Brooklyn Bridge Park: Pier 1 and Pier 3-4 Uplands Methods Document

Prepared by:

Research Fellow- Nicholas Pevzner, Lecturer, Department of Landscape Architecture, University of Pennsylvania
Research Assistant- Sean McKay, PLA, MLA Candidate, University of Pennsylvania

Overview of CSI: This investigation was conducted as part of the Landscape Architecture Foundation's 2016 *Case Study Investigation* (CSI) program. CSI matches faculty-student research teams with design practitioners to document the benefits of exemplary high-performing landscape projects. Teams develop methods to quantify environmental, economic and social benefits and produce Case Study Briefs for LAF's *Landscape Performance Series*.

The full case study can be found at: https://landscapeperformance.org/case-study-briefs/brooklyn-bridge-park

Overview of Research Team Strategy

Brooklyn Bridge Park (BBP) is a large and complex constructed landscape, parts of which remain under construction at the time of this case study's publication, and which upon completion will eventually occupy 85 acres along the Brooklyn, NY waterfront. The park repurposes piers 1-6 of the former industrial owner, the Port Authority of New York and New Jersey, and retains the pier names from the prior industrial use. For the purposes of this LAF case study, the research team focused its attention solely on Pier 1 and Pier 3-4 Uplands (13.6 acres), an area outlined below in Figure 1.

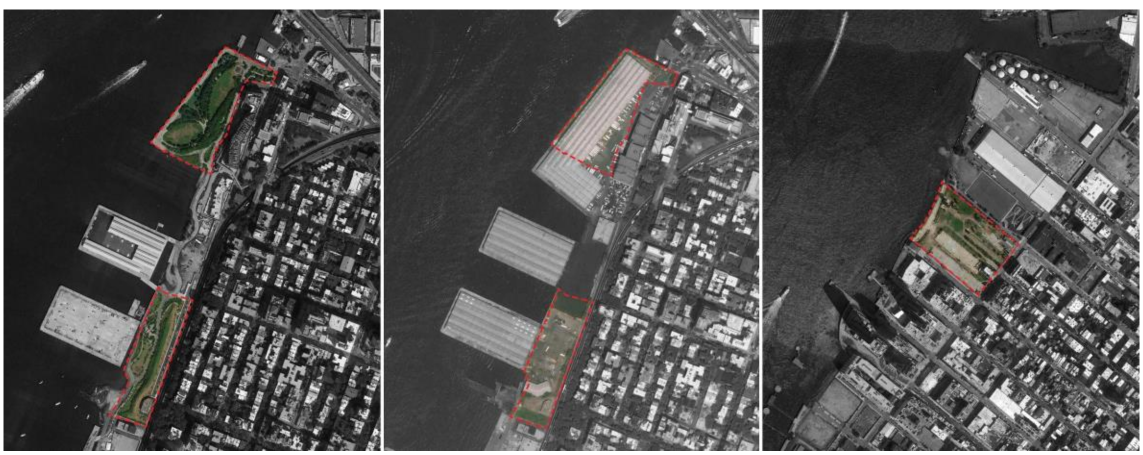
Reference/Comparison Landscapes

In order to assess the performance of a landscape, it needs to be evaluated against some kind of benchmark. In approaching an assessment of landscape performance at Brooklyn Bridge Park, the research team took a comparative approach, with some analyses including a comparison with a "traditional" park of similar size in the same region, and other analyses including a comparison with the pre-existing condition of the BBP study site prior to park construction.

For the nearby "traditional" reference landscape, we identified East River State Park as an appropriate comparison site, because of its rough equivalency in terms of:

- size (6.99 acres for East River State Park vs. 7.64 acres for Pier 1 and 5.97 acres for Pier 3-4 Uplands),
- waterfront location (also on the East River and also in Brooklyn),
- proximity (2 miles away),
- age (9 years since construction for East River State Park vs. 6 years for BBP Pier 1).

