Wetland Assessment and Monitoring Protocol Development for NYC

EXECUTIVE SUMMARY AND FINAL REPORT

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EXECUTIVE SUMMARY

New York City has lost about 99% of its freshwater wetlands since European settlement[1] and faces extreme challenges in preserving, protecting and restoring the ecological functions of the approximately 1,600 acres of freshwater wetlands that remain. The New York City Department of Parks & Recreation, Natural Resources Group (NRG) received a grant from U.S. Environmental Protection Agency Region 2 to develop and revise protocols for assessing and monitoring freshwater wetlands within New York City parklands in order to better set priorities for protection, restoration, and other management actions in wetlands and riparian systems. The overarching objective of the project was to develop an approach to wetland and riparian assessment and monitoring protocols that could include various levels of effort and scales of investigation (from GIS landscape analysis, to rapid field assessment, to monitoring) to answer specific questions relating to the need for wetlands preservation and management. Further objectives were to incorporate conservation training opportunities in a wetland assessment protocol and explore an assessment of recreational uses or other social functions provided by wetlands.

In 2007, NRG began preparing a protocol for rapidly assessing wetland conditions to allow the collection of consistent information on freshwater wetland site conditions. Initial assessments were used to identify need for additional information and helped to determine best locations for more in-depth monitoring. We reviewed the literature on wetland assessment, including sixteen wetland rapid assessment protocols that we thought could meet our needs from different states and municipalities, and met with wetland scientists from U.S.EPA, Columbia and Rutgers Universities to discuss our draft protocols. Ultimately, the wetlands rapid assessment protocol (WRAP) that was developed was most similar to that used by Westchester County in their Wetlands Assessment and Management Plan. It included a field component where physical, hydrologic and vegetative parameters were evaluated, and a list of stressors that indicated impacts to the wetland were scored to yield a "stressor score." Staten Island was selected as the study area, because of its number and range of freshwater wetlands and streams. In preparation

1 PLANYC New York City Wetlands: Regulatory Gaps and other Threats, January 2009

for developing and testing the wetlands protocol, we prepared field maps of most major parks located in Staten Island, identifying and labeling potential assessment sites based on the National Wetland Inventory (NWI) and the NYSDEC freshwater wetland maps. A total of 37 sites were assessed. Sites of past or on-going biological and habitat studies were selected as much as possible to allow comparison of WRAP results with data collected on species diversity.

In 2008, the previous season's WRAP results were analyzed and NRG staff determined that the extent and type of field data collected from the rapid assessments necessitated a thorough review of the assessment protocols. Consequently, at numerous internal NRG meetings, and meetings with external scientific advisors, the draft protocol instructions, content and format was revised to ease its use in the field, increase consistency between field crews, and reduce redundancy. Changes to the 2007 included converting the stressor score parameters into ten indicators of disturbance (trash, invasive species cover, etc.) that were scored 1-10 according to apparent degree of "stress" at a site. The revised WRAP was implemented at an additional 51 sites in 2009 by seasonal field assistants. These research assistants were trained by NRG ecologists, wetland specialists or environmental scientists, who accompanied them to about half the sites.

In addition, a GIS-based landscape analysis, begun in 2007, was further developed and added to the WRAP to provide basic information about drainage contributing to the wetland or stream site, the percent of nearby development, and proportion of impervious land use both in the drainage basins and in the buffer zone surrounding the wetland.

The wetlands assessed represented a wide range of wetland sizes, drainage basin areas, and degree of watershed development. An approximately equal proportion of palustrine (forested), emergent, and open water (less than six foot depth) freshwater wetlands were assessed over the two field seasons. This sampling suggests a slight under-sampling of palustrine freshwater wetlands, which are the dominant wetland type in Staten Island.

Results from 2009 WRAP stressor scores suggested that about 10% of the sites assessed were relatively free of visible signs of urban impacts, and about 10% of the sites were highly impacted. Based on the WRAP scores, we grouped the wetlands into three general management categories. The sites with the least stress will, in general, have a need for the least on-the ground management actions, but are potentially in greatest need of protection and preservation.

Appropriate management actions may include increased enforcement of park rules, and more in-depth faunal or vegetation analysis to determine if these sites should be used as future reference sites (such as for reference sites for restored wetlands). The sites that had the highest stressor scores and were therefore the most disturbed may need to be flagged for more active management or some type of restoration or mitigation measures, potentially including hydrologic drainage investigation, fencing, invasive plant removal, re-vegetating the buffer, and investigating and remediating sources of runoff and/or pollutants. The data from the 2007 and 2009 WRAPs were relatively well correlated, allowing the opportunity to incorporate all data in an initial management prioritization scheme. The process of developing the WRAP included efforts to verify the results by 1) comparing the stressor scores of a given wetland with the opinions and comments from wetland experts familiar with a site, and 2) by matching WRAP results with biological monitoring data from a site.

The WRAP data yielded results that corresponded to other NRG monitoring datasets. When WRAP stressor scores were compared to data from ongoing odonate monitoring conducted at the same sites, the team found an increase in species richness and diversity of odonates potentially correlated to a decrease in stressor score (lower score means less impacted). However, due to the small number of overlapping WRAP and odonate monitoring sites (6) and one outlier, the results were not statistically significant.

Our wetland assessment and monitoring training and outreach efforts began with training of in-house ecologists, environmental scientists, and several graduate students. We intend to expand our training this spring to the training of three Green Apple Conservation Corps team leaders in the use of the WRAP within Parks, who in turn will train their corp members to use the WRAP to prioritize sites for specific wetlands management actions.

In addition to the WRAP, a pilot social survey, developed in consultation with U.S. Forest Service Urban Field Station social scientists, was conducted with regular visitors at the Greenbelt Nature Center in Staten Island. The results suggested that wetlands may be the focus of place attachment for park visitors, as ponds were singled out as the most frequent landscape destination and swamps were tied for second place. In the long term, education and a better understanding of the social value of wetlands will continue to be important for wetlands management.

The following products, generated by this grant project, are found in the accompanying New York City Parks Wetlands Assessment and Monitoring report:

- Wetlands Rapid Assessment Protocol for the Field (Section 1)
- Wetlands Buffer and Drainage Basin Analysis Protocol (Section 1)
- WRAP Results and Management Prioritization (Section 2)
- Wetland and Riparian Monitoring Protocols in relation to WRAP (Section 3)
- Pilot Social Survey (Section 4)
- WRAP Conclusions and Recommendations (Section 5)

A number of specific recommendations were given that would further improve the WRAP based upon the field data and GIS maps, comparison to biotic monitoring data, and consideration of on-going management and research questions about NYC's wetland systems. We identified the following next steps for implementing these recommendations and assuring that the WRAP has the greatest possible utility in the future:

1. Conduct an assessment of how replicable each WRAP stressor score is by having multiple NRG ecologists and environmental scientists conduct assessments simultaneously at a site, and analyzing the variation in each result.
2. Dependent on the results of #1, Work with the Green Apple Corps to test the use of the WRAP in prioritizing wetland sites for invasive plant removal or trash clean up.
3. Further investigate the relationship between WRAP results and the indices of odonate diversity as an indicator of wetland community health, and, pending staff resource availability:
    a. Expand the WRAP to all remaining odonate monitoring sites, and several new sites, across the city
    b. Expand the odonate monitoring to include all appropriate WRAP sites.
4. Evaluate the effort needed and potential disadvantages or benefits of converting negative Stressor Scores to positive Condition Scores to improve the use of ranking system as a communication tool.

5. Complete development of a Stream Rapid Assessment Protocol (RAP) and collect data at additional streams.
6. Plan and conduct a detailed review of our current monitoring protocols (for example, for particular fauna and flora), with particular emphasis on a more focused approach to assessing restoration needs and performance evaluation.

SECTION 1. RAPID ASSESSMENT PROTOCOLS (RAP)

BACKGROUND AND USE

Objectives

The Natural Resources Group (NRG) of the New York City Department of Parks & Recreation (Parks) developed this Wetland Rapid Assessment Protocol (WRAP) to obtain relatively quick and standardized snapshots of wetland conditions and characteristics in Parks and on other accessible properties in New York City. This protocol will allow Parks to better track wetland conditions, classify wetlands according to management needs, and help prioritize sites for further assessment, maintenance and monitoring. In addition, the WRAP can be used to identify and assess unmapped wetlands in NYC – those that are neither identified by the National Wetlands Inventory, nor large enough to be under New York State Department of Environmental Conservation (NYSDEC) jurisdiction (>12.4 acres). This type of wetland-specific assessment and ranking has not been conducted before in the City.

The WRAP was developed and pilot tested in the borough of Staten Island; however, it is intended for implementation throughout the City. Both an office and a field component are included in the WRAP. The office component consists of locating assessment sites in parkland, identifying these sites with respect to existing wetland maps in GIS, and characterizing development and land use in GIS. The field component is conducted with maps prepared in the office, involves collection of information that cannot be ascertained remotely, and is also useful in verifying the GIS data.

In addition to the WRAP, NRG drafted a stream Rapid Assessment Protocol (RAP) to serve the same objectives as the WRAP. The stream RAP was intended to identify and assess streams in or draining to Parks' properties that often receive very little management or protection. These systems are so geomorphically and hydrologically distinct from wetlands that they require a different assessment protocol. Streams are also often disassociated from wetlands, and thus not afforded the regulatory protection of wetlands. Like the WRAP, the stream RAP can also help identify protection opportunities for fragmented, severely altered, and unprotected streams and riparian corridors that may have restoration potential.

Development of the NYC RAPs

The RAPs were developed by reviewing both the rapid assessment methods and protocols for wetlands and streams used elsewhere and the research assessing the success of many of the existing wetland assessments. Rapid assessment protocols and monitoring methodologies from fourteen states were reviewed including the Northeast and Mid-Atlantic states of Delaware (Jacobs 2007), Massachusetts (Carlisle et al. 2003), New Hampshire (Ammann and Stone, 1991), New York (Westchester County Planning Department 2008; Hatfield et al. 2004) and Pennsylvania (Brooks et al. 2002; Gray 1999). Critiques of assessment techniques were considered to determine which elements of which protocols best fit our circumstances and needs in NYC. Among the papers examined were Brinson and Rheinhardt (1996); Carletti et al. (2004); Ehrenfeld (2000, 2003); Fenessy et al. (2004); Stander and Ehrenfeld (2009); and USEPA (2002a, 2002b).

Of special interest were those papers that analyzed urban wetlands—among the issues faced in the NYC WRAP were how best to evaluate, for example, sites that had a history of fill activity, yet retained hydric soils and hydrophytic vegetation (e.g. Ocean Breeze Park). Guidance was sought on taking into account New York City's highly urban environment and specific management needs.

NRG implemented the RAPs in the field, and modified them according to comments from ecologists, hydrologists, and soil scientists at NRG, New York City Department of Environmental Protection (NYCDEP), the Natural Resources Conservation Service (NRCS) at the USDA (Staten Island office), Columbia University, Rutgers University and U.S. EPA. For example, it was in consultation with Joan Ehrenfeld, at Rutgers, that we decided to proceed with a relative ranking approach to assessing wetland impacts, rather than to seek a pristine wetland to serve as a reference condition.

Time and Effort

The time to complete each WRAP varies by site due to variations in vegetation density, accessibility, the complexity of determining the stressors associated with the site, and the amount of experience of the person performing the assessment. The WRAP should take two people no longer than a half a day in the field, though it can take as little as two hours (not accounting for travel time), and two hours in the office. Initial assessments took longer to perform and the form was shortened and manipulated for ease-of-use. Assessment teams became more efficient with practice.

The SRAP would take an equivalent amount of time and plans are underway for increasingly using the SRAP in coming seasons to assess NYC streams. One advantage to the SRAP is that it is easiest to conduct certain field observations in the winter when leafs are off, which is convenient given summer field work obligations.

Experience Needed

Users of the protocol should have experience or education in the identification of wetlands including an understanding of basic hydrology and familiarity with plant identification. Familiarity with soils is not required to complete the protocol; categories for soils were deemed optional. In order to ensure consistency we recommend that new personnel conduct the assessment first with someone with previous experience. NRG can train qualified personnel implementing the protocol on the specifics of the methodology.

Field Equipment Required

- Clipboards
- Pencils
- Field Protocol Forms
- Field Map of wetland site
- GPS unit
- Digital camera
- Waders or knee boots
- Meter tape
- Field guide to freshwater wetland flora
- Invasive plant field guide
- Soil auger
- Meter stick
- DBH Tape
- pH probe
- YSI- Dissolved Oxygen

RAPID ASSESSMENT PROTOCOL-FORM INSTRUCTIONS

The following detailed instructions refer to the Wetland RAP only, however many of the same instructions apply to the stream RAP. Both wetland and stream protocols are inserted in the appendices. As with the wetland component, training for completing the stream protocol will be conducted by NRG teams in the field.

WETLAND RAPID ASSESSMENT PROTOCOL

Complete the office work before the wetland site visit or immediately following the visit if the exact location is unknown. The office work consists of preparing maps for field use and determining some basic landscape characteristics associated with the wetland site using GIS some of which should be field verified. The methodology for the GIS analysis is described separately in Appendix F.

I. LANDSCAPE LEVEL DATA

Collect the basic landscape level resource information as available:

- Aerial photographs (historic and current)
- USGS topographic quadrangle maps (available online)
- Existing wetland maps including NWI and NYSDEC Freshwater Wetland Maps (1974 (NYC) and 1999 (Staten Island only))
- Hydric soils maps (limited availability for New York City)
- Connectivity to water bodies or streams in the office using existing GIS data layers. (Estimate the contributing topographic drainage using the protocols for drainage basin delineation given in the GIS Appendices).

Print previously prepared NRG maps (Appendix I) with the park name and boundary, major roads, and the NWI and NYSDEC mapped wetland boundaries. Use these for orientation in the field and annotate as needed. If the wetland site to be assessed is not already identified in Staten Island, or is located in another borough, produce a new map for the field. For a new map in Staten Island, use the Staten Island_Wetlands_Master map at NRG[1] and follow the procedure described in Appendix F: GIS Layers; their design and location, then Field Map Preparation. Print the map in color.

Classify the potential impact on the wetland from development by characterizing the land use type and proximity to the wetland (described in II. Buffer Analysis). Wetland size, degree of development and imperviousness in a watershed, and the abundance, size, and proximity of roads to wetlands provide indications of the likelihood of degradation of the wetland (Gergel et al 2002, Spellerberg 1998, NYCEQR). The office-based GIS landscape analysis needs to be field verified.

Assess the degree of development by determining the following stressor parameters:

- Minimum distance to development from wetland edge
- Percent development within 30m of wetland edge

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[1] *Located in J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\Maps\SI wetlands*

- Most intense Land Use (within 30m of wetland edge)
- Roads- most intense type (within 30m of wetland edge).

Record the area of the NWI and NYSDEC wetland polygon. This information, as well as the perimeter of the wetland can help determine whether multiple site assessments will be needed because the larger the size of the wetland the more likely it is that several assessments will be needed to cover the same wetland complex. Several wetland types may be located within the same mapped wetland each benefitting from a separate assessment. Tracking them separately allows for separate assessments of potential sensitivity to impacts.

Park Name Name of Park where the wetland site is being assessed.
Use the official name recorded on the Parks Properties Layer (Property field of the attribute table). If another name is commonly used, record that name in quotation marks after the official name. If an assessment site is not within Parks property, note its location and the adjacent park.

Borough Name of borough in which assessment is occurring.

Site ID Name the site using the first two letters of the first word of the park name, and the second two letters of each subsequent word in the name, followed by a site number assigned from North to South across the park. For instance the northern-most site in High Rock Park would be named HiRo_1. Also see Appendix F*:* Field Map Preparation, Naming Formula (SITE ID).

Name of Associated Waterbody (if applicable). If names are not available on the hydroline layer of the SI wetlands map, reference the 1968 Map of Staten[2]. See Appendix F: Polygon and Buffer Analysis.

Area of Wetland Polygon Determine the area (in square meters) of the NWI polygon or DEC Polygon in which the assessment took place. See the Appendix F: Polygon and Buffer Analysis, "Name and Area of Wetland Polygon" and "Find Area of wetland polygon in GIS". If the wetland is unmapped and the GIS analysis is conducted after the field component, see Appendix F: Polygon and Buffer Analysis, "If not a NWI polygon".

Mapped Hydric Soil: If a data layer exists for the site from USDA NRCS NYC Soil Survey, identify whether hydric soil is listed for the wetland polygon.

NWI Code: Record the Cowardin Classification code as given in the NWI Wetlands GIS Layer (ATTRIBUTE field of the attribute table) for each polygon. The Cowardin Classification method is used for the National Wetlands Inventory (NWI) to classify wetlands by cover type (see Figure 1 and 2, and Appendix C). Verify this mapped NWI code with the observed classification in the field. Refer to Figures 1 and 2, below.

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[2] Island with "Ye Olde Names and Nicknames"(in Maps\SI Old Maps)

II. BUFFER CONDITION- (Field Estimate and GIS Calculation)

Categorize the four buffer condition stressor parameters (Minimum distance to development from wetland edge; Percent development within 30m of wetland edge; Most intense land use within 30m of wetland edge; and, Roads- most intense type within 30m of wetland edge)

Rate each stressor with a value from 0 to 10 (with zero indicating the least stress) within the categories provided. Unless otherwise directed, assign the lowest score that applies. Use the category descriptions to guide you. Two examples are provided below:

1) "Trails and Roads" under Wetland Analysis:
   If a road goes through the wetland, score it according to the type of road and degree of use (Maximum score of 7 for permeable road and up to 10 points for a paved road).
2) "Roads" under Buffer Analysis:
   Score only the most intense road type present. See below for definition of road "intensity". DO NOT record a value for a 2-lane paved road if a 4-lane paved road is also present. Score the 4-lane paved road between 8 and 10 depending on the quantity of road within the 30 meter buffer area

1. Minimum Distance from Wetland Edge to Development Determine the **minimum** distance from the wetland to development (residential, recreational area, road etc.) using the *Ortho aerial photography* GIS layer. Record the minimum distance in meters. See Appendix F: Buffer Analysis, "Find Minimum Distance to Development". The aerial photo layer may not accurately represent the distance to development. Therefore a meter tape should be used for field measurements if development is in proximity of the 30-meter buffer.

2. Proportion Developed within 30 meters of Wetland Edge This calculation is based on the *Staten Island_developed_areas_2009* layer, which combines roadbeds, impermeable recreation areas (like basketball courts and bike trails), parking lots, structures (buildings), and a 40ft buffer around all structures. See Appendix F: Buffer Analysis, "Calculate the Proportion of Developed Area in the 30m and 100m buffer", "Multiple Clips", and "Clips dpr" on pages 31-33.

3. Most Intense Land Use (within 30 meters of Wetland Edge Using the *Land use* layer, classify the most intense type of land use that exists within a 30m radius from the polygon. In this case intense land use is defined as urban land use associated with land degradation such as pollution and open space or habitat loss. This is broken down into open space/outdoor recreation (such as ball fields/golf courses); residential- homes and apartment buildings; Public facilities/Institutions (such as universities, hospitals and other campus like settings), Transportation hubs/utilities/ Parking facilities such as (train depots, or power plants) and Commercial/Industrial/Manufacturing. See Appendix F: Buffer Analysis, Dominant Land Use within 30m buffer.

4. Roads – Most Intense Type (within 30 meters of Wetland Edge): Record the most intense type of roads within 30m of the wetland polygon. The intensity of the road type refers to the degree of surface permeability, the size, and amount of road in the 30 meter buffer area. For example, a dirt road that runs through the buffer area for 50 meters would have the highest score for a dirt or gravel road (e.g. 4). Whereas a 2-lane paved road that crosses a small corner of the buffer would

receive a score of 5. Use the *Ortho aerial photo* layer, a current atlas, and record field observations. See Appendix F: Buffer Analysis, "Roads within 30m of wetland (most intense type)". "Direct run-off into wetland" will need to be observed in the field.

III. FIELD ASSESSMENT

Begin by walking the perimeter of the wetland. While walking the perimeter take note of the appearance of both the buffer and the wetland itself. After circling the perimeter walk into the wetland until you find a "representative area" that is typical of the larger wetland. If the wetland vegetation is heterogeneous, this representative area should have that same heterogeneity. Mark the center of the typical area and delineate a circle with a 10m radius from the point. This circle will be the Vegetation Assessment where the dominant plant species will be documented. At the edge of a water body, where there are zones of distinct vegetation, the Vegetation Assessment "Circle" should be elongated and applied to a representative area within a zone or band of similar vegetation. ***Other stressors should be tabulated based on the entire wetland or wetland complex*** *(depending on whether you are scoring a patchwork- see Multiple Wetlands in Close Proximity below and Table 1). When finished in the field, remove any invasive plant material from boots and tools, especially duckweed and submerged vegetation, before leaving the area. Do not track invasive plant material to the next wetland.*

Multiple wetlands in close proximity

Wetlands that are small (<1 acre or 0.4ha), located in close proximity to each other within the same forest, flood plain, soil mapping unit, etc., and that are separated from each other by relatively narrow areas of non-wetland, should be scored together as a "single" wetland. This includes wetlands not mapped by DEC or NWI. Unmapped wetlands should be digitized with a GPS unit and added to the NRG GIS wetland layer.

Table 1. Decision table for determining whether to score wetland separately or not.

1) Is the wetland less than 1 acre (0.4 ha) in size?	Yes (go to Q 2)	No (score wetland separately)
2) Is the wetland a part of a patchwork or mosaic of wetlands on the landscape?	Yes (go to Q 3)	No (score wetland separately)
3) Are the wetlands in a patchwork or mosaic of wetlands less than 200 ft apart on average?	Yes (go to Q 4)	No (score wetland separately)
4) Do the areas that are jurisdictional or unmapped wetlands within the patchwork or mosaic cover more than 50% of the surface area of the patchwork or mosaic?	Yes (score the entire patchwork or mosaic as a "single" wetland)	No (score wetland separately)

Source: Mack 2001.

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III.a. SITE CONDITIONS AND CLASSIFICATIONS

Date Month (write out), day and year of field assessment

Evaluators All members of the field crew that participated in sampling the site

GPS Coordinates: List the latitude and longitude coordinates obtained from the GPS unit in digital degrees at the center point of the Assessment Area. Create a point on the WETLANDS layer in ARCPad. (See Appendix G.) On your Site Description and Drawing (Page 4 of the Data Form) mark the approximate center of the Assessment Area.

Current Weather: Note the typical weather at the time of survey.

Current Water Conditions: Is this a period of drought, flooding, or normal water levels? Look for indicators such as water stains, or for flooding water in upland areas. If you cannot tell- mark unknown. If a drought is suspected because of extremely dry conditions check data on the web for drought conditions: if New York City appears as a moderate hydrologic drought on http://waterwatch.usgs.gov/?m=dryw, it should be classified as a drought. Alternatively, if the previous 15 days appear to be dry spell conditions (no day with 0.04 inches or more of precipitation) according to unofficial data such as weather.com, further work should be done to determine if the mean daily rainfall of the past 29 days is less than 0.01 inches.

Time Since Last Precipitation: When was the last time of precipitation? Record this in days. If unknown write "unknown."

Within DEC Wetland Boundary?: Record if the wetland lies within the DEC wetland boundary on the GPS unit. If the area is not within the DEC boundary mark No.

Unmapped Wetland: If the wetland is not within the NWI or DEC delineations circle YES. If it is either mark NO. If this is an unmapped wetland triangulate the rough boundaries using your GPS and sketch its location on your field map. Note whether or not it is a vernal pool, if known. Determine its approximate size using your meter tape and create a new polygon in the *wetland update layer* on the SI Master Map.

Go back to page 1 of the WRAP Form to verify the NWI Code, if listed, and Buffer Analysis. Assume the GIS analysis will be correct if conditions in the field are accurately represented by the 2006 orthophotos in the GPS unit. If new construction or other changes have occurred, take GPS points, if possible, and use the measuring tools on the unit to approximate the buffer metrics. Draw any changes on the Site Description and Drawing (Pg. 4 of Assessment Form).

NWI Code Verify the Cowardin Classification documented by the office analysis or the code on the GPS unit (use the information tool on the CONUS_Wetland_... layer) with the field observations. Refer to Figures 1 and 2. If the observed vegetation classification differs from the NWI layer, document the inconsistency and record the observed class in the Landscape Level Data section of the Assessment Form.

Objective: Document changes in wetland conditions or discrepancies in the NWI map layer and maintain updated data. Confirm that the assessment is in fact being done in a wetland and determine changes in landscape conditions. This section can also be used to verify that an un-mapped wetland is indeed a wetland. Look for standing water, if there is no standing water complete the water verification checklist and check for hyrdic soils using the provided criteria. If standing water is present collect information on depth and water quality. (Gray et al. 1999)

HGM Classes[3] Determine the HGM classification…See Box 2, page 20.

Hydrogeomorphic (HGM) classification method (Brinson 1993): This method will be used to characterize the wetlands position in the landscape, and its hydrology. These classifications infer the hydrodynamic characteristics such as water inputs and outputs, and type of water flow. (Brinson 1993). Each HGM class in a similar region should express different levels of function and vary in their susceptibility and response to stressors (Stander and Ehrenfeld 2009). Classifying these can help to identify particularly vulnerable or rare wetland classes. Similar HGM classes can be compared to each other to more accurately elucidate stresses on wetlands and account for these differences in hydrology. Furthermore, the attainable ecological condition in a class can be defined by the best observed conditions and be used in replacement of a reference site (Carletti et al. 2004, Stander and Ehrenfeld 2009) This attainable condition can be identified for each HGM class in order to better understand the effects of an urban stressors independent of wetland type.

Riverine: These wetlands include stream channels, riparian areas, and floodplains. The dominant water source is overbank flow from the stream channel or interconnecting subsurface flow from wetland. These wetlands are located adjacent to the linear flow or a stream or river.

Depressional: Depressional wetlands such as vernal pools are primarily dependant upon precipitation runoff but may also be dependant upon groundwater influx. They are located in basins within closed contours. These wetlands often exhibit strong seasonal variation in the water table resulting from the seasonality of the ratio of precipitation to evapotranspiration.

Slope: Slope wetlands occur along a topographic gradient where there is a discharge of groundwater to the land surface from surrounding uplands. The evaluation gradient can be steep or slight and they may typically be found at the toe of a hillslope. Subsurface flow and precipitation are the dominant sources of water. However, they differ from depressional wetlands because they are not contained by topographic contours.

Flats: These wetlands occur in areas with low topographic relief that are fed primarily through precipitation and runoff and drained only by evaporation, transpiration, and recharge. These are very shallow wetlands with hydroperiods varying highly throughout the year.

Lacustrine Fringe: Lacustrine fringe wetlands occur on the margins of ponds or lakes where the water elevation of the lake determines the wetland water table

[3] Brinson 1993

Tidal Fringe: Freshwater tidal fringe wetlands are located in the upper part of estuaries where water level is influenced by tides.

Vernal Pool: Look for a depression in the landscape with little or no vegetation and heavily water stained leaves indicating that the area is seasonally inundated. Vernal pools in depressional landforms often occur as wetlands in the bottom of the depression and may or may not be surrounded by uplands. Vernal pools in wetland complexes occur as scattered pools throughout a more extensive wetland.

Objectives: The established standards of Cowardin and HGM classification will be used to profile the abiotic and biotic conditions of freshwater wetlands in a rapid assessment. Classifying the vegetation and hydrologic characteristics of the wetland provide information about the conditions and processes within a dynamic context. The broad classifications derived are limited in their implications and are not intended for diagnostic analysis. Rather, they are to assist in a general classification of dominant species composition and types of a wetland (Cole 1997, Cowardin 1979, Karr and Dudley 1981).

III.b. GEOPHYSICAL CONDITIONS

Standing Water? If standing water is present, than mark YES and record the maximum depth of the standing water (in cm) if it is below knee height. If standing water is above knee height at its greatest depth, record the depth (cm) at one meter and two meters. If there is NO standing water then complete the wetland verification including Hydrologic Indicators checklist (Gray et al 1999) and Hydric Soil Indicators.

Hydrologic Indicators

Drift lines – Look for deposition of debris (usually vegetation remnants, trash, sediment or other materials) roughly parallel to water flow. Deposition may occur in vegetation or on other objects. Drift lines indicate the minimum level of inundation as the maximum level may extend beyond visible drift lines.

Sediment Deposition – Look for a thin layer of sediment (either mineral or organic matter) deposited on plants and objects. This may appear to look like a coating or encrustation especially if the sediments are primarily organic. Sediment deposition is also an indication of the minimum level of inundation.

Water Marks (Scour) – Look for surface scouring where sediment has been eroded from the base of trees. Another indication can be bare patches where there is an absence of leaf litter due to scour.

Water Stained Leaves – Particularly in forested wetlands water-stained leaves may be apparent. Look for fallen leaves that are darkened (grayish or blackish) from being underwater for a period of time.

Morphological Plant Adaptations – Examine vegetation for adaptations in response to inundation. Look for pneumatophores (erect root structures), buttressing (enlarged base of trunk), multiple trunks, shallow root systems, floating stems, floating leaves, polymorphic leaves, adventitious roots (originate from the stem, branches, leaves, or old woody roots, and are often found on willows that are subject to inundation), hypertrophied lenticels (an exaggerated/oversized pore on the stem of woody plants), inflated leaves stems or roots, and air-filled tissue in roots and stems.

Hydric Soil Criteria At one hole, auger to a depth of approximately 10 to 20 inches to allow analysis of the soil profile. Examine the soil profile for the hydric soil indicators listed in the protocol. Use the Munsell Soil Color Chart to determine the color (Munsell 2009). Start with the 10YR page and switch pages as needed to match Munsell color chips to the soil. In the profile description write the depth at which redox features or other hydric soil indicators occur. Indicate where the hydric soil indicators begin and end as inches from the surface. Note the soil chroma and hue on the data sheet within several soil horizons. Low chromas indicate wetter soils. A matrix of 2 or less with redox concentrations (aka mottles consisting of >2mm diameter soft masses) or a matrix of 1 or less without redox concentrations indicate hydric soils while the brighter chromas indicate upland soils (USDA NRCS 2006; USACE 1987, USACE et al. 1989). Be aware that Staten Island soils may have their hydric color characteristics masked by red parent material. If red parent material hydric soil is found, if in doubt compare with known upland (compare vegetation) red soil for any evidence of gleying (washed out appearance in the wetland soil sample) and observe if other redox features are present and/or contact NRCS, Staten Island office. When finished, return soil to the holes as much as possible (so that no one trips on the hole) (see Appendix D.).

Water Quality If the area is ponded with enough water to cover the probes in both the pH and dissolved oxygen (DO) meters and allow at least three inches below the probe, place the meter probe just under the surface of the water two meters from the edge of the pond. Move the probe about to rinse any material or water off the probe. If the depth of water will not accommodate the probe, use a container to gather water making sure it is rinsed well with wetland water. Again, move the probe about before recording the pH and DO values.

III.c. VEGETATION (in Assessment Area):

The vegetation assessment is intended to broadly characterize the vegetation cover and structure by listing the dominant vegetation (> 20% cover in each strata) within the assessment area. Although not useful for monitoring transects or plots, this rapid method gives an outside observer some more information about the vegetation type in the assessment area and provides a more comprehensive snap shot of the site (Hatfield 2004).

Dominant Species**:**

List the dominant species in each stratum within the entire assessment area. List those species that are greater than 20% of the cover within each stratum in order of dominance. For instance, all shrubs equal 100% of the shrub layer. If half of the strata contains high bush blueberry and 20% of the strata contains spicebush, blueberry would be listed first followed by viburnum. One plant can be listed in more than one stratum if it dominates both (USACE 1987). Use the Site Description and Drawing on page 4 of the Field Form to draw the distribution of species as needed. Complete multiple forms if very distinct communities characterize the wetland. Use the list of common wetland plants attached to the end of field form for help.

Presence of Invasive Species The presence of invasive species within the Vegetation Assessment Area is classified by using a modified form of the Braun-Blanquet or Domin scale for visual estimates of cover. Both scales divide cover into percentage classes. We combined classes to produce four classes with easily estimated ranges of cover for reference. Both Braun-Blanquet and Domin were developed for native plant coverage and therefore assumed very small values at the low end of the scale (<1% for Braun-Blanquet and one individual for Domin). To adapt the scale to invasive plant cover, where zero is the lowest value on the scale, our divisions are slightly higher than the Domin scale. Use your invasive plant guide to identify common species. A list of common invasives is provided in the field sheet. List the invasive sp observed in the assessment area and sketch significant cover or invasive monocultures in the field drawing.

NOTE: Include only the invasive cover in the vegetation assessment area (typical of the whole wetland). If you find small patches of invasives that should be controlled outside of the vegetation assessment area, report these in the comments section.

VALUE ADDED METRIC *The points in this section are counted separately from the stressor scores and are used to prioritize a site or wetland complex for protection over wetlands with similar scores.*

The stressor list characterizes the types and extent of degradation to a site but does not take into account the value or function of the type of wetland or habitat regardless of condition (Fennessey et al. 2004). Once the condition has been determined using the stressor rankings, the value added metric assigns separate points for rare/threatened/endangered plants and/or habitat for fauna. Special wetland communities as defined by the New York Natural Heritage Program are also noted in this section.

Presence of rare/endangered plants: Be sure to initial if the section was completed. If no rare/endangered plants were found check "None".

Special Wetland Community: As determined by the New York Natural Heritage Program. The Red Maple-Sweetgum Swamp is assigned an S1 state rarity rank as there are only an estimated 10 to 30 occurrences statewide. The distribution of this community is primarily concentrated in Staten Island[4].

III.d. BRIEF SITE DESCRIPTION AND DRAWING:

Create a simple drawing of the site with descriptive landforms, adjacent land use, vegetation zonation, areas of invasive species, unusual features, and the location of the Vegetation Assessment Area. Indicate the direction and location of photos with an arrow. See example in Appendix C. Indicate the position from which photographs were taken on this sketch. A good site drawing and description can help one return to the assessment area if follow-up is needed.

Photos Photograph representative areas of the wetland. Include at least one photo taken from the assessment area. Include photos of any unusual features or stressors such as erosion. Begin with

[4] New York Natural Heritage Program. Department of Environmental Conservation. http://www.nynhp.org/

a photograph of the Field Form with the name of the wetland clearly focused. Write down the camera used on the Field Map and indicate the location and direction of the photo.

Average DBF of Five Largest Trees *This section is only to be completed for forested wetlands. If not a forested wetland write N/A.* This is to be measured within the Vegetation Assessment Area. Although not a sign of stress, this metric provides valuable information about the successional state of a wetland. Tree DBH, also known as Diameter at Breast Height, is the outside bark diameter at breast height. Breast height is defined as 4.5 feet (1.37m) above the forest floor on the uphill side of the tree. A DBH tape is used at breast height to circle the tree. Take care to use the side of the tape marked "diameter", which is printed in very small letters.

Fauna Observed in Wetland: Note any fauna seen or observed (e.g. bird calls, frog sounds, dragonflies, or damselflies).

III.e. FIELD STRESSORS

Evaluate the severity of degradation on a 0-10 score where 0 is completely unaffected and 10 is heavily impacted`. Read the descriptions in each category and assign a score based on the number associated with each description. The number listed under each description is the maximum score associated with each category. Stressors scores apply to the entire wetland (not just the vegetation assessment area.

Trash and Debris Take note of the amount of trash and debris in and around the wetland. Note the extent of trash - is it confined to one area or dispersed throughout? Look for evidence of dumping; piles of debris or large items such as cars, tires, construction waste, appliances, e-waste etc. Note the location of major trash and debris on your field drawing.

Evidence of physical disturbance in the form of trash and debris is described by Ehrenfeld (2000) as likely to reduce vegetative growth in wetlands through chemical retardation and by creating physical impediments. The presence of trash and debris is also an obvious sign of degradation that affect the public's perception of a place and the degree of stewardship with which it receives.

Trails and Roads within Site: Make note of the trails and roads in and around the wetland. The degree of impact of the road is categorized by amount of impervious, amount of fill, the type and degree of use, and the quantity of trails or roads. Use the following definitions:

Trails and roads can stress wetlands by increasing siltation due to erosion, increasing nutrients and contaminants due to storm water runoff as well as disturbing and/or creating barriers for fauna. In addition active use brings foot and vehicle traffic close to sensitive wetland areas where stress is created due to compaction, trail and road maintenance as well as the increased likeliness of dumping, arson, graffiti and other adverse actions (Spellerberg 1998). We have made a further distinction between trail and non-elevated road by using the US Forest Service's size metric (US Forest Service, 2005).

Walking/ Horse Trails – the presence of man-made dirt trails for non-motorized uses such as walking, hiking, horseback riding.

Elevated Road – (Dirt or Gravel): An elevated road is a road that has been obviously constructed and is elevated above the surrounding land (sloped sides and ditches or swales at the sides of the road).

Permeable or semi-permeable road – is created by filling the area with a natural or man-made material that is permeable to some degree. (e.g. gravel or dirt path, or narrow bikeway if it is half the width of the impervious portion of a paved one-lane road.)

Paved Road – Impervious/paved roads within the wetland complex.

Hydrologic Modifications Throughout the wetland complex make note of any hydrologic modifications to the wetland complex and approximate age of modification. The effect of the modification on the hydrology should be evaluated to determine if the structure is impeding flow to the site, is impounding flow in the site, or is conveying water to the site from off site. If the structure is impounding water in the site, the percent of the area that is impacted should be estimated. Look for evidence of:

Altered hydrology can reduce the integrity of the wetland and decrease its function. In an urbanized area such as New York City the hydrology of virtually all wetlands has been modified. The rapid assessment should include documentation of the cause of alterations to the area's hydrology. However, there are inherent difficulties in assessing underground, large –scale and/or historic alterations (Ehrenfeld 2000). For these reasons the stressor scoring system takes into account the age of the modification (historical modifications are given a lower score) and the degree to which the wetland has adapted to the modification, and depends only on visible evidence in the field.

Ditches – Presence of man-made ditches within the assessment area, constructed in areas that were not former streams for the purpose of conveying water into or out of the site.

Tile Drain – Human-related removal of excess water from the subsurface of soil intended for agriculture or construction.

Dike – An artificial earthen wall constructed as a defense or as a boundary built along the edge of a body of water, to prevent it from flooding onto an adjacent lowland.

Weir/ Dam/Roads/Railroad – Includes any man-made structure including dams, weirs, roads, railroads, culverts, etc. in a wetland that is impacting the flow of water through a site by either impounding and/or inhibiting water to the site.

Storm-water Inputs – Evidence of rain and snow runoff from the urban/suburban landscape, particularly from impervious surfaces.

Point source (non-stormwater) – A source of pollutants that that may be traced to a discrete point of emission. The pollutant discharge is from a discrete conveyance, such as effluent from the end of a pipe, or from a specific seepage site, if it can be traced to a buried or broken pipe.

Filling – man-made deposits of soil material, rock products, waste materials including organic materials such as brush and lawn clippings, etc. added to the wetland not due to a natural process. Garbage, trash and yard waste should be considered as fill if they are in amounts large enough to cover an area and raise the surface of the wetland. Soil excavated from a ditch and deposited in the wetland

- Isolated pieces of trash should be recorded under the Trash and Debris category.
- Excessive sedimentation due to alterations in the surrounding land use should not be included as fill, but recorded under the Sediment and Erosion stressor.

Grading – any excavation, filling, clearing, re-contouring of the ground surface or combination thereof.

Dredging – Removal of sediments from the wetland area. Assess whether the wetland has adapted to the historic modification occurring 10-80 years ago. An area has adapted if it is well vegetated with native species (e.g. a berm may be vegetated with native upland species). If the alteration has resulted in an influx of invasive species or is un-vegetated, it is considered notably altered. Record the extent of the effect. Recent alterations receive a higher stressor score (1-888-NYPARKS or eyes@parks.nyc.gov).

Sediment and Erosion Examine the entire wetland complex for signs of unnatural sedimentation (due to anthropogenic activities) or erosion. Focus particularly on tributaries and areas adjacent to the wetland. Note any recent construction in adjacent areas. Report active dumping in a wetland, construction in buffer, recent sediment or erosion to the phone number on page 4 of the assessment form

The intent of this assessment is to document evidence of excess sediments entering the wetland. Excess sediments can have negative consequences for aquatic life and reduce water quality function by causing death of wetland vegetation (Mahaney W. M. et al 2005)

Increased Nutrients Look for evidence of increased nutrients in and around the wetland.

Nutrient enrichment is one of the primary stressors damaging wetlands in many parts of the country. Nutrient additions increase net primary production, reduce dissolved oxygen, thereby reducing water quality, alter nutrient cycling and wetland plant community composition, and encourage the rapid proliferation of invasive plants (Brooks et al., 2002, U.S. EPA. 2002a).. The history of sewage treatment in the five boroughs as well as the proximity of these wetlands to development necessitates a category for direct discharges and dumping of organic waste.

- Examine the density of aquatic plants and algal mats. Excessive density of algae or algal mats results in water that has the appearance of green pea. Algal mats resemble green hairs, which grow in fur-like clumps along the pond bottom and edges, breaking off and floating to the surface to form dense mats. Die-offs of filamentous algae can create odorous conditions as the dead algae decays. Don’t confuse pollen on the surface of the water with algae.

- Keep an eye out for animal waste and dumping of organic waste (Christmas trees, potted plants, lawn clippings etc.)
- Look for direct discharges from septic or sewage treatment systems or gray water discharge that may contain phosphate detergents. Walk the perimeter of the wetland and tributaries looking for pipes or other inputs. Check for foul odors, turbid consistency, or excessive algal or plant growth around discharge point. Gray water discharge may produce soapy or oily films. Cleaning areas may discharge via an erosion gully.

Natural versus anthropogenic foam: If the foam smells fragrant or like perfume, it may be from a nearby spill or waste discharge pipe. Natural foam may smell fishy or earthy, and may be white, off-white, or brownish, and breaks apart easily when disturbed.

Pollutants in Standing Water Look for a visible sheen or slick on the water's surface. To check if the film is due to a pollutant and not bacterial, run a stick through the surface and note the behavior of the particles. If the sheen swirls back together immediately, it's petroleum. If the sheen breaks apart and does not flow back together, it is from bacteria or plant or animal decomposition. Note the extent of the pollutant.

Visible sheens or films can be evidence of oil or other chemicals in the wetland. The source may be runoff from automobiles, ATVs or other motorized vehicles, or from point-sources such as a spill or direct inputs from cleaning facilities. These inputs are harmful to wetland flora and fauna and degrade the wetland ecosystem. Although an expansive analysis of concentrations of different pollutants would give us quantitative data; this quick check of surface films and foams provides a cost-effective and rapid method for pollution assessment

Vegetation Alteration Make note of disturbances to the vegetation within the wetland area. Evaluate whether all expected strata (canopy, shrub layer, herbaceous layer) are present and if they are degraded.

Vegetation provides a sensitive measure of impacts to wetland ecosystems because vegetation responds to physical and hydrologic alterations and changes in water quality (USEPA 2002b). Wetland vegetation is the base of the food chain and, as such, is a primary pathway of energy flow and function in the system. Vegetation also provides critical habitat structure for a variety of wildlife, including amphibians, fish, birds and mammals. Often "desire lines" due to heavy foot traffic severely compact soil and prohibit growth of understory and shrub layers. The degree of alteration to vegetation is a quick, logical and repeatable way to measure the wetland's response to stress.

Look for evidence of the following, if no evidence is apparent, yet an expected strata is missing or severely damaged, it should be scored and noted:

Tree cutting – tree stumps with obvious mechanical cut marks with or without vegetative regrowth

Brush cutting – shrubs with obvious mechanical cut marks or piles of brush debris

Excessive herbivory – Look at the understory plants including shrubs and tree seedlings. Examine the terminal shoots to see if they are intact or if a browse line exists where they have been nipped off by deer or other animal. Also look for evidence of muskrats, which would be represented as floating stems in the water and a prominent browse line. Look for infestation by gypsy moth; characteristic egg masses and defoliation, especially on oaks, apple, alder, aspen, basswood, birch, poplar, willow, hawthorn, hemlock, tamarack (larch), pine, spruce, and witch hazel. The gypsy moth caterpillar has five pairs of blue spots followed by six pairs of red spots along its back. The eastern tent caterpillar has a white line down its back with light blue and black spots on its sides. The forest tent caterpillar has white footprint-shaped marks down its back and light blue stripes on its sides.) Look for evidence of viburnum leaf damage that may be indicative of the viburnum leaf beetle. Record the extent of herbivory.

Evidence of chemical defoliation – Look for shrubs or herbs (in groups) with most or all leaves pale, yellow, or yellow-white, brown, spotted with damage (not holes in leaves, but dead portions), malformed or curled.

Dominance of upland species – Trees tolerating drier soils: Striped maple, sugar maple, black birch, paper birch, hickories, common hackberry, American beech, white ash, black walnut, eastern red cedar, tulip tree, red mulberry, pines, toothed aspen, quaking aspen, wild black cherry, chokecherry, scarlet oak, blackjack oak, chinquapin, chestnut oak, post oak, black oak, American linden, Canadian hemlock). Shrubs tolerating drier soils: New Jersey tea, sweet fern, ironwood, round leaf dogwood, hawthorns, huckleberry, shrubby St, Johnswort, mountain laurel, sumacs (except poison sumac), dogberry, blackberry, raspberries, lowbush blueberry, maple-leaved viburnum.

Presence of Invasive Species (in Whole Wetland) Record the estimated presence of all invasive species in the whole wetland. Circle the species present on the list provided

The presence of invasive plant species can radically change the community composition of wetland plants thereby reducing or eliminating wildlife habitat. Mono- dominant stands are a strong sign of a degraded ecosystem. Increasing percent cover of invasives is used to quantify this stressor. This is a reliable and robust measure because percent cover is quantitative and easy to estimate in a rapid assessment (Jacobs, 2007).

DATA RECORDING AND ARCHIVING INSTRUCTIONS

Assessment Data Sheets

Data sheets must be returned to the office as soon as possible for transcription and archiving. Scan the completed data sheets and archived them in the grants WRAP Field Data Results folder. Enter all data from the completed field data sheets to the WRAP_Data_2009 Excel file for digital archiving and future analysis. Comprehensive data is input into the "Field" excel sheet. A subset of the data is copied and pasted into the "For GIS_clear" sheet for later import into the GIS wetland map.

GPS Data

Newly acquired data from the GPS unit should be transferred to the NRG GIS Project Manager (Craig Mandel or other), to download to the server. See Appendix G. ArcPad Steps for Wetlands Rapid Assessment GPS: Protocol for Downloading Data.

Converting and Recording Buffer Results

The buffer stressor score values are calculated and manually entered in a summary excel file according to directions in the Buffer Analysis section of the Field Data Form and in the protocol section II. Buffer Condition, above and the Buffer Analysis Appendices. Final Buffer Stressor Scores are input to the main Excel WRAP data sheet.

Photograhic Archive

All photographs should be copied into the Photos folder into the appropriate borough's folder. Photographs should reside within folders for each park. Name the photo using the following convention:

- First, use the name of the site (e.g. AmTr_1)
- Second, the number of the photo with assessment areas first, other landscape photos second, stressors third, and interesting details or special species fourth.
- Additionally, if multiple shots are taken from the same point, add the letters a, b, c, etc. if directions are not known, and add N, S, E, W or a combination of these if the direction of the view is known.

Additional data and descriptions are written in the Summary field of the Photograph (right click the photograph's name in Microsoft Explorer, choose properties, choose the summary tab).

