A Rapid Bio-Assessment of the Normanskill Creek Relative to the Duanesburg Sanitary Landfill

Conducted September 7th 2008 - October 11th 2008
By
The Schoharie River Center Environmental Study Team

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Contents

Abstract

The Schoharie River Center's Environmental Study Team conducted a rapid bioassement of the Normanskill Creek. Our focus was to ascertain the impact that a discharge point from an unused landfill might be having on the Normanskill creek. In the study we tested at four sites; two were above the point source, one was taken directly from the drainage water, and the fourth was below the dump. Our results showed definite influences upon the waterway, although we were unable to test for such substances as heavy metals. Further testing will be conducted to determine the full extent of the leachate on this beautiful creek.

Background

In 2008, the Environmental Study Team conducted a rapid bioassessment of the Normanskill Creek. The Normanskill Creek is a tributary of the Hudson River. The headwaters are located in the border region of Schenectady, Albany, and Schoharie counties. The Normanskill Creek drains an area of 170 square miles. It runs through a variety of habitats including wetlands, agricultural, residential, and industrial areas.

The headwaters of the Normanskill Creek have not been studied prior to this assessment. The public has concern for the water quality because the Normanskill is a source for the Watervleit Reservoir. One potential point source affecting the water quality is the old dump on Van Patten Road in the town of Duanesburg.

There were four sites on the Normanskill Creek that were tested; the site of a leachate from the closed Duanesburg town dump, two upstream and one downstream location. At site number 1, the Normanskill Creek is located next to several houses and runs parallel to Rt. 20. It is located downstream from the town highway department building and just upstream from a commercial area containing restaurants, convenient store, gas station and houses which could be potential point sources of pollution.

Site number 2 is located about ¾ of a mile downstream from the commercial area. The sample was taken at the former VanPatten flour mill site. This section of the creek runs parallel to the Delaware & Hudson Railroad and Depot Road. There was a significant amount of trash at the site.

The third site is approximately ¼ mile downstream from site 2. There is a natural riparian zone, characterized by mature trees growing right down to the water's edge. The site is adjacent to the town of Duanesburg's dump, which was closed and capped in the 1980's. The sample collected was water that was coming directly out of the bank where a large reddish-brown leachate was found, rather than the actual stream. Water from the leachate flows directly into the creek.

Site number 4 is about ten feet downstream from the leachate. The bottom of the stream was characterized by a large expansion of stones with several small step waterfalls.

Results

Chemical analysis, and bacterial analysis was completed at all four sites. Macro invertebrates were also collected. Heavy rain was recorded 24 hours prior to the test period at sites 2, 3, 4.

Site 1

N : 42.7615
W: -74.13870
Date- November 2, 2008. Approximately 13:00 hours

South

North

East

West

Site 1

N: 42.7615
W: -74.13870
Date- November 2, 2008. Approximately 13:00 hours

Location: Along Route 20 in the Town of Duanesburg less then ¼ mile west from the intersection of route 7 and 20, 4 miles from the headwaters on Darby Hill.

The creak at site 1 measured 2 meters in width and was fast flowing, with a depth ranging from 0-3 meters. Riparian vegetation on the south bank was good while riparian vegetation on the opposite bank was poor consisting of residential grass down to the waters edge.

Water chemistry data for site #1 was taken on November 2, 2008. It will be compared to data collected at other test sites on the Normanskill Creek.

The temperature was 6°C and the pH was 8.2, which is basic and just falls in the NYS DEC standards. The alkalinity was 200 mg/L, which is classified as not sensitive. The turbidity was 5 FAU and the conductivity was 325 µs. The nitrate level was 1.1, which is high according to the NYS DEC standards. The orthophosphate level was 0.07, which implies impact likely. The dissolved oxygen level was 14.2 mg/L and percent saturation was 113.8.