Primarily composed of lawn, trees, and meadow grasses planted on and around the former industrial traces of the Brooklyn Eastern District Terminal. With its simple design, simple palette of landscape elements, East River State Park represents a good example of a typical "traditional" municipal park response to a heavily used post-industrial waterfront site close to a residential neighborhood--all good analogs for BBP.



Left: BBP Study Area, 2016 Center: Pre-existing Condition, 2008 Right: East River State Park

Figure 1. *Comparison of Brooklyn Bridge Park Study Area (left) and equivalent "traditional" park (right). (Source: GoogleEarth)*

Changing Vegetation

Landscapes continue to change after design and construction, with the task of maintenance for various aspects of the design passing from the landscape architects to the client and various stewards and caretakers. Brooklyn Bridge Park was specifically designed to embrace processes of long-term change by its designers, the landscape architecture firm Michael Van Valkenburgh Associates (MVVA), through concepts like “managed succession.” Although the design drawings are frozen in time at the moment of installation, the vegetation community continues to grow and change as intended, due to natural processes and to the activities of the Brooklyn Bridge Park Corporation’s horticulture staff.

For the evaluation of Brooklyn Bridge Park’s Pier 1 and Pier 3-4 Uplands, the research team relied on design drawings provided by MVVA and on-site observations conducted by the research team on several site visits in May and June 2016, as well as on interviews with a number of staff at MVVA, the Brooklyn Bridge Park Corporation (BBPC), and the Brooklyn Bridge Park Conservancy.

Landscape Performance Benefits

ENVIRONMENTAL BENEFITS

Environmental Benefit 1

Reduces annual stormwater runoff by 80% on Pier 1. Pier 1 retains more than twice as much of the local average rainfall than a traditional waterfront park landscape reference site.

Methodology:

A water management design goal was to capture stormwater on Pier 1, filter it through a series of wetlands and store it below grade in 100,000 gallon capacity storage tanks for reuse on the Pier's irrigation system. The system capacity was designed to capture as much water from Pier 1 as possible, and also harvest the runoff from the adjacent development parcels currently under construction within the park footprint. In order to gain a coarse understanding of the stormwater capture performance, the EPA Stormwater Calculator was used to compare stormwater capture performance of 1) the pre-existing Pier 1 site condition, 2) the current Pier 1 condition and 3) the East River State Park reference landscape.

According to the U.S. EPA, "EPA's National Stormwater Calculator (SWC) is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States (including Puerto Rico). The Calculator accesses several national databases that provide soil, topography, rainfall, and evaporation information for the chosen site. The user supplies information about the site's land cover and selects the types of low impact development (LID) controls they would like to use"[1]

The EPA Stormwater Calculator requires the following inputs:

- Locations (Address or Longitude and Latitude Coordinates)
- Soil type runoff potential (low, moderately low, moderately high, high)
- Soil drainage (inches/hour)
- Topography (flat, moderately flat, moderately steep, steep)
- Precipitation (provide nearest weather station from which historical data is gathered)
- Evaporation (provide nearest weather station from which historical data is gathered)
- Land cover (% forest, meadow, lawn, desert, impervious)
- LID controls (% of impervious surface draining into LID controls, general sizing information of LID controls.

Upon entering a site location, the calculator provides local soils information to assist in providing inputs for soil runoff potential, soil drainage and topography. These values were used for all three calculated conditions. The calculator also recommends the nearest weather station for precipitation and evaporation data. This station (NY Central Park) was utilized for all three calculated conditions. Land cover % were calculated by performing area takeoffs on the following sources:

1) Site aerials obtained from Google Earth Pro dated 3/31/2006
2) 100% Construction Documents provided to the research team by MVVA.
3) Site aerials obtained from Google Earth Pro dated 9/6/2015

For the pre-existing conditions, 99% of the existing surface was classified as impervious. While some catch basins were present on site, review of the existing conditions plans contained in the 100%

[1] U.S. EPA National Stormwater Calculator. https://www.epa.gov/water-research/national-stormwater-calculator

construction document set revealed that these catchments were piped directly to outfall locations along the East River. There are no LID controls present in the pre-existing conditions.

