Assessment of Bronx River Ecosystem: pre-restoration baseline data

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Abstract- The Bronx river displays many visible signs of being a severely degraded waterway. This study was to collect baseline data on the condition of one section of the river through examinations of soil and water conditions, and the benthic macroinvertebrate populations.

The Bronx River

In the nineteenth century severe contamination of the Bronx River by human activities began. In 1844 railroad tracks were built alongside of the river from what is now Bronx Park to Valhalla. "Land adjacent to the railroad eventually became slums and dumping grounds for towns along the River" (Olson, 3). Extensive uncontrolled dumping of waste into the river led to its "noxious, odiferous, and unsanitary conditions" which a state commission was appointed to examine in 1896. Even after a sewer District was created in 1905, the extensive dumping from houses, stables, and factories continued. In 1906 the Bronx Park Commission was established and was authorized to acquire lands on either side of the river to control pollution and then make the land available for a public park in 1913.

As of 1995, the freshwater segment of the River had been reclassified from C to B (NYS DEC, 13). A class C river is described as having good quality water but is affected by runoff from prevailing developed land uses. A Class B river is described as having high quality water suitable for body contact. Such a river presumably has well established riparian buffer zones which makes highly treated nonimpacting discharges and land development acceptable. Today, despite federal and state legislation, the river is still in poor condition.

The Bronx River flows from the Kensico Reservoir in White Plains to Sound View Park in the South Bronx. For eight of its twenty miles it flows through the densely populated areas of Bronx, NY. The majority of the River's 200 square mile watershed is comprised of impermeable surfaces such as pavement, concrete and buildings (NRG, 2). The riverbank has also been affected by the presence of asphalt paths and roads and other

structures. The result of all these factors is that the river is separated from its natural floodplain and is forced to carry extremely high sediment loads in times of high flow which reduces water quality (NRG, 2).

Additionally, pollution of the river is severe. Solid waste is highly visible and includes a range of components from drink containers to rusting bicycles (fig.1). "Non-point source pollutants come out of the tailpipes of high compression internal combustion engines, or wash or are blown off slopes or fields with too spare a covering of plants and humus" (Bronx Council, 1). "Stormwater runoff in New York City typically contains between one and three ppm nitrogen with ammonia, nitrate, and nitrite being amongst the most common forms. These, in turn, become nutrients feeding algal blooms in the East, Harlem and Hudson Rivers and Long Island Sound" (Mankiewicz, Paul, 8).

Contrary to the stated classification of the River, I encountered severe erosion from a construction site which ran directly into the river where the riparian zone vegetation included grass and sparsely spaced out trees (figs 2 & 3).

Fig. 1- A pile-up of litter has developed behind a treefall. Site 1 is downstream of this dam.

Fig. 2- Runoff from a construction site uphill from the river. This is adjacent to site 3.

Fig. 3- Directly downhill from the construction site; the presence of a bike path and the lack of significant vegetation allows the heavy erosion to flow directly into the river.

Some groups such as Bronx River Restoration have been monitoring the River's status for a number of years and have been attempting to raise awareness of its poor state. These groups have also brought in groups of volunteers to take part in clean-ups which involve pulling trash and tree-falls from the river. On November 4, 1997, for example, a group went in and pulled out 5 tons of garbage and 15 tons of wood (Bronx Council, 5). Focus has also been growing on nonpoint source pollution reduction. Another group, the Natural Resources Group, is planning to undertake a large project to restore a half-mile stretch of the river in Bronx Park (Appendix 1).

Natural Resources Group

The Natural Resources Group (NRG) was founded in 1984 by New York City Parks Commissioner, Henry J. Stern, to find ways of alleviating the factors that affect the health of New York ecosystems through restoration and management projects. NRG uses its global positioning system to map out natural areas in response to requests from park managers and to delineate resources that may be disturbed by proposed public works. "Most opportunities for restoring landscapes have been projects involving mitigation for public works performed on parkland, or as part of natural-resource damage settlements" (Matsil, 7). Marc Matsil, Chief of NRG, has obtained grants, natural resource damages claims, and public works mitigations exceeding $60 million that support NRG's wetlands and woodland acquisition and restoration programs.