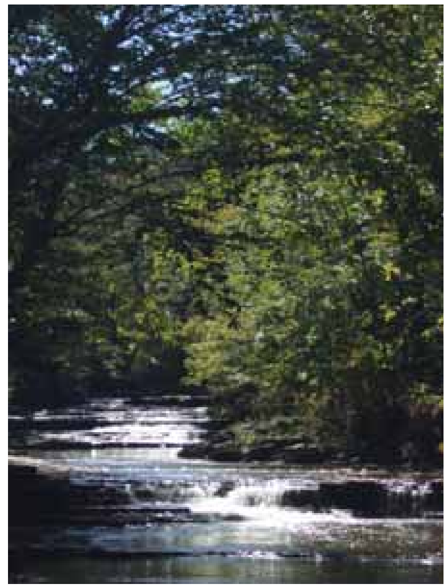
Biological indices for site 1 indicated that the water quality was non-impacted on the measures of family richness (10) and EPT richness (10) and non to slightly impacted on the

Hilsenhoff Biotic Index. Percent Model Affinity (4.3) was moderately impacted, overall the mean water quality at site 1 was non impacted (7.9) suggesting that the water quality is not limiting to fish survival or propagation.

Site 2

N : 42.77306
W: -74.12376
Date: September 7, 2008. Approximately 14:00

North



West

East South

Site 2

N: 42.77306
W: -74.12376
Date: September 7, 2008. Approximately 14:00

Location: At the Depot Road Bridge crossing the Normanskill creek, is approximately 3/4 mile downstream from site 1

The creek at site 2 measured 5 meters wide and had a moderate flow rate. It has an average depth of approximately 0.3 meters. Riparian vegetation was good with the riparian zone coming down to the water's edge.

Water Chemistries for site 2 were completed on September 7, 2008. The temperature was 22°C and the pH was 8.5, on the high end for class C water according to DEC standards. The alkalinity was 280 mg/L classified as not sensitive. The water was clear and turbidity was 9 FAU. Conductivity measured 568 µs. The nitrate level was 0.3, above the threshold required for trout propagation. The orthophosphate level was measured at 0.05mg/l. The dissolved oxygen level was measured at 8.2 mg/L and percent saturation was 91.

Site 3

N: 42.77274
W: -74.12245
Date September 7, 2008. Approximately 13:00

Water from Leachate running into the Normanskill creek.

South side site 3 Leachate Site.

Site 3

N: 42.77274
W: -74.12245
Date: September 7, 2008. Approximately 13:00

Test site #3, the actual location of the discharge, was also tested on September 7, 2008. The water temperature of the discharge was 15 °C and the pH was 7.7. The alkalinity level was greater than 1000 mg/L. The turbidity was 212 FAU, significantly higher than the upstream site. Conductivity at site 3 was 977 µs. The nitrate level was 0.5. Orthophosphate tests measured 0.0 and that the water was not impacted. The DO level was 13.4 mg/L and percent saturation was 130.7.

No biological data was collected for this site.

We observed the site to be a discharge from what we believe is the town dump. The water had an oily sheen on the surface and was an orange rust color. The water had a smell similar to that of sewage and garbage. Along the ledge there were many discharge areas. One area had a flow rate of 5 gallons every few minutes.

Site 4

N: 42.77312
W: -74.12167
Date: September 7, 2008. Approximately 12:30

North

West

East

South

Site 4

N: 42.77312
W: -74.12167
Date: September 7, 2008. Approximately 12:30

Location: Test site #4 is located just downstream from the discharge location.

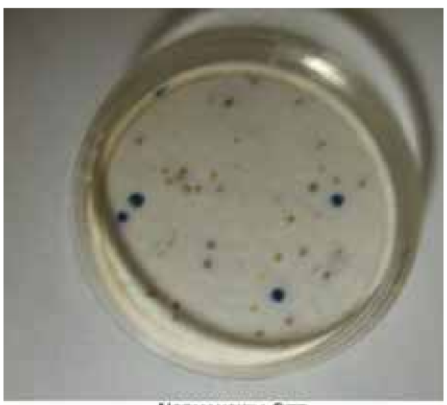
The temperature was 21°C and the pH level was 7.4. The alkalinity was 290 mg/L which indicates that the water is not sensitive. The turbidity was 11 FAU and the conductivity was 563 µs. The nitrate level was 0.7mg/L. The orthophosphate level was 0.02mg/L which indicates no impact. The dissolved oxygen level was 7.5 mg/L and percent saturation was 82.09.

Biological indices for site 4 indicated that the water quality was non-impacted on the measures of family richness (10) and EPT richness (10). It was not impacted on the Hilsenhoff Biotic Index. Percent Model Affinity (6.8) was slightly impacted, and overall the mean water quality at site 4 was non impacted (8.7) suggesting that the water quality is not limiting to fish survival or propagation.

