The Upper Susquehanna Watershed Project;
A Fusion of Science and Pedagogy

A Thesis

By
Todd M. Paternoster

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Abstract

There is a river monitoring network underway at Sidney Central School District called the Upper Susquehanna Watershed Project. The USWP, in its third year, has established a baseline study of the upper reaches of the Susquehanna River from its source, in Cooperstown, New York, to Afton, approximately 75 miles downstream. Along with the baseline study of the river, the USWP has begun to establish baseline data for nine of the Upper Susquehanna's major tributaries.

The USWP includes 6 additional school districts along the river and has outfitted those school districts to enable them to perform their own studies of the river. Additionally, the USWP hires summer interns from local high schools to carry out investigations, to write a report of their findings and present their findings at an annual conference. To date, the USWP has employed 29 students and four teachers.

Results and observations of the USWP, both pedagogical and scientific, indicate that this authentic, inquiry- based approach to science education is effective in inspiring students in becoming stewards of the environment and making students more interested in science. Also the USWP studies indicate relative health and stability with most indicators (chemical and biological), showing the water quality ranging from good to excellent. In no case was the water quality found to be poor. Zebra mussel veligers were found to be present in the waters of the Upper Susquehanna River.

This project uses an inquiry-based, hands-on approach to teach many scientific disciplines. The USWP has inspired and will continue to inspire hundreds of students each year, by helping them to do real world science, to become stewards of their environment and to pursue a career in science.

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Introduction

Project genesis

In 2001, the New York State Department of Environmental Conservation, at the request of the Department of Health, engineered and contracted to connect approximately 25 homes near the village of Sidney to the local water treatment plant. Prior to this date sewage from these homes entered the Susquehanna River through direct effluent pipes or by outdated riverside septic systems. This civil engineering project has undoubtedly led to an improvement in the water quality downstream from Sidney. One must ask, what kind of improvement? How can we say for sure just what positive impact this civil project will have on the Susquehanna River? It occurred to me that this question would make an interesting scientific study for my students. While there are existing river monitoring networks that we could look at for current data, such as the USGS National Water Quality Assessment Program and the NYS DEC Stream Bio-monitoring unit, by establishing our own, in-house river monitoring network, a water quality study could become an effective teaching tool. Therefore, we chose to model the DEC's recently published assessment of the Upper reaches of the Susquehanna from Oneonta to Smithboro, modifying it for teaching purposes.

Shortly after the civil engineering project was completed, I decided to bring my high school biology classes to the river at Sidney to perform simple chemical and biological assessments of the river. Given the limitations of our relatively low-grade equipment, our objective was to develop methods that would be exact and as consistent as possible. The importance of establishing a baseline became immediately apparent to all those involved. It was also obvious that this little project had already generated enthusiasm and excitement in our students, and could become a more comprehensive study.

We all saw an opportunity to do real, hands-on science while modeling environmental stewardship and helping to make our river cleaner. Together, David Pysnik, a chemistry teacher; Rich Townsend, a physics and meteorology teacher; and I proposed a project that would incorporate seven major school districts on the upper reaches of the Susquehanna into a river monitoring network. We envisioned equipping all the schools with modern sampling equipment, wireless weather stations, and a broad range of chemical test kits. We called the project The Upper Susquehanna Watershed Project (USWP).

A local calendar company, MeadWestVaco, agreed to support the project with an $80,000 donation. With these funds, we purchased a cargo van and outfitted it with cabinets, drawers, and all of the testing equipment we needed to perform as complete an assessment as possible, given available time and resources. We were also able to fully supply Cooperstown High School, Oneonta High School, Unatego, Sidney, Bainbridge, Afton and Gilbertsville/Mount Upton (G/MU, is located on the Butternut creek, which is a tributary to the Unadilla River and then to the Susquehanna). Each school received a package that included: seven hip waders, d-nets, seine nets, kick nets, a Davis wireless weather station, a full set of dichotomous keys from the How to Know Living Things series, a plant press, three years worth of HACH chemical test kits for pH, Chlorine, dissolved oxygen (d.o.), biological oxygen demand, alkalinity, phosphates, nitrogen, conductivity and Total dissolved solids (TDS). They also received three years worth (30 tests per year) of Carolina test kits for total fecal coliform.

The expectation was that each school would monitor a section nearest their school for three years and, in return, would keep the testing equipment. Sidney High School students designed and built a web page whereby each school could upload their data as soon as it was collected. Workshops were given for teachers from other schools who could benefit from training in sampling techniques and who were not comfortable with the methods. Finally, during the school year of 2003-2004, the Upper Susquehanna Watershed Project came into full swing. By taking several field trips to the river with approximately 100 high school students, the USWP began collecting data. Results from these preliminary field experiences, as with subsequent field experiences (data gathered from these curricular field experiences done with whole classes should be distinguished from that gathered by the USWP interns, the former having a sole pedagogical objective and the latter having dual objectives of both science and pedagogy) done by the biology classes, generated (and continue to generate) valuable data and discussion of results. During these curricular field experiences, students were encouraged to make observations and to assess the river given the tools and methods provided. Students then carried out simple chemical analyses (pH, D.O, temp, turbidity), performed physical measurements (flow, sediment analysis, physical habitat assessment), rapid bio-assessment, collected and preserved a sample of the local flora. The subsequent teacher-facilitated classroom discussion of observations from these curricular field experiences allowed students to assimilate first-hand data with theoretical classroom science instruction.

As part of our original proposal, we were to hire seven interns to work with us during the summer months so we could spend ample time in the field. The applications for internships were distributed to over 300 students in grades 9-12 from the participating schools. Selections were made based on availability, field experience, successful completion of chemistry, and a willingness to work as part of a team. Even the best candidates typically had minimal field experience in data collection. During that first summer, we hired one outgoing senior, three incoming juniors, two incoming sophomores and one incoming freshman. This first group of student interns established our protocol through trial and error and through this process we became consistent with our methodologies. We began taking a close look at certain questions that students had generated from the first school year's field experiences.

Concurrently with the initial development of this watershed project, I was involved in earning class credit toward my Master's thesis. I was able to incorporate the knowledge acquired in classes I was taking in the biology program at State University College at Oneonta (SUCO). Taxonomy of macrobenthic invertebrates, wetland delineation, identification of wetland flora and topics in aquatic ecology are fundamental in successfully facilitating student exploration in watershed studies. This project would likely not have happened were it not for my involvement in ecological studies at SUCO and its Biological Field Station.

Objectives

Developed by educators, the **primary objective** of the Upper Susquehanna Watershed Project is pedagogical. Our intention was to incorporate real-life science that would promote environmental stewardship into our curriculum, establishing an inquiry-based program. A large body of research supports the use of inquiry-based instruction in the science classroom (Beichner and Saul, 2003; Knight and Wood, 2005; Gibson and Chase, 2002). According to Godbey, Barnett, & Webster (2005),"the need to increase inquiry-based instruction in science has been well established" (p.26). Their study, comparing parallel activities using an inquiry-based versus a lecture approach, showed that "the revised version of the activity is as effective as the original version in teaching the concepts…..Additionally, the revised activity has the definite advantage of engaging the students to a greater extent" (p.30). Handelsman et al, (2004) state: "there is general agreement that science courses consisting of traditional lectures and cookbook laboratory exercises need to be changed. What is required instead is "scientific teaching," teaching that mirrors science at its best – experimental, rigorous, and based on evidence" (521).

We were readily able to tie our project to the New York State Standards for Science and the National Benchmarks. We found that all of the major standards could be easily covered by the USWP and that this project could potentially serve as a future model for covering state standards using inquiry-based learning. The National Science standards emphasize exploring science education "beyond the classroom" (Melber 2006). The potential was also there for the future possibility of expanding to encompass all of the major disciplines. Further, we attempted to build an extensive collaboration between schools so that the students could communicate and share what they were learning.

Of utmost importance to our project has been to engage students in an authentic scientific experience. This experiential-learning project was designed to guide students through the generation of questions, assumptions, and hypothesis; through the development of methods to test these assumptions; through hands-on data collection and modification of procedures as dictated by trial and error; to the ultimate analysis of the data and deeper, first-hand understanding of science as a process. Essential to this process is the notion of making science accessible to the student: assumptions developed through genuine student discussion were not to be confirmed or denied based solely on the existing body of book-knowledge, but by the students themselves, through hands-on scientific inquiry. According to Knight and Wood (2005), there is a great deal of evidence that lecturing is an ineffective pedagogical tool for promoting conceptual understanding. They add that “students clearly learn substantially more from inquiry-based, problem solving activities than from listening to lectures” (Knight and Wood 2005). As data were collected, our students began to ask many more questions than we could possibly study. This indicated to us that the student researchers were not only gaining an understanding of how a watershed works but that they were actively engaged in the project (see list of questions in Appendix I).

The **secondary objective** for the USWP was to establish an accurate set of baseline data which would allow us to compare future changes, raise questions to investigate, observe trends, and compare locations. During our first year in 2003 we realized that we had not gotten our baseline fully established before beginning to test some hypotheses. We revised our methods by developing the scientific protocols that allowed us to obtain our baseline data in a more consistent manner. We chose seven locations to study and we were going to focus on those alone. Portlandville was initially selected as a study site but was found to be too far from the participating schools to obtain consistent samples. Each site needed to have a complete bio-assessment (to be discussed further) performed each week; we also needed to obtain accurate chemical assessments during various times of the day and once a week for the entire summer. We also measured discharge and gathered meteorological data from the wireless weather stations positioned at each school. We did a physical habitat assessment for each site and measured total coliform, each week. After the first summer we had established a thorough assessment of the Upper reaches of the Susquehanna from Cooperstown to Afton.

The scientific data gathered by the USWP has a couple of different practical applications. First, the students use the data for analysis and discussion, to generate new hypotheses, and to modify their methods and gain a deeper understanding of many ecological principles. Secondly, the data can be used as a baseline for comparison so that future students in the USWP can perpetuate the learning that has already been started. As long as our methods remain consistent, our in-house program should be able to make reasonable comparisons that reflect actual changes occurring within the Susquehanna River.

Site Descriptions

We currently monitor six sites along the headwaters of the Susquehanna River, see Table 1, having excluded Portlandville. There are several additional sites that we occasionally test; some on the river and some are isolated ponds and wetlands within the watershed. We have also established nine sites that we monitor on the main tributaries (Table 2). Each site was chosen by considering the following factors:

- Do we have legal access?
- Is the site safe for student access?
- Is the site a good representation of that stretch of the river? (i.e. similarities in width, velocity, canopy, substrate, aquatic vegetation)
- Can we park a school bus and van nearby?
- Are there wadeable riffles?
- Is it near one of our participating schools so they may collect samples from the same site?

Most of our sites are at bridges. I will provide an overview of each site starting with our river sites numbered 1-7 (Data from Portlandville, gathered during the first year of the study, is included). Our tributary sites are lettered A through I.

Table 1 Physical Descriptions for the sites studied on the Susquehanna River by the USWP.

RIVER SITE	Loc. Descr.	LATITUDE/ LONGITUDE	Avg. Width (M)	Avg. Depth (CM)	Avg. Current Speed CM/Sec	SUBSTRATE/CANOPY FAUNAL CONDITION
#1 Afton	Rt. 41 Bridge	42°13' 40.4"N 075° 31' 24.8"W	106	95.3	41.7	Canopy- <5% Rubble- 65% Silt- 10%

#2 Bainbridge	Rt. 206 Bridge	42° 17’ 26.6”N 075° 28’ 31.8”W	120	107	40.4	Canopy- 5-8% Rubble-50% Gravel-30% Abundant filamentous algae. Faunal condition fair
#3 Sidney	Main st. Bridge	42°19’01.9”N 075°23’36.1”W	62.5	94	46.	Canopy- 2-5% Gravel-30% Sand-30% Silt-30% Some filamentous algae Faunal condition fair
#4 Wells bridge	Off Rt.7	42° 21’ 59.5”N 075° 23’ 36.1”W	64.2	82	51.5	Canopy- 5-10% Rock- 40% Silt-30% Filamentous algae Good faunal condition
#5 Oneonta	Behind Neptune	42° 26’58.6”N 075° 02’47.0”W	66.2	30	145.0	Canopy-20% Rubble-75% Good faunal condition on north, parking lots on south. Just downstream from impoundment
#6 Portlandville	Rt.28/Rt49 Bridge	42°31.58 N 74° 58.37W	X	X	X	X
#7 Cooperstown	Bassett Parking Lot below impoundment	42° 41.614’N 074°55.260’W	10.3	36.2	53	Canopy-50% Gravel-40% Very good faunal condition

Table 2 Physical descriptions for the tributary sites studied by the USWP.

Tributary Sites	Loc. Descr.	LATITUDE/ LONGITUDE	AVG Width (M)	AVG Depth (CM)	Avg. Current Speed CM/Sec	SUBSTRATE/CANOPY FAUNAL CONDITION
A- Kelsey Brook Head	Rt. 7 Bridge	42 13.68N 75 31.62W	Not Yet Established (NYE)	NYE	NYE	NYE
B-Unadilla River Head	Sidney Rt. 7 Bridge	42 18.92N 75 24.81W	NYE	NYE	NYE	NYE
C-Kerr's Creek Head	Sidney-Unadilla Back River Rd. Bridge	42 18.76N 75 20.26W	NYE	NYE	NYE	NYE
D-Ouleout Creek Head	Unadilla Covered Bridge Rd. Bridge	42 19.79N 75 17.48W	14.21	8.71	66.93	NYE
E-Otego Creek Head	Otego Rt. 7 Bridge	42 26.58N 74 58.07W	NYE	NYE	NYE	NYE
F-Charlotte Creek Head	Prosser Hollow	42 26.58N 74 58.07W	NYE	NYE	NYE	NYE

	Road Bridge					
G-Schenevus Creek Head	Rt. 28 Bridge	42 29.02N 74 58.38W	17.1	24.20	36.02	NYE
H-Cherry Valley Creek Head	Milford Rts. 166/35	42 35.46N 74 55.89W	NYE	NYE	NYE	NYE
I-Oaks Creek Head	Hyde Park Rt. 28 Bridge	42 39.82N 74 57.76W	NYE	NYE	NYE	NYE

Methods and Materials

Pedagogical Methods

I take my 10th grade biology classes to the river twice during each school year. Prior to the trip I brief the students on the various tests we can perform and the measurements we can take as well as providing them an introduction to all the equipment. I then assign tasks to small groups. Tasks will be described later and include, rapid bio-assessment, measurement of velocity and stream width/depth, plankton netting for on site microscopy, seine netting for identification of minnows, collection and preservation of local flora, on site dissolved oxygen test, pH, turbidity.

Each class trip to the river lasts approximately 80 minutes. The following class period we analyze our data as a whole group and have a classroom discussion of results and observations. Students readily draw connections from our discussion to the ecological principles they are expected to learn. Topics of discussion include limiting factors, symbiotic relationships, interdependence, geocycles, energy flow, and evolution/adaptation among many others. Once the students have made their initial trip to the river, collected data and discussed possible results they are encouraged to begin asking questions.

Pedagogical Assessment

We attempted to gather some anecdotal as well as empirical evidence of how this project might generate interest in science and the environment. In November of 2003 an Introductory Attitude Evaluation (Table 5) was given to 368 students in grades 7-12 from Bainbridge, Afton, G/M-U, Unatego and Sidney. The evaluation was designed to examine student opinions about science. A student participant is defined as one that participated during the school year as part of one of their science classes. For biology classes, the students carried out rapid bio-assessments, measured flow, determined the dissolved oxygen content and surveyed the flora and fauna at the Sidney site. For chemistry classes, the students were expected to obtain and analyze a sample from the Sidney site twice throughout the school year. The student interns were not included in this pedagogical impact study. The data collected during these "whole class" trips are not included in the results and observation section of this report. The grade of the student, gender, school and the student's level of participation in the USWP was recorded for each evaluation. Students were asked to respond to ten statements and rate the level of agreement from zero to five, five indicating strong agreement (Figure 1).

Figure 1. Pedagogical impact survey

1- Science has always been my favorite topic of study.
2- I like to find out how things work.
3- I tend to do my science homework first when I have the chance.
4- I enjoy outdoor activities where I can examine and appreciate the natural world around me.
5- My grades in science tend to be my highest grades compared to other subjects.
6- I've considered pursuing some scientific career.
7- I think that being concerned about our environment is very important.
8- I have worked or would like to work on a science project involving an environmental study.
9- I enjoy reading about science topics in the newspapers, magazines and books.
10- I think that studies which scientists perform are important in making decisions about future living styles and activities.

