Quality Assurance Program Plan

Bronx River Water Pollution Monitoring Program

Bronx River Alliance

December 2016-January 2018

Bronx River Alliance
1 Bronx River Parkway
Bronx, NY 10462

Title and Approval Page

Bronx River Water Pollution Monitoring

Bronx River Alliance

Effective Date of Plan: December 30, 2016

Michelle Luebke, Ecology Director/QA Manager — Date: 22 Feb 2017

Kathalene Lamboy, Education Coordinator — Date: 2/27/17

Drew Youngs, NEIWPCC Program Manager — Date: 2/28/17

Michael Jennings, NEIWPCC QA Manager — Date: 2/28/17

Joshua Kogan, EPA Region 2 Project Officer — Date: 03/01/17

Kathryn Drisco, EPA Region 2 QA Manager — Date: 2/22/17

Table of Contents

PROGRAM MANAGEMENT

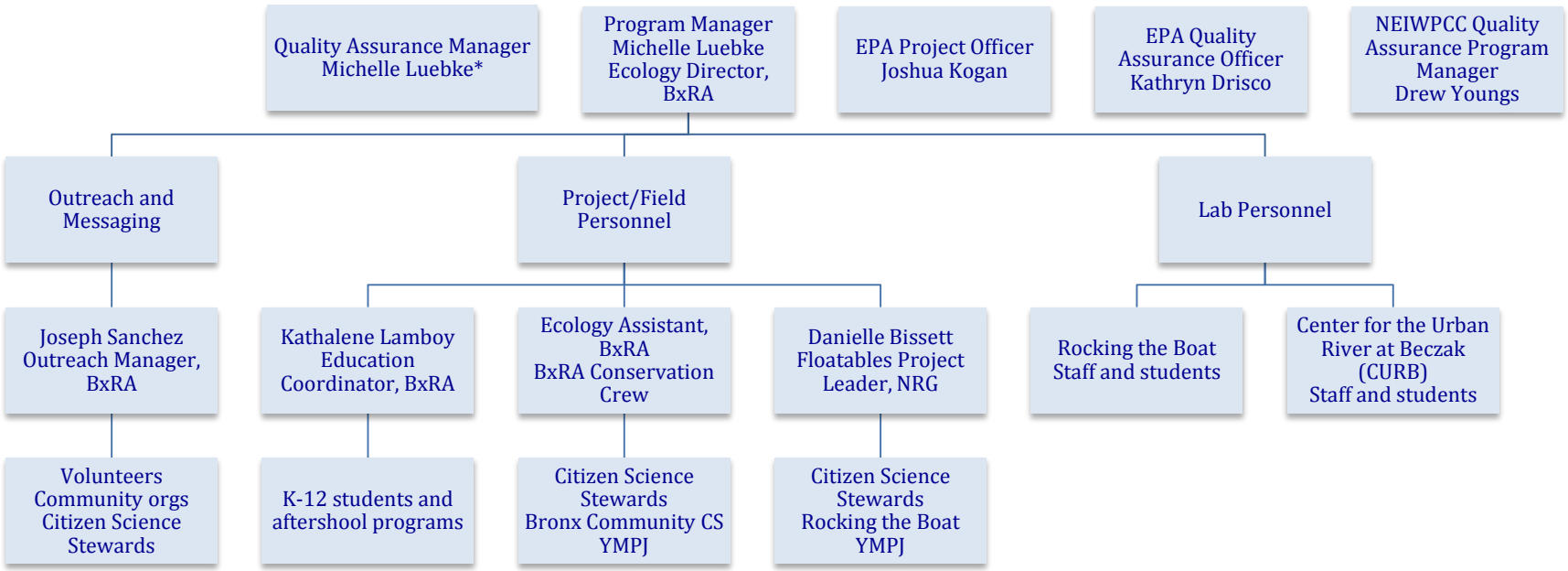
Project Contacts and Distribution List

Name/Title	Contact Information
Maggie Scott Greenfield Executive Director, Bronx River Alliance (BxRA)	E-mail: maggie.greenfield@parks.nyc.gov Phone: 718.430.1864
Program Manager Michelle Luebke, Ecology Director, BxRA	E-mail: michelle.luebke@parks.nyc.gov Phone: 718.430.4690
Quality Assurance Manager Michelle Luebke, Ecology Director, BxRA	E-mail: michelle.luebke@parks.nyc.gov Phone: 718.430.4690
Project/Field Personnel	
Project Leader for Floatables, Water Quality – Fecal Pathogens and Nutrients, and Low Dissolved Oxygen/HABs: Kathalene Lamboy, Education Coordinator, BxRA	E-mail: kathalene.lamboy@parks.nyc.gov Phone: 718.430.4614
Project Leader for Floatables: Danielle Bissett, Ecological Restoration Project Manager for the Bronx River Watershed, New York City Parks Department of Parks and Recreation, Natural Resources Group (NRG)	E-mail: Danielle.bissett@parks.nyc.gov Phone: 212.360.1453
Outreach and Messaging Leader: Joseph Sanchez, Outreach Manager, BxRA	E-mail: joseph.sanchez@parks.nyc.gov Phone: 718.430.4636
Field/Lab Personnel and Data Management for Floatables and Water Quality – Fecal Pathogens and Nutrients: Ecology Assistant, BxRA	E-mail: TBD Phone: 718.430.4665
Field Personnel for Floatables and Fecal Pathogens and Nutrients: BxRA Staff: Michael Mendez, Penny Brown, Elaine Feliciano, Jose Santiago, Elvin Cruz Seasonal Staff, supervised by above	E-mail: Michael.mendez@parks.nyc.gov Phone: 718.430.1864 E-mail: elaine.feliciano@parks.nyc.gov Phone: 718.430.1864
Partner Organizations	
Ryan Palmer, Director, Center for the Urban River at Beczak (CURB) at Sarah Lawrence College	E-mail: rpalmer@sarahlawrence.edu Phone: 914.377.1900 x15
Dan Shapley, Water Quality Program Manager, Riverkeeper	E-mail: dshapley@riverkeeper.org Phone: 914.478.4501 x226

Jessica Schuler, Director of the Thain Family Forest, New York Botanical Garden (NYBG)	E-mail: jarcate@nybg.org Phone: 718.817.8061
EPA Region 2 Project Officer Joshua Kogan	E-mail: Kogan.Joshua@epa.gov Phone: 212.637.3733
EPA Quality Assurance Officer Kathryn Drisco	E-mail: drisco.kathryn@epa.gov Phone: 732.906.6800
NEIWPCC Program Manager Drew Youngs	E-mail: dyoungs@neiwpcc.org Phone: 978.349.2525
NEIWPCC Quality Assurance Manager Michael Jennings	E-mail: mjennings@neiwpcc.org Phone: 978.349.2520
Citizen Science Stewards	
Projects: Floatables, Water Quality – Fecal Pathogens and Nutrients Bronx Community Charter School (BxC)	Contact Name: Sasha Wilson E-mail: sasha@bronxcommunity.org Phone: 718-944-1400
Projects: Floatables, Water Quality – Fecal Pathogens and Nutrients Rocking the Boat (RTB)	Contact Name: Sam Marquand E-mail: sam@rockingtheboat.org Phone: 718.466.5799
Projects: Floatables Youth Ministries for Peace and Justice (YMPJ)	Contact Name: David Shuffler E-mail: dshuffler@ympj.org Phone: 718.328.5622

The Bronx River Alliance will maintain the official QAPP and distribute to the above named individuals once approved. The approved document also will be posted on the Bronx River Alliance website where it may be downloaded and referenced by the general public.

PROGRAM ORGANIZATION*



* See restrictions defined under the roles of the Quality Assurance Manager in cases of limited staff.

PROGRAM OVERSIGHT:

PROGRAM MANAGER will be the responsible official for overseeing the water quality monitoring program, comprising the various impairment-focused projects; budgeting; assigning field and lab personnel with project tasks; and reporting, including data collection, data analysis, interpretation, and communication. Michelle Luebke will coordinate program/project needs to the project, field, and lab personnel and convene periodic project-planning meetings.

EPA and NEIWPCC Officers will be the responsible official(s) for reviewing, advising, and approving this QAPP. If outside oversight is needed, they may provide project-specific recommendations.

QUALITY ASSURANCE (QA) MANAGER will be the responsible official for writing, submitting, and executing this QA Program Plan (QAPP). This will be achieved through spot checks of: field methods, field datasheets, manually-entered digital data, charts and graphs, and lab procedures. During field and lab audits, the QA Manager should primarily observe and intervene only to prevent contamination (of sample, person, equipment, etc.). These audits are necessary to document adherence to protocol and to ensure accuracy and consistency among field and lab personnel, with and without the presence of a supervisor. Michelle will provide technical input, data interpretation, and methodological review.

In the event that staff is limited, the Program Manager may also serve as the QA Manager as long as the individual (Michelle Luebke) agrees to personally adhere to the QAPP and does not act as both roles during periodic audit(s).

For all data-gathering events for all staff and volunteers, the following conditions need to be met to adhere to QA standards:

- the person who collects or field-analyzes water samples should not be the same person who records data; roles may be traded during the event as long as methods and notation are properly communicated and the validity of the data are not compromised
    - the collector checks the data sheet before leaving the site for agreement on any subjective assessments and for completeness
    - when field personnel are calling out numbers, the recorder should repeat numbers back to the collector(s) to ensure accuracy
- the person who collects water samples, when possible, should not be the same person who processes samples in the lab
    - during lab processing, the water collector ensures protocol adherence and oversees contamination prevention
    - either person may read test results, but all tests should be photographed and stored with electronic data for documentation

If these conditions cannot be met, the QA Manager must be provided with a clear and valid justification. If there is no concern for biased or inaccurate data, there will be no need to flag these values in the database.

For detailed descriptions of specific project methodology and QA/QC procedure, please refer to the *Bronx River Citizen Science Stewards Volunteer Monitoring Program Training Manual* (Appendix A).

PROJECT PERSONNEL:
Bronx River Project Specialists will be responsible for executing their particular project activities, coordinating personnel to complete the tasks for each project included in this plan when appropriate, and data entry/analysis. He/she will ensure that the project budget is adhered to. He/she will communicate with the Program Manager on work accomplished in this plan and any problems or deviations that need to be resolved.

PARTNER ORGANIZATIONS are Center for the Urban River at Beczak (CURB) at Sarah Lawrence College; Riverkeeper; New York Botanical Garden (NYBG); and New York City Parks Department of Parks and Recreation (NYC Parks), Natural Resources Group (NRG). These are organizations who will work collaboratively on particular projects to facilitate an exchange of ideas and sharing of resources.

CITIZEN SCIENCE STEWARDS are individuals or groups that participate in one or more data-gathering and educational events. They are located within the Bronx River watershed, in both Westchester and Bronx counties, and represent academic institutions, grantors, community-based organizations, and local/regional volunteer networks including, but not limited to, Bronx Community Charter School (BxC), Rocking the Boat, and Youth Ministries for Peace and Justice (YMPJ). All activities by all groups will be accompanied by a BxRA and/or NRG employee to ensure consistency in data collection, unless the Citizen Science Steward(s) have demonstrated proper field/lab procedures and has been approved by either the Project Manager or Quality Assurance Manager to collect samples independently.