The Bronx River Restoration

The proposed restoration project in the Bronx River is intended to reduce the sediment loads and restore the natural hydrologic, chemical, and biological processes

within and downstream of the restoration site (NRG, 2). A major part of this project will involve eradication of the invasive exotic Japanese knotweed (*Polygonum cuspidatam*) which has invaded over 6.5 acres and has no ecological value other than holding the bank of the river together (figs. 4 & 5). Japanese knotweed is a native plant of eastern Asia that was introduced in America as an ornamental in the late 19th century (Randall, 77). It is extremely hardy and typically grows along urban riverbanks. It grows densely and quickly and reproduces by spreading rhizomes; the tiniest of which can grow into a new plant. Once Japanese knotweed becomes established, it typically precludes other plants from growing in its dense shade which results in a monoculture that native species of animals are repelled from (NRG, 3).

In addition to the removal of Japanese knotweed in the area, NRG will replant native species of woody and herbaceous plants, restore the natural floodplain, and monitor hydrological and biological conditions for a period of five years (or as long as grant money will allow).

Fig. 4- Japanese knotweed from Newcomb's Wildflower Guide

Fig 5- Dense growth of Japanese Knotweed on the riverbank

This Assessment

In this assessment I recorded some of the general physical features of the river including width, current speed canopy cover, temperature. I then measured substrate composition; the chemical aspects of the water and soil including pH, nitrogen, ammonia, and phosphate levels, and dissolved oxygen in the water; and the biodiversity of the benthic macroinvertebrate populations. All of these features contribute to the general representation of the ecosystem's condition. During and after the restoration, these and some other factors will continue to be measured and compared to this baseline data to determine the overall effect of the restoration.

METHODS

(Materials for all methods are listed in Appendix 2.)

Sample Collection

Four sites were selected for examination. Sites one and two are in the north and south ends, respectively of the proposed restoration area. Sites three and four were selected for having comparable physical features with sites one and two such as current velocity, depth, and width. These two sites are north of the restoration site in Bronx Park (Appendix 1).

Three types of samples were collected: water, soil, and benthic. Water samples were simply collected in clean one-Liter containers by holding the open container slightly below the surface of the water until it filled up.

The core sampler for the soil samples is a tube 120 cm in length and 7 cm in diameter. To take the samples the tube was pushed as deep into the sediment as possible at an undisturbed site. A rubber stopper was placed firmly into the top opening of the tube to help prevent loss of soil. Then, as the tube was pulled up out of the soil, another stopper was placed tightly into the bottom opening (fig 6). After carefully carrying the tube out of the river the top stopper was removed and a plunger placed into the top

opening Then, with the tube horizontal on the ground, the plunger was slowly pushed down towards the sediment allowing the water to flow out of the top of the tube and keeping the sediment in tact (fig 7). The soil was then pushed out of the tube and every two centimeter segment was placed in a plastic bag and labelled with 0-2 cm being the first puck and thus the bottom of the core. The bags of soil were then taken to a freezer where they remained until analysis.

