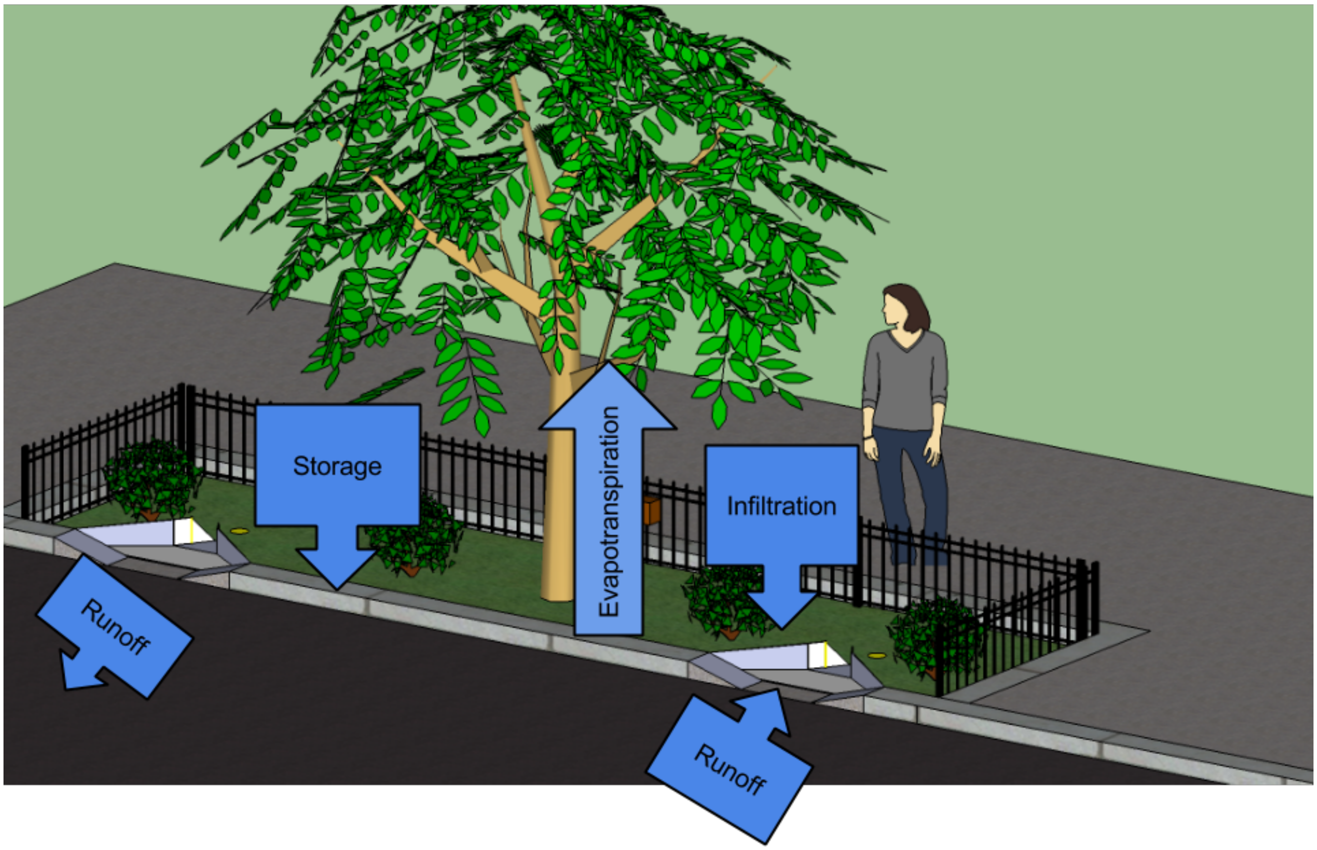

Green Innovation Grant Program: Monitoring Plan

Prepared for: New York City Parks and Recreation

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The Sustainable Water Resource Engineering Laboratory at Drexel University

EXECUTIVE SUMMARY

Objective

The purpose of this project is to quantify the ability of Right of Way Bioswales (ROWB) and Stormwater Capture Greenstreets (SCGS) to modify the hydrologic response of individual blocks.

Research Questions

1) How much water can the green spaces retain?
2) Under which conditions does it perform well?
3) What design features of the construction perform well and which do not?
4) What effect does the greening have on sewer flow?
5) What effect does the greening have of the micro-climate?

Monitoring Plan

There are three distinct elements of the monitoring plan based on the research questions above. Monitoring will take place in the sewer, inside the green infrastructure facility, and of the surrounding climate. Pre-green sewer flow conditions will be monitored to establish baseline sewer flow conditions. Monitored will continue after the green infrastructure is installed to compare sewer flow conditions. Hydrologic performance within the green infrastructure will be monitored using remote sensing equipment. There will be Internet-ready data loggers in the sewer and inside the green infrastructure facility that record measurements over long periods of time.

Installation Plan

Installation of the sewer flow sensors will come first to establish baseline conditions. Installation of the sewer sensors will require DEP support and because this requires confined space access, this can be a challenging task without full DEP commitment. Sensors will be installed in the green infrastructure facility one year after the sewer flow sensors are installed.

Maintenance Schedule

Equipment will need to be regularly maintained. Sewer flow sensors will need to be service with DEP support at least once a month. The flume must be cleaned regularly to keep it clear of excess sediment buildup and debris.

Equipment Cost

Remote monitoring equipment will be needed for this research project. An itemized list of the equipment, price estimates, and vendors is attached. Total expected equipment cost is around $220,000.

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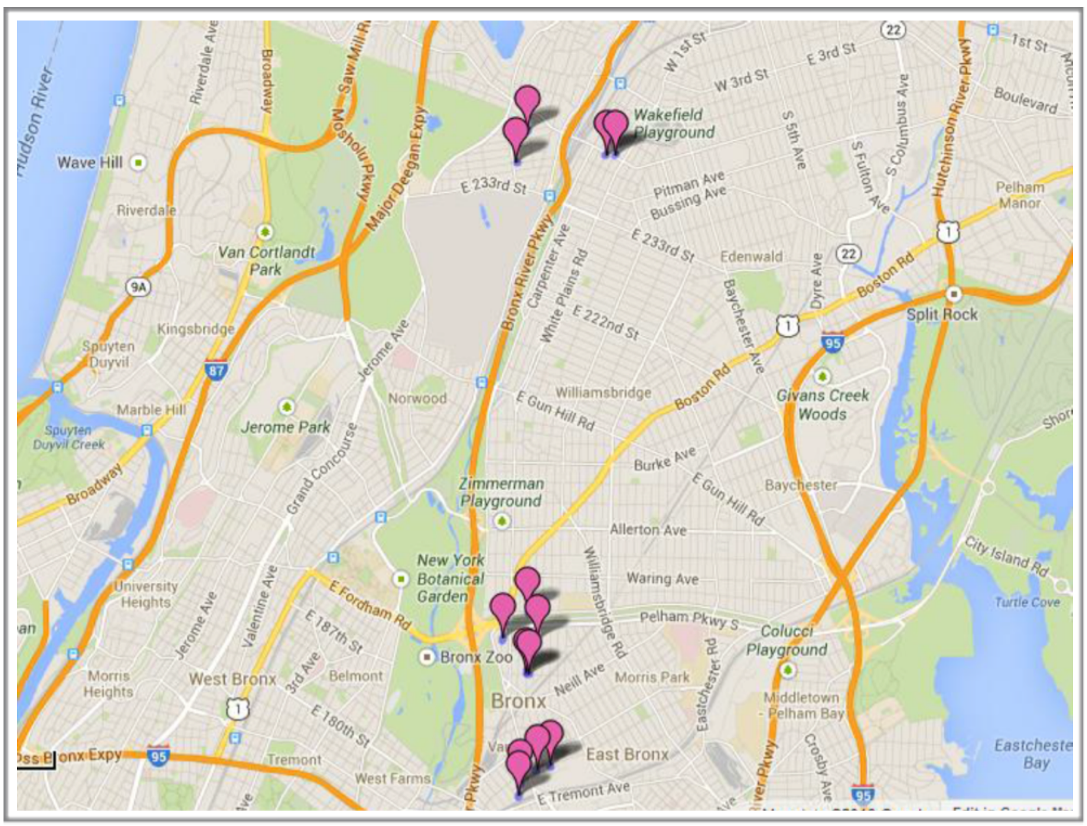
MONITORING PLAN