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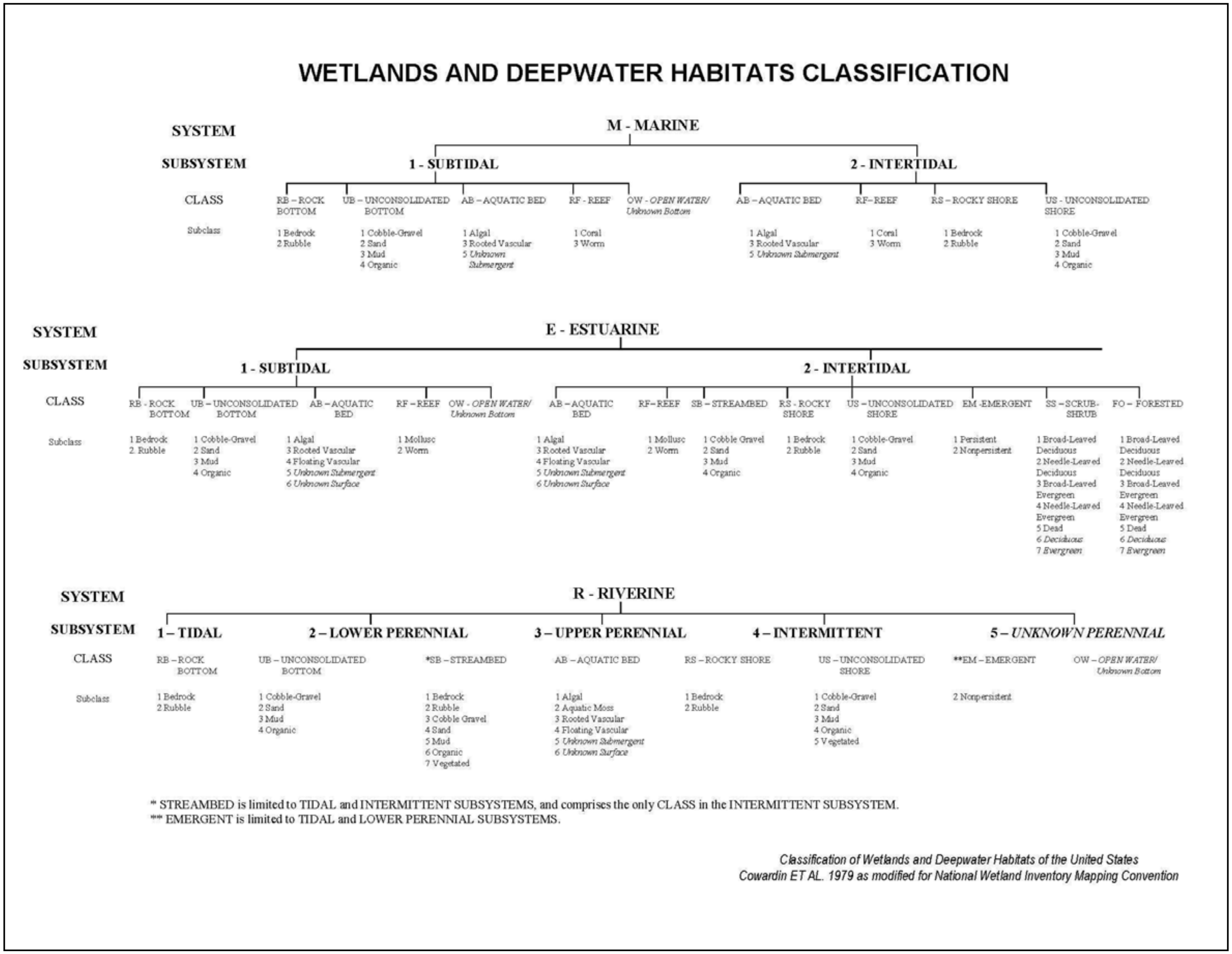


Figure 2. **Cowardin Classification table: Marine, Estuarine, and Riverine Wetlands (Cowardin et al. 1979).**

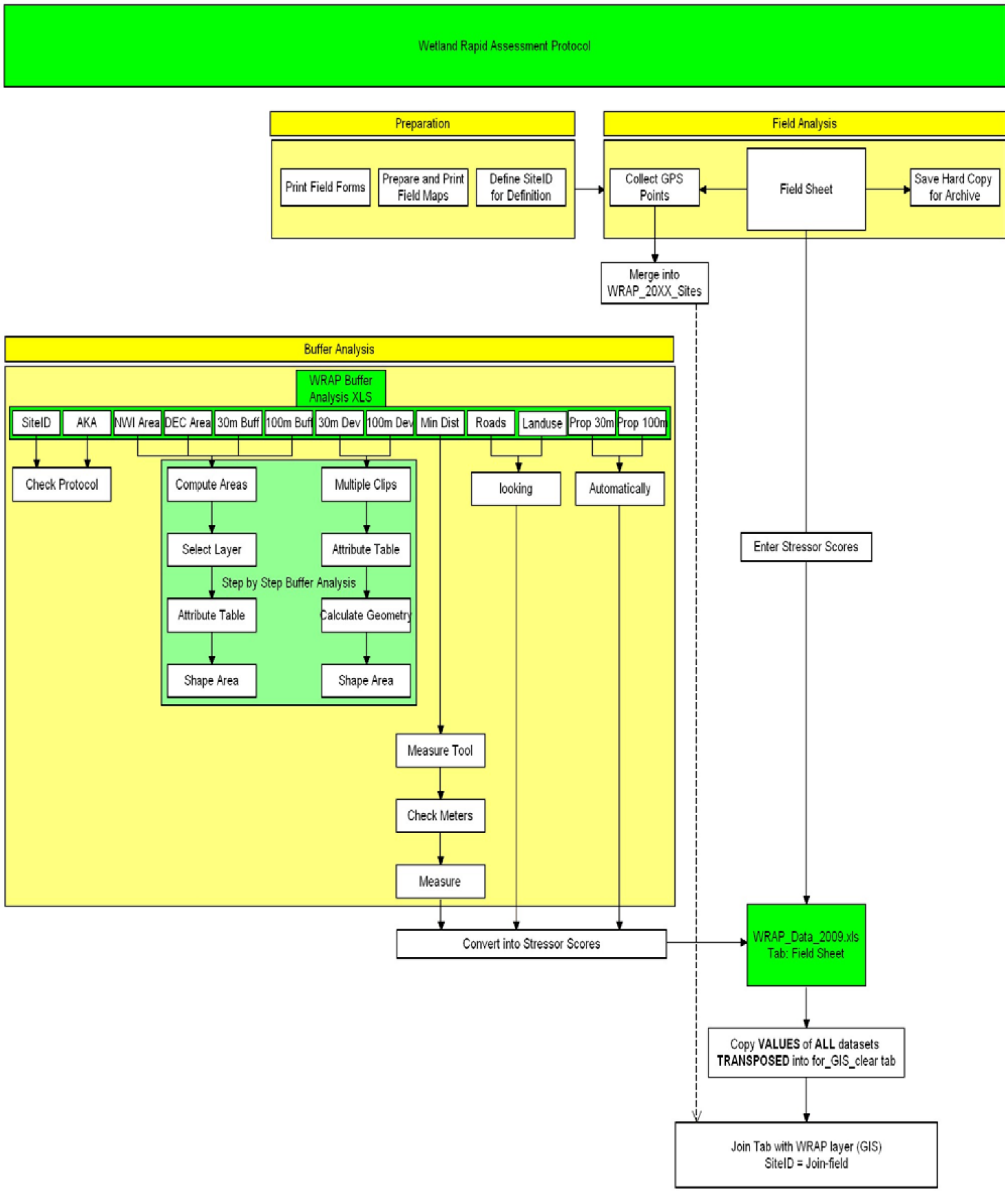


Figure 3. Relationship between the office, field, and GIS components of the Wetlands Rapid Assessment Protocol

Table 2. Hydrogeomorphic (HGM) Classification of Wetlands showing associated dominant water sources, hydrodynamics, and examples of subclasses. Adapted form Burkhardt, 1996.

Hydrogeomorphic class	**Dominant water Source**	**Dominant hydrodynamics**	**Examples of subclass**
Riverine	Overbank flow from channel	Unidirectional, horizontal	Bottomland hardwood forests, Riparian forests
Depressional	Return flow from groundwater and interflow	Vertical	Prairie potholes, marshes, vernal pools, kettle ponds
Slope	Return flow from groundwater	unidirectional, horizontal	Fens, seeps, springs, wet meadows
Flats (mineral/organic soil)	Precipitation	Vertical	Wet pine flatwoods, peatlands, interfluves, large floodplain terraces (Everglades)
Tidal and Lacustrine Fringe	Overbank flow from estuary, Overbank flow from lake	Bidirectional, horizontal	Chesapeake Bay marshes, Great Lakes marshes

APPENDIX A: FIELD FORM

Lacustrine and Paulstrine Freshwater Rapid Assessment Data Form   New York City Department of Parks and Recreation, Natural Resources Group

I. LANDSCAPE LEVEL DATA-Complete in Office with GIS and Field Verify			
Park Name:	**Borough:**	**Site ID:**	
		Name of Associated Waterbody/stream:	
Mapped Hydric Soil? Yes No Unknown		**Area of Wetland Polygon:** DEC m^2 NWI m^2	
NWI CODE (GIS Cowardin Classification): Same as observed in field? **Yes** ☐ **No** ☐ **If No, Describe:**			

II. BUFFER CONDITIONS- Field Estimate and GIS Calculation				
Parameter	**Optimal**	**Sub-optimal**	**Marginal**	**Poor**
1. Minimum Distance from Wetland Edge to Development	>100m (>300ft)	100-30m (300-90ft)	30-5m (90-15ft)	5-0m (15-0ft)
Max. Score	0	4	7	10
Field Verification: Is distance consistent with GIS calculation? Yes No FIELD SCORE: GIS SCORE				
Comments:				
2. Proportion Developed within 30m of Wetland Edge	0	0-3%	3-10%	>10%
Max. Score	0	4	7	10
Field Verification: Is distance consistent with GIS calculation? Yes No FIELD SCORE: GIS SCORE				
Comments:				
3. Most Intense Land Use (within 30m of Wetland Edge)	Natural Area (Preserves, Forested Area, Meadow)	Open Space: Managed Lawn, Outdoor Recreation (Athletic Fields, Golf courses, etc)	Single or Dual Family Residential	Apt Complex/Public Facilities/Institutions/ Parking Lot /Utilities/ Manufacturing/ Commercial/ Industrial
Max. Score	0	4	7	10
Field Verification: Is distance consistent with GIS calculation? Yes No FIELD SCORE: GIS SCORE				
Comments:				
4. Roads -Most Intense Type (within 30m of Wetland Edge)	No roads	Mostly dirt or gravel. The road material is permeable or semi-permeable	Mostly 2-lane paved. Road material is impermeable.	Mostly 4-lane paved or direct run-off into wetland. Road material is impermeable.
Max. Score	0	4	7	10
Field Verification: Is distance consistent with GIS calculation? Yes No FIELD SCORE: GIS SCORE				
Comments:				

III. FIELD ASSESSMENT

III.a.Site Condition and Classification

Park Name:	**Site ID:**	**Borough:**
Date:	**Time:**	**Evaluators:**
GPS Coordinates: ,		**Current Weather:**
Current Water Conditions: Unknown Drought Flooding Normal		Da**ys Since Last Precipitation:**
Within DEC Wetland Boundary? Yes No		**HGM Classification:**
Unmapped Wetland? (Neither NWI or DEC) Yes No		Riverine Slope Tidal Fringe Depressional Soil Flats Lacustrine Fringe
Buffer Condition (return to page 1, verify GIS data): Yes No		**Vernal Pool?** Yes No

III.b. Geophysical Conditions

Is there standing Water?

Photo #__________
draw location on page 4

if NO

Complete Wetland Verification

Depth to saturation: ______________ cm

Wetland Hydrologic Indicators:

Check all that apply

- ☐ Drift lines
- ☐ Sediment deposition
- ☐ Water marks
- ☐ Water stained leaves
- ☐ Morpholigical plant adaptations
- ☐ Hydric Soils? (See criteria below)

if YES

Depth of standing water at 1m from edge: ________ cm

Depth of standing water at 2m from edge: ________ cm

Maximum depth of standing water: ________ cm

(if under knee height)

pH ________ Dissolved Oxygen ________

2 meters from edge at the surface

Hydric Soil Criteria:

- ☐ Organic Peat and/or muck in top 20 cm
- ☐ Sulfidic Odor
- ☐ Gleyed or Low-Chroma Colors
- ☐ Redox concentrations: masses, concretions, pore linings (incl. oxidized root channels)
- ☐ High Organic Content in Surface Layer of Sandy Soils
- ☐ Organic (dark) streaking in Sandy Soils

Profile Description   Where the matrix chroma is "2" or less at 10" to 20" below the surface in a mineral soil, the soil is hydric.

Depth (inches-beginning and end)	Matrix Color (e.g. 10YR 3/2)	Redoximorphic Features: Redox concn Color (Mottles) (e.g. 10YR 4/4)	Redoximorphic Features: % Abundance of Redox concn (e.g. 25%)	Texture, Concretions, Structure (e.g. clayey, Fe/Mn concretions)
____________	____________	____________	____________	____________
____________	____________	____________	____________	____________

Special Soil Color   red parent material   Yes   No

APPENDIX A: FIELD FORM

Lacustrine and Paulstrine Freshwater Rapid Assessment Data Form New York City Department of Parks and Recreation, Natural Resources Group

III.c. VEGETATION (in the 10 m diameter Assessment Area) *If there are numerous distinct vegetation communities complete multiple forms.*

ID Dominant Species (>20% COVER) in each strata (Trees, Shrubs, Herbs, Vines and Emergents).

Photo #______________

draw locations on page 4

TREES AND SAPLINGS(> 3m)

1. ______
2. ______
3. ______
4. ______
5. ______

SHRUBS (< 3m or a multi-stemmed woody plant)

1. ______
2. ______
3. ______
4. ______
5. ______

HERBS/GRAMANOIDS

1. ______
2. ______
3. ______
4. ______
5. ______

VINES

1. ______
2. ______
3. ______
4. ______
5. ______

SUBMERGED and/or FLOATING AQUATIC

1. ______
2. ______
3.
4. ______
5. ______

Parameter	Optimal	Sub-optimal	Marginal	Poor
Presence of Invasives	None	< 5% to 25%	>25% to 75%	>75%
Max. Score	0	4	7	10

Score: Comments:

COMMON INVASIVES		SUBMERGED OR FLOATING AQUATIC INVASIVES	
Asiatic Bittersweet (Celastrus orbiculatus)	Garlic Mustard (Alliaria petiolata)	Fanwort (Cabomba caroliniana)	Water Lettuce (Pistia stratiotes)
Amus Honeysuckle (Lonicera maackii)	Common Reed (Phragmites australis)	Eurasian Water Milfoil (Myriophyllum spicatum)	
Japanese Honeysuckle (Lonicera japonica)	Mugwort (Artemisia vulgaris)	Crispy-leaved Pondweed (Potamogeton crispus)	
Porcelain Berry (Ampelopsis brevipedunculata)	European Alder (Alnus glutinosa)	Hydrilla (Hydrilla verticillata)	Rock Snot (Didymosphenia geminata)
Bittersweet Nightshade (Solanum dulcamara)	Tree of Heaven (Ailanthus altissima)	Parrot Feather (Myriophyllum aquaticum)	
Purple Loosestrife (Lythrum salicaria)	Norway Maple (Acer platanoide)	Common Water Hyacinth (Eichhornia crassipes)	European Frogbit (Hydrocharis morsus-ranae)
Japanese Stilt Grass (Microstegium vimineum)	Kudzu (Pueraria Montana)	Water Chestnut (Trapa natans)	
Japanese Knotweed (Fallopia japonica)	Multiflora Rose (Rosa multiflora)	Floating Primrose Willow (Ludwigia peploides)	
Mile-a-Minute Weed (Polygonum perfoliatum)	Other	Other	

III.d. Brief Site Description and Drawing *(Include description of site, approximate scale of drawing, adjacent land use, roads, trails, vegetation zonation, faunal observations, and location of Assessment Area. Include location and direction of photographs taken with ↑.*

Camera Model/Type: ___________________________

Photos-Show location and view direction of: Assessment Area, Stressor Points,Special Species

Fauna Observed in Wetland

Average DBH of 5 largest trees within the Assessment Area

"HOT SPOT" Reporting: (Who do I contact if I observe…?)

Active dumping in a wetland, construction in buffer, recent sediment or erosion, graffiti, or unsafe conditions (describe):

Report to Central Communications: 1-888-NYPARKS or eyes@parks.nyc.gov

New invasive - including those underlined on pg 7 or small patch of invasive (describe) and report to supervisor

APPENDIX A: FIELD FORM

Lacustrine and Paulstrine Freshwater Rapid Assessment Data Form   New York City Department of Parks and Recreation, Natural Resources Group

III.c. FIELD STRESSORS

Each assessment element can be rated with a value of 0 to 10. Unless otherwise directed, assign the lowest score that applies.

WETLAND ANALYSIS- Complete in Field- Apply to whole wetland or wetland complex

Parameter	Optimal	Sub-optimal	Marginal	Poor
1. Trash and Debris	No evidence of trash or dumping	Scattered trash and debris throughout the site (cans, bottles, plastic bags etc).	Trash and debris is abundant within the site, or larger trash is present (tires, evidence of partying, etc).	Evidence of dumping (piles of debris or large items) including abandoned cars, car parts, e-waste or large piles of debris.
Max. Score	0	4	7	10
SCORE: Comments:				
2. Trails and Roads	No trails or roads	Lightly used walking trail. Road is permeable.	Active walking, horse or bike trail or non-elevated road (dirt, ATV, etc.). Road is permeable or semi-permeable.	Active elevated road (dirt or gravel) or paved road. Road is impermeable.
Max. Score	0	4	7	10
SCORE: Comments:				
3. Hydrologic Modifications	No modification to the wetlands is evident OR, historic alterations (past 10-80 years) have allowed high quality habitat.	Hydrology has been altered historically (past 10- 80 years). Evidence of a ditch, drain, dike, berm, weir/dam, roadbed/ railroad, stormwater inputs/culvert, filling/grading, excavation, or flow diversion. Low intensity alteration that affects a small portion of the wetland or the natural area has adapted (e.g. berm is vegetated with trees shrubs and ground cover).	Hydrology has been altered historically in the past 10-80 years. Wetland area appears notably altered. (e.g. area is dominated by invasive or upland plants, or is un-vegetated)	Hydrology has been altered recently. Noticeable alteration adversly affects a significant proportion of the wetland.
Max. Score	0	4	7	10
SCORE: Comments:				

4. Sediment and Erosion	There is no evidence of an anthropomorphic source of sediment or erosion.	There is evidence of sediment loading to the tributaries or adjacent areas wetland (erosion or sediment deposits/plumes). OR There is evidence of off-road vehicle use.	There is evidence of direct sediment loading to the wetland (erosion or sediment deposits/plumes).	There is active or recent construction adjacent to the site. There are no visible or inadequate erosion/sedimentation barriers and there is evidence of sedimentation.
Max. Score	0	4	7	10
SCORE: Comments or N/A:				
5. Increased Nutrients	There is no sign of increased nutrients. There are only low densities of aquatic plants (duckweed) or algal mats, no signs of deposition or dumping of organic waste (lawn cuttings, old potted plants, etc.), and no evidence of direct discharges from a septic, sewage, or cleaning system.	There is a moderate density of aquatic plants (duckweed), or algal mats (6-25% cover of water surface) OR some deposition/dumping of organic waster (lawn cuttings, old potted plants etc). Algal mats resemble green hairs, which grow in fur-like clumps along the pond bottom and edges, breaking off and floating to the surface.	High density of aquatic plants or algal mats (25-50% cover of water surface) OR excessive deposition/dumping of organic waste (large piles of organic debris).	Excessive density of aquatic plants or algal mats (> 50% cover of water surface). AND/OR Water has the appearance of green pea soup (not surface pollen). AND/OR Septic odor.
Max. Score	0	4	7	10
Score: Comments:				
6. Pollutants in Standing Water	No visible sheen on water surface except evidence of rainbow film due to bacteria (run stick through film – film will break into pieces and remain broken)	Visible film on water due to petrochemicals (run stick through film - film will break into pieces then come back together). Present but not widespread	Visible film on water due to petrochemicals (run stick through film – film will break into pieces then come back together). Present at significant levels and widely distributed	
Max. Score	0	4	10	
Score: Comments or N/A:				

7. Vegetation Alteration	Vegetation cover is not visibly altered. All vegetation strata expected is present. No evidence of tree cutting, brush cutting, excessive herbivory (no signs of deer, muskrats, gypsy moth, rabbits, or viburnum beetle), or evidence of chemical defoliation. The presence of upland species is consistent with the topology.	Vegetation is moderately altered. Although all strata are present, there are small gaps in coverage. Evidence of tree cutting, brush cutting, aquatic weed control, excessive herbivory, or chemical defoliation. Minor tree or brush cutting or chemical defoliation consistent with park maintenance of trails, etc.	Vegetation has been severely altered. Not all expected strata are present, or all are present but there are substantial coverage gaps, or upland species dominate.	
Max. Score	0	4	10	
Score: Comments:				
8. Presence of Invasives in Whole Wetland	None	< 5% to 25%	>25% to 75%	>75%
Max. Score	0	4	7	10
Score: Comments:				

III.f. Value Added Metric (Special Wetland Communities and Rare/Endangered Species)

These points are counted seperately from stressors and prioritize a region for protection

Presence of Rare/Endangered Plants (circle) :

Primrose-leaf violet *(Viola primulifolia*)
Soapwort gentian (*Gentiana saponaria*)
Eastern gama grass (*Tripsacum dactyloides*)
American featherfoil (*Hottonia inflata*)
American Strawberry Bush (*Euonymus americanus*)
Sweet Bay Magnolia (*Magnolia virginiana*)
Swamp Cottonwood (*Populus heterophylla*)
Southern Dodder (*Cuscuta obtusiflora var. glandulosa*)
Button-bush Dodder (*Cuscuta cephalanthii Engelm* .)
Square-stemmed spike rush (*Eleocharis quadrangulata*)

Willow Oak (*Quercus phellos*)
Persimmon (*Diospyros virginiana*)
Possumhaw (*Ilex decidua*)
Slender Blueflag (*Iris prismatica*)
Cat-tail sedge (*Carex typhina*)
Other
None

Special Wetland Communities:

Red Maple- Sweetgum Swamp
Vernal Pool
Mature Forested Wetland
Threatened/endangered fauna observed:
____
Migratory songbird/waterfowl habitat:
Species seen ___________________
Other: _____________________
No special wetland community_____

THIS SECTION WAS COMPLETED _______***(initial)***

VI. Common Wetland Vegetation in NYC

Trees

(Acer negundo) Box Elder FAC+
(Acer rubrum) Red Maple FAC
(Acer saccharinum) Silver Maple FACW
(Fraxinus pennsylvanica) Green Ash FACW
(Liquidambar styraciflua) Sweet Gum FAC
(Nyssa sylvatica) Black Gum FAC
(Populus deltoides) Cottonwood FAC
(Populus heterophyllum) Swamp Cottonwood FACW+
(Quercus bicolor) Swamp White Oak FACW+
(Quercus palustris) Pin Oak FACW
(Salix nigra) Black Willow OBL
(Ulmus americana) American Elm FACW-
(Baccharis halimifolia) Eastern Baccharis FACW

Shrubs

(Aronia sp.) Chokeberry FAC(W)
(Iva frutescens) Jesuit's Bark FACW+
(Viburnum denatum) Northern Arrowwood FACW-
(Clethra alnifolia) Sweet Pepperbush FAC+
(Cornus amomum) Silky Dogwood FACW
(Lindera benzoin) Spicebush FACW-
(Salix discolor) Willow OBL
(Sambucus canadensis) Common Elderberry FACW-
(Vaccinium corymbosum) Blueberry FACW-
(Decodon verticillatus) Swamp Loosestrife OBL
(Cephalanthus occidentalis) Buttonbush OBL

Vines

(Smilax sp.) Catbriar/Greenbriar

(Toxicodendron radicans) Poison Ivy

Herbs and Graminoids

(Aster novae) New England Aster FACW-
(Aster novi-belgii) New York Aster FACW+
(Boehmeria cylindrica) False Nettle FACW+
(Carex sp.) Sedge OBL
(Sagittaria spp.) Arrowheads OBL
(Eupatoriadelphus fistulosus) Hollow-stemed Joe-Pye-weed FACW
(Hibiscus moscheutos) Rosemallow OBL
(Impatiens capensis) Jewelweed FACW
(Juncus effusus) Common Rush FACW+
(Symplocarpus foetidus) Skunk Cabbage OBL
(Typha latifolia) Broadleaf cattail OBL
(Peltandra virginica) Arrow Arum OBL
(Alisma subcordatum) Water Plantain OBL

APPENDIX B. Stream Rapid Assessment Protocol Field Form

I. Landscape Level Analysis-OFFICE

Park Name:	**Borough:**	**Site ID-Segment Code:**
		Name of associated waterbody (DS / US) :
Stream Name:	**Watershed:**	**Name of associated wetland (DS / US) :**
		Mapped 2001 Hydro layer? (Y/N)
NWI CODE (GIS Cowardin Classification):		**Mapped 2006 Hydro layer? (Y/N)**
Same as observed in field? Yes ☐ No ☐(Describe)		**Mapped elsewhere? Source:**_______________
Within DEC Wetland Boundary?	Yes No Partial	**Unmapped Wetland? (Neither NWI or DEC)** Yes No
APPROX FLOODPLAIN WIDTH		**Unmapped Stream?** Yes No
VALLEY CROSS SECTION WIDTH		

II. Field Assessment

Date:	**Time:**	**Evaluators:**

GPS Coordinates:	Description (e.g. upstream and downstream ends of reach)	**GPS Coordinates:**	**Description**
,		,	
,		,	
,		,	

Temperature: (Air) _____°C (Water) _____°C **Current Weather:**

Past 48 hr. weather:

FLOW CONDITIONS:	Ephemeral	Perrennial	Intermittent	Undetermined
(Check)	__________	__________	____________	______________

APPROX FLOODPLAIN WIDTH (if not determined above in GIS, calculate using space above)

SUBSTRATE SIZE (Check if Pebble Count conducted ____________)

Dominant (check up to 2)

Bedrock ____ Boulder ____ Cobble ____ Gravel ____ Sand ____ Silt/Clay ____ Concrete/Riprap ____

Sub-dominant (if >~25% cover) Check up to 2

Bedrock ____ Boulder ____ Cobble ____ Gravel ____ Sand ____ Silt/Clay ____ Concrete/Riprap ____

DOMINANT STREAM TYPE (Circle one)

Alluvial:	Pool/riffle	Planebed/Straight	Dune/Ripple	Step-pool
	Meandering	Backwater	Braided	
Threshold:	Bedrock		*Other:*	Channelized
Altered:	Yes No	Describe: ______________________________		

ID Dominant Species (>20% COVER) in each strata (Trees, Shrubs, Herbs, Vines and Emergents).

TREES (Total % Cover of Layer = ______)

	FLOODPLAIN	BANK
1.		
2.		
3.		
4.		
5.		

SHRUBS (Total % Cover of Layer = ______)

	FLOODPLAIN	BANK
1.		
2.		
3.		
4.		
5.		

HERBS/GRAMANOIDS (Total % Cover of Layer = ______)

	FLOODPLAIN	BANK
1.		
2.		
3.		
4.		
5.		

VINES

	FLOODPLAIN	BANK
1.		
2.		
3.		
4.		
5.		

SUBMERGED and/or FLOATING AQUATIC

1. ______
2. ______
3. ______
4. ______
5. ______

IV. Value Added Metric (Special Wetland Communities and Rare/Endangered Species)

These points are counted seperately from stressors and prioritize a region for protection

Presence of Rare/Endangered Plants :

Primrose-leaf violet ______
Soapwart gentian ______
Square-stemmed spike rush____
Eastern gamma grass ______
Southern Dodder ______
______
American featherfoil ______
Iris prismatica ______
______

Swamp Cottonwood______
Willow Oak______
Persimmon______
Possum Haw______
American Strawberry Bush______
Sweet Bay Magnolia______
Other ______
None ______
THIS SECTION WAS COMPLETED ______
(initial)

ADD INVERTS

Stoneflies (Plecoptera)
Caddisflies (Trichoptera)
Mayflies (Ephemeroptera)

Threatened/endangered fauna observed:
______
Migratory songbird habitat:
Other: ______

V. Brief Site Description and Drawing *(Include description of site, approximate scale of drawing, adjacent land use, vegetation zonation, location of Assessment Area, trails, and exact location of any permanent monitoring plot. Link vegetation zonation to dominant cover table (III) as needed.)*

Invertebrates Observed in Wetland

Tally Large Woody Debris (LWD)

> 10 cm diameter & > 1m long ____________________
log jams ____________________

"HOT SPOT" Reporting: (Who do I contact if I observe…?)

Active dumping in a wetland, construction in buffer, recent sediment or erosion, graffiti, or unsafe conditions (describe):

Report to Central Communications: 1-888-NYPARKS or eyes@parks.nyc.gov

New invasive or small patch of invasive (describe) and report to supervisor

III. SEGMENT SURVEY SHEET

Minimum survey length = 20 x stream length Make all observations while walking UPSTREAM

Segment Code: **Stream Name**

Section A: General Characteristics

1.Describe location and extent of segment (i.e. from _____ to _____)Indicate any landmarks or roads that would help locate your segment:

START ____

END ____

REPEAT IF SAME CHANNEL CONDITIONS AFTER STREAM DISRUPTION

START ____

END ____

2.**Measure the depth and the width of the stream at four points along the segment.** Record the values in the chart below

Then add the values and divide by 4 to find your averages.

Location (straight reach, or describe)			
Typical Point	**Bankfull Wi** (m) / (ft)	**Bankfull Depth** (m) / (ft)	**Note**
Point 1			
Point 2			
Point 3			
Point 4			
Average			

STRESSOR	Y/N (Describe)	GPS (yes/no)	
Dam			
Trail Crossing Stream			
Vehicle Crossing			
ATV use			
Outfall			
Water Quality Issue			
Encampment area			
Hiking Trail			
Large litter			
Other			

3. **Estimate the number of Pools: (****TALLY AS YOU DO STREAM WALK****)**

☐ Check if there are no pools

☐ Check if currently no flowing water

\# Pools

	Location (straight reach, ben	**A) Max depth (m)**	B) Min depth at downstre	**Residual pool depth (A-B)**
Pool 1				
Pool 2				
Pool 3				
Average				

Section B: STREAM CONDITION SCORING

WALK THE ENTIRE SEGMENT AND MAKE NOTES ON EACH CHARACTERISTIC IN THE SPACES PROVIDED. RATE EACH PARAMETER AFTER COMPLETING THE ENTIRE STREAMWALK ON YOUR SEGMENT. EACH ASSESSMENT ELEMENT CAN BE RATED WITH A VALUE OF 1 TO 10. RATE ONLY THOSE ELEMENTS APPROPRIATE TO THE STREAM SEGMENT YOU ARE ASSESSING. USE THE SEGMENT SURVEY SCORE SHEET TO RECORD THE SCORE THAT BEST FITS THE OBSERVATIONS YOU MAKE BASED ON THE NARRATIVE DESCRIPTIONS PROVIDED. UNLESS OTHERWISE DIRECTED, ASSIGN THE LOWEST SCORE THAT APPLIES.

Did you walk this whole section of the stream? YES_____ NO_____ MOSTLY_____

Scan the field sheets and transfer the scores recorded into the Excel Stream RAP File.

- -

1. CHANNEL CONDITION

What to do: Evaluate if the channel is in it's 'natural' state, or if there has been some alteration.
What to look for: Signs of channelization or straightening of the stream may include an unnaturally straight section of the stream, high banks, berms, or lack of flow diversity (i.e. if an area only has one type of flow, such as **riffles** throughout the entire segment, no pools or slow moving sections). Drop structures, irrigation diversions, culverts, bridge abutments, and **riprap** also indicate changes to the stream channel.

Natural channel; no structures, dikes. No evidence of **downcutting** or excessive lateral cutting**.**	Evidence of past channel alteration, but with significant recovery of channel and banks.	Altered channel: <50% of the length having **riprap** and/or **channelization**. Excess **aggradation**; braided channel. Structures present restrict **flood plain** width.	Channel is actively **downcutting** or widening. >50% of the reach with **riprap** or channelization. Structures prevent access to the **flood plain.**	Can not evaluate OR Not applicable
10	7	3	1	N/A

NOTES:____ **Score ________**

2. HYDROLOGY

What to do: Estimate the flooding frequency for your segment. You may know your segments flood habits just from your knowledge of your local stream.
What to look for: Evidence of flooding includes high water marks (such as water lines on trees or structures located in the buffer), sediment deposits or stream debris on stream banks or within the **floodplain**.

Flooding every 1.5 to 2 years. No evidence of dams, dikes or other structures limiting the stream's access to the **flood plain**. Channel is not **incised**.	Flooding occurs only once every 3 to 5 years; limited channel incision.	Flooding occurs only once every 6 to 10 years; channel deeply **incised**.	No flooding; channel deeply **incised** or structures prevent access to **flood plain** or dam prevents flood flows.	Can not evaluate OR Not applicable
10	7	3	1	N/A

NOTES:____ **Score ________**

3. BANK STABILITY

What to do: Estimate the size or area of the bank affected by erosion relative to the total bank area in your segment.
What to look for: Signs of erosion include unvegetated stretches, exposed tree roots, or scalloped edges. Evidence of construction, vehicular, or animal paths near banks suggests conditions that may lead to the collapse of banks. This may be hard to evaluate during high water.

Banks are stable; banks are low (at elevation of active flood plain): outside bends that are eroding are 33% or more protected with roots that extend to the **base-flow**	Moderately stable; banks are low (At elevation of active flood plain): less than 33% of eroding area of banks in outside bends is protected by roots that extend to the **base-flow** elevation.	Moderately unstable; banks may be low, but typically are high (flooding occurs 1 year out of 5 or less frequently): outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into stream, some slope failures apparent).	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream, numerous slope failures apparent).	Can not evaluate OR Not applicable
10	7	3	1	N/A

NOTES:____ **Score ________**

4. RIPARIAN ZONE

What to do: Examine both sides of the stream and note where vegetation does and does not exist.
What to look for: Compare the width of the **riparian** zone to the **active channel width**. A common problem is lack of shrubs and understory trees. Another common problem is lack of regeneration (presence of only mature vegetation and lack of seedlings).

Natural Vegetation extends at least two **active channel widths** on each side. (i.e. if stream is 2 ft. wide, the natural vegetation is 4 ft. wide on each bank.)	Natural vegetation extends one **active channel width** on each side. OR If less than one width, covers entire **flood plain**.	Natural vegetation extends half of the **active channel width** on each side.	Natural vegetation extends a third of the **active channel width** on each side.	Natural vegetation less than a third of the **active channel width** on each side. OR Lack of regeneration	Can not evaluate OR Not applicable
10	8	5	3	1	N/A

NOTES:____ **Score ________**

5. PRESENCE OF INVASIVE SPECIES IN RIPARIAN ZONE

What to do: Examine both sides of the stream and estimate the percent cover of invasive species for this reach.
What to look for: See list below of common invasives.

None	< 5% to 25%	>25% to 50%	>50% to75%.	>75%	Can not evaluate OR Not applicable
10	8	5	3	1	N/A

NOTES:____ **Score ________**

COMMON INVASIVES	Bittersweet Nightshade (Solanum dulcamara)	**SUBMERGED OR FLOATING AQUATIC INVASIVES**	
Asiatic Bittersweet (Celastrus orbiculatus)	Porcelain Berry (Ampelopsis brevipedunculata)	Rock Snot (Didymosphenia geminata)	Water Lettuce (Pistia stratiotes)
Amus Honeysuckle (Lonicera maackii)	Multiflora Rose (Rosa multiflora)	Eurasian Water Milfoil (Myriophyllum spicatum)	Fanwort (Cabomba caroliniana)
Garlic Mustard (Alliaria petiolata)	Japanese Stilt Grass (Microstegium vimineum)	Crispy-leaved Pondweed (Potamogeton crispus)	Hydrilla (Hydrilla verticillata)
Purple Loosestrife (Lythrum salicaria)	European Alder (Alnus glutinosa)	European Frogbit (Hydrocharis morsus-ranae)	Other
Japanese Knotweed (Fallopia japonica)	Mile-a-Minute Weed (Polygonum perfoliatum)	Parrot Feather (Myriophyllum aquaticum)	
Kudzu (Pueraria Montana)	Common Reed (Phragmites australis)	Common Water Hyacinth (Eichhornia crassipes)	
Japanese Honeysuckle (Lonicera japonica)	Mugwort (Artemisia vulgaris)	Water Chestnut (Trapa natans)	
Norway Maple (Acer platanoide)	Other	Floating Primrose Willow (Ludwigia peploides)	

6. WATER APPEARANCE

What to do: Evaluate the clarity of the water.

What to look for: The deeper an object in the water can be seen, the lower the amount of **turbidity**. Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. This measure should be taken after a stream has had the chance to “settle” after a storm event.

Very clear or clear but tea-colored; objects visible at depth 3 to 6 ft. No oil sheen on surface; no noticeable film on submerged objects or rocks.	Occasionally cloudy, especially after storm event, but clears rapidly: objects visible at depth 1.5 to 3 ft.; may have slightly green color; no oil sheen on water surface.	Considerable cloudiness most of the time; objects visible to depth 0.5 to 1.5 ft.; slow sections may appear pea-green; OR bottom rocks or submerged objects covered with heavy green or olive-green film. OR Moderate odor of ammonia or rotten eggs	Very **turbid** or muddy appearance most of the time: objects visible to depth <0.5 ft; slow moving water may be bright green; other obvious water pollutants; floating algal mats, surface scum, sheen or heavy coat of foam on surface; OR Strong odor of chemicals, oil, sewage, other pollutants.	Can not evaluate OR Not applicable
10	7	3	1	N/A

NOTES:____ **Score ________**

7. NUTRIENT ENRICHMENT

What to do: Evaluate the amount of aquatic vegetation present.

What to look for: Some aquatic vegetation is normal and indicates a healthy stream. Excess nutrients cause excess growth of algae and aquatic plants, which can create a greenish color to the water. Clear water and a diverse aquatic plant community without dense plant populations are optimal for this characteristic.

Clear water along entire segment; diverse aquatic plant community includes low quantities of many species of aquatic plants; little algal growth present.	Fairly clear or slightly greenish water along entire segment; moderate algal growth on stream substrates.	Greenish water along entire segment; overabundance of lush green aquatic plants; abundant algal growth, especially during warmer months.	Pea green, gray, or brown water along entire reach; dense stands of aquatic plants clog stream; severe algal blooms create thick algal mats in stream.	Can not evaluate OR Not applicable
10	7	3	1	N/A

NOTES:____ **Score ________**

8. BARRIERS TO FISH MOVEMENT

What to do: Look for barriers within the stream segment that potentially can block fish passage through the segment.
What to look for: Some barriers are natural, such as waterfalls and boulder dams. Note the presence of human developed barriers, their size and whether provisions have been made for fish passage. Beaver dams generally do pose a problem for fish migration. Also look for structures that may not involve a drop, but still present a hydraulic barrier. Small culverts or large ones with insufficient water depth and slopes may cause high water velocities that prevent fish passage.

No barriers	Seasonal low water levels inhibit movement within the stream segment.	Drop structures, culverts, dams, or diversions (<1 ft. drop) within the stream segment.	Drop structures, culverts, dams, or diversions (>1 ft. drop) within 3 miles of the segment.	Drop structures, culverts, dams, or diversions (>1 foot drop) anywhere within the stream.	Can not evaluate OR Not applicable
10	8	5	3	1	N/A

NOTES:____ **Score ________**

9. **INSTREAM FISH COVER**

What to do: Observe the number of different habitat and cover types within a representative section of your segment. Each type must be present in appreciable amounts to score.
Habitat Types to look for: Logs/large woody debris, deep pools, overhanging vegetation, boulders/**cobble**, riffles, undercut banks, thick root mats, dense beds of emergent/floating leaf vegetation, isolated/backwater pools, other:___________________

Greater than 7 habitat types available.	6 to 7 habitat types available.	4 to 5 habitat types available.	2 to 3 habitat types available.	None to 1 habitat types available.	Can not evaluate OR Not applicable
10	8	5	3	1	N/A

NOTES:____ **Score ________**

10. POOLS

What to do: Look for deep and shallow pools existing within your stream segment.
What to look for: Pool diversity and abundance are estimated based on walking the stream or probing from the streambank with a stick. You should find deep pools on the outside of meander bends. In shallow, clear streams a visual inspection may provide an accurate estimate. In deep streams or streams with low visibility, this assessment characteristic may be difficult to determine and should not be scored. See residual pool depth calculations, page 4.

Deep and shallow pools abundant; greater than 30% of the pool bottom is obscure due to depth, or the pools are at least 5 feet deep.	Pools present, but not abundant; from 10 to 30% of the pool bottom is obscure due to depth, or the pools are at least 3 feet deep.	Pools present, but shallow; from 5 to 10% of the pool bottom is obscure due to depth, or the pools are less than 3 feet deep.	Pools absent, or the entire bottom is visible.	Can not evaluate OR Not applicable
10	7	3	1	N/A

NOTES:____ **Score ________**

11. INSECT/INVERTEBRATE HABITAT

What to do: Observe the number of different types of habitat and cover within a representative section of stream. Each cover type must be present in appreciable amounts.
Habitat Types to look for: Fine woody debris, submerged logs, undercut banks, cobble, boulders, coarse **gravel**, riffles, leaf packs, root mats, other:_________________

At least 7 types of habitat available. Habitat is at a stage to allow full insect colonization (woody debris and logs not freshly fallen).	4 to 6 types of habitat. Some potential habitat exists, such as overhanging trees, which will provide habitat, but have not yet entered the stream.	2 to 3 types of habitat. The substrate is often disturbed, covered, or removed by high stream velocities and scour or by sediment deposition.	None to 1 type of habitat.	Cannot evaluate OR N/A
10	7	3	1	N/A

NOTES:____ **Score ________**

12. CANOPY COVER

What to do: Try to estimate how much of the river's corridor has tree canopy (cover). (N/A when **active channel width** is >50 feet or at meadow, grassland, etc.).
What to look for: Estimate areas with no shade, poor shade, and shade. The relative amount of shade is estimated by assuming that the sun is directly overhead and the vegetation is in full leaf-out condition.

The stream corridor has >60% canopy cover.	Average width of canopy cover is between 40 – 60%.	Average width of canopy covers between 30 and 40% of the stream channel.	Tree canopy covers <30% of the stream corridor.	Can not evaluate OR NA
10	7	3	1	N/A

NOTES:____ **Score ________**

13. EMBEDDEDNESS

What to do: Do not assess this element unless **riffles** are present or they are a natural feature that should be present. This characteristic should be used only in **riffle** areas and in streams where this is a natural feature. Estimate what percent of bottom particles are buried in sediment in the **riffle** areas.
What to look for: The measure is the depth to which objects are buried in the sediment. This is made by picking up particles of **gravel** or **cobble** with your fingertip at the fine sediment layer. Test for complete burial of a streambed by probing with a stick.

Gravel or **cobble** particles are less than 20% embedded.	**Gravel** or **cobble** particles are 20 to 30% embedded.	**Gravel** or **cobble** particles are 30 to 40% embedded.	**Gravel** or **cobble** particles are > 40% embedded.	Stream bottom is completely embedded.	Cannot evaluate OR N/A
10	8	5	3	1	N/A

NOTES:____ **Score ________**

14. TRASH

What to do: Look for trash in the riparian zone as well as the water channel itself.

No evidence of **trash** or **debris**.	Lightly scattered **trash** and **debris** throughout the site (cans, bottles , plastic bags, etc)	Trash and debris is more heavily scattered throughout the site or has accumulated in small areas.	**Trash** and **debris** is abundant within the site, or larger trash is present (tires, evidence of partying)	Evidence of **dumping** (piles of debris or large items).	Can not evaluate OR NA
10	8	5	3	1	N/A

NOTES:____ **Score ________**

APPENDIX C. Cowardin Classification Definitions (Cowardin et al. 1979)

Riverine – Wetlands with an open conduit either natural or artificial which is periodically or naturally created or links two bodies of standing water.

Lacustrine - Wetlands and deepwater habitats (1) situated in a topographic depression or dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30% areal coverage; and (3) whose total area exceeds 8 hectares (20 acres); or area less than 8 hectares if the boundary is active wave-formed or bedrock or if water depth in the deepest part of the basin exceeds 2 m (6.6 ft) at low water. Ocean-derived salinities are always less than .5 ppt.

Limnetic. – Refers to all deepwater habitats within the Lacustrine System; many small Lacustrine Systems have no Limnetic Subsystem.

Littoral. – All wetland habitats in the Lacustrine System have a Littoral Subsystem. It extends from the shoreward boundary of the system to a depth of 2 m (6.6 feet) below low water or to the maximum extent of nonpersistent emergents, if these grow at depths greater than 2 m.

Palustrine – All nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and all such tidal wetlands where ocean-derived salinities are below .5 ppt. This category also includes wetlands lacking such vegetation but with all of the following characteristics: (1) area less than 8 ha; (2) lacking an active wave-formed or bedrock boundary; (3) water depth in the deepest part of the basin less than 2 m (6.6 ft) at low water; and (4) ocean-derived salinities less than .5 ppt. The Palustrine System was developed to group the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie, which are found throughout the United States. It also includes the small, shallow, permanent or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; in isolated catchments; or on slopes. They may also occur as islands in lakes or rivers. The erosive forces of wind and water are of minor importance except during severe floods ***Classes:***

Rock Bottom The Class Rock Bottom includes all wetlands and deepwater habitats with substrates having an areal cover of stones, boulders, or bedrock 75% or greater and vegetative cover of less than 30%. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semipermanently flooded.

Unconsolidated Bottom The Class Unconsolidated Bottom includes all wetland and deepwater habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semipermanently flooded.

Aquatic Bed The Class Aquatic Bed includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Water regimes include subtidal, irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semipermanently flooded, and seasonally flooded.

Unconsolidated Shore The Class Unconsolidated Shore includes all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock; (2) less than 30% areal cover of vegetation other than pioneering plants;

and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded. Intermittent or intertidal channels of the Riverine System and intertidal channels of the Estuarine System are classified as Streambed.

Moss-Lichen Wetland Class includes areas where mosses or lichens cover substrates other than rock and where emergents, shrubs, or trees make up less than 30% of the areal cover. The only water regime is saturated.

Emergent Wetland Class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed.

Scrub-Shrub Wetland includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. All water regimes except subtidal are included.

Forested Wetland is characterized by woody vegetation that is 6 m tall or taller. All water regimes are included except subtidal.

Open Water class has an unknown bottom.

APPENDIX D. Hydric Soil Notes and Criteria

Soil Definitions (Source: Richardson & Vepraskas 2000, Hurt and Vasilas 2006 https://www.nwo.usace.army.mil/html/od-rwy/hydricsoils.pdf):

Organic Peat or Muck: Consists of muck, mucky peat, or peat, which is decomposed organic material such as leaves or moss.). Organic matter has a soft texture and dark color. It will leave a dark stain when rubbed between the fingers.

Sulfidic Odor: Rotten egg smell

Gleyed or Low-Chroma Colors: are bodies of low chroma ≤2 (intensity of color) and ≥4 value (lightness) in the Munsell Book. In effect, dull, pale colors. They are also referred to as redox depletions. NOTE: Look at wet soils in the sunlight when using the Munsell Book.

Matrix: Think of the matrix as the 'background' or primary color (≥60%of the area).

Concretions: Concretions are a kind of redox concentration (see below). Concretions are hard, generally spherical-shaped bodies made of soil particles cemented by iron oxides or hydroxides. The color is variable and can be any shade of red, orange, yellow or brown. They range in size from less than 1mm to over 15cm in diameter. Magnesium concretions and nodules can appear black or dark reddish black. Iron concretions are often <2mm when found in dark surfaces.

Redox Concentrations: Three kinds of redox concentrations have been defined: Fe masses, Fe pore linings, and Fe nodules and concretions. Iron masses are soft accumulations of Iron oxides that occur in the soil matrix, away from cracks or root channels. They can be any shape. The color is variable and can be any shade of red, orange, yellow or brown. Pore linings are accumulations of Iron oxides and hydroxides that lie along root channels or cracks. Pore linings do not need a live root in order to form. (Oxidized rhizopheres are thought to form on tissue when the root is alive.) Pore linings are generally soft, but can be cemented together. Nodules and concretions are hard, generally spherical-shaped bodies made of soil particles cemented by iron oxides or hydroxides. They range in size from less than 1 mm to over 15cm in diameter. Magnesium concretions and nodules can appear black or dark reddish black. Iron concretions are often <2mm when found in dark surfaces.

Organic Content in Surface Layer of Sandy Soil: Soft, organic material (see above) as a distinct layer (describe thickness in profile description) in the upper (describe where it begins and ends in profile description) layer of sandy soil (Figures 3 and 4, Box 4).

Organic (Dark) Streaking in Sandy Soil: Look for dark vertical streaks below the surface. These streaks represent organic matter being moved downward in the profile. When soil is rubbed between the fingers, the organic matter will leave a dark stain on the fingers. See Figures 3 and 4, Box 4 for determining Sandy Soil.

Mineral Soil Material: >85-88% mineral material by weight. (Most soils are mineral soils that consist of different proportions of silt, clay, and sand.)

Red Parent Material: Soil material with hue of 7.5YR or redder, with a matrix value and chroma of 4 or less.

Textural Analysis of Sandy vs. Loamy textures*: sandy samples won't ribbon*. Roll a ball of soil in your hand . Squeeze and push the material up across your index finger with your thumb. If the soil maintains a thin ribbon it is more clay or loam as opposed to sand.