Project/Task Organization

Name	Title	Affiliation	Responsibilities (specific to each project)
Michelle Luebke	Program Manager	BxRA	Oversees quality assurance manager, data collection, team organization and training, etc.
Michelle Luebke	Project Quality Assurance Manager	BxRA	Quality assurance, oversight and assessments, data verification, evaluation and usability, ensuring corrective actions are completed, etc.

Kathalene Lamboy	Project Leader for Floatables, Fecal Pathogens and Nutrients, and Low Dissolved Oxygen/HABs and Education Manager	BxRA	Oversees all educational material, including classroom-led data collection, development of related curricula, and outreach to academic institutions, etc.
Joseph Sanchez	Outreach and Messaging Leader	BxRA	Oversees outreach material and works with educators to create appropriate messaging and advocacy, etc.
Danielle Bissett	Project Partner – Field Personnel for Floatables	NRG	Responsible for data collection for Project WASTE, water quality monitoring, wildlife tracking, and other major river-related activites.
Ecology Assistant, Intern, or other BxRA Staff	Data Collection, Management, and Analysis Coordinator Lab Personnel	BxRA	Responsible for data collection, management, analysis, and communication of key trends.
Sam Marquand	Project Partner – Field & Lab Personnel for Floatables and Fecal Pathogens and Outreach	RTB	RTB students and staff participate in data collection for Project WASTE, *Enterococci* monitoring, water quality monitoring, wildlife tracking, etc. as well as community outreach.
David Shuffler	Project Partner – Field Personnel and Outreach for Floatables	YMPJ	YMPJ students and staff participate in data collection for Project WASTE, water quality monitoring, wildlife tracking, etc. as well as community outreach.
Ryan Palmer	Project Partner – Lab Director for Fecal Pathogens and Nutrients	CURB	Lab director who manages lab personnel, if different than those listed above, for fecal pathogens
Jessica Schuler	Project Partner – Field Personnel and Outreach for Floatables	NYBG	Forest director who manages field personnel for NYBG hotspot assessment in Project WASTE

Problem Definition and Project Objectives

PROBLEM DEFINITION

Once a river clean enough to be considered for NYC's water supply, by the turn of the 20th century, the Bronx River had degraded into an "open sewer." It is currently listed as impaired on the New York State Department of Environmental Conservation (NYSDEC) 303(d) list for floatables, fecal pathogens, and low Dissolved Oxygen (DO) levels, affecting the health of the ecosystem, wildlife, and humans as well as contributing these pollutants to the New York Harbor and Long Island Sound. In order to improve, protect, and restore the Bronx River, a robust water quality-monitoring program is necessary to determine the types, locations, and severity of inputs. By addressing these water pollutants at their sources, we will begin to reverse the degradation of this urban river and promote ecosystem recovery and restoration.

FLOATABLES: In 2015 NY/NJ Baykeeper conducted a study of plastics and found that at any given time, 165 million plastic pieces are floating in New York Harbor; the pieces that were large enough to identify were from single-use, disposable food and beverage containers. Plastic trash discarded in densely urban areas, like the Bronx and Westchester counties, enters the Bronx River where through sun and wave action, breaks down into microscopic particles. If the amount of trash in the river could be reduced, we will reduce the prevalence of small- and microplastics in our local and global waterbodies, which disrupt aquatic life and enter the food chain.

FECAL PATHOGENS: Another major source of water contamination is fecal pollution from illicit discharges, illegal connections, failing infrastructure, and/or wet-weather overflows. Although the only permitted Combined Sewage Outfalls (CSOs) to the river are in the brackish water near the mouth, evidence indicates fecal pathogens above EPA-designated threshold levels throughout the entire extent. Recreational activities on the river put people into direct contact with the water, and they lack information on its health and safety.

LOW DISSOLVED OXYGEN/HARMFUL ALGAL BLOOMS (HABS): Urban impervious surfaces, such as roofs, roads, and sidewalks, shed stormwater runoff. Impervious surfaces also introduce pollutants like oils and grease; metals; salts; and nutrients, like nitrogen and phosphorus, into the stormwater runoff. Excess nutrients encourage the growth of photosynthetic organisms, resulting in the degradation of water quality and numerous incidents of HABs. As these organisms die – especially the large blooms in the hot summer months when DO levels are already limited by higher water temperatures – decomposition results in further biochemical oxygen demand (BOD). Much of the Bronx River is in MS4 areas, meaning this polluted stormwater runoff goes directly into the river untreated, resulting in HABs in downstream reaches. These high BOD levels decrease the available DO, thereby impeding the river's ability to host fish and wildlife, and large toxic blooms impede recreational pursuits, like fishing and boating.

This Bronx River water quality-monitoring program is designed to address the following questions:

1. What are the types, materials, quantities, brands, and sources of floatable pollution?
2. By targeting educational outreach efforts and messaging at businesses, communities, and individuals to reduce street-borne trash, do volumes of floatables in the river decrease?
3. Where are the inputs with elevated levels of fecal indicator bacteria levels after a rain event? Where are the inputs with elevated levels during dry-weather conditions?
4. Have the concentrations of fecal pollution changed over time?
5. Where are the major nutrient loads? Can we determine the source(s)? By reducing the nutrients and other road contaminants, do the Dissolved Oxygen (and other water quality parameters') levels improve?
6. Are the blooms present in the river harmful to the health of the ecosystem, wildlife, and humans? Are there predictable patterns and/or are they attributable to anything in particular?

PROGRAM OBJECTIVES (LINKING DATA RESULTS WITH POSSIBLE ACTIONS)

FLOATABLES: Project WASTE (Waterway and Street Trash Elimination) is our newest Citizen Science Stewardship project focused on source reduction of trash pollution and development of a tailored outreach strategy that includes structural improvements, hands-on trash collection and assessment, community advocacy, and targeted messaging. We have installed a trash boom at the border between the Bronx and Westchester counties to collect the floatables in the river at that point. Another trash boom, maintained by the New York City Department of Environmental Protection (NYCDEP), collects floatables in the downstream estuary section of the river at Concrete Plant Park, approximately one mile from the mouth of the river where it enters New York Harbor. This project is intended to document the types, materials, quantities, brands, and sources of floatable pollution in the Bronx River.

- Objective 1: Conduct trash assessments using standardized protocols in each boom location and other in between "hotspots" where trash accumulates
- Objective 2: Use data to document what types of floatables are the most common and most persistent in our waterways and differences/similarities between booms
- Objective 3: Analyze data to determine the quantity and types of floatables originating upstream in Westchester or entering the river within the Bronx, informing our outreach strategy to those communities, municipal officials, and businesses

Fecal pathogens: Since 2014 we have sampled fecal pollution during the summer recreational season to educate and protect the public. In 2016 we added sample sites in Westchester County to have a holistic watershed-level understanding of where and to what degree fecal pollution is affecting the river. We plan to continue monitoring *Enterococci* levels and standard water quality parameters at established sites along the entire length of the Bronx River and its tributaries. This investigation will help us determine the point sources of fecal pathogens (i.e. outfalls) during dry- and wet-weather conditions and whether there are any changes in concentrations or locations of contamination over time. This information will assist in identifying possible source(s) that contribute to the identified outfall(s).

- Objective 1: Collect water samples for *Enterococci* (using Enterolert®) and water quality data (temperature, DO, pH, conductivity, salinity) using a YSI multiparameter meter at established sites along the river, documenting fluctuations in conditions
- Objective 2: Collect targeted outfall samples to determine the level of fecal indicator bacteria in the effluent by sampling upstream, downstream, and at the outfall, noting especially when an outfall is flowing during dry-weather conditions (which may indicate aging infrastructure or illicit connections)
- Objective 3: Analyze data to prioritize action at locations with the highest documented fecal pathogen levels and/or locations with elevated levels for a prolonged period of time

Low Dissolved Oxygen/Harmful Algal Blooms (HABs): We plan to monitor nutrients in water samples taken from both the channel and outfalls throughout the watershed. This investigation will help us determine the point sources of nutrients (i.e. outfalls), especially those that result in HABs and/or other oxygen-depleting conditions. This information will assist in identifying possible source(s) that contribute to the identified outfall(s). We hope to better understand diurnal fluctuations of dissolved oxygen, especially the lowest levels that are reached in the summer months. In collaboration with academic institution and research agency partners, we will monitor HABs to better understand causes and toxicity levels so that we may best communicate health advisories to surrounding communities and river-users. The primary research to be undertaken by the Alliance related to this topic will be documenting nutrient and chloride/ne concentrations to help locate point-sources of pollution, which will be folded into the water quality monitoring protocol.

- Objective 1: Collect water samples (Nitrogen, Phosphorus, Chloride/ne) for processing with a photometer and water quality data (temp, DO, pH, conductivity, salinity) using a YSI multiparameter meter at established sites along the river, documenting fluctuations in conditions
- Objective 2: Collect targeted outfall samples to determine the composition of the effluent by sampling upstream, downstream, and at the outfall, noting especially when an outfall is flowing during dry-weather conditions (which may indicate aging infrastructure or illicit connections)
- Objective 3: Record site conditions, including the water's color and clarity, to assist in identifying algal blooms. Analyze all data to look for trends and relationships
- Objective 4: Analyze data to prioritize action at locations with the highest documented nutrient levels and/or locations prone to HABs

DATA USERS

Floatables: Project WASTE will analyze the types of floatable trash found in the Bronx River at points upstream and downstream; attempt to identify its sources; and engage public officials, businesses, and students in creative ways to reduce it. Data from the trash assessments will be analyzed by Alliance Staff and participating schools to determine the make-up of floatables in the river and provenance (Bronx vs. Westchester County) and identify businesses (e.g., foam cups from Dunkin Donuts, plastic bags from local grocery stores) whose products most frequently end up trapped in the booms. It also will help us evaluate the effectiveness of the upstream boom at preventing trash from travelling downstream. The project will contribute to reducing the volume of plastic trash entering the Bronx River and New York Harbor/Long Island Sound by determining major local point sources of the trash that enters the river and by engaging Citizen Science Stewards and students in data-driven participatory outreach and public education to reduce inputs.

At the advocacy level, the Bronx River Alliance will supply these data to NYSDEC, NYCDEP, EPA, Westchester County officials, and others who can use the data to address input of floatables and to enforce better compliance with MS4 permit requirements. The Alliance also will use the data to inform our outreach messaging, communicating findings to the public via our website, newsletter, and social media regarding floatable litter in the river and actions that the public can take to reduce it. We also will use these data in our educational modules to engage students in understanding human impacts on the river.