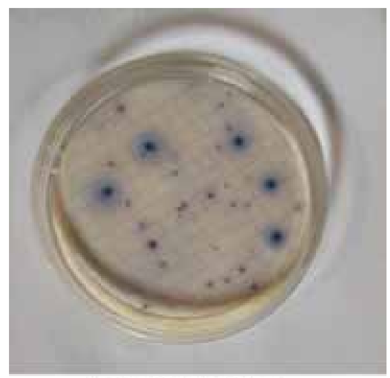
Bacterial Results

Bacterial analysis was conducted at three sites. Two of sites were upstream from the discharge point and the third was just downstream. Both sites 2 and 4 were above the state standards of 1200 per 100mL for allowable E-Coli levels.

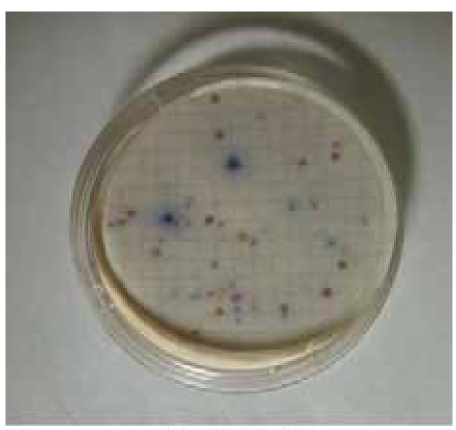
	Site 1	Site 2	Site 4
E-coli (100mL)	800	1900	1600
Coliform (100mL)	3800	1200	3300
Total (100mL)	4600	3100	4900



NORMANSKILL SITE 1



NORMANSKILL SITE 2



NORMANSKILL SITE 4

Discussion

Our assessment of the stream indicates that although the macro invertebrate results show the stream as non-impacted, the presence of the discharge site coming from the town dump negatively impacts the overall water quality of the stream.

While the discharge from the dump is unknown, the water coming from the site is negatively impacting the creek. The turbidity of the discharge water is significantly higher than that of the rest of the stream. The nitrate levels of test site 3 are higher than the steam and we believe that this is the reason for the significantly higher nitrate levels at test site 4, located further downstream.

Although our macro invertebrate data shows the stream as non-impacted we were unable to collect a full sample of macro invertebrates at the test site downstream from the discharge site. We believe that this result might be due to the effluent coming from the discharge site. We also observed that there were no Decapoda collected at site 4 while there was an abundance (16) of Decapoda collected at site 1. This, we also believe, could be a possible impact from the discharge site. The EPT richness at site 4 was also significantly less than at site 1, although still non-impacted according to DEC standards. (EPT was measured as 18 at site 1 and 11 at site 4)

Our results indicate that from site 1 to site 4 the number of e-coli colonies doubled which in part could be due to the fact that between the two sites the stream runs through the village of Duanesburg. Coliform also drastically increases from site 2 to site 4. Overall Total coliform is the highest at site 4 (downstream from both the town of Duanesburg and the discharge site)

In summary, the Normanskill creek along the sites tested had some of the most picturesque scenes that we have ever captured. The area leading up to the discharge included numerous falls and cliffs along the creek bank. Beautiful areas like these can provide an enjoyable experience along the creek and an example of how clean and well balanced the environment can be. They are overshadowed by the presence of the discharge areas just downstream. It is unknown as to what is being discharged at this site due to lack of testing resources. We believe based on our assessment of the data, the leachate is a possible negative impact on the surrounding environment.

The water quality of the Normanskill is important because the Normanskill feeds the Watervelliet reservoir. This reservoir serves as a source of drinking water for the city of Watervelliet and the town of Guilderland. We feel that further testing needs to be done by the Environmental Study Team as well as the State of New York DEC to fully understand the potential impacts on the Normanskill creek.

Conclusions

- Because we lack the ability to complete tests for heavy metals and other toxic substances further testing needs to be completed by NYS DEC.
- Further bacterial tests need to be completed to assess if the increase in coliform is entering the creek from the town of Duanesburg residence and businesses that live along the banks of the creek.
- Because we were unable to collect a full sample of macro invertebrates further analysis needs to be completed to assess macro invertebrate populations downstream from the discharge area.
- Further Testing needs to be done by the Environmental Study Team, as well as the state of New York DEC, to fully understand the potential impacts of the Town of Duanesburg Sanitary Landfill on the Normanskill and the surrounding area.