All of the evaluations were then tabulated for the total number of points each student received from rating statements 1-10. For the purposes of this study, only those evaluations from Sidney High School students will be analyzed. The evaluations were then broken into various groups according to their level of participation. During May of 2006 we redistributed the evaluations to Sidney High students. Results (average and range) from similar groups were compared to detect any significant (±5%) change. The groups were divided as follows; non-participant freshman, participant freshman, non-participant sophomores, participant sophomore, non participant juniors and participant juniors. For each group we have two sets of data; our initial evaluation from when USWP first began and one set from current students. Additionally we have surveyed participant seniors and non participant seniors. Results are described in the discussion section.

It is the intention the directors of the USWP to further investigate the pedagogical impact by requesting another round of evaluations from our participating schools. Ideally we will also attempt to gather post-graduation data to determine if the USWP has increased the number of science majors, particularly the environmental sciences.

Physical Assessments

Physical habitat assessment was an important aspect of our baseline data. First, the students scanned the site for any major disturbances (ex. parking lots, large effluent pipes, bank erosion etc). Next the students determined the extent to which the stream was covered by vegetation (canopy). Next we picked a suitable location at the site to measure depth and velocity. For measuring depth, we have two methods: one method for rivers and one method for streams. Since the river sites were too treacherous to attempt a crossing, we instead used the bridges. Using a 10 lb weight attached to a 200 foot rope, we dropped the weight into the water at 6 meter increments along the bridge. The rope is marked with red marking to indicate every meter and 25 centimeters. The depth was determined to be the distance between the weight and the first mark that appears out of the water. From this we were able to obtain an accurate profile of the river at each site. Velocity was then obtained using a General Oceanics Mechanical Flowmeter Model 2030 from a depth of approx. six inches. The flowmeter is filled with tap water before each use to maintain neutral buoyancy. Velocity measurements were taken at two locations from each site. For locations that we could not reach on foot, the flowmeter is tethered to the rope with weight, and suspended the flowmeter over the water from the bridge and then dropped for a count of ten seconds into the water. The number of times the propeller rotates is directly related to stream velocity.

For streams, we stretched a 50 M tape across the stream. Depth was recorded at intervals of 1 M. The average depth was determined by adding the depths and dividing by the number of measurements taken plus two additional measurements of zero depth.

-Flow

Discharge, or flow, was approximated for each site by first determining stream velocity, methods described above, and then acquiring average depth, also above. With this data we used the following formula to determine flow: Flow=Area x Velocity (Stapp & Mitchell 1996).

Biological assessments

-Rapid bio-assessment

We followed the protocol from Bode et al.,1997 in the Biological Stream Assessment guide. We used three methods of assessment: biotic index, EPT richness, and percent model affinity.

At each of our sites we chose a few locations to perform a kick-net sampling from an area of wadeable riffles. During the sampling, one student held a 1x1 m², 500-µm mesh, kick net while 2-3 others disturbed the substrate with both hands and feet. The benthic macroinvertebrates would drift into the net. The sample was then transferred into a 9'x13' white enamel pan. The students then transfer the critters into the bottom of a styrofoam egg carton, sorting them into preliminary groups. One of the students would tally the specimens being transferred into the egg carton with a hand held counter. As the organisms in the samples became scarce and were harder to see, the students would pick a portion of the enamel pan to look much closer at. Students would then use a magnifying glass to assist in visualization. At this point the protocol calls for transferring the specimens into 95% ethanol. For many of our assessments, we determined the biotic richness in the field and returned the specimens. Other times, however, we did transfer them into 95% ethanol and then to the lab for identification and preservation in 70% ethanol. We could have improved this technique by returning our original sample, exceeding 100 organisms, to the lab and then randomly removing them after applying the red stain.

-Biotic Index

Biotic index was determined from our 100 organism sample using the Biotic Index worksheet established by Bode et al., 1997 in the Biological Stream Testing manual. Each organism is assigned a value depending on the organism's sensitivity to poor water quality. The number of each group is recorded and then that number is multiplied by the biotic value. We summed the biotic values for all organisms in our 100 organism sample. The sum was divided by 10 to get the biotic value of our sample. The assigned biotic values for each group are given below:

Table 3 Biotic values for various macrobenthic organisms (Bode et. al. 1997)

Organism Type	Assigned Biotic value
Mayfly, Stonefly, Caddisfly, Dobsonfly, Riffle beetle	10
Other Beetle Larva, Crane Fly Larva	8
Scud, Clam, Crayfish, Dragonfly Damselfly, Black fly	6
Midge	5
Snail	4
Sowbug, Leech	2
Aquatic worms	0

The biotic value for our sample can then be compared to water quality ranges established by Bode et al (1997). They are:

Water quality ranges (Bode et al 1997)
>79: excellent water quality
60-79: good water quality
40-59: fair water quality
<40: poor water quality

-EPT Richness- A value for EPT richness was determined by counting the number of species for each of the three groups; Ephemeroptera, Plecoptera and Trichoptera. We had difficulty keying them out to species but we were able distinguish between species. We added up the total number of apparent species among these three groups. That number was compared to the EPT richness range shown below.

EPT Richness Range (Bode et al 1997)
>10: excellent water quality
6-10: good water quality
2-5: fair water quality
<2: poor water quality

-Percent Model Affinity- This assessment compares the community of our sample to the community of a model stream for New York State (table 4). From our original data sheet for each 100 organism sample we determined the absolute difference in numbers of individuals per group with the number of individuals in the model community. The absolute differences were summed and multiplied by .5. The product was subtracted from 100. This is the percent model affinity value (Bode et al 1997).

Table 4 Percent Model Affinity**-** Shows the expected number of each group in a model stream (Bode et al. 1997).

Ranges for Percent Model Affinity (Bode et al. 1997)

Groups	# of individual in model community/100
Mayflies	40
Stoneflies	5
Caddisflies	10
Midges	20
Beetles	10
Worms	5
All others	10

>64: excellent water quality
50-64: good water quality
35-49: fair water quality
<35: poor water quality

-Identification of Zebra Mussel Veligers

A 2.4m conical plankton net with a 30 cm diameter opening and 64µm mesh was purchased from Wildlife Supply Company®. Samples were taken from location with a depth of at least 30 cm. The net was suspended in drift three times for 5 minute increments. The bucket of the net was emptied into Nasco bags partially filled with 95% ethanol. The samples were then taken back to the lab where they were analyzed using a cross polarization technique learned from Horvath (personal communication). A stereomicroscope with 40x magnifying capabilities was retrofitted with a polarizing camera filter hot glued to the objective and polarizing film on the stage above the light. Identification technique was verified by returning samples to the Biological Field Station and observed by both Dr. Horvath and Mike Gray (pers. Comm.). Differences were noted between ostracods and veligers. To perform a qualitative assessment, we dispensed 3-5 ml's of sample onto a glass plate for observation. For consistency we repeated this three times for each bag. If no veligers were found it was so noted. We would expect that if they were present we would have seen them in one of our three subsamples. Each sample was preserved for future reference. When possible, digital images were captured of the veligers at 40x mag. We sampled each site five times during the summer of 2004, using the same protocol each time.

-Fecal Coliform Bacteria

For assessing fecal coliform we performed both quantitative and qualitative assessments. We used 250 ml. styrene bottles to collect our water samples. The samples were brought back to the lab for either the chemical (qualitative) or the biological (quantitative) tests. Some of the samples were stored in the refrigerator at 4° C.

For the biological test we used Levine EMB Agar from Carolina biological supply. From our sample we dispensed 100 ml into a sterile Corning polystyrene filter with a 500 mL funnel and a .22 micron cellulose acetate membrane. The sample was filtered through and the filter membranes were placed on Levine EMB agar in 9cm Petri plates and then incubated 24-36 hours at 44.5 °C. The colonies were then counted. Plates where colonies were too numerous to count were first put on a colony counter dividing the plate into grids. We did try to dispense only 1ml of our sample into the filter and then multiply total colonies by 100 to get total coliform/100ml. This was used when colony numbers were found to be over 2000/100ml. Total coliform counts were recorded as colonies per 100mL.

For the chemical test, which was done mostly at the beginning before we had established our protocol for quantifying coliform, we used the HACH coli-MUG technique, which confirms both total coliform and the presence of *Escherichia coli.* The samples are poured into small vials containing a concentrated coli-MUG solution of Lauryl Tryptose. The vials are then inverted several times, to ensure that the inner vial is filled with liquid and that no air bubbles are present. The vials are then placed in a dri-bath incubator at a temperature of 35º Celsius. At the end of 24 hours, the tubes are each examined. The presence of bubbles in the inner vial determines the presence of coliform bacteria. After examining the vials for air bubbles, the vials can be examined for fluorescence under a UV light. The fluorescence suggests a presence of *Escherichia coli*. If no fluorescence was detected, samples were allowed to incubate for up to 48 additional hours.

Chemical assessments

For all tests, except for dissolved oxygen, the 500 ml. sample bottles were brought back to the laboratory for analysis using Hach chemical test kits. For quality assurance we frequently have students performing side by side tests using the same sample. The students did not communicate with each other. Results were compared and typically found to be identical. Further quality control was accomplished using a Hach® Portable Datalogging Colorimeter Model DR/850. The colorimeter was used to test the accuracy of each kit prior to using it for the summer. The colorimeter has the 50 available parameters that we can use. To determine the water quality, we compared our results for the chemical tests to the water quality standards used by the Isaac Walton League Save Our Stream Program (Table 5).

Table 5 Water quality standards for chemical tests (Stapp and Mitchell 1996).

	Excellent	Good	Fair	Poor
Dissolved Oxygen % sat	80-120	70-80	50-70	<50
Fecal Coliform (Col/100ml)	0-50	50-200	200-1000	>1000
pH Units	7.0-7.5	6.5-7.0 7.5-8.5	5.5-6.5 8.5-9.0	<5.5 >9.0
Chloride (mg/l)	0-20	20-50	50-250	>250
Total phosphate (mg/l)	0-0.2	0.2-0.5	0.5-2.0	>2.0
Nitrate (mg/l)	0-3	3-5	5-10	>10
Turbidity (NTU)	0-5	5-20	20-70	>70
Total dissolved solids (mg/l)	0-100	100-250	250-500	>500

Total dissolved solids

For this we used a HACH® Pocket Pal TDS tester. Range is 10-1990ppm. Accuracy is ±2% of reading at 25º C.

Chloride

We used a Chloride Test Kit HACH® model 8-P. This has low range (0-100 mg/l) and high range (0-400 mg/l) capabilities.

Turbidity

We used a HACH® turbidimeter model 2100P which provides us with measuring a range of 0-1000 NTU with a resolution of 0.01 NTU. Accuracy is ±2%.

Phosphate

We used Orthophosphate Test Kit Model PO-19. Results were recorded in the range 0-50 mg/l phosphate.

Nitrates

We used a Nitrate Test Kit HACH® model NI-11. This kit has a range of 0-50 mg/l nitrate.

Alkalinity

We used an alkalinity test kit with low range (5-100mg/l) and high range (20-400mg/l) capabilities.

Conductivity

We used a sensION5 HACH® Conductivity meter. Measurements were recorded in µmhos/cm.

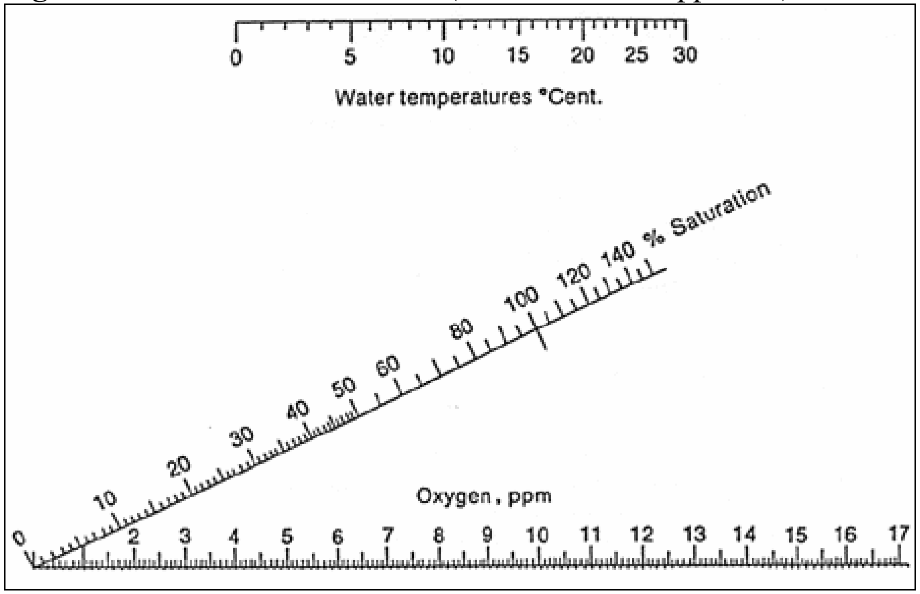
pH

We used a wide range (4-10) pH test kit. One drop of Sodium thiosulfate was dispensed into the sample if Chloride levels were high. Next, indicator solution was added and color change was compared to blank in a color comparator with a color disc.

Dissolved Oxygen

We used Dissolved Oxygen Test Kit Hach® Model OX-2P. Our range was 1-20 mg/l. Analysis of dissolved oxygen was always carried out on site at the van. We also recorded the water temperature in order to determine the percent saturation of each site (Fig.2).

Figure 2 Percent Saturation Scale (Mitchell and Stapp 1996)



Results and Observations

The USWP has accumulated a large amount of biological, chemical, physical, meteorological and pedagogical data. Over the previous three years we have conducted over 1000 chemical assessments, performed approximately 60 rapid bio-assessments, gathered over 3000 records of meteorological data from the Susquehanna valley, tested approximately 40 samples for fecal coliform, pressed and preserved many plant specimens, collected over 200 samples for zebra mussel veliger identification, brought approximately 1000 students to the river and trained roughly 50 teachers in performing a river assessment and attempted to evaluate the pedagogical impact that this project has had on over 1000 students. I will attempt to include as much of the data as possible in this paper. Much of the data from our first two years will not be tabulated among the current set of data (2004-present). This decision is based on the fact that our sampling techniques differed slightly from our current methods. Also, these data include samples from various places outside our seven listed sites. This data from various other places we have collected will prove useful for future reference as we begin, again, to move away from our seven sites.

Table 6 Shows the results from pedagogical impact survey given to participants and non-participants.

PEDAGOGICAL ATTITUDE EVALUATION SURVEY

	NON- PARTICIPANTS		***PARTICIPANTS***	
	2003	***2006***	***2003***	***2006***
Freshmen	***AVG. 26.3 N=11***	***AVG. 26 N=42.***	***Not Applic.***	***NA***
Sophomores	***AVG. 31.3 N=29***	***AVG. 30.8 N=26***	***AVG. 31.5 N=34***	***AVG. 35.9 N=28***
Juniors	***AVG. 29.3 N=19***	***AVG. 30.4 N=25***	***AVG. 38.1 N= 16***	***AVG. 38.5 N=7***
Seniors	***NA***	***AVG. 30.5 N=31***	***NA***	***AVG. 35 N=17***
TOTALS	***AVG. 29.7 N=59***	***AVG. 29 N=124***	***AVG. 33.6 N=50***	***AVG. 35.9 N=52***

Non-participant average score = 29.2 (n=183)
Participant average score=34.7 (n=102)
Percent (%) difference=16

Results of Rapid Bio-assessments

***Table* 7** Summary of three Biological Community Parameters. Water quality ranges for the three parameters are as follows. Biotic Index:>79=excellent, 60-79 = good, 40-59=fair, <40 = poor. Sites 6&7 had not been assessed to date:

	Biotic Index	EPT Richness	Percent Model Affinity
Site #7 Cooperstown	No data	ND	ND
Site #6-Portlandville	ND	ND	ND
Site #5-Oneonta	93.8	9	54
Site#4-Wells Bridge	87	6	51
Site#3-Sidney	90.3	6	58
Site#2-Bainbridge	86.9	7	73
Site#1-Afton	129	7	74
Average	**97.4**	**7**	**62**

***See appendix II for complete worksheets for rapid bio-assessments**

Chemical Analysis

Table 8 Comparison of chemical data of yearly averages from each of the seven sites studied by the USWP over 2 years.

