Water Quality

Water Quality Series

Onondaga Creek Fact Sheet

INTRODUCTION

Water quality includes a wide variety of parameters that environmental scientists use to measure the "health" and character of natural waters. Water quality technicians, scientists, and citizens make physical and chemical measurements, including:

- temperature
- dissolved oxygen
- salinity (specific conductivity; total dissolved solids)
- alkalinity and pH
- suspended solids and turbidity
- hardness (calcium and magnesium)

With the exception of hardness, each of the above is discussed in a Fact Sheet to follow. Hardness is simply the sum of calcium and magnesium ions; both are components of salinity.

More specific measurements can be made of both dissolved and particle-bound substances. While too numerous to list, the more important of these include:

- major ions (e.g. chloride, sulfate)
- nitrogen species (ammonia, nitrate, organic nitrogen)
- various forms of phosphorus
- trace metals (e.g. copper, iron)
- trace organic chemicals (e.g. pesticides, PCBs, herbicides)

Concentrations of these substances cover an extremely wide range, from part-per-trillion levels (e.g. dissolved mercury) to part-per-thousand levels (e.g. chloride ion). The major ions are addressed in the Fact Sheet on salinity, while nitrogen and phosphorus are discussed at length in individual Fact Sheets. Trace metals are discussed in a section on regulatory compliance in the Summary Fact Sheet. Organic chemicals have been omitted due to the absence of data.

Finally, pathogenic micro-organisms can make a waterbody unsuitable for recreation. These are commonly measured through the use of indicator bacteria, such as fecal coliforms and enterococci, as discussed in the Pathogens Fact Sheet.

Water quality investigations

Many organizations and individuals have collected a large body of water quality data from Onondaga Creek. Water samples are predominantly collected manually. Sampling sites are shown in Figure 1. The great majority of sampling effort has been concentrated in the urbanized lower section of Onondaga Creek. Table 1 summarizes data collected during the period 1988-2004. Data for the middle portion of the creek (Onondaga Nation) are limited to a study conducted by Upstate Freshwater Institute over the period July 2002 – May 2003. USGS has conducted, and continues to conduct, a number of investigations in the Tully Valley. Very few data exist for the West Branch of Onondaga Creek sub-watershed.

In addition, huts with automated data collection equipment have been established at three locations along the creek (Table 2). Each of these automated samplers is associated with a USGS gaging station.

In the Fact Sheets that follow, the primary sources of data are:

1. Onondaga County monitoring program for years 1993-2004
2. Onondaga Nation Monitoring Program (July 2002 - May 2003)
3. U.S. Geological Survey water quality data (1987 – 2002), and
4. A detailed study of phosphorus conducted in 1989-1990

Secondary sources of data include investigations by graduate students, and citizen-based monitoring efforts (Project Watershed).

Table 1. Major Sample Collection Efforts in Onondaga Creek.

Stream Reach	Time period	Locations	No. of samples	Investigating organization
LOWER ONONDAGA CREEK: Nedrow and Syracuse	1970? –1998 2000-present	Spencer St.	~850	Onondaga County (see annual monitoring reports)
	1998-present	Kirkpatrick St.	181	
	1992-present	Dorwin Ave.	374	
	July 2002 - May 2003	Spencer St.	24	Upstate Freshwater Institute (UFI, 2004)
		Kirkpatrick St.	24	
		Dorwin Ave.	24	
	1993-1994	Kirkpatrick St.	26	Upstate Freshwater Institute (Effler *et al.* 1995a and 1995b)
		Dorwin Ave.	26	
	Apr. 1988- Sept. 1990	Kirkpatrick St.	1058	Upstate Freshwater Institute (Heidtke 1992)
		Dorwin Ave.	1076	
MIDDLE ONONDAGA CREEK: Onondaga Nation	July 2002 - May 2003	Two main-stem sites; four tributary sites	126	Upstate Freshwater Institute (UFI, 2004)
WEST BRANCH, ONONDAGA CREEK	July 2002 - May 2003	W. Branch at Hitchings Rd.	21	Upstate Freshwater Institute (UFI, 2004)
UPPER ONONDAGA CREEK: Tully Valley and Headwaters	1988-present	Tully Valley, four sites on main-stem	85	U.S. Geological Survey (Kappel *et al.* 1996 and USGS database)
	July 2002 - May 2003	Three main-stem sites	72	Upstate Freshwater Institute (UFI, 2004)

Table 2. Automated Sample Collection Huts along Onondaga Creek. The highlighted entry has data which are currently accessible via the Internet.

Location	Agency	Period of operation	Data access	Parameters measured[1]
near Cardiff (Route 20)	Onondaga County	started May 2006	not currently available[2]	DO, T, ORP, pH, SC
Syracuse at Dorwin Ave.	UFI	Aug. 22, 2003 – present	on-line[2]	T, SC, T_N, C_{660}
Syracuse at Spencer St.	UFI	March 2006 – present	to be posted[2]	T, SC, T_N, C_{660}
	Onondaga County	July 2004 – present	published[3]	DO, T, pH, SC, T_N

[1] Parameters are: dissolved oxygen (DO), temperature (T), oxidation-reduction potential (ORP), hydrogen ion potential (pH), specific conductivity (SC), turbidity (TN), and beam attenuation coefficient, λ = 660nm (C660).
[2] Go to www.ourlake.org for Dorwin Ave. data. Spencer St. data are not posted as of August 2007.
[3] See Onondaga County's 2005 Ambient Monitoring Program report.

Water quality results

Water quality data are summarized in the following Fact Sheets:

1. Temperature
2. Dissolved oxygen
3. Salinity
4. Alkalinity and pH
5. Turbidity and suspended solids
6. Nitrogen
7. Phosphorus
8. Pathogens
9. Compliance with water quality standards
10. Summary

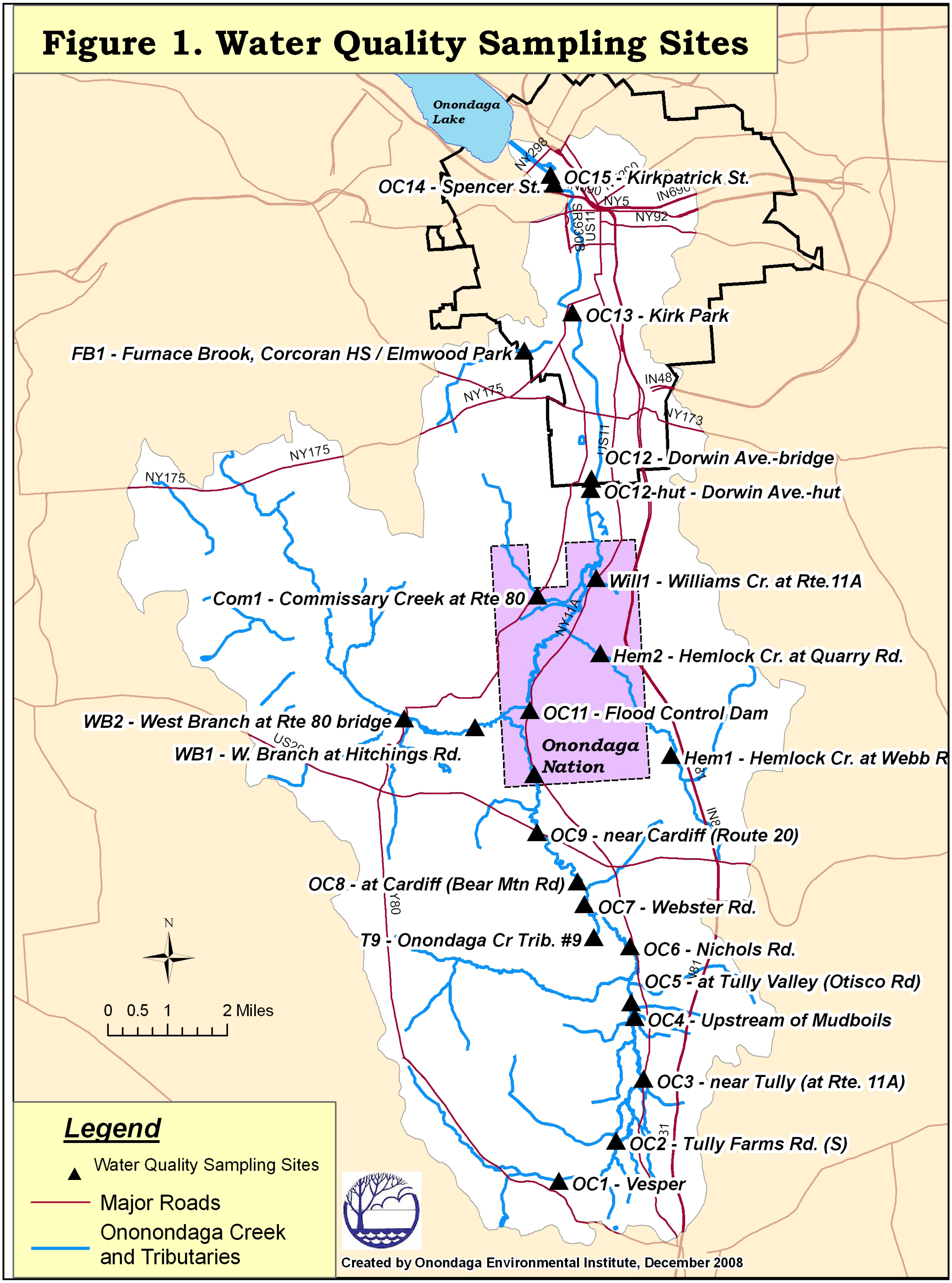

Figure 1. Water Quality Sampling Sites

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Temperature

Water Quality Series

Onondaga Creek Fact Sheet

INTRODUCTION

Water temperature in Onondaga Creek is largely a function of season, varying between a low of freezing (32º F; 0º C) in the winter to upwards of 73º F (23º C) in the summer. Temperature can be locally influenced by:

- seepage of groundwater --a relatively constant year-round temperature ~50º F (10º C)
- domestic or industrial wastewater, and
- overhanging and canopy vegetation which provides shade.

Trout require low temperatures year-round. Excessive heat in the summer can limit the available habitat and/or threaten the sustainability of fish populations.

FINDINGS

Water temperature throughout the Onondaga Creek watershed was measured as part of the Onondaga Nation study (UFI, 2004) (see Figure 1). UFI findings are as follows, by season:

- **Summer 2002:** There is a progressive increase in temperature as the creek flows through the Tully Valley, reaching a maximum of ~68º F (20º C) at Dorwin. Tributaries have similar temperatures, except Williams Creek which is probably spring-fed. There is a 4º F (2º C) drop at Spencer and Kirkpatrick St. sites, reflecting the influence of spring-fed tributaries (e.g. Furnace Brook) and direct fresh and saline springs within Syracuse (W. Kappel, pers. comm.., 2006). The highest temperature recorded during the study, 73º F (23º C), occurred in the West Branch, at Hitchings Road.
- **Winter 2002/3:** Creek temperature is ~32º F (0º C) until Dorwin. The 4º F (2º C) increase in Williams Creek and downstream of Dorwin probably reflects springs which are warmer than the creek.
- **Fall 2002 and Spring 2003:** Creek temperature is relatively constant throughout. Tributaries have temperatures comparable to the main stem.

Temperature data collected by Onondaga County between 1993 and 2004[1] show:

- **Dorwin:** Summer temperatures equaled or exceeded 77º F (25ºC) in 1995, 1998, and 1999. The highest temperature recorded was 83.5º F (28.3ºC) on July 6, 1999.
- **Spencer:** The maximum temperature recorded was 70.4º F (21ºC)
- **Kirkpatrick:** The maximum temperature recorded was 71.1º F (22ºC)

IMPLICATIONS

- As water temperature approaches 70º F (21ºC), trout are less able to compete with other fish species for food. Lethal temperatures for trout range from 73ºF to 79ºF (23º– 26ºC)(Cushing and Allen, 2001). Data collected by UFI in 2002-03 show that temperatures remain relatively cool (<70ºF) in the upper parts of the watershed, in certain tributaries (Hemlock Creek and Williams Creek), and in the furthest downstream site (e.g. Spencer). County data confirm that Spencer and Kirkpatrick remain cool during the summer. However, County data also show that temperatures at Dorwin are often inhospitable to trout during the summer. The 70ºF threshold was exceeded every summer during the 1993-2004 interval.
- The elevated temperatures observed by UFI at Cardiff and by both UFI and the County at Dorwin Ave. are probably related to the relative lack of vegetation in these sections of the creek.
- Water temperatures at Spencer, Kirkpatrick and locations upstream of the flood control dam would appear to support a cold-water fishery.
- Temperature has implications for dissolved oxygen (DO), as explained in the DO Fact Sheet.