Fecal pathogens: This investigation will help us determine the sources of fecal pathogens during dry- and wet-weather conditions and test for illicit discharges from outfall effluent, which will be communicated to the appropriate official(s) at the responsible organization(s). As a result of our monitoring and data-driven advocacy work, officials investigated an outfall with extremely elevated levels of fecal bacteria (irrespective of weather conditions) and corrected multiple illicit connections into the storm sewer. Our most recent monitoring showed fecal pathogen levels significantly reduced from that point source. As monitoring continues, we will continue to use data to identify pollution inputs so that our partners can work to eliminate the source(s).

As a condition of our collection permit from Westchester County, the fecal pathogen data collected from this project will be used by Westchester County Department of Health (DOH) officials as screening level data; if any site from our round of sampling has *Enterococci* levels above the EPA-designated threshold, the DOH will repeat the test in the same location(s).

All data[2] are shared with our local and regional agencies and Citizen Science-based water quality monitoring partners, including but not limited to, New York City Water Trail Association, Riverkeeper, Rocking the Boat (RTB), Center for the Urban River at Beczak (CURB), NYSDEC, NYCDEP, and EPA. This information reaches a wide audience through our fliers, web posts, newsletter, and social media platforms to inform the public of water quality trends on the river. The data are used for educational purposes not only to our K-12 students, but also our adult volunteers and Citizen Science Stewards.

Low Dissolved Oxygen/Harmful Algal Blooms (HABs): Users will include project partners and their affiliates. This investigation will help us determine the nutrient loading in different parts of the river and test for illicit discharges from outfall effluent, the findings of which will be communicated to the appropriate official(s) at the responsible organization(s). We post all Bronx County data on our website <www.bronxriverwater.org>, distribute information in our newsletter and at outreach and education events, and share widely on our social media outlets.

[2] Once approval has been granted for dissemination of the Westchester samples.

Background and History

BACKGROUND

Water quality monitoring on the Bronx River has been ongoing for the past 20 years, documenting changes in water and air temperature, pH, Dissolved Oxygen (DO), conductivity, and salinity. *Citizen Science on the Bronx River: An Analysis of Water Quality Data*,[3] is a report prepared for the Bronx River Alliance in 2014 by Fuss and O'Neill. This report reviewed and analyzed available water quality data collected by the Bronx River Alliance, volunteers and partner groups, from the 1990s through 2013. The report summarized over 1,000 water quality samples, identified trends and data gaps, and made recommendations for future monitoring of the river. These recommendations were considered in the design of the subsequent water quality monitoring program.

In 2014, we began monitoring for fecal indicator bacteria, specifically *Enterococci,* as part of EPA's Citizen Science water quality testing program.[4] This decision was made because the Bronx River has multiple inputs from Combined Sewage Overflows (CSOs) within the estuary portion of the river. These CSOs release untreated sewage, containing excess nutrients and pathogens, into the river after small rain events (as little as 1/10th of an inch of rain can trigger a CSO). The discharge from these overflows adversely impacts water quality in the river on a regular basis and are a primary cause of water quality impairment of the Bronx River. As climate change shifts weather patterns, increased rainfall and flooding may exacerbate this situation. While only the lower estuary portion of the river is affected by CSOs, the rest of the watershed is subject to either direct drainage or Municipal Separate Storm Sewer Systems (MS4), causing street litter and pollutants to enter the river through storm drains. In June 2016, we installed a trash boom[5] at the county border and began assessing and removing floatable trash in large quantities. Prior to this, no information was available on the type and quantity of trash pollution flowing into the river. Funding from the NEIWPCC/EPA Trash Free Waters grant received in May 2016 supports the efforts of Project WASTE in conducting trash assessments, education, and outreach with Citizen Science Stewards. The water quality and fecal pathogen testing is funded through *The Lower Hudson Urban Rivers Collaborative: Promoting Stewardship through Community Science and Engagement* grant awarded to the Sarah Lawrence College Center for the Urban River at Beczak.

HISTORY

Investments in the Bronx River have improved habitat and water quality, removed debris from the river, engaged Citizen Scientist Stewards in data collection, and raised awareness about the

[3] http://bronxriverwater.org/assets/upload/citizenscience_waterquality_ds_final.pdf (Appendix B)
[4] EPA-reviewed QAPPs in 2014 and 2015.
[5] The trash boom was purchased with mitigation funds from an oil spill. There was limited funding for maintenance and installation that was utilized to pilot the methodology and collect pre-boom-installation conditions.

importance of this valuable natural resource in a highly-urbanized setting. Recent investments have helped expand the greenway along the river and constructed both a fish ladder and an eel passage providing migratory river herring and American eels access to upstream freshwater spawning habitats. The Bronx River has engaged thousands of NYC residents in recreational and educational programming, and plays an essential role in the community. Water quality monitoring and hands-on civic engagement are important elements of this role to sustain the wildlife and human interaction with the river. Despite a long history of river protection and restoration, DO levels remain dangerously low, especially in hot summer months, and wildlife have suffered major die-offs. We hope that by creating a holistic watershed-level approach to addressing the major pollutants, namely floatables; fecal pathogens; and nutrients, causing low DO and HABs; and preventing them at the source(s), the Bronx River ecosystem will recover and continue to improve.

Project Locations

Floatables:
The upstream trash boom is located in Muskrat Cove Park, Bronx, NY, between the 233rd Street bridge and a crossing of the Metro-North railway. This location was chosen because of its proximity to the border between the Bronx and Westchester counties and vehicle access to transport people, equipment, and bags of trash following clean-out events. The downstream trash boom, maintained by the NYC DEP, collects floatables in the downstream estuary section of the river at Concrete Plant Park, which is approximately one mile upstream from the mouth of the river. Hotspots are defined as locations where trash accumulates (i.e. blockages, bends, and bridge piers) and have been established between the two booms at the following locations (in downstream order): upstream end of the Island in the Bronx Forest, the Stone Mill at the New York Botanical Garden (NYBG), the Twin Dams at the Bronx Zoo, the 182nd Street dam at River Park, and the scuppers at the 174th Street bridge in Starlight Park.

Water quality – fecal pathogens and nutrients:
The sample locations in both Westchester and Bronx Counties for water quality testing, including *Enterococci,* chloride/ne, and nutrients have been established at 26 study sites. Not all parameters have been tested consistently at all sites.[6] In Westchester County, study sites 1-8 were originally chosen by the Bronx River Watershed Coalition, a group of agencies, municipalities, and nonprofits formed in 2003 and dedicated to water quality issues on the river.[7] They are all located on County-owned property, primarily in parks. In 2016, two additional sites were added by Alliance staff to serve as upstream controls; one is located in the headwaters of Clove Brook (site #10) and the other is in Davis Brook (site #9) before the confluence that creates the upper

[6] Fuss and O'Neill. 2014.
[7] For more information: https://www.westchestergov.com/planning/environmental/BronxRiver/BronxRiverPlan.htm

Bronx River. In the Bronx, study sites constitute our sentinel sites where Citizen Science Stewards have been monitoring water quality for decades. This research is designed to document current conditions and to measure any observable changes over time to better understand how natural and man-made features affect water quality throughout the entire length of the Bronx River. All sites are spaced approximately 1-4 miles apart, helping isolate areas with the highest levels of fecal indicator bacteria concentrations, chloride/ne, and/or nutrient loadings to find the point(s) of origin.

Westchester study sites:

- Highclere Lane, Valhalla (WC 10): This site is located in the headwaters of Clove Brook, upstream of the confluence with Davis Brook, and serves as a control for all samples. There is minimal development upstream of this site, although the brook runs through residential land upstream of and at this site. Also upstream are constructed wetlands and some new development.
- Main Street, Valhalla (WC 9): This site is located in the headwaters called Davis Brook, before it goes underground and reemerges renamed the Bronx River, and serves as a secondary control for all downstream samples. There is quite a bit of residential and mixed use upstream of this point, and Styrofoam and other floatables have been observed upstream.
- South Kensico Avenue, Pat Henry Field, Valhalla (WC 8): This site is located in the parking lot of Pat Henry Field and appears to have minimal impact due to a fence blocking access. Reports indicate that water from the Kensico Reservoir may have joined with Davis Brook upstream of this site, but it is unclear where this connection occurs.
- Westchester County Center, White Plains (WC 7): This site is accessed on the left bank by the County Center parking lot and is heavily-used by humans, as evidenced by a clear desire path and a garbage accumulation that was not transported downstream. Fine sediment accumulation is apparent, as is in-stream garbage accumulation. For finer-scale studies of source-detection of fecal and trash pollution inputs, study sites should be added between here and WC 8.
- Greenacres Avenue, Hartsdale (WC 6): This site is located upstream of the County Tennis center and parking lot, near Brook Lane. Care should be taken to sample the mainstem of the river, rather than the side channel closest to Brook Lane.
- Intersection of Popham and Garth Road, Scarsdale (WC 5): This site is accessed from the pedestrian path along the river, upstream of the Popham Rd bridge crossing. Input of bags of dog feces may be an issue of concern.
- Bronx River Parkway at Leewood Drive, Eastchester (WC 4): This site is opposite Leewood Golf Club and a parallel drainage appears to have water quality issues attributable to runoff. It

is not clear whether this drainage empties into the river or not. The site is accessed from the pedestrian path at Leewood Dr before it goes under the Bronx River Parkway. Trash accumulation evidenced here, obviously from upstream inputs.

- Dewitt Avenue/ Paxton Avenue, Bronxville (WC 3): This site is located within green space at the confluence with the Grassy Sprain Brook. The sample should be taken downstream of the confluence in the center of the channel.
- Bronx River Parkway south of Cross County Parkway, Yonkers (WC 2): This site is located in the middle of a clover-leaf intersection of the Bronx River and Cross County Parkways. Care should be taken pulling off the parkway onto the median. Access to the channel is best at the off-ramp of the Bronx River Parkway south of the crossing of the Cross County. Sampling occurs in the mid-channel, downstream of the triple culverts of the off-ramp.
- Bronx River Parkway between McLean Avenue and Wakefield Avenue, Yonkers (WC 1 = SWS-02): This site is located at the border between the two counties and is the same as the Muskrat Cove channel site described below. It serves as the downstream-most site in Westchester County and should be used as the baseline to gauge pathogen levels as the river enters NYC.

Bronx study sites:

- Muskrat Cove North channel (SWS-02 = WC 1): This site is where the river enters the Bronx from Westchester County, located upstream of the outfall pipe (Muskrat Cove pipe, Bx 2), and serves as the baseline for all Bronx County samples to gauge pathogen levels as the river enters NYC.
- Muskrat Cove pipe (SWS-21): This site tests a stormwater outfall carrying a constant flow from McClean Avenue in Yonkers, which historically has extremely high levels of pathogens, suggesting that there may be problems with inputs to the pipe. This sample is taken from shore into the middle of the flowing pipe to prevent self-contamination of waders and minimize splash onto skin.
- East 219th Street (SWS-03): This site is located at the Shoelace Park canoe/boat launch one mile south of SWS-21 is downstream of another Yonkers outfall previously found not to carry any pathogens, downstream of a Metro North rail station, and is accessible to the public. (Some sites have been chosen to increase the opportunity for recruiting curious park visitors and for accessibility by our stewards). Samples are taken from a small dock that enters the channel along the left bank.