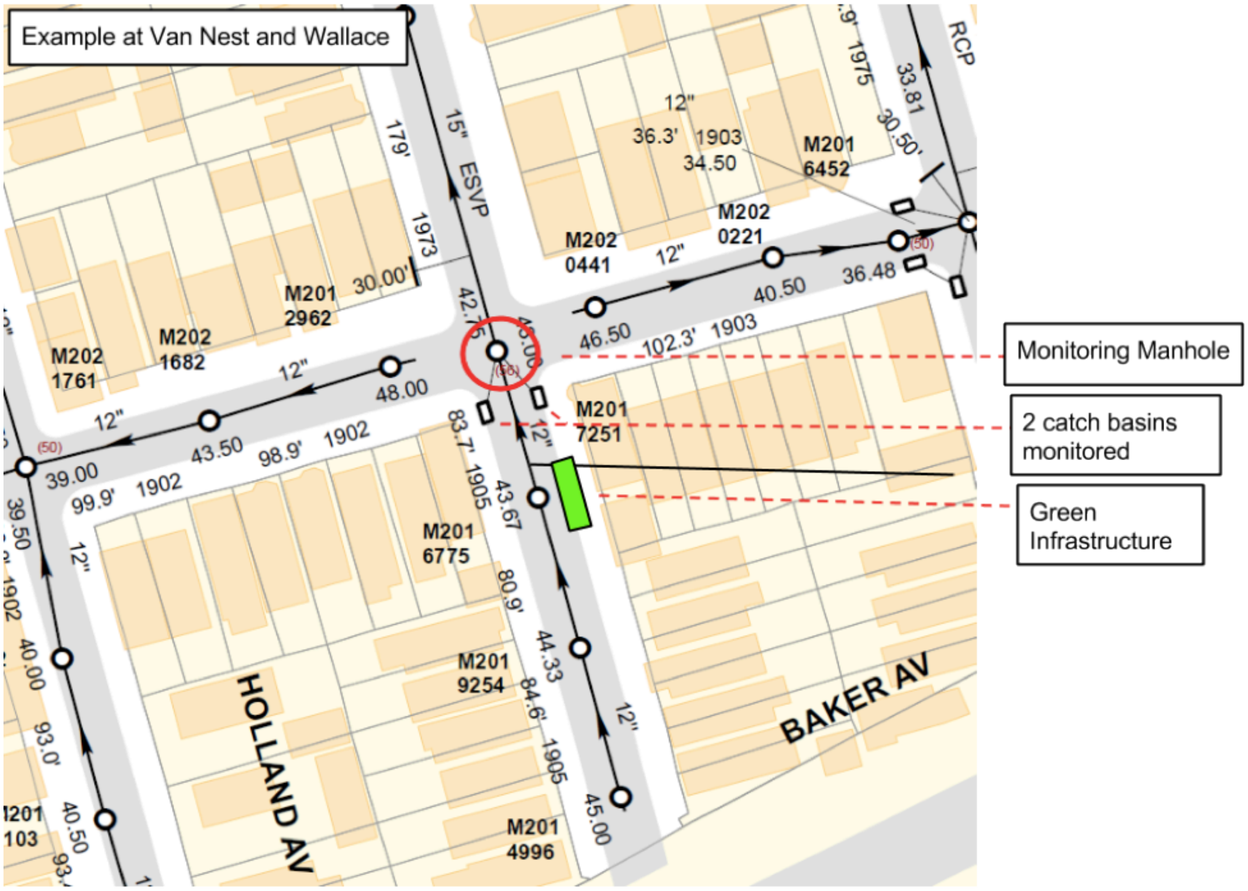
In order to quantify the effectiveness of GI at reducing stormwater runoff into the sewer, five pilot green infrastructure facilities (either ROWB or SCGS, conditions permitting) will be constructed in in the Bronx. The project goals are to:

1. Quantify stormwater capture performance of the GI
2. Quantify reductions to sewer flow
3. Understand the effect of the GI on the microclimate

Monitoring will be performed in the GI facilities, as well as in the collection system on both sides of the down-gradient end of the block. Since the GI facilities are slated for one side of the block only, the post GI monitoring will enable comparison of greened and ungreened scenarios during the same rainfall events. On the greened side of the block, the study will also enable comparison of pre- and post- GI hydrologic response.



Potential GIGP Sites: Based on pending boring results, these sites will be narrowed down to 5 total sites.

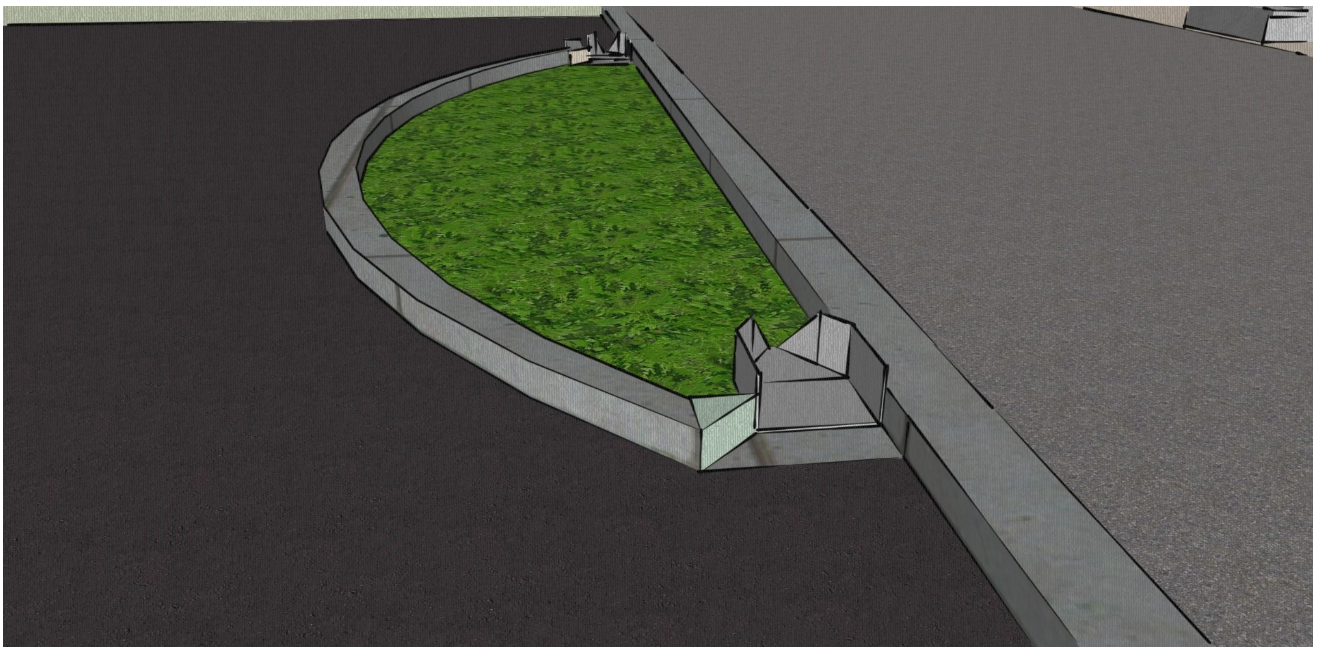


Example Monitoring Setup. In the example of Van Nest and Wallace shown here, stormwater discharge through the catch basins will be monitored at their outfall into the combined sewer. After one year of pre-green baseline conditions are obtained, the conditions will be monitored with the presence of green infrastructure on one side of the street alongside the hydrologic conditions inside the facility.

Quantify Stormwater Capture Performance of the Green Infrastructure

The flow into the green spaces (bioswales and/or stormwater capture greenstreets) will be monitored using h-flumes at the inlet. Each h-flume will be equipped with a pressure transducer (or potentially ultrasonic sensor) to record the depth of flow through the flume. This measurement allows for direct monitoring of the inflow the inlet. Additionally, the rainfall on the site will be monitored using two tipping bucket rain gauges (part of the onsite climate station). Shallow wells will be installed to determine ponding inside the green space. Vertical infiltration will be measured using nested piezometer clusters. Each piezometer will be installed at a different depth. Pressure transducers in each piezometer will indicate when downward moving wetting front has reached the piezometer head depth.

H-Flume: Example of the h-flume that will be used at the inlets. Flumes used at GIG will likely not have the green box as shown above.



Conceptual Green Infrastructure Design: Example of flume orientation and design for the bump-outs and right-of-way bioswales (in preparation).