Based on on-site observations and interviews with MVVA staff, the Construction Document conditions are assumed to represent the current on-site conditions in terms of coverage category and sizing of stormwater storage systems. The calculator requires input of the percentage of impervious area that is treated by LID practices. Based upon review of 100% Construction Documents grading plans, the catchment for all impervious surface runoff and percentage of total impervious surface area was determined. For the purposes of calculations, 45% of all impervious surfaces on Pier 1 are assumed to drain directly into the rainwater harvesting system. 20% drains into catchment wetlands that eventually drain into the rainwater harvesting system. These were classified as “rain gardens” based on the options available within the EPA calculator. The remaining impervious surface (35%), located at the waterfront periphery of Pier 1, sheet flows directly into the East River.

For the reference site, based on site observation and site aerials, there are assumed to be no drainage structures or LID controls present on the East River State Park site. The site slopes from its entry along Kent Avenue down to the East River. 64% of the park’s area was determined to be impervious.

The results of the EPA Stormwater Calculator are present below for the Pier 1 pre-existing conditions (Figure 16), Pier 1 current conditions (Figure 17) and East River State Park (Figure 18).

Statistic	Current Scenario
Average Annual Rainfall (inches)	59.89
Average Annual Runoff (inches)	53.72
Days per Year With Rainfall	81.00
Days per Year with Runoff	71.00
Percent of Wet Days Retained	12.35
Smallest Rainfall w/ Runoff (inches)	0.12
Largest Rainfall w/o Runoff (inches)	0.18
Max. Rainfall Retained (inches)	0.16

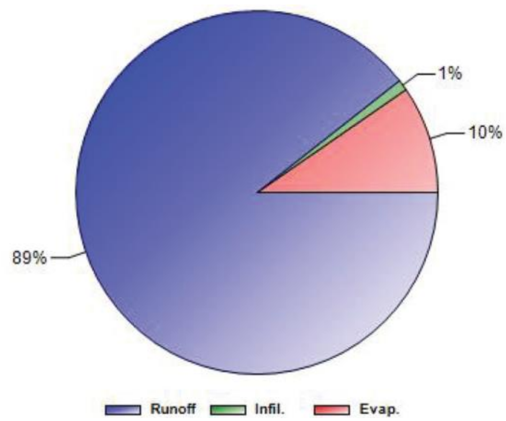


Figure 16. *Brooklyn Bridge Park Pier 1 Pre-existing Conditions EPA Stormwater Calculator Results.*

Statistic	Current Scenario
Average Annual Rainfall (inches)	59.89
Average Annual Runoff (inches)	10.04
Days per Year With Rainfall	82.00
Days per Year with Runoff	28.00
Percent of Wet Days Retained	65.85
Smallest Rainfall w/ Runoff (inches)	0.69
Largest Rainfall w/o Runoff (inches)	0.68
Max. Rainfall Retained (inches)	2.75

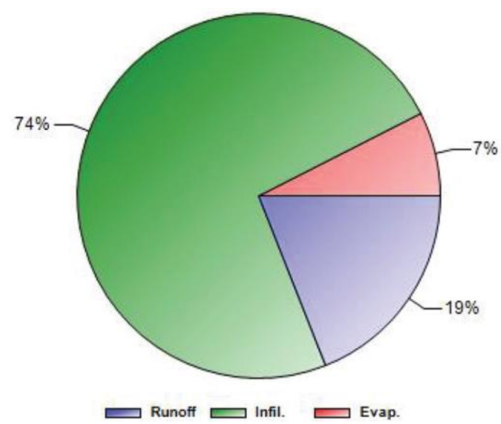


Figure 17. *Brooklyn Bridge Park Pier 1 Current Conditions EPA Stormwater Calculator Results.*

Statistic	Current Scenario
Average Annual Rainfall (inches)	59.89
Average Annual Runoff (inches)	40.83
Days per Year With Rainfall	81.00
Days per Year with Runoff	64.00
Percent of Wet Days Retained	20.99
Smallest Rainfall w/ Runoff (inches)	0.19
Largest Rainfall w/o Runoff (inches)	0.23
Max. Rainfall Retained (inches)	0.62