1 Onondaga County data throughout this water quality series are taken from annual monitoring reports listed under Water Quality References (Stearns & Wheler 1994-1997; EcoLogic, LLC *et al*. 1999-2005).

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Dissolved Oxygen

Water Quality Series

Onondaga Creek Fact Sheet

INTRODUCTION

Dissolved oxygen (D.O.) is one of the most important water quality indicators because nearly all aquatic life, ranging from bacteria to fish, requires oxygen. Even plants, which produce oxygen via photosynthesis during the daylight hours, need oxygen to respire. Only certain forms of microorganisms do not require oxygen to survive. In addition to its critical biological role, oxygen also regulates chemical reactions in aquatic systems.

D.O. is highest (13-15 mg/L) in cold weather, and lowest in the summer (8-9 mg/L) because the solubility (the ability to dissolve in water) of oxygen decreases as temperature goes up. High salinity decreases D.O. solubility as well.

New York State Department of Environmental Conservation (NYS DEC) sets a regulatory standard of 4 mg/L absolute minimum concentration, and 5 mg/L measured as a daily average anywhere in the creek watershed. For waters designated for trout, which includes most of Onondaga Creek and its tributaries[2], the minimum daily average is 6 mg/L. For waters designated for trout spawning, which includes some tributaries of Onondaga Creek, the minimum is 7 mg/L (NYS DEC, 1999).

Oxygen Sources:

- aeration from the atmosphere
- aquatic plants, algae (photosynthesis)

Oxygen Sinks (inputs which remove oxygen):

- sewage inputs
- carbonaceous (organic) matter
- sediment oxygen demand

FINDINGS

Oxygen levels in Onondaga Creek are generally healthy throughout its length. D.O. is highest in the headwaters and most tributaries, and decreases as the creek flows through the Tully Valley, reaching a minimum at the flood control dam on the Onondaga Nation. D.O. increases at Dorwin, possibly due to aeration at the dam's outflow, but also reflecting the input of highly oxygenated waters from Hemlock, Williams, and Commissary Creeks. D.O. reaches another minimum at Spencer/Kirkpatrick (see Figure 2).

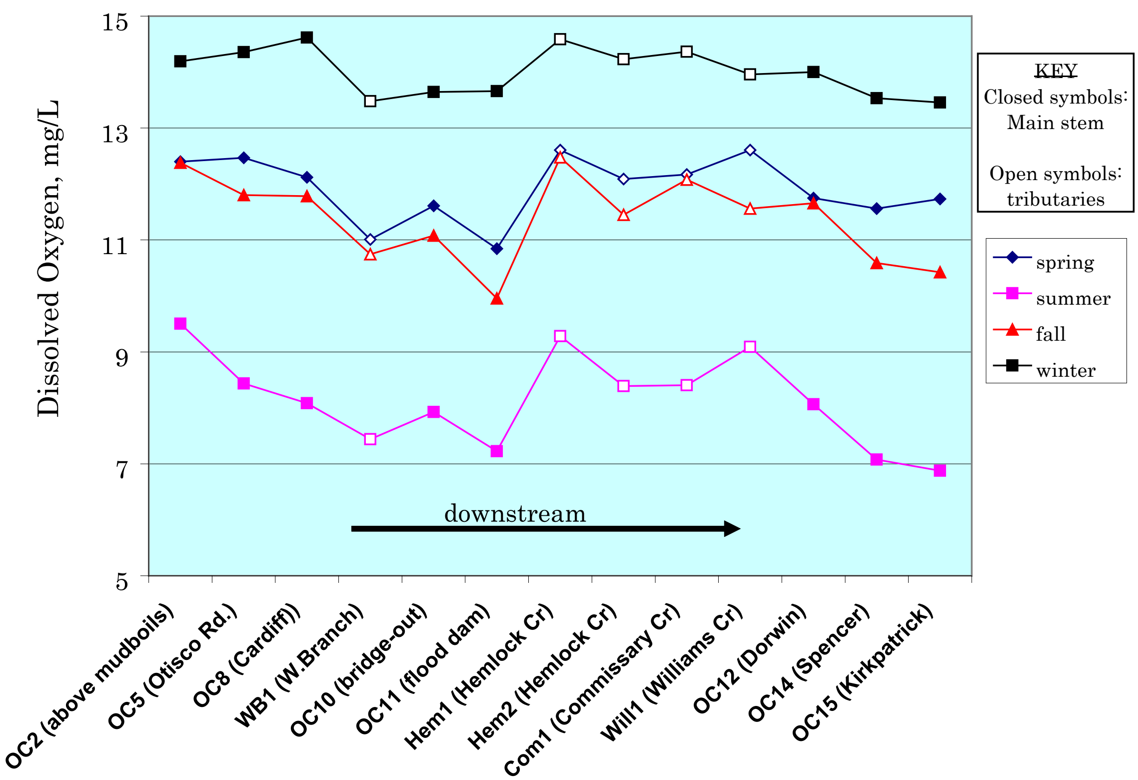
In 1994 and 1995, Onondaga County, at the city of Syracuse's request, sampled the waters of the Inner Harbor. It was found that water at the surface was well-oxygenated, but that water at depth (1-foot above the sediments) frequently fell below the New York State (NYS) standard of 4 mg/L. The deep waters within the South Pier were almost devoid of oxygen during the entire summer. (Stearns and Wheler, 1996) Factors such as high sediment oxygen demand (SOD), stagnation in terminal bays, and density stratification from brine springs could all contribute to low D.O.

IMPLICATIONS

Onondaga Creek is generally well-oxygenated throughout its length, sufficient to support most fish species. At times, D.O. levels drop below the 6 mg/L NY state standard for trout. Poor oxygen conditions which exist in parts of the Inner Harbor during the summer would preclude fish and macro-invertebrates in those specific areas. It is likely these conditions would lead to an odor problem due to putrefaction.

2 The Onondaga Creek mainstem from the Onondaga Nation south to its headwaters, and several tributaries including the West Branch, Hemlock Creek and Kennedy Creek are all designated as trout streams.

Figure 2. Average dissolved oxygen concentrations in Onondaga Creek and four tributaries, 2002-2003. For sampling locations, see map (Figure 1 in Temperature Fact Sheet). Seasonal averages are for spring [March 20–May 27, 2003], summer [July 3 –Sept. 9, 2002], fall [Sept. 23–Dec. 17, 2002], and winter [Jan. 7 –March 6, 2003]. (UFI, 2004)



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Salinity

Water Quality Series

Onondaga Creek Fact Sheet

INTRODUCTION

Natural waters contain dissolved solids, primarily inorganic salts. Salinity is the concentration of salts in water. These salts consist of:

Major Positive Ions	Major Negative Ions
calcium (Ca^{++})	bicarbonate (HCO_3^-)
magnesium (Mg^{++})	sulfate ($SO_4^{=}$)
sodium (Na^+)	chloride (Cl^-)
potassium (K^+)	

Other dissolved inorganic constituents, including nitrate (NO_3^-), silica (SiO_2) and iron oxides (e.g. Fe_2O_3), occur at relatively minor concentrations. Dissolved salts do not affect the appearance of water, as long as they remain in solution. Dissolved salts above 500 mg/L can affect the usefulness of water as a source of drinking water and above 1000 mg/L for agricultural purposes. Salts can adversely affect some freshwater organisms. (Allan, 1995)

Salinity (saltiness) can be measured as:

- "Total dissolved solids" (TDS) [units = mg/L]
- specific conductivity (or conductance) [units = microSiemens per cm (µS/cm)]
- sum of individual ions (e.g. chloride) [units = mg/L]

Table 3 provides the reader with a frame of reference for differing levels of salinity in the environment.

Table 3. Typical concentrations of TDS and chloride[3] ion in various types of water.

Water	mg/L TDS	mg/L Cl^-
Rainwater	5-15	
pristine mountain stream	10-20	
"Average world river"	110	8
Otisco Lake	250	14
drinking water, recommended maximum	500	
Onondaga Lake	1200	480
seawater	34,500-35,500	23,500
spring at Kirkpatrick St.	104,000	64,000

3 Note that CHLORIDE is not the same as CHLORINE, which is used to disinfect drinking water, and wastewater.

Salinity Sources:

- mudboils and sulfur springs, Tully Valley
- salt springs near Spencer Street

Road salt also contributes to higher salinity in local waterways. Researchers studying the Mohawk River basin in New York State concluded that the two major components of road salt, sodium and chloride, had increased by 130 and 240%, respectively over the period 1952-1998 (Godwin *et al.* 2002). [Other constituents in the water had either decreased or remained constant.] However, in absolute terms, the observed increase was less than 13 mg/L for each ion, which is insignificant in relation to Onondaga Creek.

Salinity Sinks: none

FINDINGS

The salinity of Onondaga Creek experiences two major increases as it flows downstream. The first occurs in the Tully Valley, as the creek flows past the mud boils and Bare Mountain, the site of a landslide in 1993 and several historic landslide sites (W. Kappel, pers. comm., Wieczorek *et al.* 1998). The USGS measured specific conductivity and major ions on July 20, 1998. Sodium and chloride concentrations in the Tully Valley are compared to the Mohawk River basin below:

	Sodium, mg/l	Chloride, mg/l
Mohawk R. basin average, 1990s[1]	13.2	20.4
Onondaga Cr., upstream of mudboils, 1998[2]	15-50	20-50
Onondaga Cr., downstream of mudboils, 1998[2]	175-340	270-525

[1]Godwin *et al.* (2002). [2] McKenna *et al.*(1998)

As Onondaga Creek flows past the mudboils and Bare Mountain, salinity increases by a factor of four (see Figure 3A). Sodium and chloride increased up to ten times. Data collected in 2002-2003 by UFI (2004) show less substantial, but similar, increases, depending on season (Figure 3B).

A second major increase in salinity occurs as the creek flows through the city of Syracuse. Figure 3B shows a consistent year-round increase in salinity between Dorwin (the southern boundary of the city of Syracuse) and the two downstream sites (Spencer and Kirkpatrick). The increase between Spencer and Kirkpatrick is due to a known salt spring entering Onondaga Creek with a salinity *three times that of seawater.* (EcoLogic LLC, *et al.*, 2004, 2005)

For Onondaga Creek, the major ions and quantities transported downstream each year to Onondaga Lake are given in Table 4, as sampled at Kirkpatrick between 1998-2004. (EcoLogic, *et al.*, 2000-2005)

IMPLICATIONS

Salinity concentrations increase in Onondaga Creek due to inputs from the mudboils and the 1993 landslide in Tully Valley. Given the low levels of sodium and chloride in the Mohawk River, which is only affected by road salt, compared to the much higher levels in Onondaga Creek it may be concluded that road salt is not a significant source of salinity in the Onondaga Creek basin.

Salinity concentration increases again due to highly saline groundwater discharge to Onondaga Creek in the Spencer and Kirkpatrick area. It should be noted that salt springs have historically been present where the creek enters Onondaga Lake. As such, it seems likely that indigenous organisms, at least in these areas, are tolerant of elevated salinity.

Chloride is high in this system relative to others (UFI, 2004). Chloride concentrations in natural waters are typically low, and generally lower than bicarbonate concentrations (Hem, 1985). Onondaga Creek is unusual in that chloride concentrations are much higher than bicarbonate concentrations.

Table 4. Average loadings of dissolved solids in Onondaga Creek (1998-2004).