Quantify Reductions in Sewer Flow

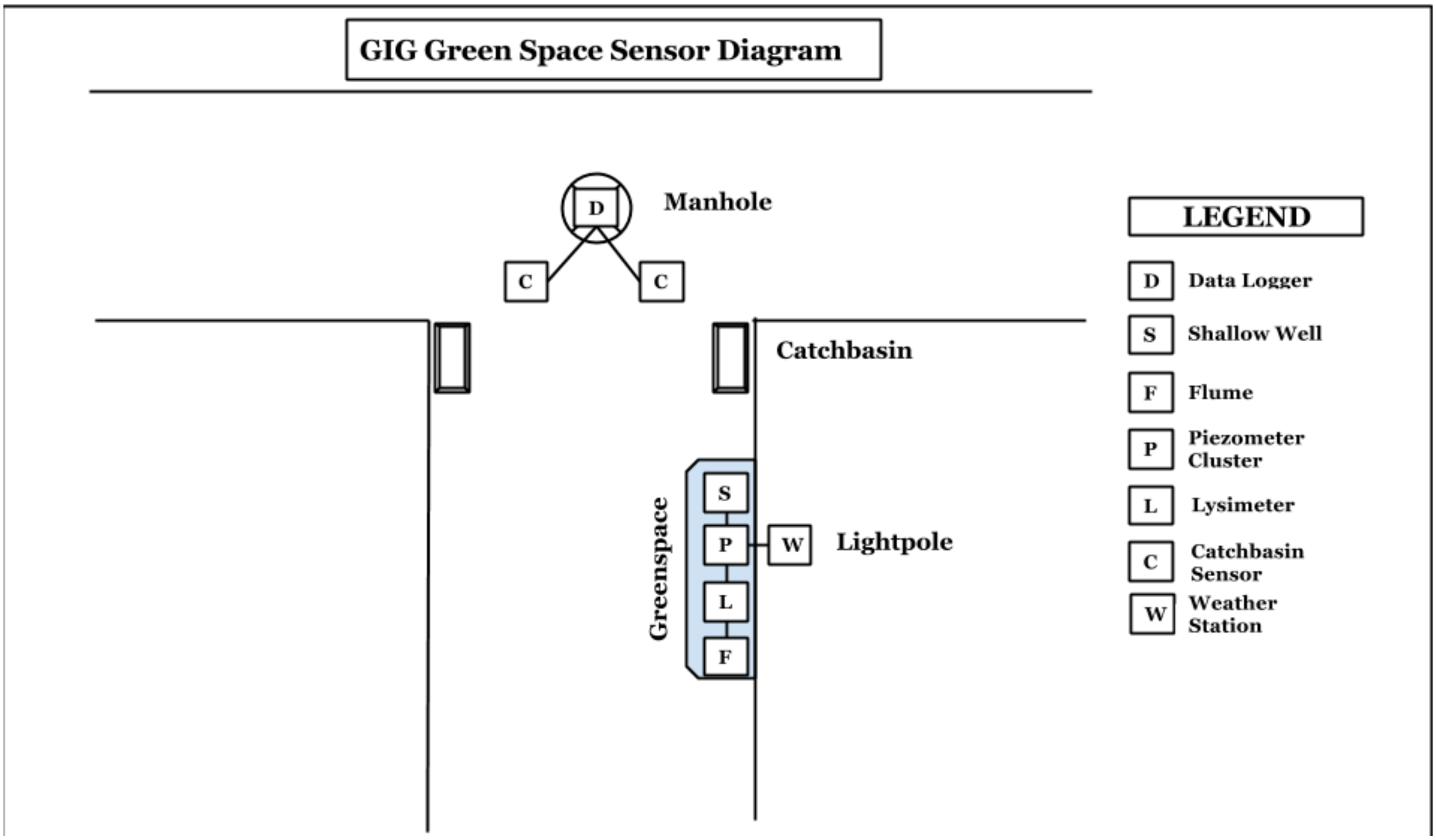
In order to understand the effect of the green space on sewer flow, first pre-greened conditions must be established. To establish baseline pre-green conditions, flow from the catchbasins at either end of each pilot block will be monitored continuously using remote data-logging equipment mounted in manholes. Spring rings will be installed in the catchbasin outfall pipes at the first downgradient manhole. A logger will be mounted to the manhole ladder (shown in figure below). We propose using the HACH FL900 system, which the Drexel team is also using at the DEP-funded Stratford Avenue Pilot project. Catchbasin flow will continue to be monitored after greening has occurred. This comparison will show the greening effect on sewer flow relative to pre-green conditions alongside a comparison to the adjacent non-green catchbasin.

Sewer Flow Sensor. Flow sensors such as this HACH FL900 are mounted inside the catchbasin pipes using spring rings that put outward pressure on the pipe. The sensor is connected to a data logger mounted to the manhole ladder by steel wire. An antenna is mounted to the roof of the manhole rated to withstand traffic (not shown). Link: http://www.hachflow.com/portable/Flo-tote3-FL900.cfm

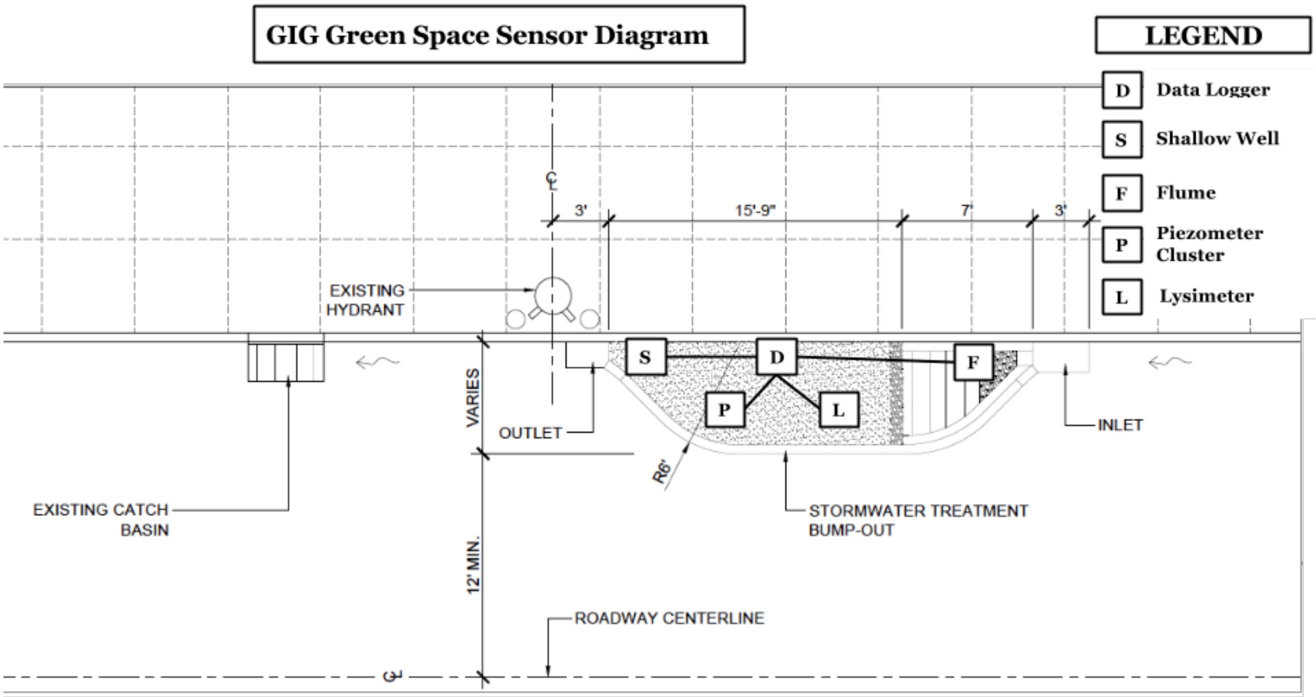
Understand the Effect of Greening on the Microclimate

In order to measure the effect of the green space on the microclimate of the immediate area, a climate station will be installed on a light pole adjacent to the future location of the green space. Basic climatic data such as temperature, relative humidity, rain, solar radiation, and barometric pressure will be measured continuously to establish pre-green baseline conditions. After the green space is implemented, these reading will again be sampled for comparison to the baseline. As a continuation of previous evapotranspiration research which compares measured results to Penman Monteith estimates, a lysimeter will be installed to the center of the green space to directly measure evapotranspiration rates.