RATIONALE OF DATA COLLECTED AND METHODS

Physical

The *physical survey* is essential to a stream study because aquatic fauna often have specific habitat requirements independent of water composition, and alterations in these conditions affect the overall quality of a water body (Giller and Malmqvist, 1998). Additionally, the physical characteristics of a stream affect stream flow, volume of water within the channel, water temperature, and absorbed radiant energy from the sun.

Testing sites are evaluated for: stream size and gradient; surrounding land use; presence/absence of upstream damns; algal or weed growth; presence/absence of oily film, grease globules, or unusual odor or color; riffle size; substrate size; presence/absence of shelter for fish; flow pattern; channel alteration; stream bank cover and stability; disruption of riparian bank cover; width of riparian vegetation zone; and the presence of litter. Habitat condition was scored as excellent, good, fair, or poor (see physical survey/habitat assessment data sheets for scoring parameters). Site photos were taken of the upstream area, downstream area, and banks of each testing site, and are included in the attached physical survey/habitat assessment sheets.

Water temperature directly affects both the nature of aquatic fauna and species diversity; temperature tolerance is organism specific, and the reproductive cycle (including timing of insect emergence and annual productivity) will vary within different temperature ranges. Temperature can also affect organisms indirectly as a consequence of oxygen saturation levels. As water temperatures rise, the metabolism of aquatic organisms increases, with an attendant increase in their oxygen requirements. At higher water temperatures, however the oxygen carrying capacity of water decreases because of a diminished affinity of water for oxygen.

Optimal water temperature ranges and lethal limits of water temperature vary among different organisms. The ratio of Plecoptera to Ephemeroptera (individuals and numbers of species) has been found to drop as the annual range of temperature increase (Hynes, 1970). The optimal temperature range for brook trout is 11-16º Celsius with an upper lethal limit of 24º Celsius (Hynes, 1970). NYS DEC does not have a water quality standard for water temperature.

Temperature was recorded by grab samples with a glass thermometer.

Turbidity, or the cloudiness of the water, is caused by multiple factors such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and other microscopic organisms. Because of the ability of trout to sight feed is restricted at turbidity levels above 50 Nephelometric Turbidity Units (NTU), salmonid displacement will occur above this level. A turbidity of less than10 NTU is recommended for trout propagation (Watersheds, 1994).

The Hach DR 890 colorimeter was used in this study, which measures turbidity in Formazin Attenuation Units (FAU) (The equivalency ratio is 1FAU/1NTU).

NYS DEC does not have a numeric standard for turbidity.

Percent cobble embeddedness, is the degree to which gravel-sized and larger particles are surrounded by sand-sized and smaller particles, is an indicator of a stream's ability to support trout survival and propagation. If deposition of sediment occurs in a spawning area, it can be detrimental to trout reproduction. Trout eggs require a well-oxygenated environment; the eggs are laid in permeable gravel beds with many open places to allow continuous bathing of the eggs with cool, oxygenated water. Sediment deposition destroys this environment by clogging these open spaces, leading to oxygen deprivation and buildup of metabolic waste. When cobble embeddedness reaches 50-60%, a stream loses its salmonid fry. Furthermore, although habitat quality is still considered fair for trout survival (though not propagation) at 50-75% embeddedness changes in the bethnic macroinvertebrate fauna population, on which trout feed; begin to occur (Harvey, 1989).

Velocity was calculated at the time of macroinvertebrate collection because an optimal macroinvertebrate collection site has a velocity between 0.l45 and 0.75 meter/second. Velocity was determined by averaging the time it takes a float to travel a marked distance midstream and near each bank, and dividing the distance of the course by the average time.

Chemical

Dissolved Oxygen (DO) level is a function of water turbulence, diffusion, and plant respiration. The NYS DEC standard for dissolved oxygen for this class C stream is 5 mg/L (see appendix V).

A significant drop in DO concentration can occur over a 24-hour period, particularly if a waterbody contains a large amount of plant growth. Oxygen is released into the water as a result of plant photosynthesis during daylight; dense plant growth within a stream can therefore elevate the DO level significantly. At night photosynthesis ceases and DO may drop to levels maintained by diffusion and turbulence. A pre-dawn DO level will, in this case, reflect the lowest DO concentration in a 24 hour period and thus provide important data on the overall health of the system.