Fig 6- Removing a core sample at site 3

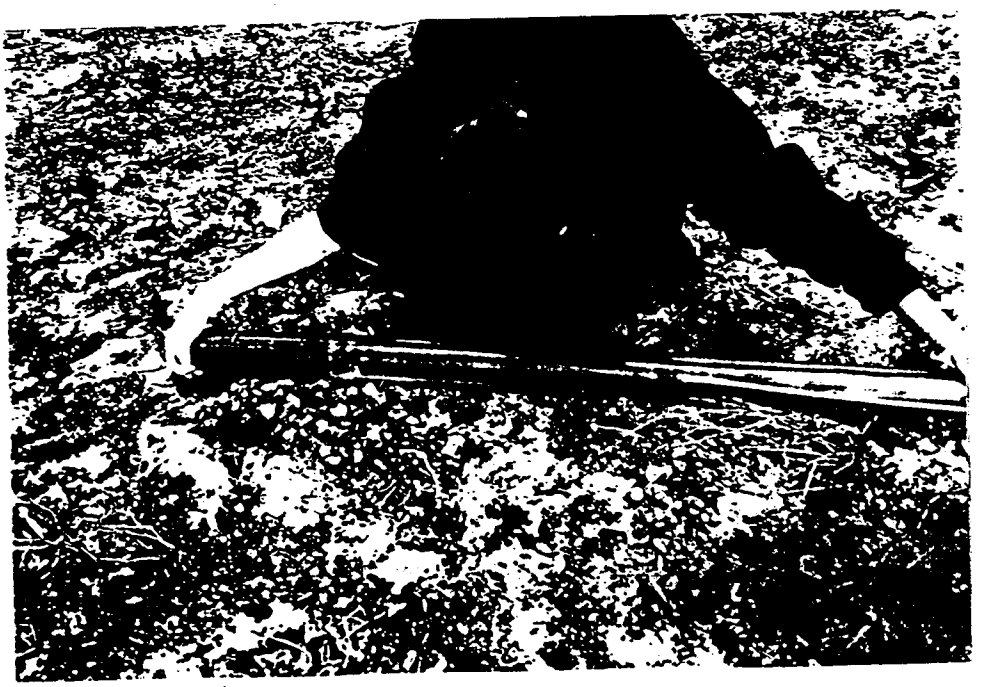

Fig 7- Pushing the plunger into the core sample, water is flowing out the open end while the soil remains in place.

For benthic sample collection, I used the kick method recommended by the New York Department of Environmental Conservation and the Environmental Protection Agency. This utilizes a D-net which is a net on a D-shaped frame and a long pole. The sieve standard for this collection is 0.595 mm. Starting at an upstream point in the site the net is held so that its top is touching the ground and its opening faces the sampler. Then, while the sampler walks slowly downstream and kicks up the sediment, the sample is caught in the net (fig. 8). It is important, especially when lifting the net out of the water, to ensure that the current does not carry away the sample. The sample is then placed in a jar and saturated with alcohol and taken to the lab for analysis.