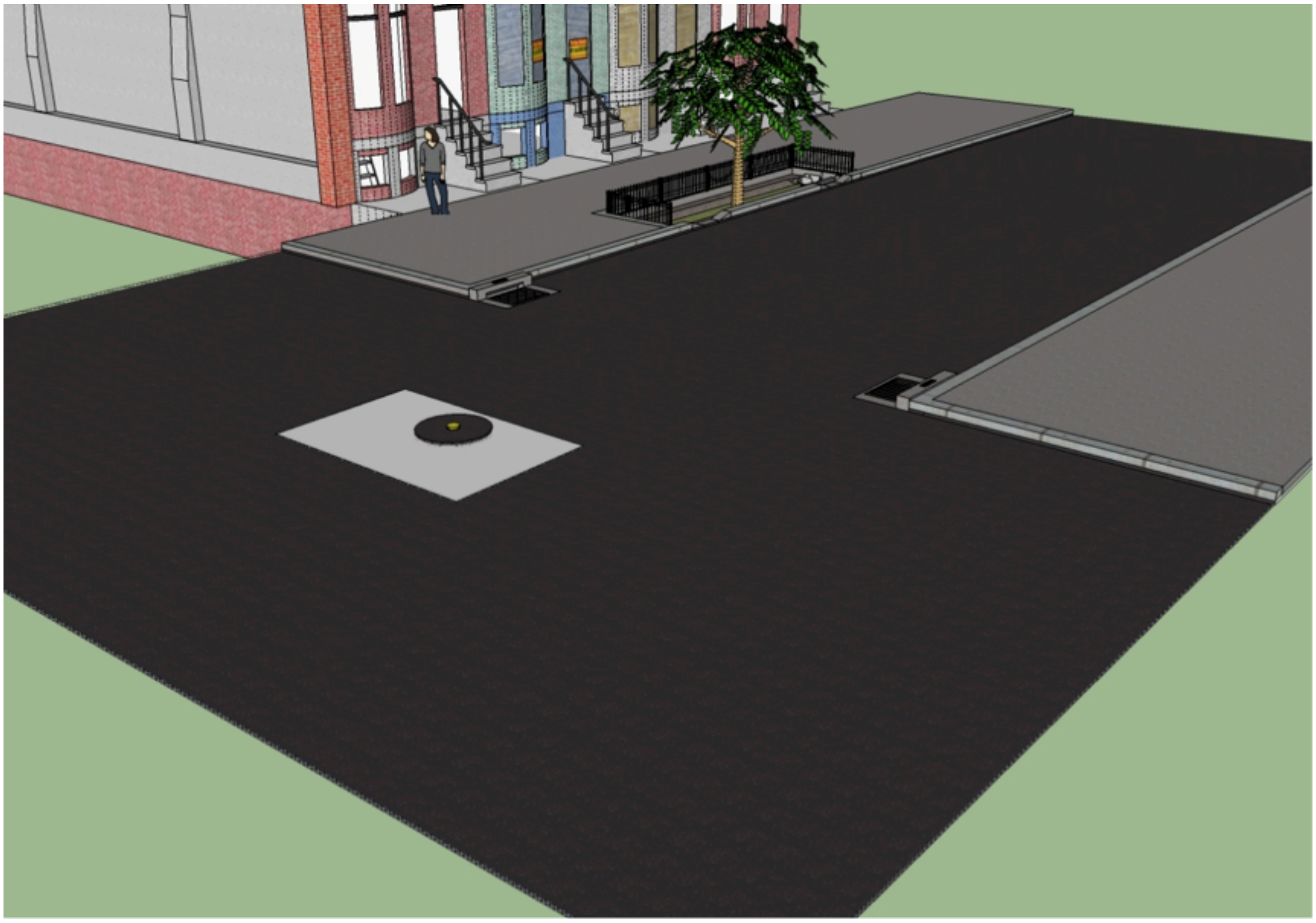
Climate Station: Example of Climate Station Mounted on a street pole adjacent to the Jacob Javits Center in Manhattan.



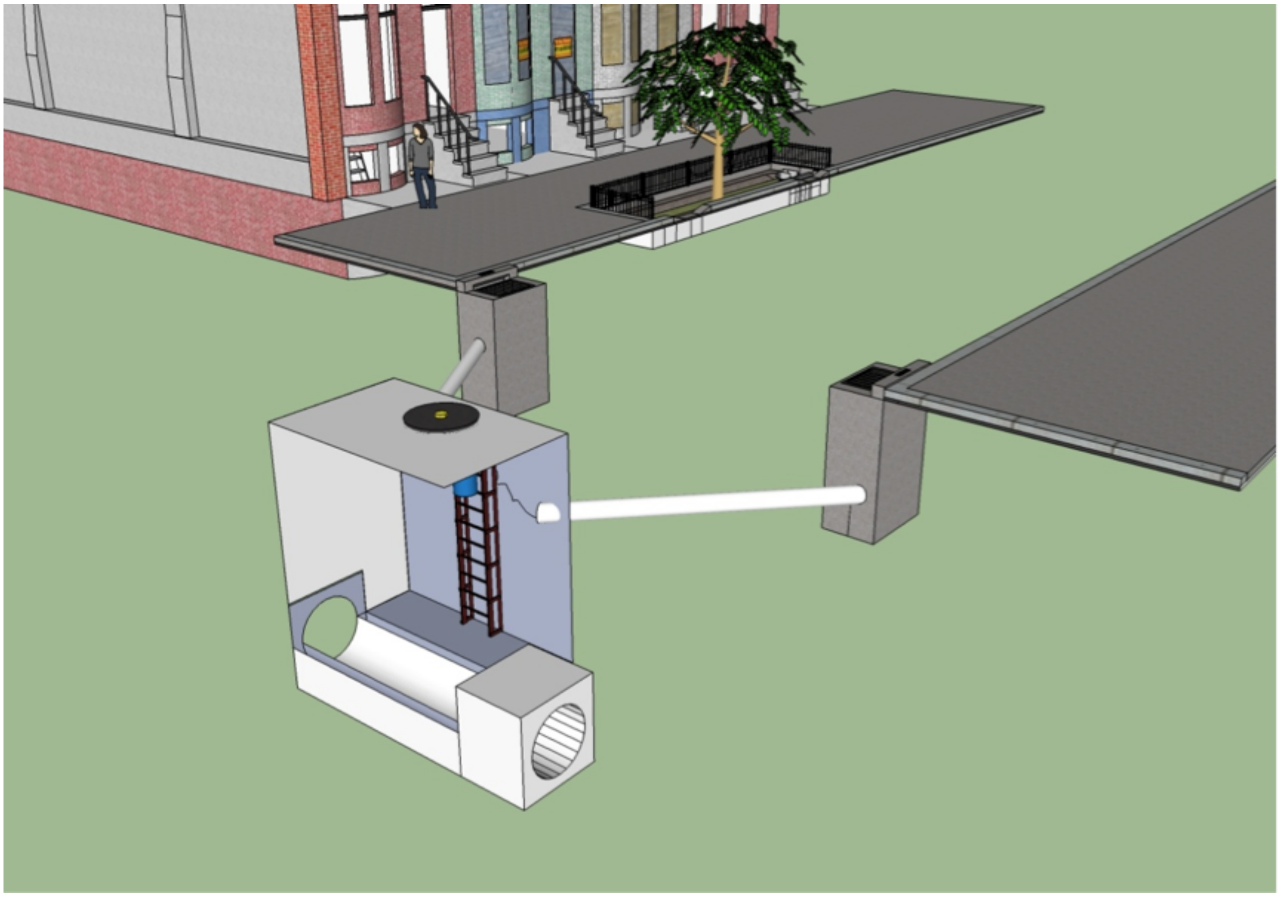
GIG sensor diagram. The greenspace sensors are connected to the weather station data logger which is mounted to a lightpole. The sewer data logger connects to sensors in both catchbasins.