USWP Chemical/Biological Parameter River Site Comparison of Averages																	
Site	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
1 Afton	93.8	8.8	469.6	7.3	0.03	3.36	46.1	9.26	78	89.7	186.9		20.2	19	129	7	74
2Bainridge	91.2	8.4	224	7.57	0.04	2.8	45.2	6.42	100	114	211.4		20.7	19.9	86.9	7	73
3-Sidney	84.4	7.8	344.5	7.51	0.06	3.36	40.2	9.09	92.8	101	190.8		19.7	17.7	90.3	6	58
4Wells Br.	83.5	7.75	176.6	7.4	0.04	5.02	45.3	10.1	99.6	93.5	227		22.1	20.1	87	6	51
5Oneonta	92.5	8.4	152.6	7.5	0.04	3.97	45	6.58	112	106	229		23.1	20.05	93.8	9	54
6Portlandville				7.9	0.05	5.13	53.3		143	153							
7Cooperstow	80.3	7.2	294.5	7.7	0.05	4.64	49.4	2.87	141	132	305		23.4	21			
Average	**87.6**	**8.05**	**276.06**	**7.55**	**0.04**	**4.04**	**46.3**	**7.38**	**109.4**	**113**	**225**		**21.5**	**19.6**	**97.4**	**7**	**62**

***See appendix III for data sheets for each of the sites above**

Table 9 – Shows the results from a qualitative assessment performed on the Susquehanna identifying the presence of Zebra mussel veligers using cross-polymerization microscopy.

Veliger Identification

	Site #1 Afton	***Site #2 Bainbridge***	***Site #3 Sidney***	***Site #4 Wells Bridge***	***Site #5 Oneonta***	***Site #6 Portlandville***	***Site #7 Cooperstown***
1 July 04	***None***	***None***	***Veligers present***	***Veligers present***	***Veligers present***	***Not sampled***	***Not samples***
8 July 04	***None***	***None***	***None***	***Veligers present***	***Veligers present***	***Not sampled***	***Not sampled***
14 July 04	***None***	***None***	***Veligers present***	***Veligers present***	***Veligers present***	***Not sampled***	***Not sampled***
19 July 04	***Veligers present***	***None***	***Veligers present***	***Veligers present***	***Veligers present***	***Not sampled***	***Not sampled***
29 July 04	***Veligers present***	***Veligers present***	***Veligers present***	***Not sampled***	***Not sampled***	***Not sampled***	***Not sampled***
2 Aug 04	***Not sampled***	***Veligers present***	***Veligers present***	***Veligers present***	***Veligers present***	***Not sampled***	***none***
28 April 05	***Not sampled***	***Not sampled***	***Not sampled***	***Not sampled***	***Veligers present***	***Not sampled***	***Not sampled***
27 June 05	***None***	***None***	***None***	***Not sampled***	***Veligers present***	***Not sampled***	***none***
28 June 05	***Not sampled***	***Not sampled***	***None***	***Not sampled***	***Not sampled***	***Not sampled***	***Not sampled***
29 June 05	***Not sampled***	***Not sampled***	***Not sampled***	***None***	***Not sampled***	***Not sampled***	***Not sampled***
10 August 05	***None***	***None***	***None***	***None***	***Veligers present***	***Not sampled***	***none***
FREQUENCY OF VELIGERS	***2 out of 7 28.5%***	***2 out of 8 25%***	***5 out of 8 62.5%***	***5 out of 7 71.4%***	***8 out of 8 100%***	***0 out of 0 0%***	***0 out of 3 0%***

Discussion of Results

There is, was, and will continue to be, a wide range of data collected by the USWP. Many different techniques were employed over the course of 3 years. We have learned what works for us and remained consistent with our methods. By limiting ourselves to the methods that work best for us, we have sacrificed some degree of scientific validity. As was mentioned earlier, the USWP was designed to be a fusion of science and pedagogy. We feel we have accomplished that. There may be some methods that may not hold up to scientific peer review but have maximized the educational value of that experience. We have held true to our beliefs that consistency is the key to proper data collection. Where we have seen flaws in our methods, we have modified them. This endeavor has been an ever- changing pursuit to have our students obtain a thorough and accurate picture of the ecology of the Susquehanna. The USWP will continue to ask questions, collect data, inspire students, train teachers and monitor the health of the Susquehanna. There are, in addition, a number of questions that can be answered using the data we have collected thus far. First I will discuss the results from the chemical and biological tests performed for each site and then address some specific questions for which our data will allow us to draw reasonable conclusions. Finally I will address the pedagogical impact that the USWP has had on generating interest in science, teaching environmental stewardship and awareness.

Discussion of chemical/biological data from each river site (1-7)

Site #1- Afton

Overall, the Afton site had very high ratings using our biological indices. For both Biotic index and Percent model affinity the water quality was shown to be excellent. Using the EPT richness test, the water quality was shown to be good. There appeared to be a good amount of diversity represented by nine different groups from a 100 organism sample. It should be noted that it is highly likely that our collection techniques did not yield more species due to the ease with which the larger more obvious organisms are picked from the net first. As we improve, we will likely find a greater diversity within all of our sites. Chemically, our Afton site appeared very healthy (Fig.2, water quality standards) and stable. There were 17 separate sample dates from Afton. The most surprising was the low nitrate and phosphate averages, 3.36 mg/l and .03 mg/l respectively. The nitrate results (range = 0-8.8) indicate good water quality and phosphate results are good as well. During one sample date the nitrate levels reached their maximum 8.8 mg/l and turbidity doubled to 7.29 NTU. Unfortunately we have not been able to record rainfall data during the summer because the participating teachers from the schools where the weather stations are mounted are away from their rooms, unable to report the data. It is likely that prior to that day there was a significant rainfall event that carried fertilizer or manure into the river and increased the turbidity. The chloride average was 46.1 mg/l this too indicates good water quality. However, during 2 sample dates 23 and 25 August, the levels reached 100 mg/l. Upon further investigation we found that the Afton School swimming pool is often partially drained into a nearby stream. Further investigation is in order. Fecal coliform levels were fair (average- 469.6 col/100 ml.) except for one day when 1200 col/100ml was recorded. On that same day, % saturation of Dissolved oxygen dropped 5.8% below the average of 93.8 to 88% although this number is still within the excellent range. The pH at Afton is excellent (7.3) as well as total solids at 78 mg/l.

Site #2- Bainbridge

The three biological indices indicate that the water quality in Bainbridge is excellent to good. Both the biological index and percent model affinity tests result in excellent water quality. The EPT richness showed water quality to be good. There were nine different groups of macro-invertebrates represented in our 100 organism sample. We found at least 7 different species of EPT groups. Mayflies and caddisflies were the 2 dominant groups. Thirty five percent of our organisms sampled were mayflies and 21 percent were caddisflies. The fecal coliform levels in Bainbridge were slightly high and considered to be fair. The range was 37 – 462 col/100 ml. and the average was 22 col/100ml. The results from our chemical analyses support our biological investigation. There were 17 sample dates at Bainbridge done during the summer months. The average pH was 7.57, this is with in the range of good water quality. The chloride levels were slightly high (45.2 mg/l) but within the good range. On 22 August 2005 the levels reached 120 mg/l. Afton levels were also high on the 23 August. Dissolved oxygen percent saturation average was 91.2, excellent range, along with phosphates (0.04 mg/l and nitrates (2.8 mg/l).

Site #3 Sidney

Water quality in Sidney is good to excellent, according to a rapid bioassessment performed on 30 June 2004. Using the biotic index test, the water quality appears excellent with a score of 90.5 but the other 2 parameters (EPT richness -6 and Percent model affinity-58) indicate the water quality is good. Sidney had a fair amount of diversity among the macroinvertebrate community. From our 100 organism sample, there were at least 10 different groups represented with caddisflies making up 27 percent with at least 3 different species. The chemical analysis supports the biological analysis. Many of the chemical tests fall within the good range for water quality. For the 18 sample dates the phosphate levels averaged 0.06 mg/l which is excellent but the nitrate levels at 3.36 mg/l and the chloride levels at 40.2 mg/l are both within the good range. Incidentally, the chloride levels were at their lowest during the period when both Bainbridge and Afton registered their highest chloride levels. This indicates that there was some type of discharge between Sidney and Afton prior to the sample date. Fecal coliform levels were higher than all the other sites. At an average of 344.5 col/100ml and a range of 121-568 col/100ml, this indicates fair water quality. Our sampling site in Sidney is upstream from our sewage treatment plant. There are several farms upstream of our sampling site that may be contributing. Our sampling site is located directly across the river from the location of the capitol project that diverted raw sewage into the municipal water treatment plant. It may be the case that several houses on Riverside in Sidney are still contributing waste through effluent pipes that remain improperly connected. Also, there are several large trailer parks just upstream from our sampling site that may be contributing fecal matter. Further investigation is necessary and will likely be carried out by the USWP. The pH of the water at Sidney was 7.4 and considered excellent in that regard. Turbidity is another that parameter that seems good with an average of 10 NTU's. The percent saturation of dissolved oxygen is also excellent with an average of 83.5.

Site #4 Wells Bridge

A rapid bioassessment was conducted at the Wells Bridge site on 29 June 2004. It was determined that the biotic index indicates excellent water quality with a score of 87. The EPT test and percent model affinity test both indicate good water quality with respective score being 6 and 51. Wells Bridge diversity was the greatest among our river sites. Thirteen different groups of macro invertebrates are present in the original 100 organism sample. There appears an even distribution among 5 major groups; mayfly, stonefly, caddisfly, riffle beetle, and scud all contained 13-19 organisms. Crayfish (8/100) were more abundant here than at any other site. The entire width of the river at this site is relatively shallow at a consistent depth averaging 82 cm.

A chemical analysis was performed on 13 different samples over 2 summers. The results indicate excellent dissolved oxygen with a percent saturation level at 92.5, good fecal coliform average at 152.6 with a range of 93-322, excellent pH at 7.5, excellent phosphate at 0.04. The nitrate levels were good at 3.97 mg/l. Turbidity in Wells Bridge is good as well. Average turbidity at the Wells Bridge site was 6.58 NTU.

Site #5 Oneonta

The Oneonta site had a biological assessment performed on 29 June 2004. Only the biotic index indicated excellent water quality with a rating of 93.8. Both the EPT test and the percent model affinity indicated that the Oneonta site is in good condition with 9 EPT species and only 54 percent affinity to a model stream. The dominant group of macroinvertebrates was the caddisflies. Of the original 100 organism sample, caddisflies represented 35 percent. Mayflies made up 24 percent and the stoneflies 16 percent. It did not appear that Oneonta harbored a great deal of diversity among macroinvertebrate groups with only 10. The site is immediately below an impoundment which may affect the species dispersal. The substrate at this site is very rocky and the average current speed is 145 cm/sec. This is triple the speed of most other sites.

For the chemical analysis, we sampled 13 times over 2 summers. The results verified the biological assessment and indicate that the water quality is good to excellent. The dissolved oxygen percent saturation at 92.5 is excellent. Fecal coliform levels ranged from 58-213 col/100ml with a good average of 152.6 col/100ml. Nitrates levels ranged from 0-6.6 mg/l with a good average of 3.97 mg/l. Phosphates seem to be excellent at 0.04 mg/l and the chloride levels remained steady with a range from 40 – 60 mg/l and a 45 mg/l average. Turbidity was good ranging from 6.9 – 11 NTU with an average of 6.6 mg/l. The pH of the river at Oneonta is consistent as well with a range of 7.2-7.7 an excellent average of 7.5.

Site #6 Portlandville
At Portlandville we only sampled three times during the summer of 2004. We have yet to perform a bio assessment. The chemical assessment indicated that the water is basic (7.9) with high nitrogen content. At 5.13 mg/l, this site represented the highest average level of nitrogen than any other site. The chloride levels of 53.3 mg/l average were in the fair range for water quality. The chemistry of Portlandville may require further investigation as we have only sampled three times.

Site #7 Cooperstown
A rapid bio assessment was conducted at our original Cooperstown site located on the high school grounds. We were unable to collect a 100 organism sample in a reasonable amount of time. The location had a very low flow with mostly sandy, silty substrate. The canopy at the original site was 80%. From our collection we did find 17 out of 41 were filtering caddisflies. Snails and dobsonfly were the 2nd and 3rd dominant species with 6/41 and 7/41 respectively. We did analyze the chemistry of our original location on 9 separate occasions. From those nine samples we found that turbidity, phosphates and percent saturation of dissolved oxygen were all in the excellent range. Turbidity average was 2.87 NTU, phosphates were at 0.048 mg/l and the percent saturation was 80.3. This is on the low end of the excellent range and the lowest reading of any of our sites. Further investigation is required as to why the Dissolved oxygen content average, at 7.2 mg/l is so low. Perhaps our site is located downstream of the water treatment plant, perhaps it is because of the proximity to the source of the river, Otsego Lake. The pH of the water ranged from 7.3-8.1 with an average of 7.7. The average alkalinity was 132mg/l. Fecal coliform average at our original Cooperstown site was 294.5 col/100ml from only 2 samples with a range of 102 – 487 col/100 ml. Chloride levels were slightly high at 49.4 mg/l with a range of 25 – 60 mg/l. This value is within the good range for water quality.

General State of the Upper Susquehanna River

By averaging the values from each of the parameters for each site we can see the general state of the Susquehanna from Cooperstown to Afton (Table 8). The averages of these parameters show that the water quality is generally good with some parameters being excellent. Dissolved oxygen was consistently excellent with an average of 8.05 mg/l and a percent saturation of 87.6. The levels of fecal coliform throughout the Upper Susquehanna were slightly high and considered to be fair. With an average # of col/100 ml sample at 276.06 there may be some cause for concern. This was only the parameter that is considered less than good. We hope to find possible sources of contamination. The pH of the water averaged 7.55 which is just above the excellent range. Average phosphate was excellent at 0.04 mg/l. This is a good indication that only minor adjustments may need to be made to meet the proposed legislation calling for the reduction in phosphate discharges. The nitrates, however, were high but still considered to be good at an average of 4.04 mg/l. During the summer of 2005 the average was excellent. Turbidity of the water was good as well with an average of 7.38 NTU. The total dissolved solids average was just out of the excellent range. The average of 109.4 mg/l is considered to be good. The biological parameters also show good to excellent water quality (Table 28). The biological index, with an average of 97.4 indicated excellent water quality from Oneonta to Afton. However, the EPT richness test, as well as the percent model affinity test, indicated good water quality. There was an average of 7 EPT species present at each site. As a whole stretch, the river has a 62 percent affinity to a model stream. When compared to the biological assessment performed by the NYS DEC stream bio-monitoring unit in 2003 which confirmed that the stretch of the river is slightly impacted to non-impacted, the USWP results seem to agree. We felt it was important to use the same techniques employed by professionals. In the event that we find a discrepancy between their published reports and our data, we would be able to attribute that discrepancy to something other than our collection methods.

By comparing the data generated by the USWP to similar studies performed downstream, one can gain a greater understanding of any spatial or chronological trends in water quality. The Pennsylvania Department of Conservation and Natural Resources has an effective river monitoring program underway called Watershed Education. This study involves school districts in the major river basins of Pennsylvania, the Susquehanna being one of those basins. We can detect minor changes in water quality when we look at their data and compare it to ours. We must be cautious to draw conclusions as the methods may not be the same. The collection period is from June 2003-Oct 2005 and involves 14 different high schools located along the banks of the Susquehanna as it winds through PA. (PDCNR 2006) The average conductivity of the tests by this group was 197.74 umhos/cm., USWP was 225 umhos/cm. The phosphate level increased downstream from .04 mg/l to .338 mg/l. However the nitrate average decreased substantially from 4.04 mg/l to .52 mg/l. The pH of the river decreased as well from 7.55 to 6.82. Coliform levels were unavailable from this group. Dissolved oxygen averages went up from 8.05 mg/l to 10.07 mg/l. It appears as though much of the testing was done during the school year where the temperatures would be lower rather than our data which was collected mostly in the summer where temperatures are highest and D.O. lowest. Alkalinity dropped dramatically from 113 mg/l to 29.6 mg/l.

Discussion of chemical analysis of tributary sites (A-I)

Site A - Kelsey Brook

We have performed a chemical analysis on 6 different samples from our Kelsey Brook site. It does not appear that Kelsey Brook is contributing any pollution into the Susquehanna River. Many of the tests indicated excellent water quality here, including dissolved oxygen, pH, phosphates, nitrates turbidity and total solids. Only the chloride was in the good range. With an average chloride level of 30.8 mg/l and a range of 20 – 40, the levels seem quite acceptable and did not appear to contribute to the high levels recorded for Site #1-Afton, during the summer of 2004. The dissolved oxygen content was consistent with an average of 9.6 mg/l and a percent saturation of 92.5. The pH level fluctuated quite drastically which may require further investigation to see if this is a trend and why that is so. The range for pH was 6.3 – 8.4 with an average of 7.2. Phosphate and nitrate levels were both consistent with averages of 0.03 mg/l and 2.7 mg/l respectively. Turbidity remained excellent in all 6 samples tested. The average was 1.5 NTU and the total dissolved solids averaged only 67.8 mg/l.

