update and Upgrade Septic Systems</u>

Leaking septic systems are a direct input of bacteria into groundwater which can pollute drinking water and contaminate streams. It is important to recall that the presence of *E. coli* is not the only indicator species of biological pollution—it is just the simplest and most widely tested for. *E.coli* often occurs in tandem with other pathogenic bacteria, viruses and protozoans, such as those that cause cholera, dysentery, and Giardia. Upgrading septic systems with denitrification systems and fixing leaking systems is a necessary solution to mitigate this input.

Green and Living Infrastructure

In more populous areas, CSOs can be a large source of contaminants (particularly bacteria). CSOs occur where a municipality has combined storm and sanitary pipes and where rainfall inundates the system, resulting in more water than the pipes can handle. This results in an overflow situation where the pipes discharge excess untreated water directly into waterbodies. Implementing green and living infrastructure in both urban and suburban areas can drastically mitigate CSO events. By utilizing green and living infrastructure elements like rain barrels, raingardens, wetlands, and other installations meant to trap rainwater and runoff, less water goes into the sewer system resulting in fewer overflow events. In agricultural or suburban areas with larger swaths of open land, utilizing living infrastructure such as woodlands, meadows, and riparian buffers, and living shorelines to intercept stormwater and overland runoff can also help reduce runoff. In agricultural or suburban areas which larger swaths of open land, natural or constructed wetlands and bio-filtration systems can also be beneficial.

Recommended Actions to reduce bacterial inputs into streams:

Short Term	• Utilize livestock exclusion fencing to limit livestock access to and crossing of streams ○ Cost: Medium • Install alternative watering facilities for livestock away from streams ○ Cost: Medium • Install riparian buffers and covers crops to reduce stormwater runoff which can wash animal byproduct directly into waterways ○ Cost: Medium • Install liquid manure retention and targeted spreading systems to prevent manure runoff from crop fields. ○ Cost: High
Long Term	• Encourage the installation of wetland treatment systems or other living infrastructure to replace grey systems ○ Cost: Low to Medium • Install vegetated bio-filtration systems such as bioswales and rain gardens ○ Cost: Low • Install Living Shorelines along riparian land ○ Cost: Low to High • Replace aging infrastructure and remove CSO/SSO outfalls from municipal sewer systems ○ Cost: High

Nutrient Load

Goal: Reduce loadings of nutrients, specifically phosphorous

Benefit: Limiting phosphorus limits algae growth (including nuisance blue-green algae such as *Microcystis spp.)* and allows for more dissolved oxygen in a waterbody. In turn, this results in better aquatic species health and overall cleaner water.

Best Management Practices

High levels of nutrients such as phosphorous and nitrates were found in the waterbodies tested within the sub-watershed. As stated above, all the waterbody segments sampled within the Buffalo River Sub-watershed recorded average phosphorus readings above the NYSDEC guidance value for Lake Erie Eastern basins of 10 µg/L with Sprague Brook recording the highest average phosphorus Interestingly, as the map shows there is agricultural activity in the upper reaches of Sprague Brook. Although this may suggest correlation, it does not show causation. Similarly, nitrate measurements were also found to be above NYSDEC standard value of 10,000 µg/L. The prevalence of high nutrient levels is likely due to the number of sources or inputs including: storm water runoff, wastewater treatment plants, CSOs, septic systems, fertilizers, and improper disposal of lawn debris. Two of the best ways to combat nutrient inputs are through improving land use practices and education.

Land Use

Making minor to moderate changes to the way in which a person interacts with their land can have significant benefits to waterbody health. The actions outlined below provide examples of tactics both private homeowners and agricultural landowners can implement.

Education

Many of the changes that could result in the greatest improvement on the overall health of water bodies are behavioral. Encouraging changes in actions or promoting different protocols can be beneficial to combatting nutrient loadings along waterways. For instance, while in the field, the data collection team observed a number of piles of grass clippings abutting the stream and getting blown into the water. Inputs of grass clippings and yard waste into a waterway cause a direct increase in nutrients. Similar minor changes in farming practices or utilizing well known best practices can have significant impacts to the health of a waterbody. Suburban communities can benefit from individual small changes like using phosphorous-free fertilizer and consulting local town or village officials on lawn debris pick-up policies.

Recommended Actions to reduce nutrient loadings

Short Term	• Agricultural landowners should coordinate with Erie County Soil and Water Conservation District to enact best management practices which reduce nutrient and sediment loading from entering local waterways.
	  ○ Cost: Low
	• Municipalities should host educational workshops for riparian landowners pertaining to funding opportunities and financial assistance for implementing best management practices for runoff mitigation
	  ○ Cost: Low
	• Encourage no till farming practices
	  ○ Cost: Low
	• Utilize cover crops to keep fertilizer laden soil in place
	  ○ Cost varies by crop planted and need to be addressed. For example, planting clover can be inexpensive and eliminate some nitrogen from the soil
	• Provide educational stormwater trainings for designers and highway officials to ensure stormwater law compliance
	  ○ Cost: Low
	• Implement "no mow" zones
	  ○ Cost: Low
	• Appropriately dispose of lawn debris
	  ○ Cost: Low
	• Use phosphorous-free fertilizer
	  ○ Cost: Low

Long Term	• Develop and implement educational trainings for homeowners about lawn care techniques, debris disposal, native plant species
	  ○ Cost: Low
	• Promote rotation grazing for livestock
	  ○ Cost: Low
	• Implement and enforce pesticide and fertilizer use standards and regulations.
	  ○ Cost: Low
	• Increase watershed stewardship by installing markers and signage for storm drains.
	  ○ Cost: Medium