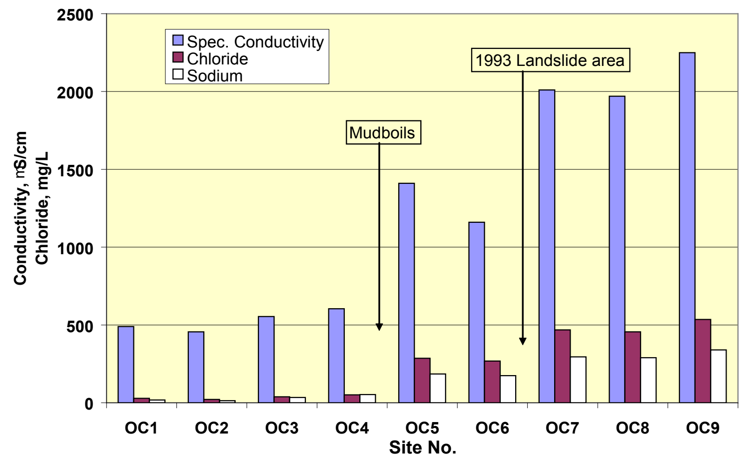


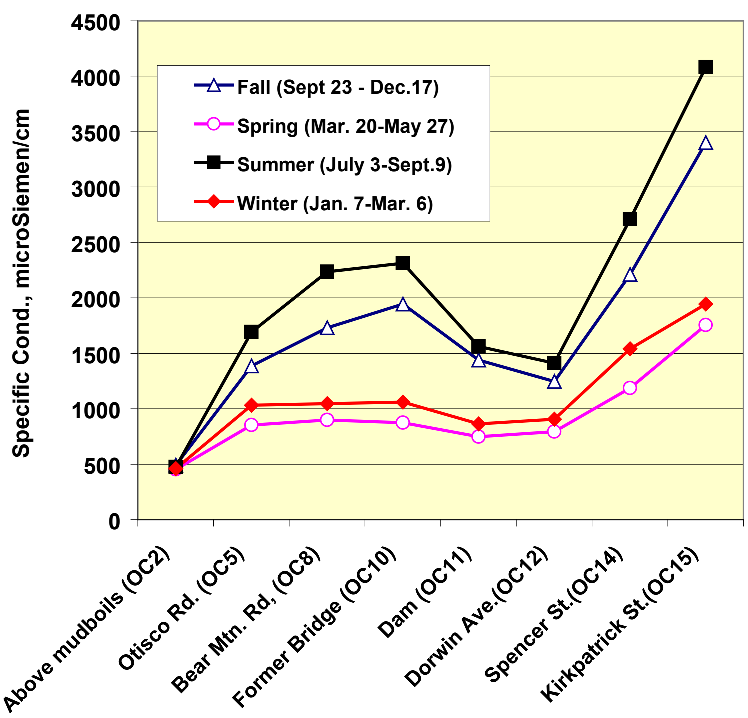
Figure 3A. Specific conductivity, sodium and chloride concentrations in the Tully Valley on July 20, 1998. (USGS web site waterdata.usgs.gov/nwis)

	Percentage (by weight)	Average loading (metric tons)*
Chloride	35%	61,900
Bicarbonate	21%	38,600
Sodium	21%	37,040
Sulfate	11%	18,500
Calcium	10%	17,100
Magnesium	2%	3,600

* 1 metric ton = 1000 kg = 2,205 lb

INTRODUCTION

FIGURE 3B. Seasonal averages of specific conductance along Onondaga Creek. (UFI, 2004)



Alkalinity is a measurement of ions that control the pH of water. A pH of 7 is considered neutral. A pH value above 7 is considered alkaline and below 7 is considered acidic. Alkalinity is determined primarily by the amount of bicarbonate and carbonate ions in water. Water draining from land characterized by limestone (calcium carbonate) rock can be strongly alkaline. Generally, alkaline waters are more biologically productive than acidic waters (Cushing and Allan, 2001).

FINDINGS

The Onondaga Creek watershed has a higher than normal amount of carbonate-enriched glacial sediments due to erosion of limestone bedrock in the north-central part of the Onondaga Creek valley (roughly Nedrow through the Onondaga Hill area), which gives the water relatively high concentrations of bicarbonate. As a result, the water is somewhat alkaline, with pH typically in the range 7.5 – 8.7, and an overall average of 8.0 (UFI, 2004). Figure 4 shows average, minimum, and maximum pH values measured throughout the watershed.

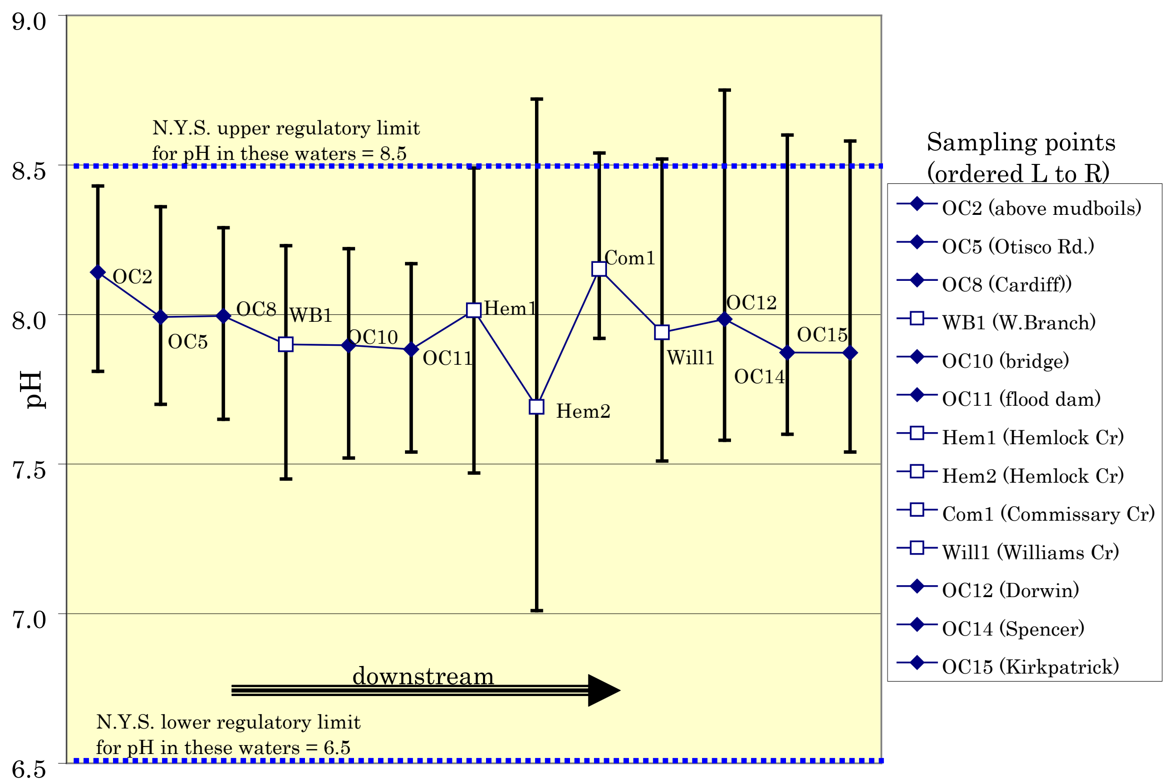


Figure 4. Average pH measured at eight locations along Onondaga Creek, and four tributaries from July 3, 2002-May 23, 2003. Error bars indicate maximum and minimum observations. (UFI, 2004)

Note that pH in rural settings (OC2 through OC11) tended to experience less fluctuations than those in an urban environment (OC12, OC14, and OC15). Hemlock Creek stands out as an exception to this generalization: the upstream site (Hem1) varied a full pH unit, while Hem2 was the most variable site of all sites, ranging from pH 7.0 to pH 8.7. The high variability at the downstream site (Hem2) may be related to the presence of a landfill between these two sites. (UFI, 2004)

Total alkalinity measured by Onondaga County at Dorwin has averaged 222 mg/L as $CaCO_3$ (4.4 meq/L) over the time period 1993-2004.

IMPLICATIONS

The Onondaga Creek watershed is dominated by limestone and glacial sediments, which give the water a stable pH. It is not susceptible to acid rain, as are streams and lakes in the Adirondacks. Local inputs of acids, such as from the landfill on Hemlock Creek, could cause a localized drop in pH. Elevated pH can cause ammonia toxicity to fish. The creek pH does exceed the NYS standard of 8.5 on occasion.

A survey of Fish and Wildlife Service literature[4] shows that the pH values (maximum = 8.7) observed in Onondaga Creek are unlikely to adversely affect fish populations. The optimal pH range for brook and rainbow trout extends to pH 8.0, but the range of tolerance extends to 9.8. Brown trout can tolerate up to pH 9.5.

4 US Fish and Wildlife Service, Habitat Suitability Index Models: Brown trout. Biological Report 82(10.124) (1986); Rainbow trout. Biological Report 82(10.60) (1984); Brook trout. Biological Report 82(10.24) (1982); and others.

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Turbidity & Suspended Solids

Water Quality Series

Onondaga Creek Fact Sheet

INTRODUCTION

Particles in water are measured two different ways: turbidity (Tn) and total suspended solids (TSS). Tn and TSS are well-correlated (the presence of one predicts the other) and very dynamic: they are ***low*** when stream flow is constant, ***high*** during storm events.

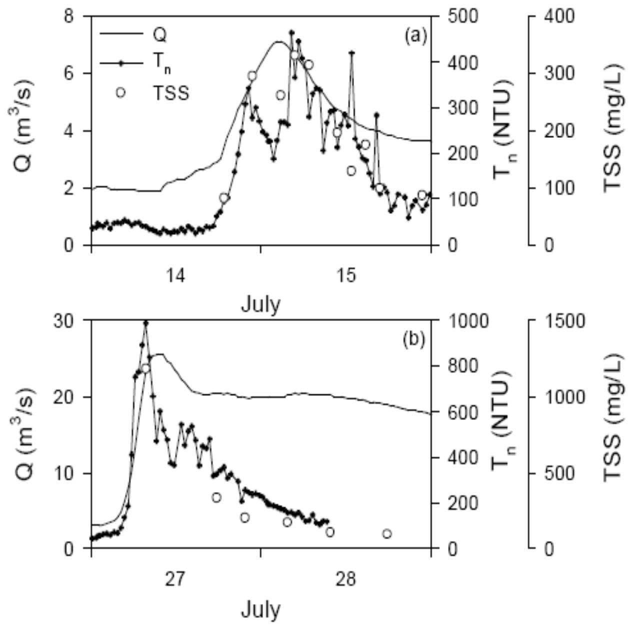
FINDINGS

Sources of Suspended Solids:

- **Existing sediments** in Onondaga Creek are resuspended during storm events (see Figure 5A).
- **Mudboils** have contributed large quantities of sediments (see Figure 5B).
- **Erosion of soils** from farming, streambanks and roadbanks, and intermittent but persistent landslides (Blatchley and Reese 2000; W. Kappel, pers. comm..) (see Figure 5B).
- **Urban run-off** (storm sewers and combined sewer overflows).
- **Particles** are primarily inorganic; organic matter is not a big contributor.

Deposition of Suspended Solids:

- Flood control dam may intercept sediments when water backs up behind the dam (<1 times per year).
- "Copious quantities of sediment cover the stream bottom and the banks of the creek downstream of the 'mud boils'" (Effler *et al.*, 1992)
- Deposition of suspended sediment likely occurs at the Inner Harbor.
- Wetlands upstream and downstream of the dam potentially intercept sediment.
- Deposition is unlikely in urban, channelized sections where flow velocities are high.



Variables shown:	Graph symbol	Graph axis
Flow = Q (m^3/s)*	solid line	left side
Turbidity = Tn (NTU)	small dots + line	right side
Total Suspended Solids = TSS (mg/L)	open circles	right side
Date		bottom

*Flow units are cubic meters per second [1 m^3/s = 35.3 cubic feet per second].