Site B - Unadilla River

We were able to analyze seven samples taken from our Unadilla site over 2 summers. The Unadilla River does not appear to be adding any detectable phosphate and nitrate pollution into the Susquehanna. We have yet to test for coliform at this site but we have tested further up stream near New Berlin, Mt. Upton and Rockdale. We performed a fecal coliform test at each of those sites and found very high levels that exceeded 2000 col/100 ml sample. We will investigate further during the summer of 2006 to see if this is a trend. We also still need to perform a rapid bio-assessment that is scheduled for that same summer. From the chemical data we have concluded the water quality in the Unadilla River at Sidney is excellent. Only the turbidity at 7.4 NTU, the chloride levels at 28.3 mg/l and the pH at 7.8 were in the good range, the rest of the chemical parameters were excellent. Dissolved oxygen was consistent at 9 mg/l and a percent saturation of 93. The phosphates and nitrates were both excellent with 0.028 mg/l and 2.6 mg/l averages respectively. Total dissolved solid was at 97.3 mg/l and conductivity averaged 243.
A tributary to the Unadilla River is Butternut Creek which enters the river at Mt. Upton, NY. A study was done on the Butternut by Stensland (2005) in 2004 through the SUCO's Biological field station. From his work, it appears that the Butternut is contributing very few nutrients to the Unadilla River. The nitrates and phosphates were both lower in the creek than in the river, as would be expected. The water is slightly more acidic in the Butternut than in the Unadilla river with an increase from 7.2 to 7.6.

Site C -Kerr's Creek

We collected and analyzed seven samples from our Kerr's creek site. The results indicate, again, excellent water quality. Kerr's creek does not appear to be contributing much pollution, if any at all, into the Susquehanna. The chloride levels as well as the pH of the creek were in the good range. pH was 7.7 and the chloride average was 33.5 mg/l. This is slightly high. Dissolved oxygen was at the low end of the excellent range for our sample dates with a percent saturation just at 80. Phosphate level was extremely low at 0.02 mg/l and nitrates were low as well with an average of 2.34 mg/l. The range of nitrate (0 – 6.6 mg/l) did however, exceed the excellent range. Total dissolved solids and turbidity were both excellent as well. The results of total solids test (35 – 87 mg/l)consistently stayed within the excellent range with an average of 60.6 mg/l. Turbidity was also consistently excellent with a range of 0.54 NTU – 2.81 NTU and an average of 1.26 NTU. Alkalinity was 65.7 mg/l and conductivity was 144.9 umho/cm.

Site D – Ouleout Creek

We were able to sample Ouleout creek on 9 separate occasions over the last 2 summers. The results indicate that the water quality is excellent except for slightly high chloride levels (27.2 mg/l), turbidity at 11 NTU and a slightly basic reading of pH at 7.62. Dissolved oxygen average was 8 mg/l with a percent saturation level consistent at 85.5. Phosphates and nitrate were low here as well. Phosphate average was 0.07 mg/l with a range of 0 - .54 mg/l. Nitrates average was 2.2 mg/l and a range of 0 – 6.6 mg/l. The Ouleout site is directly downstream from East Sidney Reservoir. There is very little development around the lake and little chance for nitrates and phosphates to accumulate. It expected that they will be consistently low. The alkalinity level was 69 mg/l and conductivity was 119.8 umho/cm.

Site E – Otego Creek
We were able to sample Otego creek on 7 separate occasions and most tests indicate excellent water quality. Chloride levels were slightly high with a range of 25 – 40 mg/l and an average of 32 mg/l. Turbidity also fell in the good range with an average of 12.4. There was one reading on 17 August 2004 when the turbidity reached 44.3 NTU. We have no available rainfall data for that day to make any correlation with. Dissolved oxygen was excellent at 8.6 mg/l and a percent saturation of 87.5. The pH was lower than most tributaries at 7.32. Both the phosphates and nitrates were excellent at 0.01 mg/l and 2.35 mg/l respectively. The nitrate levels did reach 6.6 mg/l on the same date that the turbidity level was high. This may indicate runoff which would contribute to non point source pollution from fertilizers and such. We will closely monitor the rainfall data hereafter so that we can accurately correlate such a relationship. The alkalinity average was 66.8 mg/l and the conductivity average was 179.4 umho/cm.

Site F – Charlotte Creek
We sampled Charlotte Creek on 7 separate occasions. The chemical analyses indicated that the water quality is excellent except that the pH is slightly high at 7.58 and, again, the chloride levels are slightly above the excellent range at 30.7 mg/l. The dissolved oxygen was consistent with an average of 8.3 mg/l and a percent saturation of 84. Both the phosphate and the nitrate levels were excellent with averages of 0.02 mg/l and 1.8 mg/l respectively. Turbidity and total solids were both excellent as well with averages of 3.4 NTU and 52.1 mg/l. The alkalinity of Charlotte creek is 60.6 mg/l and conductivity is 123.2 umho/cm.

Site G – Schenevus Creek
We sampled Schenevus creek on 6 separate occasions over 2 summers. The chemical analyses showed excellent water quality for all measured parameters except for the chloride levels which proved to be rather high. The average chloride level was 85.4 mg/l with a range of 40 mg/l – 353 mg/l. The sample with a chloride level of 353 mg/l appears to be an anomaly. The remaining sample dates had consistent chloride levels at 40 mg/l and one date had 45 mg/l. It may be that chlorides were discharged into the stream. If we record levels that high again we will certainly investigate further. The dissolved oxygen levels were excellent at 8.3 mg/l with a percent saturation of 83. The phosphate and nitrate levels were both excellent. Phosphate range was 0 - .12 mg/l with an average of .03 mg/l. The nitrate levels ranged from 0 – 6.6 mg/l with an average of 2.47 mg/l. The nitrogen levels were 6.6 mg/l on three separate occasions during the summer of 2004 and then they were 0 for the remaining sample dates during the summer of 2005. We will closely monitor this discrepancy in the future. Turbidity was consistently excellent at 3.8 NTU. The amount of total dissolved solids in the water was 87.4 mg/l. Alkalinity was 85 mg/l and the conductivity was 201 umho/cm. Fecal coliform was measured on 30 August 2005 and found to be 66 col/100ml which is good.

Site H – Cherry Valley Creek
We sampled Cherry Valley creek on 6 separate occasions over 2 summers. The chemical analyses showed excellent water quality for several parameters and good for others. The dissolved oxygen content of the water was excellent with an average of 8.3 mg/l and a percent saturation of 91. Phosphates and nitrates were also at excellent levels in the creek. For the phosphate the range did exceed the criteria for excellent water quality on one occasion. The range for phosphate was 0- .3 mg/l with an average .07 mg/l. On the day that the phosphate levels were highest, so too was the turbidity. This may indicate that runoff may have contributed the phosphates from some location upstream. Unfortunately we have no rainfall data for that day. We will closely monitor this in an attempt to establish a correlation. The average turbidity fell within the good range at 10.6 NTU but reached 22.7 NTU on 17 August 2004. Chloride levels, again, were slightly high. At 32.5 mg/l the level is within the good range, although the chloride levels were very consistent at this site with no obvious spikes in concentration. Total solids were excellent at 86.9 mg/l. The pH was slightly basic at 7.53 with a range of 7.2 – 8. The alkalinity was 104 mg/l and the conductivity was 200 umho/cm.

Site I – Oaks Creek
We obtained samples on six separate occasions from Oaks Creek. The chemical analyses showed that Oaks Creek has the poorest water quality of all the tributary sites. Of the parameters that we measured, only three of them had excellent ratings, the remaining averages were good. The phosphate levels have been consistently excellent in all of the sites, Oaks creek is no exception. With average level at 0.02 mg/l and a range of 0 – 0.06 mg/l, there seems little reason to be concerned with phosphate levels. There was a spike in the Nitrogen level in June 2005. The average nitrogen was 3.12 mg/l which is good and the range was 0 – 7.7 mg/l. Chloride was also good with an average of 31.6 mg/l and turbidity was excellent averaging 4.9 NTU. Total dissolved solids were good at 125 mg/l with a range of 49 – 160 mg/l. The alkalinity and conductivity levels averaged 130 mg/l and 559 umho/cm respectively.

Discussion of Zebra Mussel Studies

Zebra Mussels have made their way into the Susquehanna via Goodyear Lake. We have collected adult specimens from Goodyear Lake and have been able to verify that these adults are contributing veligers into the river below Goodyear Lake. We know of no other source for the veligers that is within our studied watershed area that is below Goodyear Lake. We have positively identified veligers all the way down to Afton. We see increasing frequency of positive veliger identification within our samples as we move closer to the known source. We found veligers in 100% of our samples from Oneonta and 74.1% of our samples from Wells Bridge contained veligers. In Sidney, we found that only 62.5% of our samples contained veligers and 25% from Bainbridge. Afton was found to contain veligers in only 28% of our samples. We have been on the lookout for adult colonies along the Susquehanna and have not yet found any. The conditions are suitable for their inevitable establishment (Gray 2005). We are likely to find them on the bridge abutments.

We will closely monitor our tributary sites for any veligers. We will pay particular attention to the Ouleout Creek. It is likely that East Sidney reservoir will have adults soon if not already. Perhaps there is another tributary that is contributing veligers into the river below Bainbridge that may account for why Afton had a higher frequency than did Bainbridge. During the summer of 2005, sites were not sampled as often because we had begun to look at the tributaries. We had difficulty in the tributaries as depth did not reach 12 inches in certain stretches. We collected samples anyway. It is also important to note that during the days when we made runs to collect samples, we always started in Afton and ended in Cooperstown in order to prevent the further spread of veligers downstream. The net was then sprayed with white vinegar to help dissolve the shells of any veligers that may have been retained within the net even after rinsing.

Discussion of Pedagogical Impact

From the 285 surveys that were tabulated from Sidney High School, the students that participated in the USWP scored 16 percent higher than those that did not participate. Sample size for non-participants was 183, for participants it was 102. The average score for participants was 34.7 out of 50 and for non-participants the average score was 29.2 out of 50. Although it appears that the USWP clearly has had a positive impact on students' attitudes toward science and the environment it should be noted that this evidence is anecdotal. The data may represent a true impact but there were other factors that may explain this difference between the groups. For instance, as the students enter their junior year they are all required to participate, but as seniors, participation is exclusively voluntary. Many of the participating seniors are doing so because there attitudes toward science and the environment are already positive. Likewise, those that do not choose to participate do so because of their possible dislike for science already. The sophomores and the freshmen groups consist both of classes where participation is mandatory and classes where participation is not presented as an option. The students are assigned to a class randomly. If we look at the sophomore class alone, participants averaged 35.9 (n=28) and non-participants averaged 30.8 (n=26). This difference represents a 14 percent increase in students' positive attitude toward science. Allowing the students to go to the river with a real purpose increases the likelihood that they will appreciate what the instructor is trying to teach. That appreciation carries over into the classroom and beyond. Students are likely to remember aspects of a particular field trip well into adulthood (Melber 2006). Overall, we feel that our data supports the idea that the USWP will enhance students' interests in science and help promote environmental awareness. There is a wide body of anecdotal evidence that does help to support this claim. From increasing numbers of applicants for summer internships, to students independently asking how they can get involved, to parents commenting how there student wouldn't stop talking at the dinner table about how awesome his/her experience was down by the river; it is very clear that the USWP has generated excitement toward learning science while protecting our environment. Traveling up and down the Susquehanna River to test the waters lends itself to discussing possible areas to investigate and connections to make with the biotic and abiotic factors of the environment. It is not the intent of the USWP, at this point, to provide the scientific community with new discoveries that will lead to a greater understanding of the Susquehanna River. Instead, we are hoping that by making science accessible now, then when the students are participating at the University level, they can then provide the scientific community with their own new discoveries. A study conducted by Gibson and Chase (2002) suggests that students engaged in an authentic exploration maintain a more positive attitude about science and a higher interest in science as a career. The number of questions posed and still unanswered means that this project could carry on indefinitely

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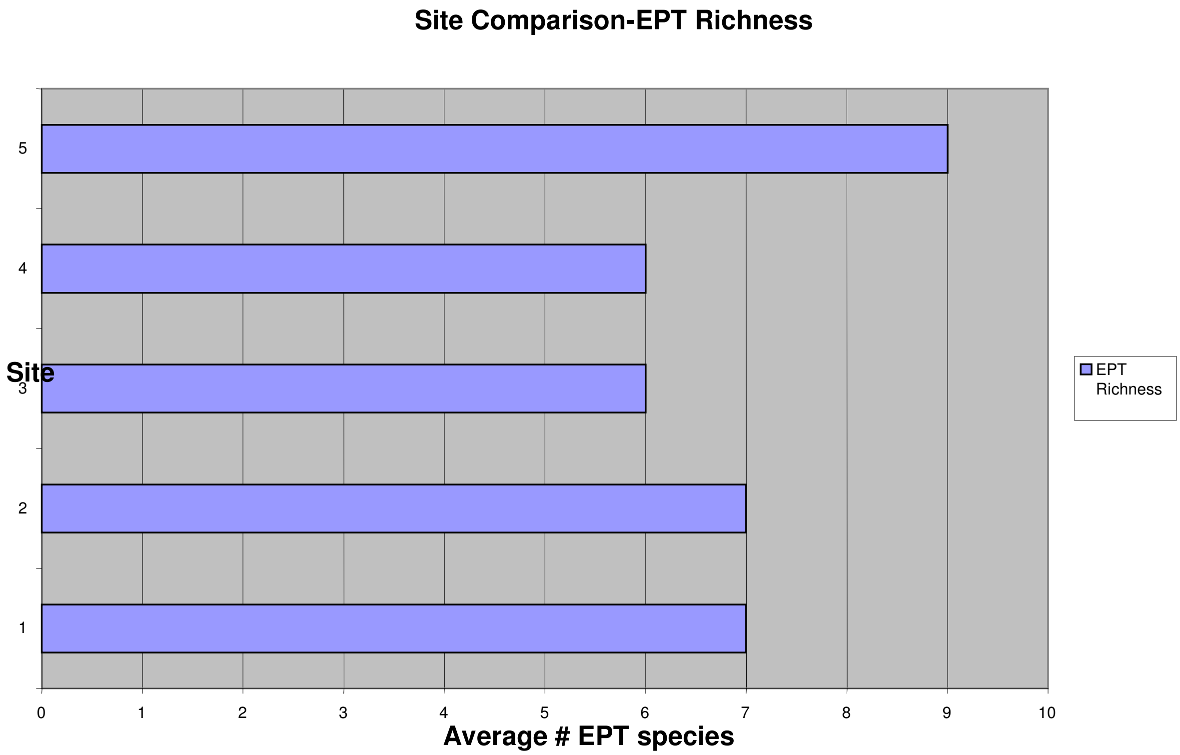
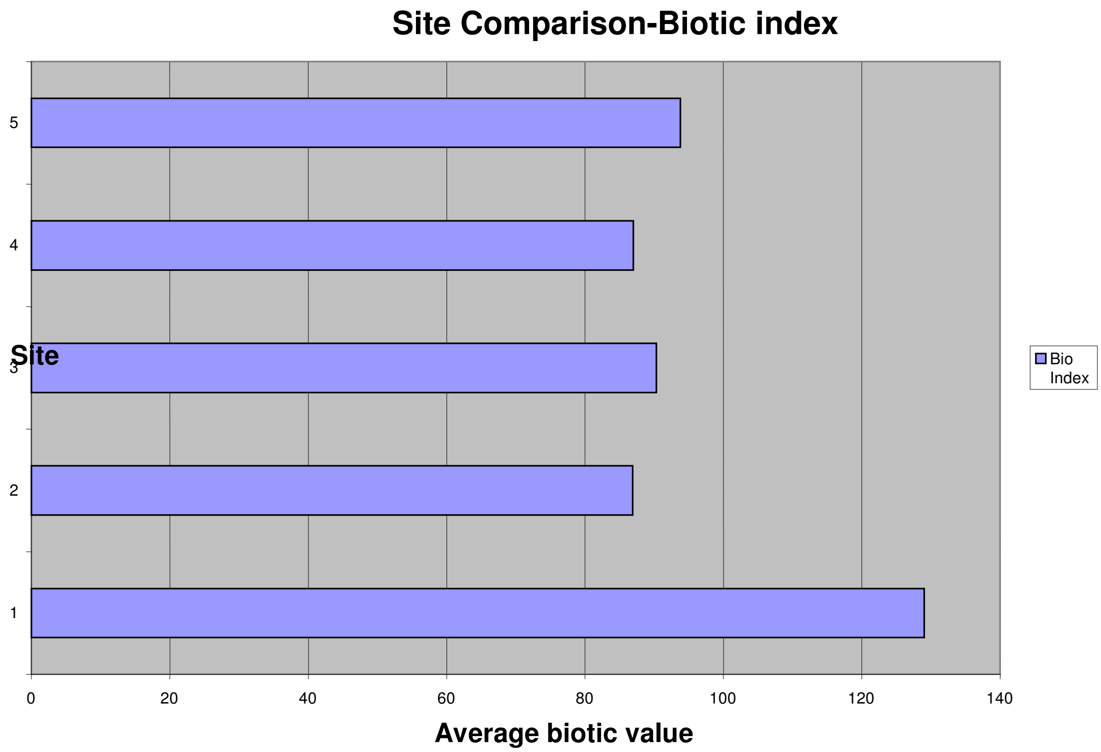
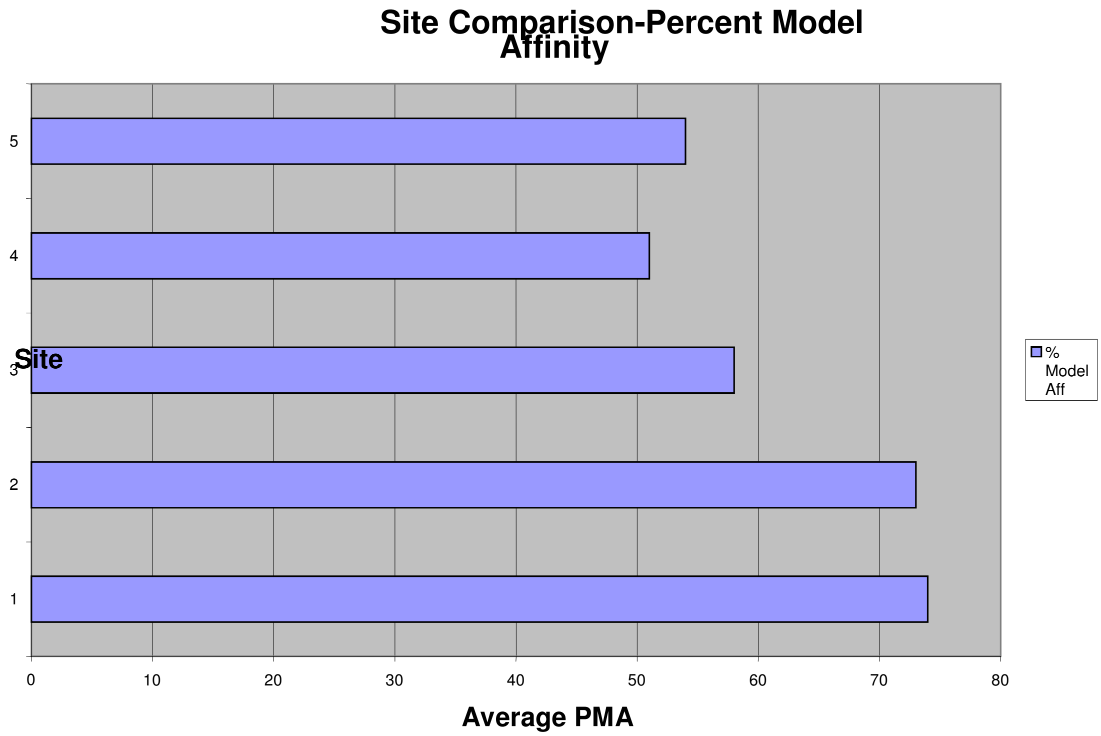
Appendices