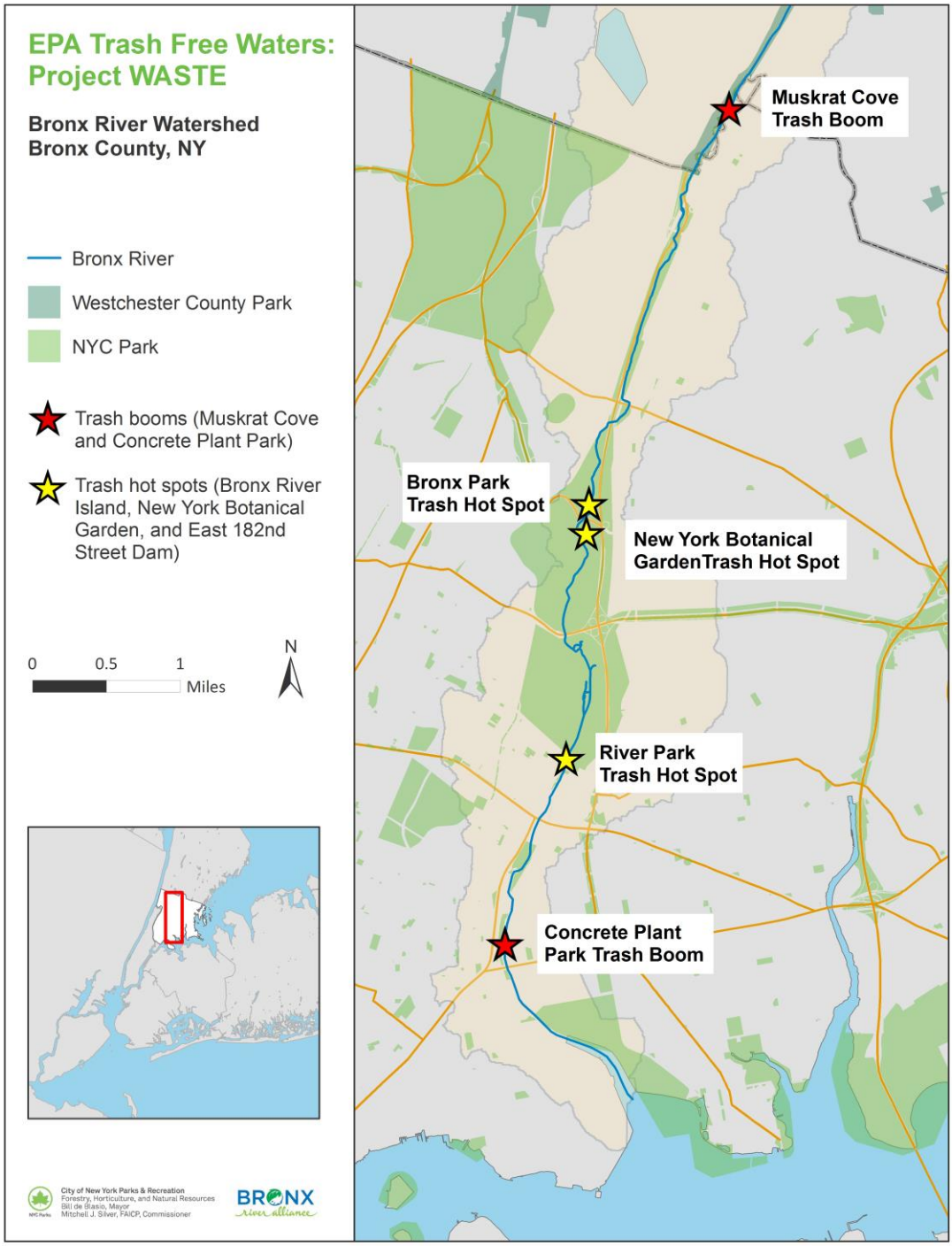
- Burke Ave (SWS-06): This site is located in the Bronx Forest near the bridge. Study site is accessed off the education trail on the right bank (looking downstream). Samples are taken at the center of the channel opposite a boulder outcropping.
- New York Botanical Garden (SWS-09): Located inside the NYBG grounds near the Stone Mill.
- Mitsubishi River Walk (SWS-10): Located next to the Bronx Zoo. May be accessed on foot, but permission may be needed to enter with a vehicle. This is outside of the admission area, so no fee is required to access this study site.
- 182nd Street dam (SWS-11): This site is located in the downstream-most freshwater impoundment, just upstream of the river's estuarine tidal influence. This site is the location of both the fish ladder and eel passage that provide access to the freshwater upstream habitat for migratory fish species. Samples here are to be taken after the river flows past the Bronx Zoo complex but before it reaches CSO outfall HP-007. The fish ladder will offer access for sampling directly from the river upstream of the dam.
- Starlight Park (SWS-14N): North of the tidal weir (low-head that becomes partially exposed at low tide), it is the first sample site downstream of two CSO outfalls, HP-007 and HP-004. Almost one mile south of Bx 3 and the river's first deep-water section, Starlight Park is also a major green space with public access. The dock enters the channel and samples will be taken from the north dock in mid-channel, upstream of the weir.
- Starlight Park South (SWS-14S): Access from the southern dock in the channel south of the weir.
- Concrete Plant Park dock (SWS-15): At the boat launch downstream of the park plaza. Care must be taken depending on tide, or a bucket may be thrown over the railing to access more of the center channel. These samples are from the right bank, near shore.
- Hunts Point Riverside Park (SWS-16): Located across from the bulwarked CSO outfall HP-008; past testing found that tidal influences may cause pathogens to collect at this site, which is popular with fisherman and unauthorized swimming. The dock enters the channel and samples will be taken from the right bank, accessed from the dock.
- Soundview Park Pipe (HP-009[8]): Samples are to be taken directly in front of CSO outfall HP-009, which discharged more than 800 million gallons of untreated stormwater/sewage in the past year; it is also near CSO outfall HP-010. The site will be reached by boat and sampled using the same hand sampling methods from the upstream side of the boat. This site will not be targeted for wet weather sampling due to risk of exposure to pathogens.

[8] This is the name of the outfall, not our study site name.

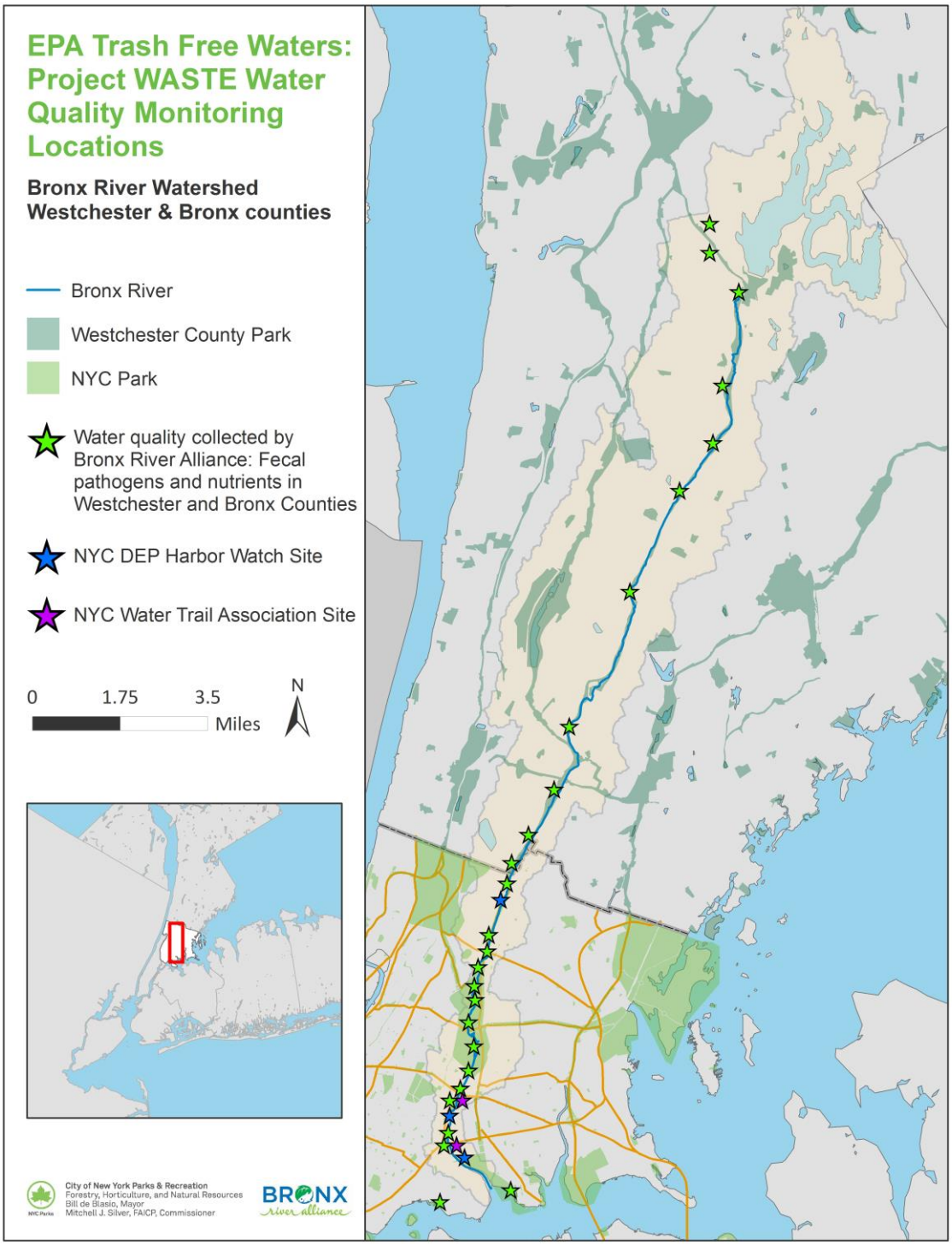
- Soundview Park Channel (SWS-01): Samples are taken at the river's mouth, which will provide water quality of the outflow of the Bronx River as it enters the East River and Long Island Sound, will be reached by boat.