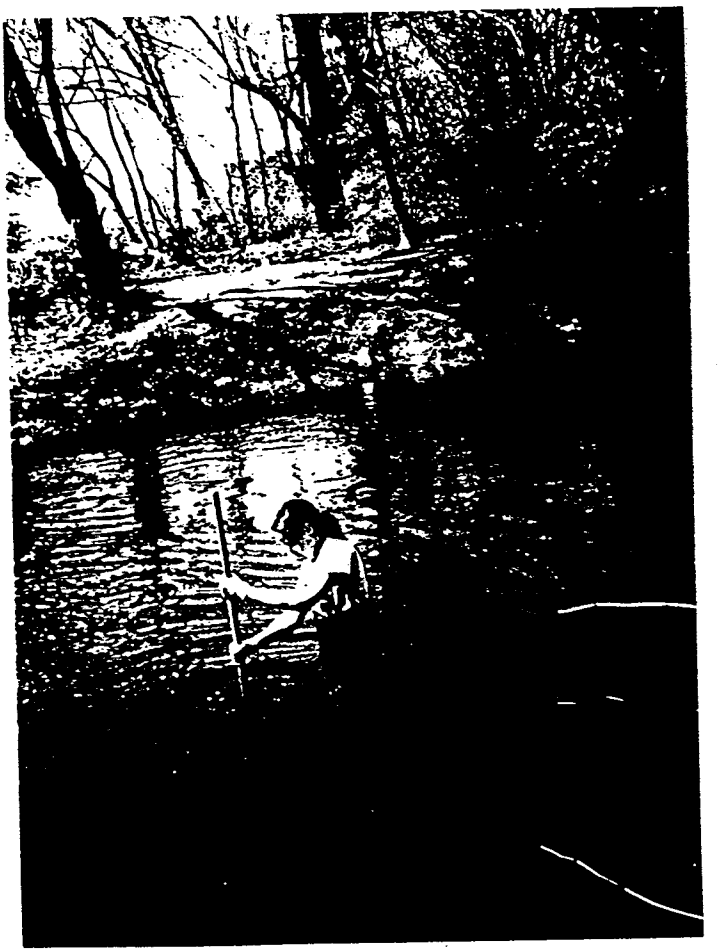

Fig 8- Taking a kick sample at site 1

Additional On-Site Tests

Additionally, I tested dissolved oxygen, water pH, conductivity, and total dissolved solids using meters. To test the turbidity, I used a secci disk, a disk 20cm in diameter divided into two black and two white quadrants. The disk is lowered into the water to the depth when the black and white portions are no longer distinctly visible. This depth is recorded along with the total depth of the river at the same spot. I tested current velocity by timing a stick floating on the surface of the river over a measured distance. I estimated canopy density to a rough percentage.

Water Tests

To conduct all the water tests I used the "Hach Drel/2000 Advanced Water Quality Laboratory" and tested for Phosphorous, Nitrogen Ammonia, and Nitrate MR (fig 8). I performed two tests for each site to minimize error. The procedure for Phosphorous is equivalent to the USEPA method number 365.2 for wastewater and Standard Method 4500P-E for drinking water. Begin by setting the meter for test 490 and turning the dial to 890nm. Then, fill each sample cell with 25 mL of sample water. Add the contents of one PhosVer 3 phosphate Powder Pillow and swirl to mix. Wait two minutes. Fill an extra sample cell with 25mL of sample water and zero the spectrophotometer with this sample. Then place each sample cell in the spectrophotometer and read the display. Finish with a standard cell holding only distilled water. All results are given in mg/L of P.

The test for Ammonia is equivalent to USEPA method number 350.2 for wastewater. Begin by setting the meter for test number 380 and turn the dial to 425nm. Fill the 25mL cells with sample water and one with distilled water, this will be the blank. Add three drops of Mineral Stabilizer and mix. Then add three drops of Polyvinyl Alcohol Dispersing Agent and mix. Finally, pipet in one mL of Nessler Reagent and mix. Wait for one minute for the reaction to take place. Put the blank in the spectrophotometer to zero

it. Read the meter for each sample and then for a standard of pure distilled water. Results for this test are in mg/L NH_3.

The test for Nitrate is a Cadmium reduction method. Begin by setting the machine for test number 353 and turning the dial to 400nm. Fill the sample cells with 25mL of sample water and one with distilled water. Add the contents of the NitraVer 5 Nitrate Reagent Powder Pillow to each cell and shake to mix for one minute. Let the reaction take place for five minutes. Zero the meter with the distilled water solution then read the meter for each sample. Finish with a standard of pure distilled water. The results for this test are in mg/L N NO_3.