Appendix I – graphical representations for site comparison of each of the chemical and biological parameters studied. Afton(1), Bainbridge(2),Sidney(3), Wells Bridge(4), Oneonta(5), Portlandville(6), Cooperstown(7)

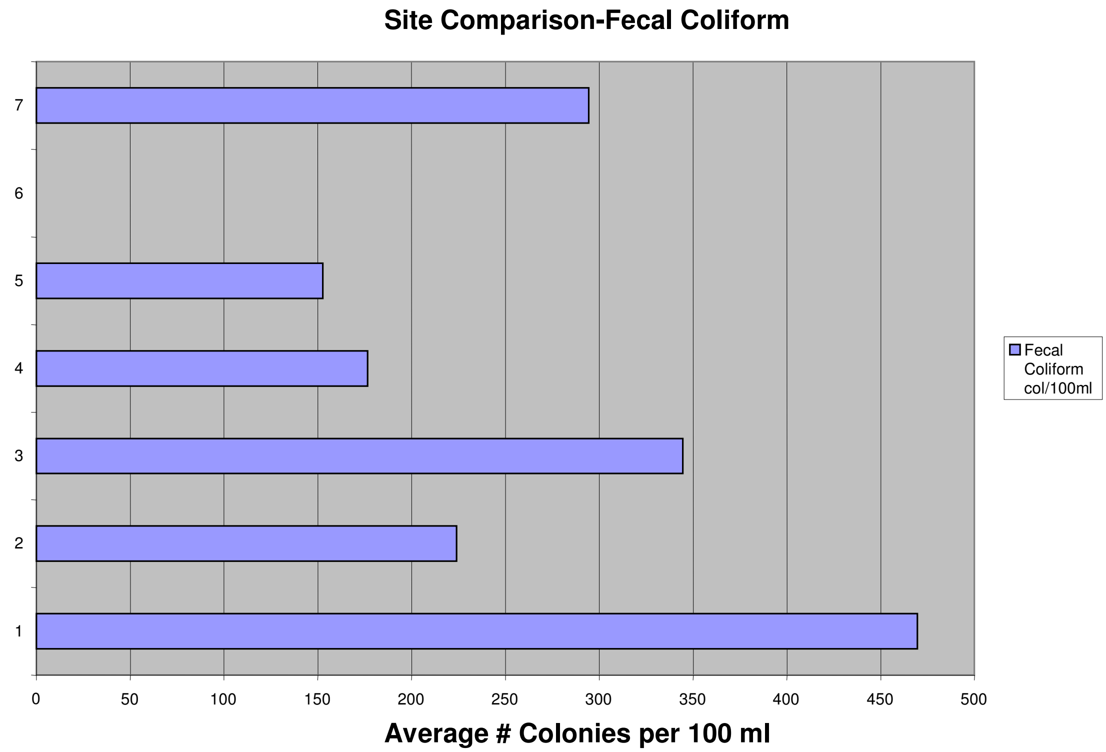


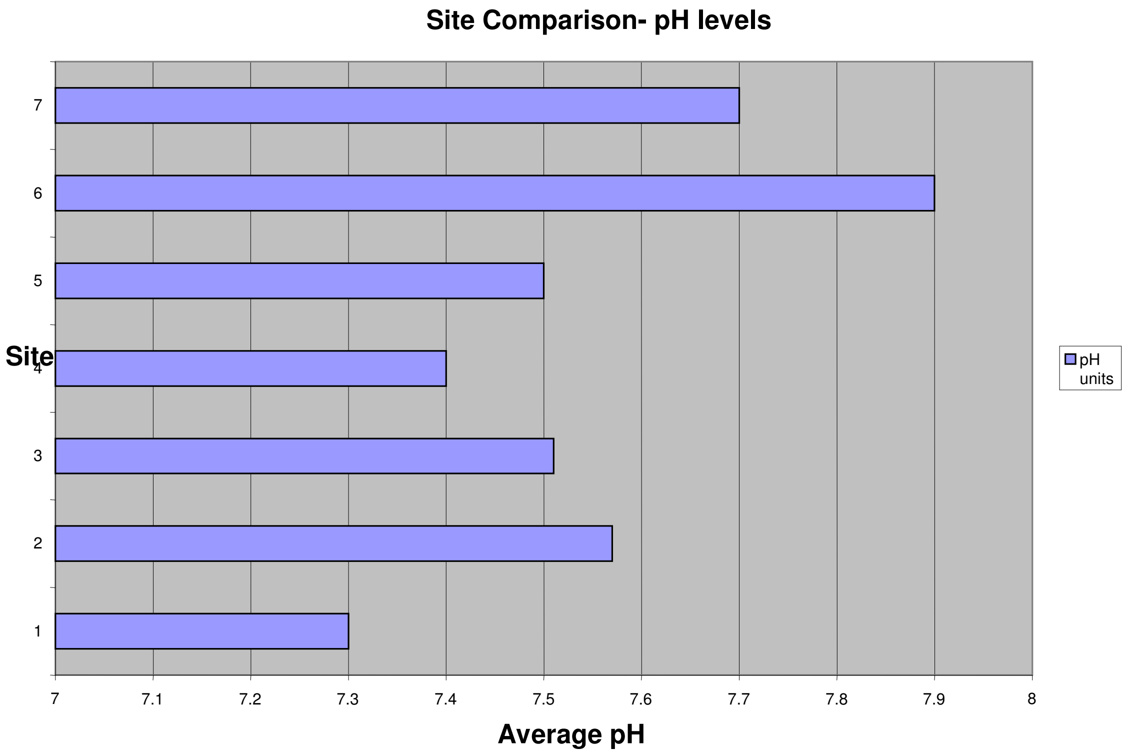


Average Biotic values for sites 1-7

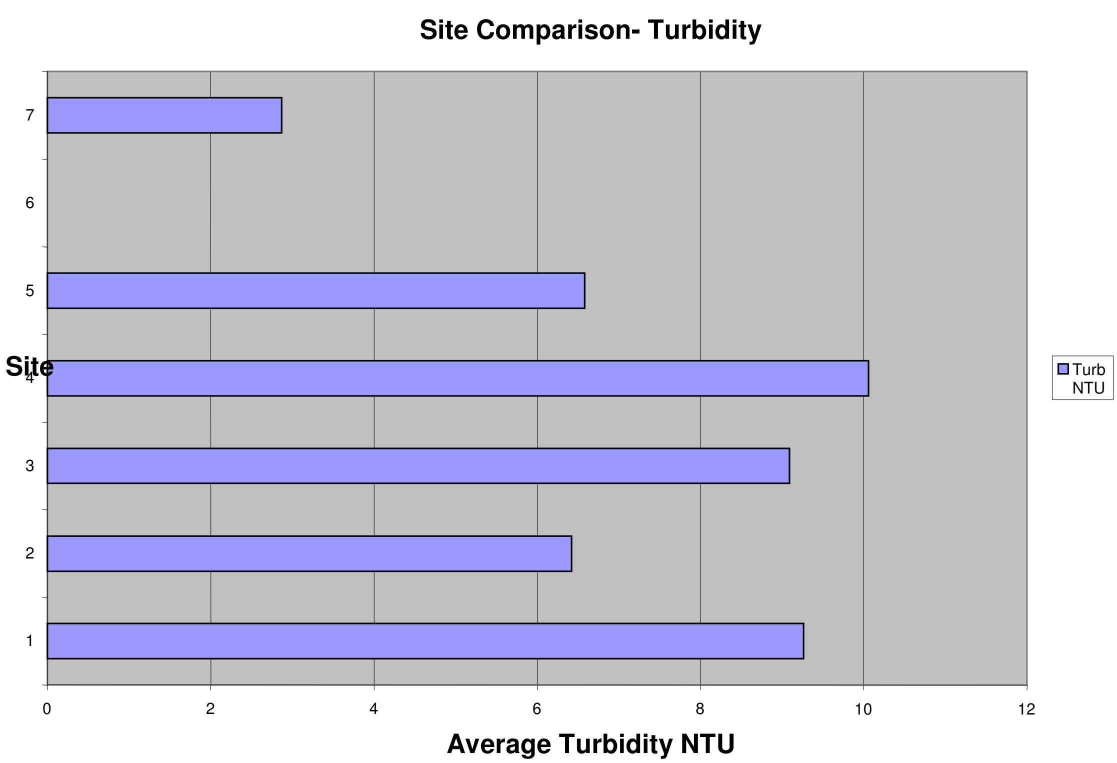


Percent Model Affinity

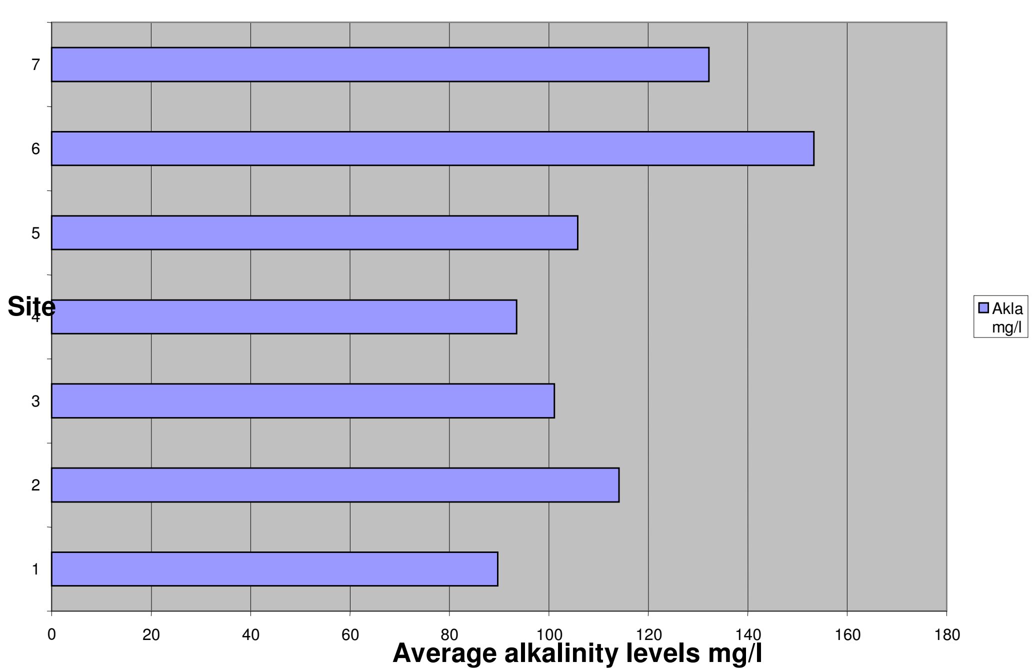

Site Comparison-Fecal Coliform
7
6
5
4
3
2
1
0
50
100
150
200
250
300
350
400
450
500
Average # Colonies per 100 ml
Fecal Coliform col/100ml

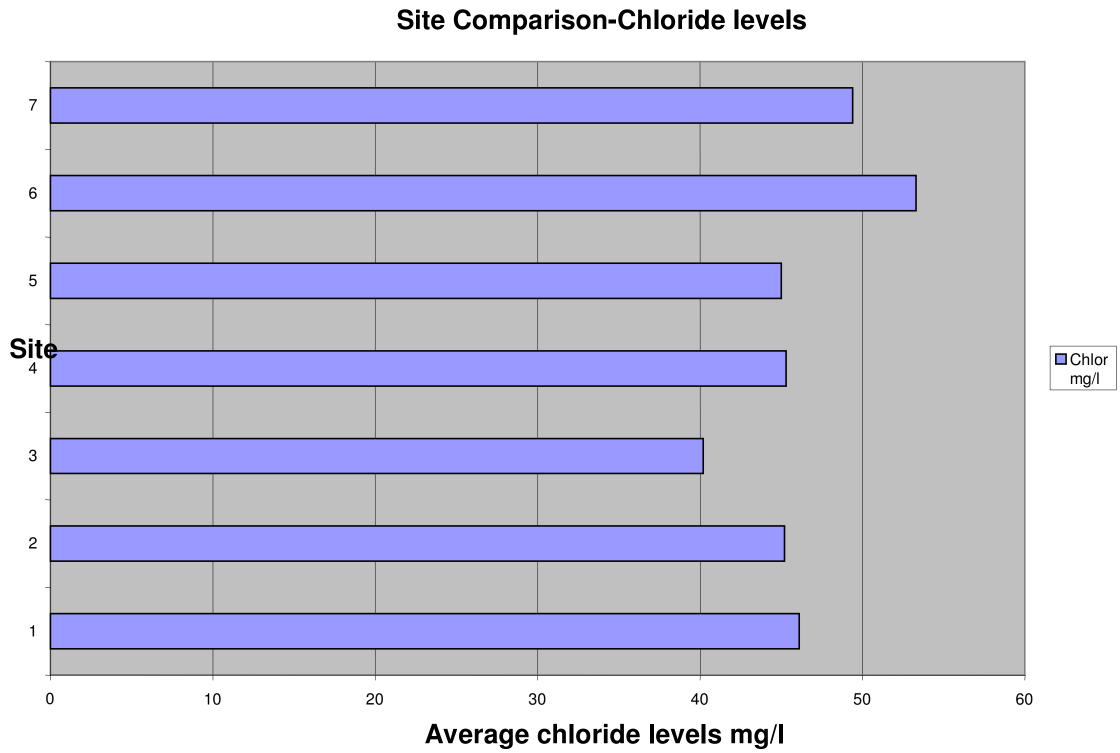

Site Comparison- pH levels
Site
7
6
5
4
3
2
1
7
7.1
7.2
7.3
7.4
7.5
7.6
7.7
7.8
7.9
8
Average pH
pH units