DO was measured using the modified Winkler titration with microburet method.

It is also important to consider *percent oxygen saturation*, since dissolved oxygen levels vary inversely with water temperature. Percent saturation is the maximum level of dissolved oxygen that would be present in the water at a specific temperature in the absence of other influences, and is determined by calculating the ratio of measured dissolved oxygen to maximum dissolved oxygen for a given temperature. (The calculation is also standardized to altitude or barometric pressure.)

Percent oxygen saturation falls when something other than temperature, such as dissolved solids or bacterial decomposition, affects oxygen levels. Trout are particularly sensitive to slight drops in oxygen saturation and will migrate away from streams when oxygen saturation falls. Similarly, certain macroinvertebrates are sensitive to varying saturation levels, and because the ability of these organisms to migrate away from the changing conditions is limited, a drop in saturation can be lethal. Saturation levels can significantly fluctuate during a 24-hour period depending on the amount of nutrients entering the water system, the densities of plankton, aquatic plants, and algae in the water, and the amount of light for photosynthesis.

During daylight, oxygen saturation levels can increase to supersaturation levels in streams with dense vegetation and high levels of photosynthesis. Supersaturation of water with oxygen produces the potential for gas bubble trauma (over-inflated swim bladder, exophthalmia, and bubbles in gill lamellae) in fish and other aquatic organisms. During the night, when photosynthesis ceases and plants continue to utilize oxygen for respiration, dissolved oxygen concentration and saturation levels can drop critically low.

A healthy stream contains near 100 percent oxygen saturation at any given temperature (Hynes, 1970).

NYS DEC has not adopted percent oxygen saturation as a water quality standard. The US EPA recommends a maximum of 110% oxygen saturation for the protection of aquatic life. The assessment was included in this study because of our belief that it is vital to the complete evaluation of the health of a stream.

Conductivity is a measure of the ability of an electrical current to pass through a stream; it is dependent on both the concentration of dissolved electrolytes within the water and water temperature. When inorganic ions are dissolved in water, conductivity increases. Organic ions, such as phenols, oil, alcohol and sugar, can decrease conductivity (EPA, 1997). Warmer water is also more conductive and, therefore, conductivity is reported for a standardized water temperature of 25 degrees Celsius. Measurements are reported in microsiemens per centimeter (µS/cm).

In the United States, freshwater stream conductivity readings vary greatly from 50-1,500µS/cm. The Conductivity of most streams remains relatively constant, however, unless an extraneous source of contamination is present. A failing septic system would raise conductivity because of its chloride, phosphate, and nitrate content, while an oil spill would lower conductivity.

Conductivity between 150 and 500µS/cm is considered a good mixed-fisheries range (EPA, 1997). A Corning conductivity meter was used to measure conductivity. NYS DEC does not have a standard for conductivity.

The *pH* and *alkalinity* are measures of a stream's acidity and its buffering capacity, or ability to neutralize acidic influences and resist changes in pH. A desirable pH for salmonid is 6.5-8.5. An alkalinity of greater than 20 ppm helps to protect a stream from pH altering influences (such as acid rain). An Oakton pH testr meter and the Lamotte alkalinity test kit direct reading titrator method were used to obtain pH and alkalinity, respectively. The NYS DEC standard for pH is 6.5-8.5. No standard has been established for alkalinity.

In most fresh water streams, *nitrates* and *phosphates* are in short supply and are therefore the nutrients that limit plant growth. Because of this, even small excess amounts of these substances can significantly impact a stream. Typically, natural levels of nitrate nitrogen (NO_3-N) are <1.0 mg/l. Phosphorus (P) levels of >0.05 mg/l indicate that impact is likely; at levels >0.1 mg/l impact is certain. Increased levels of these nutrients often indicate that sewage, animal manure, fertilizer, and other types of contamination from commercials sites, residential homes, or farms are entering the system.

These nutrients affect aquatic organisms indirectly when elevated levels increase plant proliferation and, ultimately, decaying plant material in the stream. Bacteria that decompose this material require oxygen, depleting the dissolved oxygen. Excessive plant growth also physically changes the substrate on which macroinvertebrates live, altering the diversity of the macroinvertebrate community on which trout feed.