PROJECT MAPS

FLOATABLES:



WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:



Project Schedule

Activities for Project WASTE	Responsible Entity	Time Period
Grant awarded to BxRA to support Project WASTE	NEIWPCC + EPA	5/21/16
Boom installation at Muskrat Cove Park (MCP)	BxRA	6/16/16
Develop curricula for street trash assessments	BxRA	Sep – Oct 16
1st quarterly report due to EPA and NEIWPCC	BxRA	10/10/16
Street trash assessments with schools and development of student-led outreach strategies	BxRA + Schools	Oct 2016 – Dec 2016
Youth-led outreach to local businesses, municipalities, and elected officials	BxRA + RTB + YMPJ	Dec 2016 – Feb 2017
Analyze trash assessment data to determine sources – geographic origin and/or specific brands	BxRA	Dec 2016 – Feb 2017
2nd quarterly report due to EPA and NEIWPCC	BxRA	01/10/17
QAPP submitted and approved	BxRA + NEIWPCC + EPA	February 2017
Promote strategic placement of trash and recycling bins and develops institutional collaboration for their maintenance	NRG	Jan – May 2017
Students in Bronx and Westchester schools generate peer-to-peer outreach methodology and carry out projects with support of BxRA staff	Schools + BxRA + YMPJ + RTB	Jan – Aug 2017
Trash assessments at MCP boom every 2 weeks (as needed)	BxRA + 10 CSS/event	March – Nov 2017
Visual assessment of CPP boom every 2 weeks (as needed), accuracy check with RTB, and coordinate boom cleanout with NYCDEP. Ensure final volumes and dates are obtained from NYCDEP.	NRG + RTB	March – Dec 2017
Partners clear and assess floatable trash "hotspot" every 2 weeks (as needed)	NYBG + NRG	March – Dec 2017
3rd quarterly report due to EPA and NEIWPCC	BxRA	04/10/17
4th quarterly report due to EPA and NEIWPCC	BxRA	07/10/16
5th quarterly report due to EPA and NEIWPCC	BxRA	10/10/17
Complete final analysis of assessment data to gauge project success	BxRA	Dec 2017

Submit final report to EPA and NEIWPCC		01/01/18
Activities for Water Quality – Fecal Pathogens and Nutrient Monitoring	**Responsible Entity**	**Time Period**
Program Development		
Assemble partners, refine project schedule, and review approved QAPPs	CURB (lead) + BxRA + RK	Jan – April 2017
Citizen Science Stewards recruitment with the assistance of CURB and Riverkeeper (RK)	CURB (lead) + BxRA + RK	Jan – April 2017
Community Science Water Quality Program		
Training and Introductory Event for all CSS to meet each other, learn the science and rationale behind the testing program, and understand proper field and lab protocols	CURB (lead) + BxRA + RK + CSS	04/08/17
Hire Support Staff (Intern)	BxRA	May 2017
Monthly water quality samples taken by CSS at Westchester study sites and delivered to the CURB lab for processing	CSS + CURB	May – Oct 2017
Weekly water quality samples taken at Bronx study sites and processed at the RTB lab	BxRA + RTB + CSS	June – Sep 2017
At least one member of the team will represent the EPA UWSG partnership at River Rally 2017.	CURB (lead) + BxRA + RK	Summer 2017
Review of Data and Procedures	BxRA	September 17
Community Program to Discuss Project Data	BxRA + RTB + YMPJ + Schools + other partner orgs	October 2017
Knowledge Sharing and Reporting Event for all CSS to talk about the experience and provide feedback	CURB (lead) + BxRA + RK	Nov 2017
Data Sharing and Interpretation		
Data will be distributed via the BxRA website and emailed to a local outreach list.	BxRA	April 2017 – March 2018
STORET Input	BxRA (lead) + CURB + RK	Winter 2017/18
Data Analysis and Interpretation to determine temporal and spatial variation and patterns	RK (lead) + BxRA + CURB	Winter 2017/18
Regional Summit to invite stakeholders to hear results of monitoring and to discuss next steps	CURB (lead) + BxRA + RK	03/01/18
Final report due to EPA	CURB (lead) +	

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Complete final analysis of assessment data to gauge project success	BxRA	Dec 2017
Submit final report to EPA and NEIWPCC		01/01/18
Activities for Water Quality – Fecal Pathogens and Nutrient Monitoring	**Responsible Entity**	**Time Period**
	BxRA + RK	04/01/18

Activities for Low DO/HABs study	Responsible Person/Entity	Time Period
Summer monitoring for HABs	USGS	July – Aug 2016
Discuss collaboration and develop monitoring protocol	USGS (lead) + BxRA	Dec 2016 – April 2017
Support field efforts of partner organizations	USGS (lead) + BxRA	May – Oct 2017
Education and outreach to public about findings	BxRA	Oct 2017 – March 2018
Create report of findings, identify mitigation solutions, and recommend future collaborations	USGS (lead) + BxRA	Spring 2018

Existing Data

Existing Data	Data Source	How Data Will Be Used	Acceptance Criteria
Concrete Plant Park boom data	NYC DEP and/or contractors	Document volume and frequency of boom clean-out events pre- and post-June 2016	Both pre- and post-data must be available; a partial set is not informative
Water Quality and *Enterococci* Data	Bronx River Alliance studies from 2014 – present, located on EPA STORET Database and on bronxriverwater.org	Used by BxRA to compare to new water quality data and to communicate health risks to community if threshold values are exceeded Provided to NYC DEP for Long Term Control Plan analysis	All data to date have been collected using the same methodology as proposed and in accordance with 2014 and 2015 QAPPs
Water Quality and Fecal Pathogen Data	NYC DEP for Long Term Control Plan analysis	Used by BxRA to compare to new water quality data and assess changes over time	If *Enterococci* lab methods comparable to fecal coliform data
Water Quality and Fecal Pathogen Data	Westchester County Bronx River Watershed Coalition	Used by BxRA to compare to new water quality data and assess changes over time	Have not yet been able to obtain data for review
Water Quality and Fecal Pathogen Data	Westchester County Citizen Volunteer Monitoring Program data	Used by BxRA to compare to new water quality data and assess changes over time	Have not yet been able to obtain data for review
HAB data	United States Geological Survey (USGS)	Used by BxRA and USGS to document locations, extent, and toxicity of previous algal blooms	Must be in the Bronx River and be considered a HAB

Quality Objectives

PRECISION:

FLOATABLES:

Standardized trash assessment protocols are to be used at all hotspot and boom locations, with all staff trained to properly identify items in the same manner. There is an associated visual diagram with size descriptions on the datasheet (Appendix C) to minimize discrepancies among participants. A before and after photo of the site must be taken for all events and all locations if removal occurs. For the downstream boom at Concrete Plant Park, only one reference photo is required, since removal does not occur during assessment; for data consistency, this photo should be taken at the beginning of the event.

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Field – A YSI Pro Plus multiparameter probe will be used to measure water quality parameters and will be calibrated to known solution standards according to manufacturer's guidelines no more than 24 hours before sampling. Due to the time necessary for particular parameters to give an accurate reading (e.g. DO), measurements will not be recorded until the readings have stabilized for at least 5 seconds. Multiple readings should taken at 10% of the study sites during each sampling event. Each of the parameters will need to be within 1/10th of difference at a total of three different locations in the center of the channel: upstream left of body, upstream center, and upstream right of body, without shuffling and disturbing bottom sediment. Care must be taken to not change the depth of the probe too significantly between repetitions or any differences could be attributable to changes in the water column, and not evidence of low precision. Once a month during the recreational season (May-Oct), standards will be used to test the accuracy of the YSI multimeter.

Laboratory – Lab replicates (10% of the total samples, minimum of 1) will be randomly selected and processed as a separate sample to determine lab precision by dividing one grab sample into separate sample processing bottles. At least one field duplicate will be processed for each sampling date by collecting two separate grab samples at the same site, for 10% of the samples taken (minimum of 1). Replicate and duplicate sites will be selected randomly at the start of the season. If results vary by greater than 60%, we will examine handling and storage of the reagents and sampling equipment currently in use to ascertain whether contamination has occurred. Reagents and supplies will be replaced where necessary.

Existing data – Ensure that precision was upheld and strict QAPP guidelines were followed during the previous sampling years.

BIAS:

FLOATABLES:

Since the Concrete Plant Park boom will be assessed primarily visually from the bulkhead on the right bank with only occasional boat-based reference assessments, it is possible the amount of floatables in the layer under plastic bottles, largely composed of Styrofoam, straws, miscellaneous hard plastic pieces, will be under-reported. Care must be taken to examine as much of the full variety of floatables as possible, but this is already expected in those data.

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Field – All water quality samples are taken at the mid-channel of the river in order to have a well-mixed representative sample and to document conditions from the headwaters to the mouth.[9]

Laboratory – With each set of samples for a given survey date, 1 positive and 1 negative control will be processed as controls to determine if sample bias has occurred due to contamination. If the negative control indicates presence of contamination, the entire batch will be flagged, and we will examine handling and storage of the reagents and sampling equipment currently in use to ascertain whether contamination has occurred. Reagents and supplies will be replaced where necessary.

REPRESENTATIVENESS:

FLOATABLES:

The upstream trash boom was installed in its present location at 233rd Street, Bronx, NY, which is less than 0.5 miles downstream of the border between the Bronx and Westchester counties, to capture all floatable pollution originating upstream in Westchester. The downstream trash boom was in place prior to the study, but due to its location 1 mile upstream from the mouth of the river, it can be assumed to capture approximately all floatable pollution originating within the Bronx. Some data loss may occur during rain events that cause spillage over the top of the upstream boom, or if the boom becomes dislodged and releases trash prior to an assessment; these would be captured in the Bronx total, rather than the Westchester total, however we expect this to be minimal. All hotspots are located between these two structures and will add to the Bronx trash total and will aid in identifying

[9] Currently the only exceptions are sites SWS-21 and BxR-009, both outfall pipes and chosen specifically to test for sewage inputs; this should not be misinterpreted as constituting bias, but rather is an integral part of the study design. As more outfalls are identified for more intensive monitoring, these also will become part of the study design, not evidence of bias.

input source location(s).

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Field – All of our water quality, fecal pathogen, and nutrient study sites are spaced approximately 1-4 miles apart and are representative of all different habitats and flow conditions from the headwaters of Clove and Davis Brooks to the mouth at the East River/Long Island Sound. Water quality monitoring may occur year-round, but fecal pathogen sampling occurs during May – October, corresponding to the summer recreational season. Year-round pathogen sampling is cost-prohibitive.

Existing data – Data from decades-long water quality monitoring efforts were analyzed in *Citizen Science on the Bronx River: An Analysis of Water Quality Data* (Fuss and O'Neill 2014), recommending future analyses, and establishing the sentinel sites in the Bronx for water quality, fecal pathogens, and nutrients. The same *Enterococci* sample sites from 2014 – 2016 have consistently represented the entire length within the Bronx. The Westchester County study site locations were determined by the Bronx River Watershed Coalition in 2003 and are spaced every few miles. The Westchester County Citizens' Volunteer Monitoring Program (CVMP) monitored water quality from 2003 – 2010, but data, including study site locations, have not yet been obtained for review.

COMPARABILITY:

FLOATABLES:

We are using the same Rapid Trash Assessment SOP at both booms and hotspots to ensure comparability among locations and over time, although the downstream boom will use visual assessment tools only. There will be periodic QA checks using boats to groundtruth the Visual Assessment to improve accuracy and comparability.

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Field – We are using standard water quality measurement methods for a wadeable system, a calibrated YSI Pro Plus multimeter, and following SOPs for any site-specific data collection to ensure that our data will be comparable with data from other local and regional studies as well as comparable to our previous studies.