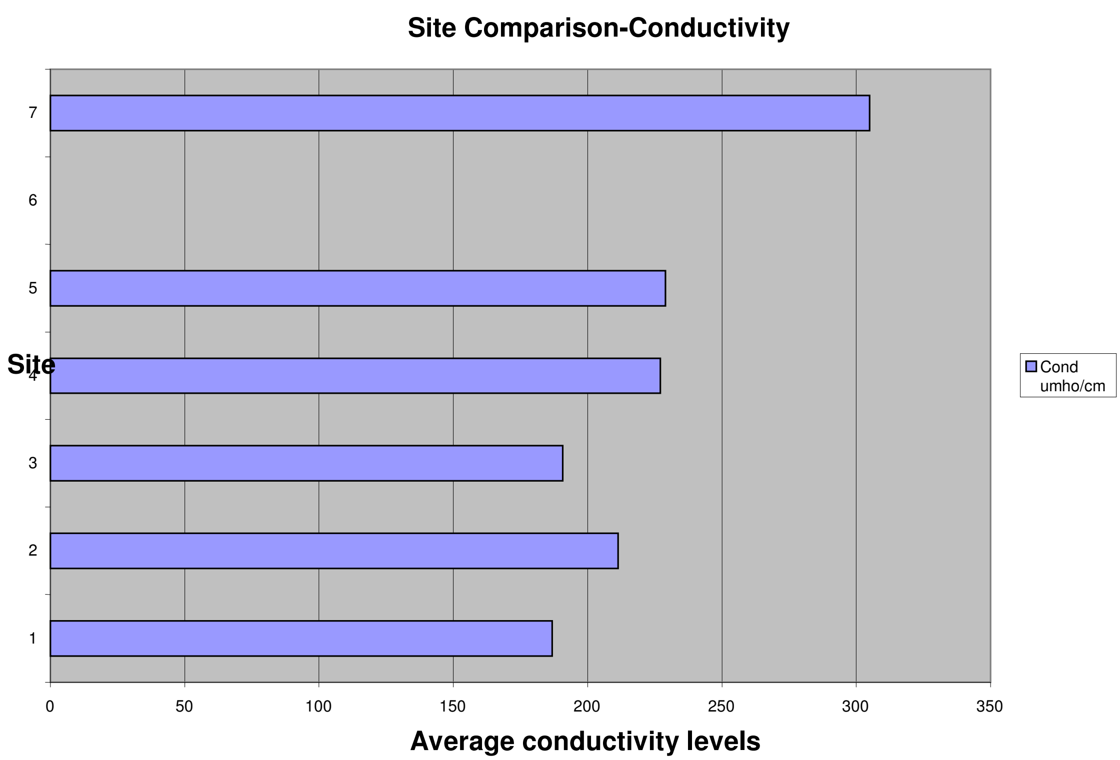
.

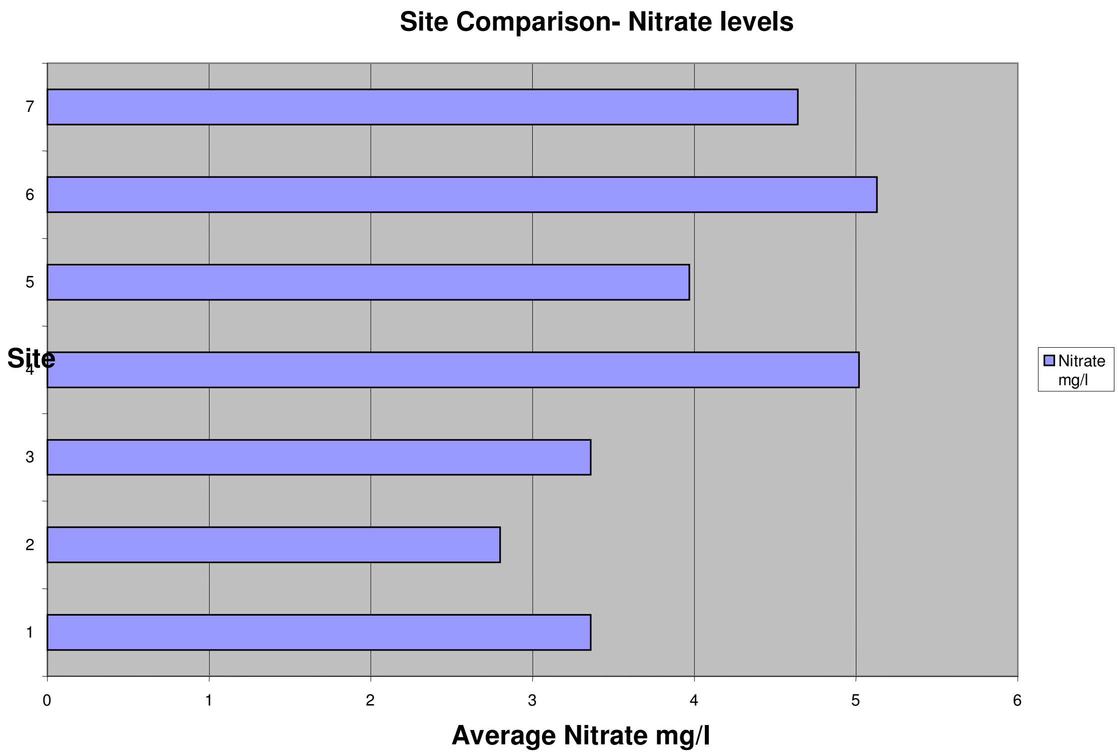

Site Comparison- Turbidity
Site
7
6
5
4
3
2
1
0
2
4
6
8
10
12
Average Turbidity NTU
Turb NTU

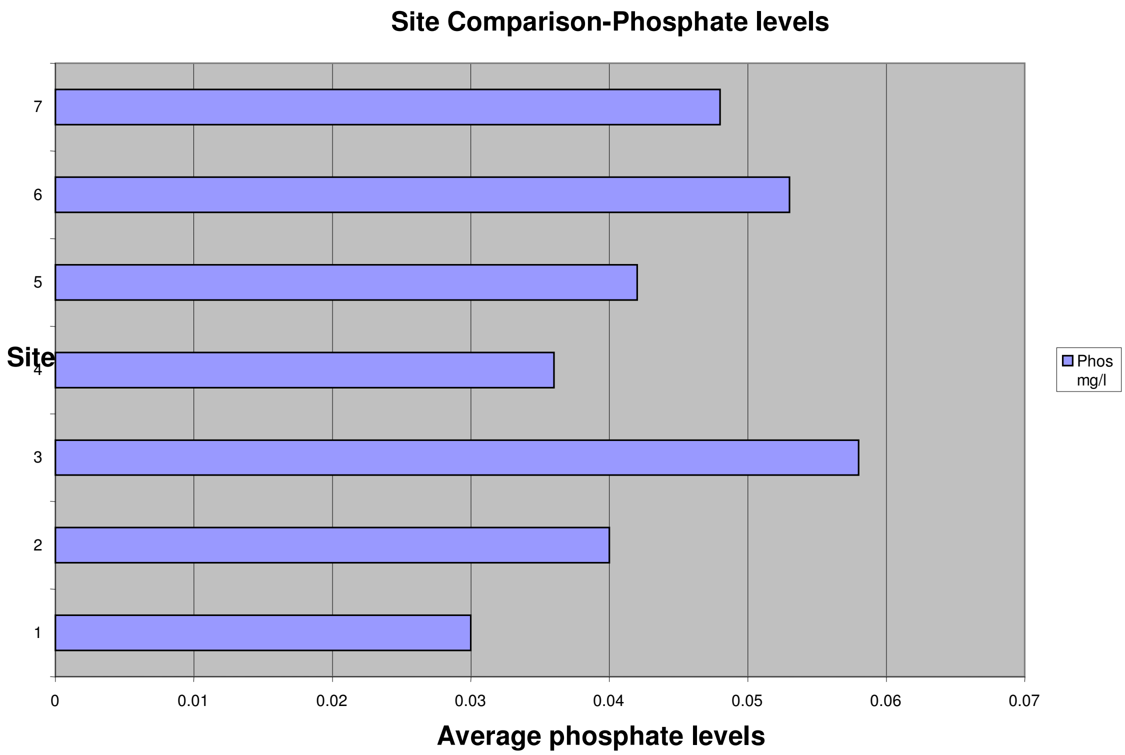
Site Comparison-Alkalinity

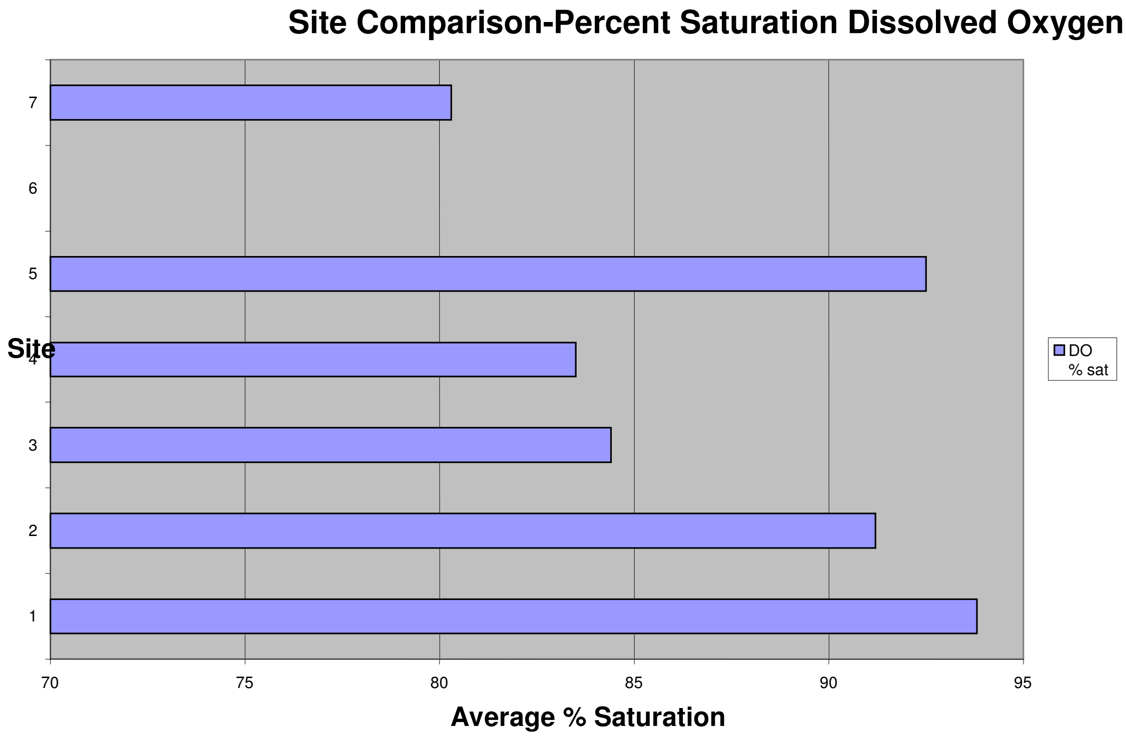



Site Comparison-Chloride levels
Site
7
6
5
4
3
2
1
0
10
20
30
40
50
60
Average chloride levels mg/l
Chlor mg/l


Site Comparison-Conductivity
Site
7
6
5
4
3
2
1
0
50
100
150
200
250
300
350
Average conductivity levels
Cond umho/cm


Site Comparison- Nitrate levels
7
6
5
4
3
2
1
Site
0
1
2
3
4
5
6
Average Nitrate mg/l
Nitrate mg/l


Site Comparison-Phosphate levels
Site
7
6
5
4
3
2
1
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
Average phosphate levels
Phos mg/l



Site Comparison-Percent Saturation Dissolved Oxygen
Site
7
6
5
4
3
2
1
70
75
80
85
90
95
Average % Saturation
DO % sat

Appendix II Data sheets from rapid bio-assessments performed at USWP river sites. Shows the number of each group of macrobenthic organisms from a 100 count sample.

Site #7 *Cooperstown (Data sheet only-* unable to sample 100 organisms)*

Location:	Cooperstown			**Data Sheet Rapid Bio-assessment**
Date : 28 July 2004	**Identified by:**	Todd Paternoster		
Organisms				**No. of Organisms in Sample**
Mayfly				5
Stonefly				
Caddisfly				17
Dobsonfly				7
Riffle Beetle				
Water Penny beetle larvae				
Beetle Larvae(not riffle or water penny)				3
Crane Fly larvae				
scud				
Clam				
Crayfish				2
Dragonfly				1
Damselfly				
Blackfly				
Midge				
Snail				6
Sowbug				
Leech				
Aquatic worm				
Totals				41

Site #5- Oneonta

						Data Sheet Rapid Bio-assessment		
	Location:	**Oneonta**				**Date:**	29-Jun-04	
	Identified by:	Todd Paternoster						
Organisms	:					**No. of individuals in sample**		
Mayfly						24		
Stonefly						16		
Caddisfly						35		
Dobsonfly						4		
Riffle Beetle								
Water Penny beetle larvae						7		
Beetle Larvae(not riffle or water penny)						3		
Crane Fly larvae								
Scud						2		
Clam								
Crayfish						4		
Dragonfly								
Damselfly								
Blackfly						3		
Midge								
Snail								
Sowbug								
Leech								
Aquatic worm						2		
Totals						100		

EPT Richness Worksheet

Location: Oneonta Site #5	**Date:** 29 June 2004
EPT Groups	**Number of Species in Sample**
Ephemeroptera- Mayflies	**3**
Plecoptera- Stoneflies	**3**
Caddisflies-Trichoptera	**3**
Total EPT	**9**

Percent Model Affinity Worksheet

Location: Oneonta Site #5					**Date:** 29 June 04
Groups	**No. Individuals in sample**		**No. individuals in Model Community**		**Absolute Difference**
Mayflies	**24**		**40**		**16**
Stoneflies	**16**		**5**		**11**
Caddisflies	**35**		**10**		**25**
Midges	**0**		**20**		**20**
Beetles	**3**		**10**		**7**
Worms	**2**		**5**		**3**
All others	**20**		**10**		**10**
Totals	**100**		**100**		**92**

Calculations: PMA= 100-[sum of absolute diff. x (.5)]

PMA = 54

Biotic Index

Location: **Oneonta** Site #5		**Date:** 29 June 2004	
Organisms	**No. of individuals**	**Biotic value**	**Total Biotic value**
Mayfly	**24**	**10**	**240**
Stonefly	**16**	**10**	**160**
Caddisfly	**35**	**10**	**350**
Dobsonfly	**4**	**10**	**40**
Riffle Beetle		**10**	
Water Penny larvae	**7**	**10**	**70**
Beetle Larvae (not above)	**3**	**8**	**24**
Crane fly larvae		**8**	
Scud	**2**	**6**	**12**
Clam		**6**	
Crayfish	**4**	**6**	**24**
Dragonfly		**6**	
Damselfly		**6**	
Blackfly	**3**	**6**	**18**
Midge		**5**	
Snail		**4**	
Sowbug		**2**	
Leech		**2**	
Aquatic Worm	**2**	**0**	**0**
Totals	**100**	**xxx**	**938**

Calculations: Total biotic values/10= biotic value for sample

Biotic value=93.8

Site #5

Biotic index =93.8 (Excellent)

EPT Richness=9(Good)

PMA = 54(Good)

Site #4- Wells Bridge

				Data Sheet Rapid Bio-assessment				
	Location:	Wells Bridge				**Date** 29 June 2004		
	Identified by:	Todd Paternoster						
Organisms						**No. of individuals in sample**		
Mayfly						13		
Stonefly						15		
Caddisfly						19		
Dobsonfly								
Riffle Beetle						14		
Water Penny beetle larvae						9		
Beetle Larvae(not riffle or water penny)								
Crane Fly larvae								
Scud						13		
Clam						2		
Crayfish						8		
Dragonfly						3		
Damselfly								
Blackfly								
Midge						2		
Snail						1		
Sowbug								
Leech								
Aquatic worm						1		
Totals						100		

EPT Richness

Location: Wells Bridge #4	**Date:** 29 June 2004
EPT Groups	**Number of Species in Sample**
Ephemeroptera- Mayflies	**2**
Plecoptera- Stoneflies	**2**
Caddisflies-Trichoptera	**2**
Total EPT	**6**