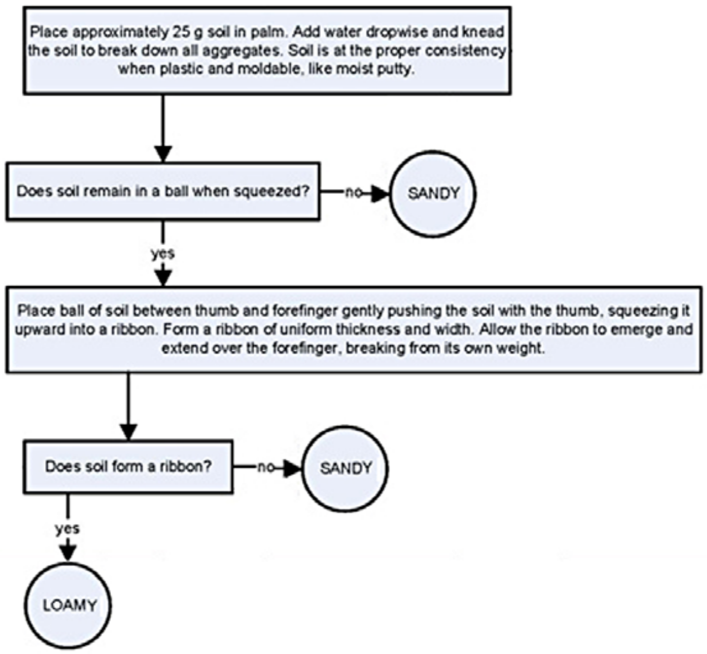


Figure 1. Determining Sandy versus Loamy soil

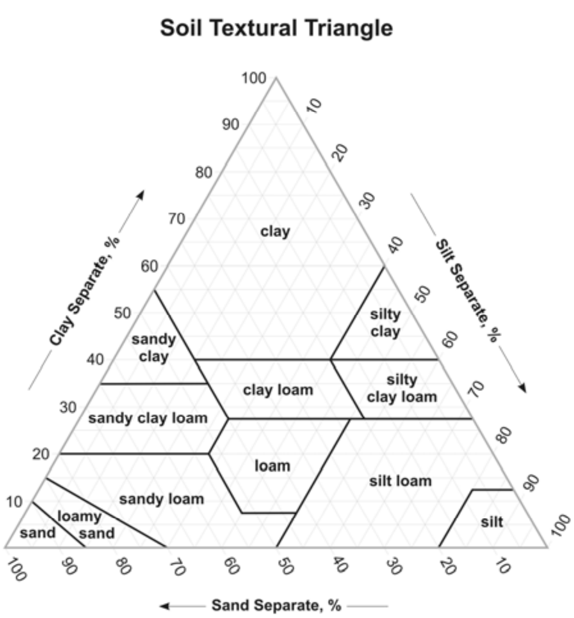


Figure 2. Soil Textural Triangle. Reference: http://soils.usda.gov/education/resources/lessons/texture/

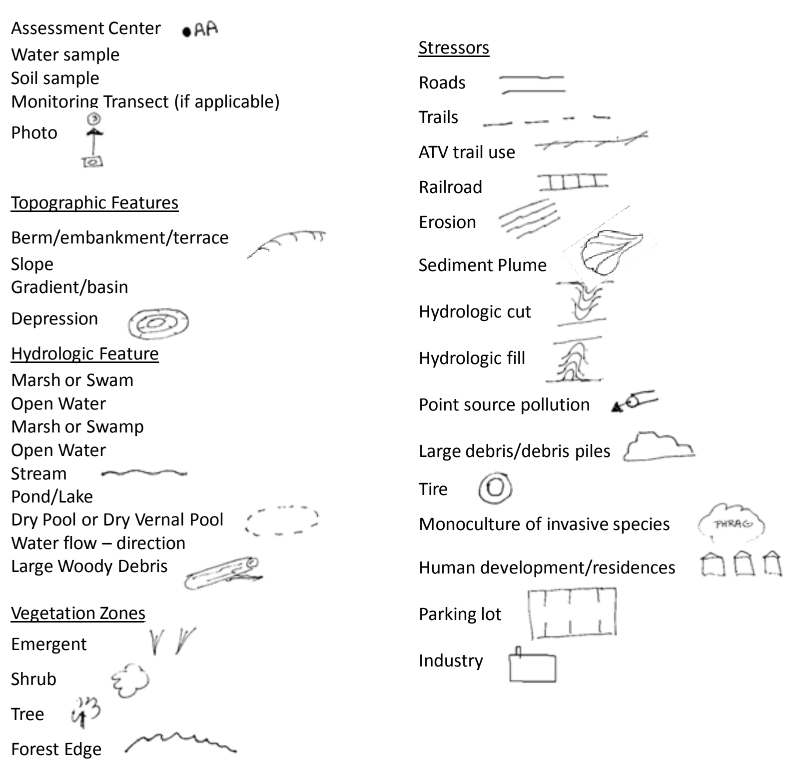
APPENDIX E. Field Sketch for WRAP

The field sketch is a quick hand-drawn plan view cartoon map completed in the field of the essential, defining landscape features at the assessment site. Size the map to encompass the entire survey area and label the north arrow.

Include and lable the following features in the field sketch:

- Center point of the WRAP assessment site for the vegetation assessment
- Location of any additional data collected, such as water quality, soil samples, and transects or plots
- Important topographic and hydrologic features such as discharge pipes, drainage ditches, culverts, streambanks or floodplains.
- Significant stressors, if observable should be represented in the sketch and labeled. If distinguishable, the buffer area, floodplain, and topographic gradients should be represented.
- Photo points (represented by arrows labeled with the picture number, e.g.).
- Structures such as trails, roads, boardwalks and such can be represented in order to orient the site and its characteristics.

The vegetation can be represented by drawing the vegetation zone, with symbols (trees, shrubs, emergents), or both. Areas of open water can be similarly represented.



APPENDIX F. GIS Layers, Maps and Buffer Analysis for WRAP

This appendix provides descriptions of the wetland GIS layers and where they are located and instructions on the GIS analysis of development in the wetland buffer. The protocols are outlined for determining the following:

- *Minimum distance from the wetland edge to development*
- *Dominant land use within the 30m and 100m buffer area around the wetlands*
- *Proportion of developed area within the 30m and 100m buffer area around the wetlands.*

Field Map Preparation

If PDF maps do not exist in (location) for the park in question, use the following procedure to create Field Maps:

- Use the SI_Wetlands_Master map located in J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\Maps\SI wetlands.
- Open the map. Turn on the the Hydroline_2001_SI layer, NYSDEC_SI_FRESHWATER_WETLANDS, NWI_WETLANDS, Aerials 2006, SI_DPR_Major_Roads, SI_DPR_Roadbed_2006, and the VW_PARKS_SI layer.
- Pan or zoom to the park in question by opening the Attribute Table of VW_PARKS_SI. Select the Park in the field by clicking the far left of that row then right click and choose zoom or pan to select. Choose all wetlands within the park perimeter and export to a separate layer (specify where and name).
- Add a text field named SITE ID to the attribute table and name the wetland polygons according to the naming convention described below Naming Formula (SITE ID). Turn on wetland labels, road labels, and major road labels taking care to choose a color and size that can be read over the orthophoto. Choose the map view, change the titles and legend if necessary and print.
- New Master maps must be made for boroughs other than Staten Island. Follow the procedures below in "GIS Layers; their design and location".

Naming the wetland site (Site ID)

Wetland sites to be assessed usually correspond to the NWI polygon, and are named by taking the first two letters of the park name then adding an underscore followed by a site number assigned from North to South across the park. *Example:* Mariners Marsh site 1 = MaMa_1 and High Rock Park = HiRo_1. Many sites are known by another name. This can be specified in the AKA field of the attribute table. *Example:* SiteID = MaMa_2; AKA = Monument Pond.

If a single NWI wetland will be assessed in more than one place then each assessment site will be numbered with a decimal from north to south. Each of these sites will be given a point and a buffer analysis. *Example*: ArHeWo_3 and ArHeWo_3.1.

If a NEW, unmapped wetland is located in a park where other wetlands have been assigned Site ID's, use the name of the site to the north e and add the letter 'a' to distinguish it. More letters can be used if more unmapped and unnamed wetlands occur between the same two named wetlands.

GIS data layer descriptions and locations

The map-file *Buffer Analysis Master.mxd* is saved in the Grants -> GIS -> Buffer Analysis folder and contains all the necessary layers for the wetlands buffer analysis plus the Buffer Analysis Tool Box. To save your edits, make sure that you are the only one with the file open.

- **Buffer Analysis.mdb** (J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\GIS\Buffer Analysis\)

  Buffer 30m + Buffer 100m
  These layers contain the 30m respectively the 100m buffer for the *Wetland Polygon* layer, needed for the clipping during the Buffer Analysis

  COMPUTING LAYER
  This group-layer contains modified versions of DPR roadbed, sidewalks and buildings which are not for actual work in ArcGIS, but for several other tasks the modelbuilder has to perform. It is recommended to switch them off. DO NOT MODIFY, ERASE OR WORK WITH THOSE LAYERS The group they are in should be toggled *INVISIBLE* when opening the map.

- **Grant_DB.mdb** (J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\GIS\)

  Hydroline_2001_SI
  This layer contains rivers and streams in the area of Staten Island.

  Landuse_2006
  This layer contains the year 2006 land use. It contains 12 categories.
  - Unknown
  - One and Two Family Buildings
  - Multi-Family Walkup Buildings
  - Multi-Family Elevator Buildings
  - Mixed Residential and Commercial Buildings
  - Commercial and Office Buildings
  - Industrial Manufacturing
  - Transportation and Utility
  - Public Facilities and Institutions
  - Open Space and Outdoor Recreation
  - Parking Facilities
  - Vacant Land

  This layer is not spatially precise therefore it cannot be used to calculate impervious area. *Example*: in Arden Heights woods there are gaps in this layer where roads are planned.

  NYSDEC_SI_FRESHWATER_WETLANDS

This layer contains the Freshwater Wetlands. It has been clipped to Staten Island.

NWI_Wetlands
This polygon layer was created in 2007 by the U.S. Fish and Wildlife Service by using aerials to trace wetlands. These are not delineations but locate recognized wetlands in the National Wetland Inventory. This layer should not be altered. Only the freshwater polygons are represented on this layer as the estuarine layers have been deleted. The Cowardin classification of vegetation type is represented in the pattern of the polygon and its attribute table. Cowardin Classes in the layer are:

- Palustrine Aquatic Bottom
- Emergent
- Forested Scrub Shrub
- Forested
- Scrub Shrub
- Palustrine Unconsolidated Bottom

In addition there are 14 subdivisions for these categories. The layer info can be found at:
http://www.fws.gov/wetlands/data/WMSLayerInfo.html

WRAP_wetland_points 2007
This is a point layer representing sites visited during the wetland rapid assessment. The points that represent the assessment locations are assigned siteID in the attribute table. Other points may be the location of unmapped vernal pools were no assessment was completed. The source of the points (whether GPS or located using aerials and the observers knowledge) should also be specified in the attribute table.

WRAP_Wetland_Polygon_update
In some areas there was no NWI wetland polygon therefore this layer was created so a buffer analysis could be completed. These are assigned siteID and their Cowardin class is specified in the attribute table.

BlueBelt_Land
The Staten Island bluebelt is a series of altered or constructed waterways designed by DEP in order to catch and treat stormwater runoff. This layer represents the bluebelt pathway.

SI_DPR_Buildings_2006
This layer contains all buildings, date 2006. It has been clipped for Staten Island.

SI_DPR_Major_Roads
This layer contains all major roads. It has been clipped for Staten Island.

SI_DPR_Railroad_Lines
This layer contains all railroad lines. It has been clipped for Staten Island.

SI_DPR_Roadbed_2006
This layer contains the roadbed, date 2006. It has been clipped for Staten Island.

SI_DPR_Sidewalk_2006
This layer contains sidewalks, date 2006. It has been clipped for Staten Island.

Staten Island_developed_areas_2009
This layer is intended to as a proxy for imperviousness. This layer combines roadbed(100% impervious), impermeable recreation areas (100% impervious areas like basketball courts and bike trails) , parking lots (100% impervious), Structures is the layer representing buildings (100%), and 40ft buffer around all structures(aprox. 60% impervious).

This layer was created with help from Eymund Diegel of AKRF. This layer is not intended to be exhaustive. It should be updated as new development is built or discovered.

VW_PARKS_SI
This layer contains the boundaries of the New York City parks, including their names. It has been clipped for Staten Island!

- **Aerials 2006** (J:\NRG\GIS\GIS_Data\NYCMAP_Orthos\2006 Orthos\StatenIsland\)

Aerials 2006
This group-layer contains the orthophotos (9) of Staten Island.

- **Streams_DB.mdb** (J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\GIS\Buffer Analysis\Streams)

WRAP_Streams
This layer contains the GPS data from the fieldwork, representing the assessmentsites, photopoints and the actual bed of the stream.

Stream_Line
This layer is for visualization. It represents the stream based on the GPS-data from "WRAP_Streams."

Buffer_30m_Stream_Line and Stream_100m_Line_Buffer
These layers contain the 30 respectively 100m buffers around the "Stream Lines."

Buffer ToolBox
The Buffer Toolbox includes all tools required for the Buffer Analysis. It should open on load of the map. If it does not, it can be found here: *J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\GIS\Buffer Analysis\Buffer Analysis.mdb*. It contains the following tools:

- Buffer
- Clip
- Clip DPR
- Merge
- Multiple Clips

Buffer, Clip and Merge are the standardized tools that ArcGIS provides, put together in one toolbox to improve the workflow. Multiple Clips and Clip DPR have been created for this project. They have the following purposes:

Clip DPR

This Model is part of an analysis, that's going further than the original Buffer Analysis. You can easily find out the coverage (in percent) of the different DPR-layers within a buffer of 100m and a buffer of 30m. The actual workflow will be pointed out later.

Multiple Clips

ArcGIS has got the issue that the clipping of several areas, which has been done simultaneously, results in one polygon, which cannot be analyzed properly. Therefore the given model enables you to select multiple buffers of one category (100 or 30m) in order to clip all of them in one step, resulting in one polygon of the clipped area for each buffer selected. The actual workflow will be pointed out later.

Name and Area of Wetland Polygon

First locate and name NWI polygon of WRAP site.

Locate and select wetland polygon:

1. Open VW parks attribute table, sort by name, click on row of park, on left side there is an arrow to right click and click zoom to. The Wrap wetlands points may also be used to zoom to a specific location.

2. Select NWI Wetlands layer in the list of layers located in the far left window and deselect all others. Then use the select tool to select the polygon where the WRAP was done.

3. Record the NWI Cowardin Class indicated by the NWI wetlands layer in the WRAP data sheet. SPECIFY FIELD OF ATTRIBUTE TABLE

Naming the NWI polygon

In order to name the polygon go the Start editing and open the layer. It should display NWI wetlands layer in the window below. Each polygon will be named by the Naming formula **(SITE ID)** described above.

Open the attribute table for NWI wetlands layer by right clicking on it and press open attribute table.

1. Add a field (must be in Edit session) name the fields site ID and specify text, then add a site (include "and known as" (AKA) name as needed) and specify text. Fill in the new fields with the site names.

2. Name WRAP GPS point in "wetlands" point layer with same procedure. If no GPS taken than create a point in the layer at the assessment location point (as best estimated)

If not an NWI polygon:

1. This should only be done with a GPS point to ensure accuracy. Name the GPS point in the “wetlands” point layer.

2. Select WRAP_update_wetland layer and deselect all others. Start an edit session of the layer, create new field, use pencil tool and draw polygon using “aerials” layer for accuracy of shape and size.

3. Name the polygon in the WRAP_update_wetland layer with established naming formula.

Find area of wetland polygon in GIS (NWI or WRAP update, and DEC):

1. Using the select tool, select the (NWI or WRAP update, and DEC) polygon; open attribute table, right click the SqMeter field then click Calculate Geometry and specify the unit of measurement as square meters.

2. Record areas of the NWI polygon on the field sheet and in the buffer analysis excel sheet.

Waterbody:
Look at the hydroline layer and use the ID tool to identify an upstream or downstream river or stream that is connected to the wetland.

Staten Island Wetlands flora/fauna WRAP Database:
Add under Note any information about other flora/fauna data collected at the site previously ,if known, or on date of assessment.

Buffer Analysis

Find the Minimum Distance to Development:

1. Select the measure tool. Click from edge of wetland polygon the closest development represented by the “Developed Areas” layer. Double click to release measure tool.

2. Make sure distance is being measured in square meters and record data in WRAP sheet and buffer analysis excel sheet.

Create 30m and 100m Buffers:

1. Two buffer layers have been created using the NWI wetlands polygons. One layer is for 30m and one is for 100m. These have been created by using the Buffer-tool from the Buffer Analysis Toolbox. After their creation the geometry data (area in square meters) has been updated.

2. For each WRAP_update_wetland a new buffer must be created each time a new wetland polygon is mapped. Select the polygon to buffer and double click the buffer tool in the Buffer analysis toolbox. The Input is the WRAP_update_wetland, change the output class name, specify the dissolve type as type NONE, and linear unit is the size of the buffer.

3. Select buffers, open attribute table, hit selected tab. In order to find a single buffer when multiple are selected either highlight or deselect to row in the attribute table. In order to highlight the row just double click on it. In order to deselect a row click once then right click on the arrow on the left and press deselect.

4. Calculate geometry an find areas of both the 100m and 30m buffers and record in the buffer analysis excel sheet.

Calculate Proportion of Developed Area in the 30m and 100m buffer:

1. Clip or clip multiple(shortcut) : Select the buffer(s) to be clipped and double click the clip or (clip multiple) tool in the Buffer Analysis Toolbox. Set the input class as Staten Island developed area, the clip class as the buffer (30m or 100m) to be clipped, and name to the output class.

2. The output class should be placed in the correct folder with the other clips and named with the siteID and buffer size. *If the buffer does not overlap with developed areas then there is no need to clip. When clipping multiple buffers select the buffers to be clipped and use multiple clip model in Buffer analysis toolbox. Select the buffer distance and name the output according the siteID and buffer size (ex. ArHeWo30)

3. You may need to add a field named SqMeter (you need to stop editing in order to add a field). Add the field named SqMeter and specify double as the type. Then edit layer to calculate the geometry in square meters. Calculate geometry and enter area of development in 30m and 100m buffers into buffer analysis excel sheet.

4. Afterward verify that the proportion of the buffers that are developed is consistent with the visual representation of the GIS map. For example if the proportion of the buffer developed is calculated to be over 100 than there has obviously been an error in data entry.

Determine Most Intense Land Use within 30m buffer:

1. Toggle on Land Use layer and observe most intense (e.g. commercial vs residential) type.

2. Record the data as represented by the layer (ex. Residential, vacant land, open space. Etc.) See Buffer Analysis: Most Intense Land Use within 30 meters of Wetland Edge, page 5.

Roads within 30m of wetland (most intense type)

1. Toggle on the roadbed layer and zoom in on the wetland polygon and observe if there are any roads within the 30m buffer. If so then, make the roadbed layer transparent in order to observe the type of road. (See Buffer Analysis: Roads, page 5.) Record this in buffer analysis spreadsheet and in WRAP field sheet.

Multiple Clips

The Multiple Clips tool has been designed to improve the workflow during the buffer analysis. It will support you while computing the percentage of the buffer area that has been developed in any way. One of the issues of ArcGIS Clip tool is that, if you want to clip multiple buffers in one step, it will only create one polygon, which makes it impossible to proceed with the analysis. As using one step for all needed clips saves a lot of time, this tool will support you doing that. See "Visual Step by Step – Multiple Clips" (page 35) for diagrams.

1. Select at least one feature of one of the buffer-layers.
    a. Please note that you can only perform several clips with features from ONE of the buffer layers at a time
2. Double-click the ***Multiple Clips*** tool in the Buffer Analysis Toolbox.
3. Choose the clipping-feature in the top-box.
    a. Only buffer 100m and buffer 30m are valid
4. Select the path and name where the clipped feature should be saved
    a. The default path is J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005**\GIS\Buffer Analysis\TEMP\Clips**
    b. Save your Files in that folder
    c. Use an obvious name
5. Press ***OK***
6. The output-file should be added to the map automatically
7. Open the attribute table of the layer
    a. Right-click onto Square Meters and click calculate geometry
    b. Select ***Area*** and ***Square Meters*** and press ***OK***
8. If you want your created file to remain in the map for longer than the current editing session please move it into the group-layer ***Clips*** by drag and drop and make sure that it is possible to identify it by its name.
9. If you want to erase your map after the editing session, erase it from ArcMap first and from the folder it has been saved to in ArcCatalog.

Clip dpr

The previously mentioned Tools Clip DPR 100m and Clip DPR 30m are located in the Buffer Analysis Toolbox. (*See Buffer Toolbox above for further information*).
The goal of this tool is to give you detailed information on the type of development clipped by a 30 or 100m buffer.

1. Select the buffer you would like to be analyzed. (The selection will be easier, if you have got the appropriate layer marked for selection only.)
2. Double click onto the CLIP DPR tool in the Buffer Analysis Toolbox
3. Choose the clipping-feature. This should be buffer 30m or buffer 100m with one feature selected.

4. Choose the output-file. The default one is stored inside the geodatabase under the name TEMPORARY_Merged_100. This one will be overwritten each time the model is run with default parameters. Please use an obvious name and keep the geodatabase clean.

5. After the model has finished (approximately 3minutes) the output will be added to the map automatically.

6. Open the attribute table, right-click onto the ***Shape_Length***, click ***Calculate Geometry***, Property should be ***Area***, Units should be ***square meter*** and click ***OK***.

7. Right-click onto Shape_Length again, click Summarize, the field to summarize should be FEATURE_CO, the summary statistics should be SUM for Shape_Length and choose an output table.

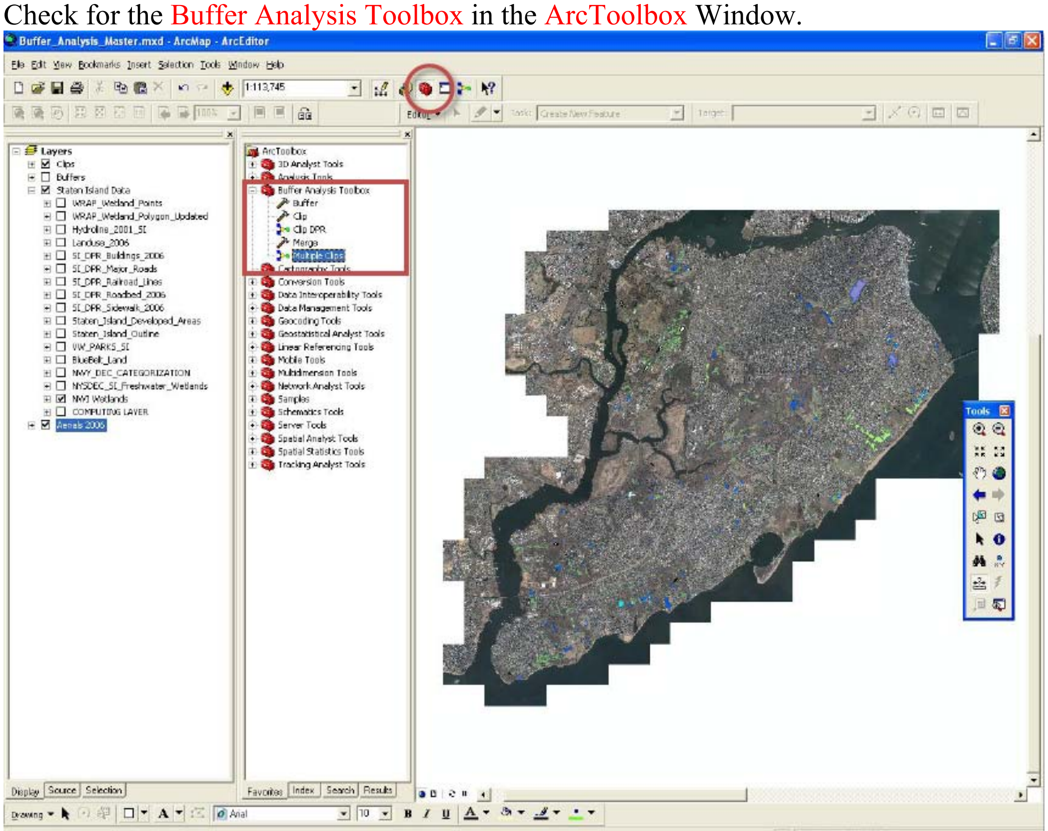
8. You can now use the created table for further analysis.

Buffer Analysis summary protocol with visuals

1. Open the map:

   J:\NRG\Grants\EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\GIS\Buffer Analysis\Buffer_Analysis_Master.mxd

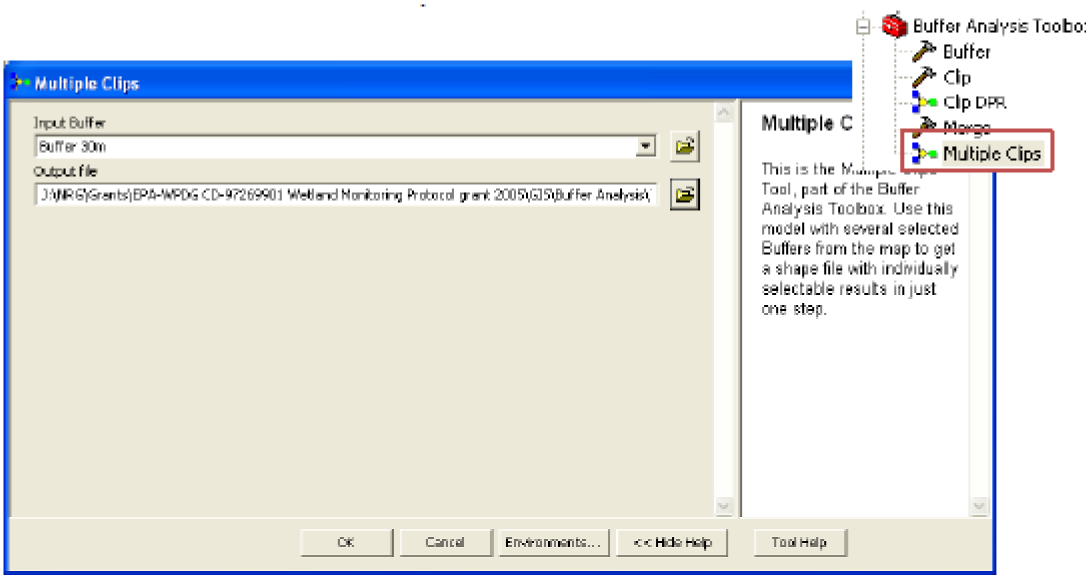
2. Check and prepare the map
   - Check for the Buffer Analysis Toolbox in the ArcToolbox Window.



   - Switch off layers you do not need, e.g. the DPR-layers.

3. Select at least three features from one of the buffer layers, e.g. 3 from 30m **OR** 4 from 100m but **NOT** 3 from 30 **AND** 4 from 100m
    - **TIP:** To make selection easier go to Selection at the bottom left of the screen and activate only the layer you want to use.

    - **TIP:** If the buffers intersect and it is difficult to select only the ones that you need, use the attribute table to do your selection.
4. Hit the Multiple Clips tool in the toolbox



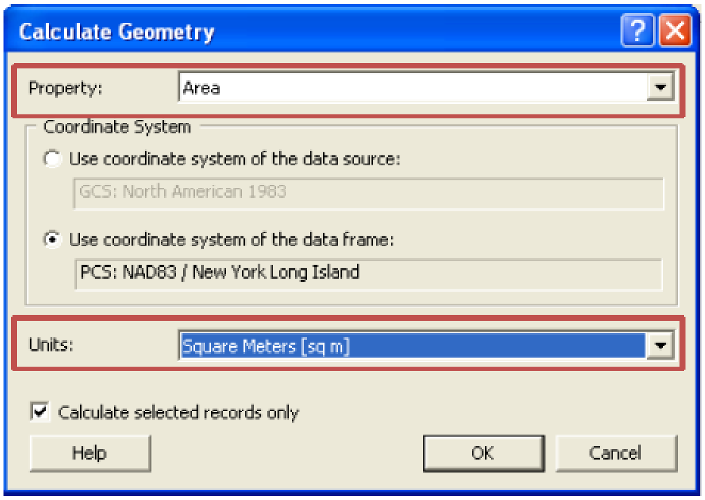
    - Choose the Input Buffer (only 30m and 100m are valid) and the Output File

Default folder should be
…\GIS\Buffer Analysis\Temp\Clip…
Use a unique and obvious name.

    - Press OK and the created file will be added to the map
        - Move it into the Clips Group Layer in order to keep the map clean

5. Open the Attribute Table by right clicking onto the layer and choosing the point Open Attribute Table

- Right-click title of row SqMeters, click Calculate Geometry -> SqMeters



- Select Area and Square Meters and press OK

6. Open “WRAP Buffer Analysis Results.xls” in *J:\NRG\Grants|EPA-WPDG CD-97269901 Wetland Monitoring Protocol grant 2005\GIS\Buffer Analysis* and fill in or calculate the appropriate information for each field, as summarized below in Table 1. Additional instructions are found in the excel file.

Table 1. Fields to be completed in “WRAP Buffer Analysis Results.xls” worksheet for each wetland assessment site.

Field	**Unit**	**Instructions**
SiteID	Letter / #	To determine the Site ID, see the Naming section above.
NWI Wetland Area	sq m	Select wetland(s) and open the attribute table, marking show selected only.
DEC Wetland Area	sq m	Select wetland(s) and open the attribute table, marking show selected only.
Area 30m Buffer	sq m	Select buffer(s) and open the attribute table, marking show selected only.
Area 100m Buffer	sq m	Select buffer(s) and open the attribute table, marking show selected only.
Developed 30m	sq m	Select the previously created clipped shapes from developed area, open the attribute table (show selected only), and use the (recalculated!) values.
Developed 100m	sq m	Select the previously created clipped shapes from developed area, open the attribute table (show selected only), and use the (recalculated!) values from SqMeters/Area.
Min Distance	m	Measure the closest distance between the wetland and developed area inside the 30m buffer.
Roads	#	Check for roads inside the 30m buffer using your eyes.
Most intense Landuse	name	Visually determine the most intense land use for the stressor score determination.
Proportion	%	The proportion will be computed automatically

APPENDIX G. ArcPad Steps for Wetlands Rapid Assessment GPSing

1. The following layers should be loaded on the GPS unit:
   Citywide_DPR_Hydroline_2001
   SI_Parks
   NYSDEC_Freshwater_Wetlands
   CONUS_Wetland__polygons_Dissolve
   Staten Island 2006 Orthophotos (S1.SID through S.6SID)
   WETLANDS
2. Turn on unit. Click on 'Start' dropdown menu. Choose ArcPad 7.0.
3. Select "Choose an existing Map", then: \My Documents\WRAP\WRAP w Images.apm. Hit OK.
4. In the top row of the toolbox choose the satellite dropdown menu (in pink). Click 'GPS Active' then click on 'GPS Position Window'.
5. Wait until the satellite data stabilizes, then record the Longitude and Latitude position.

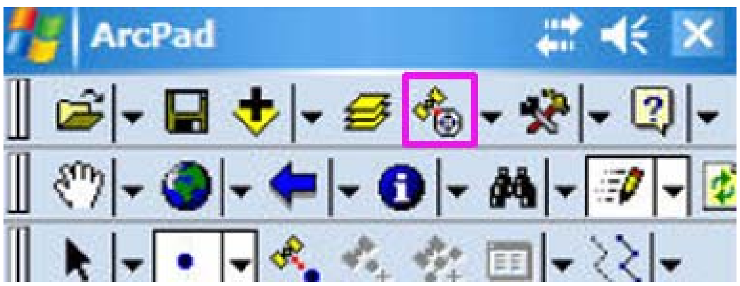


Figure 1. Highlighted pencil in Arcpad

6. When collecting a point for the assessment area, make sure you are writing to the correct layer. Use the Pencil tool dropdown menu in the second row to make sure WETLANDS is bordered in red.
7. If the pencil is not highlighted in white, as in Figure 1., click on the icon to activate it. The third row of editing tools will appear. To create a point in the WETLANDS layer, click on the satellite icon in the third row next to the point icon. An attribute table will appear to fill in. Click on the name of the field and fill in the information.
8. When finished in the field, deselect the Pencil tool to stop editing. Select the dropdown menu to the right of the Folder idon in the first row and choose Exit.
9. The WETLANDS layer is written to the memory card. Do not move it to the internal memory, as battery failure will erase all data from the internal memory.

Protocol for Downloading Data
Give the unit to GIS Manager to download the data with a temporary file name to the server and then remove the points from the WETLANDS layer on the GPS unit.

NOTE: If you want to navigate to points already collected, you must download the points from the server to the GPS unit. (NAME OF LAYER)

APPENDIX H. Drainage Basin Delineation Protocol

1. BACKGROUND

The following is a guideline for sub-basin delineation from a Digital Elevation Model in the context of wetland rapid assessment. This document was originally developed as part of the GIS component of the Wetland Rapid Assessment.

Watersheds are a logical way of dividing the landscape and represent a physically-based valid alternative to buffer analysis for rapidly assessing potential landscape impacts.

2. OBJECTIVE

The objective is to generate a set of polygons representing the contributing area draining to any point of interest associated with each wetland system in the study area. The approach is to establish, where possible, a "hydrologic connection" between the wetland system and the hydrologic component represented by the topographic drainage network.

The major issue in the process is to determine the best location for the interest point associated with each wetland. This point represents the hydrological outlet of the sub-basin being delineated and the issue is to find a location (a point), which is representative of a wetland system (an area). If a monitored/surveyed point already exists in the wetland being analyzed, the location of the interest point could be related to the location of this existing point. The choice of the interest point is also based on the digitalized stream network. In this particular case, the highly urban environment that characterizes Staten Island results in the digitalized drainage layer being discontinuous and constrained by the infrastructures.

3. METHOD

Based on the Digital Elevation Model of the area[1]:

- Generate the flow direction, flow accumulation, watershed and stream layers using the *watershed delineation* tool under Watershed Delineation Toolbox. If not available download from:

http://support.esri.com/index.cfm?fa=downloads.geoprocessing.filteredGateway&GPID=16

  To generate the stream layer choose an appropriate threshold value of flow accumulation (in terms of number of cells). In some areas unrealistic parallel flow patterns will be observed in the calculated stream network. This is due to the fact that the *watershed delineation* tool uses the D8 method (Jenson and Dominigue, 1988, O'Callaghan and Mark, 1984) for flow direction calculation, This is a single flow direction method which

[1] see: Staten Island 16 feet resolution Digital Elevation Model - J:\NRG\Users_Interns\Matteo Ferrucci\SI \si_dem

cannot model flow divergence and thus generates parallel flow lines along certain directions, especially in flat areas.

- Generate a shapefile of the *interest points* associated with every wetland based on the digitalized and the calculated stream lines, and on eventually existing monitoring points. If some monitoring points are already present in the area (as is the case for Staten Island), use the following guidelines to locate e reasonable and representative interest point*:*

  - Given the monitoring points associated with a wetland system, consider the one that is the most downstream. Proceed downstream until the first river bifurcation is reached, such that all the monitoring points are located in the proximity of the upstream branches. Use the digitalized or the calculated stream network based on the consistency with an orthophoto of the site (if available)[2]. If both are consistent with the orthophoto it's advisable to use the calculated stream network since this would result in a more reasonable sub-watershed delineation when using the *watershed* tool. The snapping option could be useful at this stage.

  - If it's clear from other data sources that the wetland is shared by two or more watersheds, i.e. crosses a drainage divide, use one interest point for each wetland and generate two different watersheds.

  - If the wetland system is clearly independent from the hydrologic system of streams[3], simply do a buffer analysis or relate the wetland under consideration to the general basin delineation grid generated using the *watershed delineation* tool (if the existing points belong to 2 different basins merge the basins together). This could be the case in highly urbanized area, flat areas or if the monitoring points are at the head of a stream (small contributing area). Alternatively, the wetland can be grouped together with other wetlands with which it shares common topographic characteristics, and the associated watershed can be used for the analysis.

- Generate a grid of sub-basins upstream of the points of interest using the *watershed* tool, with the flow direction grid and the shapefile of the interest points as inputs.

- Convert the sub-basin grid into a polygon layer using the *raster to polygon* tool. If there are major inconsistencies between the digitalized network and the watershed delineation, manual editing of the watershed polygons should be considered.

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[2] NRG's Staten Island 2006 aerials – at M:\Aerials\2006_Orthos\StatenIslan

[3] NRG's "Citywide 2001 stream layer" – at M:\Citywide.gdb\Physical \citywide_DPR_Hydro_Centreline_2001

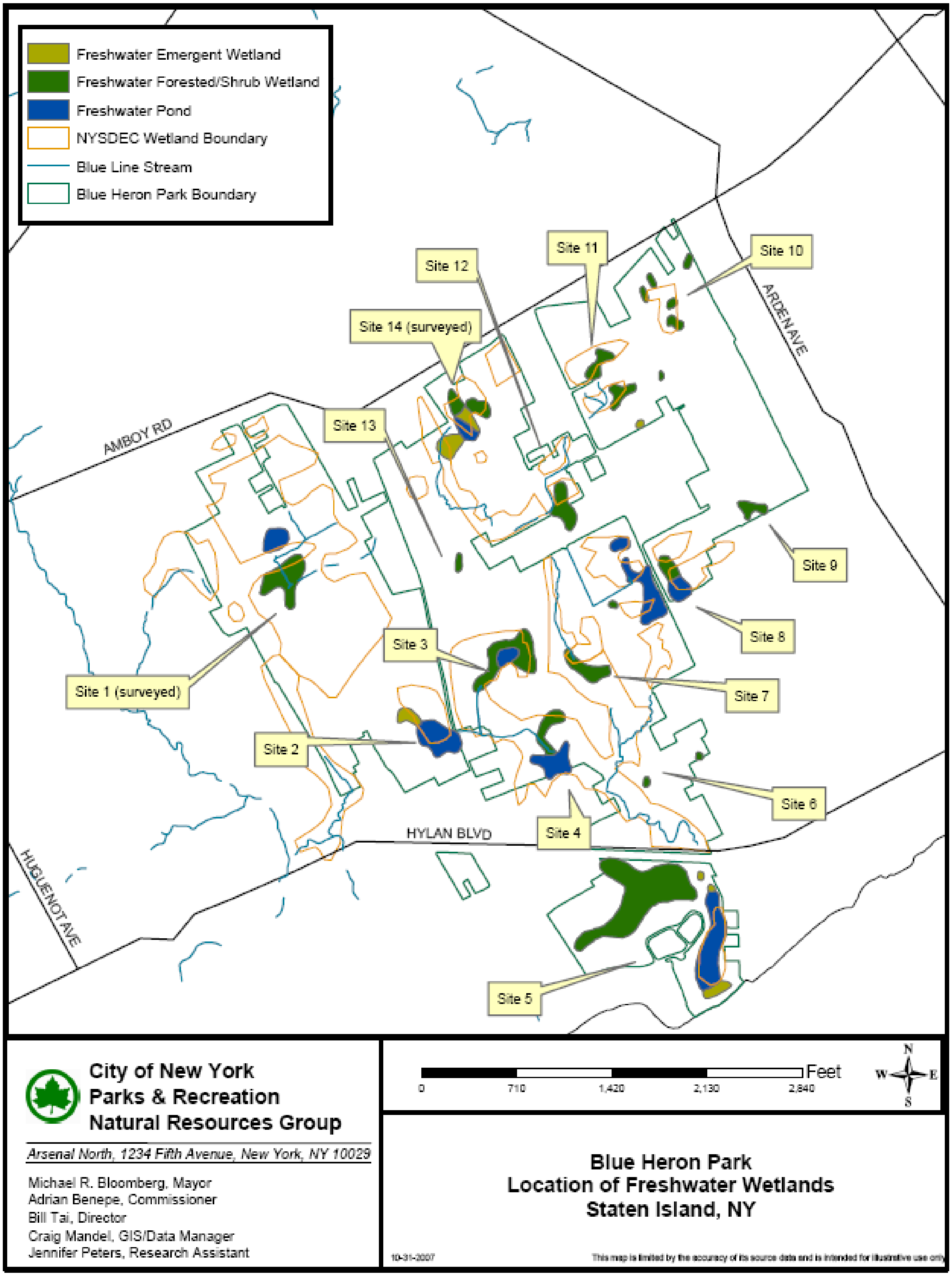
- The polygons of the sub-watershed can be correlated with other information, including land use and development, vegetation, slope, etc., to analyze of wetland assessment results, and group together watersheds with drainage areas of similar physical or land use characteristics.

REFERENCES

Jenson, S. K., Domingue, J. O. (1988), Extracting topographic structure from digital elevation models, *ISPRS Journal of Photogrammetric Engineering and Remote Sensing*, 54, 1593-1600

O'Callaghan, J. F., Mark, D. M. (1984), The extraction of drainage networks from digital elevation data. Computer Vision, *Graphics and Image Processes*, 28, 323-344

APPENDIX I. EXAMPLE OF FIELD MAP FOR WRAP



SECTION 2: RAPID ASSESSMENT RESULTS

FIELD SITES VISITED

2007 Field Season

Thirty-seven wetland rapid assessment surveys were conducted by NRG and seasonal field research assistants over 17 days from July through October in 2007 (Figure 1). Wetlands were selected for rapid assessment based on the recommendations of NRG ecologists to represent a broad range of wetland sizes, Cowardian classifications, and geographic diversity within Staten Island.

2009 Field Season

In 2009, between June and September, we conducted 51 wetland rapid assessments at 23 different Park properties on Staten Island over 23 days (Figure 2). Full-time NRG staff accompanied the seasonal research assistants to 23 of the rapid assessments sites: four of the site visits were conducted with the senior NRG wildlife ecologist, and the rest of the site visits were conducted by the research assistants with other NRG ecologists, wetland specialists or environmental scientists. The field research assistants conducted the remaining site assessments independently.

Time and Effort

As anticipated, the time to complete each WRAP varied by site and depended on whether the assessor was familiar with both with the site and the vegetation, difficulty of accessing the site, wetland size, the heterogeneity or homogeneity of the wetland, and other factors such as vegetation density and site configuration. Generally, however, the WRAP took two people about three hours per site, including transport time once they were in Staten Island. This was the time and level of effort involved with no water quality testing and with minimal investigation for evidence of hydraulic soils. Water quality and further soils analysis may between one-half hours to one-hour effort per site.

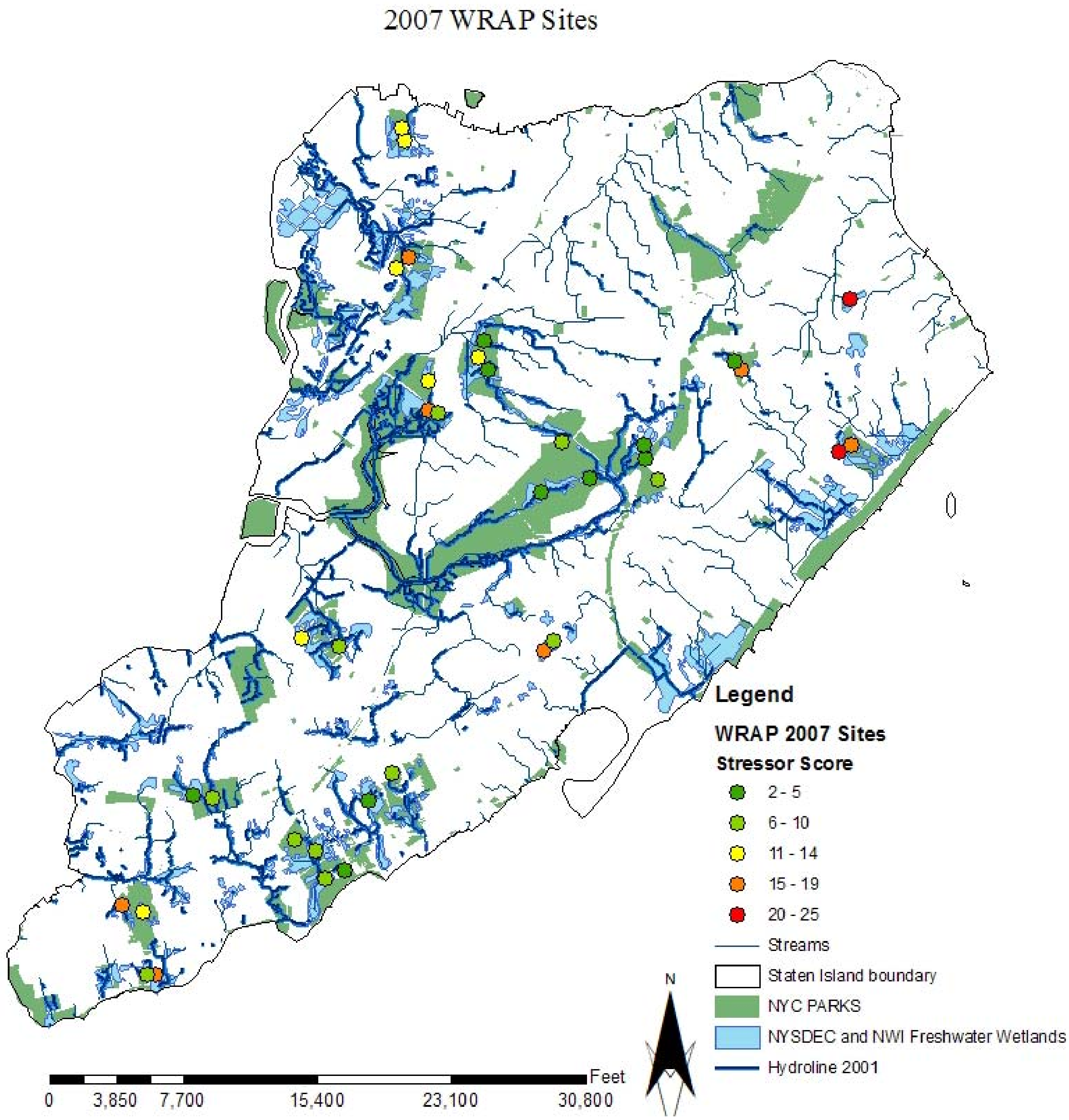


Figure 1. Wetlands Rapid Assessment Sites in 2007.

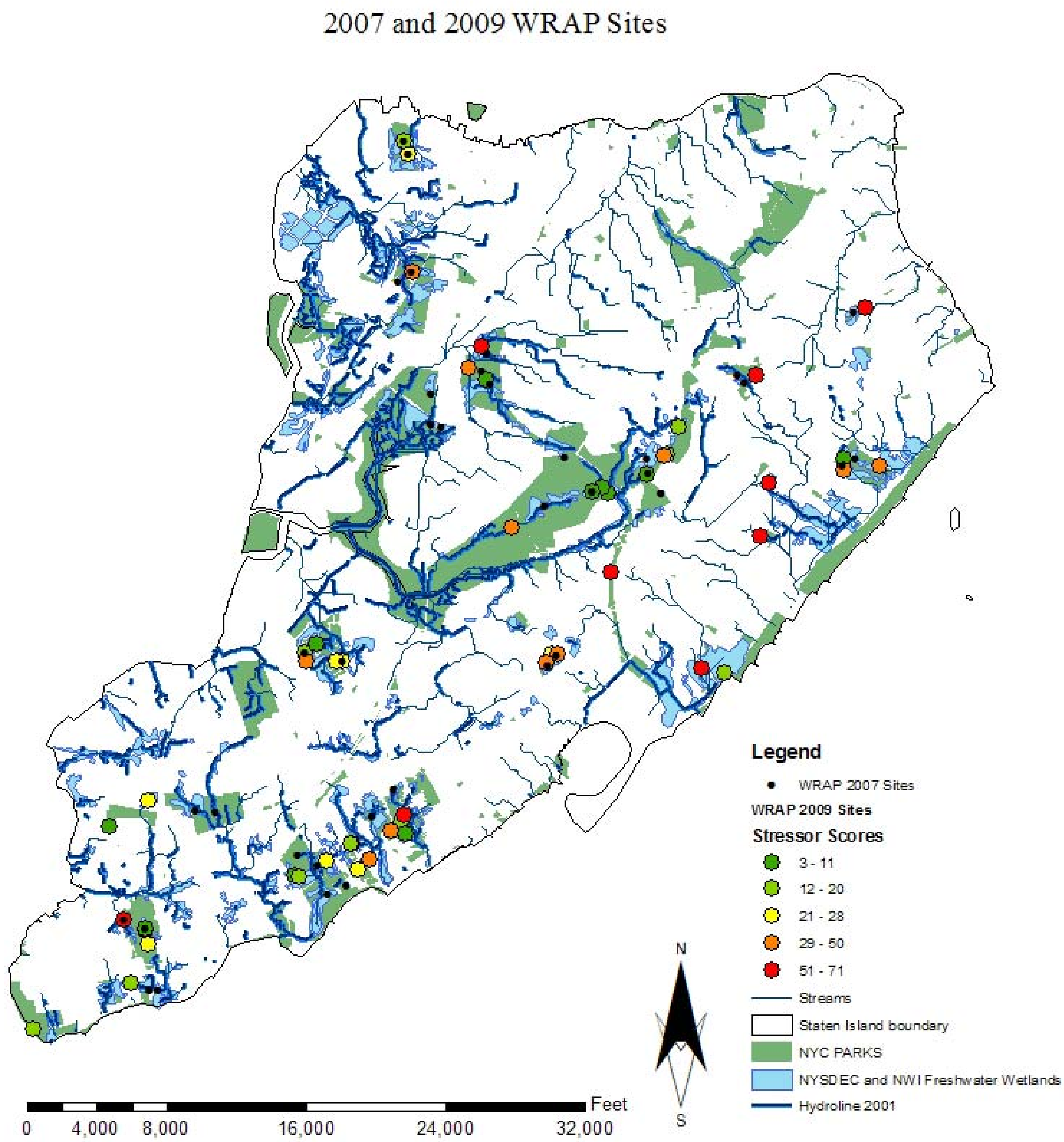


Figure 2. Wetlands Rapid Assessment Sites in 2009.

SUMMARY CHARACTERISTICS OF WETLANDS

Wetland Catchment Area and Land Use

The wetlands assessed in 2007 and 2009 were located in 18 drainage basins (Figures 3), and contributing drainage areas ranged in size from 19-1,750acres. This large variation was due to a combination of the wetland's location within the drainage network and the local geology. For example, on the glacial outwash plane forming the southeast shore of Staten Island and the marine coastal plain (Figure 4), there were several wetlands at low elevations in a low relief landscape that were not connected to a larger drainage network and had very small drainage areas. Several wetlands that appeared topographically disconnected from the larger surrounding watersheds, however, may have been connected through drainage infrastructure or small natural drainage networks that were not visible at the resolution of the available USGS DEMs.