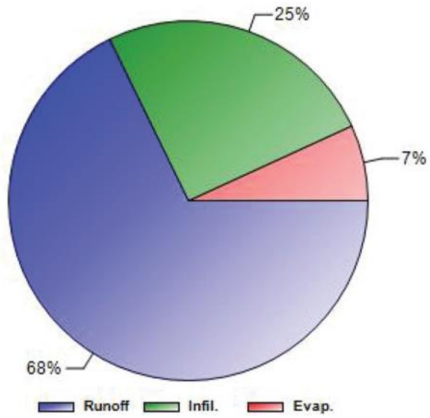


Figure 18. *East River State Park EPA Stormwater Calculator Results.*

Based on EPA Stormwater Calculator results, Pier 1 current conditions reduce average annual runoff by 81.3% relative to preexisting conditions *[(53.72-10.04)/53.72]* and reduce the number of days per year with runoff by 43 (71-28). In comparison to East River State Park, Pier 1 current conditions retain 51.4% more of the local average annual rainfall *[(40.83-10.04)/59.89]*.

Limitations:

The EPA Stormwater Calculator is a tool primarily used to compare different development scenarios at a planning level with relative ease and simplicity. The inputs considered in calculations do not account for actual site topography, drainage patterns or more complex LID controls such as the interconnected systems of wetland and below-grade stormwater detention chambers employed on Pier 1. Since the same inputs were provided for all three conditions, the calculations serve as a rough performance metric of each condition relative to one another; however the validity and accuracy of actual runoff and retention amounts is unknown but presumed to be relatively low.

Sources:

Brooklyn Bridge Park. 40°42’05.11” N 73°59’44.21” W. GOOGLE EARTH. March 31, 2008.
East River State Park. 40°43’118.29” N 73°57’41.00” W. GOOGLE EARTH. September 9,2015.
Michael Van Valkenburgh Associates. Brooklyn Bridge Park *100% Construction Documents*. PDF.
U.S. EPA National Stormwater Calculator. https://www.epa.gov/water-research/national-stormwater-calculator

Environmental Benefit 2

Provides annual functional benefits approximately 4 times greater in value per sf in the “managed succession” planting areas on Pier 1 compared to a “traditional” planting typology. The “managed succession” planting areas provide annual benefits valued at $2,055, including 4,370 lbs of gross carbon sequestration, 2,246 cu ft of annual avoided runoff, and 966 lbs of pollutant removal.

Methodology:

The “managed succession areas” on Pier 1 and Pier 3-4 Uplands at Brooklyn Bridge Park are densely planted zones, characterized by a mixed planting of shade tree species, understory trees and shrubs, and an herbaceous layer.

Because the “managed succession” areas are so densely planted, inter-plant competition prompts many trees to assume irregular growth forms, growing away from one another and competing for available light.

Due to this irregularity in growth form and canopy shape, the design team used *i-Tree Eco* to compute the trees' functional benefits, rather than the simpler *i-Tree Design* tool.

The research team used *i-Tree Eco* to compare ecosystem service metrics -- carbon storage, carbon sequestration, avoided stormwater runoff and pollution removal -- of the "managed succession" planting typology[2] utilized extensively on Pier 1 at Brooklyn Bridge Park, to the regularly spaced tree planting typology with open understory that is typical of many park environments and exemplified at East River State park.

i-Tree Eco Tool
According to the U.S. Forest Service, *i-Tree Eco* "is designed to use field data from complete inventories of trees or randomly located plots throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects and value to communities."[3]

The *i-Tree* suite offers two ways of quantifying these ecosystem services on a site scale: *i-Tree Design* and *i-Tree Eco*. *i-Tree Design* employs a web-based interface and takes 4 inputs for each tree specimen:

- Species
- Diameter
- Condition
- Tree exposure to sunlight

i-Tree Eco, meanwhile, takes 12 inputs related to the location, size and form of each specimen:

- Land Use
- DBH of up to 6 individual trunks (accounting for multistem specimen)
- Height of each DBH measurement
- Crown condition (accounting for any leafless spots within the crown)
- Total Height
- Crown: Top Height
- Crown: Base Height
- Crown Width (N/S)
- Crown Width (E/W)
- % of crown missing
- Crown light exposure (# of sides of crown receiving direct sunlight)
- Street tree (Y/N)

While the *i-Tree Design*'s smaller number of inputs allow for quick and simple quantifications, they do not account for variations in vegetation form and structure. In the "managed succession" areas of the study site, given the close planting and intended competitive character of vegetation, unique vegetative structure and irregular canopy conditions have developed. *i-Tree Eco* allows for a much broader range of inputs per specimen, which begin to account for vegetative structure and specimen form in more detailed ways.

Field Samples to Characterize a Typical "Managed Succession" Planting
In order to establish the typical vegetative structural conditions in the "managed succession" planting areas, the research team established two 5m x 5m representative quadrats (Figure 10). All woody vegetation falling within these quadrats with a DBH greater than 1" were surveyed. For each surveyed specimen, the following characteristics were recorded:

- Location of trunk base within quadrat

[2] The "managed succession" characterization is based on terminology utilized by MVVA in planting plans. In terms of appearance and management, areas denoted "managed succession" and "dense hedgerow" on design documents are difficult to distinguish from one another, being effectively identical.

[3] US Forest Service. "i-Tree Applications." https://www.itreetools.org/applications.php

- Relative position of DBH to trunk base (if leaning)
- DBH
- Height
- Top of canopy height
- Bottom of canopy height
- Position of canopy relative to trunk base
- General size, shape and dimension of canopy
- Plan view sketch of trunk and canopy
- Elevation view sketch of primary branching pattern and canopy location

A sample of the in-field recordings for each specimen are included in Figure 11. Horizontal locations and distances were measured using field tape. Vertical heights were measured using a 25' tape measure for low vegetation and a clinometer for taller vegetation. Canopy measurements were estimated by finding the ground plane position of the furthest canopy points and measuring the distance to the trunk base and the relative distances of the canopy's to longest dimensions utilizing a field tape. Plan view sketches were drawn based on canopy measurements, with approximations of the canopy shape made by standing directly below the tree canopy. All elevation view sketches were drawn from the same orientation for each quadrat and scaled based upon height and canopy measurements. All measurements were taken in imperial units.

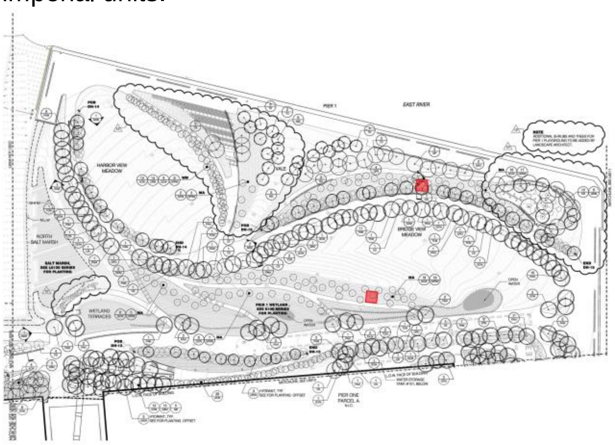


Figure 10. *Representative 5m x 5m Quadrat Locations.*

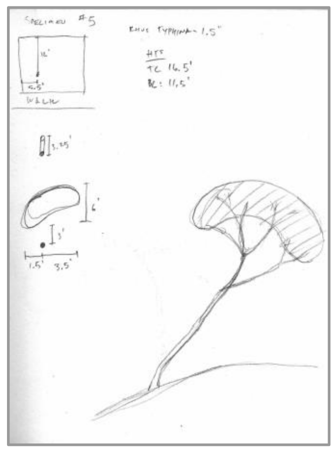


Figure 11. *Sample Field Survey Recordings.*

Each sample quadrat was set up as a separate project within *i-Tree Eco v1.6* using the fields noted below in Figure 12. Specimen information collected in the field was entered manually into the *i-Tree Eco* database (Figure 13).