Figure 5A. Two storm events in 2004 (July 14-15 and July 27-28) show highly dynamic nature of suspended matter in Onondaga Creek at Dorwin. (Prestigiacomo et al., in press)

Note: The vertical scale in the bottom graph is much greater than the top graph.

Onondaga Creek
CONCEPTUAL REVITALIZATION PLAN

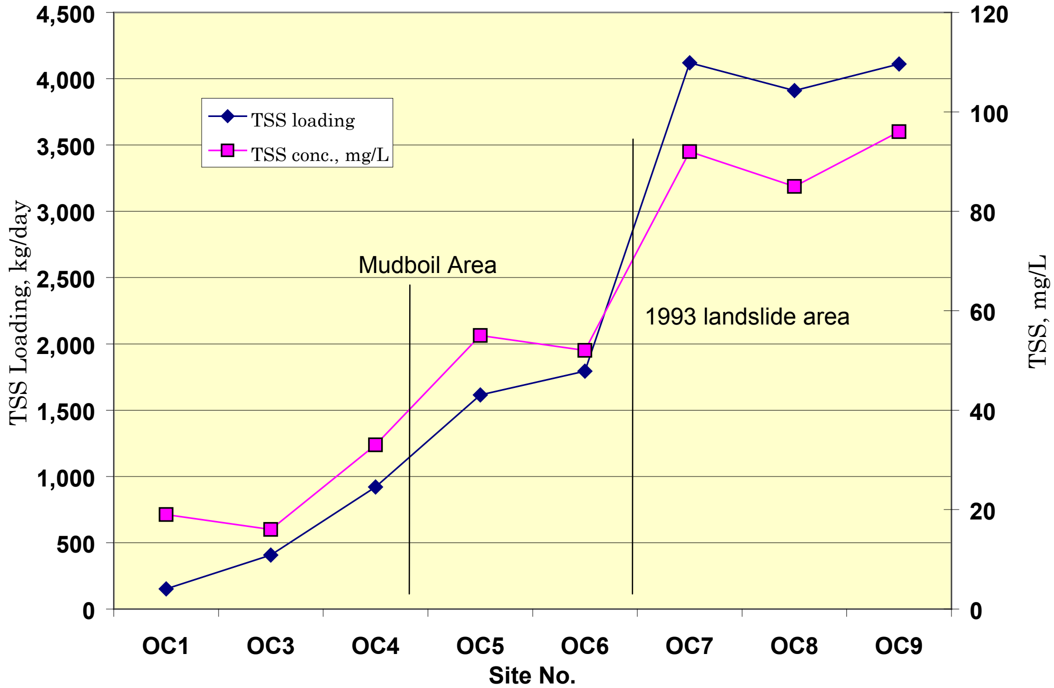


Figure 5B. Suspended Sediment in Tully Valley, July 20, 1998.

Data source: USGS web site waterdata.usgs.gov/nwis

IMPLICATIONS

- High turbidity may be a natural feature of Onondaga Creek, due to persistent mudboils (see Mudboil Fact Sheet). However, mudboil activity is reported to have increased greatly over the years 1936-1951 (Rubin *et al.*, 1991). In addition, the oral history of the Onondagas relates that water in the creek ran clear prior to the 1940s (Smardon, 1998).
- A major portion of Onondaga Creek (from the mudboils to the mouth) has been identified as impaired for public bathing, aquatic life support, and aesthetics due to the presence of excessive silt and sediment (NYSDEC, 2005).
- Ecological effects of fine suspended solids include:
  - suffocation of aquatic insect eggs/larvae (macroinvertebrates),
  - interfere with fish reproduction,
  - clog and abrade fish gills.
- Aesthetically displeasing.
- Serves as transport mechanism for toxic substances (e.g. pesticides), pathogens, and phosphorus.
- Can interfere with navigation by filling in channels (FISRWG, 1998)
- A large quantity of suspended sediment is added daily to Onondaga Lake; further study is needed to better quantify this.

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Nitrogen

INTRODUCTION

Nitrogen and phosphorus are essential nutrients for all forms of life, but can be detrimental if present in too high concentrations. In freshwater, phosphorus is generally the nutrient that limits the growth of aquatic plants and algae.

Nitrogen (N) is cycled through streams, lakes. and soil in a variety of forms (Table 5).

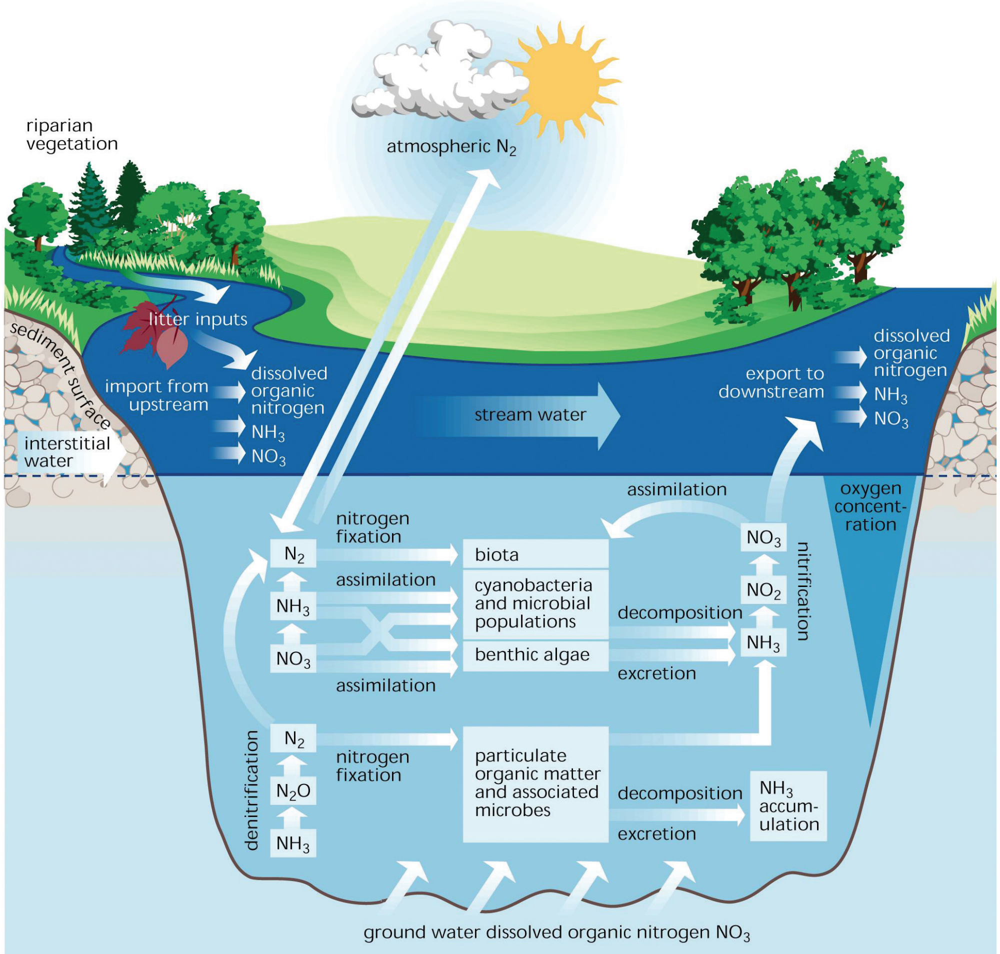
Different microbes in soil or water can decompose wastes containing organic N to various forms according to a step-wise progression. First ammonia is formed, which can be oxidized to nitrite. Nitrite is easily converted to nitrate. Nitrate is the form which tends to accumulate in groundwater and surface waters. (ATSDR, 2001)

Humans have had a profound impact on the global nitrogen cycle (see Figure 6). Surface waters, such as Onondaga Creek, can become polluted with organic N, ammonia, and nitrate through fugitive release of fertilizers from farms and landscaping uses, via storm water runoff and groundwater discharge, animal or human wastes from agricultural operations, septic tanks, combined sewer overflows, leaky sewer pipes, sewage treatment facilities, and atmospheric deposition from the combustion of fossil fuels (Cushing and Allan, 2001).

Table 5. Forms of nitrogen found in aquatic environments

Form	Symbol	Significance
Nitrogen gas	N_2	diffuses from the atmosphere and remains as an inert gas dissolved in water; used only by N-fixing bacteria
Organic N		organic matter which can be decomposed
Ammonia	NH_3	excreted by many organisms; utilized by plants, algae; toxic to fish
Nitrite	NO_2^-	an intermediate form; toxic to fish
Nitrate	NO_3^-	utilized by plants; can be toxic at high concentrations to fish and humans, especially infants, i.e. drinking water levels > 10mg/L

Figure 6. Dynamics and transformations of nitrogen in a stream ecosystem (FISRWG, 1998).



FINDINGS

Dissolved nitrogen gas: not measured, since it's inert.

Organic N: Onondaga County data from 1985-2004 show average organic-N concentrations of 0.28-0.55 mg/L at Spencer and/or Kirkpatrick St., with an overall average of ~0.3 mg/L. During storm events, organic N levels have risen as high as 5 mg/L, probably indicating inputs of nitrogen-rich organic matter contained in sewage.

Ammonia: Onondaga County data from 1985-2004 show average ammonia concentrations of 0.080-0.27 mg/L at Spencer and/or Kirkpatrick St., with an overall average of 0.14 mg/L. Concentrations are quite variable, ranging up to 0.32 mg/L at Dorwin Ave., and up to 1.46 mg/L at downstream locations. UFI data for the period July 2002 – May 2003 show an overall average of 0.038 mg/L ammonia for all locations. For the rural stream segments, the highest values of 0.15 mg/L and 0.17 mg/L were observed just downstream of the mudboils, and in the West Branch, respectively. In the urban downstream segment, a maximum of 0.80 mg/L was observed at Kirkpatrick.

New York State (NYS DEC, 1999) has adopted USEPA's 1984 water quality standards for ammonia, based on toxicity. These chronic toxicity criteria vary as a function of pH and temperature. An analysis of data collected by UFI between 2002 and 2003 throughout the watershed reveals no violations of this standard. Onondaga County reported no violations of this standard in Onondaga Creek for the years 1993-2003. Compliance was 93% in 2004.

Nitrite: Nitrite (NO_2^-) is typically present at very low concentrations in water, as it is readily converted to nitrate by bacteria. The concentrations of nitrite in Onondaga Creek for 1993-2004 are summarized below:

Concentration (mg/L)	Dorwin	Spencer/ Kirkpatrick
Min (detection limit)	<0.01	<0.01
Max	0.41	0.18
Average	0.018	0.017

Source: Onondaga County Ambient Monitoring Program, 1993-2004

NYSDEC (1999) has established two water quality standards for nitrite:

- 0.10 mg/L warm water fishery
- 0.02 mg/L cold water fishery

Both standards apply to Onondaga Creek.

Both warm and cold water fish inhabit Onondaga Creek. Many warm water fish species, such as mottled sculpin, white suckers, and creek chub occur throughout the Onondaga Creek watershed. Cold water loving species, such as brown and brook trout, are stocked throughout Onondaga Creek by Onondaga County. Fish surveys by NYSDEC and others have documented the presence and reproduction of cold water fish in the upstream portions of Onondaga Creek (e.g. Tully Valley, West Branch). Coldwater fish have been documented in the Dorwin Ave /Nedrow area also. Warm water fish predominate north of Dorwin Ave. Trout are stocked at Dorwin, and in Furnace Brook, and Cold Brook.

Nitrite levels have been in compliance with the warm water standard almost 99% of the time at both upstream and downstream monitoring sites. The cold water standard appears to be appropriate for Dorwin Ave. Thus, the compliance rate drops to 87 to 88%.