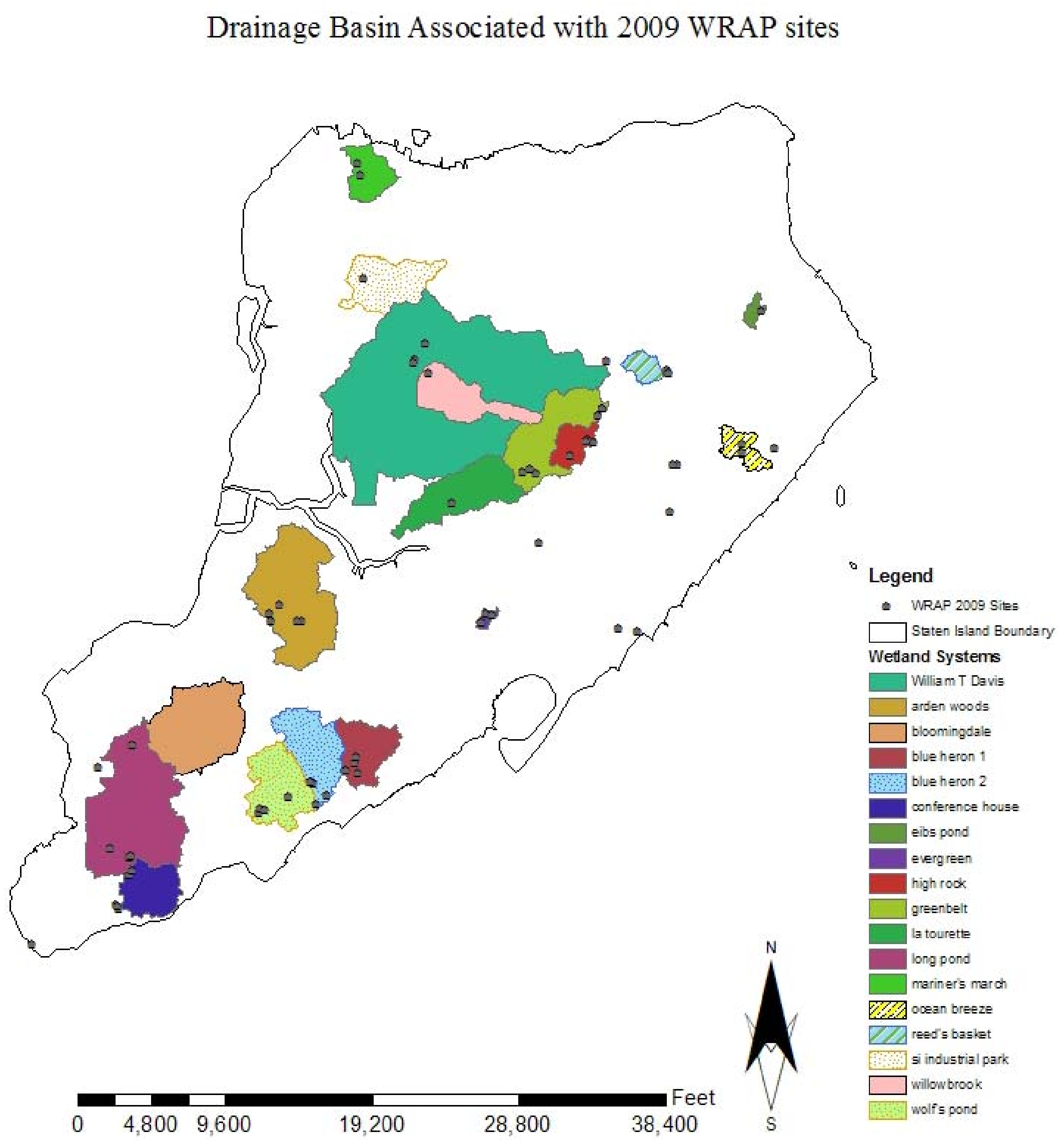


Figure 3.Drainage basins associated with WRAP sites based on 30m DEMs. Staten Island, August 2009. All delineations were corrected to match 2 ft contour lines for NYC.

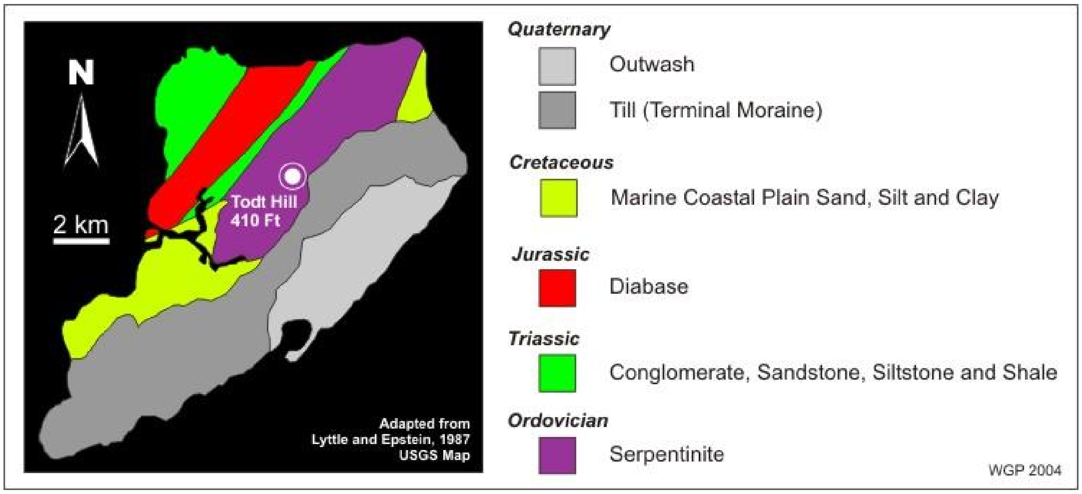


Figure 4. Geology of Staten Island:http://academic.brooklyn.cuny.edu/geology/powell/NYCgeology/staten%20island/staten_island.htm

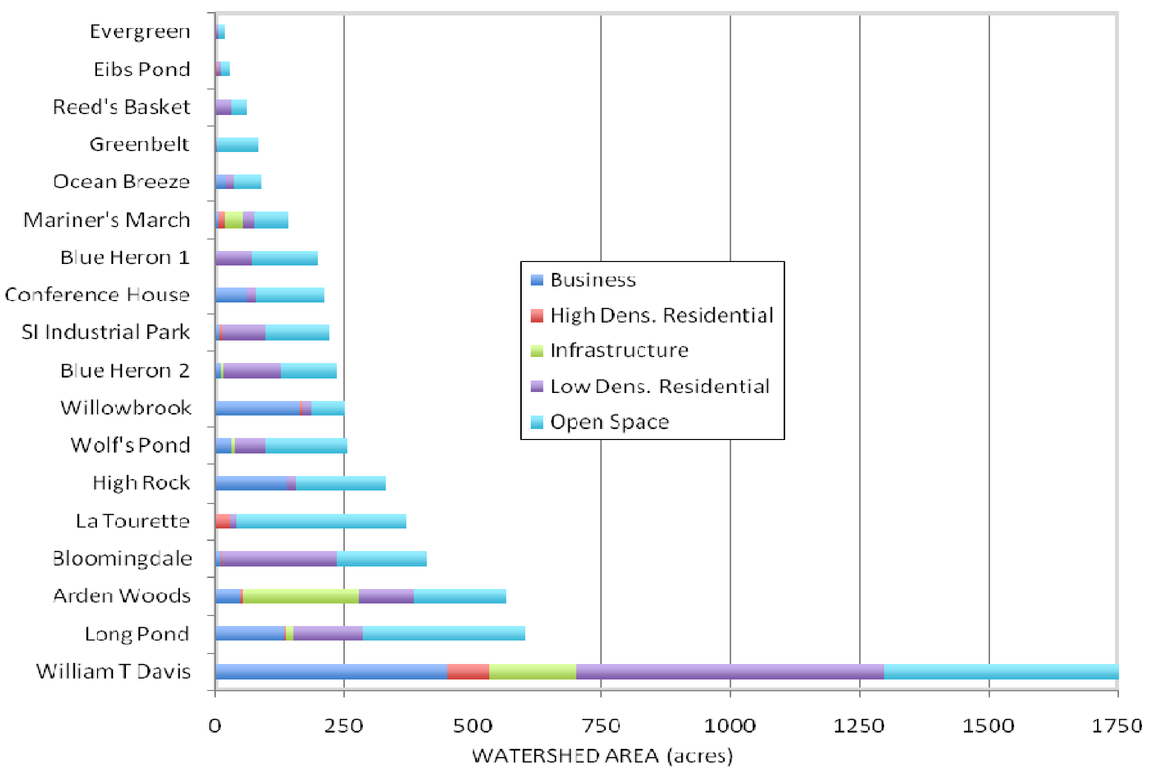


Figure 5. Land use types as a proportion of total watershed area for each catchment.

In addition to representing a wide range of sizes, the wetlands assessed had a wide range of development associated with their watersheds as seen in Figure5. For example, percent open space in the watersheds ranged from 19% to over 95%. High density residential development and infrastructure appear to represent a relatively low portion of the overall development in the watershed. In contrast, business and residential developments typically occupy a significant proportion of the land use in the watershed, indicating that these might be land use types where it is particularly important to better understand the nature of the impacts and the potential opportunities for improving riparian and wetland protection.

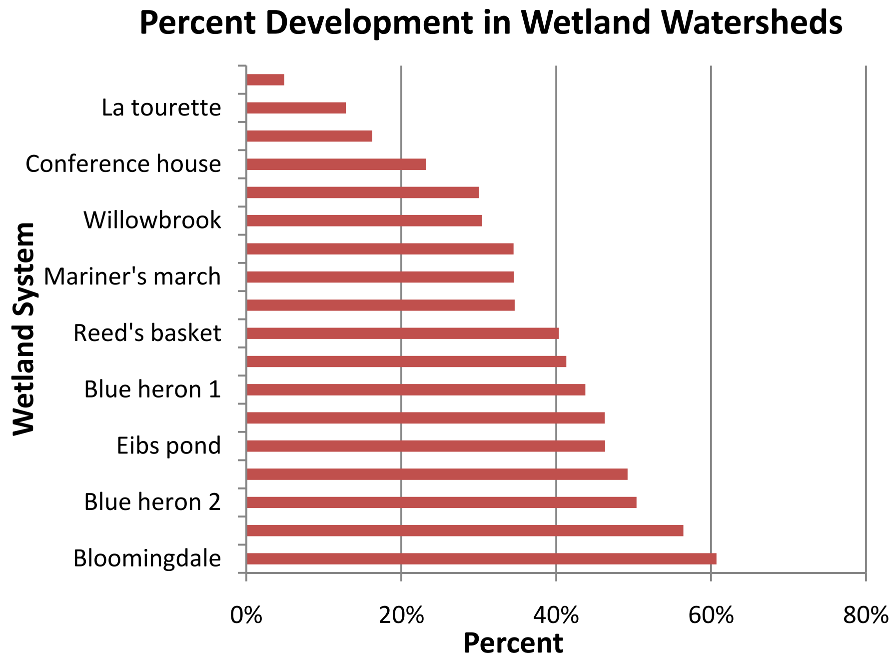


Figure 6. Percent development in the drainage basins associated with WRAP sites.

The percent development of the drainage basins associated with the WRAP sites ranges widely from about 5% to about 60% (Figure 6). Percent development was calculated based from a development layer developed by Eymund Diegel at AKRF (see Wetlands Rapid Assessment Protocol section) and does not always coincide exactly with the percent of developed land calculated using the 2006DoITT land use layers. The developed layer includes a 30ft around houses and other structures, to represent the typical occurrence of built structures (sidewalks, walkways, patios, driveways) around built structures. A more accurate layer of impervious surfaces is not available at this time. Percent development is not necessarily a strong indicator of impacts at small wetland sites where specific disturbances can have disproportionately large impacts, or in larger wetlands, where the distribution, type, and configuration of development and impervious surfaces can result in varied impacts in different parts of the wetland which are difficult to ascertain from a desktop analysis.

All but one of the wetlands assessed were associated with drainage basins that were more than 10% developed, a threshold above which the loss of sensitive species in streams is typically observed in urban streams (Booth 1991, CWP 2003). As has been well documented in the literature (Konrad et al. 2005), percent development is not always a good indicator of the degree to which land use is influencing a wetland or stream system. For example, the distribution and type of development, and the degree of connectivity that the impervious surfaces have in a development can influence the extent and type of impact on the downstream receiving waters (Walsh 2004). About half of the wetlands were in drainage basins which were 10-40% developed; in watersheds with this range of development it may be particularly important to understand the type, configuration of the development, and the degree of connectivity of the impervious areas.

Wetland Buffer Analysis
The utility of the data resulting from the buffer analysis was quite varied, given the frequent inaccuracy of the NWI and DEC mapped wetlands. This inaccuracy can be a result of the inaccuracy in the NWI data layers, since the wetlands were mapped from aerial photography in the 1990s and have not been updated. The DEC freshwater wetlands layer is based on delineations from XXX year and have not been updated either.

There was no strong correlation between the Field stress score observed and the percentage of developed area within the 30m buffer. Perhaps an urban landscape is so fragmented that the buffer analysis stress score does not adequately capture the built environment characteristics of the area surrounding the wetland.

At Evergreen Park, for example, the buffer analysis stress score is artificially low because of the inaccuracy of the NWI and DEC spatial data (Figure 7). The field assessment revealed the wetland to be in closer proximity to development than the GIS estimate. For example, the NWI polygon that was buffered to calculate the proportion of development in the buffer zone did not precisely represent the wetland location. All three wetland sites in Evergreen Park were closer to development than the centroids of the three polygons represented in the NWI layer. As a result, the percentage developed within the 30m buffer is greater in the field than calculated by the GIS analysis. Impacts of development at the wetlands in Evergreen Park included dumping of garbage and landscape clipping, compacted soil from traffic, and the loss of shrub and herb cover in many areas. For example, the entire northern boundary of EvSi_1 was less than 30m from development. The site EvSi_3 was in part converted into the backyard of the closest residence. Ideally, when calculating the level of development around a particular site, the WRAP buffering analysis would be based on a wetland boundary polygon that has been delineated in the field through characterization of hydric soils and vegetation.

Evergreen/Seidenberg Park

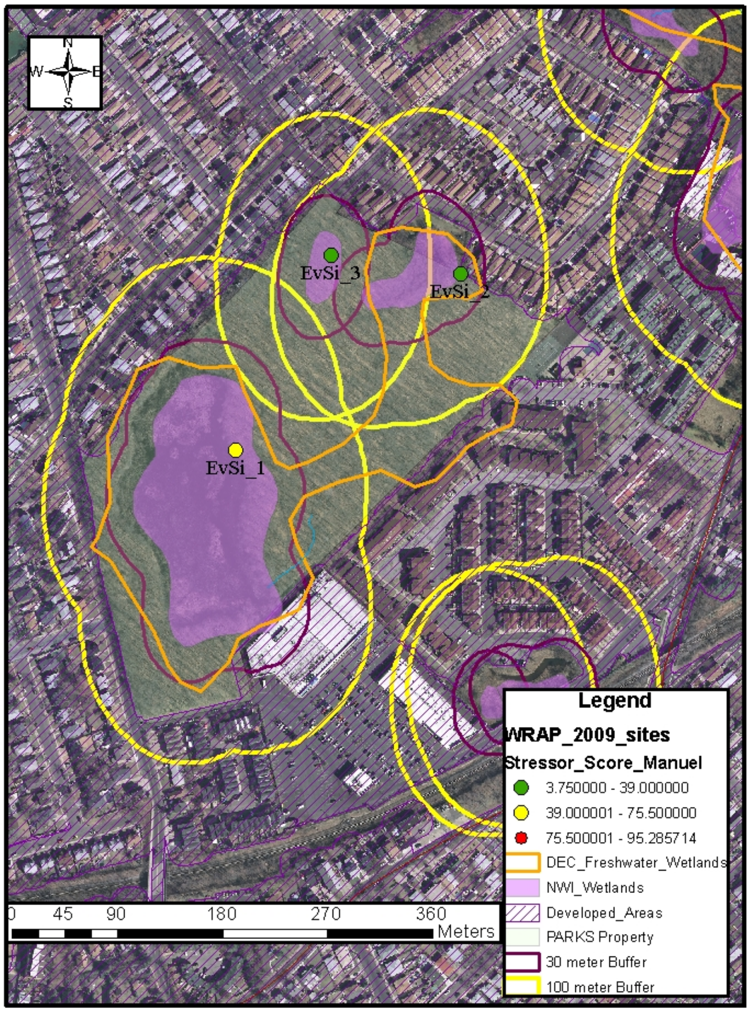


Figure 7. Results from 30 m and 100 m buffers around NWI wetlands at Evergreen/Seidenberg Parks. Here, the centriods of NWI wetlands do not accurately reflect wetland locations (as determined by location of the WRAP scoring point) and the GIS analysis underestimates development in the buffer zone because of inaccuracies in the NWI and DEC polygons.

At Ocean Breeze Park, the NWI polygons were relatively accurate based on our observations in the field. This allowed us to relatively accurately calculate the percentage of developed area within a 30m buffer of the OcBr_1 site (Figure 8).

When the base wetland mapping layer is accurate, and the development or land use layer is accurate, the buffering analysis may provide a useful base line against which changes in a park or surrounding landscape can be measured. For example, a given percent development in a buffer zone around a wetland can be compared from over time both at a site of interest or in total across the entire city to identify trends. The compilation of wetland delineation survey results in a GIS layer to map current wetland boundaries, inspection of aerial photos and verification of remote sensing wetland mapping that is necessary to produce useful information from the buffer analysis are tasks that are long term priorities for NRG.

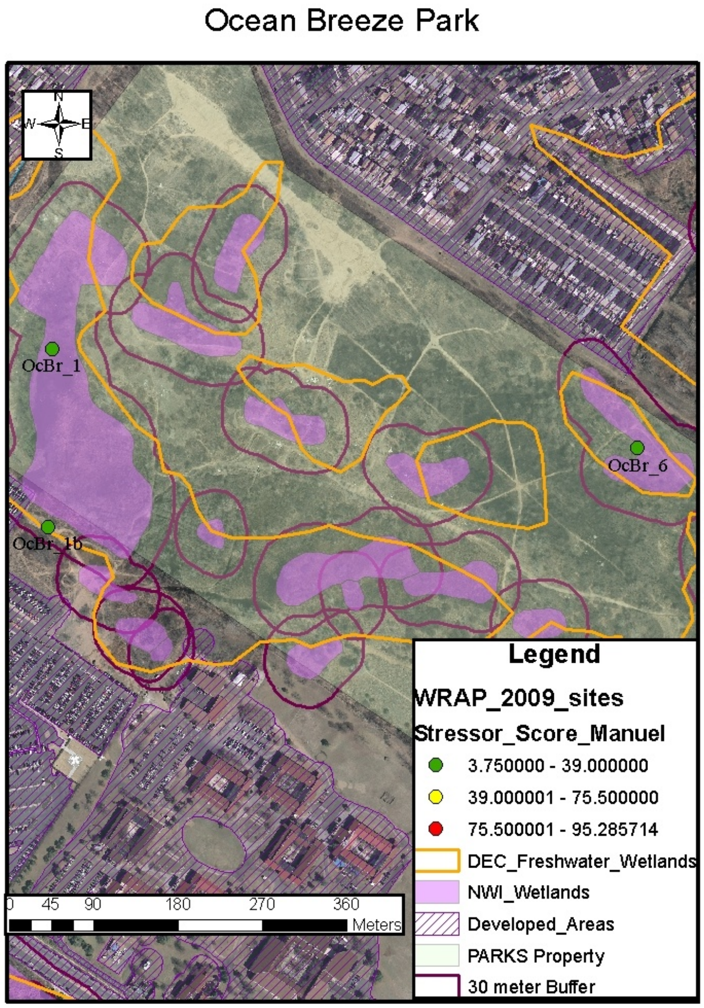


Figure 8. Results from 30 m and 100 m buffers around NWI wetlands at Ocean Breeze Park. Here NWI mapping does reflect wetland locations and the GIS analysis accurately estimates development in the buffer zone.

Wetland Classes Assessed

The vast majority of the 50 wetlands assessed on Staten Island were depressional wetlands according to the hydrogeomorphic classification system of Brinson 1993. Using the vegetation-based Cowardin classification system the WRAP results indicated that:

1 10 sites (21%) were palustrine emergent wetlands (PEM), consisting predominantly of herbaceous and graminoid vegetation, with an open canopy.

1 8 sites (16%) were palustrine emergent systems with open water and an unconsolidated bottom (PEM/PUB or PUB/PEM).

2 18 sites (38%) were open water with unconsolidated bottom (PUB).

3 12 sites (25%) were palustrine forested systems (PFO).

The site assessments were conducted in NWI wetlands that were, on average, between 1 and 3 acres. The smallest NWI sites were less than a twentieth of one acre, and the largest sites were open water emergent and forested wetlands that were larger than twelve acres (see Table 1).

Table 1. Distribution and Size of Wetland Types Assessed using the WRAP during 2009.

	Hydrogeomorphic Wetland Type			Cowardin Classification Type			
	Depressional	**Riverine**	**Soil Flats**	**PEM**	**PUB/ PEM**	**PUB**	**PFO**
No. of WRAP sites	45	1	2	10	8	18	12
Percent of WRAP sites	63%	12%	25%	21%	16%	38%	25%
Total NWI area (ac)	83.9	1.25	48.7	10.51	21.63	23.43	42.34
AVG NWI area (ac)	1.6	1.25	9.7	1.05	2.7	1.3	3.53
MAX NWI area (ac)	12.3	1.25	33.1	5.15	14.85	4.81	12.33
MIN NWI area (ac)	0	1.25	0.7	0.04	0.2	0.09	0.04
Percent of NWI area	99%	0%	2%	11%	22%	24%	43%

The predominately palustrine emergent and open water wetlands WRAP sites stand in contrast to the predominance of palustrine forested wetlands on Staten Island as a whole. As Table 2 shows, the Staten Island NWI wetlands are 29% palustrine emergent marsh (199 total sites), 25% palustrine unconsolidated bottom wetlands (263 total sites), and 46% palustrine forest (336 total sites).

Table 2. Distribution of Cowardin Wetland Classes in Staten Island.

	EMERGENT	**Unconsolidated Bottom**	**Scrub Shrub**	**FORESTED**
AREA	**PEM**	**PUB**	**SS**	**PFO**
TOTAL (ac)	334.04	248.32	35.41	521.49
Percent of total	29%	22%	3%	46%
AVG (ac)	1.69	23.11	1.04	1.55
MAX (ac)	30.20	56.53	4.16	14.13
MIN (ac)	0.03	6.24	0.04	0.03
Mapped wetlands (#)	199.00	230.00	33.00	336.00

For comparison, the Cowardin vegetation cover classes identified at the WRAP sites in the field were collapsed into the standard three freshwater wetlands categories, PEM, PUB and PFO. The PEM/PUB category often documented on the WRAP form was combined with the PEM category, because it was assumed that PEM was usually dominant (Figure 9). More WRAP sites were located in emergent and open water wetlands than forested palustrine wetlands, perhaps because of the relative ease in identifying emergent and palustrine wetlands and the more frequent biological monitoring at those types of sites. We may want to select future WRAP sites carefully so that the distribution of NWI wetland types is sampled proportionately.

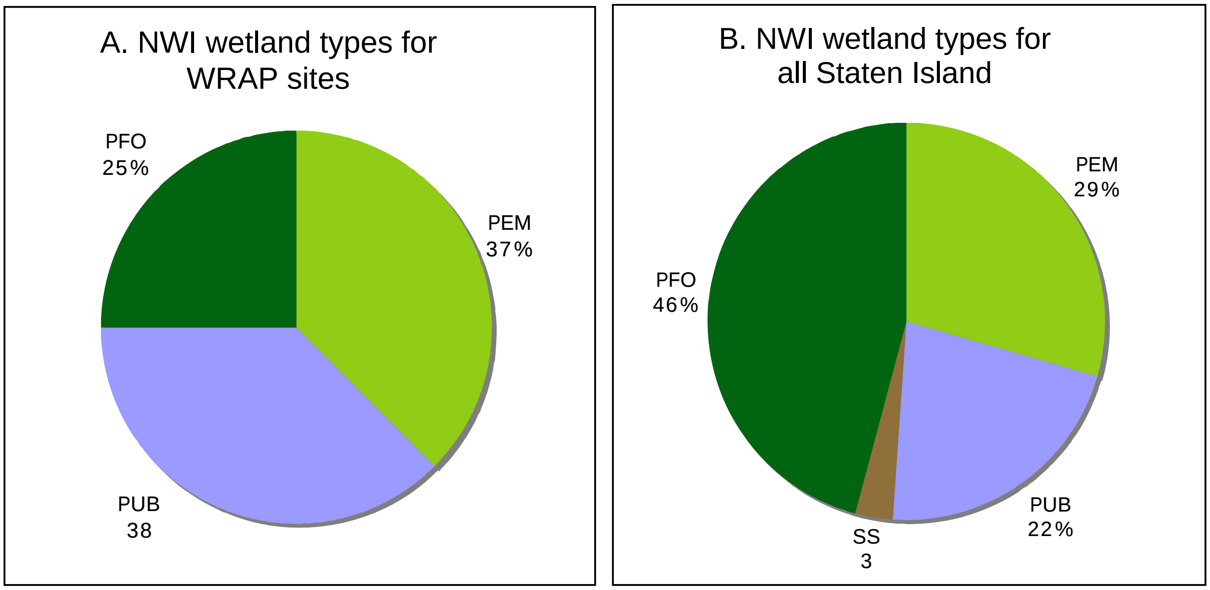


Figure 9. A. The proportion of NWI wetland types (Cowardin classification) sampled at WRAP sites in 2009. B. The proportion of wetland Cowardin classes across Staten Island.

Wetland Vegetation Characteristics

The WRAP data records up to five plant species in each vegetation cover class, with each species occupying a minimum of 20% area of that cover class. This data allows for an assessment of the dominant plant species in each cover class (Figures 10-15). One short-coming that was noted in the WRAP was that total percent cover of vegetation for each vegetation class was not documented – this parameter will be added to the future WRAP analyses. Currently, the percent cover of the total area has to be inferred from the classification of the wetland as emergent, forested or open water, or from the stressor index of degree of vegetation alteration. Despite this problem, the vegetation data was useful for identifying the character of the wetland cover. This data will also be useful in identifying wetlands where specific types of habitat are present and associated biotic monitoring might be indicated. For example, the presence of button bush as one of the dominant species may suggest the site is desirable odonate habitat.

Dominant cover is defined in this study as a species observed to cover at least 20% of the tree, shrub, herb, vine, or aquatic vegetation type within the assessment area. The dominant wetland forest type was the red maple swamp, with sweet gum the second most common dominant swamp forest tree, and, collectively, pin oak, swamp white oak, and red oak the next most dominant. Other tree species were not common in forested wetlands, but became much more common where there was greater light availability at the edges of emergent and open water wetlands. Emergent wetlands were dominated by sweet gum, red maple and oak species in descending order. A similar order was evident in ponded wetlands with unconsolidated bottoms, but there are a greater number of sites dominated by sweet gum and fewer sites dominated by oak species. Trees present in the palustrine unconsolidated bottom wetlands were typically in the shore zones surrounding the ponded water.

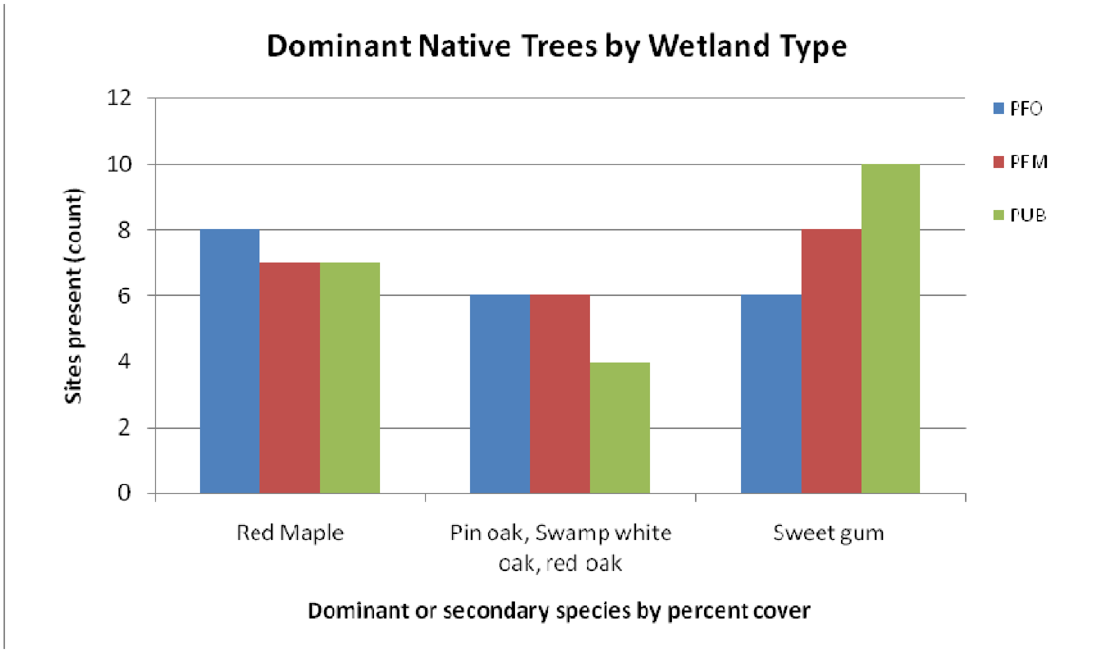


Figure 10. Tree species with dominant cover by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested.

A large variety of shrub species are dominant in these wetlands with many species dominant in only one wetland. Although this is consistent with the different hydrologic conditions in the various wetland types, it does point to the relatively high diversity in this stratum. Five species are present in all the wetland types: high bush blueberry, arrow-wood viburnum, buttonbush, sweet pepperbush, and spicebush. Forested sites are dominated by arrow-wood viburnum, high bush blueberry, sweet pepperbush, buttonbush, and spicebush in descending order. Emergent sites are dominated most frequently by buttonbush and high bush blueberry, secondly by sweet pepperbush and arrow-wood viburnum, and lastly by spicebush. The shrub species most dominant in the open water sites (high bush blueberry and arrow-wood viburnum) are clearly indicative of upland zones surrounding the ponded area. Buttonbush is also dominant in four wetlands of this type indicating marsh areas surrounding open water. Sweet pepperbush and spicebush dominate only one site each.

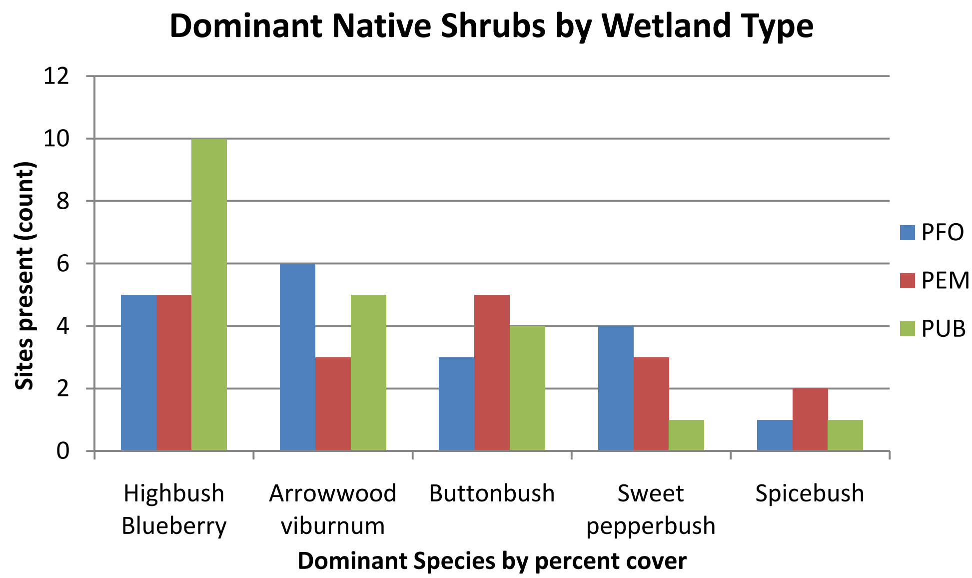


Figure 11. Shrub species with dominant cover by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested.

Each wetland type is dominated by distinctly different herb and graminoid species. Canada mayflower and poison ivy are found most often in forested sites. Swamp loosestrife, native rushes and sedges, as well as arrow arum dominate emergent sites, whereas *polygonum* species, Canada mayflower, and swamp loosestrife are most prevalent in open water sites. Again, a sloped shore zone is the likely factor contributing to the presence of Canada mayflower in the ponded wetlands.

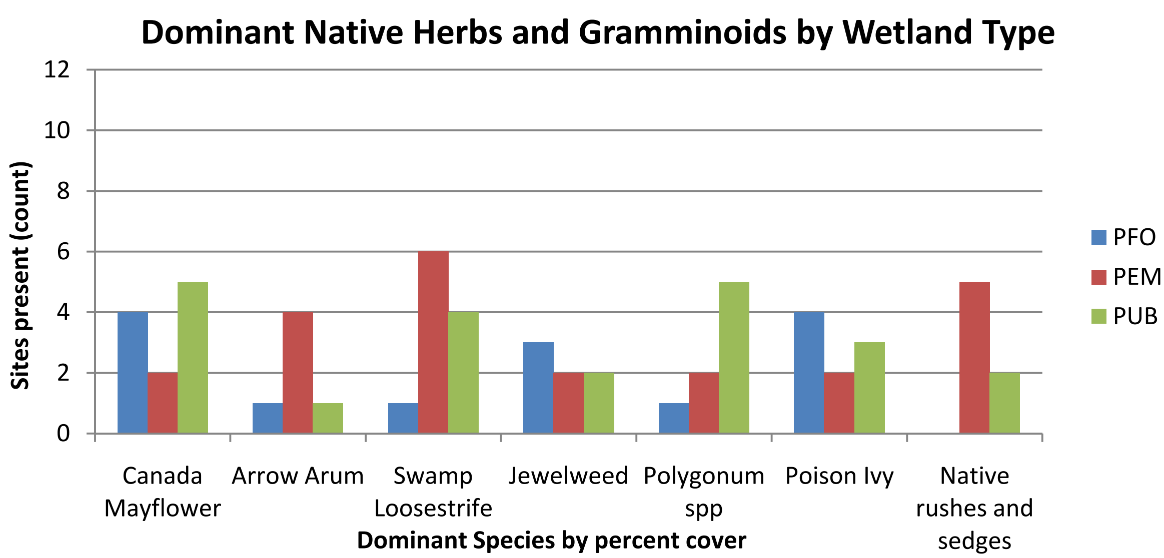


Figure 12. Herb and graminoid species with dominant cover by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested.

Only two vines dominate these wetlands: poison ivy and Smilax species such as catbrier and oak briar. Smilax is more common in general, with slightly fewer sites in shore areas surrounding open water.

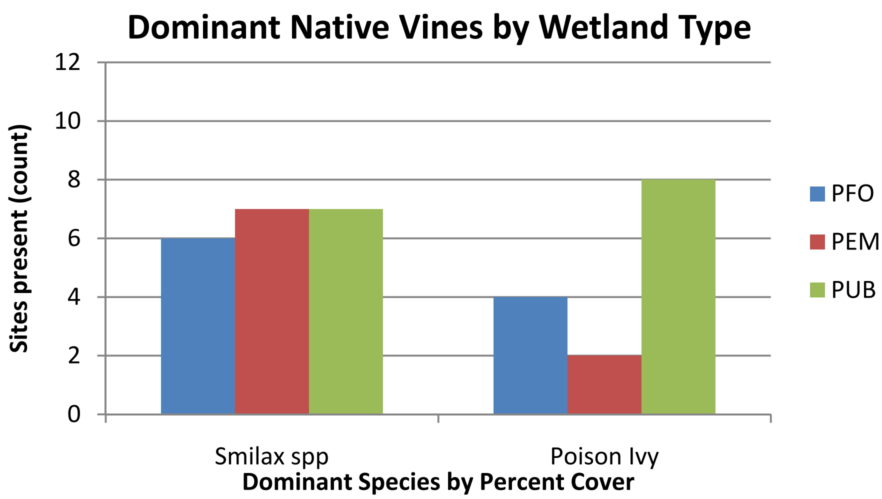


Figure 13. Vine species with dominant cover by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested.

Duckweed is the most dominant species in flooded areas. Spatterdock and *Ludwigia palustris* also dominate flooded areas of some wetlands. *Ludwigia palustris* appears in both the shallow areas of ponds as well as on the drier edges of flooded areas, which explains their presence in one forested wetland.

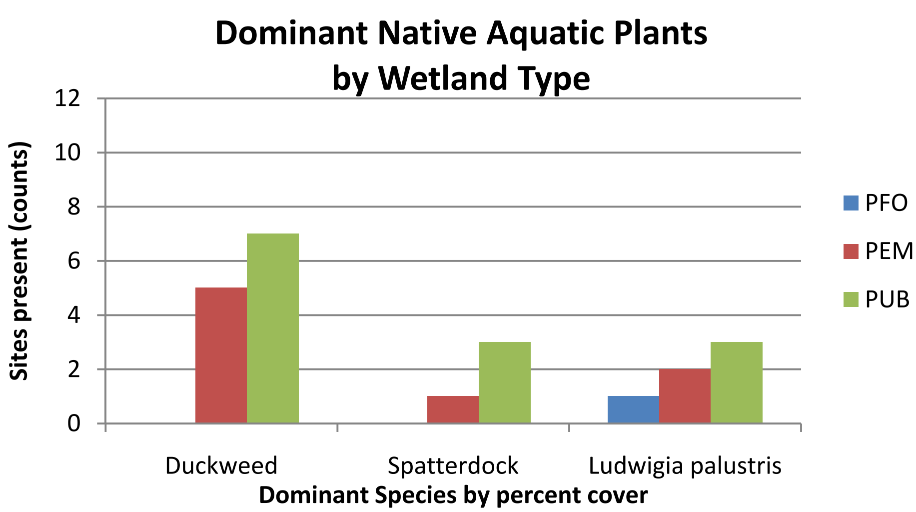


Figure 14. Aquatic species with dominant cover by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested.

Invasive species dominate open water sites most often, followed by forested and emergent sites. Although an invasive aquatic plant inhabits one open water site, the higher score is mainly due to invasive trees and vines dominating the upland areas surrounding the open water.

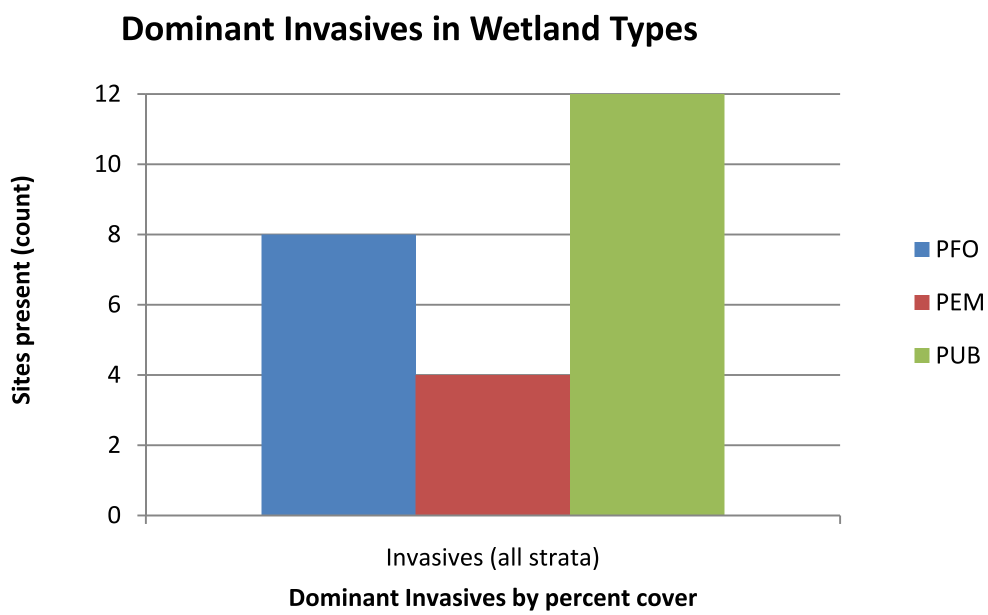


Figure 15. Invasive species with dominant cover in all strata by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested.

Table 3. Invasive Species with dominant cover by wetland type. Cowardin Classification System: PEM = Palustrine Emergent, PUB = Palustrine Unconsolidated Bottom, PFO = Palustrine Forested. Summary table of invasive species observed as dominant cover.

		Number of sites where Invasive species is dominant			
Dominant Invasive Sp.	**Exotic?**	**PFO**	**PEM**	**PUB**	**total**
Phragmites	yes	0	8	3	11
Japanese Knotweed	yes	1	1	1	3
Multiflora rose	yes	0	1	1	2
Purple Loosestrife	yes	0	1	0	1
Asiatic Bittersweet	yes	0	0	2	2
Duckweed	no	0	5	9	14
Tree of Heaven	yes	0	0	1	1
total		1	16	17	34

Presence of Invasive Plants
Three sites scored the highest possible score of ten in this stressor parameter and each was dominated by an invasive herb covering at least 75% of the total vegetation cover area in the assessment area. The Boundary Avenue site (BoAv_1) is a forested wetland dominated by knotweed and is the only forested wetland observed to have a dominant invasive plant. The other two sites dominated by invasives, the Great Kills sites (GrKi_1, GrKi_2), are primarily *Phragmites* and are the only estuarine sites visited by the study.

Vegetation Alteration
Two sites scored the highest possible score of ten in this stressor parameter and can be characterized by observations of increased nutrients, algal mats, and duckweed in the standing water. In the La Tourette golf course the assessed site (LaTo_10) also contained Asiatic bittersweet and multiflora rose. At the Willow Brook Park site (Wi_5) the primary vegetation was lawn grass, the shrub layer was absent, and a large *Phragmites* monoculture was observed.

STRESSOR SCORE RESULTS

Stressor scores were calculated for the 2007 WRAP work as well as 2009 data, and the results are presented below. In addition, we describe what changes have since been made to the 2007 protocol for the 2009 WRAP data collection, how the WRAP field scores compare to landscape characteristics, and the results of our effort to compare WRAP results to other evaluations of wetland condition such as expert opinion and the Floristic Quality Assessment Index (Lopez and Fennessy 2002).

2007 STRESSOR SCORES AND WRAP RESULTS

The stressor scores data from 2007 ranged from 2 to 23 for the 37 sites assessed with a mean of 9.7 and a median of 8.5. The maximum possible score was approximately 40 (trash and debris was counted on a per piece basis and had no defined limit). The following observations were made from the data:

Invasive plants: Within the vegetation assessment area (circle of 10 m radius), five sites were dominated by invasive plants, and 15 sites (fewer than half of the total) had invasive plants with >5% cover. Twenty-one sites had no invasive plants.

Hydrologic disturbance: The majority of sites (24) were observed to have unaltered, or unobstructed drainage patterns, while 11 sites had altered drainage patterns and 2 had blocked drainage features. Hydrologic disturbances were difficult to determine in the field, particularly since some disturbances are historical and may affect sub-surface hydrology in ways that cannot be detected through rapid assessment.

Roads/Trails: More than half of the sites assessed (24) had some kind of trail or path in the immediate vicinity. Only four sites had ATV trails or larger dirt roads.

Wetland size and condition: Most of the wetlands were between 3 and 10 acres. This wetland size had the highest average stressor score (11), while the 2 wetlands that were less than 0.3 acres in size (Figure 16) had the lowest mean stressor score (4).

Plant species richness: Although a detailed inventory of plant species was not conducted, species richness associated with the rapid assessment was conducted and compared to the stressor scores for the site. Richness of dominant species had a mean of 5.7 with a standard deviation of 3.1. The sites with the 2 highest stress scores had a species richness one standard deviation lower than the mean, and the site with the lowest stressor scores had a species richness one standard deviation about the mean. There may be a negative correlation between species richness and degree of stress at a site.

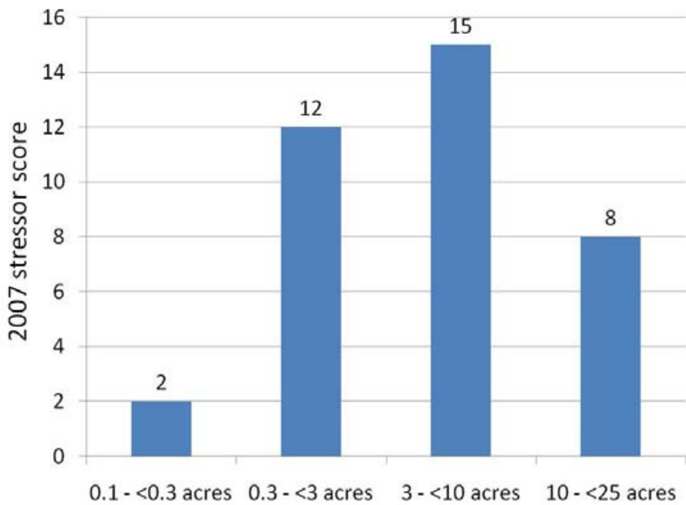


Figure 16. Stressor scores and sizes of wetlands assessed in 2007, including number of sites in each size category.

MODIFICATIONS TO 2007 WRAP PROTOCOL FOR 2009 ASSESSMENT

In the fall of 2008, five NRG ecologists and environmental scientists conducted the 2007 version of the WRAP at the Sweet Bay Magnolia wetland together. The goal of the group assessment was to review the 2007 protocol, clarify our understanding of the parameters used, and identify ambiguities, inconsistencies, and redundancies that should be addressed for future WRAP efforts. Consequently, at numerous internal NRG meetings, we revised the protocol, and clarified the objectives and format of the WRAP. Several meetings were held with Dr. Matt Palmer of Columbia University, who has advised us in this project, and suggested some analyses techniques that we used.

Several changes were made to the 2007 WRAP protocol to make it easier to use in the field. With respect to the field form, the following changes were made:

1 Municipality was deleted.

2 Cowardin is now verified in field and in GIS. Revised does not ask for % of area.

3 Size of wetland is now in square meters not acres (no longer a range) from GIS.

4 Average buffer width is deleted (this is now only a stressor as this was repetitive)

5 Intensity of surrounding land use was eliminated (this is now only a stressor as this was repetitive)

6 "Semi to permanently inundates/saturated or regularly inundated/saturated or seasonally inundated or seasonally saturated" was removed as this was difficult to figure out in the field.

7 Position in landscape was confusing and was replaced with HGM classifications.

8 Hydrologic indicators (primary and secondary) were combined into one category.

9 Water pH was moved into water quality section (but still rarely documented).

10 Sources of water into wetland were eliminated as this was difficult to determine in the field and is captured in the HGM Classification scheme.

11 "Special wetland communities" was moved into the value added metric portion of the form.

12 Vegetation-only vegetation that occupies at least 20% cover in a stratum is documented, and the dominant species in that stratum are listed in order.

The Stressor List check list in the field form was revised to provide more detail about the stressors on the sheet where the score is written, although the parameters evaluated did not change greatly. The following changes were made:

13 Buffer Width was estimated in field and then verified in GIS. Revised version does not take into account type of vegetation in buffer.

14 Buffer assessed in 2007 was 100m, 2009 looks at 30m. This was narrowed because it is difficult to see 100m around the perimeter of the wetland. 30m/100ft also corresponds to the NY State regulation distance for the protected "adjacent area." (CEQR Technical Manual) and so can be expected to represent a threshold distance beyond which development is unlikely to impact the wetland.

15 Development density was replaced with land use data (from PLUTO 2006). And Ball field (2pts) as well as parking lot (3pts) has been added to "other buffer stressors."

16 Sedimentation- plowing, and forest harvesting was not relevant for NiCad was removed, and heavy grazing was double counted in vegetation alteration.

17 Increased nutrients- Score was increased to be worth 2pts up from 1pt. This accounts for removing the section on turbidity and the importance given to this stress by reviewers.

18 Vegetation Alteration- Mowing, and >50% invasives were removed (double counted).

19 Forest Harvesting was eliminated. This was not relevant to NYC.

20 Dominant Forest Age was changed to Average DBH of 5 largest trees. No longer a stressor, just give information about the successional state of the site.

21 Presence of invasive species (%) was changed to the Braun-Blanche cover classes. List of common invasives was added so can just be circled/underline in the field.

22 Excessive Herbivory was removed (redundant)

23 Turbidity was removed. This category was redundant with increased nutrients and sedimentation.

24 Canopy Cover was removed. The wording was confusing, so it was revised.

25 Canopy Classification was removed as not was not a stressor, and the causes of cover loss are covered in the "vegetation alteration" category.

26 Human Disturbance/Dumping. Scoring was revised do that it was not 1pt per piece. Trash no longer is as heavily weighted in the assessment.

2009 STRESSOR SCORE DATA

The 2009 Stressor scores were based on a scale of 0 to 120 (12 stressor parameters x potential score of 10 each) and ranged from 3 to 83 for the 51 sites with an average of about 20 for the field stressor score and about 34 for the total stressor score. Figures 17- 19 show the distribution of stressor scores for emergent wetlands, open water (unconsolidated bottom) and forested wetlands. Open water wetlands appear have a higher inner quartile range of stressor scores (are more impacted) than forested and emergent wetlands.