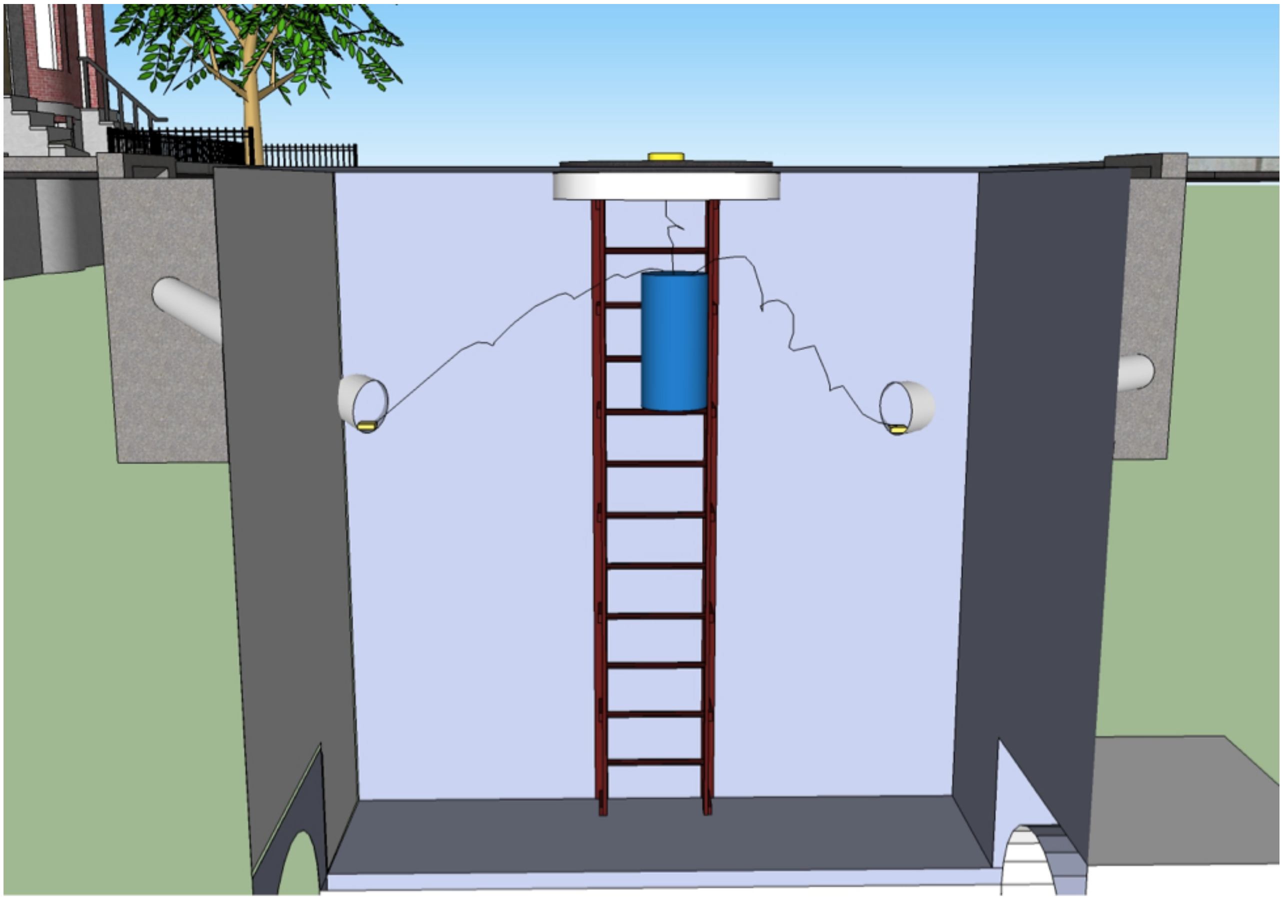
Conceptual GIG sensor diagram. Inflow is monitored using a flume, evapotranspiration using a lysimeter, infiltration using piezometers, ponding using a shallow well, and recorded and transmitted using a data logger.



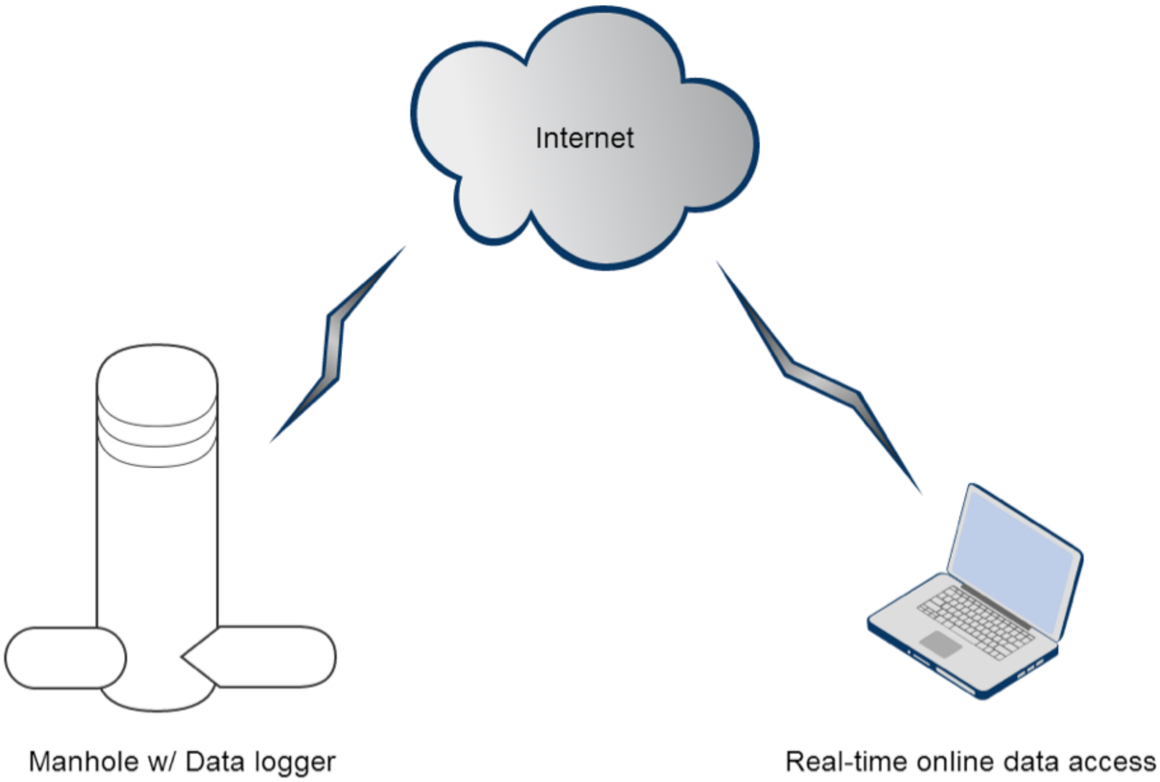
Conceptual Site Layout: Sites will be chosen with two catchbasins collecting runoff from an individual street. A ROWB or Bump-out green street will be built on one side of the street.



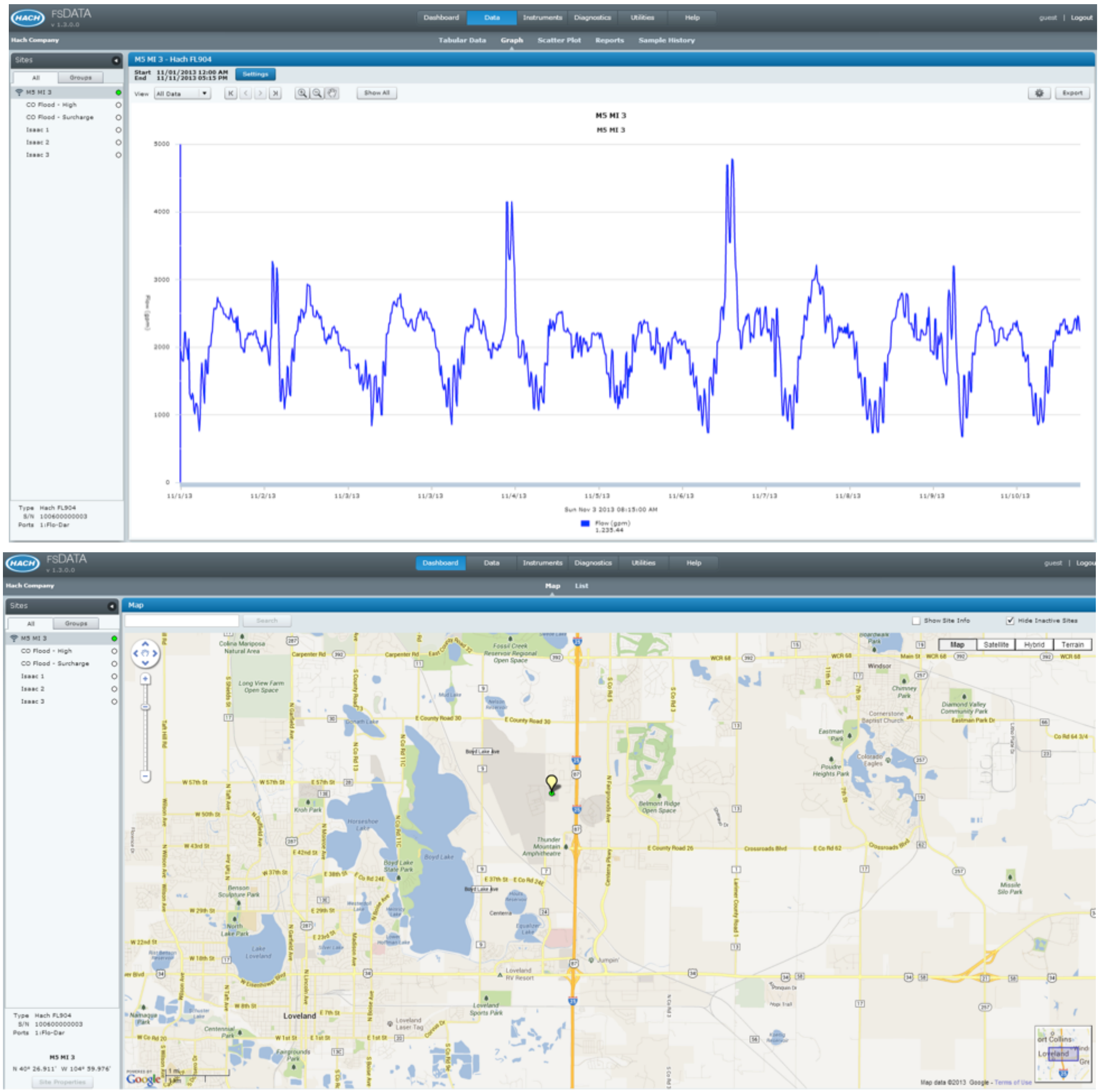
Example catchbasin configuration: 2 catchbasins meet up in the manhole. Flow Senosrs are placed in each catchbasin pipe exit into the manhole.