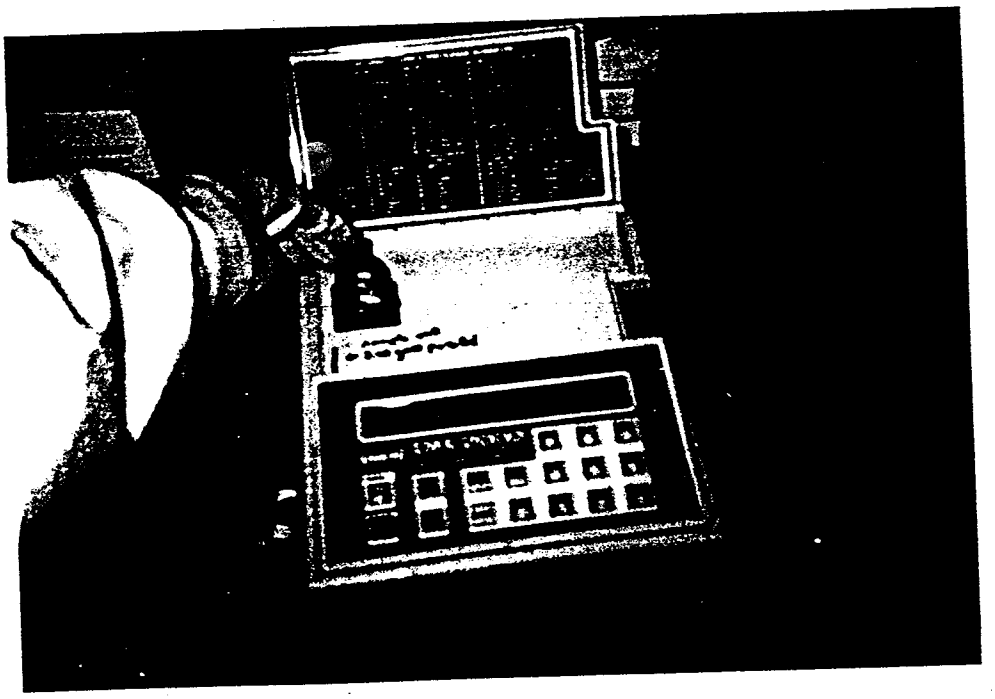

Fig 9- Placing a sample cell into the Hach Drel/2000 spectrophotometer

Soil Tests

To measure the proportions of sand and mud in each 2cm puck of soil I used a wet sieving technique. Begin by placing approximately a teaspoonful of each puck on a watchglass labelled with the depth of the puck in the core. After allowing the samples to melt, run each individual sample through sieve #230, which separates mud from sand, by squirting them with water from a squirt bottle. Then pour the mud and water into a 400mL pre-weighed beaker and poured the sand into a separate pre-weighed beaker. Each beaker must be labelled for puck depth and soil type: mud or sand. After dividing each sample into mud and sand, put all the beakers into the oven at 80^0 C until the water evaporates. Then weigh each of the beakers. The difference between the final weight and that of the pre-weighed beakers is equivalent to the weight of sand or mud in each beakers. Finally, convert these results to percentages of sand and mud in each puck of the core.

Benthic Macroinvertebrate Sorting and Testing

Benthic macroinvertebrates are defined as animals sufficiently large enough to be seen with the naked eye, which spend at least a portion of their life cycle within or upon the surface substrate. They are valuable in assessment of ecological health as they have specific levels of pollution tolerance so their presence or absence in a system reflects the level of harmful impact humans have had on the ecosystem (NYS DEC, 1991 pp48-61). Cleaning and sorting the macroinvertebrates is an extremely time-consuming and potentially quite frustrating process. That said, the actual methods are rather simple. Place one teaspoon of soil on a petri dish at a time. Then, while looking at the sample through a microscope, use tweezers to move around the dirt and pull out any organisms. Put all the organisms in a vial labelled for the site and date of collection. After picking through all the soil samples, sort the animals to the most specific group possible referring to a good field

guide for aquatic insect identification and keep record of the numbers and groups of animals on a data sheet (Appendices 3 & 4).

Three tests of macroinvertebrate populations are applicable when the kick sampling method is used (NYS DEC, 1991, pp29).

1) *Species Richness* is the total number of species or taxa found in the sample. For 100-specimen samples in New York State, the expected ranges are greater than 26 for non-impacted streams, 19-26 for slightly impacted streams, 11-18 for moderately impacted streams, and less than 11 for severely impacted streams.