Nitrate: Nitrate (NO_3^-) can enter aquatic systems through multiple pathways, identified in the introduction. Nitrate, like N_2 gas, is a very stable form of nitrogen. Its concentration tends not to vary. This is evident in Onondaga Creek, where concentrations average about 0.9 mg/L for the period from 1985 to 2004. Nitrate on the creek follows a yearly cycle, reaching a maximum concentration of 1.3 to 2 mg/L in the winter, and minimum of ~0.5 mg/L in the summer. This pattern is documented by long-term monitoring conducted by Onondaga County. (Onondaga County, 1993-2004)

Data collected by UFI (2004) throughout the watershed show similar results, with an overall average concentration of 0.84 mg/L with little variation from upstream to downstream. Certain tributaries such as Williams Creek and Commissary Creek, were significantly lower than the main channel. Conversely, the West Branch had somewhat higher levels of nitrate.

Nitrate above 10 mg/L is prohibited by USEPA in drinking water supplies, as it can be toxic to infants (ATSDR, 2001). High levels of nitrate in natural waters can potentially cause death of fish. Over 30 mg/L of nitrate can inhibit growth, impair the immune system, cause stress, and reduce energy levels in fish. Onondaga Creek nitrate levels are too low to exhibit these effects.

IMPLICATIONS

In the urban Onondaga Creek stream corridor:

- **High organic N** levels during storm events indicate that discharges and runoff containing N-rich wastes such as sewage and/or manure are entering the creek.
- **Ammonia** levels are below NYS toxicity standards, but occasionally reach concentrations which are close to these standards.
- **Nitrite** meets the standard for a warm water fishery. The standard for a cold water fishery is exceeded 12% of the time at Dorwin Ave.
- **Nitrate** levels in the rural and urban stream segments are similar (see below).

Monitoring data upstream of Dorwin are limited to a one year study (UFI, 2004), so it is difficult to draw definitive conclusions regarding nitrogen in the rural stream segments of Onondaga Creek:

- **High organic N**. No data are available
- **Ammonia** levels upstream of Dorwin tend to be lower than in the urban corridor. However, sporadic instances of elevated ammonia occurred in the West Branch and at Bear Mountain Rd., which may be associated with fertilizer inputs.
- **Nitrite.** No data are available
- **Nitrate** levels tend to be consistent throughout the watershed, except that some tributaries (e.g. Williams Creek) are lower, while others (West Branch) are higher. The overall pattern is consistent with other watersheds where nitrate is closely tied to agricultural land use.

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Phosphorus

INTRODUCTION

Like nitrogen, phosphorus (P) is a nutrient that exists in a variety of forms. The many forms of P can be categorized into four major groups as shown in Table 6.

Table 6. Major categories of phosphorus in the aquatic environment.

	Dissolved	Particulate
Inorganic	**soluble reactive P** (SRP) free phosphates & some condensed phosphates e.g. *fertilizer, detergents, and fecal matter*	**inorganic P** which is attached to particles e.g. P adhering to *clays & silts*
Organic	**dissolved organic P** A by-product of natural decay. (Generally a small fraction of total phosphorus [TP].)	**organic P** which is attached to particles e.g. *algal cells and more complex compounds within fecal matter*

Plants use P as an essential nutrient, with SRP being the form most readily available to plants. However, the amount of TP is the single most important water quality parameter, since this represents the sum of all forms that could ultimately become available. Generally, concentrations of P are very low—(5-30 µg/L [part-per-billion]) in unpolluted waters.

High concentrations of TP can lead to algae blooms and excessive plant growth (a phenomenon referred to as eutrophication). NYS has established a guidance value of 20 µg/L to prevent eutrophication in lakes, but has no equivalent guideline for streams.

EcoLogic, a consultant for Onondaga County, has documented both rural and urban stream segments of Onondaga Creek, where the creek appears to suffer from "nutrient enrichment." This is characterized by:

- greenish water,
- overabundance of lush aquatic vegetation, and/or
- abundant algal growth.

Nutrient enrichment is typically due to excessive phosphorus.

Potential sources of P in the Onondaga Creek watershed include:

- septic tank and sewer pipe leakage
- soil erosion
- fertilizers (agricultural and lawn)
- street and highway runoff
- CSOs

Silts and clays (e.g., mud boil sediment) can remove soluble phosphorus by the processes of adsorption, followed by deposition. This material, if resuspended, reintroduces the phosphorus into the water column. In this manner it can act as a latent source of TP.

FINDINGS

Phosphorus concentrations

A UFI (2004) study conducted between 2002 and 2003 found:

- TP is predominantly in the particle phase throughout the watershed. On average, 75% of P was particulate. The remainder was dissolved.
- Total P upstream of the mudboils (OC2) was lower than at the next downstream location (OC5-Otisco Rd).
- The average level of total P in the tributaries was 14 µg/L, compared with 36 µg/L in the creek's *mainstem*.

Onondaga County data collected biweekly, from 1993 to 2004, showed the following average TP concentrations:

- 48 µg/L at Dorwin, and
- 64 µg/L at Spencer and Kirkpatrick

During storm events, short-term increases of TP can reach concentrations up to 500 µg/L. These levels occur at Dorwin and at the two downstream sites (see Figure 7).

Phosphorus loadings

The total quantity of phosphorus delivered by Onondaga Creek to Onondaga Lake per day or year is referred to as the loading. A rigorous estimate of TP loading was performed by Heidtke (1992). Based on over 2100 samples collected from April 1988 to September 1990, Heidtke estimated an annual output of 30,000 kg. The data also showed, on average, 38% coming from rural sources (upstream of Dorwin) and 62% from urban sources (between Dorwin and Spencer). Urban sources consist primarily of combined sewer overflows and storm sewer runoff. A HSPF Surface Watershed Model has been developed by The USGS. This model, if supported by adequate monitoring data, should provide more up-to-date loading estimates.

IMPLICATIONS

Phosphorus concentrations in Onondaga Creek appear to be high enough to cause excessive plant growth. Efforts that would help reduce this problem include:

- reduction of fertilizer usage (agricultural and residential)
- streambank stabilization
- interception, treatment or reduction of storm water
- reduction/elimination of CSO releases
- control of other potential sources (see list on p. 1)

The *loading* of TP from Onondaga Creek to Onondaga Lake is of special significance because phosphorus loadings to Onondaga Lake are under intense scrutiny by state regulators (NYSDEC). A major reduction in P loading to the lake has been achieved with the construction of a new treatment process at the Metro sewage treatment plant. However, further reductions are needed to reach target levels in the lake.[5] This has ramifications for watershed management, because Onondaga Creek has been identified as a major source of phosphorus. Other strategies for reducing TP loading are listed above.

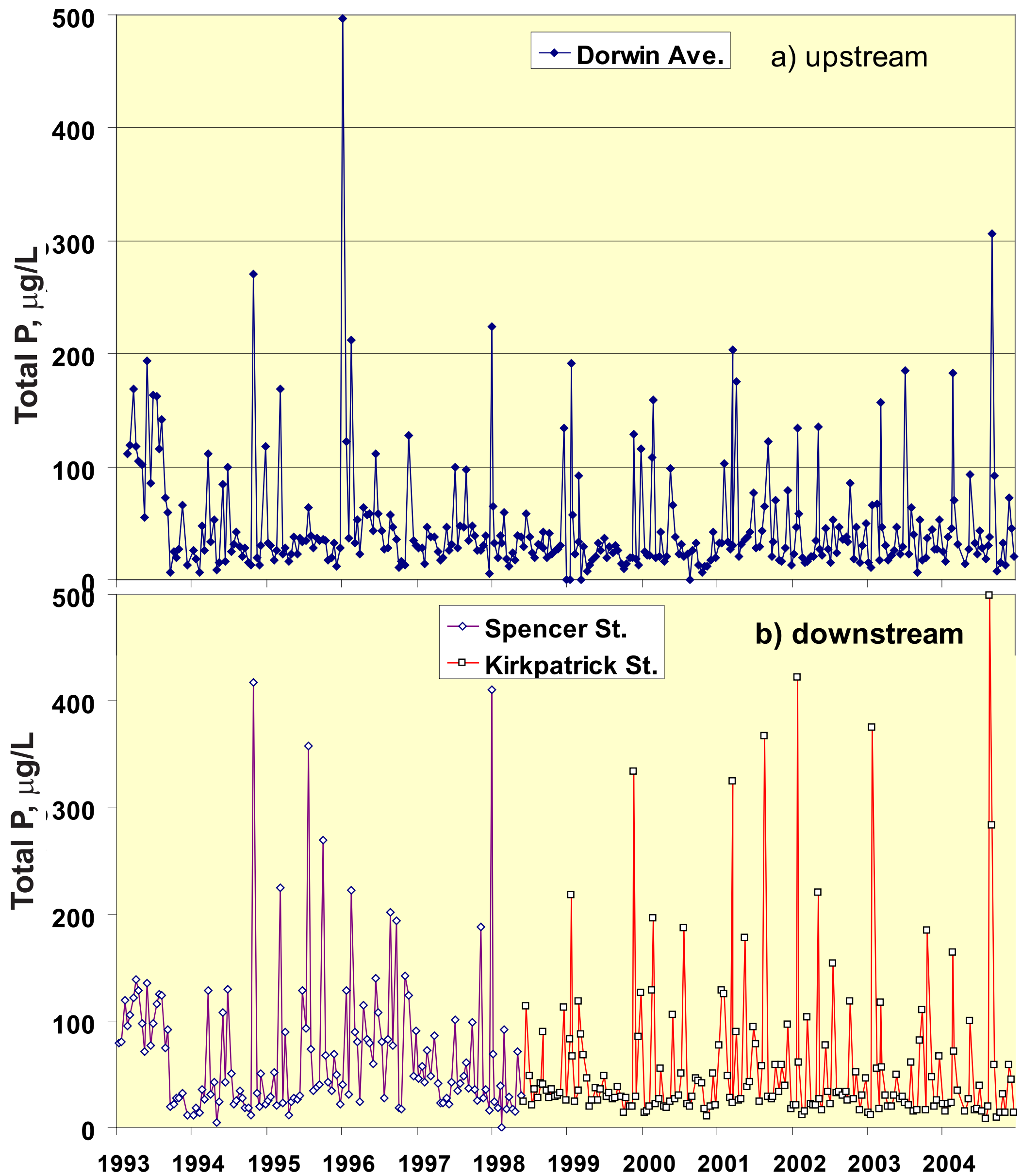
5 The target level for TP in the lake is 20 µg/L, a level which is expected to eliminate excessive growth of algae. A Total Maximum Daily Load (TMDL) for phosphorus was issued by NYSDEC in 1998, and is due to be revised by 2009. The existing TMDL calls for a 50% reduction in TP from all of the lake's tributaries.

Figure 7. Total phosphorus concentrations in Onondaga Creek, 1993-2004, at a) Dorwin and b) Spencer and Kirkpatrick.

Each point represents an individual sample. Detection limit = 1 µg/L.

Non-detects shown at the detection limit.

Sources: O.C. Ambient Monitoring Reports for years 1993-2004 (EcoLogic et al. 1999-2005; Stearns & Wheler, 1994-1997).



Pathogens

Water Quality Series

Onondaga Creek Fact Sheet

INTRODUCTION

Pathogens are microorganisms--bacteria, viruses, and protozoans--which cause disease. Pathogens are commonly associated with decomposing carcasses and fecal material from animals of all kinds (human, other mammals, birds) . Sources of fecal contamination to surface waters include untreated sewage, on-site septic systems, domestic and wild animal manure, and storm runoff. (USEPA, 1997)

Two bacteria groups, coliforms[6] and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human feces. Although generally not harmful, they indicate the potential presence of pathogens that also live in human and animal digestive systems. It is not practical to test for every pathogenic organism, so water is tested for indicator bacteria instead. (USEPA, 1997)

The fecal bacteria indicators tested in Onondaga Creek are:

1. **fecal coliforms:** a subset of total coliform bacteria, are more fecal-specific in origin than total coliforms.
2. ***Escherichia coli:*** a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. Testing for harmful strains of *E. Coli* is possible, but not commonly practiced.
3. **fecal streptococci:** generally occur in the digestive systems of humans and other warm-blooded animals.
4. **Enterococci:** a subgroup within the fecal streptococcus group. Enterococci are typically more human-specific than the larger fecal streptococcus group.