Sensor Configuration: Data-logger (blue) hangs from ladder using steel wire. Flow sensors are place in each catch basin pipe and wired to the data-logger. A traffic rated cellular antenna is placed on the lid of the manhole (shown yellow) or buried in the pavement (not shown)



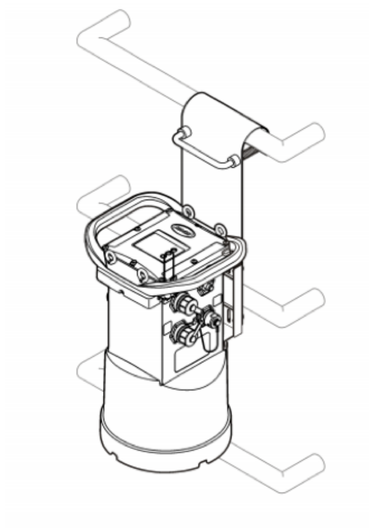
Data Transfer: Flow data collected from the logger is sent in real-time to the internet. This allows for real-time access on any computer with an internet connection.



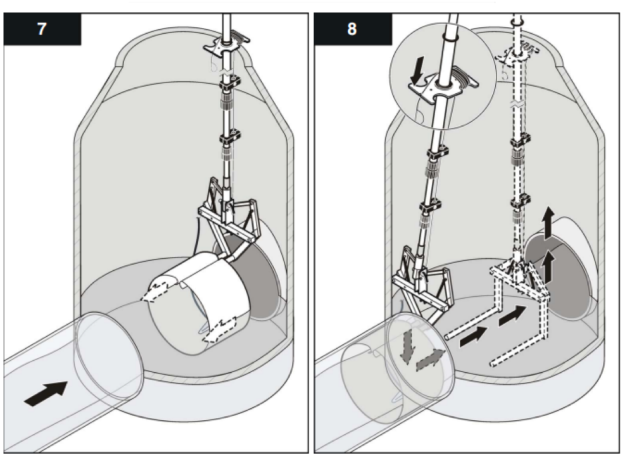
Online Sewer Flow Data Access: Shown here is the user-interface of the online monitoring tool, FSDATA, provided by the manufacture

INSTALLATION PLAN

Installation for this project occurs in multiple phases. The first phase is to establish pre-green conditions of the sites by installing the sewer sensors. Because confined space sewer entry may be necessary especially during initial installation of each of the five monitoring setups, the research team seeks DEP's assistance. The installation involves installing the spring rings (metal cylindrical pipe inserts that brace the sensor in place without impeding sewer flow) and mounting the data logger to the manhole ladder using steel wire and clamps provided by the manufacturer. Once these components are secure and the manhole lid is closed, a small traffic-rated antenna will be mounted to the top of the manhole. This antenna is durable and able to withstand normal traffic conditions.