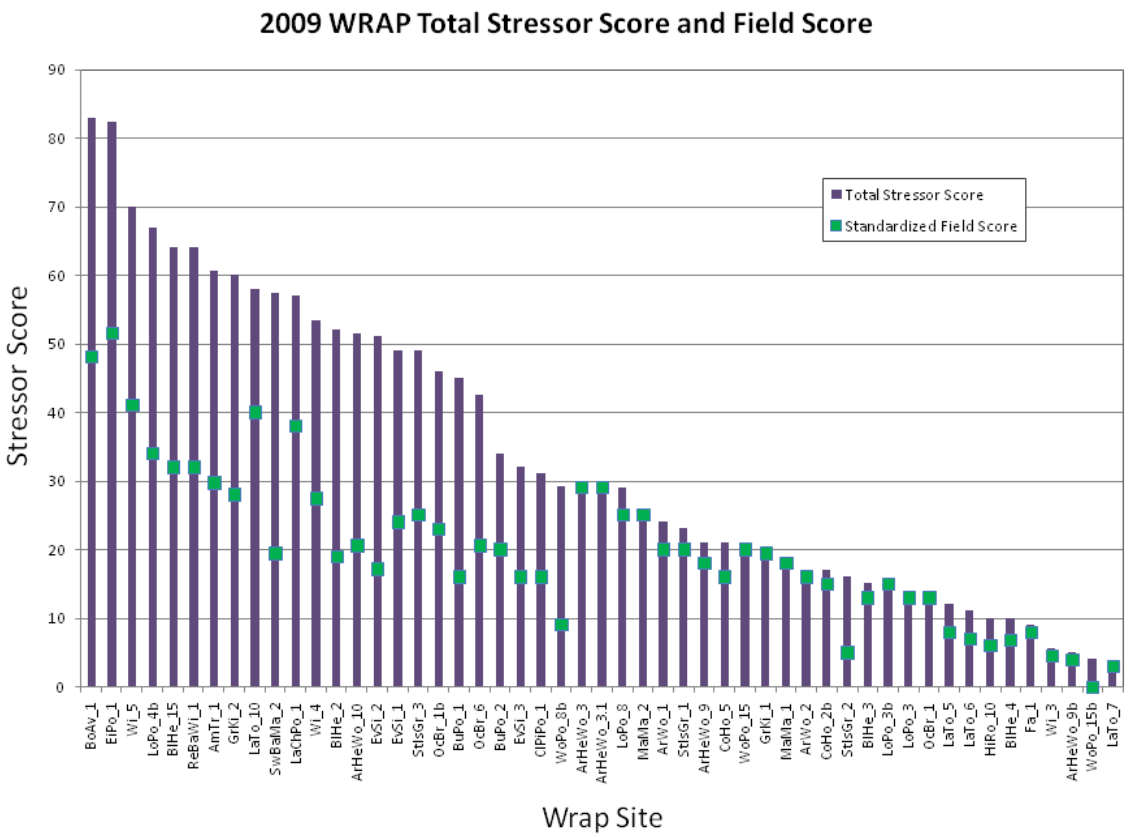


Figure 17. Stressor scores (total and the standardized field stressor) scores for all 2009 WRAP sites. The field stressor score is the sum of the eight stressors assessed in the field (trash and debris, trails and roads, hydrologic modifications, sediment and erosion, increased nutrients, pollutants in standing water, vegetation alteration, and presence of invasive species),

standardized to reflect the number of stressors applicable and counted for a particular wetland type. The total stressor score is the standardized field stressor score added to the four stressors calculated in the GIS buffer analysis (Minimum distance to development, impermeable area within 30 m, land use within 30 m, and roads within 30 m).

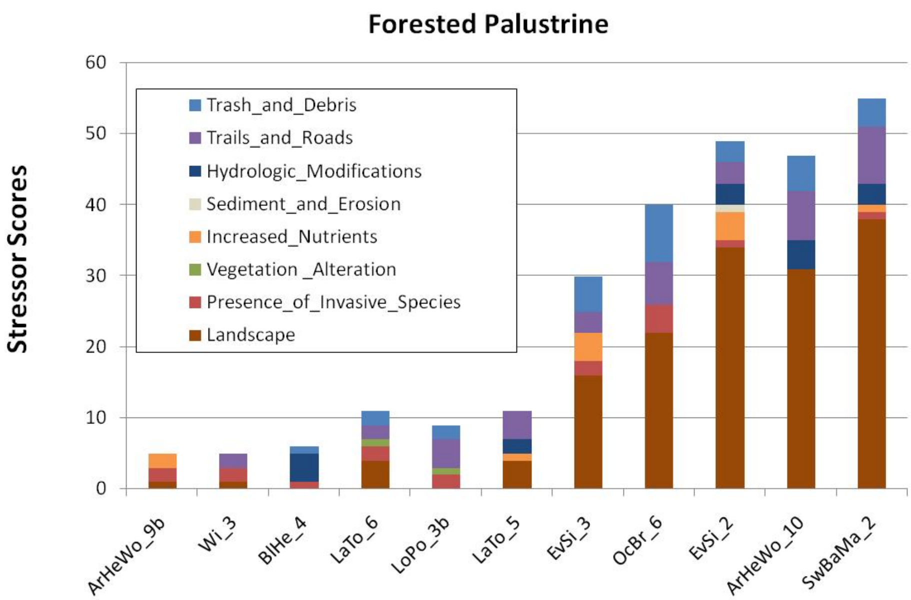


Figure 18. Breakdown of total stressor score for forested palustrine wetlands. The landscape score account for >30% of the total score at all sites but about four.

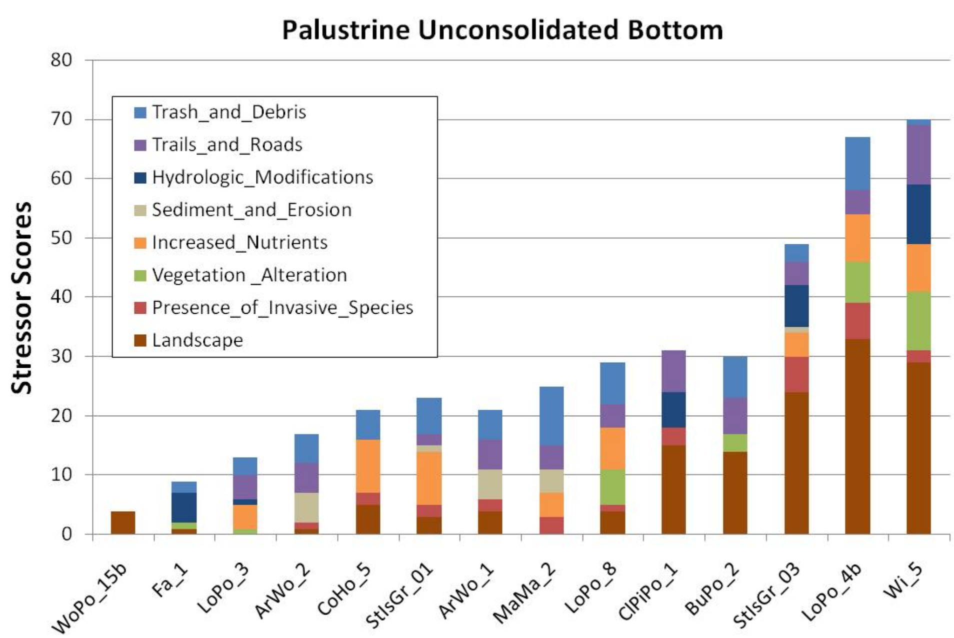


Figure 19. Breakdown of total stressor score for palustrine wetlands (unconsolidated bottom). At the 2nd- 9th sites (left to right) the landscape (GIS-based) stressor scores are a <25% of the total score; at the other six sites the landscape score is >30% of the total.

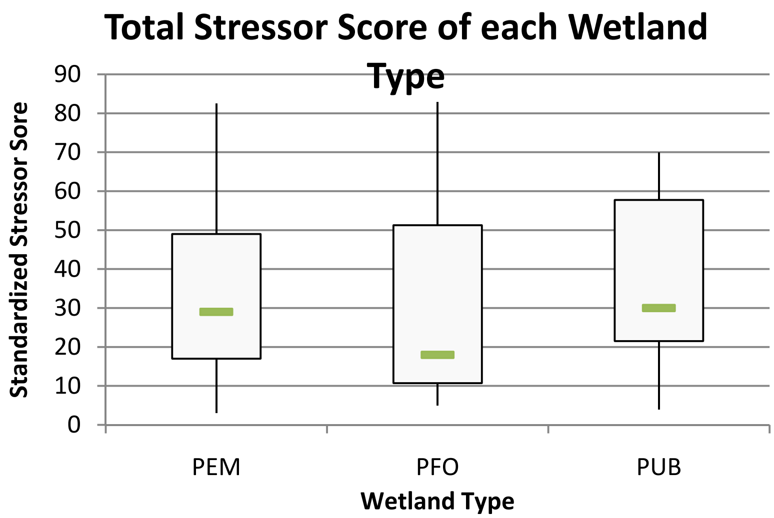


Figure 20. Range and median for Total Standardized Score by wetland class. Total Standardized Score is calculated by summing the GIS and standardized field stressor scores for each wetland class.

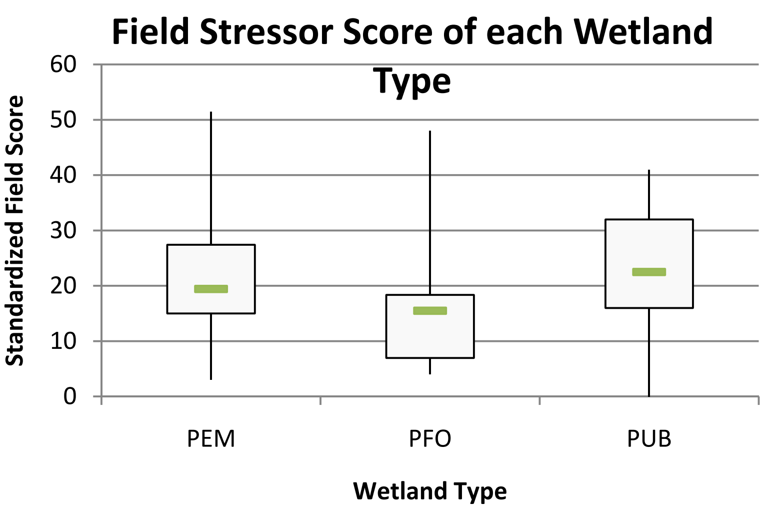


Figure 21. Range and median for standardized field stressors for each of the three wetland classes.

Frequency Distribution of Stressor Scores

The frequency distributions of the field stressor scores for all of the WRAP sites assessed show a close to normal distribution (Figure 22). However the distribution of the landscape (GIS Buffer Analysis) scores is not normal. Most wetlands have either have little or no development in their buffer zone or they have a large range of development.

The frequency distributions of each of the twelve stressors were plotted individually and all have non-normal distributions (Figures 23 and 24). Eight stressors displayed high frequencies for a stressor score of zero, indicating no impact or stress in twenty-one to thirty-three of the wetlands. Three of these, Land Use within 30 m of Wetland, Impermeable Area within 30 m of Wetland, and Most Intense Type of Road within 30 m of Wetland, have an additional peak in the distribution, indicating bimodality. This lack of a normal distribution means we cannot expect a simple correlation with other parameters. Land Use within 30 m of Wetland and Most Intense Type (or highest volume) of Road within 30 m of Wetland have similar distributions and their values may also be correlated. This is not surprising as larger roads usually accompany increasing development. The four stressors Presence of Invasive Species, Minimum Distance to Development, Trash and Debris, and Trails and Roads, are widely dispersed and fairly even. Presence of Invasive Species is skewed to the left, as is Trash and Debris; Trails and Roads display some bimodality. Only two wetlands received a score above zero (no pollution) for Pollutants in Standing Water. This may not be a useful stressor for most New York City Parks. However, although it appears infrequently, it may be indicative of conditions that can easily be addressed, such as outflow pipes from surrounding development. The lack of large peaks (aside from zero) in many of the stressor score frequency distributions may help explain the lack of a distinct threshold in stressor score values between management prioritization types.

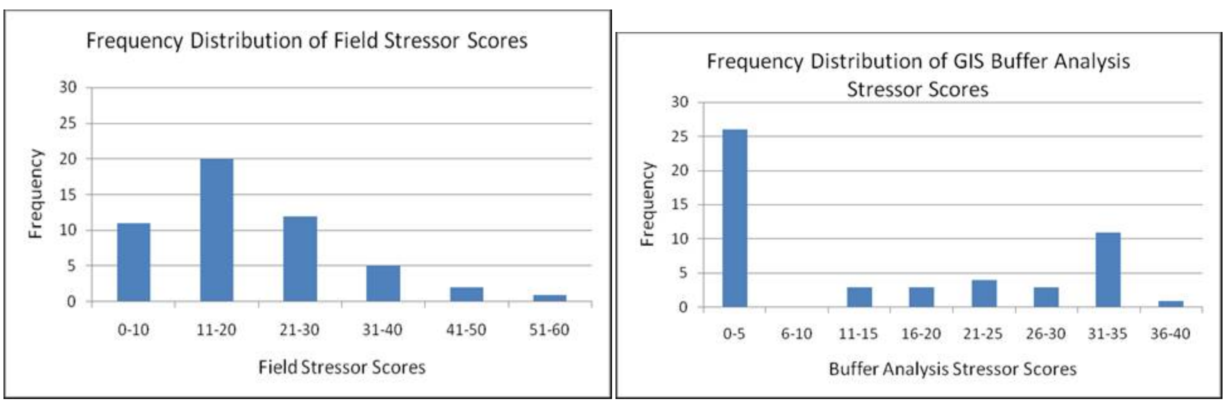


Figure 22. Frequency distributions of field stressor scores and GIS buffer analysis stressor scores.

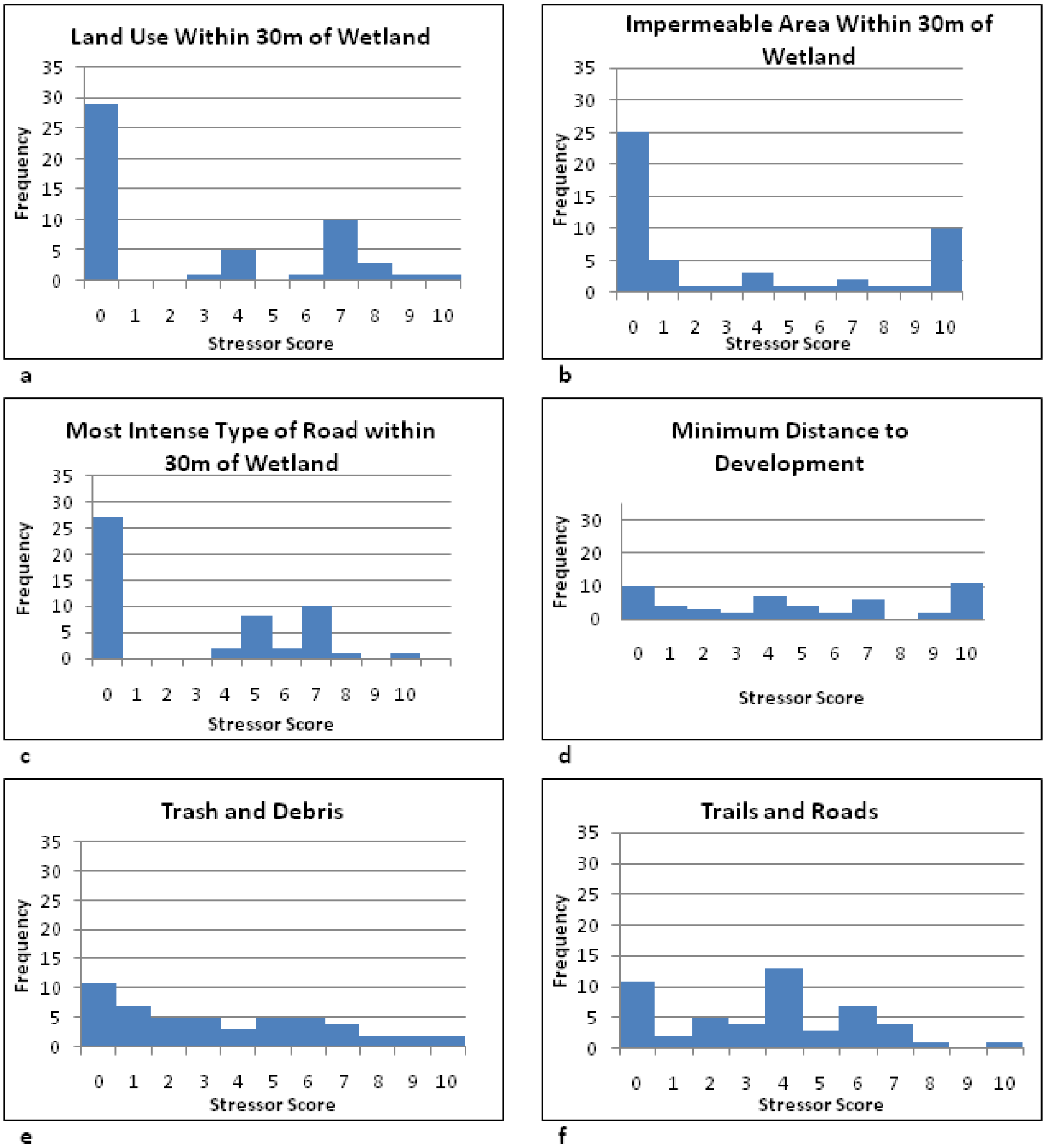


Figure 23. Frequency Distributions of Stressor Scores for (a) Land Use in 30 m buffer, (b) Impermeable Area in 30 m buffer, (c) Most Intense Type of Road in 30 m buffer, (d) Minimum Distance to Development, (e) Trash and Debris, and (f) Trails and Roads

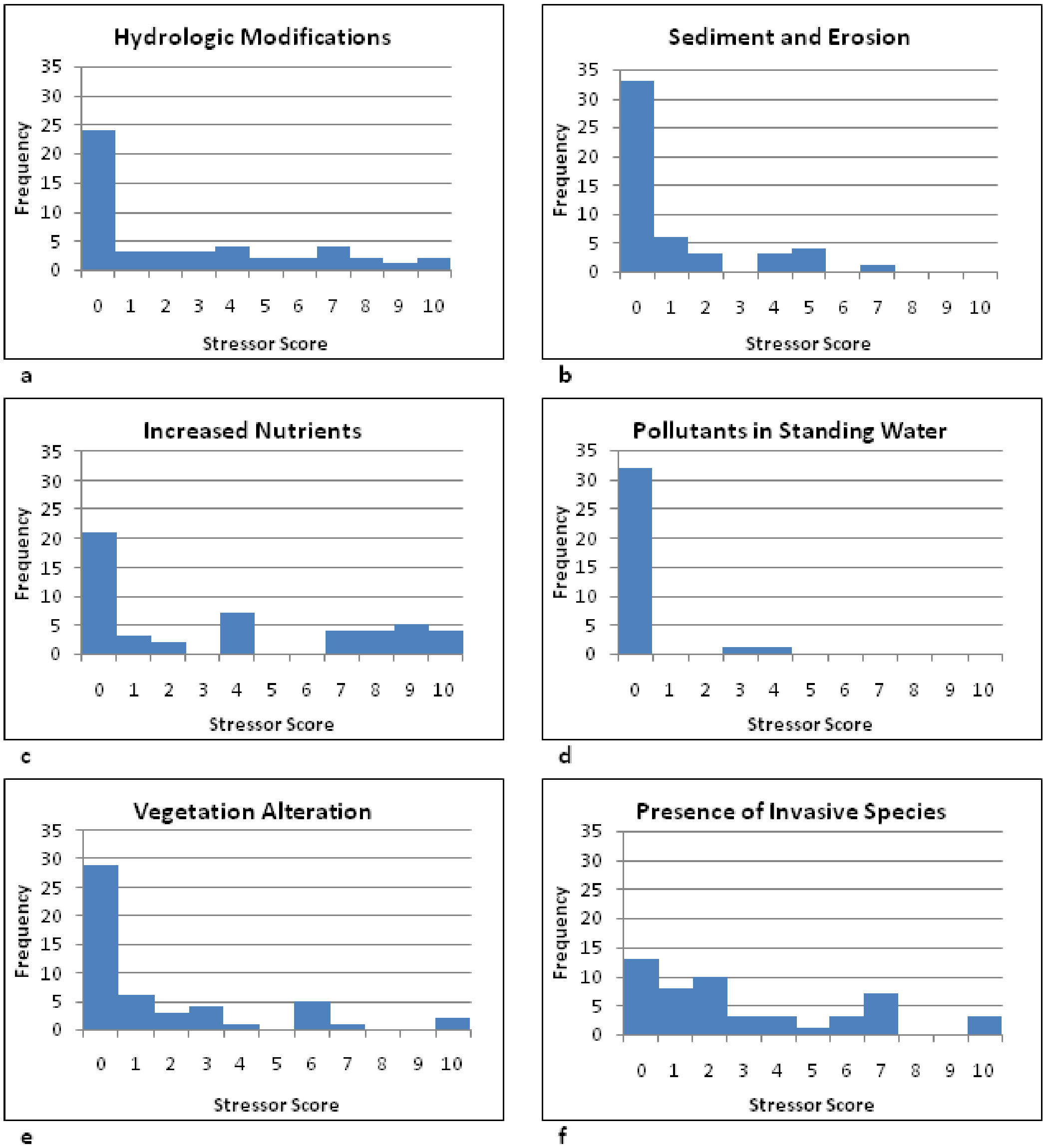


Figure 24. Frequency Distributions of Stressor Scores for (a) Hydrologic Modifications, (b) Sediment and Erosion, (c) Increased Nutrients, (d) Pollutants in Standing Water, (e) Vegetation Alteration, and (f) Presence of Invasive Species

Watershed Characteristics vs. Field Stressor Scores

WRAP site scores were plotted against the percent development in drainage basin associated with the site and in the buffer area around the wetland. There is a wide variation in the percentage area of undeveloped land and percentage area of open space for the particular drainage basin with which the WRAP site was associated. There was no trend showing that lower stressor scores correlate to more open space or less development in a drainage basin (Figures 25 and 26). Interestingly, there is a slight correlation between increased vacant lots and stressor score, potentially suggesting that vacant lots are not always quality open space, depending on the condition and perhaps historical use of that land.

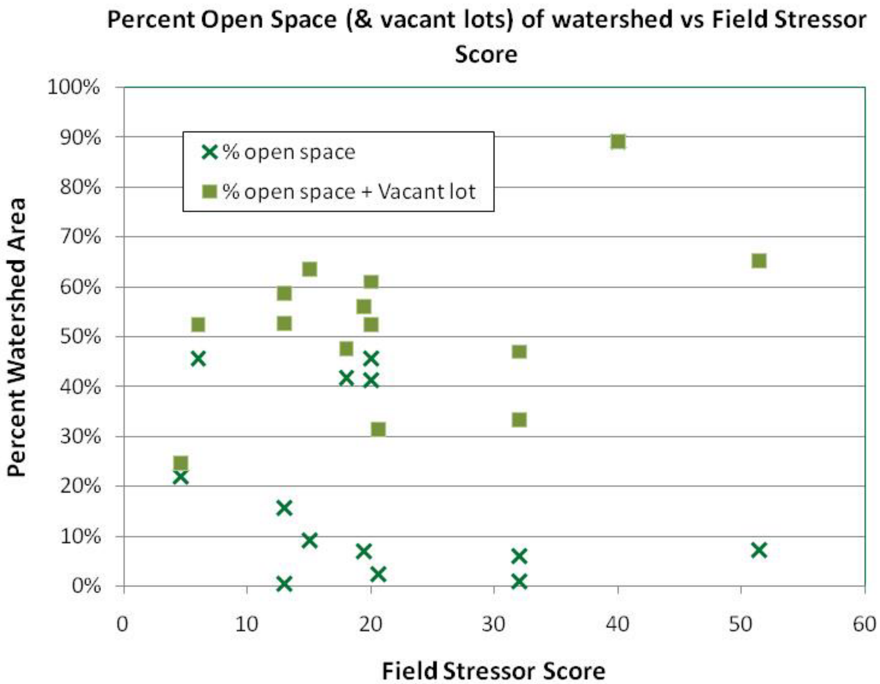


Figure 25. Percent open space in watershed vs. Field Stressor Score. There is no positive correlation between % open space in the watershed and lower stressor score, as may have been expected. Adding vacant land area to open space in fact suggests a slightly positive relationship between percent open space and vacant land, and higher stressor scores.

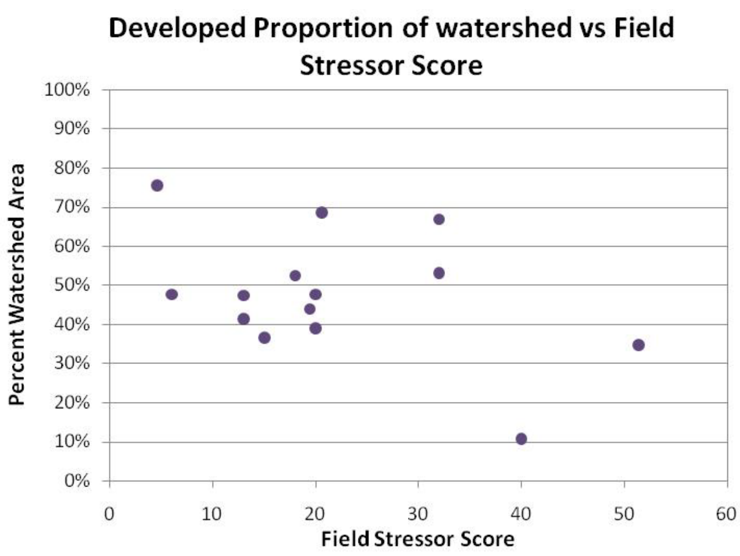


Figure 26. Percent development in watershed vs. Field Stressor Score. There is no positive correlation between % development in the watershed and lower stressor score, as may have been expected. Adding vacant land area to open space in fact suggests a slightly positive relationship between percent open space and vacant land, and higher stressor scores.

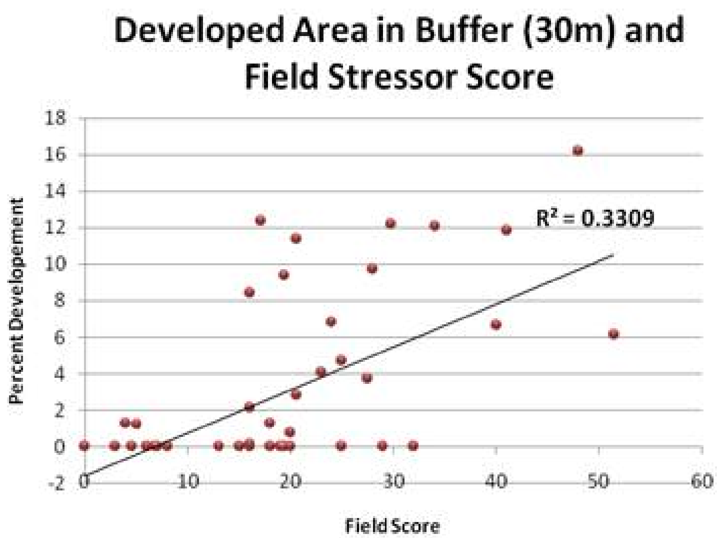


Figure 27. Percent development in 30m buffer around wetland vs. Field Stressor Score. There is wide variation in the % area developed for almost all values of Field Stressor Score. This suggests that the buffer analysis may not be useful for this purpose, or may need to be tested on a subset of wetlands where the wetland boundary has been verified.

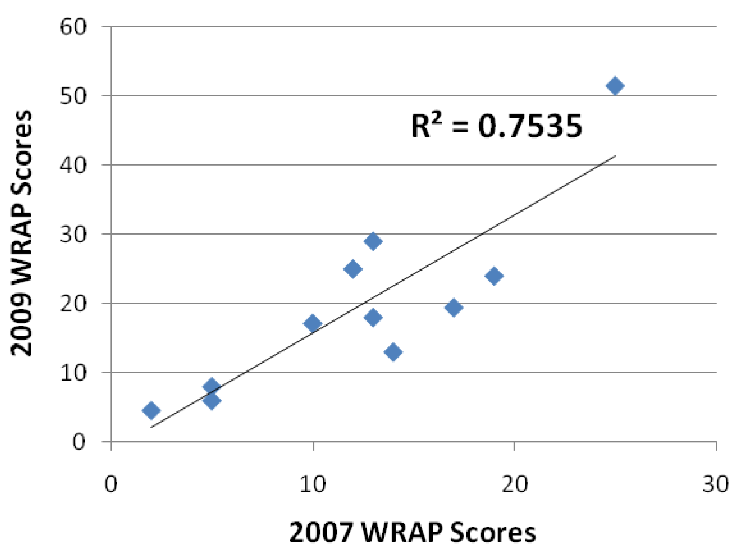


Figure 28. Comparison of 2007 and 2009 WRAP scores. The strong correlation between the stressor scores from different WRAP versions implies that the results from either WRAP do not differ greatly.

The highest scoring site (most impacted) had the same resulting score using both protocols (Eibes Pond). Two other sites that were scored as highly impacted in 2007, Sweet Bay Magnolia and Evergreen Bond, were also among the top 30% of the stressor score range in 2009. Similarly, one of the lowest scoring sites (least impacted) was the same using both protocols (Willow Brook). Two other sites which had relatively low stressor scores in 2007, LaTourette and Loosestrife Swamp in High Rock Park also had among the lowest stressor scores range in

2009. The greatest variation between scores is found at the sites with intermediate stressor scores.

Method Refinement: Testing of Weighting Stressor Scores

Every stressor may not have the same degree of impact on the ecological integrity of a wetland or the level of ecosystem services delivered. For example, trash might have a superficial impact and belie intact hydrologic processes at a site. Alternatively, increased nutrients may be more significant than other stressors. These differences in the significance of different parameters can be addressed by weighting the scores of the parameters differently.

Guidelines for weighing the unique urban stressors found in New York City Parklands do not currently exist. To explore the potential need for weighting the stressor parameters differently, the four field researchers who collected most of the data and helped develop the WRAP were asked to quantify their confidence level in the repeatability, accuracy, and importance of the thirteen WRAP stressors. They were also asked to suggest whether any parameters should be given more or less weight. Responses were varied; few individuals suggested lowering the weight of the minimum distance to development. No other suggestions were agreed upon by two or more individuals. However, three individuals rated two indicators of high importance: increased nutrients and portion developed within 30 meters of the wetland. We explored adjusting the weights of these three stressors: reducing the minimum distance by 50% and increasing by 50% the increased nutrients and portion developed within 30 meters. No appreciable change to the management priorities resulted. We concluded that a thorough literature search be conducted at a later date to find supporting scientific evidence for revising the weighting of any given stressor parameter.

Method Validation: Expert Survey of Wetland Condition

One method employed to calibrate the WRAP results was solicitation of wetland expert opinions on the level of disturbance at the wetlands that were assessed. We prepared a survey asking experts were asked to score wetland disturbance on a numerical scale from one (1), least degraded, to five (5) as most degraded. “Don’t Know” was also an option if the individual was not familiar with the site. All wetland sites scored by the WRAP protocol were present on the surveys as well as a lumped category for all wetlands in each park (See Table 4). Experts were also asked to list ecosystem services provided by the site, however no individuals responded to this portion of the survey.

The survey was sent to nineteen wetland professionals from the New York City area that was familiar with wetlands on Staten Island. Five individuals, primarily from NRG, responded to the survey of 2007 sites and four individuals completed the 2009 site survey. Using data from 2009, we compared the average expert scores to the WRAP scores if two or more experts were familiar with the site and arrived at a numeric score. Thirty-seven specific sites out of a total of 55 were compared.

There was little agreement between the relatively subjective expert scoring and the WRAP scores for highly disturbed wetlands. Only one wetland with an expert score greater than or equal to 3.5 was in the WRAP management category of highest concern. The same was true for wetlands that the WRAP data analysis showed were least disturbed and slated for highest protection; only one specific wetland received an expert score less than or equal to two (2). This may be due to the fact that only four to five experts scored the sites and one individual's scores were significantly higher than the other professionals, skewing the average. Adjusting for this skew by using 2.50 as the upper limit generates six wetlands scored by experts that correspond to WRAP analysis of least degraded sites. Another source of the disparity between the expert and WRAP scores may be that some wetlands might have been visited by the experts in the past and present conditions may differ.

Table 4. Example of the Wetland Expert Opinion Survey. Two of the 37 wetland sites which were give to the wetland experts are listed below.

PARK	WETLAND SITES (See Maps)	Wetland Disturbance (1 is least degraded)						List ecosystem services provided by the site (e.g. habitat, flood control)
	Whole Park	1	2	3	4	5	Don't Know	
	Site 3	1	2	3	4	5	Don't Know	
	Site 9	1	2	3	4	5	Don't Know	
	Whole Park	1	2	3	4	5	Don't Know	
	Site 3	1	2	3	4	5	Don't Know	
	Site 6	1	2	3	4	5	Don't Know	

Floristic Quality Index

To look for a potential relationship between the WRAP stressor scores and plant species information that had been collected at various Parks over the past decade, we also calculated the Floristic Quality Assessment Index for Staten Island parks.

The Floristic Quality Assessment Index (FQAI) was designed to reduce subjectivity, and create an objective standard for evaluating the quality of plant communities (Lopez and Fennessy 2002). The quality of each species is assessed using a coefficient of conservatism (0 to 10) which is assigned based on the ecological tolerance of that species. The FQAI is essentially a weighted average of the species richness weighted for the coefficient of conservatism (Andreas et al 2004). The Bowman's Hill Wildflower Preserve located in New Hope, Pennsylvania has published a Plant Stewardship Index Calculator (PSI) on its website (http://www.bhwp.org/db) for Pennsylvania and New Jersey. This tool calculates the plant stewardship index as well as the floristic quality index. The FQAI differs from the PSI in that the FQAI uses only native plants to compute the index while the PSI takes into account non-natives (adventives or introduced species) as well. We chose to use the New Jersey database for its ecological similarities to Staten Island. The Bowman Hill database uses coefficients of conservatism based on the following scale:

0 to 3 = Plants with a high range of ecological tolerances/found in a variety of plant communities

4 to 6 = Plants with an intermediate range of ecological tolerances/associated with a specific plant community

7 to 8 = Plants with a poor range of ecological tolerances/associated with advanced successional state

9 to 10 = Plants with a high degree of fidelity to a narrow range of habitats

The species lists entered into the FQAI calculator were generated by Marge Garguillo over a period from 1998 - 2006 and represent park-wide data. Each plant for each Park is entered into the database by genus and species. When all the plants are entered the FQAI and PSI were recorded. The FQAI scores were plotted against WRAP stressor scores for all the parks where WRAPs were conducted (Figures 29-30), but no correlations were observed. There is a potential negative relationship between FQAI and WRAP stressor score, but it is not statistically significant.

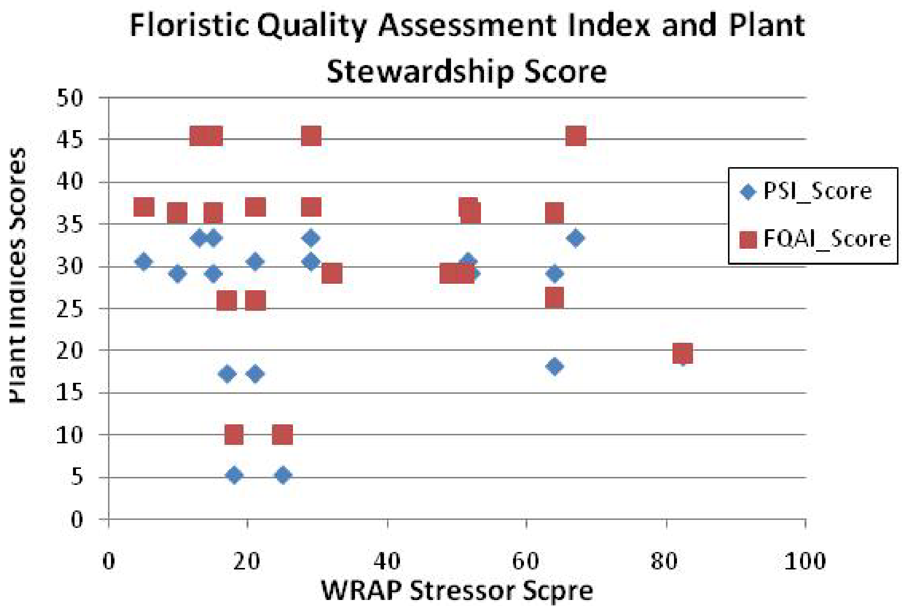


Figure 29. Floristic Quality Assessment Index and Plant Stewardship Index Scores vs WRAP scores. The FQAI is a weighted average of the species richness weighted for the coefficient of conservatism which uses only native plants. The PSI is a weighted average of the species richness weighted for the coefficient of conservatism which uses native and nonnative plants. There was not apparent correlation between the FQAI or PSI and WRAP scores.

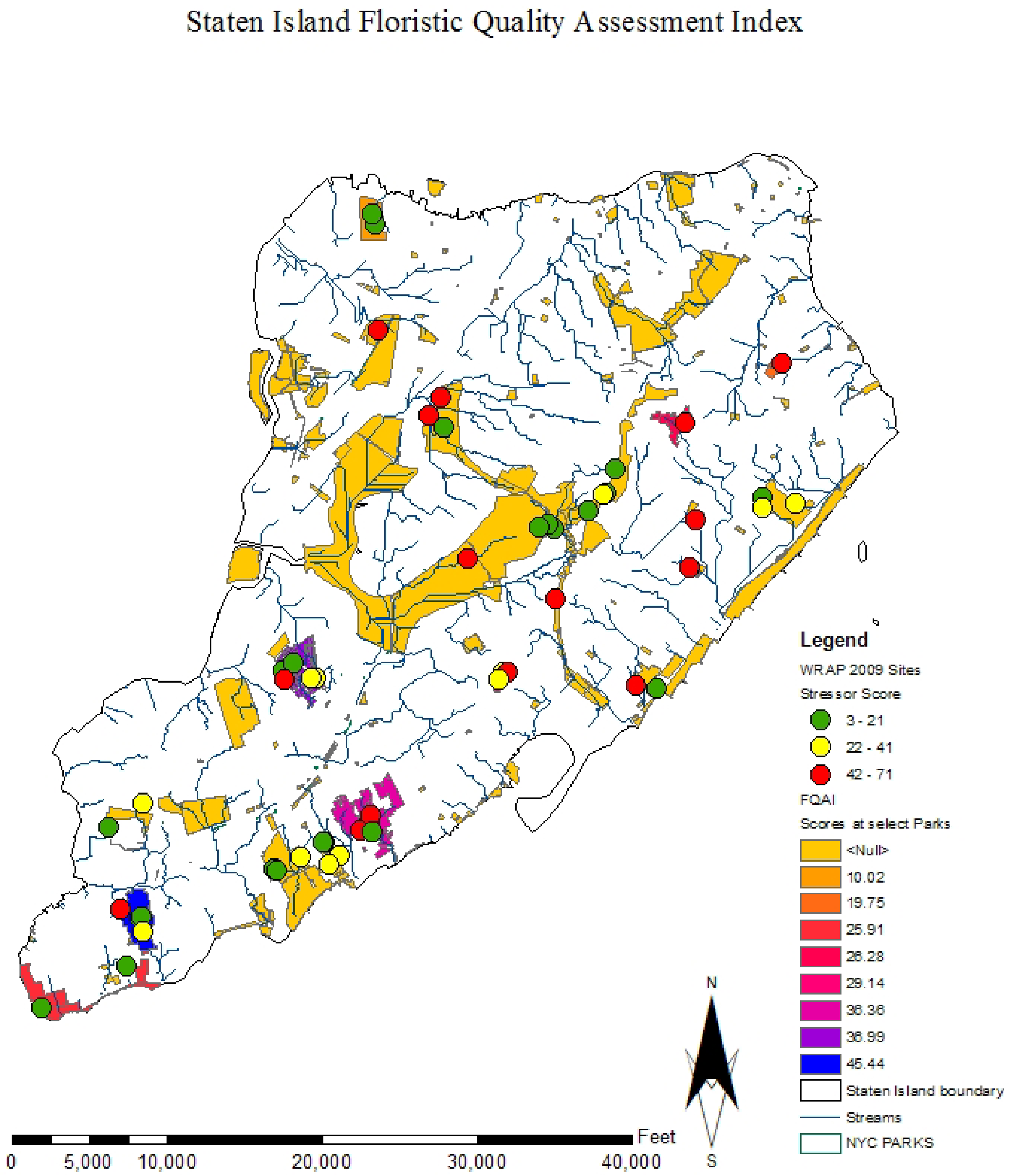
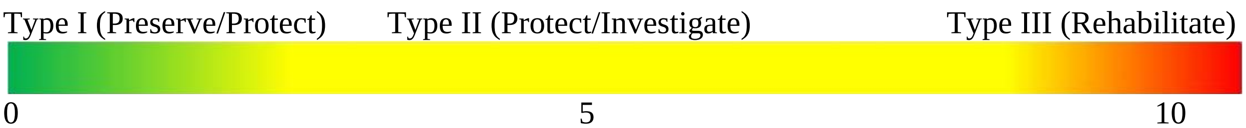


Figure 30. Map of Parks and with Floristic Quality Assessment Index Score and WRAP scores.

WETLANDS MANAGEMENT PRIORITIZATION BASED ON WRAP

Wetland sites that have been assessed using the 2009 WRAP were grouped into three general management categories according to their calculated stressor scores (Figure 31). The sites with the least stress will in general have a need for the least intensive management actions, while the sites that are most impacted will be earmarked for more active management. Although most wetlands will fit into more than one broad management class, these groups serve as a broad guide for prioritizing management actions. Although any combination of management actions may be used at all sites, the typical management actions associated with each classification have been laid out below.



Type I: The wetlands associated with the “Preserve” group are those that should be preserved and protected. These are the sites that have the lowest score on the stressor checklist and exhibit relatively few impacts in their current state. Also included in this group are sites that are special wetland communities, habitats or breeding places for rare/threatened/endangered species. Management actions associated with this class are primarily aimed at preventing changes to surrounding landscape that could impact the wetlands. These actions are generally minimal and may include increased enforcement of park rules, and more in-depth faunal or vegetation analysis. These sites may also be used as reference sites for further monitoring studies

Type II: The wetlands in the “Protect/Investigate” group are those that need to be shielded from future damage or that require further investigation to determine their need for preservation versus rehabilitation. These are sites the majority of the sites found in the middle range of the stresser scores. Associated types of typical management actions include: trash removal, installation of fences to discourage dumping, increased enforcement of no-motorized vehicles rules, early intervention to prevent colonization of invasive plants, existing invasive species removal and enforcement of erosion and sediment control of surrounding areas. These sites might be most vulnerable to future neglect or increased hydrological disturbance in the landscape.

Type III: Wetlands grouped under “Rehabilitate” are those that are in need of interventions to return the site to a less degraded state. These are sites which received the highest scores on the stressor checklist and are the most impacted. The associated typical management actions are the most intense and include; hydrologic drainage investigation, vegetating the buffer, planting native species, investigating sources of increased nutrients and diverting direct runoff or point-source pollution. These sites might also require fencing, trash and invasive removal but on a more extensive level as they are particularly vulnerable to further degradation

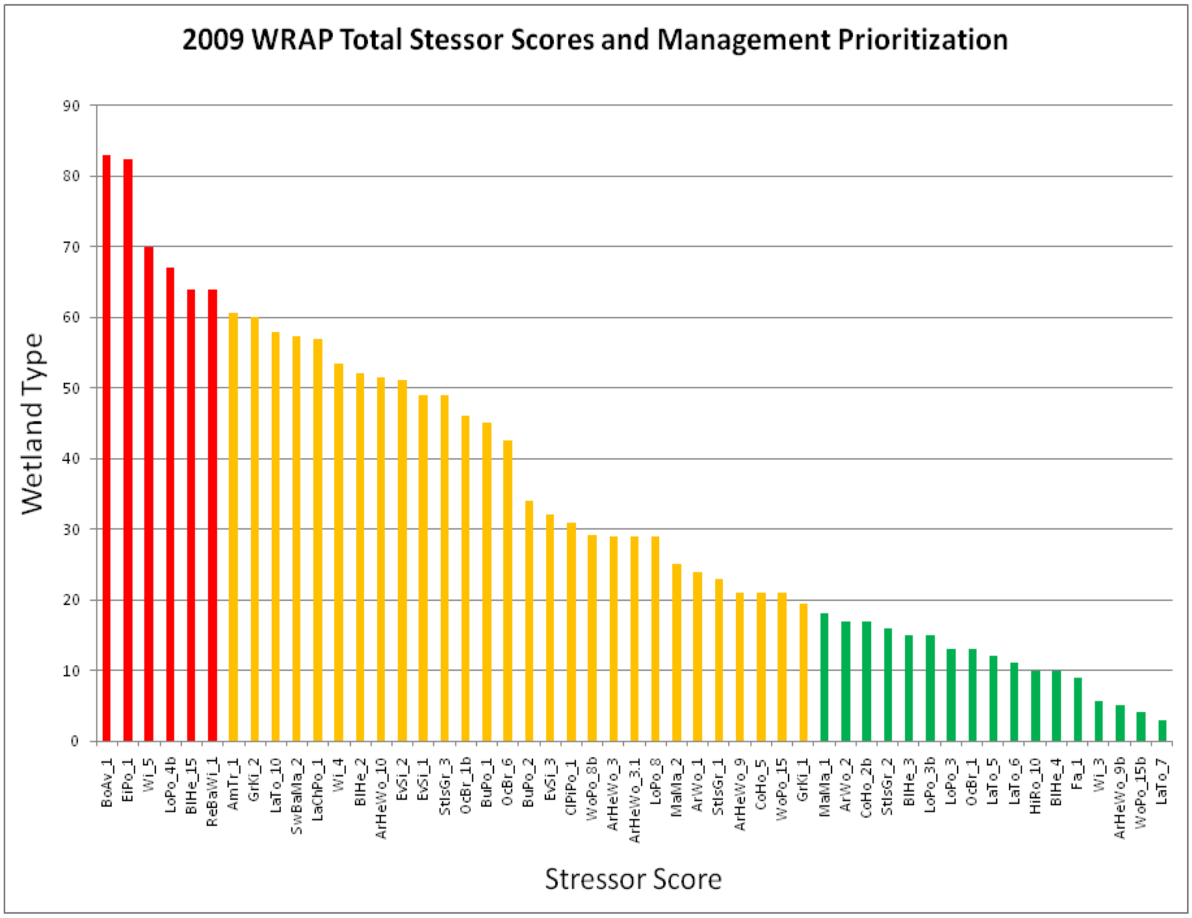


Figure 31. Distribution of stressor scores and associated prioritization for management action.

STREAM RAPID ASSESSMENT PROTOL RESULTS

The stream rapid assessment protocols (RAP) included a condition scoring approach based on giving higher scores for least impacted and altered condition. This positive approach to scoring condition has the advantage of being intuitive (higher score, better result) and potentially being more readily comparable to other indices of biological conditions that increase as conditions improve. The best possible condition was a 10 for any given parameter, so with 14 parameters assessed in the RAP, the best possible score for stream condition was 140.

Six streams and 10 reaches were assessed (Figure 32): 1) the stream at Egbertsville Ravine (Eg Ra), which is a tributary to Richmond Creek; 2) Dead Man’s Creek (DM C); 3) Manor Creek (MC) (both Dead Man’s and Manor are tributaries to Egbertsville Ravine; 4) the stream at Reeds Basket Willow (which comes largely culverted after it leaves Reeds Basket Willow Park); 5) the stream in the golf course at La Tourette Park, and 6) the stream downstream of Blue Heron Park. At Dead Man’s Creek, Manor Creek, and Reeds Basket Willow (which is mostly piped after it leaves the Park), several reaches were assessed. The streams were all gravel-cobble streams, and all of the streams were perennial, to our knowledge, except Manor Creek and Blue Heron Creek. At most of the streams, native riparian species were dominant (Table 5).

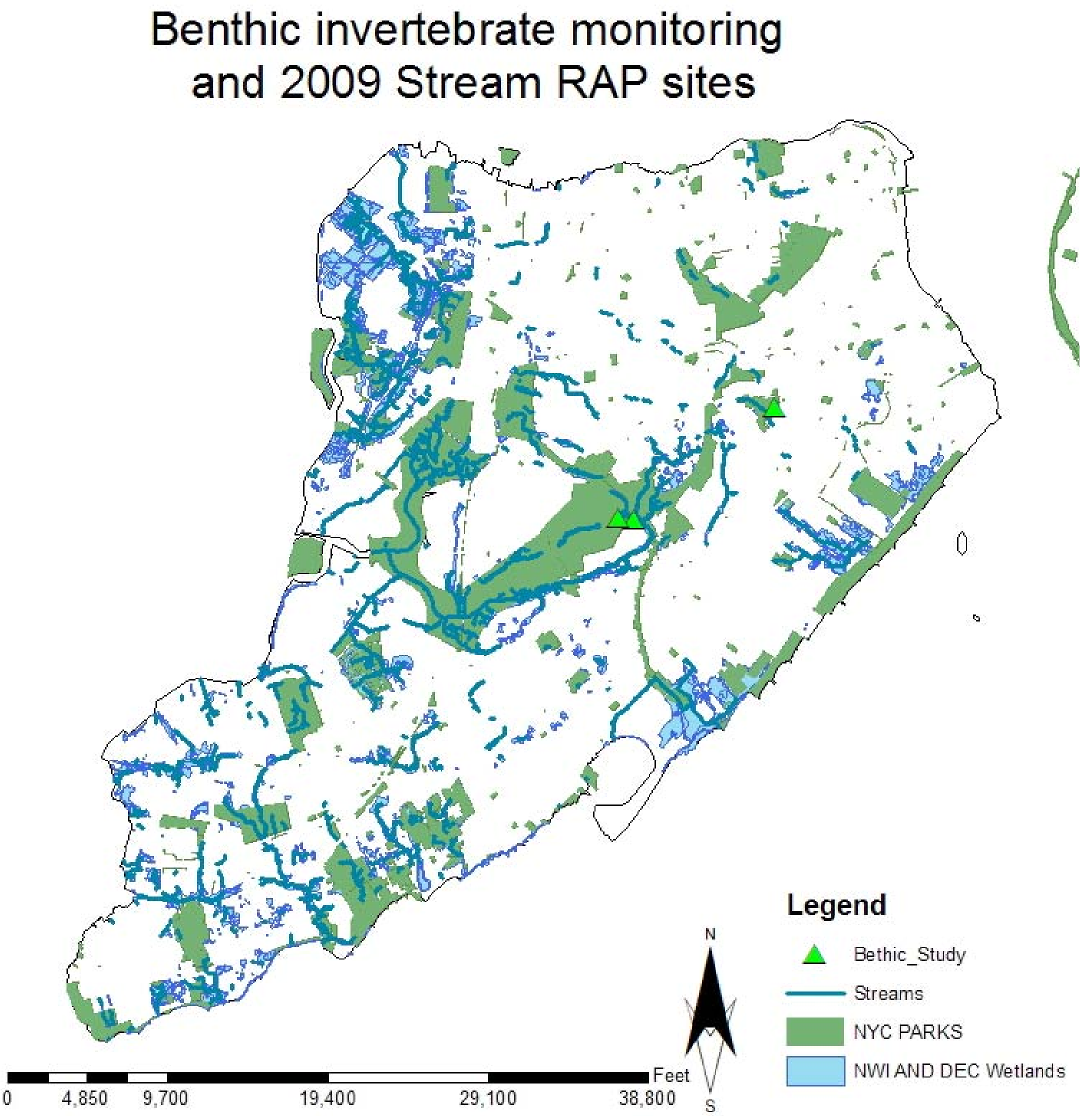


Figure 32. Stream Rapid Assessment Sites in 2009 and benthic invertebrate sampling sites.