Note that **none of these tests distinguish between human and animal fecal contamination.** More sophisticated tests (DNA sequencing) which distinguish between the two exist, but are expensive. DNA testing was conducted in the nearby Owasco Lake watershed to determine sources of fecal contamination. Multiple sources of E. coli were identified, including humans, waterfowl, farm animals, deer, and pets (Pezzolesi, 2000).

Regulatory guidelines are:

- USEPA recommends use of *E. coli* and enterococci as the best indicators of health risk, but actual standards are at the discretion of individual states and localities.
- New York State DEC has set a numerical water quality standard (monthly mean) of 200 units/100ml based on the fecal coliform test. This is the legal limit for all waters in the Onondaga Creek Watershed.
- New York State Dept of Health (NYSDOH) has set limits for bathing beaches based on: fecal coliforms, enterococci, and E.coli (see table below). These legally do not apply to Onondaga Creek, since no bathing beaches are present, but serve as a useful point of reference.

Table 7 NYS Department of Health Upper Limits for Indicator Bacteria at Bathing Beaches (Ref: NYSDOH, 2004

Indicator test	Single sample (#/100 ml)	Monthly mean (#/100 ml)[1]
Fecal coliform bacteria	1,000	200
enterococci	61	33
E. coli	235	126

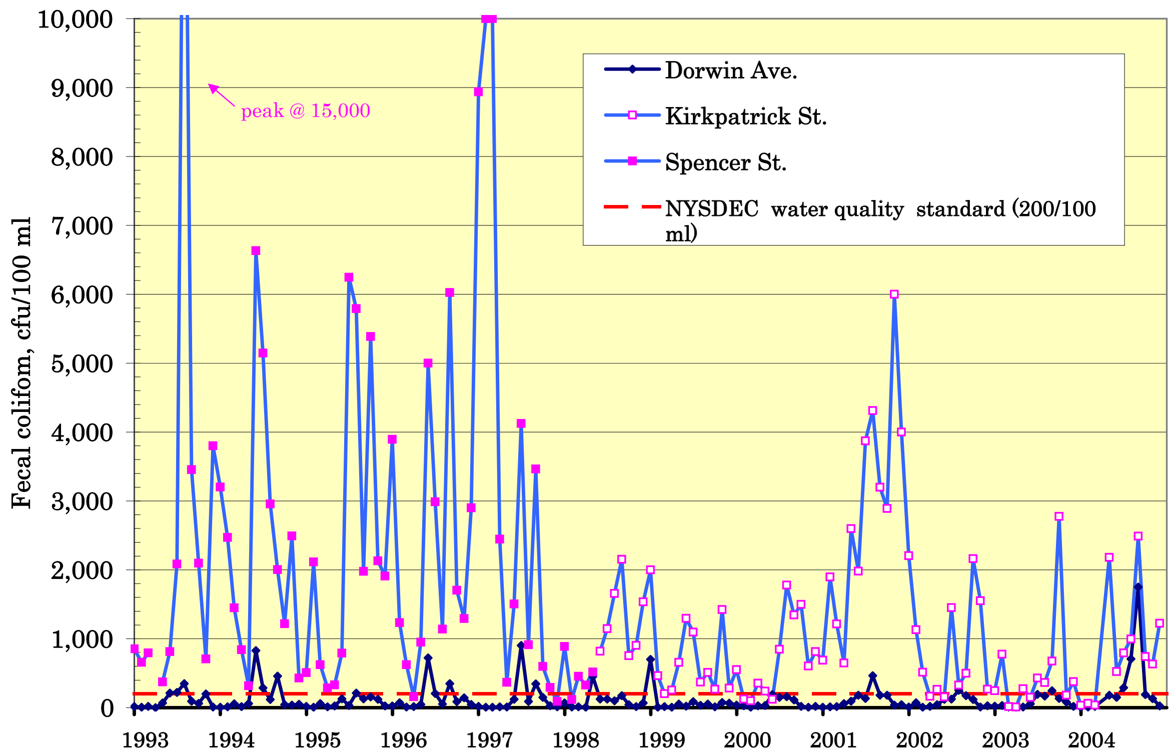
[1]Based on the geometric mean of the total number of samples collected in a 30-day period. No minimum number of samples is specified in the regulations.

6 Coliforms, as the name suggests, are bacteria having a form similar to E. Coli, which is a major bacterium present in the intestinal tract of humans and other warm-blooded animals.

FINDINGS

Routine monitoring

Fecal coliforms: Onondaga County has monitored fecal coliforms in Onondaga Creek upstream (Dorwin Ave.) and downstream (Spencer and Kirkpatrick Streets) of the city of Syracuse biweekly. Monthly averages[7] computed for the period 1993-2004 are shown in Figure 8. Concentrations downstream greatly exceed the upstream concentrations



in nearly all pairs of samples, indicating a persistent source (or sources) of contamination. The NYSDEC monthly standard for fecal coliforms was exceeded 14% of the time at Dorwin Ave., and 89% of the time at Spencer St.

A general reduction in fecal coliforms at Spencer St. is evident after mid-1998. Since 1998, Onondaga County has implemented improved quality controls for its ambient monitoring program (Ecologic LLC *et al*, 2000). However, Onondaga County (Office of the Environment, pers. comm. 2007) has indicated that no change in bacteria sampling protocols has occured. Over the period July 1998 through May 1999, Onondaga County upgraded deteriorated siphons which carry sewage underneath Onondaga Creek. Each pipe was inspected and relined, thereby reducing leakage of sewage into the creek (OCDDS 2000). Onondaga County initiated some upstream sewer separation projects and a CSO storage system (under Erie Blvd.) which may have helped reduce bacteria levels; however, most of these improvements did not take effect until 2002.

The Spencer St./Kirkpatrick St. sampling site is downstream of nearly all combined sewer overflows (CSOs) which discharge into Onondaga Creek. We hypothesized that high levels of fecal coliform resulted from CSO discharges prior to sampling. However, an investigation of the relationship between rainfall (which triggers CSO events) and fecal coliform concentration showed a poor correlation. Fecal coliforms are often high (>1000 units/100 ml) when no rain fell on either the sampling date or the two days prior.

7 Geometric means are shown, in keeping with the NYSDEC regulatory standard. However, regulations specify the collection of five samples per month. County data used in the analysis, which included both routine and high-flow events, had a frequency of 2-4 samples per month.

We also hypothesized that temperature might influence fecal coliform levels, since fecal bacteria tend to die off more quickly at higher temperatures (Auer *et al.* 1996). Again, no relationship was found. It is recognized that sediments can harbor large quantities of micro-organisms over long periods of time (Davies *et al.*, 1995). Therefore, resuspended sediment could be a major source of fecal coliforms to the water column. An analysis of suspended solids and fecal coliforms showed a moderate degree of correlation at Dorwin Ave., but poor correlation at Spencer St./Kirkpatrick St. Finally, it is possible that sewers continue to leak into the creek during dry periods. Further testing would be required to find the true sources of bacteria. Bacteria at Dorwin Ave. were significantly higher during summer months compared to winter, which suggests agricultural sources.

Limited data have been collected by Project Watershed in the Tully Valley, the West Branch, and Furnace Brook. High fecal coliforms were recorded at Bear Mountain Road/Tully Farms Rd. (up to 10,000 units/100 ml). Since 2001, fecal coliforms appear to have declined at this site which is an active agricultural area. Fecal coliforms in the West Branch (1998-2006) and at Kirk Park (2004-2006) were consistently below 200 units/100 ml but few samples were collected at these two locations.

Enterococci: Onondaga County conducted routine monitoring of enterococci from January 1999 to April 2001. Results are summarized in the table below. As a means of evaluating the suitability of the creek for contact recreation, these data were compared with the NYSDOH standard for bathing beaches, 61 units/100 ml in a single sample (NYSDOH, 2004).

Enterococci (units/100ml)	Dorwin Ave.	Kirkpatrick St.
Average concentration	115	940
Fraction > 61	38%	82%

These data indicate:

- Significant fecal contamination is entering the creek between the up- and down-stream sites, reinforcing the findings of the fecal coliform testing;
- When compared to state health department standards, the frequency of exceedances at the upstream site is greater for enterococci than for fecal coliforms.

Storm event monitoring

Onondaga County has also measured pathogens (fecal coliform, *E.coli*, and enterococci) at four locations[8] during selected storm events. The data show:

- levels of bacteria vary greatly over short periods (1-5 days)
- bacteria are usually much higher downstream compared to upstream
- rainfall intensity has a strong influence on severity of contamination: intense storms lead to greater concentrations of bacteria in the creek
- high levels of fecal coliforms (>60,000 units/100 ml), *E.coli*, and other indicators at Route 20, as well as downstream locations, occur during heavy rainstorms. These results corroborate the findings of Project Watershed, which indicate significant sources of bacteria in the Tully Valley prior to 2001.

8 Route 20 (near Cardiff), Dorwin Ave., Kirkpatrick St., and Hiawatha Blvd.

IMPLICATIONS

Water quality violations Pathogenic bacteria are a concern in Onondaga Creek, especially in the downstream (urban) section. The state water quality standard for fecal coliform bacteria is routinely and grossly exceeded. Enterococci data support these findings. Consequently, contact recreation is precluded at the downstream sites (Spencer and Kirkpatrick Sts.) nearly all of the time, and at the upstream site (Dorwin Ave.) about 15% of the time, based on the NYSDEC and NYSDOH standards.

Combined sewer overflows CSOs are a known source of untreated sewage to the downstream section of Onondaga Creek. Elimination of untreated CSO discharges will help reduce bacterial inputs the creek. Onondaga County is undertaking a CSO abatement program which will significantly reduce the quantity of bacteria discharged into the creek. Projects include the Midland Ave Regional Treatment Facility (RTF) which is under construction, and the Clinton St./Armory Square RTF, which is under design.

Other urban sources High fecal coliform levels at Spencer and Kirkpatrick Streets did not correlate well with rainfall, which implies a source other than CSO discharges. Suspended sediments show a weak correlation at Spencer and Kirkpatrick Streets. Leaky sewers are another possible source. A combination of factors is suspect. Further investigation will be required to determine the sources of bacteria in the urban part of Onondaga Creek.

Stormwater There are numerous storm water outfalls which direct street runoff into the creek. The extent to which these outfalls contribute bacterial contamination to Onondaga Creek is unknown.

Rural areas High levels of fecal coliform bacteria have been measured in the Tully Valley, probably reflecting agricultural sources. Field application of manure and the intrusion of dairy cattle into local streams are likely sources of fecal contamination. Leaking septic systems and wild or domestic animal feces are other possible sources.

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INTRODUCTION

New York State has issued two types of water quality standards: narrative and numerical. The narrative standards are descriptive in nature, such as the narrative standard for turbidity: "no increase that will cause a substantial visible contrast to natural conditions" (NYS DEC, 1999). Numerical standards establish chemical concentrations or other quantitative measures (e.g. pH) which are not to be exceeded. Dissolved oxygen is an exception in that standards set minimal concentrations.

In the preceding Fact Sheets, we have touched on compliance with New York State water quality standards for a number of parameters, namely: dissolved oxygen, fecal coliform bacteria, ammonia, and nitrite. In this Fact Sheet, compliance with these standards, as well as several heavy metals and cyanide, are summarized.

New York State has established water quality standards for organic chemicals, such as DDT and PCBs. In reviewing the available literature, OEI has found little or no data for these chemicals. Thus, compliance for these chemicals is largely unknown.

FINDINGS

Compliance with numerical standards over a 13-year period (1993-2005) is summarized in Table 8. Compliance rates are primarily taken from Onondaga County monitoring reports for 1993- 2005.[9] In these reports, compliance in Onondaga Creek is calculated based on combined data from Dorwin Avenue, Spencer St. and Kirkpatrick St. These are the values presented in Table 8, with the exception of nitrite and fecal coliform bacteria. OEI-computed compliance rates are shown for these two parameters at the upstream and downstream sites separately to more accurately portray water quality issues.