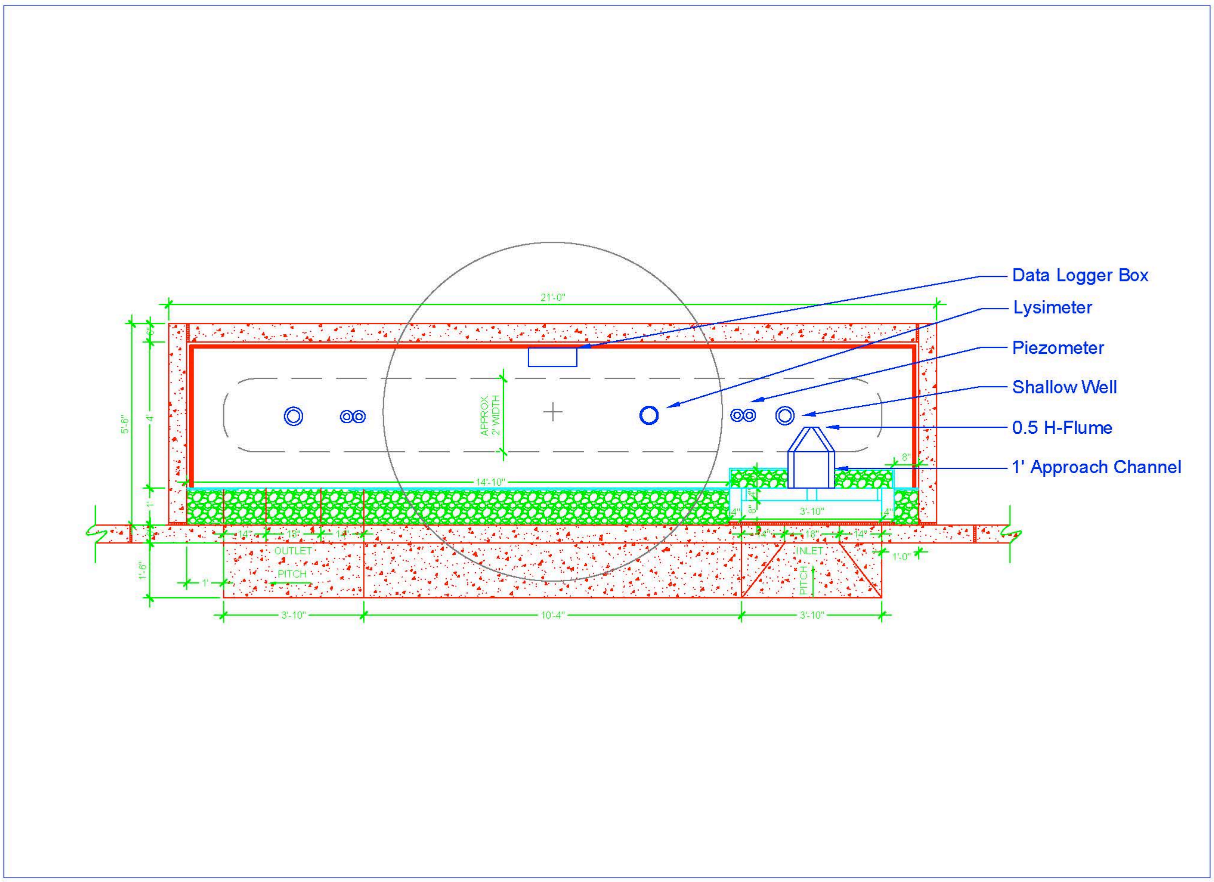


Data Logger Mounting: HACH FL900 mounted on manhole ladder

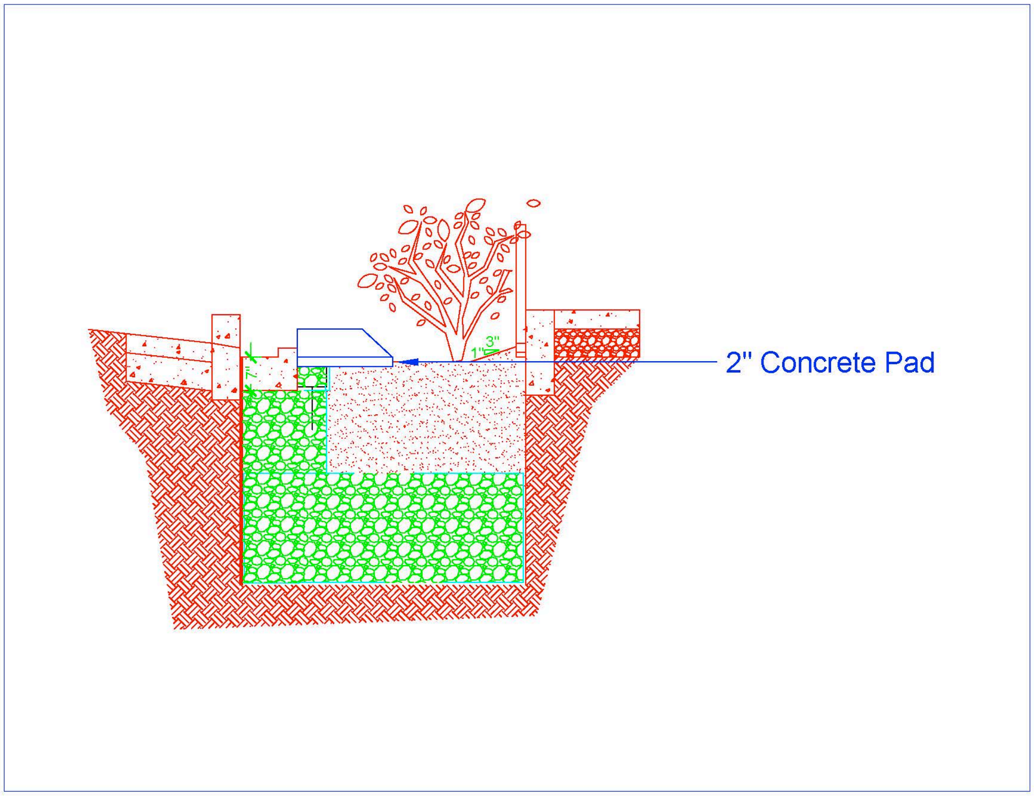


Sensor Installation: As a way to avoid confined space entry, the tool shown above can place the spring ring in the pipe from ground-level.

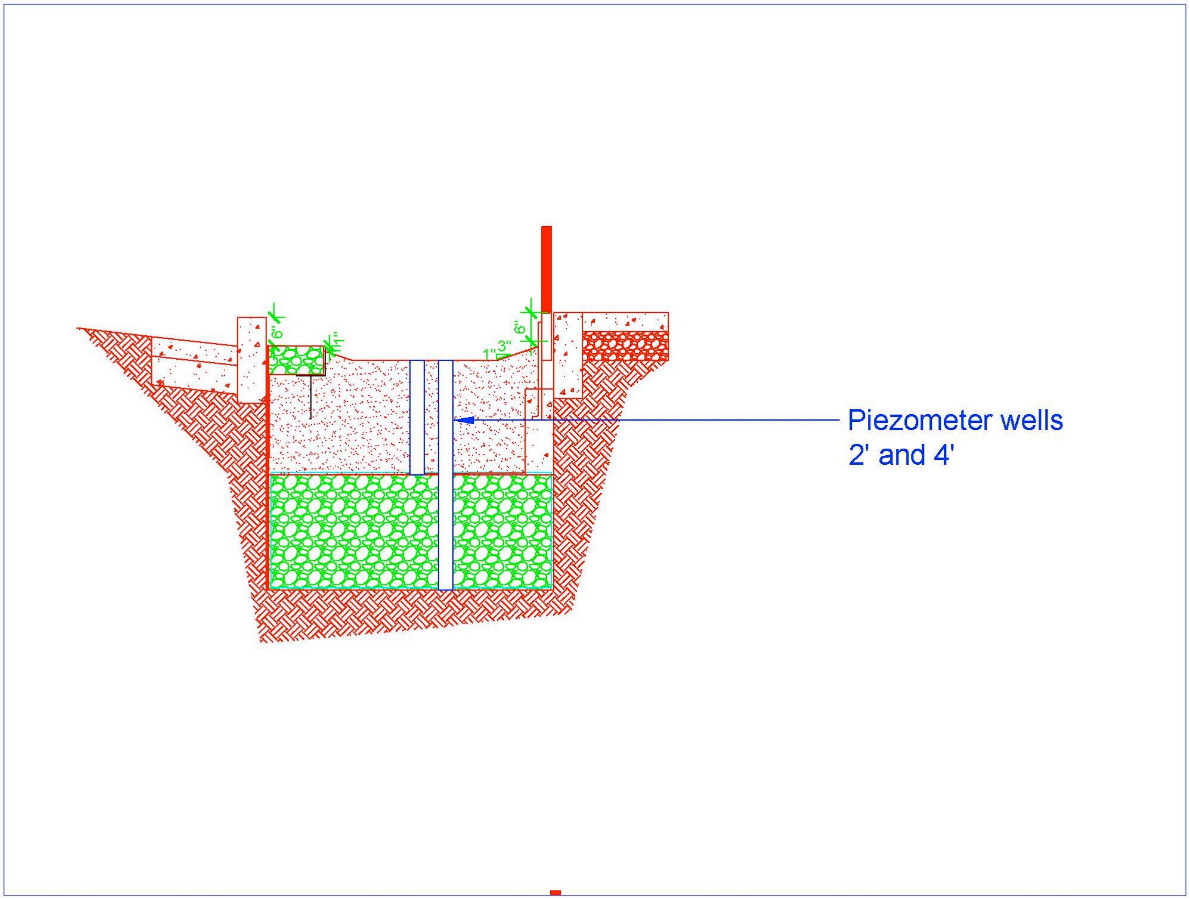
The second phase of installation will occur during the site greening. During this phase, sensors inside the green space will be installed. This includes installing the lysimeter, shallow wells, piezometer, soil moisture sensors, and flume. Climate stations will be mounted on a street pole adjacent to the future location of the green space. Approval from the NYC Department of Transportation will be needed (but was formally obtained by DU on another project in Manhattan).



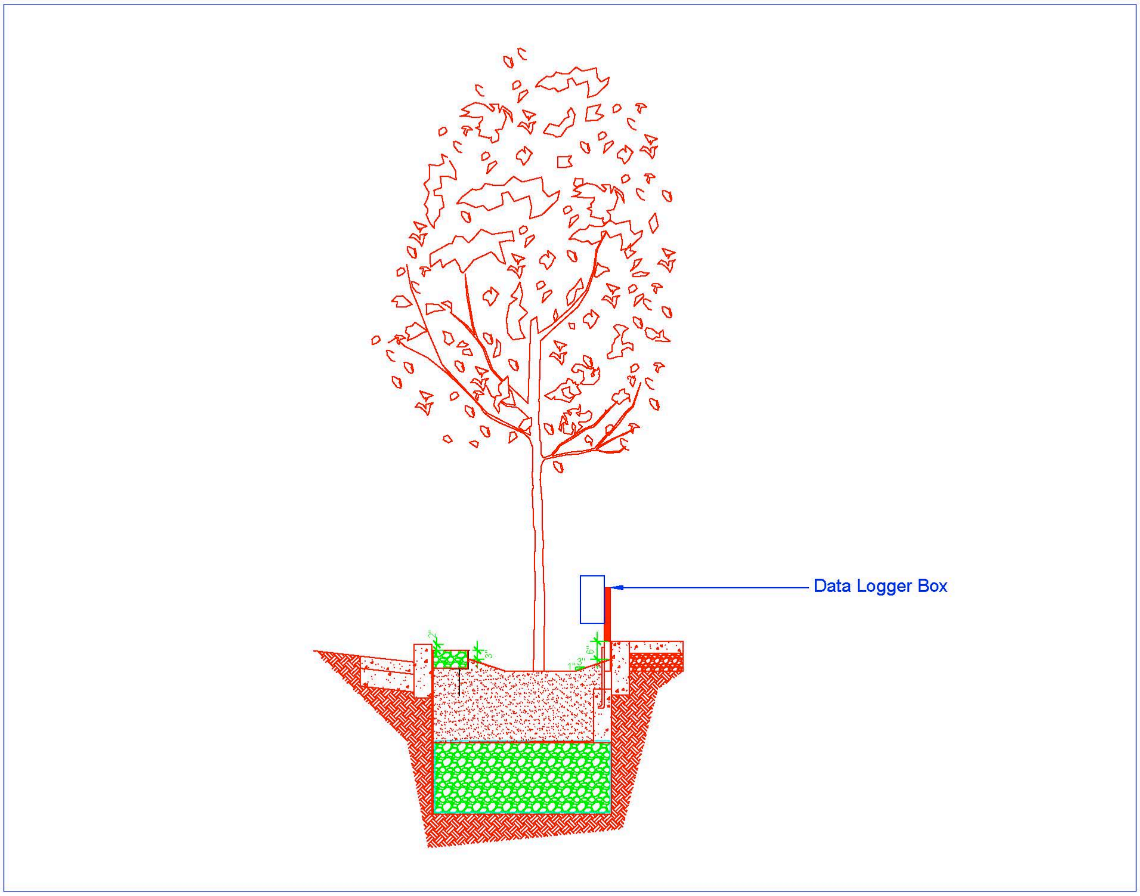
Plan View of Sensor Layout: Shown here is the sensor layout for a ROWB. Inflow is measured with an H-Flume, infiltration with piezometers, ponding with at either of the bioswale with shallow wells, evapotranspiration is measured with a lysimeter (design pending), and everything is connected to a datalogger mounted to the ROWB metal fence.