2) *EPT value* is the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in the average 100-organism sample. Greater than 10 indicates a non-impacted stream, 6-10 is slightly impacted, 2-5 is moderately impacted, and 0-1 is severely impacted.

3) *Biotic index* is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals. On a 0-10 scale, tolerance values range from intolerant to tolerant respectively. Values of 0-4.50 indicate non-impacted streams, 4.51-6.50 indicate slightly impacted, 6.51-8.50 indicate moderately impacted, and 8.51-10.00 indicate severely impacted.

RESULTS

The following four charts contain the test results.

On-Site Information
chart 1

	SITE 1	SITE 2	SITE 3	SITE 4
date	4/13/98	4/13/98	4/14/98	4/14/98
time	14:00	14:45	14:00	15:00
weather	22°C, sunny, clear skies	22°C, sunny, clear skies	23°C, sunny, clear skies	23°C, sunny, clear skies
site description	downstream of large treefall loaded with garbage, dense knotweed on banks, aligned with Adee Ave.	off southwestern tip of the island, downstream of small treefall, dense knotweed on island, aligned with Arnow St.	downhill from heavy construction, very little vegetation on accessible side (East), Bronx Parkway and knotweed on West, aligned with 220th St.	downhill from construction, steep slope down to river on east side, Parkway on West, aligned with 213th St.
odors	strong tar-like odor		strong tar-like odor	
pH	7.70	7.77	8.30	8.24
DO (mg/L)	9.8	11	10.8	11.2
secci depth(ft/ft)	3.5/3.5	2.0/2.0	2.0/2.0	2.5/2.5
conductivity(ms/cm)	0.68	0.62	0.64	0.59
current velocity(ft/s)	0.91	2.00	1.67	2.00
TDS(g/L)	0.34	0.30	0.31	0.29
temperature (°C)	13.7	13.5	14	13.3
Estimated Canopy cover	60%	5%	5%	25%

Water Test Results
chart 2

	Site 1		Site 2		Standard
	cell 1	cell 2	cell 3	cell 4	cell 5
Nitrate (mg/L)	0.6	0.8	0.7	0.5	0.8
Nitrogen, Ammonia (mg/L)	0.83	0.69	2.39	1.04	1.57
Phosphorous (mg/L)	0.7	0.12	0.06	0.09	0.06

	Site 3		Site 4		Standard
	cell 6	cell 7	cell 8	cell 9	cell 10
Nitrate (mg/L)	0.5	0.5	0.5	0.5	0.8
Nitrogen, Ammonia (mg/L)	0.23	0.22	0.62	0.26	1.24
Phosphorous (mg/L)	0.05	0.07	0.13	0.1	0.33

Soil Test Results
chart 3

Core 1

	SAND		MUD	
	total weight (g)	% of sample	total weight (g)	% of sample
0-2 cm	7.02	77.22	2.09	22.99
2-4 cm	2.1	82.68	0.44	17.32
4-6 cm	missing	-	-	-
6-8 cm	2.18	84.17	0.41	15.83
8-10 cm	1.74	86.14	0.28	13.86
10-12 cm	2.43	92.75	0.19	7.25

Tests Performed by
Central Park
Soil and Water Laboratory

	Site 1	Site 2	Site 3	Site 4
pH	6.69	6.48	5.85	6.14
% Coarse Fragments	5.4	14	1.5	7.1
% Sand	92	83	77	70
% Silt	4	11	17	23
% Clay	4	6	6	7

Benthic Tally
chart 4

SITE 1

Taxa	Total number	Average tolerance level of taxa	% Abundance
Oligochaeta	17	8.64	56.7
Hirudinea			
Arynchobdellida	1	7	3
Crustacea			
Amphipoda	1	5.83	3
Chironomidae	11	7	37

SITE 2

Taxa	Total number	Average tolerance level of taxa	% Abundance
Oligochaeta	4	8.64	57
Chironomidae	2	7	28
other	1	-	14