General water quality parameters

Non-compliance issues exist primarily for fecal coliforms and nitrite. The DEC water quality standard for fecal coliform bacteria was violated routinely at Spencer and Kirkpatrick Streets (averaging eight out of every nine months), and less often at Dorwin Avenue (one out of every nine months).[10] Nitrite was out of compliance about 1% of the time at Spencer and Kirkpatrick Streets and 12% at Dorwin Ave.

Heavy metals and cyanide

These substances, which have not been discussed in the Fact Sheets, are monitored due to their toxicity to fish and other aquatic life. Water quality standards for several metals (cadmium, chromium, copper, lead, nickel, and zinc) vary with the hardness of the water.[11] **Arsenic, cadmium, chromium, nickel**, and **zinc** were 100% compliant at all three monitoring sites. **Cyanide** and **lead** were nearly 100% compliant: in each case a single sample exceeded the standard during the entire 1993-2005 interval. **Copper** was occasionally non-compliant during two years: 2000 and 2005.

Iron was largely out of compliance with the 300 µg/L standard: between 45% and 100% of all samples in a given year were above this regulatory limit. NYSDEC has recently proposed withdrawing iron as a regulated parameter, and may replace the 300 µg/L standard with a 1000 µg/L guidance value (NYSDEC, 2007). While the waters of Onondaga Creek would often be above the guidance value, these would no longer be considered water quality violations. Iron has ranged from 1,500 to 14,000 µg/L in the Tully Valley, based on sampling performed by USGS in 1989 and 1990, indicating that this is not an urban phenomenon. Iron is known to occur in the local shales and the glacially derived sediments, and hence in water discharging from shale bedrock and from the Tully Valley floor (W. Kappel pers. comm., 2007).

The water quality standard for **mercury** is extremely low: 0.0007 µg/L. This is significantly below the detection limit achieved by Onondaga County's analytical laboratory (0.2 µg/L prior to 2003; 0.02 µg/L 2003-2005). Hence it is not possible to quantify compliance. A sample containing, say, 0.01 µg/L mercury would be reported as

9 Stearns & Wheler (1994, 1995, 1996, 1997) and EcoLogic LLC et al. (1999, 2000a, 2000b, 2001, 2003a, 2003b, 2004, 2005, 2006).

10 It is assumed, in calculating compliance rates, that the standard of 200 cfu/100 ml (monthly geometric mean) applies year-round.

11 Hardness has averaged 314 mg/L as $CaCO_3$ at Dorwin Ave., and 415 mg/L as $CaCO_3$ at Spencer/Kirkpatrick St.

"non-detected," but would exceed the water quality standard by a factor of 14. However, it is possible to make some general observations. Over the time interval 1993-2004, mercury has been detected once at Dorwin Ave. (0.2 µg/L) and three times at Spencer/Kirkpatrick St. (0.02 – 1.1 µg/L).[12]

While somewhat dated, the most reliable source of mercury data for the waters of Onondaga Creek comes from graduate research conducted at Syracuse University by Gbondo-Tugbawa (1999). The creek was sampled approximately monthly between October 1995 and September 1996. Rigorous bottle preparation and clean-sampling procedures were employed to prevent potential sample contamination. Laboratory analysis achieved a detection limit under 1 ng/L (1 part-per-trillion).[13] The 15 samples collected from Onondaga Creek near Spencer St. ranged from 5.0 - 14.5 ng/L, indicating persistent non-compliance with the 0.7 ng/L water quality standard for mercury.

Table 8. Compliance with water quality standards in Onondaga Creek, for the period 1993 – 2005, based on monitoring data collected by Onondaga County. Cells are shaded green when compliance >90%; yellow, between 65% and 89%, and orange, <65%.

Parameter	Current WQ Standard[1]	Compliance Rate [2]	
General water quality		**Dorwin Ave.**	**Spencer/ Kirk. St.**
Dissolved Oxygen, minimum daily average	> 5 mg/L	100%(1993 -2005), except: 92-96% (1995-1997)	
Dissolved Oxygen, minimum at all times	> 4 mg/L	100% (1993 -2005), except: 92%(1997); 96% (1995)	
Fecal coliform (monthly avg)	< 200 #/100mL	86% [(3)]	11% [(3)]
Ammonia	< 0.3-2.4*	100% (1993-2005), except 2004 (93%)	
Nitrite (warm water fishery)	< 100 µg/L	N/A[(4)]	99%
Nitrite (cold water fishery)	< 20 µg/L	88%	N/A[(4)]
Heavy metals & cyanide			
Arsenic	< 150 µg/L	100% (1993 -2005)	
Cadmium	< 3.5-5.6 µg/L**	100% (1993 -2005)	
Chromium	<300-500 µg/L**	100% (1993 -2005)	
Cyanide, free	< 5.2 µg/L	100% (1993 -2005), except one sample in 2002	
Copper	< 16-26 µg/L**	75 - 100% (1993 -2005)	
Iron	< 300 µg/L	0% - 55% (1993 -2005)	
Lead	< 7-14 µg/L**	100% (1993 -2005), except one sample in 2002	
Mercury	< 0.0007 µg/L	<100% (cannot be quantified due to analytical limitations) (1993 -2005)	
Nickel	<90-150 µg/L**	100% (1993 -2005)	
Zinc	<140-240 µg/L**	100% (1993 -2005)	

Notes:
1 Water quality (WQ) standards are from Rules and Regulations 6 NYCRR Part 703 (NYSDEC 1999). Typical ranges are shown where the standard depends on conditions at the time of sampling, as noted below:
*The ammonia standard varies as a function of temperature and pH
**Standards for cadmium, chromium, copper, lead, nickel, and zinc vary with hardness.
2 Compliance rates shown were determined by Stearns & Wheler (1994-1997) and EcoLogic LLC (EcoLogic LLC et al. 1999-2006) for the period 1993-2005, except for fecal coliform and nitrite, which were determined by OEI using available monitoring data (1993-2004).
3 NYSDEC regulations specify that compliance be based on the geometric mean of 5 (or more) samples collected per month; typically Onondaga County collects 2-4 samples per month. Compliance was evaluated by computing the geometric mean of the samples collected in each calendar month, exclusive of storm samples.

4 See Fisheries Fact Sheet.

12 A value of 1900 µg/L, reported for June 15, 1994, has been rejected as being invalid.
13 Analysis of total mercury was done by oxidation, purge and trap, and cold-vapor atomic fluorescence spectrometry (CVAFS). Laboratory blanks were always <1.0 ng/L

IMPLICATIONS

Urban watershed Onondaga County collects water samples and evaluates water quality compliance in the downstream, urban part of the watershed (i.e. Dorwin Ave. and points downstream). OEI has supplemented the county's evaluation with independent analysis, based on county data.

Water quality compliance in Onondaga Creek at Dorwin Avenue, Spencer St. and Kirkpatrick St , 1993-2005, has been 100% for a number of parameters, including: arsenic, cadmium, chromium, nickel, and zinc. Several parameters have been nearly 100% compliant: ammonia, cyanide, and copper. Dissolved oxygen was out of compliance numerous times during the period 1995-1997, but otherwise in compliance with both the 4 and 5 mg/L standards. Iron was largely out of compliance, with violations of the existing 300 µg/L standard as high as 100% (1993). Iron may be a natural phenomenon, but there are no supporting data from the headwaters (upstream of mudboils area), or major tributaries including the West Branch, or the Onondaga Nation.

Nitrite was in compliance with the warm water fishery standard of 100 µg/L at Dorwin Ave., and Spencer and Kirkpatrick Streets. However, fish monitoring indicates that the cold water standard is probably applicable at Dorwin Ave. (see *Fish Fact Sheet*). On this basis, compliance at Dorwin Ave. was 88% (1993-2004).[14] Little or no data exists to evaluate compliance in the upstream portions of the watershed, most of which are designated as trout streams. More monitoring is needed to determine the source(s) of nitrite, and the degree of compliance upstream of Dorwin Avenue.

The fecal coliform standard has been routinely violated at all three sites sampled by Onondaga County for all 13 years of monitoring reported herein. The violations are most frequent and most severe at the downstream sites (see Pathogens Fact Sheet). There is little doubt that this is linked to the combined sewer overflows (EcoLogic LLC *et al.* 2006 and prior years), but, as noted in the Pathogens Fact Sheet, there is little direct correlation between CSO events and fecal coliform concentrations. More intensive monitoring of fecal coliforms within the city of Syracuse is needed to develop a better understanding of the sources of these bacteria. In addition, sampling is needed in upstream rural communities to check compliance and determine sources of contamination.

It is impossible to determine compliance for mercury based on the existing data. Several exceedances have been observed when concentrations exceeded the analytical detection limit achieved by Onondaga County (currently 0.02 µg/L). However, much more sensitive techniques exist. The CESE laboratory at Syracuse University, for example, achieves a detection limit of 0.0002 µg/L.

Rural watershed In its review of available data, OEI has not located any past or on-going evaluation of water quality compliance in the rural watershed. Data collected by UFI (2002-2003) and USGS (1989-2001) were deemed too limited to adequately evaluate compliance in the rural watershed, although OEI did evaluate compliance with ammonia standards using data collected by UFI. Thus, compliance with water quality standards in the upstream, rural watershed is essentially not determined.

14 Under current NYSDEC stream classification, water at Dorwin Ave. is not designated for trout, a cold water species. Thus, from a strict interpretation of regulation, this stream reach is a warm water fishery. From a planning perspective, evaluation against the cold water standard is also appropriate.

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Summary of Water Quality
Onondaga Creek Fact Sheet

INTRODUCTION

This final Fact Sheet summarizes the quantitative water quality parameters discussed previously (Table 9A), along with some qualitative parameters, such as water appearance and odor (Table 9B). The creek was divided into four reaches (see Figure 9) to allow a comparison among different parts of the watershed.

Quantitative parameters: Sufficient data exist to provide a general assessment of certain parameters throughout the watershed, namely temperature, dissolved oxygen, salinity, pH, turbidity, and nitrate. However, data for ammonia, nitrite, fecal coliforms, and phosphorus are generally adequate to assess water quality only in lower Onondaga Creek (Nedrow and Syracuse).

In Table 9A, water quality in Onondaga Creek was largely assessed in terms of its suitability for cold-water fish, such as trout. This criterion is based on a number of factors:

1. The ability of a stream to support naturally reproducing and surviving cold water fish populations reflects on the degree of degredation of the whole stream ecosystem. Cold water fish are an important sentinel species due to the water quality and habitat requirements necessary for reproduction and survival.
2. Water quality parameters represented in the table are usually measured in order to assess suitability for aquatic biota (such as cold water fish) and human recreational use.
3. Much of the creek watershed is classified by New York State for supporting trout [C(t)] or trout spawning [C(ts)]. These classifications apply to the creek mainstem south of Commissary Cr., the entire West Branch, and numerous tributaries and sub-tributaties. Fish survey data support the state classifications (see Fish and Habitat fact sheets).
4. O*nondaga Lake: A Plan for Action* recommends, over the long term, "a suitable year-round habitat for a sustainable consumptive warm and coldwater fishery in the Lake and its tributaries" (OLMC, 1993). This plan was adopted by the Onondaga Lake Partnership in 2000 (OLP, 2000) and is the current management plan for the Onondaga Lake watershed.

Water quality was also evaluated for "impairment" based on criteria established under the Great Lakes Water Quality Agreement, as amended in 1987 (IJC, 1987). Specific criteria relevant to Onondaga Creek include: loss of fish and wildlife habitat, degradation or decline of fish populations, degradation of aesthetics, restrictions on fish and wildlife consumption, and undesirable algae.

A color scheme was developed to help interpret overall water quality conditions in the four reaches of Onondaga Creek. Green denotes those reaches where the parameter appears to be suitable for cold-water fish, or is not expected to lead to impairments. Yellow denotes areas where data show restrictions for cold-water species, or limited impairments. Red indicates definite and severe impairments. Reaches with inadequate data are white.