The streams condition scores ranged between 60 and just above 100 (Figure 33), suggesting that all the streams had some evidence of impacts and disturbance, but also that none were in very bad conditions. When the condition scores were plotted against percent development in the drainage basin, there was a relatively strong negative correlation (R^2= 0.682), as one would expect (Figure 34).

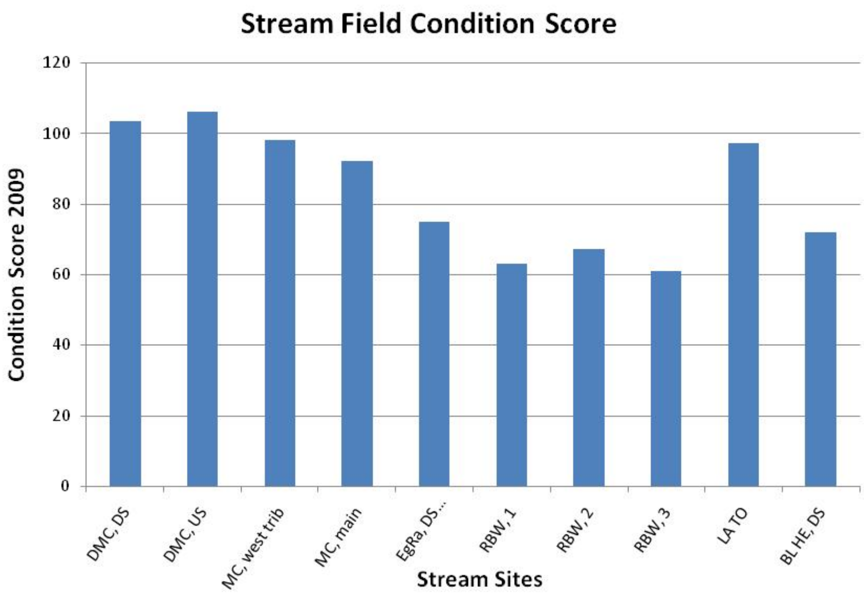


Figure 33. Stream RAP conditions scores.

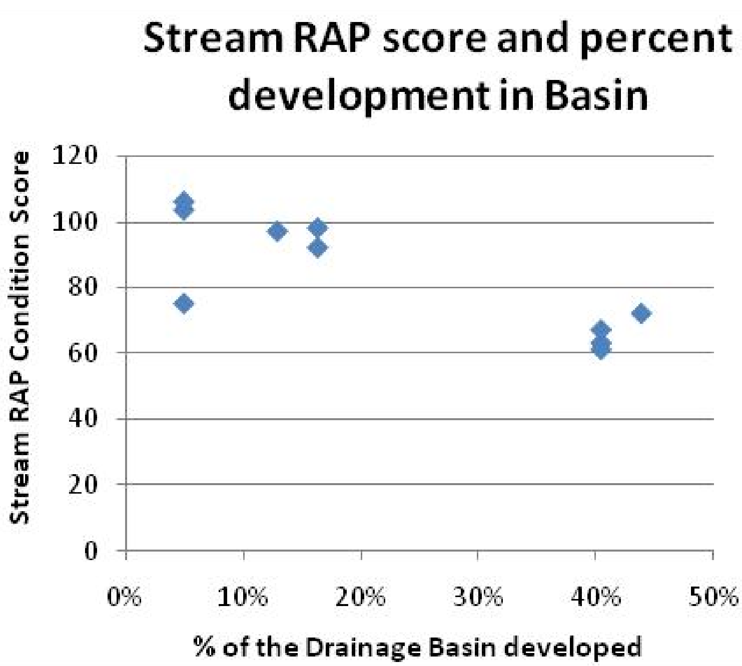


Figure 34. Stream RAP scores plotted against percent development in the Drainage basins. (R^2= 0.682). This apparent decrease in the condition of the stream with an increase in development in the drainage areas is typical of urban streams.

Table 5. Dominant riparian species at the stream sites.

	Trees		Shrubs		Herbs and Graminiods		Vines	
Stream Site	Dominant	Sub-dominant	Dominant	Sub-dominant	Dominant	Sub-dominant	Dominant	Sub-dominant
DMC, DS	red maple	green ash	spicebush		jewelweed		grape	
DMC, US	red maple	ash	multiflora rose	spicebush	multiflora rose		cat briar	poison ivy
MC, west trib	red maple	red oad	spicebush		jewelweed	cinnamon fern	cat briar	poison ivy
MC, main	red maple	sweet gum	spicebush	multiflora rose	jewelweed		Virginia creeper	catbriar
RBW, 1	Am. Beech		spicebush				multiflora rose	
RBW, 2	Am. beech	red oak	spicbush		Virginia creeper	fern	multiflora rose	honey suckle
RBW, 3	Am. beech	oak	multiflora rose	blueberry	jewelweed		cat briar	
LA TO	red maple	sweet gum	spicebush	arrowwood vibernum	wood fern	cinnamon fern	virginia creeper	

DISCUSSION

With the large number of small wetlands, it is challenging to identify and visit them all and to tease out the varied and cumulative effects of urban development that impact them. The NWI maps served as an initial guide of identifying the scope of potential sites to assess (Table 6), though clearly only a small fraction of the one thousand polygons from the NWI mapping were sampled. Basing the landscape analysis, and in particular the buffer analysis, on these boundaries, however, was very problematic, since essentially every NWI (or NYSDEC) boundary would have to at least be checked against the aerial photography, and ideally corrected and verified using soil data, and saved into a new map layer, to complete the analysis. NYSDEC wetlands larger than 12 acres that are regulated by New State Department of Environmental Conservation were mapped in 1974, and NWI mapping from aerials was conducted in the 1990s. There has been no official update of these maps, so many of these boundaries are inaccurate and do not represent the extent of NYC's wetlands.

Table 6. Area of mapped NWI vs NYSDEC wetlands on Staten Island.

	Freshwater Wetlands in Staten Island			
	Total Area (acres)	**No. of polygons**	**Overlapping Mapping (acres)**	**Overlapping Mapping (%)**
NWI	1866	1,023	1097	59%
NYSDEC	1316	339	1097	83%

Another important wetland characteristic that was not quantified, but should be considered in future analyses is the extent of fragmentation of the assessed wetland being assessed. We conducted an initial test of the degree of fragmentation of mapped wetlands in Staten Island as shown in Figure 35. This GIS operation suggests that more than half of the total wetland area is considered to be fragmented (classified as "patch", "edge", or "perforated." In the future, once reliable GIS wetland layers are developed from current data sources, the utility of this fragmentation analysis should be explored further.

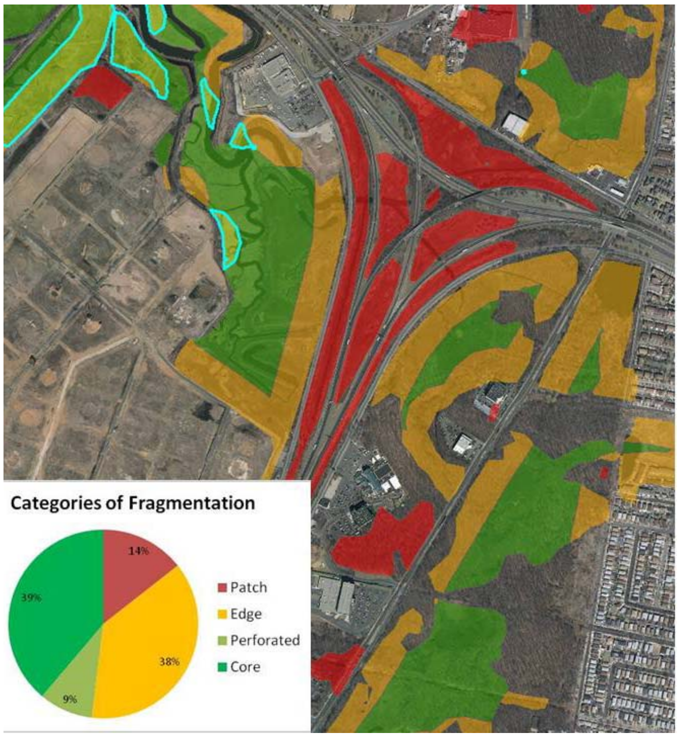


Figure 35. Example of Fragmentation Tool in ArcGIS for Staten Island. Sample view of wetland at Staten Island Industrial Park.

The RAP has proven to be a useful first step in collecting some basic, standardized information about a wide range of wetlands and being able to quantify the time and resources needed to collect this information. Further analysis of the data will determine what questions about resource conditions and potential management action are best answered with this RAP data. There are a number of potential adjustments to our field site selection, protocols, and analysis that we will be considering as our implementation of both the wetland and the stream RAP continues.

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Site_Name	AKA	Park_Name	Date	Time	Evaluators	Borough	Current_Weather	Current_Conditions	Time_Since_Last_Precipitation	GPS_Coordinates	Name_of_Associated_Waterbody	Tree1	Tree2	Tree3	Tree4
EiPo_1	Eibs Pond	Eibs Pond Park	7/6/2009		KM, NM, KA	Staten Islar	Sunny	Normal	96 hours	From Nate	Eibs Pond	Ailanthus	grey birch		
EvSi_3	Site 3	Evergreen/Siedenburg Park	7/22/2009	2:50pm	KM, KA, LV	Staten Islar	Sunny	Unknown	12hrs	No		Red Oak	White Oak	Sweet Gu,	
AmTr_1	school pond	Amudsen Trail	6/22/2009		KM and KA a	Staten Island		Normal	12 hrs	no		Sweet Gum	White Oak	Sassafras	Black Willo
LaTo_6	stream floodplain	La Tourette Park	7/16/2009	2:30pm	KM and KA	Staten Islar	Sunny	Unknown	5	40*34'57.8"N, 74*07'54.9"W		Red Maple	Ash		
SwBaMa_2	INDUS-2	Sweet Bay Magnolia	7/1/2009		KM and KA a	Staten Islar	Cloudy	Normal	12 hrs			red maple	sweet gum		
EvSi_2	Site 2	Evergreen/Siedenburg Park	7/22/2009	1:40pm	KM, KA, LV	Staten Islar	Sunny	Unknown	14 hrs	No		Red maple			
BlHe_4	site 4	Blue Heron Park Preserve	7/9/2009		KM, KA, NM,	Staten Islar	Cloudy	Normal	0	no		Red Maple	Sweet Gum		
WoPo_15b	Site 15b	Wolfe's Pond	7/24/2009	12:16pm	NM, KM, KA,	Staten Islar	Sunny	Normal	12 hrs	41*31'21.2"N, 74*11'48.2"W	Little Acme P	sweet gum	white oak	nyssa	
LaTo_5	VP SW of Rd_at fork	La Tourette Park	7/16/2009	1:15pm	KM and KA	Staten Islar	Sunny	Unknown	5	40*35'0.9"N, 74*08'0.5"W		swamp whi	red maple	ash	
LoPo_3b	Long Pond	Long Pond Park	7/30/2009	11:33am	KA,KM, LV	Staten Islar	Sunny	Normal	12 hrs	40*30'49.66"N, 74*13'38.93"W		red maple	sweet gum	oak	
BoAv_1	Boundary Avenue Park		9/4/2009	9:30am	KM, FY, VR, E	Staten Islar	Cloudy	Unknown		40*34'32"N, 74*06'2.4"W		Sweet Gum	Red Oak	Black Oak	
GrKi_2	Phrag Grove	Great Kills Park	8/26/2009	1:15pm	NM, KM, KA	Staten Islar	Sunny	Normal	4 days	no					
GrKi_1	Cedar Grove	Great Kills Park	8/26/2009	12:06pm	NM, KM, KA	Staten Islar	Sunny	Normal	4 days	40*33'16.0"N, 74*06'29.71"W		Winged Sumac			
LaChPo_1	Last Chance	Last Chance Pond Park	8/26/2009	2:10pm	NM, KM, KA	Staten Islar	Sunny	Normal	4 days	40*35'03.717"N, 74*05'56.795"W	Last Chance P	Red Maple	Sweet Gum		
OcBr_1	Hospital Pond	Ocean Breeze	7/29/2009	1:12pm	NM, KM, KA,	Staten Islar	Cloudy	Drought	24 hrs	yes		black willow			
LaTo_10		La Tourette Park	9/11/2009	12:30pm	KM, AS	Staten Islar	Rain	Unknown	0			pin oak	sweet gum	red maple	
BlHe_15	Butterfly Pond	Blue Heron Park Preserve	8/11/2009		LV, KM, KA	Staten Islar	Sunny	Normal	24 hours	?	Butterfly Pon	Riverbirch	Nyssa	Sweet Gum	Mulberry
LoPo_4b	Poison Ivy Pond	Long Pond Park	7/30/2009	10:10am	KM, KA, LV	Staten Islar	Sunny	Normal	12 hrs	40*30'55.3"N, 74*13'54.9"W		red maple	cottonwood		
StIsGr_3	Pump House Pond	Staten Island Greenbelt	8/19/2009	1:10pm	KM, KA	Staten Islar	Sunny	Normal	12 hours	40*35'18.724"N, 74*07'14.12"W	Pump House	red maple	beech	sweet gum	
CoHo_2b	cat tail pond	Conference House Park	7/27/2009		KM, KA, Che	Staten Islar	Cloudy	Normal	12 hrs	40*29'53.2"N, 74*15'01.5"W					
Wi_4	Willowbrook BMP	Willowbrook Park	8/27/2009	10:30am	KM, KA	Staten Islar	Overcast	Normal	0		BMP				
MaMa_1	Site 1	Mariner's Marsh	7/20/2009	1:50pm	EP, KM, KA, I	Staten Islar	Cloudy	Normal		No		grey birch	black willow		
OcBr_1b	Polygonum Pond	Ocean Breeze	7/29/2009	1:54pm	NM, KM, KA,	Staten Islar	Cloudy	Drought	24 hrs	yes		sweet gum	birch	cottonwood	
MaMa_2	Monument Pond	Mariner's Marsh	7/20/2009	2:40pm	EP, KM, KA, I	Staten Islar	Cloudy	Normal		No	Monument P	sassafra			
ReBaWi_1		Reeds Basket Willow Swamp	9/4/2009		KM, FY, VR, E	Staten Islar	Cloudy	Normal		40*36'4.3"N, 74*6'5.3"W					
ClPiPo_1	Clay Pit Pond	Clay Pit Ponds State Park	8/6/2009	2:30pm	KA, LV, EP, S	Staten Islar	Sunny	Unknown	4 hours	40*32'0.264"N, 74*13'36.8"W	Clay Pit Pond	Sweet Gum	Pin Oak	Red Maple	
StIsGr_1	Pouch Pond	Staten Island Greenbelt	8/19/2009	10:34am	KM, KA	Staten Islar	Sunny	Normal	12 hours	40*35'35.1"N, 74*07'03.6"W	Pouch Pond	swett gum	nyssa sylva	red maple	
CoHo_5	paw paw pond	Outside Conference House Park	7/27/2009	3:02pm	KM, KA	Staten Islar	Cloudy	Unknown	0	40*30'20.07"N, 74*13'49.9"W	paw paw pon	sweet gum	red maple		
ArWo_1	First Pond	Arbutus Woods	6/16/2009		KA and SS an	Staten Islar	Cloudy	Unknown	24 hrs	40*31'38.5"N, 74*11'06.4"W		Sweet Gum	Beech	White Oak	Red Oak
Wi_5	Willowbrook Pond	Willowbrook Park	8/27/2009	1:40pm	KM, KA	Staten Islar	Sunny	Normal	0	40*36'21.32"N, 74*09'30.01"W	Willowbrook	Bald Cypres	Elm		
ArHeWo_9	Muskrat Den Swamp	Arden Heights Woods	7/21/2009	3:30pm	KM, KA, LV	Staten Islar	Overcast	Normal	1 hr	yes		Red Maple, Sweet Gum			
Wi_3	WLBRK_3	Willowbrook Park	8/27/2009	11:45am	KM, KA	Staten Islar	Sunny	Normal	0	40*36'02.06"N, 74*09'27.44"W		Sour Gum	Red Maple		
EvSi_1	Evergreen Pond	Evergreen/Siedenburg Park	7/22/2009	12:22pm	KM, KA, LV	Staten Islar	Sunny	Normal	12 hrs	No		Red Oak	White Oak	sweet gum	grey birch
LoPo_8	House Pond	Long Pond Park	7/30/2009	1:59pm	KA, KM, LV	Staten Islar	Sunny	Normal	16 hrs	40*30'41.0"N, 74*13'36.9"W		red ample	sweet gum	beech	pin oak
ArWo_2	Cinnamon pond	Arbutus Woods	6/17/2009		KM and SS	Staten Islar	Sunny	Normal	48hrs	40*31'38.9"N, 74*11'05.1"W		Red Oak			
ArHeWo_9	Site 9	Arden Heights Woods	7/21/2009	1:18pm	KM, KA, LV	Staten Islar	Cloudy/Dri	Normal	0	yes		Sweet Gum			
BlHe_2	Spring Pond	Blue Heron Park Preserve	8/11/2009	0.104167	LV, KM, KA	Staten Islar	Sunny	Normal		40*31'46.14"N, 74*10'37.06"W	Spring Pond	Sweet Gum	Nyssa	Red Maple	
BuPo_2	Bunker Pond	Bunker Ponds Park	8/13/2009	2:02pm	KM, KA	Staten Islar	Cloudy	Normal	24 hours	40*31'24.6"N, 74*11'01.97"W		Red Maple, Sour Gum, Sweet Gum, Pin Oak, V			
BuPo_1	Hibiscus Pond	Bunker Ponds Park	8/13/2009	0.055556	KM, KA	Staten Islar	Cloudy	Normal	24 hours	40*31'29.39"N, 74*10'53.31"W		Red Maple, Swamp White Oak, Beech			
BlHe_3	Blue Heron Pond	Blue Heron Park Preserve	8/11/2009	0.428472	LV, KM, KA	Staten Islar	Sunny	Normal		40*31'51.3"N, 74*10'29.00"W	Blue Heron P	Sweet Gum	Red Maple	Grey Birch	
LoPo_3	Long Pond	Long Pond Park	7/30/2009	12:15pm	KA, KM, LV	Staten Islar	Sunny	Normal	14 hrs	4p*30'50.9"N, 74*13'38.49"W		sweet gum	grey birch	white oak	nyssa sylva
WoPo_15	Little Acme	Wolfe's Pond	7/24/2009	12:42pm	NM, KM, KA,	Staten Islar	Sunny	Normal	12 hrs	40*31'20.57"N, 74* 11'45.52"W		sweet gum	red maple	pin oak	
WoPo_8b	Jewelweed Haven	Wolfe's Pond	7/24/2009	2:25pm	NM, KM, KA,	Staten Islar	Sunny	Normal	13 hrs	40*31'29.4N, 74*11'25.0"W		Red maple	sweet gum	elm	
Fa_1	Fire Pond	near Fairview Pond Park	8/6/2009	0.485417	KA, LV, EP, S	Staten Islar	Cloudy	Normal	0	yes		White bircl	red maple		
HiRo_10	Loosestrife Swamp	High Rock Park	8/19/2009	2:20pm	KM, KA	Staten Islar	Sunny	Normal	12 hours	40*35'08.94"N, 74*07.2673"W	Loosestrife S	red maple	sweet gum	white oak	
StIsGr_2	Hourglass Pond	Staten Island Greenbelt	8/19/2009	12:10pm	KM, KA	Staten Islar	Sunny	Normal	12 hours	40*35'19.91"N, 74*07'12.21"W	Hourglass Po	sweet gum			
LaTo_7	Button Bush Swamp	La Tourette Park	7/16/2009	11:55am	KM and KA	Staten Islar	Sunny	Unknown	5	no					
ArHeWo_3	Muskrat Swamp	Arden Heights Woods	8/12/2009	10:15am	KM, LV, DH,	Staten Islar	Sunny	Normal	48 hours	40*33'22.1"N, 74*11'13.14"W	Muskrat Swa	Pin Oak, Red Maple, Sweet Gum			
ArHeWo_3	Muskrat Swamp- veg 2	Arden Heights Woods	8/12/2009	10:15am	KM, LV, DH,	Staten Islar	Sunny	Normal	48 hours	yes	Muskrat Swa	Red Maple	Pin Oak	Sweet Gum	
OcBr_6	Site 6	Ocean Breeze	7/29/2009	11:57am	NM, KM, KA,	Staten Islar	Sunny	Drought	24 hrs	40*35'13.9"N, 74*4'34.1"W		cottonwoo	pussy willow		
		Arden Heights Woods	8/12/2009	12:10pm	KM, LV, DH,	Staten Islar	Sunny	Normal	48 hours	40*33'22.2"N, 74*11'39.9"W		Pin Oak, Red Maple, Sassafras			

Site_Name	Tree5	Shrub1	Shrub2	Shrub3	Shrub4	Shrub5	Herbs_Gramanoids1	Herbs_Gramanoids 2	Herbs_Gramanoids 3	Herbs_Gramanoids 4	Herbs_Gramanoids 5	Vines1	Vines2	Vines3	Aquatic1
EiPo_1		knotweed	multiflora rose	bayberry			picked weed	arow arrum	decodon	goldenrod		porcelain berry			ludwigia
EvSi_3		sweet pepperbush	blueberry	sassafras			cinnamon fern	mystery plant	poison ivy	virginia creeper					
AmTr_1	w	Buttonbush, Maple Leaf Viburnum	Maple Leaf Viburnum				Poison Ivy, Mugwort, Dog	Mugwort	Dog Bane			Wild Grape	Woody Nightshade		
LaTo_6		Highnush blueberry	spicebush	ash			jewelweed	garlic mustard	skunk cabbage			poison ivy			
SwBaMa_2		arrow wood viburnum	highbush blueberry				canada mayflower	cinnamon fern				catbriar			
EvSi_2		sweet pepper bush					cinnamon fern					catbriar			skunk cabb
BlHe_4		Arrow_wood viburnum	Red Maple				Ferns	Canada Mayflower	jewelweed	poison ivy		Greenbriar	poison ivy		
WoPo_15b		Highbush Blueberry					smartweed	decadon	canada ma	swamp milkweed		dodder			duckweed
LaTo_5		arow weed viburnum	silky dogwood									poison ivy			
LoPo_3b		nyssa sylvatica	highbush blueberry	bottonbush			ferns	canada mayflower				catbrair			skunk cabb
BoAv_1		Viburnum					Knotweed								
GrKi_2							Common Reed					Climbing Boneset			
GrKi_1		Winged Sumac	Blackberry				Common Reed	Fern sp.	Goldenrod	smartweed		Climbing B	morning glory		
LaChPo_1		Highbush Blueberry	Buttonbush				Common Reed	Arrow Arrum							Duckweed
OcBr_1		bottonbush					phragmites	bullrush	juncus can	scirpus am	spike rush	paliganum			small wate
LaTo_10		multiflora rose	sassafas				jewelweed	skunk cabbage				asiatic bitte	porcalain b	poison ivy	
BlHe_15	Black wido	Locust	sweet gum	blackberry			Jewelweed	mugwort				swamp ros	Hydrilla	arrow-arro	duckweed
LoPo_4b		poison ivy	arrow leaf viburnum				poison ivy	knotweed	phragmites			poison ivy	catbrair	asian bitter	duckweed
StIsGr_3		highbush blueberry	swamp fetterbush				pickerel weed	polyganum							fanwort
CoHo_2b		Groundsall tree					Phragmites	cattail	seaside gol	mugwort		morning glory			algea
Wi_4		Eastern Baccharis					Cattail	Purple Loosestrife	Arrow Arur	Pickerelweed		Climbing Boneset			Duckweed
MaMa_1							Phragmites	tussock sedge							polyganum
OcBr_1b		willow	Rhus				spike rush	goldenrod	phragmites	polyganum	false pimpe	grape	porcalain berry		
MaMa_2							phragmites	cattail	american sedge						arow head
ReBaWi_1		bottonbush					porcelain berry								
ClPiPo_1		Buttonbush	blueberry				Marsh st johns wort	polygonum							Spatter doc
StIsGr_1		nyssa sylvatica	maple leaf viburnum	highbush blueberry			canada mayflower	virginia creeper	oatbriar	microstigiu	poison ivy	catbrair	poison ivy		duckweed
CoHo_5		arrow - leaf viburnum	spicebush	highbush blueberry			swamp milkweed	poison ivy	decadon			catbriar	poison ivy		duckweed
ArWo_1		Arrow-wood Viburnum, Highbush	Highbush Blueberry	Sassafras	Beech		Canada Mayflower, Ferns	Ferns	Whitewoo	Mugwort		Posion Ivy,	Catbriar	Virginia Creeper	
Wi_5							Turf Grass	Common Violet							Duckweed
ArHeWo_9		Arrow-wood Viburnum, Highbush Blueberry, Buttonbush					Canada Mayflower, Smartweed								Ludwigia
Wi_3		Arrowwood Viburnum	Sweet Pepperbush				Smartweed	Jewelweed				Dodder			
EvSi_1		blueberry	sweet pepperbush	sassafras			ferns					catbriar	poison ivy		decadon
LoPo_8		sweet pepperbush	blueberry				poison ivy	canada mayflower				catbriar	poison ivy		duckweed
ArWo_2		Maple Leaf Viburnum, Sweet Pepperbush					Canada Mayflower, Cinnamon Fern								
ArHeWo_9		Buttonbush, Arrow-wood Viburnum, Red Maple					Virginia Creeper, Poison Ivy					Poison Ivy, Catbriar, Virginia Creeper			
BlHe_2		Blueberry	Nyssa	Buttonbush			Decadon	smartweed	ludwigia			Smilax			nymphea o
BuPo_2	Vhite Oak	Arrow-wood Viburnum, Sour Gum, Highbush Blueberry					Canada Mayflower					Catbriar, Poison Ivy			Spatterdoc
BuPo_1							Swamp Rose Mallow, Swa	Swamp Loosestrife	Dodder			Catbriar			Duckweed
BlHe_3		ButtonBush	Blueberry				Decadon	Marsh st Johns wort	cutgrass						Sphagnum
LoPo_3	tica	buttonbush	vaccinium				decadon	swamp milkweed				catbrair			millfoil
WoPo_15		highbush blueberry	smooth alder				canada mayflower	cinnamon fern	swamp milkweed			catbriar			
WoPo_8b		arrowwood viburnum					jewelweed					catbriar			
Fa_1							smilax	polygonum	upatorium			oatbriar			spike grass
HiRo_10		sweet pepperbush	red maple	highbush blueberry			swamp loosestrife	swamp rose mallow	jewelweed	marsh st jo	arow - arru	catbriar	dodder		
StIsGr_2		highbush blueberry	swamp azalea				decadon	marsh st johns wort	polyganum			dodder			white wate
LaTo_7		bottonbush					swamp loosestrife								bottonbusl
ArHeWo_3		Spicebush, Buttonbush, Arrow-wood Viburnum					Common Reed					Catbriar			Duckweed
ArHeWo_3		Arrow-wood Viburnum, Sour Gum	Sour Gum	Nyssa		Spice bush	Arrow Arum, Ludwigia, Common Reed					Catbriar			Duckweed
OcBr_6		pin oak	sweet gum				Poison Ivy	ferns	panicum			poison ivy			
		Sassafras, Arrow-wood Viburnum					Poison Ivy, Canada Mayflower					Catbriar			

Site_Name	Aquatic2	Aquatic3	Aquatic4	Aquatic5	HGM_Classification	Cowardin_Classification_NWI	NWI_Class_is_same_as_in_field?	Within_DEC_Wetland_Boundary	Area_of_wetland_polygon_m^2_NWI	Area_of_wetland_polygon_ac_NWI	Area_of_wetland_polygon_ac_NWI	Standing_Water	Value_Added_Metric	Average_DBH_of_5_Largest_Trees	Minimum_Distance_to_Development	Impermeable_rea within_30m_of_wetland	Land_Use_within 30m	Roads_Most_Intense_Type_Not_Trails_within_30 m	Trash_and_Debris
EiPo_1					Depression	PEM/PUBH	yes	yes	60094	19.79	10-20	yes			10	6	8	7	6
EvSi_3					Depression	PFO	yes	no	1517	0.50	< 1	no			5	2	4	5	5
AmTr_1					Depression	PUB/PEM	yes	no	1330	0.44	< 1	yes			7	10	7	7	3
LaTo_6					Depression	PFO	yes	yes	407	0.13	< 1	yes			4	0	0	0	2
SwBaMa_2					Soil Flat	PFO	yes	yes	21190	6.98	5-10	no			10	9	9	10	4
EvSi_2	age					PFO	yes	yes	3093	1.02	1-5	yes			10	10	7	7	3
BlHe_4					Soil Flat	PFO		yes	2920	0.96	< 1	yes			3	0	0	0	1
WoPo_15b	humped bl	ludwiga			Depression	PUBH	yes	yes	452	0.15	< 1	yes			4	0	0	0	0
LaTo_5					Depression	PFO	yes	yes	151	0.05	< 1	no			4	0	0	0	0
LoPo_3b	decadon	arrow - arrum			Depression	PFO	yes	yes	791	0.26	< 1	yes			0	0	0	0	2
BoAv_1					Riverine	PFO	yes	no	5061	1.67	1-5	yes			10	10	8	7	6
GrKi_2					Soil Flats	E2EM	unknown	yes	133994	44.14	> 20	no			10	10	7	5	1
GrKi_1					Soil Flats	E2EM	unknown	yes		0.00	< 1	no			0	0	0	0	1
LaChPo_1	Spadderdock				Depression	PUB	no	yes	1612	0.53	< 1	yes			4	0	7	8	9
OcBr_1	' plantain				Depression	PEM	yes	yes	601	0.20	< 1	yes			0	0	0	0	6
LaTo_10					Depression	PUB	yes	yes	4898	1.61	1-5	yes			7	7	4	0	2
BlHe_15					Depression	PUB	no	no	4866	1.60	1-5	yes			10	10	7	5	0
LoPo_4b					Depression	PUB	yes	yes	537	0.18	< 1	yes			9	10	7	7	9
StIsGr_3					Depression	PUB	yes	yes	969	0.32	< 1	yes			10	5	4	5	3
CoHo_2b	burrweed	ludwigia			Depression	PEM	no	no	481	0.16	< 1	yes			2	0	0	0	0
Wi_4					Depression	None	no	yes	14501	4.78	1-5	yes			9	4	8	5	0
MaMa_1	sphagnum				Depression	PEM	yes	yes	509	0.17	< 1	yes			0	0	0	0	10
OcBr_1b					Depression	PEM	no	yes	172	0.06	< 1	no			5	4	10	4	8
MaMa_2	viburnum				Depression	PUB	yes	yes	7949	2.62	1-5	yes			0	0	0	0	10
ReBaWi_1					Depression	PUB	yes	yes	4365	1.44	1-5	yes			10	10	7	5	4
ClPiPo_1	:h				Depression	PUB	yes	yes	19467	6.41	5-10	yes			7	1	0	7	0
StIsGr_1					Depression	PUB	yes	yes	2320	0.76	< 1	yes			3	0	0	0	6
CoHo_5					Depression	PUB	yes	yes	4307	1.42	1-5	yes			5	0	0	0	5
ArWo_1					Depression	PUB	yes	yes	1716	0.57	< 1	yes			4	0	0	0	5
Wi_5					Depression	PUB	yes	yes	17128	5.64	5-10	yes			10	10	4	5	1
ArHeWo_9					Depression	PFO	yes	yes	49918	16.44	10-20	yes			0	1	0	0	0
Wi_3					Soil Flats	PFO	PFO/PEM	yes	32829	10.81	10-20	no			1	0	0	0	0
EvSi_1	duckweed				Depression	PEM	yes	yes	20835	6.86	5-10	yes			10	7	4	4	7
LoPo_8					Depression	PUB	yes	no	405	0.13	< 1	yes			4	0	0	0	7
ArWo_2					Depression	PUB/PEM	yes	no	813	0.27	< 1	yes			1	0	0	0	5
ArHeWo_9					Depression	PFO/PSS	yes	yes	49918	16.44	10-20	yes			2	1	0	0	4
BlHe_2	spatter doc	bladderwort			Depression	PUB/PEM	yes	yes	5810	1.91	1-5	yes			10	10	7	6	1
BuPo_2	k				Depression	PUB	yes	yes	5837	1.92	1-5	yes			7	1	0	6	7
BuPo_1					Depression	PEM	yes	yes	4853	1.60	1-5	yes			7	8	7	7	7
BlHe_3					Depression	PUB/PEM	yes	yes	7348	2.42	1-5	yes			2	0	0	0	6
LoPo_3	ludwigia	sphagnum			Depression	PUB	yes	yes	10115	3.33	1-5	yes			0	0	0	0	3
WoPo_15					Depression	PUBH, PEM	no	yes	3989	1.31	1-5	yes			1	0	0	0	3
WoPo_8b					Depression	PEM	no	yes	1531	0.50	< 1	no			6	4	3	7	2
Fa_1	cutgrass	ludwigia illustrius			Depression	PUB	yes	no	357	0.12	< 1	yes			1	0	0	0	2
HiRo_10					Depression	PEM	yes	yes	5971	1.97	1-5	yes			4	0	0	0	0
StIsGr_2	r lilly				Depression	PUB	no	yes	7516	2.48	1-5	yes			5	1	0	5	0
LaTo_7	ıswamp loosestrife				Depression	PEM	yes	yes	1477	0.49	< 1	yes			0	0	0	0	0
ArHeWo_3	Blue Green Algae				Depression	PEM/PUBH	yes	yes	4082	1.34	1-5	yes			0	0	0	0	1
ArHeWo_3					Depression	PEM/PUBH	yes	No	4082	1.34	1-5	yes	Red Maple- Sweetgu		0	0	0	0	1
OcBr_6					Soil Flat	PEM	no	yes	6086	2.00	1-5	no			6	3	6	7	8
					Depression	PFO	yes	yes	3559	1.17	1-5	no			7	10	7	7	5

Site_Name	Trails_and_Roads	Hydrologic_Modifications	Sediment_and_Erosion	Increased_Nutrients	Pollutants_in_Standing_Water	Vegetation_Alteration	Canopy_Cover	Presence of_Invasive_Species	Field_Stressor_Score	Field score count	Field Score Standardized	GIS_Stressor_Buffer_Score	Total_Stressor_Score	Normalized_Score	Standardized Score
EiPo_1	4	7	5	10	n/a	6	zero	7	45	7	51	31	76	69	82
EvSi_3	3	0	0	4	n/a	0	zero	2	14	7	16	16	30	27	32
AmTr_1	6	4	4	7	n/a	0	zero	2	26	7	30	31	57	52	61
LaTo_6	2	0	0	0	0	1	zero	2	7	8	7	4	11	9	11
SwBaMa_2	8	3	0	1	n/a	0	zero	1	17	7	19	38	55	50	57
EvSi_2	3	3	1	4	n/a	0	zero	1	15	7	17	34	49	45	51
BlHe_4	0	4	0	0	n/a	0	zero	1	6	7	7	3	9	8	10
WoPo_15b	0	0	0	0	n/a	0	zero	0	0	7	0	4	4	4	4
LaTo_5	4	2	0	1	n/a	0	zero	0	7	7	8	4	11	10	12
LoPo_3b	4	4	0	0	0	3	two	2	15	8	15	0	15	13	15
BoAv_1	0	7	7	n/a	n/a	6	one	10	36	6	48	35	71	71	83
GrKi_2	0	n/a	n/a	n/a	n/a	3	n/a	10	14	4	28	32	46	58	60
GrKi_1	0	3	0	0	n/a	3	n/a	10	17	7	19	0	17	15	19
LaChPo_1	3	9	0	10	0	0	n/a	7	38	8	38	19	57	48	57
OcBr_1	0	0	0	0	0	0	n/a	7	13	8	13	0	13	11	13
LaTo_10	1	7	4	9	0	10	n/a	7	40	8	40	18	58	48	58
BlHe_15	4	10	1	10	0	0	n/a	7	32	8	32	32	64	53	64
LoPo_4b	4	0	0	8	0	7	n/a	6	34	8	34	33	67	56	67
StIsGr_3	4	7	1	4	0	0	n/a	6	25	8	25	24	49	41	49
CoHo_2b	2	0	0	7	0	0	n/a	6	15	8	15	2	17	14	17
Wi_4	0	8	0	9	n/a	2	n/a	5	24	7	27	26	50	45	53
MaMa_1	4	0	0	0	0	0	n/a	4	18	8	18	0	18	15	18
OcBr_1b	4	0	0	7	0	0	n/a	4	23	8	23	23	46	38	46
MaMa_2	4	0	4	4	0	0	n/a	3	25	8	25	0	25	21	25
ReBaWi_1	1	5	5	9	n/a	1	n/a	3	28	7	32	32	60	55	64
ClPiPo_1	7	6	0	0	0	0	n/a	3	16	8	16	15	31	26	31
StIsGr_1	2	0	1	9	0	0	n/a	2	20	8	20	3	23	19	23
CoHo_5	0	0	0	9	0	0	n/a	2	16	8	16	5	21	18	21
ArWo_1	5	0	5	0	3	0	n/a	2	20	8	20	4	24	20	24
Wi_5	10	10	0	8	0	10	n/a	2	41	8	41	29	70	58	70
ArHeWo_9	0	0	0	2	0	0	n/a	2	4	8	4	1	5	4	5
Wi_3	2	0	0	0	n/a	0	n/a	2	4	7	5	1	5	5	6
EvSi_1	6	2	2	2	0	4	n/a	1	24	8	24	25	49	41	49
LoPo_8	4	0	0	7	0	6	n/a	1	25	8	25	4	29	24	29
ArWo_2	5	0	5	0	0	0	n/a	1	16	8	16	1	17	14	17
ArHeWo_9	7	0	2	4	0	0	n/a	1	18	8	18	3	21	18	21
BlHe_2	4	8	0	4	0	1	n/a	1	19	8	19	33	52	43	52
BuPo_2	6	0	0	0	4	3	n/a	0	20	8	20	14	34	28	34
BuPo_1	7	0	0	1	0	1	n/a	0	16	8	16	29	45	38	45
BlHe_3	4	1	2	0	0	0	n/a	0	13	8	13	2	15	13	15
LoPo_3	4	1	0	4	0	1	n/a	0	13	8	13	0	13	11	13
WoPo_15	5	0	0	10	0	2	n/a	0	20	8	20	1	21	18	21
WoPo_8b	0	6	0	0	n/a	0	n/a	0	8	7	9	20	28	25	29
Fa_1	0	5	0	0	0	1	n/a	0	8	8	8	1	9	8	9
HiRo_10	6	0	0	0	0	0	n/a	0	6	8	6	4	10	8	10
StIsGr_2	3	2	0	0	0	0	n/a	0	5	8	5	11	16	13	16
LaTo_7	2	1	0	0	0	0	n/a	0	3	8	3	0	3	3	3
ArHeWo_3	6	0	1	8	0	6	four	7	29	8	29	0	29	24	29
ArHeWo_3	6	0	1	8	0	6	four	7	29	8	29	0	29	24	29
OcBr_6	6	0	0	0	n/a	0	four	4	18	7	21	22	40	36	43
	7	4	0	0	n/a	2	four	0	18	7	21	31	49	45	52

APPENDIX B. PHOTOS

WETLAND MANAGEMENT PRIORITIZATION TYPES

Type I: Preserve / Protect

Figure 1 Blue Heron 3

Figure 2 La Tourette 7

Figure 3 Wolf's Pond 15b

Figure 4 Arden Heights Woods 9b

Figure 5 High Rock 10

Figure 6 Ocean Breeze 1

Type II: Protect / Investigate

Figure 7 Arden Heights Woods 3. Evidence of increased nutrients in the foreground (duckweed). High degree of ATV use and vegetation alteration off camera

Figure 8 Mariners Marsh 2. High degree of trash and debris, moderate road/trail use and sedimentation off camera.

Figure 9 Arden Heights Woods 2. Trash and debris, ATV use, and sedimentation off camera

Figure 10 Evergreen 2. High percentage of development in the 30 meter buffer as well as moderate scores in all but one field category.

Type III: Rehabilitate

Figure 11 Boundary Ave 1. Evidence of knotweed infestation and trash

Figure 12 Reed's Basket Willow 1. Evidence of nutrient enrichment and possible pollutant source

Figure 13 Long Pond 4b. Evidence of Phragmites infestation and nutrient enrichment

Figure 14 Willowbrook 5. Evidence of vegetation alteration.

Examples of Wetland Classifications

Emergent

Figure 15 La Tourette 7

Figure 16 Wolf's Pond 8b

Figure 17 Ocean Breeze 6

Figure 18 Ocean Breeze 1

Forested

Figure 19 Sweet Bay Magnolia 2

Figure 20 Willowbrook 3

Forested

Figure 21 Long Pond 4b

Figure 22 Willowbrook 5

Open Water with Unconsolidated Bottom

Figure 23 Blue Heron 15

Figure 24 Bunkers Pond 1

SECTION 3. MONITORING PROTOCOLS AND RESULTS IN RELATION TO RAP RESULTS

INTRODUCTION

The wetland and stream rapid assessment protocols (WRAP) focused on collecting basic qualitative and quantitative information relatively quickly, as described in Sections 1 and 2 of this report. The WRAP is implemented to describe the relative conditions of wetlands and is intended to help set priorities for management or further study of wetland physical, biological, and/or geochemical parameters. In this section of our report, we present wetlands and stream monitoring protocols that have already been implemented by NRG for a number of different studies, as well as some wetland monitoring data that has been compared to the results of the WRAP. Figure 1 shows the location of monitoring and inventory sites for odonates, amphibians and benthic invertebrates as well as the WRAP sites on Staten Island. We discuss broad recommendations for next steps towards conducted a in-depth review of our current monitoring protocols and prioritizing them to answer specific questions about the management, ecology, and processes of our urban wetlands.

ODONATE MONITORING AT WRAP STIES

The odonate monitoring protocols were developed to assess the condition of dragonfly populations and associated habitat conditions at various wetlands around the City and evaluate the utility of dragonfly community composition as a bio-indicator for wetland condition (Creveling 2003). At six of the sixteen sites monitored, WRAPs were conducted, which allowed some comparison of the results from the odonate monitoring to the results from the Wetland Rapid Assessment, as presented below.

Monitoring protocols

Adult Count Procedures

Fifteen-minute adult point counts were used to survey adult odonates. The method of counting from fixed points was selected, rather than standard walks or transects, because it allows an observer to become familiar with an area of habitat and to watch without being distracted by having to walk through an area (which allows for more detailed data to be collected). Observation from a fixed point also enables one to observe insects leaving and returning (which may help minimise double counting of highly mobile individuals). Survey points within each wetland were chosen strategically. As most sites were fairly homogeneous and roughly oblong or oval in shape, four points were selected: one at each end and one on either side. Specific survey points at these locations were chosen researchers according to the best viewpoint(s). Effort was made to select points that would represent the different areas of habitat at a site, if the wetland was somewhat heterogeneous. Because of large size and/or heterogeneity with restricted visibility, five points rather than four were selected at four sites (Arden Heights, Willow Wetlands, Bucks Hollow, and Idlewild). Although selecting the specific point count locations randomly, rather than strategically, would have been a preferable study design, practical issues such as highly restricted visibility from or difficulty in physically accessing many potential sample points precluded using this approach. In addition, diversity of habitats within each site would have necessitated much stratification of random samples; stratified areas would have had to be defined in much the same (subjective) manner as was used to determine our 'strategic' viewpoints.

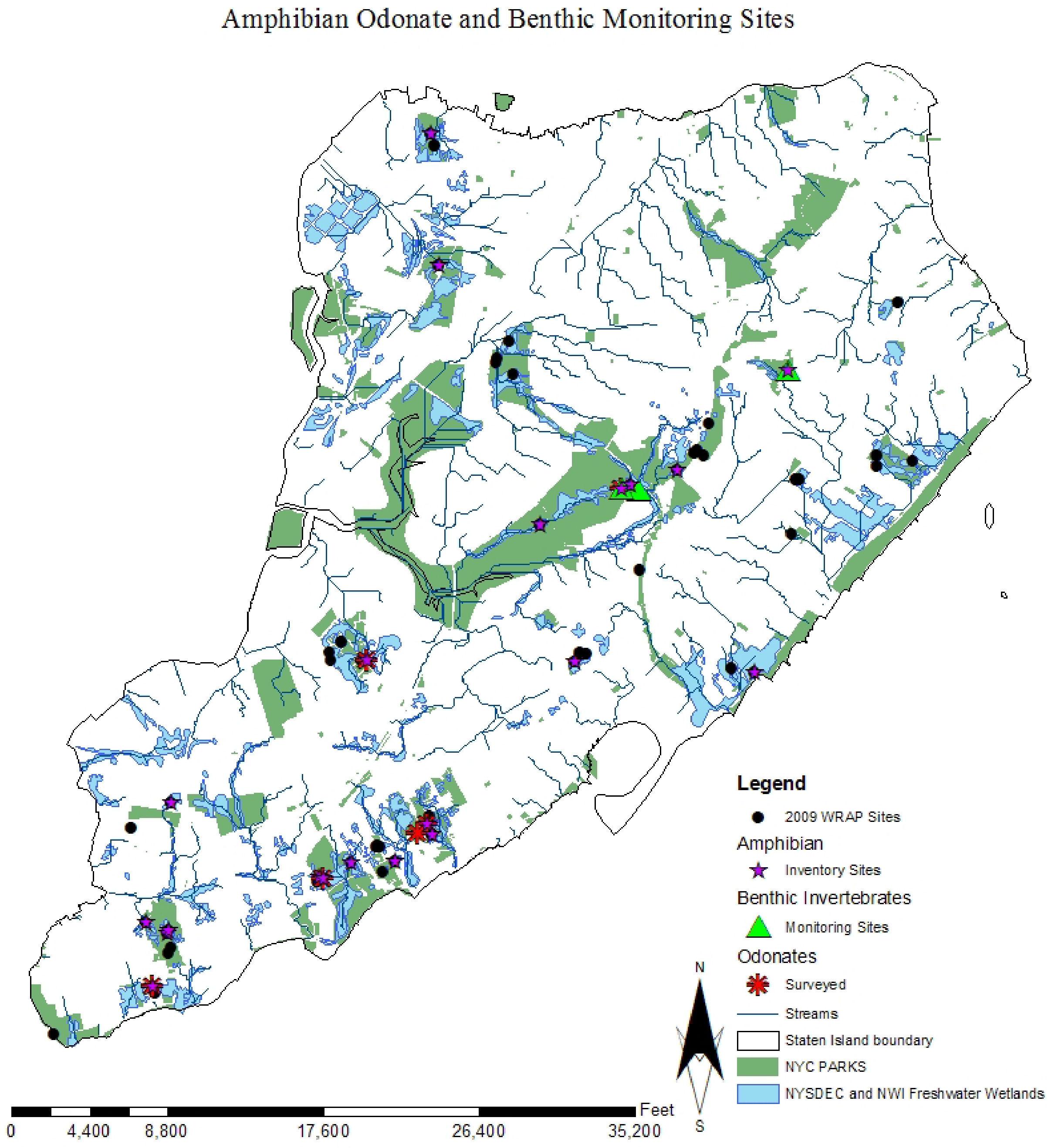


Figure 1. Odonate, Amphibian, and Benthic Invertebrate monitoring and inventory sites and WRAP sites on Staten Island.

All counts were conducted on warm, sunny days between 10:00-14:00, when the majority of odonate species are most active (Samways and Steytler 1996). The size of the portion of wetland surveyed from each point was an area with a radius of no more than 15 metres. During each survey, the same amount of time was spent counting the more visible species (often at a distance) and the less visible species (most *Zygoptera*) (closer, often within vegetation). Both males and females were counted, with the gender noted as "unknown" if sex could not be distinguished. Many other studies (e.g., Steytler and Samways, 1995; Samways and Steytler, 1996; Suh and Samways, 2001) have used only male odonates because they are usually easier than females to identify on the wing and because they are found in higher proportions near water (Corbet, 1962, in Samways and Steytler, 1996; Steytler and Samways, 1995; Suh and Samways, 2001). However, both sexes were included here because most females in the region have fairly distinctive characteristics and because knowledge about their use of wetland habitats, even if it is proportionally lower than the percent of males that use wetlands, is still valuable and needed. Binoculars were used to identify any individuals that were too far away to recognise by plain sight. In the case of still-unidentifiable individuals or species, specimens were collected (after the end of the15-minute count) with aerial nets or by hand to identify and release or, if needed, to preserve with acetone for further examination. References used to key out species include Dunkle (1990), Carpenter (1991), Westfall and May (1996), Dunkle (2000), and Needham *et al*. (2000). Tallies were made of the number of individuals of each species and a general categorization of their behaviours, using a set data sheet. Categories included: "flying, chasing, perching, perch height, perch substrate, and ovipositing." Note was also made of teneral individuals or pairs in tandem. Presence/absence and abundance data may be most important for assemblage analysis, but behavioural information may be valuable for assessing how odonates use their surrounding environments.