Laboratory – We are using standardized protocols, including EPA-approved lab safety methods, following Enterolert® protocols, and abiding by any additional restrictions the lab might require. These methods will ensure our data are comparable to other local and regional studies.

Existing data – Previous water quality studies were under the guidance of QAPPs from 2014

and 2015, which were used in the development of this document to maintain consistency through time. Although not EPA-funded, data from the 2016 sampling season also was conducted in accordance with these documents.

COMPLETENESS:

FLOATABLES:

For all trash assessment events at the upstream Muskrat Cove boom and all hotspots where removal is required during assessment, completeness is defined as 100% removal of floatable pollution from the boom. If 100% removal is not possible in a single event due to dangerous conditions or time constraints, the rest of the material must be removed and assessed within 48 hours with no rain event in between. If storm conditions prevent this from occurring, the data will be flagged as an incomplete removal and analyzed accordingly.

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Field – A minimum of 3 samples must be collected in at least 60% of the study sites each recreational season (May-Oct) for our water quality monitoring program. We will collect and analyze 100% of *Enterococci* samples determined to be representative for the study each season. If weather or other issues impede a sampling event, the event will be rescheduled, understanding that some sampling events will need to be collected during or immediately following a rain storm to accurately capture wet-weather conditions.

Lab – We will analyze 100% of all fecal pathogen and nutrient samples collected in the field.

SENSITIVITY:

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Field – The YSI Pro Plus has the following built-in accuracy and sensitivity for each parameter:

Conductivity = ±0.5% of reading or 0.001 mS/cm, whichever is greater
Dissolved Oxygen = ± 2% of reading or 0.2 mg/L, whichever is greater
pH = ±0.2 units
Salinity = ±1.0% of reading or ±0.1 ppt, whichever is greater
Temperature = ±0.2°C

Lab – The IDEXX Quanti-Tray 2000 Enterolert Most Probable Number (MPN) method allows detection of 1 colony forming unit per 100 mL in undiluted samples. As per standard methods, samples collected in saline or brackish water are diluted tenfold, making the lower limit 10 colony forming units per 100 mL. The MPN method can quantify up to 2,419.6 Enterococci per 100 mL without dilution (24,196 with a tenfold dilution). Enterolert®

methods claim "50% fewer false positives and 95% fewer false negatives than the standard membrane filtration (MF) method."[10]

Data Collection Methods

SAMPLING DESIGN

FLOATABLES

The purpose of Project WASTE is to address trash pollution in the Bronx River by documenting the quantities, types, materials, and brands of floatable trash found at key locations (Table 1). This study is designed to understand source inputs by separating the floatables that originate in Westchester County from those originating in the Bronx through the use of a floating trash boom installed at the border between the two counties.[11] All the wadeable sites – Muskrat Cove boom (Site 1, Table 1) and 5 hotspots (Sites 2-6, Table 1) – will include full removal of all litter and debris during boom/hotspot trash assessment events.

Data are tallied and recorded using a rapid trash assessment protocol (Appendix D) modified from the California State Water Resources Control Board's Rapid Trash Assessment protocol designed for the State's Surface Water Ambient Monitoring Program (SWAMP).[12] Modifications are slight, adjusting for perennial flow conditions causing accumulations at in-stream blockages, like booms and dams, rather than dry-weather conditions that might distribute trash along a dry streambed. Thus, rather than assess a 100' reach, we assess the entire contents of a boom or an established hotspot and record the dimensions of the accumulation. As in SWAMP's protocol, photos are taken before and after assessment events at each site to provide a visual archive and to compare to tally results to refine analytical comparison among visual trash assessments.

Sampling teams will be composed of BxRA Staff, Citizen Science Stewards, community groups, and interested individuals. In order to maintain consistency of data collection methods throughout the project, there will be at least two trained BxRA Staff responsible for conducting a brief overview and training at the beginning of each event to all participants. They will have sample items and photos depicting the various categories of trash types in the protocol to answer any questions before the assessments begin. When possible, returning volunteers will be paired with new volunteers to better instruct and answer any questions. All questions in the field should

[10] See https://www.idexx.com/water/products/enterolert.html
[11] All trash accumulation in the upstream boom likely originated in Westchester County; these items are regularly tallied and removed so that any trash accumulation in the downstream boom can be assumed to have originated in the Bronx. Trash collected at hotspots and in the downstream Concrete Plant Park boom originated in the Bronx.
[12] www.waterboards.ca.gov/sanfranciscobay/docs/**swamp**thrashreport.pdf

be referred to the most senior BxRA staff member present; any other questions should be referred directly to Michelle Luebke, the QA Manager.

Participants count the contents of the boom/hotspot, recording the items in the appropriate category on the Rapid Trash Assessment datasheet (Appendix C). At least one experienced BxRA Staff or volunteer should have a tally sheet and assist other tally-takers to correctly record the various trash items and categories collected by the other participants. As the trash is tallied, it is removed from the upper boom and put into bags. At the end of the assessment, all bags are brought up to the staging area and counted before being disposed at Ranaqua, the Bronx Borough headquarters for NYC Parks. Volume is calculated according to the total volume of each bag and how full it is, allowing us to not only correlate the volume with the tally of the contents, but also compare total volume removed to any change in volume recorded at the downstream boom, as measured by the NYC DEP.

These trash assessment clean-out events at the upstream boom (Site 1) should occur 1-2 times per month, except in the winter months when less frequent clean-outs may be sufficient. In cases where danger of freezing may occur that would damage the boom or be dangerous for participants, the boom will be removed (approximately January – February). Hotspots will be observed and when accumulation is sufficient, will be assessed with full removal, indicating the time period between events (i.e. frequency), total volume of trash removed at each event, and individual tally totals for trash pieces. These quantities will be added to the CPP boom, since they occur downstream of the Muskrat Cove boom.

The Concrete Plant Park (CPP) boom (site 7) is located within the estuary section of the river, which is not wadeable, preventing clean-out assessments. Visual assessments will be conducted here, led by NRG staff, including the photo documentation procedure and binoculars for determining the contents of the boom. Students from Rocking the Boat led by NYC Parks and NRG Staff will perform periodic boat-based assessments of a proportion of the boom contents, dividing the trapped material into 1 m^2 quadrats and ground-truthing the contents of randomly-selected sections. This boom site is maintained by NYCDEP and requires mechanical harvesting from a boat to remove debris. Frequency and volume of floatables in the Concrete Plant Park boom are recorded by the NYCDEP during these mechanical clean-out events, and data are shared with NYC Parks and the Alliance.

Analysis of the boom and hotspot data will occur during the winter when trash assessment events are infrequent or ice advisories dictate the boom to be removed. Data will be tallied and compiled into quantities of categorized trash items to determine the most common and/or persistent, into common brands found at given locations to identify possible source(s), and into easy-to-understand information to incorporate into outreach and education materials. Data from the NYCDEP about CPP boom clean-out frequencies and volumes will be used to analyze pre- and post-boom conditions, correlate visual and boat-based assessments to volumes harvested,

and enhance the accuracy of using binoculars from the bulkhead and using high-resolution photographs at the office. They also will be compared to rainfall data to see if patterns in debris accumulation are correlated to weather conditions. Using project data, NRG will determine where in riverfront parks additional trash and recycling bins would make the biggest trash reduction impact, and coordinate the placement and maintenance of the bins. Trash assessment data directly inform the outreach and education messaging, encouraging participation in continued trash assessments, thus generating more data in an iterative and dynamic opportunity to evaluate effectiveness of project activities.

Project staff will coordinate outreach to businesses selling identified brands to encourage the reduction of single-use, disposable trash, and to local officials who can support trash initiatives (e.g. availability of trash/recycle bins). Alliance staff has developed a curriculum called *What's Floating?* to help students understand the relationship of street debris to water pollution. Educators will guide students to create and carry out their own public awareness projects, developing communication and outreach strategies to reach residents, students, and workers in Bronx River watershed communities with messages about floatable debris. Information on the volume and frequency of clean-outs from the Bronx River Floatables Control facilities will enhance understanding of street trash. These floatables control measures[13] capture street litter and debris that enter the sewer system from CSOs during rain events in the Bronx.[14] Thus, they are good indicators of street trash quantities present in particular neighborhoods before and after the study period. Where possible, these neighborhoods will receive targeted outreach messaging related to reducing street trash to determine if there is an observable decrease in response to messaging. By supporting the students to use data-driven advocacy and develop their own outreach projects, we tap their expertise on how to best communicate with their peers and the community, and deepen their commitment to stewardship of their local environment.

TABLE 1 – PROJECT WASTE STUDY SITES

Study Site #	Study Site Name	GPS Coordinates	Channel location and type
1	Muskrat Cove boom	40.894656, -73.862333	Whole channel – upstream boom
2	Island, Bronx Forest	40.868458, -73.873487	Mid channel – hotspot
3	Stone Mill at NYBG	40.861139, -73.875385	Left bank – hotspot
4	Twin Dams at the Bronx Zoo	40.854307, -73.874615	Right bank – hotspot
5	182nd Street dam, River Park	40.843204, -73.876656	Right bank – hotspot

[13] Constructed in 2012 on outfalls HP-004, HP-007 and HP-009
[14] According to the NYCDEP, "Of [the five CSO outfalls which discharge to the Bronx River], Outfalls HP-004, HP-007 and HP-009 contribute to over 99% of the storm and CSO overflow events that are discharged to the river." http://www.nyc.gov/html/dep/html/dep_projects/cp_bronx_river_floatables.shtml

6	174th St Bridge, Starlight Park	40.835158, -73.881045	Bridge scuppers – hotspot
7	Concrete Plant Park boom	40.825484, -73.884603	Whole channel – downstream boom

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS

Water quality monitoring study sites (Table 2) have been established in locations from the headwaters of the Bronx River in Clove and Davis Brooks, to the mouth at Soundview Park, spaced approximately 1-4 miles apart and representative of the different habitats and flow conditions present within the watershed. At each of these locations, a YSI Pro Plus mulitparameter water quality meter will be used to collect data for water temperature, pH, Dissolved Oxygen, conductivity, specific conductance, and salinity. All but 1 of the samples are either wadeable or accessible from a dock, as is necessary in the estuary section; the downstream-most sample (BxR-009) is located at the outfall of the Hunts Point Wastewater Treatment Plant (HP-009) and is only reached by boat. Photos should be taken at all sites, both upstream and downstream.[15] All photos will be labeled using the date, site, and the direction of flow and saved in the appropriate folder on the Alliance's server.