Reference streams are used for comparative purposes. They do not necessarily represent pristine or background conditions, but would be expected to have similar physical, chemical and biological characteristics. OEI was able to locate only two publications which established reference streams to Onondaga Creek. The Owasco Inlet, in Cayuga County, New York was used as a reference stream in research examining the survival and energetics of stocked Atlantic salmon (Coughlin and Ringler 2005). It was selected for relatively low human impact, and hydrology that was broadly similar to Onondaga Creek. The W. Branch of the Tioughnioga River, located upstream of Cortland, New York, was used by the USEPA (1996) as a reference for a study examining macroinvertebrate community assessment in detecting water quality impairment due to combined sewer overflows in Onondaga Creek. Water quality data in these publications are quite limited. A comprehensive comparison with an appropriate reference stream would entail considerable research effort, and is beyond the scope of this project.

Qualitative parameters: The appearance and odor of a stream are more than just aesthetic issues, they are important indicators of ecosystem health as well. Excessive algae indicate eutrophic conditions; slime deposits indicate excessive organic matter; hydrogen sulfide odors indicate a lack of oxygen. Data on appearance and odor were gathered from Project Watershed, a citizen-based water monitoring program, and stream mapping reports produced for Onondaga County (EcoLogic LLC, 2001 and 2003).

Notes for Table 9A:

1 Interpretation of information for this table was made using best professional judgment based on limited or potentially incompatible data. For definitions of terms used in the table, see next page. For detailed water quality and chemistry information for Onondaga Creek, see the corresponding fact sheets.

2 Owasco Inlet, Cayuga County, New York and the West Branch of the Tioughnioga River, Cortland County, New York, are the only two streams used as reference streams to Onondaga Creek that could be located in the available literature (Coghlan, 2004, USEPA, 1996). A reference stream is used for comparative purposes. It does not necessarily represent pristine or background conditions, but would be expected to have similar physical, chemical and biological characteristics.

3 Evidence of eutrophication is cited in stream mapping reports produced for Onondaga County's Department of Water Environment Protection (EcoLogic, LLC, 2001, 2003).

Definitions of Terms Used:

Suitable: based on the requirements for cold-water fish, such as trout. Rationale for this criterion is given on p.1.

Unsuitable: unlikely to meet the requirements for cold-water fish and other sensitive organisms.

Impaired: stream water quality demonstrates natural and/or anthropogenic change in the chemical, physical or biological integrity sufficient to cause loss of fish and wildlife habitat, degradation or decline of fish populations, degradation of aesthetics, restrictions on fish and wildlife consumption, undesirable algae, and other negative impacts to beneficial uses (adapted from Great Lakes Water Quality Agreement of 1978, Amended 1987, (IJC, 1987)).

Unimpaired: no measured or readily apparent lowering of water quality.

Elevated: data shows consistent increase as compared to other sections of Onondaga Creek.

No data: data not located in available literature.

Limited data: data in available literature is inadequate to draw conclusions.

Pulse: elevation of parameter of limited and definable time duration (Allan, 1995)

Eutrophication: the process by which waters become rich in mineral and organic nutrients (most commonly nitrogen and phosphorus) that promote a proliferation of plant life, especially algae, that, via respiration and decomposition, reduces dissolved oxygen content and can cause the asphyxiation death of other organisms. (USEPA, 2001; USGS, 2002).

Table 9A. Summary of Quantitative water quality parameters by stream reach[1]

					Reference Streams to Onondaga Creek[2]	
Parameter:	**Upper Onondaga Creek: Tully Valley& Headwaters**	**Major Tributary: The West Branch of Onondaga Creek**	**Middle Onondaga Creek: The Onondaga Nation**	**Lower Onondaga Creek: Nedrow and Syracuse**	**Owasco Inlet: Multiple Sampling Sites (2002-2003) (Coghlan, 2004)**	**West Branch of Tioughnioga River, Homer, NY Downstream of Rte 11 Bridge (EPA, 1996)**
Temperature	Suitable for cold-water fish	Suitable for cold-water fish	Suitable for warm-water fish; Periodically unsuitable for cold-water fish	Spencer Street: Suitable for cold-water fish Dorwin Avenue: Periodically unsuitable for cold-water fish	Upper Onondaga Creek is generally cooler; Lower Onondaga Creek is comparable	Single data point (13 C) indicates comparable to Onondaga Creek
Dissolved Oxygen (DO)	Suitable for cold-water fish	Suitable for cold-water fish	Suitable for cold-water fish; DO at dam on Onondaga Nation is lower than upstream	Suitable for cold-water fish; Inner Harbor has impaired DO at depth	Overall, DO is somewhat higher than Onondaga Creek.	Single data point (10mg/L) is comparable to Onondaga Creek
Salinity	Unimpaired above mudboils; Elevated levels downstream of mudboils on Bare Mtn.	Unimpaired	Elevated levels	Increased concentrations downstream of Spencer Street due to groundwater discharge	Upper Onondaga Creek is comparable; Lower Onondaga Creek is 3-4x more saline	No data
pH	Suitable range (7.0 – 8.5)	Suitable range (7.0 – 8.5)	Occasionally high pH (>8.5) Hemlock Creek: variable	Sporadically high pH (>8.5)	Systems were comparable; reported pH range 8.0-8.9	Single data point (pH=8) is comparable to Onondaga Creek
Turbidity	Impaired downstream of mudboils and landslides	Unimpaired	Impaired	Impaired	Comparable high turbidity during storm events, up to 440 NTU. Significantly lower under baseflow conditions.	No data
Nitrogen:						
Ammonia	No data	Slightly elevated via sporadic pulses, but non-toxic to fish	Slightly elevated at times, but non-toxic to fish	Higher than upstream; occasionally approaches toxicity standard	No data	No data
Nitrite	No data	No data	No data	Suitable for warm-water fish; Periodically unsuitable for cold-water fish	No data	No data
Nitrate	Unimpaired	Unimpaired	Unimpaired	Unimpaired	No data	No data
Total Phosphorus	Limited data, evidence of eutrophication[3], increases below mudboils	Limited data	Limited data	Abundant data, evidence of eutrophication, pulses during storm events	No data	No data
Pathogens (Fecal Coliforms)	Route 20: Most storm samples exceed contact recreation standards	No data	No data	Spencer Street: Exceeds contact recreation standards 89% of the time Dorwin Avenue: Exceeds contact recreation standards 14% of the time	No data	No data

* See notes on previous page

Table 9B. Summary of Qualitative Descriptors of Onondaga Creek Waters

Qualitative Description	Upper Onondaga Creek: Tully Valley	Major Tributary: The West Branch of Onondaga Creek	Middle Onondaga Creek: The Onondaga Nation	Lower Onondaga Creek: Nedrow and Syracuse
Water Appearance[1]	**Project Watershed:**			
	Solvay Road: Clear (1999-2004) Bear Mountain Road: Clear or brownish, muddy (1999-2005)	Route 80: Clear, foamy (1998-2004)	No data	Near Dorwin Ave.: Clear or brownish, muddy (2003-2006) Furnace Brook: Clear (1991, 1997-2003) at Kirk Park: Clear-brownish, muddy (2004)
	Onondaga County: (2000,2002)			
	Vesper: Ranked poor Fellows Falls to north of Solvay Road: Ranked Fair to Excellent; Otisco Road to Rt. 20: Ranked Poor	No data	Multiple sites ranked poor (assessed in 2000 only)	Dorwin to Seneca Turnpike: Ranked Fair Newell to East Adams: Ranked Poor to Fair Kirkpatrick to above Spencer: Ranked Fair
Odor[1]	**Project Watershed:**			
	Solvay Road: No odor to occasionally musky (1999-2004)	Route 80: No odor (1998-2004)	No data	Near Dorwin Ave.: No odor Furnace Brook: No odor
	Bear Mountain Road: No odor			at Kirk Park: No odor
	Onondaga County: (2000,2002)			
	Sulfur odor noted at one site	No data	No data	Sewage odor noted from Midland Avenue to Spencer Street

1 Water appearance and odor information was extracted from the Project Watershed Central New York database (http://projectwatershed.org, accessed in September and October, 2006) and stream mapping reports produced for Onondaga County's Department of Water Environment Protection (EcoLogic, LLC, 2001 and 2003). For protocols used to evaluate qualitative water quality parameters, see references.

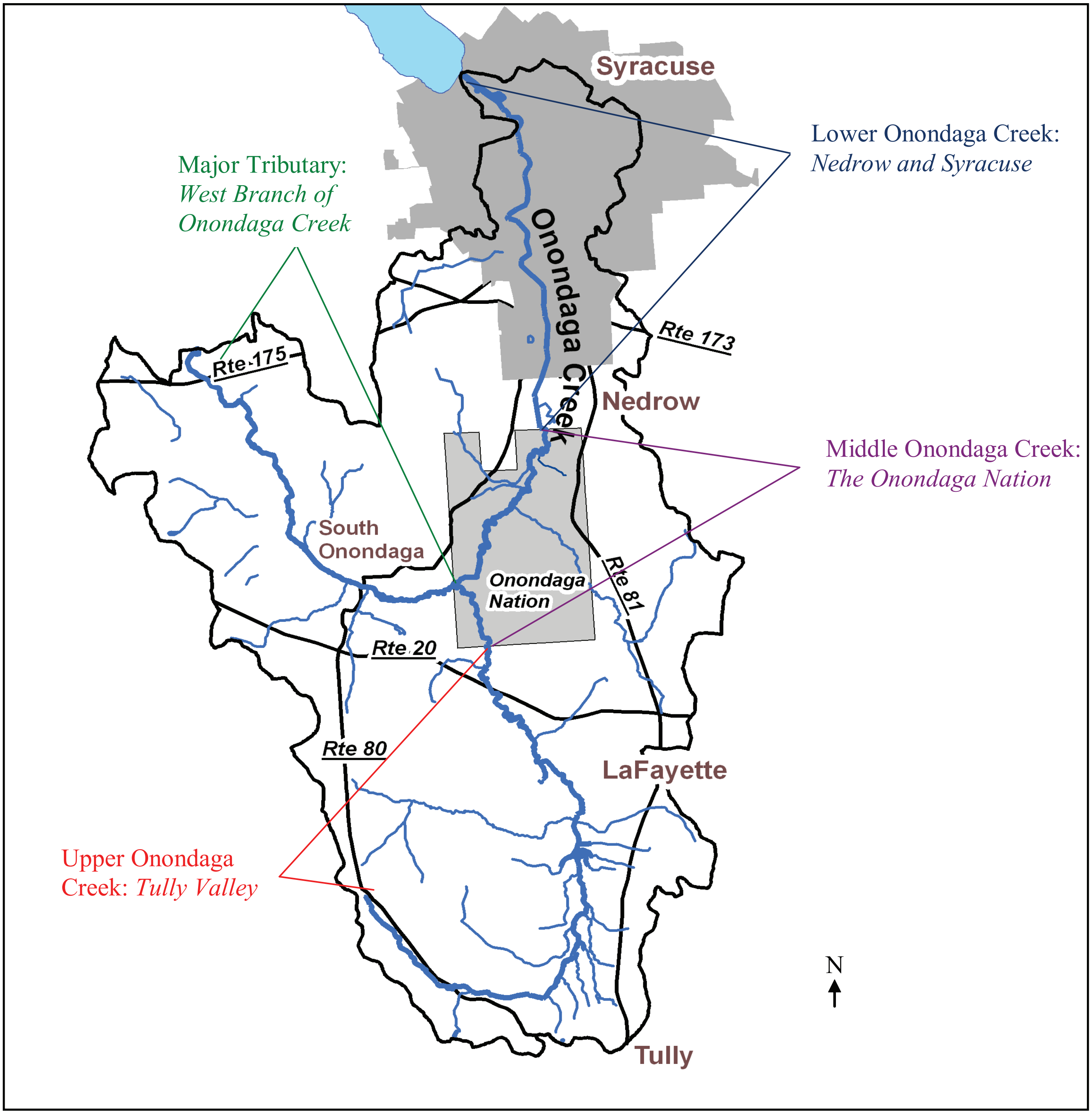

Figure 9: The four reaches of Onondaga Creek as described in the Onondaga Creek Water Quality Summary Fact Sheet.

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