<u>Site Habitat Assessment Procedures</u>

For most sites, WRAP habitat assessments were conducted on a day when reptile or amphibian surveys were conducted (Table 1 and 2). A very rough measurement of the wetland size was taken by running a transect metre tape roughly parallel to the longest side of the wetland and then running another metre tape at a 90° angle to the first transect to measure the maximum length and width (to enable a rough calculation of surface area) of each site. Water visibility depth was measured with a Secchi disk, and pH, dissolved oxygen, and temperature with YSI hand-held field instruments. Depth was measured at one and three metres from the wetland edge at a given point, as well as in the centre (if it was not deeper than chest-high). Substrate was described by character (organic muck, silt, sand, cobbles, or rock). The rest of the habitat measurements were made by "eyeball-estimation", and include percent cover of the entire wetland for:

- midday shade
- emergent vegetation (subdivided into: % graminoid< 1.5 m; % graminoid> 1.5 m; % broad-leaved herbs; % live shrub; % dead shrub; % trees)
- floating vegetation (subdivided into: % < 1 cm in diameter; % > 1 cm in diameter)
- submersed vegetation
- invasive vegetation
- exotic vegetation
- open water

Surrounding land cover types also were assessed, by estimating percent cover in the areas 1-10 m and 10.1-100 m around each wetland. The cover types found included: tall herb, scrub (or thick understory layer of woodland), woodland, recreational lawn, golf course lawn, road, railway/railyard, other pavement/buildings, unpaved paths, rock and scattered trees/"parkland". Estimations were made after having walked around and through each wetland site. Both observers wrote down estimates individually and then compared with each other to find discrepancies and discuss any potential misperceptions on the part of one person. After discussion, estimates may have been changed or left the same, accordingly (averages were used for analysis). Suspected low accuracy of the estimations from 10.1-100m precludes these data from being included. Instead, land use types for a much greater area surrounding each wetland, a circle of two kilometres in diameter (r = 1km), were used as a measure of larger habitat areas surrounding each wetland. (In two parks, Alley Pond Park and Blue Heron Park, this circle was laid around the mid-point of two wetlands (Decodon and Lily Pad Ponds, and Blue Heron and Spring Ponds) to assess the surroundings for each simultaneously rather than having great overlap for each individual site.) These surrounding land covers were classified into general type (by examining aerial photographs), and percent covers were calculated using GIS. Cover types were grouped into only four categories:

- woodland
- tall herb
- recreational and golf course lawn
- roads and buildings/other structures

Amongst all these parameters, 16 habitat variables (of a range of types, i.e., representing water quality, vegetation structures, and surrounding land covers) were used for analysis. Environmental variables selected had the greatest presence detected and/or the greatest suspected ecological importance. These factors included:

1. wetland area (m^2)
2. Secchi depth
3. water pH
4. water DO
5. % cover shade
6. % cover invasives
7. % cover graminoids
8. % cover broad-leaved herbs
9. % cover shrubs
10. % cover floating vegetation
11. % cover open water
12. % herb within 10 m of wetland edge
13. % wood within 10 m of wetland edge
14. hectares of wood within 1 km radius of wetland centre
15. hectares of lawn within 1 km radius
16. hectares of paved or developed surfaces within 1 km radius

Data analysis was performed using a combination of univariate and multivariate techniques in the following programs: Microsoft Excel 2000, SYSTAT version 10, and PC-ORD. Species abundances were averaged per site and log transformed, as were most habitat variables. Species assemblages were determined using TWINSPAN, a polythetic divisive classification method, and a hierarchical clustering method in SYSTAT. Spearman's rank correlation coefficients were calculated to compare to (Pearson's) r-squared values that are automatically calculated in excel plots. Throughout much of the analysis, species names were abbreviated by combining the first two letters of each genus and species name.

Results

The results of the odonate monitoring in terms of species richness and Simpson's diversity score are presented below in Figures 2-4. Figure 2 shows that the WRAP sites were not sites with the highest biological diversity, but had a range of diversity typical of most of the odonate monitoring sites.

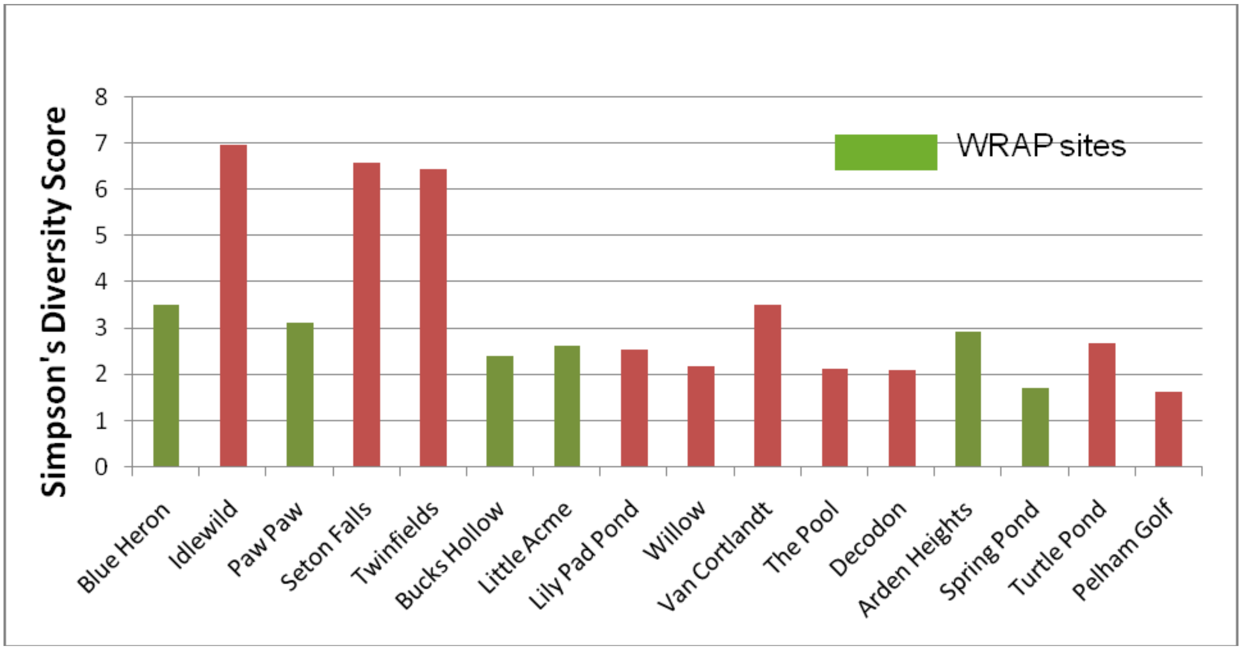


Figure 2. Odonate diversity scores at wetlands in NYC from Creveling 2003.

There appeared to be a correlation between decreasing stressor scores (fewer impacts) and increase diversity of odonates at the six sites where WRAP was conducted (Figure 2). The relatively small number of sites and the one outlier (at Buck Hollow) kept this from being a strong correlation, however. The relationship between the WRAP scores and the odonates species diversity was also not strong, although the trend of fewer impacts associated with greater diversity was indicated.

Though odonates have been used for to evaluate changes over time at a wetland and response to wetland restoration or management actions, only relatively recently have regional metric been begun to be developed for use in evaluating overall wetland health or biological integrity. Odonates have the potential to be used as biological indicators of wetland condition, but to develop a meaningful metric for odonates, they need to be monitoring over a range of conditions within wetlands of the same class (EPA 2002); this monitoring is being planned city-wide by NRG ecologists. One of the reasons for conducting rapid assessments of a wide range of wetlands was to establish an inventory of wetland conditions, characteristics, and categories that can be used to help identify these classes and sites within each class that can serve as a reference.

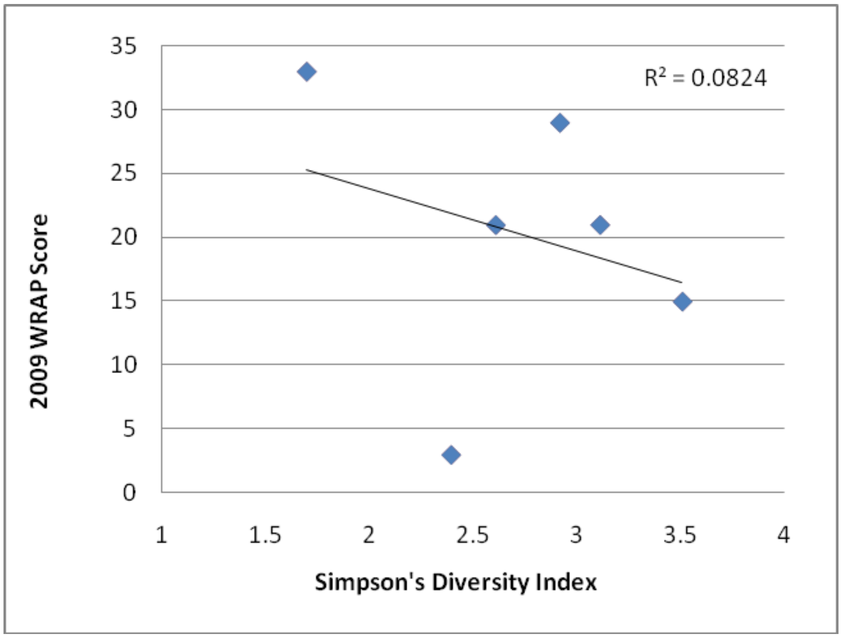


Figure 3. Odonate diversity scores from (Creveling 2003) vs. WRAP stressor scores. Shows a potential decrease in stressor score associated with an increase in the diversity index.

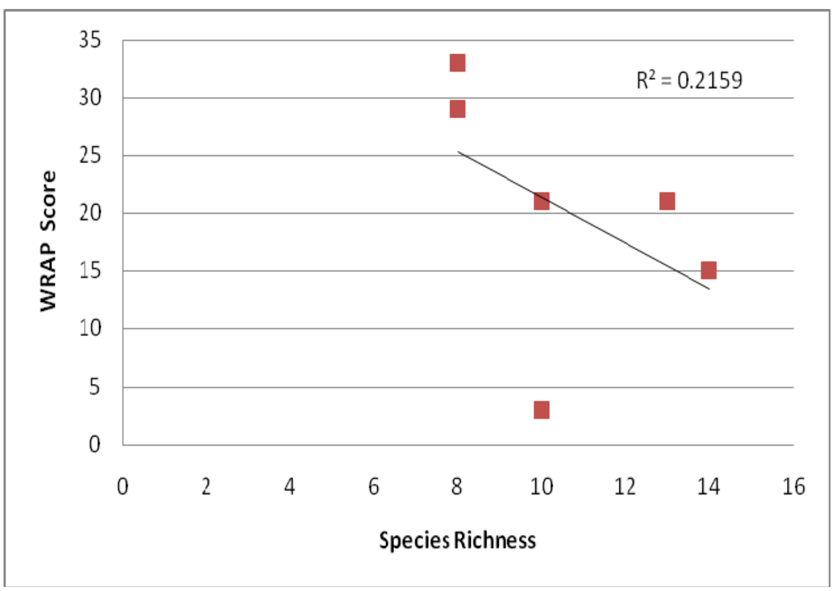


Figure 4. Odonate species richness scores (Creveling 2003) vs WRAP stressor scores. Shows a potential decrease in stressor score associated with an increase in species richness.

There was not association found between the development in the watersheds and the diversity indices or species richness at these sites.

SALAMANDER AND BENTHIC INVERTEBRATE MONITORING AT STREAM RAP SITES

Introduction

A four-year study of salamander populations, sediment deposition, water quality, and benthic invertebrate communities was conducted in four streams on Staten Island, New York from 1999-2003.

Monitoring protocols

We compared: densities and size distributions of two salamander species; densities, taxa composition, and pollution tolerance indices from benthic invertebrate samples; amounts of sediment deposited in baseflow and rain event conditions; and concentrations of nutrients, dissolved oxygen, suspended and dissolved solids and other water quality variables.

Salamanders

Although some research has been done on the best techniques for monitoring stream salamanders, no one method has emerged as the standard (Jung 2002, Connery 2000, Droege 1999, Ohio EPA 1999, Pauley 1999, Rocco et al. 1999, Pauley and Little 1998, Welsh and Ollivier 1998, Welsh et al. 1997, Heyer et al. 1994, Murphy et al. 1981).

We used two different methods to estimate population densities of stream salamanders: leaf bags and transects. We constructed leaf bags of nylon deer fencing with a one-inch mesh as in Pauley and Little (1998). A mesh rectangle 40 cm x 30 cm was sewn into a cylinder along the long axis with nylon twine. The cylinder was filled with leaf litter from the banks of the study stream and weighted by adding several large stones. The bag was then closed tightly using a nylon cable tie and secured to the stream bottom with a railroad spike. Each leaf bag occupied approximately .045 m2 of substrate. Ten leaf bag locations were randomly chosen for each study stream. Leaf bags were placed in the streams in mid-March of 2000. We allowed invertebrates and salamanders to colonize the bags before checking them in mid-April and again in early June of 2000. We removed invertebrates and salamanders from leaf bags by placing a white plastic dishpan adjacent to the leaf bag and quickly lifting the bag up and into the dishpan. A small amount of water from the stream was used to wash salamanders and invertebrates from the bag. All salamanders and crayfish were identified, measured (SVL and TL) and released. We used keys in Bishop (1941), Eaton (1956), Altig and Ireland (1984) and Petranka (1998) for salamander identification and an unpublished key (Daniels 2000) for crayfish identification. Additional invertebrate species found in leaf bags were noted.

Salamander populations were estimated using one-meter wide cross-stream belt transects (Connery 2000, Stehman 2000). Ten locations upstream from the zero point were randomly chosen for each stream and sampling date. The downstream edge of the transect was placed at this location and a measuring tape and stakes used to outline a rectangle 1m wide running across the stream including the portion of the bank one meter from the water's edge on either side. The length of the transect was recorded, along with the date, time, number of observers, and weather observations. On most occasions pH, dissolved oxygen, and water temperature were recorded. Total dissolved solids was measured at a subset of sampling events. Observers caught salamanders and associated fauna by placing a steel mesh tea strainer, shaped into a triangle, downstream of each cover object and lifting the cover object quickly (Jung 2002, Heyer 1994). Salamanders, invertebrates, and fish were often washed into the strainer using this technique. When salamanders, odonates, and crayfish were observed after escaping the strainer, they were collected by gently prodding them into the strainer. All cover objects were sampled in this way, and the stream bottom was observed after sampling to ensure that all fauna had been observed. The number of minutes elapsed during sampling were recorded for each transect. Salamanders were identified to species, aged, sexed, and measured (SVL and TL in cm). Deformities or damaged/regenerated tails were noted. Crayfish and odonates were identified and measured (TL).

We sampled ten transects each at East Branch, Egbertville Ravine, Manor Creek, and Reed's Basket Willow in April and June of 2000. Manor Creek was dropped from the study when it dried in the Summer of 2000, and Forest Hill was added. We sampled transects in the remaining four streams in April, June, August, and October of 2001 and in May of 2002.

Sedimentation

We initially constructed sediment traps from 2-1/2 liter plastic paint buckets. We nested one bucket within another to allow for easy removal. We inserted a wire lath and stone baffle to simulate the roughness of the stream bottom. Studies have shown that the change in turbulent flow over an open container can bias sediment deposition measurement (Bond 2000, Lisle 1989). In April 2000 we tested two traps at MC. We then placed five traps in EB, ER, MC, and RBW in April 2000 and again in May 2000. The traps were left in place 27 days in April and 30 days in May. The plastic bucket sediment traps were abandoned subsequently because: 1) they were too buoyant and subject to popping out of the stream bed; 2) the white buckets were highly visible, encouraging vandalism; 3) the wire and stone baffles were easily dislodged by stream-borne debris; and 4) wire baffles easily become clogged by organic matter.

In 2001 we constructed improved sediment traps from 3.75" diameter steel cans filled with washed, commercially available, Delaware River stone. The stone was sorted using a 1/2" wire mesh; only gravel >1/2" was used in the sediment traps. We generated random distances from our downstream zero point and from the right bank for trap placement. We installed ten steel can sediment traps in EB, ER, FH, and RBW in July of 2001. Traps were buried in the substrate so that the rim was flush with the surface. The traps remained in place for one week during which there was no precipitation for a measurement of baseflow sediment deposition. We again installed ten sediment traps in each stream in August of 2001 when a rain event was predicted to measure stormflow sediment deposition. Rain gauges at each site, installed under an open canopy, measured the amount of rain received locally during stormflow sediment measurements.

Upon return to the laboratory, we removed the river stone and washed the remaining sediment into a 16 oz. plastic container. Sediment was then air-dried for one or two weeks. River stone used in each can was dried separately and weighed. Each sample of air-dried sediment was weighed to the nearest .1 g.

We determined particle size percent distributions for the two April 2000 test samples from MC using a hydrometer. This analysis requires 100 g of sediment. For sediment samples greater than 100g, we took a 100 g subsample. By timing the settling of the sediment in water, we determined the percent gravel, sand, silt, and clay. Percent organic matter was determined from the May 2000 sediment samples by weight loss following burning in a muffle furnace. For samples collected in 2001, 2004 and 2008, we sorted sediment by grain size using a Keck Soil Sifter.

Benthic Invertebrates

Benthic invertebrate samples were taken at riffles at the stream sites using the protocols described in detail in Appendix A. To ensure a known area of riffle was being sampled a Hess sampler was used. A Surber sampler also allows for sampling in a know area, but a Hess sampler can be more versatile in that it can also be deployed in lenthic conditions. For monitoring studies, NRG deploys such quantitative methods as opposed to semi-quantitative methods, such as a kick sample. New York State Department of Environmental Conservation uses kick sampling when sampling many streams across the entire state.

Results

Sedimentation

The large amounts of fine sediment and sand collected in some of our samples illustrated the severe erosion and sedimentation problems urban areas face. We tested two types of sediment traps and found that small (3.75” diameter) steel cans filled with smooth rocks were easy to use and appeared to accurately assess amounts of sediment deposited in the different streams.

Salamanders

Our study showed that salamander populations are healthy, and presumably growing or remaining stable, at three sites. We compared leaf bags, 1 m^2 belt transects, and a Hess cylinder used as a drop-box for estimating salamander densities. We concluded that leaf bags are the least labor-intensive method that gives results indicative of true densities. Sediment, total nitrogen, and total dissolved solids were greatest at the site with the highest salamander densities, and therefore we did not feel that salamander populations were useful for assessing water quality or sediment problems between streams in New York City. Results from 2008, however, suggested that within a stream, salamanders populations vary with changes in the amount and particle size of sediment. The rarity of some species of salamanders within the City makes assessment of their populations useful as a management tool; sites where rare species of salamander are found merit a higher degree of protection to ensure that increases erosion, sedimentation, storm water runoff or other human manipulations in the landscape do not jeopardize these species.

Benthic Invertebrates

Benthic invertebrates reflected water quality at the one site located downstream of an impoundment, but were not instructive as to water quality at the other three sites.

In 2008, the Forest Hill stream had the highest HBI value, and the greatest increase in HBI score compared to 2001 (Figure 5). This increase in HBI may have been a result of detrimental changes in the upstream hydrology at the site. There was also an increase, although a smaller one, in the HBI values from 2001 to 2008 at the other three sites. The percent EPT by individuals dropped significantly at the Forest Hill stream site, as well, which may further confirm the fact that there was a significant disturbance at this site (Figure 6). At the other three sites, percent EPT individuals appeared to increase by 100 to 700%, for which there is no clear explanation.

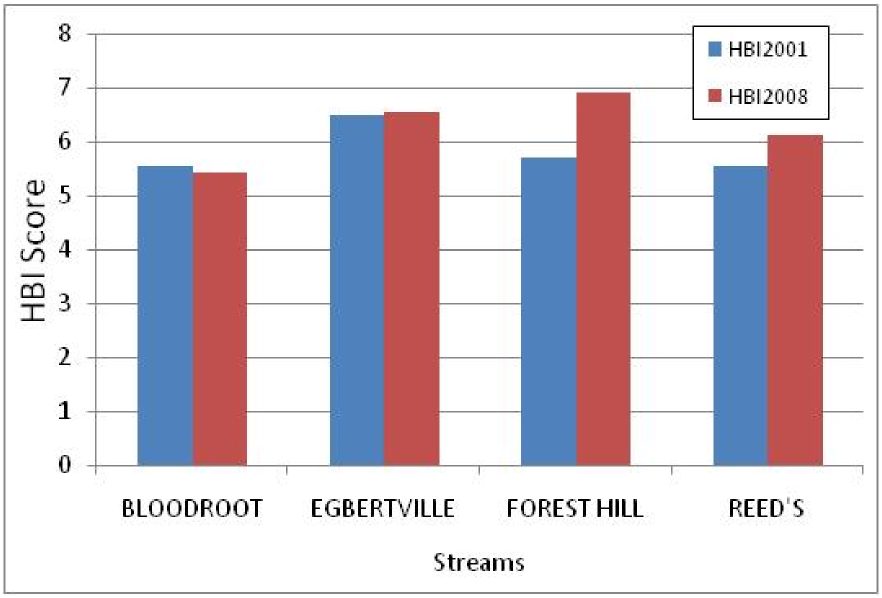


Figure 5. HBI Score at four Staten Island Streams in 2001 and 2008. Indicates a potential worsening of conditions at the Forest Hill stream.

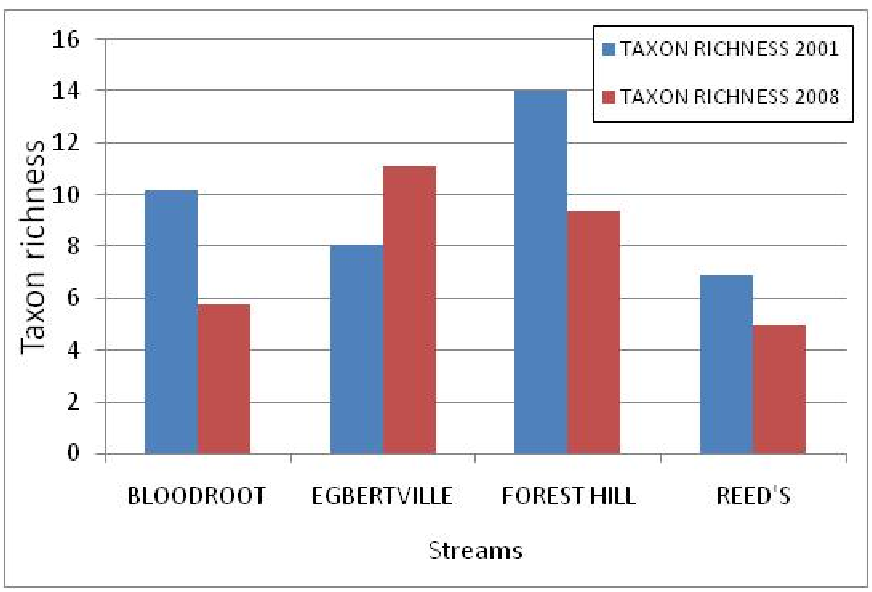


Figure 6. Taxon Richness at four Staten Island Streams in 2001 and 2008. Indicates a potential worsening of conditions at the Forest Hill, Reeds and Bloodroot streams.

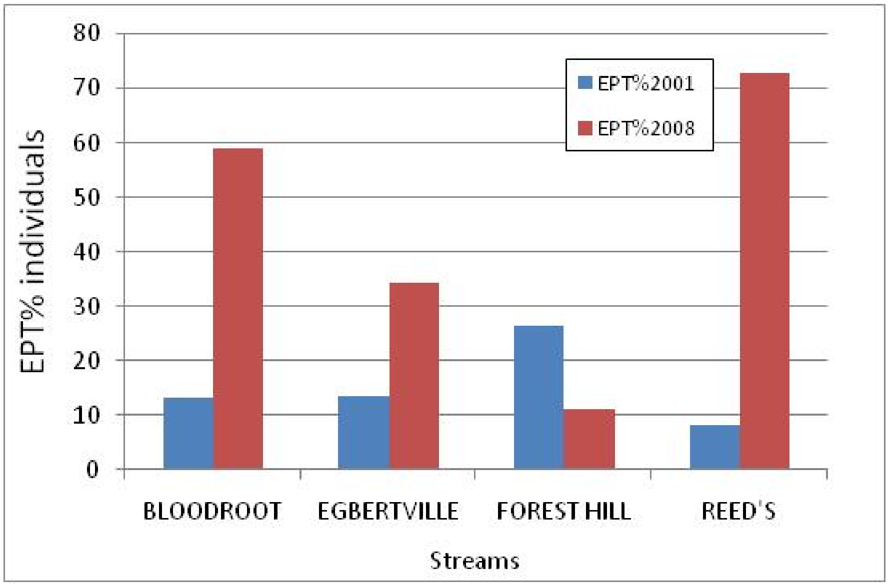


Figure 7. EPT % Individuals at four Staten Island Streams in 2001 and 2008. Indicates a potential worsening of conditions at the Forest Hill stream, but a strong increase in the percent of sensitive individuals at Reeds, Bloodroot and Egbertville streams.

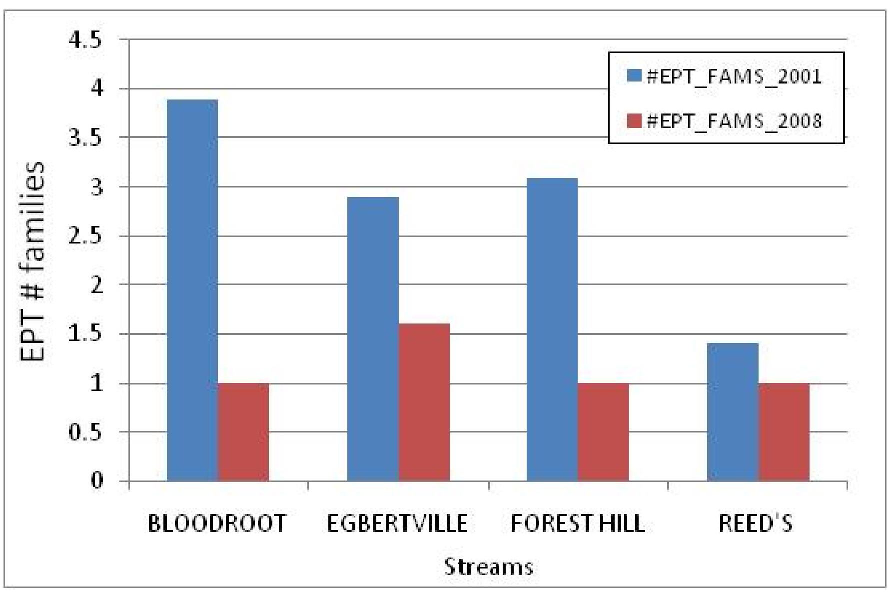


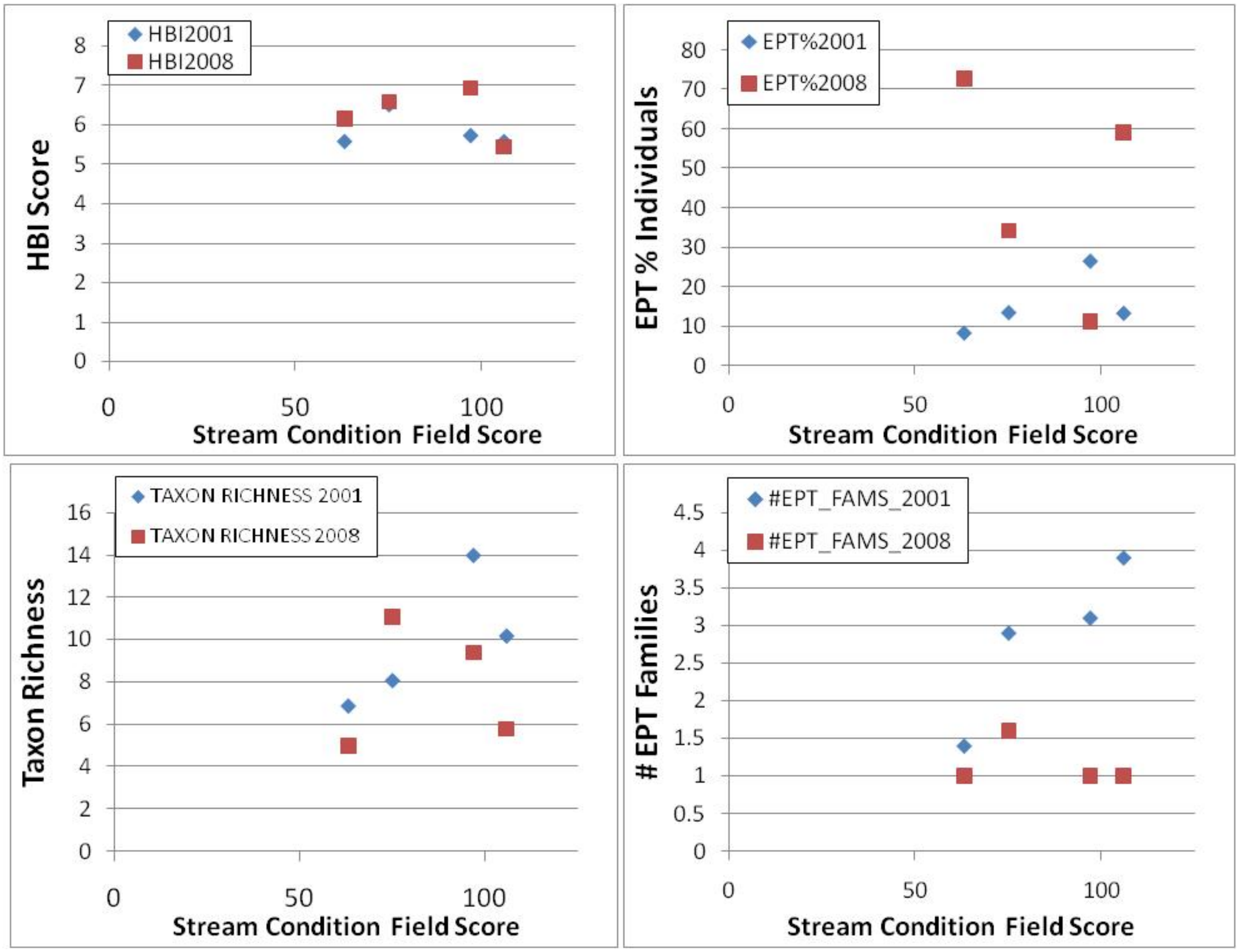
Figure 8. EPT Numbers of Families at four Staten Island Streams in 2001 and 2008. In contrast to the % EPT score, indicates a potential worsening of conditions at all streams.

When EPT was counted by families, instead of by individuals, the results appear to be reversed. The number of EPT by family decreased from 2001 to 2008 at all sites. The HBI, number of

EPT families, and taxa richness are analogous to New York State Department of Environmental Protection (DEC)'s approach to rating streams from non-impacted to severely impacted based on Species Richness, HBI, and EPT value. Although the DEC values are not comparable because they are based on kick-sampling and slightly different monitoring protocols, it is still instructive to compare the Staten Island 2001 and 2008 benthic invertebrate scores to the DEC's Water Quality Assessment Criteria. The scores indicate that all four streams qualify as "non-impacted" according to their HBI and EPT scores, although Reeds Basket Willow did qualify as "slightly-impacted" according to its 2001 EPT score. The 2008 monitoring suggests that the four streams sampled are "moderately impacted" using the DEC criteria (Table 3).

Table 3. NYSDEC's Water Quality Assessment Criteria for Flowing Waters (1998)

	Species Richness	**Hilsenhoff Biotic Index**	**EPT value**
NON-NAVIGABLE WATERS			
Non-impacted	>26	0.00-4.50	>10
Slightly impacted	19-26	4.51-6.50	6-10
Moderately impacted	11-18	6.51-8.50	2-5
Severely impacted	0-10	8.51-10.00	0-1



Figures 9. Benthic invertebrate indices and stream condition scores.

There was no apparent relationship between the benthic indices calculated in 2008 at the four streams and the field RAP condition score calculated for the sites. The 2001 benthic indices, however, did suggest there may be a correspondence between increased EPT and Taxon richness and higher stream RAP condition score, which would be to be expected, in theory (Figure 9). There was no obvious relationship between the benthic indices and percent development in the drainage basins for these streams. In theory, the benthic communities show evidence of increased degradation with greater development in the watershed, but very local conditions can also have a significant impact on the benthic community at a site. The wide range of scores for EPT, HBI, and Taxon richness is typical for streams in watersheds with a relatively low development, as is shown in Figure 10. EPT and Taxon are also generally lower at the site with the most development (except for the unusually high EPT % individuals in 2001 at the site with 40% development (Reeds Basket Willow),

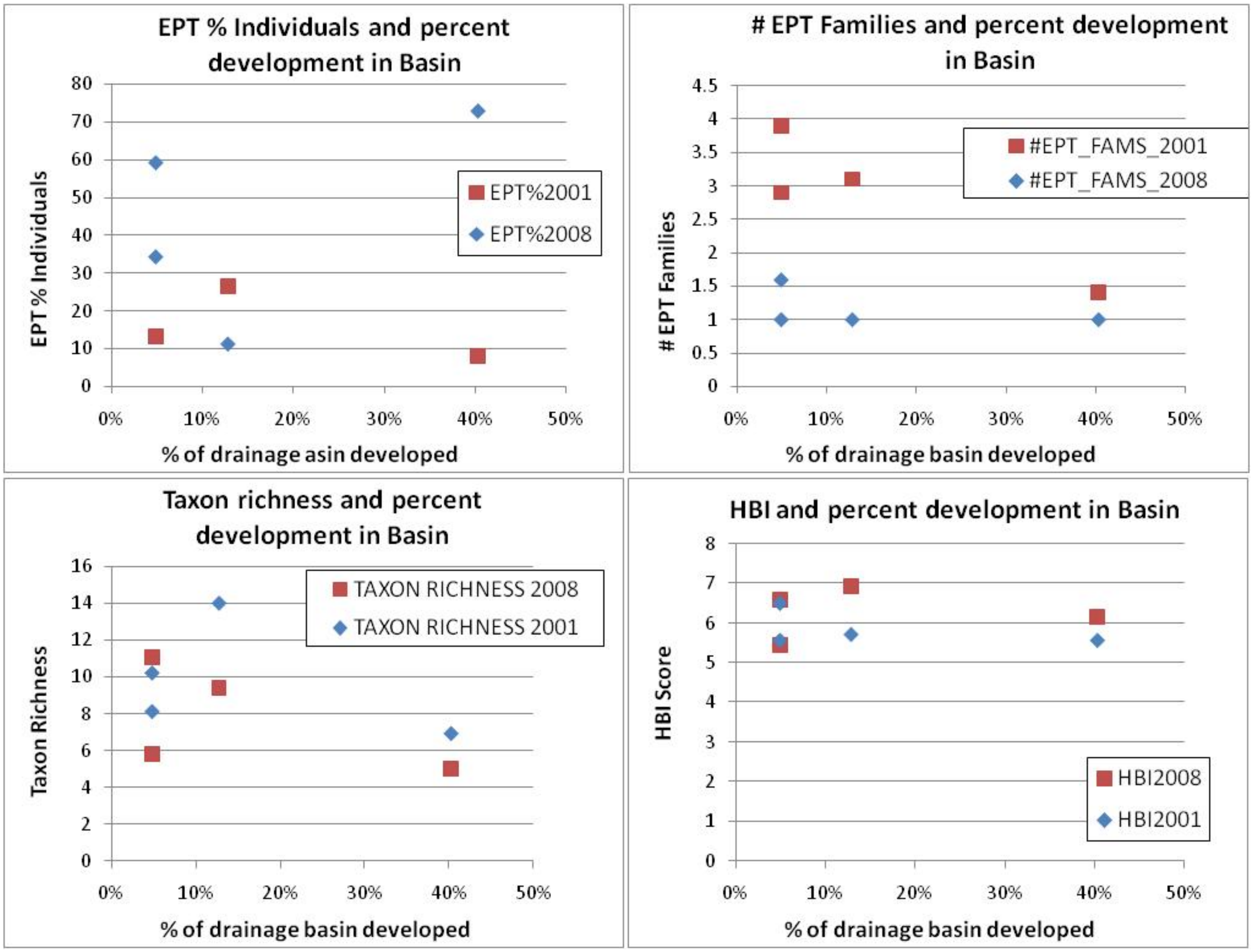


Figure 10. Benthic invertebrate indices and percent development in drainage basin.

TURTLE AND VERNAL POOL AMPHIBIAN SURVEYS AT WRAP STIES

Introduction

Turtle mark-recapture and vernal pool-obligate amphibians monitoring protocols were implemented by NRG ecologists in 2009 to study of freshwater turtles and a survey of vernal pool-obligate amphibians (see Appendix B for additional detail).

Monitoring protocol

At most turtle survey sites, five plastic mesh funnel traps and five coated twine hoop traps were employed. Fewer traps were used at several sites due to spatial and depth constraints. The vernal pond surveys included 5 funnel traps with smaller plastic mesh and five steel minnow traps modified with wider entrance/exits holes. All traps were checked at least once every 24 hours and set partially submerged to allow animals access to the air. Turtles were measured, weighed, and marked on the shell with a unique notch or combination of notches and released unharmed. Notes were taken on sex, reproductive status, and apparent condition for all animals captured. Snout-to-vent length and total length were recorded for amphibians and plastron and carapace length & width & height for turtles.

Results

Below (Tables 1 and 2) are lists summarizing trapping for the 2009 season. Seven turtle survey sites yielded thirteen individuals, while two vernal pond sites yielded 57 tadpoles and three larval salamanders. The species of turtles found included seven *Chrysemys picta,* five *Chelydra serpentina,* and one *Trachemys scriptaelegans*. The larval frog and salamander species included 40 *Rana sylvatica,* sixteen probable *R. clamitans,* and one *Pseudacris crucifer*, as well as three *Ambystoma maculatum*. These figures represent typical numbers for captures of turtles and *Rana spp.*, and perhaps low numbers for the *Ambystoma*. All turtles captured, except one young *Trachemys scripta elegans*, are native. *T. scripta* are commonly sold in Chinatown as pets and often released by owners in Parks' waters. They tend to be most common in ponds in well-visited horticultural parks surrounded by dense residential development. The *R. clamitans* (green frog) tadpoles use many types of habitats and do not indicate either good or bad habitat. The *R. sylvatica* (wood frog) and *P. crucifer* (spring peeper) tadpoles and the *A. maculatum* indicate fishless waters. *A. maculatum* generally indicates better quality water and surrounding upland habitat (they spend most of their time on or burrowed into, upland, other than the breeding season). *Kinosternon* species may be sensitive to eutrophication based on one study.

We would like to continue our survey efforts in the future in hopes of assessing the status of less-common species such as *Kinosternon subrubrum* and *Sternotherus odoratus*. The relationship between the WRAP scores and the reptile and vernal pool-amphibian surveys are of yet inconclusive.

Table 1. Reptiles in Staten Island and associated WRAP stressor scores*

Date	Species	Qty	Location	WRAP	
				SITE #	Stressor Score
5/4/09	*Chelydra. serpentina*	1	Ocean Breeze Park	OcBr (1)	17
5/19/09	*C. picta*	1	Chelsea Marsh	NA	
5/20/09	*C. serpentina*	2	Chelsea Marsh	NA	
5/20/09	*C. picta*	1	Chelsea Marsh	NA	
5/26/09	*C. picta*	1	Evergreen/Seidenburg Pond	EvSi (1)	47
6/1/09	*C. picta*	1	Buttonbush Swamp	LaTo_7	26
6/2/09	*C. picta*	1	Buttonbush Swamp	LaTo_7	26
6/2/09	*C. serpentina*	1	Buttonbush Swamp	LaTo_7	26
6/2/09	*Trachemys scripta*	1	Buttonbush Swamp	LaTo_7	26
6/16/09	*C. picta*	2	Kingdom Pond/Arbutus Woods	ArWo (1)	68
6/16/09	*C. serpentina*	1	Kingdom Pond/Arbutus Woods	ArWo (1)	68

Table 2. Amphibians in Queens and Staten Island and associated WRAP stressor scores*

Date	Species	Qty	Location	WRAP	
				SITE #	Stressor Score
6/2/09	*Rana* species	1	Buttonbush Swamp, S.I.	LaTo_7	26
6/3/09	*Rana* species	3	Buttonbush Swamp, S.I.	LaTo_7	26
6/4/09	*Rana* species	1	Buttonbush Swamp, S.I.	LaTo_7	26
6/9/08	*Rana* species	5	Blue Heron Pond, S.I.	BlHe (3)	69
6/10/09	*Rana* species	3	Blue Heron Pond, S.I.	BlHe (3)	69
6/11/09	*Rana* species	3	Blue Heron Pond, S.I.	BlHe (3)	69
7/7/09	*Rana* species	11	Alley Pond Park, Qns	NA	
7/8/09	*Rana* species	7	Alley Pond Park, Qns	NA	
7/8/09	*Pseudacris crucifer*	1	Alley Pond Park, Qns	NA	
7/8/09	*Ambystoma maculatum*	1	Alley Pond Park, Qns	NA	
7/9/09	*Rana* species	4	Alley Pond Park, Qns	NA	
7/9/09	*A. maculatum*	2	Alley Pond Park, Qns	NA	
7/13/09	*Rana* species	5	Cunningham Park, Qns	NA	
7/15/09	*Rana* species	9	Cunningham Park, Qns	NA	
7/16/09	*Rana* species	4	Cunningham Park, Qns	NA	

* For Tables 1 & 2 the maximum observed score was ~70 and minimum was ~2).

SALAMANDER INVENTORIES AT WRAP STIES

For over a decade, NRG and partners have conducted surveys to inventory the presence or absence of amphibians in wetlands across the city. Though this data was not collected for research studies using verifiable and replicable protocols over set limits of time and space, the surveys do provide information about distribution and occurrences of species that can be useful in helping to prioritize sites for further study. The amphibian presence-absence data is presented in Table 4. The relationship between these occurrences and the WRAP scores can be analyzed in the future.

Table 4. Amphibians presence or absence according to survey data from WRAP sites where amphibian monitoring was conducted.

PARK / LOCATION	Salamander Presence/Absence	WRAP SiteID
ARDEN HEIGHTS	Present	ArHeWo_3
BLOODROOT VALLEY	Present	StIsGr_1
BLUE HERON-BLUE HERON POND	Present	BlHe_3
BLUE HERON-SPRING POND	Present	BlHe_4
BUCKS HOLLOW	Present	LaTo_10
BUNKER POND	Absent	BuPo_1
CLAY PIT	Present	ClPiPo_1
CONFERENCE HOUSE	Absent	CoHo_5
EGBERTVILLE	Present	LaTo_6
EVERGREEN	Absent	EvSi_1
FOREST HILL	Present	LaTo_7
GREAT KILLS	Present	GrKi_1
HIGH ROCK/POUCH/KAUFMANN	Present	HiRo_10
LATOURETTE GOLF COURSE	Absent	LaTo_7
LONG POND-UNSPECIFIED	Absent	LoPo_4
LONG POND-N OF HYLAN AVE	Present	LoPo_3b
LONG POND-S OF HYLAN AVE	Present	LoPo_3
MARINERS MARSH	Absent	MaMa_1
REEDS BASKET WILLOW	Present	ReBaWi_1
RICHMOND CREEK BMPS RC3,4,5	Absent	LaTo_5
SWEETBAY MAGABSENTLIA	Present	SwBa_2
WILLIAM T DAVIS	Absent	
WOLFE'S POND-N OF HYLAN AVE	Present	WoPo_15
WOLFE'S POND-S OF HYLAN (INCL IRV NEWT)	Present	WoPo_15b

DISCUSSION

The selection of monitoring protocols and a monitoring design is inextricably linked to the formulation of the questions that are being asked and an understanding of ecological processes in our wetland systems (Parker 2002). This understanding of wetland ecosystems, as embodied in an ecosystem model, for example, must be considered in the context of our urban environment and management objectives (Maddox et al. 1999). In the highly urban environment of NYC, the inherent complexity of wetland systems is exacerbated by the array of historic and on-going anthropogenic impacts on the landscape and the wetland system, and a complicated and sometimes conflicting set of management objectives. There are many different kinds of freshwater wetlands, and there are a wide range of questions that can be asked about the conditions of our urban wetlands, and a wide range of monitoring designs and protocols that can be associated with those questions.

NRG employs a number of accepted protocols for monitoring biological and physical parameters for answering various types of wetland and riparian system management questions in general (see summary of generally available protocols in Table 5). There are currently no standard monitoring protocols available for indices of biological integrity that can be used to assess or rank wetlands according to their ability to support aquatic life, partly because wetlands vary so widely in their geography, geomorphology, hydrology, and biology. As long ago as 2002, EPA reported some 15 organizations in different states piloting bioassessment methods using invertebrates, as well as vegetation assemblages, fish, birds and algae. Despite this work on biological indices there are no standard methods or widely establish metrics available for wetlands in the New York City area, or even in comparable biogeographical regions with comparable levels of urban development. In contrast, there are widely accepted indices for streams, including for the New York State (Bode 1991, 2002).

To date, ecologists and environmental scientists at NRG have employed a variety of monitoring protocols to research certain wetland characteristics and organisms, and answer a variety of questions. Table 6 lists the biological and physical parameters that have been monitored in by NRG over the past decade as part of independent research projects or obligatory post-project assessments. In addition, chemical monitoring (pH, DO, TDS/Conductivity, Nitrogen, Phosphorus), which has not been included in Table 6, is also often conducted in conjunction with biological monitoring to characterize and evaluate site conditions. Overall, these monitoring efforts can be grouped according whether they are aimed at answering questions about the current conditions of specific species or assemblages of organisms and physical characteristics across sites (I), over time (II), or in response to restoration and management actions (III).

Depending on the type of monitoring being conducted, the methods employed, and the questions being asked, monitoring can require a wide range of effort (as well as cost, which is not discussed here). Turtle trapping, for example, is labor intensive, and should only be done to survey rare turtles, or answer questions about effects of invasive turtles on native turtle populations (ideally with a doctoral student to collect and analyze several years of data). When investigating long term trends and current health, however, other biotic data can serve as an overall index of ecological condition, incorporating the impacts of past physical, chemical and biological events in a stream or wetland (Karr 1991). Benthic invertebrate sampling in streams, for example, is widely conducted across the U.S. and on other continents to assess stream conditions at relatively low cost. The level of effort to initially develop biotic indices is high (e.g. Blocksom and Winters 2006). This holds true for salamanders and odonates in NYC wetlands, where we are still refining protocols, and still need to collect a wide range of physical and biological data to validate the salamander and odonate bio-indication potential. Once a reliable biotic indicator (or group of indices) is found, however, the effort in data collection can be drastically reduced. For example, NRG ecologists only sample salamanders at upland forest restoration sites once a year, now, although ecologists initially sampled once a month and collected data on herbaceous plants, invertebrates, and soil chemistry.

Table 5. Availability of monitoring protocols for general types of management questions.

INDICATORTYPE (or Metric)	**AVAILABILITY OF MONITORING PROTOCOLS FOR SELECT MANAGEMENT QUESTIONS**	
	Freshwater Wetlands	***Streams***
I. Current Health		
Biological	No standard protocols available. Site and species specific.	Standard protocols available for benthic invertebrates and fish
Hydro-geophysical	No standard protocols available	Standard protocols available for some regions (e.g. LWD, flow disturbance), but not locally.
II. Long-term Trends		
Biological	No standard protocols available. Site and species specific.	Standard protocols available for benthic invertebrates and fish
Hydro-geophysical	No standard protocols.	Various protocols available for channel stability, substrate, peak flows
III. Response to Restoration (or other action)		
Biological	Various protocols available. Restoration action and species specific.	Standard protocols available for benthic invertebrates and fish
Hydro-geophysical	Standard protocols require site-specific adjustment depending on specific restoration objective.	Standard protocols available for channel morphology, LWD, in-habitat features

For an understanding of processes driving change in a system, an assessment of vegetative, chemical or physical parameters is needed, in addition to biological monitoring. When studying the impacts of restoration projects or other management actions, an assessment of relevant physical and vegetative parameters (e.g. related to geomorphology, hydrology, hydraulics, or structural habitat) before and after the intervention is particularly critical, and often has to be determined on a site specific basis. In selecting biological parameters to monitor to evaluate restoration performance, the scale of the restoration is important to consider in relation to other factors that would affect the target biota, as is the timeframe of the monitoring.

NRG's investment in monitoring, whether at a high or low level for a given purpose or set of parameters, is done with limited staff resources, and implicitly requires prioritizing some projects, sites, and questions over other. Consequently, we have an on-going need to formulate and prioritize management questions and to select the best monitoring designs and key parameters that can best answer those questions. We need to continue to re-evaluate the monitoring protocols we implement at freshwater wetland restoration projects, for example, to assure the resulting data can be analyzed and used for adaptive management and for influencing restoration design approaches and policies, particularly with respect to restoration as mitigation**.** Table 6 provides and an overview of some of the future steps we may take towards developing an integrated wetland assessment and monitoring program for New York City.

In addition to the monitoring protocols that that have been used at NRG that are described above, and the wetland vegetation, benthic invertebrate, reptile and breeding bird monitoring protocols that are included in the appendices, a variety of standard protocols have been used to measure physical conditions in NYC wetlands and riparian areas. Several approaches to monitoring these parameters are described below.

Hydrology

Flow depth, frequency, and duration are used to characterize hydrologic conditions in both streams and wetlands. Wetland water depth fluctuations, measured with staff and crest-stage gages, either at set intervals or continuously, provide characterize overall wetland hydrologic conditions (Azous et al 2001), but need to be assessed in the context of the specific wetland under consideration. Hydrologic metric have been developed to assess impacts on streams, where hydrologic disturbance is known to be a large contributing factor to biotic degradation (Walsh et al 2005, Konrad et al. 2008, Kennen et al. 2009). Annual peak stream flow recurrence intervals analyses have been used with Bronx River historical USGS flow data to assess runoff conditions over time and to assess response to development (NRG 2004). This data and other metric, such as mean annual two year flow and drainage area, have been used to compare runoff conditions to other developed watersheds in the region (MMI 2005). Since there is unlikely to be any additional USGS funding to support long term monitoring, hydrologic monitoring undertaken by NRG will have to be supported by funding for a specific research or restoration project. However, there may be opportunity for NRG to consider some lake surface monitoring data collected by USGS in some locations.