TABLE 2 – ESTABLISHED WATER QUALITY MONITORING SITES

Study Site #	**Study Site Name**	**GPS Coords***	**Sample location taken**
WC 10 (control)	Highclere Lane, Valhalla, NY	41.0901, -73.7792	Mid-channel, wading – Clove Brook
WC 9 (control)	Main Street, Valhalla, NY	41.0738, -73.7732	Mid-channel, wading – Davis Brook
WC 8	South Kensico Avenue, Pat Henry Field, Valhalla	41.0669, -73.7737	Mid-channel, wading
WC 7	Westchester County Center, White Plains	41.0371, -73.7780	Mid-channel, wading
WC 6	Greenacres Avenue, Hartsdale	41.0133, -73.7928	Mid-channel, wading
WC 5	Intersection of Popham and Garth Road, Scarsdale	40.9882, -73.8106	Mid-channel, wading
WC 4	Bronx River Parkway at Leewood Drive, Eastchester	40.9691, -73.8173	Mid-channel, wading
WC 3	Dewitt Avenue/ Paxton Avenue at the confluence with the Grassy	40.9388, -73.8377	Mid-channel, wading

[15] It is preferable if a consistent order is maintained (i.e. upstream, then downstream, or vice versa) to ease photo labeling at the office.

	Sprain Brook, Bronxville		
WC 2	Bronx River Parkway south of Cross County Parkway, Yonkers	40.9231, -73.8441	Center channel, wading
WC 1 (SWS-02)	Bronx River Parkway between McLean Avenue and Wakefield Avenue, Yonkers	40.9010, -73.8602	Center channel, wading
SWS-02 (WC 1)	Muskrat Cove channel	40.9014, -73.8597	Mid-channel, wading
SWS-21	Muskrat Cove Pipe	40.9012, -73.8600	Mid-pipe on right bank, sampled from shore to prevent self-contamination
SWS-03	East 219th Street	40.8845, -73.8673	Sample from dock in channel
SWS-05	East Gun Hill Road	40.8763, -73.8702	Mid-channel, wading
SWS-06	Burke Avenue Bridge	40.8717, -73.8728	Mid-channel, wading
SWS-07	Kazimiroff Blvd Bridge	40.867, -73.8742	Mid-channel, wading
SWS-17	Bronx Zoo (Fordham Bridge “B”)	40.857, -73.8763	Mid-channel, wading
SWS-10	Mitsubishi River Walk: Bronx Zoo	40.8548, -73.8764	Mid-channel, wading
SWS-11	182nd Street, River Park	40.8435, -73.8765	Right bank, from top of fish passage
SWS-13	Tremont Avenue	40.839, -73.8789	Mid-channel, wading
SWS-14N	Starlight Park North Dock	40.8323, -73.8830	Mid-channel, sampled from end of north dock
SWS-14S	Starlight Park South Dock	40.8323, -73.8830	Mid-channel, sampled from end of south dock
SWS-15	Concrete Plant Park	40.8251, -73.885	Sampled from end of boat launch
SWS-16	Hunts Point Riverside Park	40.8180, -73.8813	Right bank, sampled from end of dock
SWS-01	Soundview Park South, mouth of River	40.8097, -73.8682	Mid stream sample, from boat

BxR-009	Soundview Park, HP-009 outfall	40.8144, -73.8708	Mid-stream sample of outfall, from boat

If routine monitoring detects elevated levels at a mid-channel sample, but not in the sample upstream, or an outfall is discovered to be flowing during dry-weather conditions, more investigation will occur to find the input source(s) using GIS- and field-based reconnaissance. If one or more outfalls are suspected to have effluent containing fecal bacteria, excess nutrients, chlorine/chloride, etc., these will be bracketed for testing: upstream, in the pipe, and immediately downstream in the mixing zone.

All samples for fecal pathogens will use the following hand-sampling method for water collection:

Location will be accessed either from the bank or via wading. Water samples will be collected into pre-labeled, sterilized 120 ml HDPE plastic bottles at 10 cm below the water's surface. Gloves will be worn, but care must still be taken not to touch the cap or the inside of the bottle to avoid contamination. These samples are taken upstream of the placement of the YSI probe to ensure that the waterbody sediment is not disturbed, possibly contaminating the sample. Each sterile bottle will have a taped cap that will break upon opening; if there is no tape or the bottle has been used, exchange for a new, sterile bottle. Immediately after closing the cap, the bottle should be placed in a pre-labeled plastic closeable bag and then placed on ice in a cooler. It will then be transported to the nearest lab facility; at the date of this writing, those are the Center for the Urban River at Beczak (CURB) housed at Sarah Lawrence College in Yonkers, NY, for the Westchester County samples, and Rocking the Boat (RTB) in the Bronx, NY, for all the Bronx samples.

Samples will be labeled with site name and date on each bottle and bag, and accompanying data sheets (Appendix E) will include site name, site number, date, time of collection, and other significant conditions. Data sheets for ambient water quality parameters will be filled out at each site by trained BxRA Staff and/or trained Citizen Science Stewards, including recording site name, site number, date, time, and names of field personnel. For QA purposes, at least 10% of study sites will have a field duplicate[16] as well as a different, randomly-selected lab replicate.[5] If there is a particular study site that has been chosen for a specific monitoring concern (e.g. SWS-21, Muskrat Cove pipe), it is recommended that the field duplicate be dedicated to that site to better document variability. If not such study site is present, the field duplicate should be randomly selected.

LOW DO/HABS:

[16] If fewer than 10 samples are taken, the minimum number of field duplicates and lab replicates is always rounded to 1.

All samples for nutrients will use the following hand-sampling method for water collection:

Location will be accessed either from the bank or via wading. Gloves will be worn, but care must still be taken not to touch the cap or the inside of the bottle to avoid contamination. These samples are taken upstream of the placement of the YSI probe (and upstream of the body) to ensure that sediment is not disturbed, possibly contaminating the sample.

Sample bottles (that are not pre-sterilized and do not contain preservatives/fixing agents) will be rinsed three times with sample water (discarding downstream of sample collection area) prior to collecting each sample. For sterile bottles, whirl-paks, or ampules that contain preservatives/fixing agents (e.g., acids, etc.) never rinse with sample water prior to collecting the sample. Also, never use a sample bottle containing preservatives/fixing agents or a sample bottle that has been used to fill an ampule for sample collection; in these cases always use a separate sampling device or bottle to collect the water sample and then transfer before testing. There should be no direct contact of any testing chemicals into the river directly. All chemicals and broken ampules will be disposed of in accordance with NYC Parks guidelines upon return to the office.

Samples will be processed immediately using a hand-held photometer and recorded on data sheets (Appendix E) including site name, site number, date, time of collection, and other significant conditions. Water quality parameters will be recorded on datasheets for each site by trained BxRA Staff and/or trained Citizen Science Stewards, including recording site name, site number, date, time, and names of field personnel. For QA purposes, at least 10% of study sites will have a field duplicate[17] as well as a different, randomly-selected lab replicate.[5] If there is a particular study site that has been chosen for a specific monitoring concern (e.g. NYBG pipe), it is recommended that the field duplicate be dedicated to that site to better document variability. If not such study site is present, the field duplicate should be randomly selected.

Using these data to document nutrient loading, we are hoping to find and address input sources of nutrients. From this point forward in the QAPP, nutrient testing will be included as part of the water quality monitoring design, since it is the only aspect of the low DO/HABs research being led by the Alliance. Any studies documenting diurnal fluctuations of dissolved oxygen or monitoring of HABs will be done in collaboration with and under the guidance of academic institution and research agency partners, whose QAQC protocols supersede this document.

[17] If fewer than 10 samples are taken, the minimum number of field duplicates and lab replicates is always rounded to 1.

WATER POLLUTION MONITORING STUDY DESIGN AND PROJECT OBJECTIVES

Matrix	# of Study Sites	# of Samples per Location	Parameter	Field QC Samples	Total Number of Samples/ Measurements	Sampling SOP Reference	Project Objective(s) for Sampling and Analysis or Monitoring
Water	7	1-2/mo March – December	Floatable pollution	Photos before & after	64 boom and hotspot clean-outs	SWAMP Rapid Trash Assessment Protocol	Documenting types, materials, quantities, brands, and sources of floatable pollution (Floatables 1-3)
Water	26	1-2/mo May – October	Water Temperature	1 duplicate reading for 10% of field readings	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, YSI manufacturer's guidelines; 2014 & 2015 QAPPs	Ambient water quality monitoring to inform analysis of fecal and/or nutrient pollution sources and concentrations (Fecal/HABs 1)
Water	26	1-2/mo May – October	pH	1 duplicate reading for 10% of field readings	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, YSI manufacturer's guidelines; 2014 & 2015 QAPPs	Ambient water quality monitoring to inform analysis of fecal and/or nutrient pollution sources and concentrations (Fecal/HABs 1)
Water	26	1-2/mo May – October	Dissolved Oxygen	1 duplicate reading for 10% of field readings	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, YSI manufacturer's guidelines; 2014 & 2015 QAPPs	Ambient water quality monitoring to inform analysis of fecal and/or nutrient pollution sources and concentrations (Fecal/HABs 1)
Water	26	1-2/mo May – October	Conductivity	1 duplicate reading for 10% of field readings	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, YSI manufacturer's guidelines; 2014 & 2015 QAPPs	Ambient water quality monitoring to inform analysis of fecal and/or nutrient pollution sources and concentrations (Fecal/HABs 1)
Water	26	1-2/mo May – October	Specific Conductance	1 duplicate reading for 10% of field readings	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, YSI manufacturer's guidelines; 2014 & 2015 QAPPs	Ambient water quality monitoring to inform analysis of fecal and/or nutrient pollution sources and concentrations (Fecal/HABs 1)
Water	26	1-2/mo May – October	Salinity	1 duplicate reading for 10% of field	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, YSI manufacturer's guidelines; 2014 & 2015 QAPPs	Ambient water quality monitoring to inform analysis of fecal and/or nutrient pollution sources and

				readings			concentrations (Fecal/HABs 1)
Water	26	1-2/mo May – October	*Enterococci* Level	10% of total samples for field duplicate	Minimum of 20 samples/season within the watershed	Hand sample collection of water and Enterolert® methods; 2014 & 2015 QAPPs	Document *Enterococci* levels at different study sites within the watershed (Fecal 1-3)
Water	26	1-2/mo May – October	Nitrogen	10% of total samples for field duplicate	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, HACH Colorimeter manufacturer's guidelines	Document nutrient levels at different study sites within the watershed (HABs 1-4)
Water	26	1-2/mo May – October	Phosphorus	10% of total samples for field duplicate	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, HACH Colorimeter manufacturer's guidelines	Document nutrient levels at different study sites within the watershed (HABs 1-4)
Water	26	1-2/mo May – October	Chlorine	10% of total samples for field duplicate	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, HACH Colorimeter manufacturer's guidelines	Document nutrient levels at different study sites within the watershed (HABs 1-4)
Water	26	1-2/mo May – October	Chloride	10% of total samples for field duplicate	Minimum of 20 samples/season within the watershed	Citizen Science Stewards Training Manual, HACH Colorimeter manufacturer's guidelines	Document nutrient levels at different study sites within the watershed (HABs 1-4)

Equipment List and Instrument Calibration

EQUIPMENT LIST

FLOATABLES:

Waders for all field personnel and Citizen Science Stewards
Waterproof datasheets (multiple tally sheets and 1 assessment matrix)
Clipboards and pens (at least 3)
Camera (or smartphone)
Gloves (latex and long, waterproof)
Grabbers
Contractor-grade garbage bags
Sieve or small aquarium net
Life Vest (optional)
Personal items, including water, hat, lunch, etc.