H-Flume Section: Inflow is measured using an H-Flume. The flume is positioned at the inlet of the bioswale.



Piezometer Section: Two nested piezometers will be located within the bioswale to measure infiltration of the stormwater.



Data Logger Mount: The data logger box can be mounted to the metal fence that is part of the standard ROWB design. This allows for ease of access and stable structural support.

MAINTENANCE SCHEDULE

As part of any good environmental monitoring plan, frequent maintenance must be done throughout the duration of the study. The following is a breakdown of what to expect for the duration of the study.

Sewer Flow

As there are five proposed sites located near one another in the Bronx, it is recommended that all sites be service at a time to reduce logistical and time demands. This means that once a month, DEP will be needed to assist with confined sewer entry into the sites. Actual locations of these sites will be selected pending survey and boring results. Ideal pre-green monitoring of each site should be conducted over the course of a year. Post-green monitoring should also be monitored for a year for comparison. This makes the total length of the study two years.

- Sewer flow sensors are often off-calibration following large rain events and require maintenance to ensure quality readings. From experience with previous sewer flow studies, this will occur about once a month and require DEP with confined space entry to enter into the sewer and remount the spring-rings. Once in the sewer, this can be fixed within a few minutes.

- The data logger in the sewer runs off batteries that need to be changed about once every 4 months. This maintenance will require DEP sewer access without confined sewer access. This is a much simpler process involving lifting the manhole cover to access the logger beneath and takes about ten minutes.

- Occasionally the antenna mounted to the roof of the manhole will get damaged (by a snowplow for example) and need replacement. This will require DEP assistance without confined space entry.

To clarify the difference between confined access and non-confined access, confined space entry is under the jurisdiction of OSHA and thus strict safety measurements are taken. NYC DEP members enter into the sewer using a tripod belay device to lower one man into the sewer. In addition, a team from a different sector of DEP is present to continuously assess the air quality inside the sewer while someone is inside. This requires coordination between both parties and is much harder to organize than for a simpler non-confined space entry. Non-confined space sewer access entails lifting the manhole lid and reaching inside to grab the data logger. Both types of access require sections of the road to be quarantined for safe entry away from traffic. Please be aware that this study needs the full commitment of the DEP to support for the FULL duration of the study. Previous experience with the DEP has shown them to respond for the initial installation then become less reliable overtime. This delay in response time can compromise the sewer flow data. For a success sewer flow study, all parties must be fully dedicated from the beginning.

Site visit at Startford Ave: DEP crew trucks blocks on-coming traffic to create a protected area around the manhole. In the case of confined-sewer entry, a tripod is setup in the protected area.

Green Space Sensors

The biggest maintenance requirement inside the green space will deal with the flume. Maintaining a clean, unclogged flume is needed to ensure quality measurements. This cleaning should be done once a week particularly after a rainstorm. The reading of the pressure transducers should be validated each time maintenance is being done onsite. This entails manually reading the depth of water of the shallow wells, the piezometer, and the flume stilling well (to be assisted by the DPR citizen scientist program). Pictures should be taken of the green space during each visit from the same vantage point to give a time-series of the green space growth and quality. Trash clean up is also important to maintain the aesthetic quality of the green space and promote a positive attitude towards it throughout the community.

Climate Station

Climate station maintenance is usually done on an as-need basis. As all data is accessible in real-time over the Internet, faulty sensor readings will be detected early. When this occurs, maintenance will need to be done assisted by a ladder to reach the climate station. Climate station maintenance is usually straightforward and will entail cleaning the radiation lens, calibrating tipping bucket rain gages, along with other wiring and programming work. There may come times when hazardous weather conditions (such as those experienced during hurricane Sandy) require the most sensitive of equipment to be secured during the storm. This would require a team to do around and take down the equipment prior to the storm. After the storm, equipment will need to be reinstalled.

EQUIPMENT BUDGET

The following equipment list represents the preferred sensors and remote monitoring equipment recommended for this study to be used at each site. The equipment is itemized in the table below including quantity, unit price, total cost, and provider. It should be noted that the prices listed are based on previous quotes. Formal quotes for this project will be obtained once the monitoring plan is finalized.

Equipment Item	Vendor	Quantity	Unit Price	Cost
H-flumes	Tracom	1	$2000	$2000
Piezometer		1	included	--
Shallow wells		2	included	--
Lysimeter	McIntyre Sons	1	$5000	$5000
Pressure transducers	Campbell Scientific	5	$900	$4500
Rain gages	Campbell Scientific	2	$600	$1200
Data logger	Campbell Scientific	1	$2500	$2500
Soil Moisture Sensor	Campbell Scientific	3	$250	$750
Net Radiation Sensor	Campbell Scientific	1	$5000	$5000
Temp/ RH Sensor	Campbell Scientific	1	$600	$600
Wind Sensor (speed and direction)	Campbell Scientific	1	$1100	$1100
Barometric Pressure Sensor	Campbell Scientific	1	$700	$700
Climate Station Mounting	Campbell Scientific	1	$800	$800
Power system (batteries, solar panels)	Campbell Scientific	1	$1000	$1000
Cell modem	Campbell Scientific	1	$1000	$1000
Cellular Data Plan	Verizon	2	$100 per month for 2 years	$4800

Equipment Item	Vendor	Quantity	Unit Price	Cost
Equipment housing box	Campbell Scientific	1	$1500	$1500
Sewer Flow Logger	HACH	1	$7500	$7500
Sewer Flow Sensor	HACH	2	$1500	$3000
Sewer Mounting	HACH	2	$200	$400
Sewer flow antenna	HACH	1	$600	$600

Estimated Total per Site ~$43,950

Estimated total for 5 sites ~$220,000

Original sensor budget (for comparison): $283,700

SITE SELECTION

The following table represents the site selection based upon several walkthroughs of potential sites. These sites were selected based on feasibility for green construction provided by Tannen Printz and ability to conduct a sewer flow study (based on DEP sewer maps). Boring test results are pending, but the sites have been ranked by preference.

Location	GI Type	Rank as of 6/4/13
East 236th Street, East of Katonah Avenue	14 x 5'	13
East 240th Street, West of Martha Avenue		1
Wallace Avenue, South of Van Nest Avenue		2
Hunt Avenue, South of Van Nest Avenue		5
Richardson Avenue, North of Nereid Avenue		4
Matilda Avenue, South of Nereid Avenue		3
Mead Street, between Garfield Street and Unionport Road	5 x 15'	11
Baker Avenue, East of Garfield Street	5 x 20'	6
Brady Avenue, East of Holland Avenue	5 x 20'	7
Holland Avenue, North of Brady Avenue	5 x 22'	8
Wallace Avenue, between Lydig Avenue and Pelham Pkwy South	5 x 20'	9
Bolton Street,between Lydig Avenue and Pelham Pkwy South	5 x 20'	10
Holland Avenue, North of Pelham Parkway North		12

RECOMMENDATIONS

Below is a short list of recommendations to consider with this monitoring plan.

- Request that the DPR citizen scientists assist in installation and maintenance.
- Communicate with DEP prior to the study to understand and communicate their role in the study.
- Monitor bump-outs rather than right-of-way bioswales as they are easier to monitor with flumes. This is because flow from the street enters the flume without any turns in the bump-out orientation making for stronger readings.
- Mounting the weather station on a street pole for each site may not be feasible. As an alternative, the data logger could be mounted to green space fencing.
- H-Flume design for the ROWB should be tested to ensure that measurements taken this way are accurate. Testing will be done prior to purchasing.