Table 6. Summary of past NRG freshwater, riparian or stream monitoring, general monitoring objectives, and potential future work.*

MONITORING PARAMETER		TYPE OF STUDY QUESTION** (I=Current health, II=long-term trend, III=restoration response)		SITE TYPE: Fresh water wetland	SITE TYPE: Stream	LEVEL OF EFFORT (L=low, M=medium, H=high)	POTENTIAL FUTURE LONG-TERM EFFORTS
BIOTA (FAUNA)	Benthic Invertebrates	Characterization of invertebrates across streams; and in response to management actions (1)	I, II, III	√	√	H	Compile and analyze existing faunal and associated site data. Evaluate utility for assessing current health (and developing bio-indicators), long term trends and / or restoration response. Test salamander & odonate monitoring protocols by implementing them at a larger set of streams and wetlands and plotting results against WRAP scores.
	Odonates	Characterization across wetlands; response to management actions	I, II, III	√		M	
	Salamanders	Response to restoration (upland); characteristics across streams (2); response to management actions	I, II, III	UPLAND	√	M	
	Reptiles	Turtle characteristics across wetlands	I	√		H	
	Breeding Birds	Before/after rehabilitation (1,3,4)	III	√	√	H	
	Fish	Before passage restoration: river herring in Bronx (6)	III		√	M	
BIOTA (FLORA)	Vegetation	Before/after restoration: species richness, cover, diversity (1,3,4,5);	III	√		M	Compile and analyze vegetation monitoring data by site. Standardize methods for each type of wetland.
		Cover classification (entitation) (7)	I, II, III	√	√		
HYDRO-GEOPHYSICAL	Hydrology	Continuous and peak flows (5)	I, II		√	L	Support expansion of USGS surface water programs; Assess hydro-periods for intermittent freshwater wetlands.
	Channel stability	Long-term, before/after bank rehabilitation (4)	I, II, III		√	L-M	Expand monitoring to more streams; determine applicability to open water or periodically inundated wetlands subject to sedimentation.
	Large Woody Debris	Characterization of across reaches (8)	I, II		√	M	
	Bed sediment	Surface particle size and deposition characterization across streams and before and after management actions (2,5)	I		√	L	Expand characterization to more stream sites.
	In-stream habitat	Characterization of across reaches (7,9)	I, II		√	H	Re-evaluate these protocols across stream types.

*Water quality monitoring is not included.

**Examples of NRG reports associated with study questions: 1 = NRG 2003; 2 = Pehek and Mazor 2003, 4,5 = NRG 2007, 6 = NRG 2009, 7= NRG 2009, 8= Bronx River Alliance 2006, 9 = NRG 2004.

Channel Stability, Substrate and Geomorphology
Channel stability is relatively inexpensive and easy to monitor, and there is abundant information on standard monitoring approaches (e.g. Scholz and Booth 2001; Rosgen 2006; Henshaw and Booth 2000). Using standard protocols, permanent cross-sections were installed on four streams in Staten Island in 2000 to allow long-term monitoring of changes in channel condition; these sites these will be re-surveyed in 2010. Other permanent monitoring stations have been installed along the Bronx River and Alder Brook in Riverdale. There are more locations throughout the city where long-term cross-sections surveys could provide a record of channel stability. Channel cross-section surveys can be coupled with monitoring of bank conditions. Numerous monitoring protocols exist and need to be further reviewed by NRG to assess their utility in characterizing banks conditions as needed for specific research questions (see e.g. Pfankuch 1975, Platts 1987, Kaufman et al. 1999, Barbar et al. 1999, Cowley and Burton 2005).

Large Woody Debris
Large woody debris (LWD) monitoring protocols are readily available and widely accepted for stream and river systems (e.g. MacDonald et al. 1991, Montgomery et al. 1995, Larson et al. 2001). LWD numbers, sizes, configuration and position in the channel can be determined to assess habitat conditions, and make compares between stream reaches or assess response to restoration or management actions. In NYC, LWD has not been correlated to other channel habitat characteristics, but baseline LWD counts have been collected on the Bronx River to compare this urban stream to reference sites and other urban streams for which data exists. LWD data may be useful to continue to collect on the highly urban, often ephemeral streams of NYC if specific management or long term changes are being investigated.

Bed Sediment
When characterizing sediment substrate in streams, two standard methods have been employed at NRG. Pebble counts (Kondolf 1997, Wolman 1954) are conducted to provide a rapid surficial assessment and characterize the typical material on the bed. Sediment traps have also been used with sieve analyses to ascertain a size distribution at the surface and below the bed, in a specific area, or over time (Bond 2002, Ellen and Mazor 2003). An extensive literature exists on methods for assessing sedimentation rates and impacts (e.g. Reid 1993, Lisle 1989). In wetlands, where it may be useful to characterize the substrate of unconsolidated bottom material, sieve analyses would be required to make accurate assessments of particle size. We need investigate what the most effective rapid assessment technique exists for this parameter.

In-stream Habitat
Extensive literature exists on assessing and monitoring in-stream habitat (e.g. Frissell et al 1984, MacDonald et al 1991, Harrelson et al. 1994, Sullivan et al 2004, McBride and Booth 2005). Monitoring approaches for habitat characteristics are typically dependent on stream type, and species of interest. NRG has primarily monitored in-stream habitat to assess stream conditions, rather than to determine whether a habitat type responded to any specific change in management actions (NRG 2004). In-stream habitat was characterized in NRG's Urban Streams Monitoring Study (Pehek and Mazor 2003) to assess differences between stream hydrogeomorphic conditions, and in a study in the Bronx River to document the range of in-stream habitat conditions over the extent of potential anadromous fish habitat (NRG 2004). In stream habitat

measurement protocols have varied between studies at NRG, which prevents comparisons (Whitacre 2007); one of our goals for the future is to review our techniques and the literature and adopt a single protocol, if possible for NYC streams.

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APPENDIX A. MONITORING PROTOCOLS IMPLEMENTED AT NRG 1999-2009.

1. BENTHIC INVERTEBRATE SAMPLING

Scope and Objectives: To characterize the benthic invertebrate population at a site.

Site selection: An area of homogeneous substrate is identified where three samples can be taken. Sampling should occur on a riffle, if one is present in the selected reach.

Equipment and supplies:

- Hip and chest waders
- "Write in rain" or equivalent paper
- Six 8 ounce glass jars per site and white sticky labels
- Permanent Markers, Pencil
- Data sheet &Field notebook
- Spray bottle
- Tweezers
- Measuring tape &Ruler in metric
- Two 16 ounce Nalgene or equivalent bottles
- GPS& Camera
- Hess sampler
- Ethanol and Distilled water
- Tape

Methods

Collection preparation

The sampling site location will be mapped using a GPS and the location is described in the field book, with measurements to the nearest notable feature, such as tree. A pebble count is conducted to describe the medium particle size on the channel bed. See Appendix A. for a description of the Pebble Count Method.

Collection protocol

Samples will be collected in late summer during low flow, since the first round of pre-restoration sampling at the Shoelace Park site was collected in August and because summer is the most appropriate time to collect benthic invertebrate samples.

Three replicate samples will be collected at each site in August during low flow. Samples will be taken from downstream moving upstream in an area on the bed closest approximating a riffle, or local area of higher gradient, faster flow, and larger bed material. Replicate samples will be spaced at least 1 m apart and at most 5 m apart.

At each station the Hess sampler (inside diameter 33.02 cm) will be dropped forcibly and quickly onto the substrate, and checked for gaps along the bottom edge. Using a trowel, the substrate within the sampler will be stirred to a depth of 3-4 inches for 30 seconds. The 1-mm mesh net is then inverted and rinsed thoroughly until all material on the net is caught in the collection container at the bottom of the net. The container is then opened over 8 oz. glass jars and the substrate is knocked and picked into the glass jar. A spray bottle with 70% ethanol is used to clean out the collection container into the glass jars.

Handling and preparation.
The jars will be labeled on the outside on white sticky labels and with labeled pieces of waterproof paper inserted in the sample. In the field the jars are filled with 70% ethanol. If another preservative is used, or the samples appear too dilute, within one day, the samples are rinsed using a 1-mm mesh net or less and preserved in a 70% ethanol solution. All samples will be stored at NRG's offices at 1234 Fifth Avenue, New York, NY, Room 237.

Data records and management
In a field notebook, the date, time, and location of the sample will be recorded, as well as any notes describing changes to the site or the protocol. Upon returning to the office, the field notebook pages are photocopied and inserted in the project notebook. Field notes will be checked when completing the Chain of Custody form.

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2. AMPHIBIANS

2.a. Twin Fields Restoration Monitoring 2002

Scope and Objectives: To determine the success of the kettle pond restoration in Twin Fields in Forest Park, Queens, in creating wildlife habitat. Success is determined by faunal similarity to natural and other created wetlands found in the published literature.

Schedule: Monitoring shall occur once per year in July.

Methods

Supplies

Before leaving for the field, make sure you have the following:

- Data sheets (write-in-rain)
- Pens or pencils
- 20 labeled 16 oz. Glass jars
- ethanol
- 0.5 x 0.5 m drop-box
- Map of site
- 100’ tape measure
- Taxonomic keys for vertebrates
- D-frame dipnet (1 mm mesh)

Site mapping: Prior to any monitoring, 10 m markers shall be placed along the perimeter of the pond at the 94’ elevation contour.

Quadrat sampling

- Select 10 random numbers between 0 and 999.
- Eliminate numbers in excess of total shore length. Each number designates a distance from the 0 m marker. Flip a coin to determine clockwise vs. counterclockwise direction. Each sample should be done in the order selected to avoid bias in testing order.
- Locate each sampling site along the exterior of the pond.
- Enter the pond radially one meter.
- Drop 0.5 m^2quadrat into the water.
- Run D-frame dipnet (1 mm mesh) through the quadrat 5 times.
- Separate all vertebrates and vertebrate egg masses into a bucket. Collect invertebrates in a jar containing 70% ethanol.
- Identify vertebrates to species. Record stage (juvenile, adult), total length, snout-vent length, sex, and behavior (such as clasping). Identify and count egg masses or individual eggs. Estimate or count number of eggs in first 10 egg masses.
- Label jar of invertebrates with sampling site, pond, park, and date (labels can be prepared ahead of time).

Laboratory analysis

After invertebrate samples are returned to the lab they will be rinsed and placed in a white dishpan with a small amount of water. All invertebrates visible to the naked eye will be removed, sorted by taxonomic group, and preserved in a vial of 70% ethanol. Invertebrates will be identified to genus except for chironomids, which will be identified to family, and oligochaetes, which will be lumped in one category.

Statistical analysis

The following summary statistics and indices will be calculated for each sample:

- Total abundance Total number of individuals in each sample

- Shannon-Wiener Diversity $H=-Sp_i\ln(p_i)$ Where p_I = proportion of individuals of the *i*thtaxon. This measure takes into account taxonomic richness as well as distribution. Higher numbers indicate better habitat quality.
- Shannon-Wiener Evenness Evenness = H/ln(S) where S = total number of taxa in a sample. Higher numbers indicate better habitat quality.
- Percent Dominance Percentage of the most common taxon out of the entire sample. Lower numbers indicate better habitat quality.
- Percent Dominance of the 3 most abundant taxa Percent of the three most common taxa out of the entire sample.
- Index of Community Integrity (ICI)
- EOT Richness and relative abundance Number of Ephemeroptera, Odonata, and Trichopterataxa in each sample, and percent of individuals belonging to those taxa. Higher numbers indicate better habitat quality.
- Ratio of EOT to Chironomidae Number of Ephemeroptera, Odonata, and Trichoptera, divided by the number of Chironomids in each sample. Higher numbers indicate better habitat quality.
- Sensitive taxa index (modified from Hilsenhoff) Sensitivity = $S(X_i t_i)/n$ where X_i = individuals in the *i*th taxon, t_i = tolerance value for the *i*thtaxon, and n = number of individuals in the sample. Lower numbers indicate better habitat quality.
- Richness and abundance of sensitive taxa Number of taxa with of pollution tolerance ratings of 2 or lower, and proportion of individuals in those taxa. Higher numbers indicate better habitat quality.
- Richness, abundance, and biomass of Dytiscid, Chrysomelid, and Curculionid Coleoptera Predatory Dytiscid (diving) beetles are among the earliest colonists of new or created. wetlands, whereas herbivorous Chrysomelid (leaf) and Curculionid weevil beetles are usually found in more mature wetlands (Fairchild et al. 2000). Chrysomelids and Curculionids are obligatorily dependent on specific species of vascular plants, and can only colonize ponds with appropriate food species. Dytiscids, however, are more general predators of small animals. Generalized detrivores (such as some Hydrophilidae) and algivores (Haliplidae) are also early colonists.
- Richness and relative abundance of non-native taxa Number of taxa of exotic origin, and the proportion of individuals in those taxa. In freshwater systems, exotic species are usually either released pets, escaped bait, or hitchhikers on aquatic plants. Lower numbers indicate better habitat quality. A preliminary list of non-native fauna in Northeastern freshwaters (lotic and lentic) is provided below.

Molluscs:	
Bivalves	
Zebra mussel	*Dreissena polymorpha*and *D. bugensis*
Henslow’s pea clam	*Pisidium henslowanum*
Asiatic clam	*Corbicula fulminea*
Gastropods	
Mystery snail	*Cipangopaludina chinensis* or *C. japonica*
Mud bithynia	*Bithynia tentaculata*
European stream valvata	*Valvata piscinalis*
Big-eared radix	*Lymnaea auricularia*

A snail	*Viviparus georgiana*
A snail	*Potamopyrgus antipodarum*
Crustaceans:	
Crayfish	
Louisiana red	*Procambarus clarkii*
Rusty crayfish	*Orconectes rusticus*
Virile crayfish	*Orconectes virilis*
Calico crayfish	*Orconectes immunis*
A crayfish	*Orconectes neglectus*
Insects	
Odonata	
Great spreadwing	*Archilestes grandis*
Vertebrates:	
Reptiles	
Red-eared slider	*Chrysemys scripta*
Fish	
Goldfish	*Carassiusauratus*
Carp	*Cyprinus carpio*

2.b. Urban Stream Monitoring Program (Pehek and Mazor 2003)

Scope and Objectives: Assess salamander populations in urban streams; develop biologically meaningful methods of measuring sedimentation in streams; and, compare benthic invertebrates and salamanders as indicators of sedimentation and water quality impairment.

Schedule: April through October

Sites: Gravel-bedded streams

Methods

Leaf bags and transects used two different methods to estimate population densities of stream salamanders. Construct leaf bags of nylon deer fencing with a one-inch mesh as in Pauley and Little (1998). Sew a mesh rectangle 40 cm x 30 cm into a cylinder along the long axis with nylon twine. Fill the cylinder with leaf litter from the banks of the study stream and weigh by adding several large stones. Close the bag tightly using a nylon cable tie and secure to the stream bottom with a railroad spike. Each leaf bag occupied approximately .045 m2 of substrate. Choose ten leaf bag locations randomly for each study stream. Place leaf bags in the streams in mid-March. Allowed invertebrates and salamanders to colonize the bags before checking them in mid-April and again in early June of 2000. Removed invertebrates and salamanders from leaf bags by placing a white plastic dishpan adjacent to the leaf bag and quickly lifting the bag up and into the dishpan. Use a small amount of water from the stream to wash salamanders and invertebrates from the bag. Identify all salamanders and crayfish, measure (SVL and TL) and release. Used keys in Bishop (1941), Eaton (1956), Altig and Ireland (1984) and Petranka (1998) for salamander identification and an unpublished key (Daniels 2000) for crayfish identification. Identify additional invertebrate species found in leaf bags.

In addition, estimate salamander populations using one-meter wide cross-stream belt transects (Connery 2000, Stehman 2000). Randomly locate ten locations upstream from a zero point for each stream and sampling date. Place the downstream edge of the transect at the zero point and use a measuring tape and stakes to outline a rectangle 1m wide running across the stream including the portion of the bank one meter from the water's edge on either side. Record the length of the transect, along with the date, time, number of observers, and weather observations. Record pH, dissolved oxygen, and water temperature. Total dissolved solids was measured at a subset of sampling events. Catch salamanders and associated fauna by placing a steel mesh tea strainer, shaped into a triangle, downstream of each cover object and lift the cover object quickly (Jung 2002, Heyer 1994). Salamanders, invertebrates, and fish are often washed into the strainer using this technique. When salamanders, odonates, and crayfish are observed after escaping the strainer, they are collected by gently prodding them into the strainer. Sample all cover objects in this way, and observe the stream bottom after sampling to ensure that all fauna had been recorded. Record the number of minutes elapsed during sampling for each transect. Identify salamanders to species, and record age, sex, and measured SVL and TL. Note deformities or damaged/regenerated tails. Identify and measure crayfish and odonates (TL).

Scoliosis study

To collect salamanders for the study of scoliosis, we will check cover objects in the stream at Reed's Basket Willow Park, Richmond County, using a metal strainer to catch E. bislineata larvae washed downstream. We will collect P. cinereus with scoliosis by checking cover objects in the forest at Inwood Hill Park. We will collect no more than 10 individuals of each species in a site where we detect a high incidence of scoliosis. Animals will be transported in a cooler to Queens College, to the laboratory of Dr. Pokay Ma, for analysis.

3. BREEDING BIRDS

<u>Birds Monitoring for Wetland Restoration in Seton Falls and Riverdale Parks</u>

A breeding bird census was conducted at Seton Falls Park during the 2001 breeding season to document breeding species and their relative abundance. The *Phragmites*-dominated restoration area was included to record the composition of the avian population breeding there prior to restoration. As a reference, a census was conducted at the cattail marsh upstream of the *Phragmites* site. This marsh, as a wetland not invaded by *Phragmites*, may host a more diverse breeding bird population than the *Phragmites* area. Approximately two hectares of the surrounding forested upland were censused to establish a base-line for breeding populations in areas where NRG is doing upland restoration work.

NRG performed eleven site visits between May 15th and July 24th, 2002, with seven of these falling between May 25th and July 10th (peak of breeding season for most terrestrial species). Ten visits were conducted in the morning, starting within an hour of sunrise; the July 2nd visit was conducted in the late afternoon, ending at sunset. To ensure bird detectability, we did not census during precipitation (rain or snow) or winds. Monitoring was conducted at the same locations in the seasons before and after the freshwater wetlands and forest restoration in the Park.

Breeding bird censuses of this type generate estimates of the numbers of avian territories for each territorial breeding species present. Although not all bird species are territorial, for example heron species that nest in colonies, of those breeding in a natural area like that of Seton Falls Park, territorial landbirds compose the vast majority. These include almost all passerines (songbirds), as well as many other species. The birds that may benefit from the wetland restoration at Seton Falls, such as Veery, Wood thrush, and other wetland-associated forest nesters that are uncommon to New York City, are effectively monitored using spot-mapping (census) techniques.

To assess the breeding bird population at our study site, spot-mapping techniques were used based on those employed by the Cornell Laboratory of Ornithology and the National Audubon Society (Robbins, 1970). Six site visits were conducted between May 20th and July 13th, 2001, and one on May 8th. Each visit began within an half an hour of sunrise, when bird vocalization peaks (Ralph et al. 1993) and lasted 1.5 to 3 hours. To ensure bird detectability, visits were not conducted during precipitation or winds.

During each visit, birds seen or heard along the census route were recorded on a survey map of the site. Species was indicated using the four letter USGS Bird Banding Codes. Breeding-related behaviors were also recorded using symbols established by the British Trust for

Ornithology (Bibby et al. 1992). These behavior registrations were used to delineate territories and to classify the breeding status of these territories as outlined below. The same census route was always walked, although the starting points varied to avoid surveying the same areas at the same time each morning. Nests were noted when encountered, but not actively sought.

The territory classification system formulated by the Natural Resources Group Salt Marsh Restoration (Brown & Alderson, 2001) was used. It fuses the National Audubon Society system (Robbins, 1970) with the system developed by the New York Federation of Bird Clubs for the NYS Breeding Bird Atlas. Any “mapped territory” as defined by the Audubon Society constitutes a “Confirmed Breeding” status under the Breeding Bird Atlas system.

Each territory was classified as a “Confirmed” (CF), “Probable” (PR), or “Possible” (PS) breeding territory according to the following guidelines. An observation of an active nest, a bird carrying food or a fecal sac, or unfledged or recently fledged young, or three observations of a singing bird on separate study visits during the species’ breeding season confirmed a territory. An observation of a bird carrying nesting material, of a male-female pair, of an aggressive encounter between nonspecific’s, or two observations of a singing bird on separate study visits during the species’ breeding season qualified a territory as a probable breeding territory. An observation of a singing bird during the species’ breeding season classified a territory as a possible breeding territory.

4. VEGETATION

Vegetation Monitoring for Wetland Restoration in Seton Falls and Riverdale Parks

In August 2002 permanent vegetation monitoring transects were established along the restored and reference wetlands associated with Rattlesnake Creek. To mark the location of these transects, fourteen re-bar stakes were placed along the wetland/upland border, creating 7 evenly-spaced transects for each site (This does not include 3 transects in the restored forested wetland that were established last year). The distance from each stake (the transect end point) to the nearest tree was measured and the angle calculated to aid in relocating the transects. Additionally, each end point was recorded with a GPS unit. The reference wetland for the restoration site was also in Seton Falls Park, upstream in the southwestern section near E. 233 Street and Baychester Avenue.

Quadrats

This methodology was used in the open marsh communities. All quadrat placement was pre-determined using a random number generator. To establish the quadrats in the field, a 100m measuring tape was stretched taut across the wetland and fastened onto 2 re-bar stakes. This served as a transect. Quadrats were then placed at the randomly-selected distance from one of these end points. The 0.5 x $2m^2$ plot frame was arranged so that one 2-meter side was placed on the eastern or western side of the transect. The number of plots per transect was determined by the number of vegetative zones the transect ran through, with an average number of 2 (Figures 1 & 4).

Quadrats within the restored and reference wetlands were monitored in August and September 2002. Data collected for all plants were stratum and percent cover of species present. Additionally, number of stems, presence of flower or fruit, plant height and number of rhizomes were noted for *Phragmites* and installed plants.

Line-intercept

This methodology was used in the forested wetland communities. Three transects were evenly-spaced in the restored and reference wetlands. Transects were set up as above.

Flora intercepting these transects were monitored in August and September 2002. Here data recorded were species and decimeter along transect (Figures 2 & 4).

<u>Urban Riparian Wetland Restoration Evaluation: A Case Study of the Bronx River</u>

Methods: Vegetation

Freshwater Vegetation Monitoring Plots

Twenty-five vegetation plots were established along the Bronx River in Bronx River Forest and Shoelace Park and monitored during September and October of 2002, 2003 and 2004 (see Appendix Map 7.1.4A and Map 7.1.4B respectively). These plots included areas that had been cleared, re-graded, stabilized and replanted using some combination of bioengineering techniques (5 plots) and areas that had been planted with native species, often after some form of invasive species removal (14 plots). Where planting had been the main restoration activity, some plots were in areas that had been planted in the late 1990s (8 plots), while others had just been restored in 2000-2002(6 plots). Three control plots were also located in areas that NRG did not manage, and an additional three reference plots were located in areas without invasive species. Monitoring plots were placed randomly within restoration areas.

Sampling was carried out by NRG field staff and plant ecologist. Plots were marked with a stake in at least one corner, and were GPS'd using a Trimble Pathfinder OXR with sub-meter accuracy. Missing plot stakes were replaced each field season during the period of 2002-2004. All plants within each plot were identified to the species or genus level, and percent cover class assigned. Cover classes were less than 1, 1-10, 10-25, 25-50, 50-75, 75-90, and 90-100 percent. For data analyses, these cover classes were converted to the average percent of each class (ie. 1-10% = 5.5%). Due to the vertical overlapping of different plant species, percent covers in a plot may add up to more than 100%. In each planting plot, plant recruitment was monitored in a 1-meter square area of the northeast corner. Japanese knotweed control areas were monitored using the same protocol, but a stem count for plant recruitment was conducted for the entire plot.

For data analysis, plots were classified as bioengineering or planting plots and most comparisons were made using these groupings. To estimate species survival, the planting plots were separated by the timeframe for which they were restored. Plots 1, 13, 14, 15, 16, and 17 were grouped together because they were restored in the 1990s. The remaining plots were classified as the 2000 through 2002 group. These are separated into two different groupings, because data is recorded for the recent restorations, but little is known about the species and methods applied to the earlier sites. Changes in Japanese knotweed percent cover in bioengineering plots, planting plots, and the two combined were examined for the three years. Survival of woody shrubs and trees were compared based on the established performance standards.

We calculated a number of summary values from the raw data that allowed for comparisons across plots. These included the percent cover of Japanese knotweed, the main invasive plant along the Bronx River, as well as the percent cover of various groups (native herbs, invasive herbs, exotic herbs, native trees, etc.), and the species richness (both overall and for natives only).

APPENDIX B: REPTILE MONITORING PROPOSAL

By Ellen Pehek.

Scope and Objectives: Characterize populations and identify potential needs for wildlife passages across roads. To acquire the information needed to adequately protect reptiles in our parks, we propose to trap, mark, and release aquatic turtles and snakes in selected parks in NYC.

Schedule: Active turtle season is Autumn, Summer, Spring.

Site selection: Ocean Breeze Park, Saw Mill Creek Park, Sweet Bay Magnolia Preserve, Wolfe's Pond Park, Fairview Park Conservation Area adjacent to Clay Pit Ponds State Park.

Methods

Hoop traps and modified funnel traps are used for aquatic turtles, and drift fences are installed with modified box traps to catch snakes and, perhaps, box turtles. Future box turtle surveys may employ dogs trained to track using box turtle scent.

To capture pond salamander larvae construct funnel traps of 1/8" (.32 cm) black plastic mesh. Plastic mesh traps with similar dimensions have been used by other researchers to capture ambystomatid salamanders (Fronzuto and Verrell 2000). For traps use cylinders 45 centimeters long and 15 cm in diameter, with a funnel protruding from each end. The small opening of the funnel is 3 cm, and the large opening is approximately 12 cm, located 20 cm beyond the end of the cylinder. Attach two plastic floats to each side of these traps so that 1/3 of the trap projects above the water surface.

Place 10 traps in a wetland in the evening and checked for captures early the following morning. Conduct trapping for a minimum of three consecutive nights in each wetland each month from May through July 2009, before larval metamorphosis. Trapped salamander larvae will be measured (snout-vent length) and released at the site of capture.

To capture larger turtles such as *C. picta* or the Red-eared Slider (*Trachemys scriptaelegans*), use commercially available hoop traps approximately 65 cm in diameter and 100 cm long. Stake hoop traps with 1/3 of the height projecting above the water to provide airspace for captured animals. Hoop traps have been used successfully to capture many types of turtles, including large basking turtles and snapping turtles (Legler, 1960, Gibbons 1990, Phelps 2004).

To capture mud and musk turtles, construct funnel traps from ½" (2.54 cm) black plastic mesh. This type of trap has proven successful in capturing a variety of herpetofauna (Muench 2004), including *S. odoratus* (Mitchell 1988) and *C. guttata* (Milam and Melvin 2001). Use cylindrical traps 60 centimeters long and 30 cm in diameter, with a funnel protruding from each end. The small opening of the funnel is 9 cm, and the large opening is approximately 30 cm, located 20 cm beyond the end of the cylinder. The plastic funnel traps will be placed in shallow areas of wetlands and secured with anchors so that about 1/3 of the trap height is projecting above the water surface. Depending on the size of the wetland, set one to five traps in the late afternoon and check the traps early the following morning. Set all turtle traps for a minimum of three consecutive nights per season. Measure carapace length using calipers and weigh and sex turtles captured. Mark turtles with an individual code by filing small notches in marginal scutes. Traps may also capture amphibians, small mammals, and insects, which should be recorded and released immediately. Set all turtle traps for a minimum of three consecutive nights per wetland.

The drift fences are made of 6 mil black plastic and will be 20 m long with box traps placed at 5, 10, and 15 m. An opening is cut into the drift fence and a box trap constructed of plywood will be placed against the opening. The box traps are approximately 60 cm long, 30 cm high, and 30 cm wide, and must provide adequate shade during the day. Open traps for the entire 24 hours for 4 consecutive days, and check them early in the morning and mid-afternoon. Conduct two 4-day trap sessions during Autumn 2008 and two during Spring 2009, when snakes and other reptiles are moving between summer and winter habitats.

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SECTION 4. PILOT STUDY OF SOCIAL SIGNIFICANCE OF WETLANDS

INTRODUCTION

NRG piloted a protocol at the Greenbelt in Staten Island to begin to assess the social significance of Parkland wetlands resources. This assessment took the form of a survey. Results could be used to target future outreach/educational efforts and to inform future management and restoration recommendations. The Greenbelt was chosen because the staff at the Nature Center located there could help distribute the survey and because the nature walks in the Greenbelt pass through a number of wetlands.

The protocol was developed in consultation with Research Social Scientists from the NYC Urban Field Station, U.S. Dept. of Agriculture Forest Service, who advised NRG on academic theories related to social surveying and provided sample approaches. The Forest Service scientists also recommended methods and techniques to expand and refine the pilot.

BACKGROUND

User surveys have been employed in national and regional parks to study the significance of natural resources from a variety of perspectives. Studies have determined issues important to visitors in State Parks (Holdnak et al. 2001), social benefits from urban greening projects (Westphal 1999), and homeowner perceptions of wildfire management in parks (Winter & Fried 2000). The concept of place attachment has been developed by social scientists to understand the emotional ties that can be formed or enhanced when a physical setting, such as a park, is imbued with meaning (Cuba & Hunmon, 1993). Place attachment is divided further into two operational concepts (Vaske 2003): place dependence and place identity. Place dependence is a functional attachment embodied in the physical characteristics of an area such as accessible hiking trails. Place identity is a psychological investment in a setting that develops over time (Williams & Patterson, 1999). Frequent visitation to a site due to proximity can increase place dependence, which in turn may lead to place identity (Moore & Graefe, 1994). Therefore, questions about an individual’s frequency of visitation and their attachment or identification have been used extensively to quantify place attachment and identify its association with a range of behaviors and attachments. Vasky and Kobrin (2001) investigated how place attachment to a local natural resource can influence environmentally responsible behavior in an individual's everyday life. Backlund (2005) questioned whether a person’s strong attachment to a specific place allowed it to be viewed as interchangeable with similar resources. Researchers have found that people may develop strong attachments to very specific physical features such as certain trees, woods, or streams (Ryan 2005; Dwyer *et al*. 1994). More recent studies by Fuller et al. (2007) found that psychological benefits, characterized by place attachment and cognitive restoration, increase with the biological diversity of urban greenspaces. Designing and testing survey options to assess visitation frequency, attachment to diverse flora and fauna as well as physical features is a first step in the process to measure the association between visitor experience of wetlands and other habitats and urban park stewardship and appreciation.

The goal of this pilot survey is to measure which amenities and physical features New York City's park visitors value, and to investigate whether the presence of specific fauna or flora add to the value of their park experience. The focus is on resources associated with the natural areas of New York City's parks that include wetlands. Therefore, resources and amenities such as recreation fields, golf courses, and sports programs are not addressed.

A pilot questionnaire was developed for distribution at the Greenbelt Nature Center for ten days in September 2009. The Greenbelt comprises natural areas as well as traditional parks. The Nature Center hosts environmental education programs, summer camp sessions as well as exercise classes, trail runs, cultural events and volunteer service within the park. A comprehensive series of trails exist throughout the area to provide access to ponds, swamps, creeks and forest. The variety of natural resources available throughout the Greenbelt as well as the active community outreach at the Nature Center provide a good cross section of New York City Parks' biophysical and social resources.

METHODS

Nature Center personnel used two methods to distribute pilot questionnaires in order to obtain a large enough sample size during the fall when visitation is limited. Patrons were approached and asked to complete questionnaires on an opportunistic basis and forms were also placed on the front desk. Questions were generally forced choice questions with respondents indicating their answers by darkening in ovals next to selected items. There were two open-ended questions on the survey for the category of "Other" with space for writing in details. The questionnaire was limited to twenty-one questions on one page in order to increase the probability visitors would complete all questions (See Appendix A).

Three sets of questions were asked. The first set is concerned with the amenities provided by the park such as trails and nature programming. The questions establish preference for specific amenities and distinguish between age specific programming, general nature programs, and programs not associated with the natural areas. The second set of questions ascertains visitor preference for specific landscape features, landforms or habitats. The third set attempts to determine if specific fauna and flora are important elements of a visitor's experience of the park and if biodiversity is valued or ignored.

Respondents were asked to rate their level of preference by the time they spent pursuing specific activities ("Once a day", "Once a week", "Once a month", "Never", "Not available") or visiting particular types of habitats ("Always visit", "Sometimes visit", "Rarely visit", "Never notice", "Not available"). The importance of specific flora, faun, and biodiversity was rated by level of appreciation. Response categories for appreciation were: "Favorite/most exciting", "Enjoy greatly", "Sometimes notice and enjoy", Not interested/Don't notice", and "Not available". In all cases the scores ranged from high to low. No demographic data was requested of the respondents.

RESULTS AND DISCUSSION

Thirty-three questionnaires were completed by patrons and staff of the Greenbelt Nature Center during the ten day period. One questionnaire was deleted due to the presence of double answers on seven questions. The remaining 32 questionnaires were used in the analysis. Frequency data for answers to the three groups of questions are displayed in Figures 1-3. The answer “Not available” was problematic for coding and it appeared to confuse some people. Two patrons indicated that all the amenities, such as hiking trails and nature programs, were either not available or never used, yet went on to rate favorite destinations and appreciation levels of flora and fauna. More specific wording limiting the area to the park would likely resolve some confusion. In addition, including the response “not available” may be more useful as a separate question to query visitors’ familiarity with the services and landscapes of individual parks. Due to the presence of only five convincing answers and the fact that “not available” does not indicate a decrease in level of involvement, coding of answers and analysis of general tendencies were done on a scale of 1 (lowest) to 4 (highest) for all questions. Any question answered as “not available” were recoded to no answer. The coding and questions are then more analogous to Likert-type scales. Table 1 lists the mean scores.

Table 1. Pilot Social Survey, Mean Score

Use of Park Ammenities	**Mean** (4=High)
Walking/Hiking Trail	2.58
Bike Trail	1.57
Guided Nature Walk	1.79
Nature Program Presentation	1.96
Nature Program for Children	1.83
Nature Program for Teens	1.56
Other	2.08
Favorite Destinations	
Pond	3.20
Open Panorama	2.84
Swamp	2.97
Meadow	2.84
Trees	3.00
General Environment	3.38
Appreciation Level	
Frogs/amphibians	3.18
Birds	3.28
Insects	2.71
Fish	2.71
Other animals	3.21
ID plants	2.86
Clean Air_general surroundings	3.52
Other	_

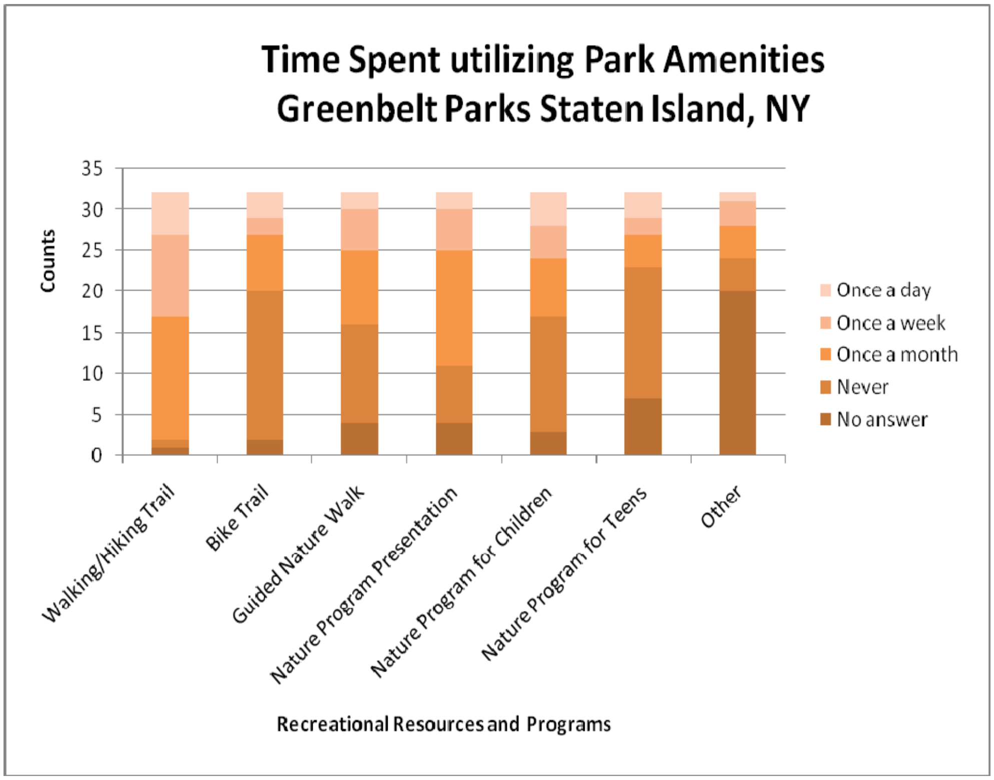

Figure 1. Pilot Social Survey: Utilization Frequency of Park Amenities.

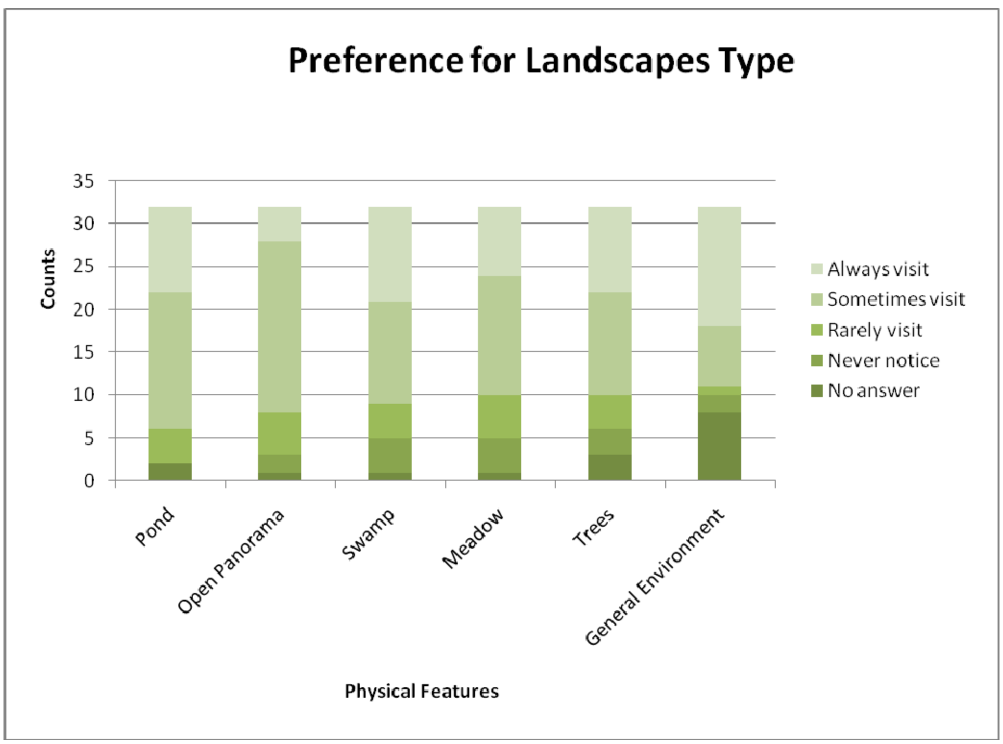

Figure 2. Pilot Social Survey: Park User Preference for Specific Destinations.

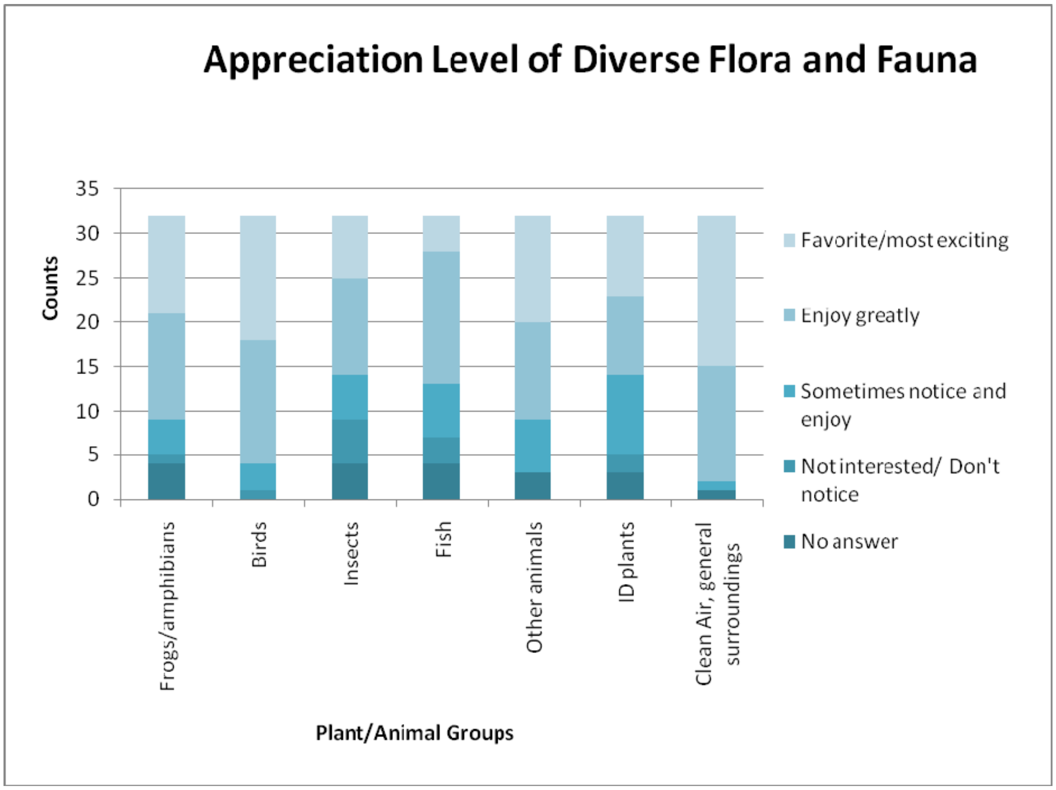

Figure 3. Pilot Social Survey: Park User Appreciation of Flora and Fauna

Hiking/Walking Trails were used most frequently followed by Other, then Nature Program Presentations (Figure 1). User preference for the landscape destinations ranked the general environment first, ponds second, and a particular tree or grove of trees third (Figure 2). No landscape element scored near to 2 (Rarely visit). Also, only 7.9% selected 'never notice' for their destinations indicating that users do notice and frequent a variety of landscape features and habitats. These high scores may be indicative of the bias inherent in conducting the survey within the confines of a nature center. Visitors to nature centers are more likely to be enthusiastic and informed about the natural resources of the park.

Users appreciated clean air and the general surroundings the most when visiting the park followed by interactions with birds, other animals, and frogs (Figure 3). Only 6.25% of respondents indicated that they didn't notice or care about the animal and plants. Again, lack of low scores may be indicative of the bias inherent in the placement of the survey. No statistics were implemented due to the small sample size.

It is clear from the answers that users appreciate a variety of habitats within the parks and the experience of animals within those habitats increases their enjoyment of the park. There is also evidence that wetlands may be the focus of place attachment. In this survey ponds were singled out as the most frequent landscape destination and swamps were effectively tied with a specific tree or grove of trees for second place. (Streams were not included in this survey, as trails in this series of parks do not lead to streamside areas.)

FUTURE RECOMMENDATIONS:

Through further collaboration with Forest Service scientists and other social science researchers, the survey could be refined and expanded. Further efforts might need to target a more diverse group of respondents, and improve the clarity of the questions asked in the survey.

Various techniques can be employed to increase the size of the survey in terms of number of respondents as well as information. If understanding local stewardship of natural parkland is to be addressed, a mailed survey, door to door surveys, or focus groups would target people who don't visit the parks as well as those that do. These techniques are also imperative in order to obtain data for those parks with no staffed centers. Another survey technique employed by social scientists is the use of incentives. Incentives such as a product or entry pass give-away to a zoo, botanic garden or local museum have successfully increased response rates among unmotivated potential respondents.

As a first step, in depth interviews with park staff would help to define who patrons are and when they use park facilities. This information could be used to improve survey design and techniques, enabling a high response rate. Mining 311 calls may also provide information about activities harmful to parks properties as well as demographics on concerned citizens. Imbedding a survey handout with the staff greeting would increase sample size at those parks with staffed facilities.

Questions addressing the following issues should be included in the expanded survey:

- Demographics should be included in order to develop appropriate outreach strategies.
- Time of day and season should be included as a variable, as use of the park landscape is not static.
- Distance from home is an important metric, because it is related to frequency of use, can increase place dependence, and lead to place identity (Moore & Graefe, 1994).
- The impact of the survey will be increased by the use of questions codified in the literature on place attachment and restorative environments. The statistics to analyze these questions are also well defined.

The suggestions compiled above will require considerable personnel hours and additional funding for materials. Granting agencies should be approached for potential funding.

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Appendix A. Pilot Survey Form for Greenbelt, Staten Island.

Please fill out the following survey to help us understand your use/appreciation of
Greenbelt Parks

1. How much time do you spend using the following park amenities:

	Once a day	Once a week	Once a month	Never	Not available
Walking/hiking trail	○	○	○	○	○
Biking trail	○	○	○	○	○
Guided nature walk	○	○	○	○	○
Nature program (presentation)	○	○	○	○	○
Nature program for children	○	○	○	○	○
Nature program for teens	○	○	○	○	○
Other program ____________	○	○	○	○	○

2. List your favorite destinations when walking/hiking/biking in order of preference:

	Always visit	Sometimes visit	Rarely visit	Never notice	Not available
Pond	○	○	○	○	○
Open panorama	○	○	○	○	○
Swamp	○	○	○	○	○
Meadow	○	○	○	○	○
Particular tree or grove of trees	○	○	○	○	○
None in particular, enjoy general environment	○	○	○	○	○

3. List your appreciation level of the following:

	Favorite/ most exciting	Enjoy greatly	Sometimes notice and enjoy	Not interested/ Don't notice	Not available
Hearing/seeing frogs or other amphibians	○	○	○	○	○
Hearing/seeing birds	○	○	○	○	○
Hearing/seeing insects	○	○	○	○	○
Seeing fish	○	○	○	○	○
Seeing other animals	○	○	○	○	○
Identifying plants/trees	○	○	○	○	○
Enjoying clean air and general surroundings	○	○	○	○	○
Other ______________	○	○	○	○	○

Natural Resources Group, NYC Parks Department September ____,2009

SECTION 5. CONCLUSIONS AND RECOMMENDATIONS

The development of wetlands rapid assessment protocol (WRAP), including both the landscape level in-office assessment, and the field assessment component, has initiated the first broad compilation of information on wetland condition by NRG in this century. The protocol has proved useful in flagging areas of concern (e.g. where invasive plants are becoming dominant) and sites of high value that might not otherwise be prioritized for protection. The WRAP results, and the stream rapid assessment results, permit a comparison to biologic monitoring data, which can help identify non-typical sites where further monitoring and assessment may be needed. The two seasons of field assessments have allowed us to quantify the staffing needs for collecting rapid assessment data and thus better plan what resources will be needed to conduct city-wide assessments over the long term. Finally, we see this protocol as a useful tool in on-going work at NRG to assess wetlands that may be transferred to parks, wetlands that have not been mapped by the National Wetlands Inventory or the New York State Department of Environmental Conservation, and other wetland sites where protection and management strategies need to be developed.

The wetlands rapid assessment protocol has potential utility in identifying and stratifying wetlands for research, stewardship and restoration planning purposes. For each of these purposes we may find that different types of information the WRAP collects are useful. Our recommendations for further analysis of the WRAP are presented here:

Wetland Rapid Assessment Protocol recommendations

- Each stressor parameter is currently weighted equally. The assumption that all parameters be given the same weight may warrant re-examination.

- Consider assessing more forested wetlands in the future, as these are the most dominant wetlands on Staten Island, according to the NWI database.

- Conduct an assessment of how replicable each WRAP stressor score is by having multiple NRG staff conduct assessments simultaneously at a site, and analyzing the variation in each result.

- Work with the Green Apple Corps to test the use of the WRAP in prioritizing wetland sites for invasive plant removal or trash clean up.

Monitoring recommendations

- Further investigate the relationship between WRAP results and the indices of odonate diversity, and, pending staff resource availability:
    - Expand the WRAP to all remaining odonate monitoring sites, and several new sites, across the city
    - Expand the odonate monitoring to include all appropriate WRAP sites.

- Collect new odonate data and conduct the WRAP again at sites from 2003 where the odonate data yielded unexpected results.

- Prioritize wetland monitoring objectives, whether for studying species populations, developing an index of biological integrity (IBI) for odonates, assessing constructed or restoration wetland performance, or investigating specific physical or ecological processes. Identify and apply for funding for priority monitoring.

- Where the data is available, compare vegetation monitoring data (such as line transects data collected or vegetation cover type mapping for other purpose with WRAP cover dominance data to assess the accuracy of the WRAP data in identifying dominant vegetation types.

- Consider and seek funding for collecting additional odonate and amphibian monitoring data at additional WRAP sites of similar type (Cowardin classification type, HGM type, size, watershed development characteristics) with different stressor rankings to expand the data base that can contribute to an IBI.

- Find partners in developing biological assessment methods (IBI) for urban wetland and investigate if available research and data collection in similar classes of wetland (with similar geographies and hydrology) might be useful in developing an IBI.