It has been documented that nitrate levels are highest just before dawn due to plant inactivity (Stevenson et al., 1996). Plant uptake of nitrates during daylight due to plant metabolism can lower the levels in the water column; at night when plant activity ceases, nitrate levels increases. Pre-dawn nitrate levels will therefore indicate the maximum nitrates present in a 24-hour period.

Nitrates (NO_3-N) and Phosphates (P) were measured using the Hach DR 890 colorimeter by chromotropic acid method and ascorbic acid reduction method, respectively. NYS DEC does not have a numeric standard for nitrates or phosphates.

Biological

Macroinvertebrates are collected by kick net and the specimens are preserved. Pollution-sensitive *macroinvertebrates*, a food source for trout, require similar chemical parameters as trout. The relative numbers of different macroinvertebrate groups indicate the overall health of an ecosystem. Perhaps more importantly, macroinvertebrate data demonstrate the effects of problems that may not be detected by chemical testing.

The NYS DEC Stream Biomonitoring Unit has utilized stream biological monitoring and water quality analysis since 1972 but the biological profiles and water quality assessments are not a part of the state's standards. They serve as a "decision threshold" to determine the need for further studies.

The Environmental Protection Agency recommends that states and tribes with biomonitoring experience adopt biological criteria into water quality standards to provide a quantitative assessment of a waterway's designated and supportive use. Currently only five states have done so; NY is not one of these states. Biological assessment was included in this study because of our belief that it is vital to the complete evaluation of the health of a stream.

The four family indices, or metrics, that are recommended by the NYS DEC Biomonitoring Unit to provide a biological profile and overall stream water quality assessment are as follows:

1. <u>Family richness:</u> The total number of families found in the sample.
2. <u>EPT richness:</u> The number of families in the three most pollution sensitive orders –Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies) – that are present.
3. <u>Biotic index:</u> The product of the quantity of a particular macroinvertebrate found and its assigned biotic value (pollution tolerance value).
4. <u>Percent model affinity, PMA:</u> A comparison of the number of identified macroinvertebrates to a New York model "non-impacted" community, based on percent abundance in seven major groups.

A Biological Assessment Profile, as outlined by the DEC, is obtained from the four metrics by converting each metrics score to a 0-10 water quality scale and calculating their mean. The mean score identifies the water quality impact as: non-, slightly, moderately, or severely impacted. [For definitions of each category, see appendix VI]. The DEC surmises the ability of each of the above water qualities to support fish and their propagation, but a particular family or species of fish is not identified. This is significant because trout are sensitive to small amounts of pollutants and slight ecological changes, whereas bass or carp, having a higher tolerance to pollutants and ecological changes, are not.

It is prudent to remember that an index is a means to convey information about the status of a waterbody, but should not be used exclusive of its component metrics and data (EPA, 1999).

The HBRW Rapid Biological Assessment includes the above indices and:

1. <u>Organism Density Per Sample:</u> An estimate of the total number of individuals in the sample.
2. <u>EPT/EPT + Chironomidae:</u> A measure of the ratio of the intolerant EPT orders to the generally tolerant Diptera family Chironomidae.
3. <u>Percent Contribution of Dominant Family:</u> The percentage of the sample made up of the most abundant family.
4. <u>Percent Composition of Major Groups:</u> The percent of the sample comprised of selected major groups. [For complete definitions of indices see appendix VII]

Bacteriological

Coliforms are a group of bacteria that include fecal coliforms and other non-fecal bacteria that are widespread in the environment. They are found in the feces of both warm- and cold- blooded animals; they commonly live alongside numerous other pathogenic organisms present in fecal material, and serve as an indicator that these organisms might also be present in the water. Fecal material can pose a health risk, cause cloudy water with an unpleasant odor, and decrease dissolved oxygen as bacteria decompose the material.

Fecal coliforms are a subset of total coliforms; they are more specific to feces but not necessarily fecal in origin. They can originate from textile, pulp, and paper mill wastes (Behar, 1997). *E. Coli* is a fecal coliform specific to fecal material from humans and other warm-blooded animals. It is an indicator of health risk from water contact. (See appendix V for NYS DEC standards)

The Micro Laboratories Coliscan Membrane method was used to determine total coliforms and E. Coli.