Percent Model Affinity

Location: Wells Bridge Site #4					**Date:** 29 June 04
Groups	**No. Individuals in sample**		**No. individuals in Model Community**		**Absolute Difference**
Mayflies	**13**		**40**		**27**
Stoneflies	**15**		**5**		**10**
Caddisflies	**19**		**10**		**9**
Midges	**2**		**20**		**18**
Beetles	**23**		**10**		**13**
Worms	**1**		**5**		**4**
All others	**27**		**10**		**17**
Totals	**100**		**100**		**98**

Calculations: PMA = 100- [sum of absolute diff. x (.5)]

Site #4 PMA = 51

Biotic Index Worksheet

Location: Wells Bridge Site #4		**Date:** 29 June 2004	
Organisms	**No. of individuals**	**Biotic value**	**Total Biotic value**
Mayfly	**13**	**10**	**130**
Stonefly	**15**	**10**	**150**
Caddisfly	**19**	**10**	**190**
Dobsonfly		**10**	
Riffle Beetle	**14**	**10**	**140**
Water Penny larvae	**9**	**10**	**90**
Beetle Larvae (not above)		**8**	
Crane fly larvae **Larvae**		**8**	
Scud	**13**	**6**	**78**
Clam	**2**	**6**	**12**
Crayfish	**8**	**6**	**48**
Dragonfly	**3**	**6**	**18**
Damselfly		**6**	
Blackfly		**6**	
Midge	**2**	**5**	**10**
Snail	**1**	**4**	**4**
Sowbug		**2**	
Leech		**2**	
Aquatic Worm	**1**	**0**	**0**
Totals	**100**	**xxx**	**870**

Calculations: Biotic value = total biotic values/10

Site #4 Biotic value = 87

Site #4

Biotic Value = 87(Excellent)

EPT Richness= 6(Good)

PMA= 51(Good)

Site #3- Sidney

Location:	Sidney Site #3			**Data Sheet Rapid Bio-assessment**	
Identified by:	Todd Paternoster			**Date:** 30 June 2004	
Organisms			**No. Organisms in sample**		
Mayfly			16		
Stonefly			11		
Caddisfly			27		
Dobsonfly			3		
Riffle Beetle			7		
Water Penny beetle larvae			18		
Beetle Larvae(not riffle or water penny)					
Crane Fly larvae					
Scud					
Clam					
Crayfish			5		
Drogonfly			5		
Damselfly					
Blackfly					
Midge			5		
Snail					
Sowbug					
Leech					
Aquatic worm			3		
Totals			100		

EPT Richness

Location: Sidney Site #3	**Date:** 30 June 2004
EPT Groups	**Number of Species in Sample**
Ephemeroptera- Mayflies	**2**
Plecoptera- Stoneflies	**1**
Caddisflies-Trichoptera	**3**
Total EPT	**6**

Percent Model Affinity

Location: Sidney Site #3					Date: 30 June 04
Groups	**No. Individuals in sample**		**No. individuals in Model Community**		**Absolute Difference**
Mayflies	**16**		**40**		**26**
Stoneflies	**11**		**5**		**6**
Caddisflies	**27**		**10**		**17**
Midges	**5**		**20**		**15**
Beetles	**18**		**10**		**8**
Worms	**3**		**5**		**2**
All others	**20**		**10**		**10**
Totals	**100**		**100**		**84**

Calculations: PMA = 100 – [sum of absolute diff. x (.5)]

Site #3 PMA = 58

Biotic Index Worksheet

Location: Sidney Site #3			**Date:** 30 June 2004	
Organisms		**No. of individuals**	**Biotic value**	**Total Biotic value**
Mayfly		**16**	**10**	**160**
Stonefly		**11**	**10**	**110**
Caddisfly		**27**	**10**	**270**
Dobsonfly		**3**	**10**	**30**
Riffle Beetle		**7**	**10**	**70**
Water Penney larvae		**18**	**10**	**180**
Beetle Larvae (not above)			**8**	
Crane fly larvae	**Larvae**		**8**	
Scud			**6**	
Clam			**6**	
Crayfish		**5**	**6**	**30**
Dragonfly		**5**	**6**	**30**
Damselfly			**6**	
Blackfly			**6**	
Midge		**5**	**5**	**25**
Snail			**4**	
Sowbug			**2**	
Leech			**2**	
Aquatic Worm		**3**	**0**	**0**
Totals		**100**	**xxx**	**905**

Calculations: Biotic value = total biotic values/10

Site #3 Biotic value = 90.5

Site # 3

Biotic Index=90.3 (Excellent)

EPT Richness= 6 (Good)

PMA= 58 (Good)

Site #2-Bainbridge

	Rapid Bio-assessment Data Sheet
Location: Bainbridge	
Date: 30 June 2004	
Identified by: Todd Paternoster	
Organisms	**No. Organisms in sample**
Mayfly	35
Stonefly	4
Caddisfly	21
Dobsonfly	6
Riffle Beetle	
Water Penny beetle larvae	14
Beetle Larvae(not riffle or water penny)	11
Crane Fly larvae	
Scud	4
Clam	
Crayfish	
Droganfly	
Damselfly	
Blackfly	
Midge	3
Snail	
Sowbug	
Leech	1
Aquatic worm	1
Totals	**100**

EPT Richness

Location: Bainbridge #2	**Date:** 30 June 2004
EPT Groups	**Number of Species in Sample**
Ephemeroptera- Mayflies	3
Plecoptera- Stoneflies	2
Caddisflies-Trichoptera	2
Total EPT	7

Percent Model Affinity

Location: Bainbridge Site #2					**Date:** 30 June 04
Groups	**No. Individuals in sample**		**No. individuals in Model Community**		**Absolute Difference**
Mayflies	35		**40**		5
Stoneflies	4		**5**		1
Caddisflies	21		**10**		11
Midges	3		**20**		17
Beetles	25		**10**		15
Worms	1		**5**		4
All others	11		**10**		1
Totals	**100**		**100**		54

Calculations: PMA = 100 – [sum of absolute diff. x (.5)]

Site #2 PMA = 73

Biotic Index Worksheet

Location: Bainbridge Site #2		**Date:** 30 June 2004	
Organisms	**No. of individuals**	**Biotic value**	**Total Biotic value**
Mayfly	35	**10**	350
Stonefly	4	**10**	40
Caddisfly	21	**10**	210
Dobsonfly		**10**	
Riffle Beetle		**10**	
Water Penney larvae	14	**10**	140
Beetle Larvae (not above)	11	**8**	88
Crane fly larvae		**8**	
Scud	4	**6**	24
Clam		**6**	
Crayfish		**6**	
Dragonfly		**6**	
Damselfly		**6**	
Blackfly		**6**	
Midge	3	**5**	15
Snail		**4**	
Sowbug		**2**	
Leech	1	**2**	2
Aquatic Worm	1	**0**	0
Totals	**100**	**xxx**	869

Calculations: Biotic Index = Total Biotic values/10

Site #2 Biotic Index = 86.9

Site #2

Biotic Index = 86.9 (Excellent)

EPT Richness = 7 (Good)

PMA = 73 (Excellent)

Site #1 – Afton

				Data Sheet Rapid Bio-assessment				
	Location:	Afton				**Date:** 1 July 2004		
	Identified by:	Todd Paternoster						
Organisms	**:**					**No. of individuals in sample**		
Mayfly						39		
Stonefly						12		
Caddisfly						7		
Dobsonfly						2		
Riffle Beetle								
Water Penny beetle larvae						17		
Beetle Larvae(not riffle or water penny)								
Crane Fly larvae								
Scud						16		
Clam								
Crayfish						4		
Dragonfly								
Damselfly								
Blackfly								
Midge						2		
Snail								
Sowbug								
Leech								
Aquatic worm						1		
Totals						100		

Percent Model Affinity

Location: Afton					Date: 1 July 2004
Groups	**No. Individuals in sample**		**No. individuals in Model Community**		**Absolute Difference**
Mayflies	**39**		**40**		**1**
Stoneflies	**12**		**5**		**7**
Caddisflies	**7**		**10**		**3**
Midges	**2**		**20**		**18**
Beetles	**17**		**10**		**7**
Worms	**1**		**5**		**4**
All others	**22**		**10**		**12**
Totals	**100**		**100**		**52**

Calculations: PMA = 100 – [sum of absolute diff. (.5)]
Site #1 PMA = 74

EPT Richness

Location: Afton	Date: 1 July 2004
EPT Groups	**Number of Species in Sample**
Ephemeroptera- Mayflies	3
Plecoptera- Stoneflies	2
Caddisflies-Trichoptera	2
Total EPT	7

Biotic Index Worksheet

Location: Afton			Date: 1 July 2004	
Organisms		No. of individuals	Biotic value	Total Biotic value
Mayfly		39	10	390
Stonefly		12	10	120
Caddisfly		7	10	70
Dobsonfly		2	10	20
Riffle Beetle			10	
Water Penney larvae		17	10	170
Beetle Larvae (not above)			8	
Crane fly larvae	Larvae		8	
Scud		16	6	96
Clam			6	
Crayfish		4	6	24
Dragonfly			6	
Damselfly			6	
Blackfly			6	
Midge		2	5	10
Snail			4	
Sowbug			2	
Leech			2	
Aquatic Worm		1	0	0
Totals		100	xxx	1290

Calculations: Biotic value = total biotic values/10

Site #1 Biotic value = 129.0

Site #1

Biotic Index = 129.0 (Excellent)

EPT Richness = 7(Good)

PMA = 74 (Excellent)

Appendix III- Chemical data from each site studied. River sites and tributary sites

Site 1 - Afton

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/30/04		8		7.4	0.04	6.6	40			60							
7/1/04		10		6.9	0.06	4.4	60			160					129	7	74
7/8/04	85	8		7.5	0.06	4.4	40			100			25	20			
7/14/04	80	7	127	7.1	0.06	4.4	40			120			21	19			
7/19/04	110	10		7.5	0.04	6.6	40			80			21	19			
7/23/04				7.3	0.04	4.4	60		58	60							
7/27/04				7.8	0.05	4.4	20		44	60							
7/29/04				7.0	0.04	4.4	40			80							
8/2/04	94	9		7.5	0.06	4.4	40	47.6		80			22	18			
8/10/04	94	9		7.6	0.02	4.4	50	3.36		140			20	18			
7/5/05		9	82	7.3	0.06	8.8	40	7.29	77	100							
7/8/05				7.3	0	0	40		99	100	208						
7/19/05				7.0	0	0	25	2.14	56	60	118.1						
8/18/05				7.3	0	0	30	3.83	87	120	184.5						
8/23/05	88	8	1200	7.3	0	0	100	3.49	132	25	276		19.3	21			
8/25/05				6.3	0	0	100	3.35	72	80	147.8						
8/27/05	106	10		7.4	0	0	20	3.02	77	100	187		13.3	18			
Average	**93.8**	**8.8**	**469.6**	**7.3**	**0.03**	**3.36**	**46.1**	**9.26**	**78**	**90**	**186.9**		**20.2**	**19**	**129**	**7**	**74**

Site 2 - Bainbridge

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/30/04		6		7.8	0.14	4.4	60			140					86.9	7	73
7/1/04		10		7.6	0.06	4.4	40			140							
7/8/04	91	8		7.5	0.06	4.4	40			120			22	22			
7/14/04	77	7	37	7.9	0.08	6.6	40			120			21	20			
7/19/04	100	9		7.3	0.06	4.4	60			120			21	19			
7/23/04				7.6	0.1	4.4	60		90	120							
7/27/04				7.7	0.1	4.4	40		113	100							
7/29/04				7.1	0.02	4.4	40			90							
8/2/04	91	9	462	7.45	0.02	4.4	40	29		110			19	19			
8/10/04	88	8		7.75	0.04	5.5	50	5		120			20	18			
8/20/04		9		7.8	0.02	6.6	40	5.1	95	100							
7/5/05				7.4	0	0	35	2.9	98	120	213						
7/8/05				7.25	0	0	30	3.5	71	120	149.8						
7/20/05				7.5	0	0	20	3.7	99	120	207						
8/18/05	101	9	173	7.8	0	0	35	3.6		120				21.6			
8/22/05				7.8	0	0	120	2.3	111	80	238						
8/25/05		9		7.5	0	0	20	2.8	123	100	249						
Average	**91.2**	**8.4**	**224**	**7.57**	**0.04**	**2.8**	**45.2**	**6.4**	**100**	**114**	**211.4**		**20.7**	**19.9**	**86.9**	**7**	**73**

Site 3 - Sidney

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/30/04		7		7.8	0.08	6.6	40			80		1.09			90.3	6	58
7/1/04		8		7.8	0.07	6.6	40			140							
7/8/04	64	6		7.5	0.02	4.4	60			120			25	21			
7/14/04	79	7		7.2	0.06	8.8	40			120			22	21			
7/19/04	80	7	568	7.4	0.06	4.4	60			80			21	19			
7/23/14		NA		7.6	0.28	4.4	60		94	100							
7/27/04		NA		7.6	0.07	4.4	40		75	120							
7/29/04		NA		7.1	0.04	4.4	40			70							
8/2/04	99	9		7.4	0.04	4.4	40	24		90			22	20			
8/10/04	84	8		7.75	0.06	5.5	50	3.6		120			24	18			
8/20/04		10		8	0.02	6.6	60	5.5	113	100							
9/20/04		NA		7		0	15						14.9	15.3			
9/29/04		NA		7.5	0.1	0	25			70			20	19			
11/16/04		NA		8	0	0	30			70			9.7	4.3			
7/5/05				7.5	0.1	0	40	6.3	93	80	186.5						
7/8/05			121	7.1	0	0	20	13	58	120	120.7						
8/18/05	101	9		7.75	0	0	40	7.9	131	140	274		19	21.9			
8/25/05				7.3	0	0	25	3.5	86	100	182.2						
Average	**84.4**	**7.8**	**344.5**	**7.51**	**0.06**	**3.36**	**40.2**	**9.1**	**92.8**	**101**	**190.8**		**19.7**	**17.7**	**90.3**	**6**	**58**

Site 4 – Wells Bridge

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/29/04				7.5	0.06	6.6	60			80					87	6	51
7/1/04		7		7.5	0.02	4.4	60			120							
7/8/04	67	6		7.5	0.02	4.4	40			140			25	21			
7/14/04	77	7	93	7.2	0.1	6.6	60			100			23	20			
7/19/04	97	9		7.2	0.06	4.4	40			60			22	20			
7/23/04				7.5	0.04	4.4	60			80							
7/27/04				7.4	0.06	4.4	60		89	80							
7/29/04				7.1	0.02	4.4	50		104	80							
8/2/04	86	8	115	7.4	0.02	4.4	40	21		100			21	20			
8/10/04	85.5	8		7.9	0.03	6.6	50	2.4		110			24	19			
8/20/04		9		7.7	0.04	4.4	40	5.9	86	80							
7/8/05				7.3		0	20	27		80							
7/20/05			322	7.25	0	0	30	2.3	100	120	211						
8/25/05	89	8		7.2	0	0	25	2.1	119	80	243		18	20.8			
Average	**83.5**	**7.8**	**176.6**	**7.4**	**0.04**	**5.02**	**45.3**	**10**	**99.6**	**94**	**227**		**22.1**	**20.1**	**87**	**6**	**51**

Site 5 - Oneonta

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/29/04				7.7	0.06	4.4	40			140					93.8	9	54
7/1/04		8	58	7.7	0.04	6.6	60			100							
7/8/04	90	8		7.5	0.04	4.4	40			120			27	22			
7/14/04	85	8		7.6	0.08	6.6	60			100			23	19			
7/19/04	87	8	213	7.5	0.06	4.4	40			100			23	20			
7/23/04				7.5	0.06	4.4	60		107	80							
7/27/04				7.5	0.1	4.4	40		108	140							
7/29/04				7.2	0.02	4.4	40	6.9		90							
8/2/04	87	8		7.45	0.02	4.4	50	11		100			23	20			
8/10/04	96	9		7.75	0.06	3.3	50	9.9		120			22	19			
8/20/04		9		7.5	0.02	4.4	40	7.6	110	100							
8/18/05	110	10		7.2	0	0	35	1.7	128		226		21	20.3			
8/25/05		8	187	7.5	0	0	30	2.1	107	80	232						
Average	**92.5**	**8.4**	**152.6**	**7.5**	**0.04**	**3.97**	**45**	**6.6**	**112**	**106**	**229**		**23.1**	**20.05**	**93.8**	**9**	**54**

Site 6 - Portlandville

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/28/04				8	0.06	4.4	60			160							
6/29/04				8	0.04	6.6	60			140							
7/27/04				7.7	0.06	4.4	40		143	160							
Average				**7.9**	**0.05**	**5.13**	**53.3**		**143**	**153**							