WATER QUALITY – FECAL PATHOGENS AND NUTRIENTS:

Waders for all field personnel
Cooler with ice
Waterproof datasheets
Clip board
Camera (or smartphone)
Labels
Sterile 120 ml HDPE plastic bottles (for each study site + 10% field duplicates)
Hardy Diagnostics 90 mL deionized water in sterilized bottles (for each study site + 10% field duplicates + 10% lab replicates)
Hardy Diagnostics 99 mL deionized water in sterilized bottle (for controls)
YSI Pro Plus multimeter (pre-calibrated)
HACH DR900 Colorimeter + standards for each test (N, P, Cl)
Pens
Personal items, including water, hat, lunch, etc.

INSTRUMENT CALIBRATION AND MAINTENANCE

Instrument/Equipment	Calibration Frequency	Maintenance Requirements
YSI Pro Plus multimeter	*Calibrate before each use per manufacturer's instructions. Check calibration at the end of each day after use.*	*As per manufacturer's instructions*
HACH DR900 Colorimeter	*Calibrated yearly as per manufacturer's instructions, but standards are to be used with each study sample processed.*	*As per manufacturer's instructions*

All calibrations for this project will be documented. Calibration records will be kept on

calibration data sheets specific to each piece of equipment. Calibration records will include date, time, name of individual doing calibration, and the calibration results themselves. Acceptance criteria for calibration checks will also be included on the data sheets.

Analytical Methods*

***This table only needs to be completed when sample analysis by a laboratory is applicable to the project.**

Matrix	Analytical Group/Parameter	Reporting Limit	Detection Limit	Analytical & Preparation Method/ SOP Reference	Sample Volume	Containers (number, size, type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)	Laboratory used for Analysis
Water	*Enterococci*	10 MPN/100mL	1 MPN/100mL	IDEXX Enterolert with Quanti-tray 2000	100mL	IDEX 120 mL vessel	Store in dark place on ice. Set in lab as soon as possible.	5 hours	RTB, CURB

Training and Specialized Experience

TRAINING

Personnel/Group to be Trained	Description of Training	Frequency of Training
Kathalene Lamboy Sam Marquand Michael Mendez Penny Brown Michelle Luebke Danielle Bissett	Proper use of YSI Pro Plus meter, GPS unit, water sampling equipment, proper hand-sampling technique, and trash assessment protocols. Instruction on lab analyses for those who will be responsible for processing fecal pathogen and nutrient samples.	Session at the beginning of the sampling season and review before each event if any uncertainty
Kathalene Lamboy Michelle Luebke Ecology Assistant, BxRA	Data Management and upload of data to Bronx River Alliance website	Session at the beginning of the sampling season

SPECIALIZED EXPERIENCE

Person	Specialized Experience	# of Years of Experience
Kathalene Lamboy	Marine ecology, species collection and ID, fecal bacteria analysis, water quality testing, laboratory methods, data entry	5
Michelle Luebke	Fluorometry, spectrophotometry, particle-size analysis, denitrification procedures, water chemistry, fecal bacteria analysis, biotic specimen collection, sediment and particle-size analysis, flow/discharge, trash assessments	17
Michael Mendez	Water quality monitoring, GI installation, plant ID, invasive species removal	12
Ecology Intern, Conservation Crew	Soil and water analysis, trash assessments, fish collection and ID	2
Danielle Bissett	Marine ecology, water and soil analysis, field and laboratory processing, GIS desktop and field-mapping, trash assessments, sonar for seafloor mapping	7

Assessments and Oversight

Assessment Type	Frequency of Assessment	What is Being Assessed	Who will Conduct the Assessment	How Issues or Deviations will be Addressed
Data Checks and Assessments	1/month	Field data entries into spreadsheet	Michelle Luebke	Verify with sampling team and

		and database		reference photos
On-Site Field Inspection – Field Personnel	1st field day and 2 weeks later for total of 2/season if both pass, more frequently if not	Field personnel against QAPP/water quality monitoring SOP	Michelle Luebke	Re-train if necessary, change BxRA Staff responsibilities if continues
On-Site Field Inspection – Citizen Science Stewards (CSS)	2 weeks into sampling season and mid-season	CSS against QAPP/SOP	Kathalene Lamboy	Re-train if necessary
Lab Protocol Inspection	1st lab day and 2 weeks later for total of 2/season if both pass, more frequently if not	Lab personnel against QAPP/Enterolert® SOP	Michelle Luebke	Re-train if necessary, change BxRA Staff responsibilities if continues

NEIWPCC may implement, at its discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan in accordance with the NEIWPCC Quality Management Plan.

Data Management

DATA MANAGEMENT

Copies of this QAPP will be distributed to all parties involved with the project, including signatories and field sampling and laboratory personnel. Any future changes or amendments to the QAPP will be held and distributed in the same fashion. Copies of previous versions of the QAPP will be clearly marked as "superseded by Revision #" so as not to create confusion.

Field Datasheets and Field Data:
All data from the field will be recorded on the correct field/calibration/laboratory datasheets (Appendices C (floatables) and E (water quality)). After each field-sampling event, the data will be checked for completeness, missing information, or questionable data. If there are any discrepancies in data entries, the QA Manager will check the field datasheets and discuss them with the field sampling and/or data entry team. The individual responsible for data entry will contact the field sampling team for the missing data and have the team clarify any discrepancies with the data. Data will be transcribed from datasheets to an Excel spreadsheet dedicated to each particular project. After data entry or data transfer procedures are completed for each sample event, data will be inspected for data transcription errors, and corrected as appropriate. After the final QA checks for errors are completed, the data will be added to the final database and

uploaded to our electronic database, bronxriverwater.org. Original datasheets will be stored in the Alliance office for 5 years after the completion of the project.

Laboratory Analytical Results:
Lab results will be electronically delivered to Michelle Luebke, entered into the appropriate Excel spreadsheet, and uploaded to our electronic database, bronxriverwater.org. Any *Enterococci* data that did not meet the quality control requirements of the laboratory will be flagged.

Data Review and Usability Determination

DATA CHECKS

Data Checks Field/Lab	Data Management
Monitoring performed per SOPs and/or QAPP	Data entry and transcription errors
Field QC samples performed correctly	Calculation/reduction errors
Measurements performed correctly	Proper data and document storage
Calibrations performed correctly	Missing data documented
Calibrations performed on schedule, meet acceptance criteria, and documented	Data uploaded on schedule
Data meets acceptance criteria	Other user-entered data QC checked on schedule
Holding times met	
Evaluate any deviations from QAPP or SOPs to determine the impact to the data and project objectives	

DATA USABILITY

Data Usability Determination
All data issues identified will be discussed with the QA Manager to determine data usability on a case-by-case basis. If 100% of all data reviewed is found to have been collected and entered correctly according to the QC criteria, data will be considered usable. Should this not be the case, the Project QA/QC Manager will conduct a further review of the data sheets resulting in the review of a total of 25% of the data sheets to find common occurrences that may be able to be isolated from the data as a whole. For example, if the pH is found to fluctuate in an irregular manner in 10% of the data, giving results that are not reasonable and/or cannot be corroborated, but other parameters and data appears reasonable, all pH data will be rejected, but the remaining data will be determined as usable and results not affected by noted QC issue. Should other procedures be found to be questionable in more than 10% of the sample data sheets, results will be rejected. All decisions to allow data that did not fully comply with QC criteria or QAPP requirements will be explained, and

any resultant limitations on data use fully discussed in the final project report.

Reporting

REPORTS

FLOATABLES:

Data from the baseline and project assessments will be analyzed by Alliance and NRG staff to determine the make-up of floatables in the river and provenance (Bronx vs. Westchester County), and identify key businesses (e.g., foam cups from Dunkin Donuts, plastic bags from local grocery stores) whose products most frequently end up trapped in the booms. Analyzing data collected using standardized trash assessments in each of these boom locations allows us to better understand what types of common floatables are the most persistent in our waterways, which are most likely to become broken down into smaller pieces and consumed by wildlife, and the quantities of floatables that pose the largest threat to human/wildlife health. This information will directly inform our education and outreach efforts associated with Project WASTE. Results from the trash assessments will be posted on the Alliance's web page (www.bronxriver.org), in our monthly e-newsletter, *The Current*, and on our social media platforms (Facebook, Twitter, and Instagram). For the public's purposes, any data that do not pass the aforementioned QA check will not be included in the presentation of data.

Summaries of these data will be sent to NEIWPCC in the form of quarterly reports, scheduled for the 10th of the month every 3 months (Oct 2016; Jan, Apr, July, Oct 2017; final report Jan 2018). The quarterly reports will provide a status update for the project, including a listing of all the activities completed in each task, preliminary results, and any difficulties encountered. When applicable, these reports will include a summary of the quality assurance data checks conducted and the results of those checks. The final project report (Jan 2018) will summarize the quality assurance data check results for the entire project along with the data usability determinations made by the Project Quality Assurance Officer. The rationale for the use of any data that does not fully comply with the quality criteria requirements of the approved QAPP will be fully explained in the final report.

Fecal Pathogens and Nutrients:

The Program Manager will submit quarterly reports to CURB for all *Enterococci* study sites beginning with the 2017 recreational sampling season, including information pertaining to:

- Sample collection records and results
- QC sample records
- Equipment calibration and use records
- Data reconciliation results and associated recommendations/limitations

- Quarterly reports of task fulfillment

Final report of results, Summary of Major Project Components, Data Use and Recommendations, and Project Conclusions.

Additionally, the Program Manager will submit reports summarizing water quality data to Westchester County officials, as per the terms of the sampling permit for all Westchester study sites (WC 1-10). Once approval for data dissemination has been granted, all data will be made available to interested parties for all study sites, including interpretation of results. These data will be posted on the Alliance's web page (www.bronxriver.org), distributed in our newsletter, and featured on our social media platforms (Facebook, Twitter, and Instagram). For the public's purposes, any data that do not pass the aforementioned QA check will not be included in the presentation of data.

The above project-related materials will be kept by the Bronx River Alliance for a minimum of three years from the date of the final Financial Status Report to EPA.

Appendices A - E

APPENDIX A: BRONX RIVER CITIZEN SCIENCE STEWARDS VOLUNTEER MONITORING PROGRAM TRAINING MANUAL

APPENDIX B: CITIZEN SCIENCE ON THE BRONX RIVER: AN ANALYSIS OF WATER QUALITY DATA, FUSS AND O'NEILL (2014)

APPENDIX C: PROJECT WASTE RAPID TRASH ASSESSMENT DATASHEETS

APPENDIX D: CALIFORNIA STATE WATER RESOURCES CONTROL BOARD, SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP), RAPID TRASH ASSESSMENT PROTOCOL

APPENDIX E (P.182-183): WATER QUALITY MONITORING DATA SHEETS (FOR FECAL PATHOGENS AND NUTRIENTS)