Water Chemistries Data

Water Chemistry Values for Sites 1-4

Tests	Site 1	Site 2	Site 3	Site 4
Weather Yesterday	Clear	Heavy Rain	Heavy Rain	Heavy Rain
Weather Today	Clear	Clear	Clear	Clear
Temperature	6°C	22°C	15°C	21°C
pH	8.2	8.5	7.7	7.4
Conductivity	325 µs	568 µs	977 µs	563 µs
Alkalinity	200 mg/L	280 mg/L	>1000 mg/L	290 mg/L
Nitrate	1.1	0.3	0.5	0.7
Orthophosphate	0.07	0.05	0.0	0.02
Turbidity	5 FAU	9 FAU	212 FAU	11 FAU
Dissolved Oxygen	14.2 mg/L	8.2 mg/L	13.4 mg/L	7.5 mg/L
Percent DO	113.8	91.36	130.7	82.09

NYS DEC FAMILY-LEVEL MACROINVERTIBRATE INDICIES

1. *Family richness:* This is the total number of Macroinvertebrate families found in a riffle kick sample. Expected ranges for 100-organism sub samples of kick samples in most streams in New York State are: greater than 12, non-impacted; 9-12, slightly impacted; 6-8, moderately impacted; less than 6, severely impacted
2. *Family EPT richness:* EPT denotes the orders of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Tricoptera). These are considered to be mostly clean-water organisms, and their presence generally is correlated with good water quality (Lenat, 1987). The number of EPT families found in a 100-organism sub sample is used for this index. Expected ranges from most streams in New York State are: greater than 7, non-impacted: 4-7 slightly impacted; 1-3, moderately impacted; and 0, severely impacted.
3. *Family biotic index:* The family-level Hilsenhoff Biotic Index is a measure of the tolerance of the organisms in the sample to organic pollution (sewage inputs, animal wastes) and low dissolved oxygen levels. It is calculated by multiplying the number of individuals in each family by its assigned tolerant value, summing these products, and dividing by the total number of individuals. On a 1-10 scale, tolerant values range from intolerant (0), to tolerant (10). Values are listed in Hilsenhoff (1988); additional values are listed in the Quality Assurance document (Bode et al., 1996). Ranges for the levels of impact are: 0-4.50, non-impacted; 4.51-6.50, slightly impacted; 6.51-8.50, moderately impacted; and 8.51-10.00, severely impacted
4. *Percent Model Affinity:* This is a measure of similarity to a model non-impacted community based on percent abundance in 7 major groups (Novak and Bode, 1992). Percentage similarity is used to measure similarity to a community of 40% Ephemeroptera, 5% Plecoptera, 10% Tricoptera, 10% coleopteran, 20% Chironomidae, 5% Oligochaeta, and 10% Other. Ranges for the level of impact are: >64, non-impacted; 50-64, slightly impacted; 35-49, moderately impacted; and >35, severely impacted.

Non-impacted: Indices reflect very good water quality. The Macroinvertebrate community is diverse, usually with at least 12 families in riffle habitats. Mayflies, stoneflies, and Caddiflies are well represented; EPT family richness is greater than 7. the biotic index values 4.50 or less. Percent model affinity is greater than 64. Water quality should not be limited to fish survival or propagation. This level of water quality includes both pristine habitats and those receiving discharges, which minimally alter the biota.

Slightly Impacted: Indices reflect food water quality. The Macroinvertebrate community is slightly but significantly altered from the pristine state. Family richness usually is 6-8. Mayflies and stoneflies may be restricted, with EPT values of 4-7. the biotic index value is 4.51-6.50. Percent model affinity is 50-64. water quality is usually not limited to fish survival, but may limiting to fish propagation.

Moderately Impacted: Indices reflect poor water quality. The Macroinvertebrate community is altered to a large degree from the pristine state. Family richness usually is 6-8. Mayflies and stoneflies are rare or absent, caddisflies are often restricted; EPT richness is 1-3. the biotic index value is 6.51-8,50. the percent model affinity value is 35 –49. Water quality often is limiting to fish propagation, but usually not to fish survival.

Severely Impacted: indices reflect very poor water quality. The Macroinvertebrate community is limited to a few tolerant families. Family richness is less then 6. Mayflies, Stoneflies, and caddisflies are rare or absent; EPT richness is 0. The biotic index value is greater than 8.51. Percent Model affinity is less than 35. The dominant species are almost all tolerant, and are usually midges and worms. Often 1-2 species are very abundant. Water quality is often limiting to both fish propagation and fish survival.

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Appendix

Site Benthic Macro-invertebrate Data Analysis Sheets