SITE 3

Taxa	Total number	Average tolerance level of taxa	% Abundance
Oligochaeta	17	8.64	31
Mollusca			
Sphaeriidae	27	6	49
Chironomidae	11	7	20

SITE 4

Taxa	Total number	Average tolerance level of taxa	% Abundance
Oligochaeta	100	8.64	76
Hirudinea	2	7	1.5
Mollusca			
Sphaeriidae	1	6	0.7
Chironomidae	29	7	22

ANALYSIS

According to the visible evidence, the Bronx River is a severely impacted river. The trash pile-ups, overgrowth of Japanese knotweed, lack of sufficient riparian zone vegetation, lack of a large floodplain, and proximity of intensive human land-use all contribute to this conclusion.

The water tests also support this conclusion as the pH range that the New York law indicates as acceptable in Title 6, Chapter 10 of the *State Rules and Regulations* for freshwater streams is from 6.5 to 8.5. The pH of the water, especially in sites 3 and 4, is in the high end of this range. The Nitrogen Ammonia test also came out as being near the New York EPA's maximum acceptable amount of .233 mg/L in several of the tests.

After identifying the benthic macroinvertebrates, I referred to the New York DEC's list of species tolerance levels (DEC, 48-67). I was unable to identify the oligochaetes or the chironomidae to a specific tolerance level so I took the average of all the tolerance levels in these groups and applied them to the analysis (Appendix 5). I did identify the mollusca, hirudinea, and crustacea specifically enough to obtain their designated tolerance level. The following chart contains the results of the species richness, EPT, and biotic index tests:

Benthic Analysis
Chart 5

	Site 1	Site 2	Site 3	Site 4
Species Richness	4	3	3	4
EPT Value	0	0	0	0
Biotic Index	7.89	8.09	7.02	8.23

According to the species richness and EPT value tests, the four sites all qualify as severely impacted by human disturbances. However, in regards to the species richness test, only site four actually had 100 individuals. Thus, the test is not perfectly applicable to the other three samples which had less than 100 individuals. I believe that the concept behind the test does apply, however, as there is a definite lack of variety in the samples as a whole. The EPT test is also slightly questionable as there is the possibility that these flies may not have begun to develop so early in the Spring. I will be conducting this test again in mid-May to confirm these results. The biotic index test indicates that the ecosystem is moderately impacted as the range for this classification is 6.51-8.50 and the range of values I calculated is 7.02- 8.23. The consistency of the results for this test indicates a high level of significance.

CONCLUSIONS

All the factors taken into account in this assessment of the Bronx River support the initial hypothesis that the river is in need of restoration work. The physical landscape and benthic macroinvertebrate populations are the strongest indication of this fact. While the restoration will take place in the area of sites one and two, it appears that the upstream sites three and four are also in need of focus. Presumably, as 100% of the sites I tested demonstrate the negative effects of human impacts, many more sites along the river are also moderately to severely impacted. Studies by Bronx River Restoration support this conclusion. Hopefully the poor conditions upstream from the restoration site will not negate the efforts of NRG. Unfortunately for the river ecosystem, political and financial restrictions do not allow more extensive restoration work to take place at one time.

Appendix I

Red box indicates proposed restoration site.

Appendix 2

Necessary Materials

Collection:

- wading boots
- scooping D-net
- jars, vials
- soil core sampler: includes tube, plunger, rubber stoppers
- airtight plastic bags
- measuring tape
- rubber gloves
- knife (to cut soil core pucks)
- one-Liter water bottles
- stopwatch (for current velocity)

Testing:

- meters: Dissolved Oxygen, pH, Conductivity, Total Dissolved Solids
- secci disk
- Hach spectrophotometer and necessary testing substances
- thermometer
- tweezers
- microscope
- ethylene
- taxonomy keys
- petri dish
- watchglasses
- soil sieves
- squirt bottle
- 400mL beakers
- containers for catching soil as it is sieved
- oven
- scale