Site 7 - Cooperstown

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
6/28/04				7.7	0.1	6.6	60			160							
6/29/04			102	7.7	0.08	6.6	60			140							
7/8/04	56	5		7.5	0.04	4.4	40			140			23	21			
7/14/04	77	7		7.3	0.06	6.6	40			100			22	20			
7/19/04	89.5	8		8	0.04	4.4	60			120			23	21			
7/27/04				7.6	0.06	4.4	40		137	80							
8/2/04	103	9		7.7	0.02	4.4	60	4.3		150			26	22			
8/10/04	76	7		8.1	0.03	4.4	60	2.7		160			23	21			
8/9/05			487	7.8	0	0	25	1.6	145	140	305						
Averag e	**80.3**	**7.2**	**294.5**	**7.7**	**0.05**	**4.64**	**49.4**	**2.9**	**141**	**132**	**305**		**23.4**	**21**			

Kelsey Brook Date	D O % sat	DO mg/l	Fecal Coliform col/100ml	pH units	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
8/13/04		10		7.6	0.06	6.6	20		38	40							
8/17/04	98	10		7.4	0.01	4.4	40	1.8		60				15			
8/25/04	87	9		8.4	0.06	4.4	40	1.3	80	80				15			
7/8/05				7	0	0	20	2.4	48	80	102.1						
8/10/05				6.5	0	0	35	0.5	87	120	182.9						
8/29/05				6.3		1	30		86	100	182						
Average	**92.5**	**9.6**		**7.2**	**0.03**	**2.7**	**30.8**	**1.5**	**67.8**	**80**	**155**						

USWP Water Chemical Analysis Date Comparison

Site B – Unadilla River, Sidney

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp °C	Water Temp °C	Bio Index	EPT Richness	% Model Aff
8/13/04		9		8		0.02	4.4	20		103	110							
8/17/04	93	9		8.1		0.14	4.4	40	9.15		120				17			
8/25/04	93	9		8.1		0.02	6.6	40	10.8	130	160				17			
7/8/05				7.3		0	0.6	15	7.47	72	100	150.6						
7/25/05				7.5		0	0	20		124		263		22.3				
8/10/05				7.9		0.02	0	35	2.27	143	180	300						
8/29/05				7.8		0	2			12.3	120	259						
Average	**93**	**9**		**7.8**		**0.03**	**2.6**	**28.3**	**7.4**	**97.3**	**132**	**243**						

USWP Water Chemical Analysis Date Comparison

Site C – Kerr's Creek

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp °C	Water Temp °C	Bio Index	EPT Richness	% Model Aff
8/13/04		7		7.8		0.02	6.6	20		35	60							
8/17/04	70	7		7.7		0.04	4.4	60	0.92		60				15			
8/25/04	90	9		8		0.04	4.4	40	0.84	57	60				16			
7/8/05				7.5		0	1	25	2.81	57	80	119.1						
7/13/05				7.5		0	0	30	0.54	60	60	131.8						
8/10/05				7.9		0	0	25	1.2	87	80	185						
8/29/05				7.5		0.02	0	35		68	60	143.8						
Average	**80**	**7.6**		**7.7**		**0.02**	**2.34**	**33.5**	**1.26**	**60.6**	**65.7**	**144.9**						

USWP Water Chemical Analysis Date Comparison

Site D – Ouleout creek

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
8/13/04		8		7.9		0.02	6.6	20		49	60							
8/17/04	85	8		7.2		0.54	4.4	40	13.3		40				18			
8/25/04	86	8		7.5		0.06	6.6	40	8.96	41	60				17			
7/8/05				7		0	0	25	40.8	33	120	72.2						
7/13/05				7.5		0	0	20	6.17	48	60	101.4						
7/25/05				7.5		0	0	20	2.03	58	20	121.4						
8/10/05				8		0	0	20	1.53	65	100	136.5						
8/18/05				7.75		0	0	30	4.44	128	80	269						
8/29/05				8.3		0.02	2	30		65	80	138.2						
Average	**85.5**	**8**		**7.62**		**0.07**	**2.2**	**27.2**	**11**	**60.8**	**69**	**119.8**						

USWP Water Chemical Analysis Date Comparison																			
Site E – Otego creek																			
Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
8/13/04		7		7.6		0	5.5	40		69	80							
8/17/04	87	9		7.4		0.08	6.6	40	44.3		60				15			
8/25/04	88	10		7.3		0.02	4.4	40	5.78	55	60				16			
7/8/05				7.2		0	0	30	6.83	67	80	149.8						
7/13/05				7.3		0	0	25	11.9	76	60	162.3						
7/25/05				7.2		0	0	25	2.24	88	28	186.5						
8/10/05				7.3		0	0	25	3.75	104	100	219						
Average	**87.5**	**8.6**		**7.32**		**0.01**	**2.35**	**32**	**12.4**	**76.5**	**66.8**	**179.4**						

USWP Water Chemical Analysis Date Comparison

Site F – Charlotte Creek

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
8/13/04		8		8.3		0.04	4.4	40		39	70							
8/17/04	80	8		7.6		0.04	4.4	40	7.7		40				16			
8/25/04	88	9		7.2		0.04	4.4	40	2.77	43	40				15			
7/8/05				7.3			0	20	3.28	52	80	115.3						
7/13/05				7.5		0	0	40	3.21	51	60	108.7						
7/25/05				7.5		0	0	15	1.59	62	54	129.8		21.7				
8/10/05				7.7		0	0	20	1.81	66	80	139.1						
Average	**84**	**8.3**		**7.58**		**0.02**	**1.8**	**30.7**	**3.4**	**52.1**	**60.6**	**123.2**						

USWP Water Chemical Analysis Date Comparison																			
Site G – Schenevus Creek																			
Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Model Aff
8/13/04		8		7.6		0.04	6.6	40		66	60							
8/17/04	90	9		7.3		0.12	6.6	40	11.2		80				16			
8/25/04	76	8		7.5		0.04	6.6	40	3.66	63	40				14			
7/8/05				4.4		0	0	40	1.11	84	80	168.4						
7/13/05				7.5		0	0		3.78	78	100	168.3						
7/25/05				7.5		0	0	40	1.46	103	140	218		21				
8/10/05				7.5		0	0	353	1.65	114	80	240						
8/29/05				7.4		0	0	45		104	100	211						
Average	**83**	**8.3**		**7.1**		**0.03**	**2.47**	**85.4**	**3.8**	**87.4**	**85**	**201**						

USWP Water Chemical Analysis Date Comparison																			
Site H – Cherry Valley																			
Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Mode Aff
8/13/04		7		7.7		0	6.6	30		73	80							
8/17/04	92	9		7.4		0.3	4.4	40	22.7		100				17			
8/25/04	90	9		8		0.06	4.4	40	13.7	83	100				16			
7/13/05				7.3		0	0	40	3.65	110	120	234						
7/25/05				7.2			0	25		89		202						
8/10/05				7.6		0	0	20	2.49	79	120	164						
Average	**91**	**8.3**		**7.53**		**0.07**	**2.56**	**32.5**	**10.6**	**86.9**	**104**	**200**						

USWP Water Chemical Analysis Date Comparison

Site I – Oaks Creek

Date	DO % sat	DO mg/l	Fecal Coliform col/100ml	pH units	BOD mg/l	Phos mg/l	Nitrate mg/l	Chlor mg/l	Turb NTU	Total Solids mg/l	Akla mg/l	Cond umho/cm	Rain prev 24hrs inches	Air Temp ℃	Water Temp ℃	Bio Index	EPT Richness	% Mod Aff
8/13/04		6		8.4		0.02	7.7	30		129	150							
8/17/04	91	8		7.8		0.04	6.6	40	4.7		160				21			
8/25/04	105	10		8.1		0.06	4.4	40	14	138	120				19			
7/13/05				7.7		0	0	35	2.2	149	160	296						
7/25/05				8		0	0	20	1.9	160	30	336						
8/10/05				7.9		0	0	25	1.8	49	160	1045						
Average	**98**	**8**		**7.98**		**0.02**	**3.12**	**31.6**	**4.9**	**125**	**130**	**559**						

Appendix IV. List of USWP generated questions/hypotheses/conclusions.

Question #1-
Is there an even distribution of common taxa of benthic macroinvertebrates along the Susquehanna from Site 1 to site 7?

Hypothesis #1-
Provided we are able to retrieve samples from sites with similar Physical Habitat Assessments, we should find that there is an even continuum of species distribution from Cooperstown to Afton. If we find that this is not the case, we will need to do further investigations to find out why. It is not likely, according to Goudrou, Neves, and Sheehan (1992), that we will find an even continuum of freshwater mussels. They point out that waters immediately downstream from waste water treatment plants are void of freshwater mussels. Wahl et al, show that taxonomic composition in a stream has more to do with stream evolutionary history than with size and other physical metrics (1995). Also, according to Sanden and Verndonschlot (2006), it can be assumed that biological communities from undisturbed sites will be broadly similar.

Conclusion #1-
Although we were unable to accurately identify our samples to the species level we did make some observations regarding the distribution and diversity of the macroinvertebrates. The dominant groups throughout the site were mayflies, caddisfly, stoneflies, dobsonflies and water pennies. Only Cooperstown did not have any stoneflies and only Wells Bridge did not have any dobsonflies. Crayfish were collected at every sight. Wells Bridge and Afton both contained a disproportionately large number of scud as compared to the other sites. Both these two sites have similar physical habitat assessment with shallow depth, low velocity and little canopy.

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Question #2-
What will a rapid bio-assessment indicate regarding the health of the Upper Susquehanna?

Hypothesis #2-
By following the protocol established by Bode et a1 1997, we should be able to draw a reasonable conclusion regarding the degree to which the Susquehanna is impacted at any given site. Although Bode and others provide substantial basis for the effectiveness of using macrobenthos as indicators of stream health, Slooth (1983) points out that the difference in pollution tolerance thresholds between species is negligibly small and the reliability of these tests should be seriously doubted.

Conclusion #2
We found mostly excellent to good water quality as indicated by the rapid bioassessment protocol by Bode et al. Nowhere did we find less than good water quality using our biological indices.

Question #3-
Does the water quality remain constant from site 1 to site 6?

Hypothesis #3-
We expect to find consistent results in water quality studies from Cooperstown to Afton. Recent studies by the American River Association claims that the Susquehanna is one of the most endangered rivers in America. It is likely that as the river runs further toward the Chesapeake Bay that it receives increasing amounts of pollutants and water quality subsequently suffers. In the short stretch from Cooperstown to Afton, there appears minimal human impact and our tests will likely indicate consistently good water quality.

Conclusion #3
Water quality is consistent from Cooperstown to Afton with only slight variations in all the parameters. Over time we will gain a broader perspective of water quality.

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Question #4-
Will a chemical analysis support the results of a rapid bio-assessment?

Hypothesis #4-
For any site studied, we should be able use HACH chemical test kits, to verify the degree to which the river is impacted. We will measure dissolved oxygen, nitrates, phosphates, pH, turbidity, chlorine, alkalinity, conductivity and fecal coliform. We anticipate that the results for both chemical and biological investigations will agree. Should our chemical data appear to contradict or simply not support our biological data, we can investigate this issue further using the school's liquid chromatographer, spectrometer and advanced titration equipment.

Conclusion #4
Our chemical analyses supported each of our biological tests. Both, chemical and biological tests, agree that the water quality of the Upper Susquehanna is good to excellent.

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Question #5-
Do any of our sites indicate poor water quality?

Hypothesis #5-
With continued improvements in water quality due to public awareness and increased enforcement of environmental policy, the Susquehanna River is likely to be only mildly impacted. Water quality is likely to be good except for, perhaps, local contamination that is quickly diluted by the river. We would expect sites nearest to industry and waste water treatment plants to have the lowest water quality.

Conclusion #5
None of our tests indicated poor water quality.

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Question #6-
Will a physical habitat assessment give us any indication of water quality at each site?

Hypothesis #6-
Perhaps more than anything else, the physical habitat associated with each site will limit the biotic diversity which, in turn, will be used to determine a biotic index. This biotic index will be used to measure water quality. We hope to establish a relationship between habitat type and observed biota at sites with similar water qualities.

Conclusion #6
We have not been able to distinguish any noticeable differences in physical habitat at each site. Minor variations in the water chemistry are likely affected to some degree by the physical habitat. Each of our sites are located at bridges and present themselves with typical human impacts; i.e. parking lot nearby, local industries on river banks, small impoundments etc. Further research is required to make any reasonable assumptions.

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Question #7-
If any sites contain chemical levels outside of the acceptable range (see appendix), can we make a reasonable assumption about why the water quality is less than good and identify a possible point and non-point source for any discrepancy?

Hypothesis #7-
At sites where the data shows a decrease in water quality, (i.e. high nitrogen levels, high phosphate levels, low biotic index, high coliform counts, low dissolved oxygen), we will attempt to visually inspect the short reach of the river for any human impact that might contribute effluent and account for the discrepancy. Provided we are able to purchase a river boat, we will be able to travel the river and begin to chart maps that illustrate the exact locations of point-source discharges as well as other human impacts that may contribute non-point source pollutants, i.e. parking lots, farmland, industry, mobile home parks, etc..

Conclusion #7
There were spikes in coliform and in chloride. When taken as an average, the results were good. These spikes may represent a larger problem with discharges somewhere. We have not been able to pinpoint any of these possible sites of discharge as of yet.

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Question #8
Can we identify any association between water temperature and dissolved oxygen?

Hypothesis#8-
In areas of low flow, we would expect higher temperatures. We will make measurements at places with low flow and higher temperature and compare the d.o. with sites with increased flow and lower temperatures. We expect to be able to illustrate the relationship between temperature and percent saturation in this way.

Conclusion #8-
This will be an area of further research as we were unable to gather enough flow data to draw any reasonable correlations. We have collected a lot of dissolved oxygen readings for various site and under various circumstances but we will need much more efficient methods for determining flow as it can change daily as with dissolved oxygen.

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Question #9-
Can the wireless weather stations near each site be utilized to compare doplar radar projections with actual rainfall data?

Hypothesis #9-
We will be able to test the accuracy of the doplar forecast by recording the data from the wireless weather stations. This data will provide us with actual rainfall amount within the Susquehanna river basin from Cooperstown to Afton. The actual rainfall data can then be compared to the projections from the doplar radar. It is expected that the estimated will differ slightly from actual. We hope to identify trends so as to make more accurate weather predictions in the future.

Conclusion #9
We have seen a trend in towards accuracy of doplar radar projections for estimated rainfall. We have too few sample comparisons however to draw a reasonable conclusion. From the 8 comparisons we have, 7 of the actual readings are within .25" of the doplar radar projections. A continuation of this comparison will likely yield consistent results.

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Question#10-
Will nitrate levels increase in the river after a significant rain event due to runoff?

Hypothesis #10-
With the widespread use of artificial fertilizers in the abundant farmland within the Susquehanna River valley, we expect to find increasing concentrations of nitrates following a significant rain event. We also hope to determine what effect, if any, does even moderate amounts of rain have on surface runoff and subsequent water quality.

Conclusion #10
There appears to be a correlation with increasing discharge and elevated levels of nitrates along with increased turbidity. Unfortunately we have been unable to obtain the rainfall data from the various schools during the summer months. By closely monitoring both the chemical levels and the rainfall data, it is very likely we will be able to establish a clear correlation.

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Question #11
Will phosphate levels increase after a significant rain event?

Hypothesis #11
There are several mobile home parks between Sidney and Unadilla. These parks, like many others yet unknown to the USWP, are likely contributors of pollutants into the river. Discharges from gray water ditches or septic systems at or exceeding maximum capacity would cause slight increases in phosphate and nitrate levels. Farmland is another source of phosphates. Monitoring of phosphate levels by the USWP during the near and distant future could be valuable resource for local government officials who have become concerned with levels of phosphate within the Susquehanna watershed due to the existing and proposed legislation attempting to lower the phosphate levels in the watershed. We may be able to pinpoint some point-source discharges and perhaps some areas of non-point source discharges that account for a higher percentage of the phosphorous and nitrate levels in the water. The subsequent regulation of these sites may benefit the watershed by drastically reducing corresponding phosphate levels within the watershed.

Conclusion #11
We observed very few spikes in phosphate levels but each time they were also associated with a rise in turbidity. It is likely there is a correlation here as well. A possible explanation for the low phosphate levels may be the streams ability to retain the nutrients.

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Question #12-
Is there a relationship between turbidity and recent rainfall data?

Hypothesis #12--
We expected that after a rainfall of at least 1.25”, turbidity would increase due to the run-off. We would also expect to compare turbidity in various parts of the river that have differing degrees of human impact. We feel that turbidity would be most stable after a rain event in areas with minimal human impact and with a healthy riparian buffer.

Conclusion #12
By comparing the data from phosphate, nitrate and turbidity levels, there does appear to be a direct relationship between rainfall and turbidity levels in the water. We see the