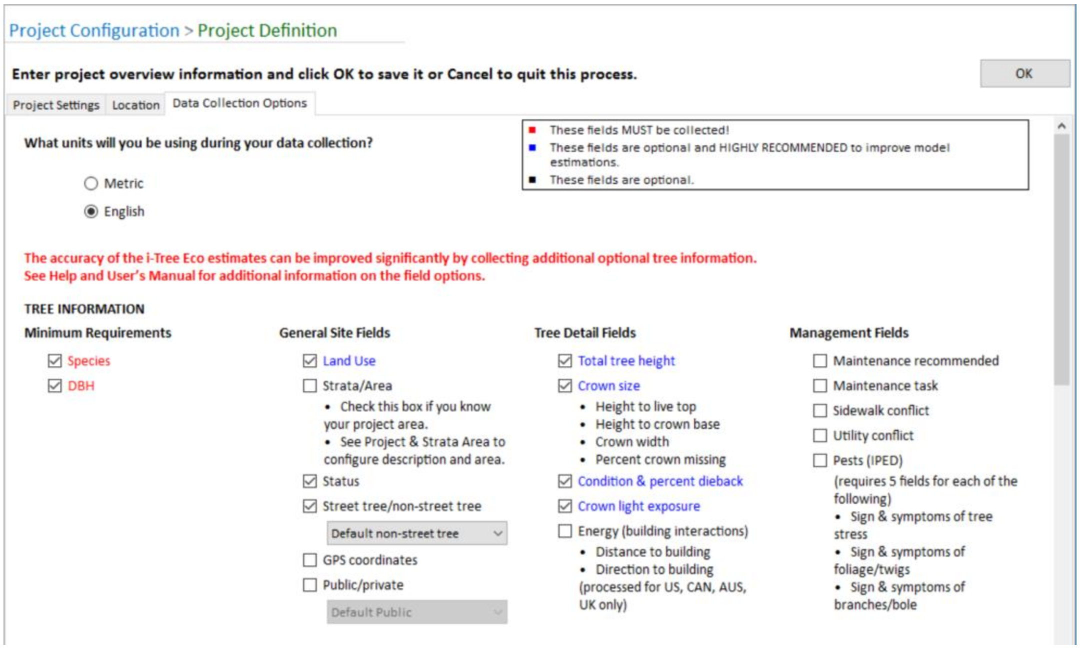


Figure 12. *i-Tree Eco Selected Project Inputs.*

ID	Crew	Survey Date	Species	Land Use	DBH 1 (in)	DBH 1: Height	DBH 1: Measured?	DBH 6: Measure	Crown:	Total Height (ft)	Crown: Top Height	Crown: Base Height (	Crown: Width N/S	Crown: Width E/W	Crown: % Missing	Crown: Light Exposure	Street Tree?
1		6/29/2016	Staghorn sumac (Rhus hirta)	Park	2.8	4.5	TRUE	TRUE	100%	26.6	26.6	15.2	12.3	9.5	0%	2 Sides	FALSE
2		6/29/2016	Staghorn sumac (Rhus hirta)	Park	3.5	4.5	TRUE	TRUE	100%	17.2	17.2	6.8	8.5	11	0%	1 Side	FALSE
3		6/29/2016	Staghorn sumac (Rhus hirta)	Park	2.5	4.5	TRUE	TRUE	100%	14	14	6	13	11.5	0%	2 Sides	FALSE
4		6/29/2016	Staghorn sumac (Rhus hirta)	Park	3.5	4.5	TRUE	TRUE	100%	26	26	19	10.5	5.5	0%	2 Sides	FALSE
5		6/29/2016	Staghorn sumac (Rhus hirta)	Park	3	4.5	TRUE	TRUE	100%	25.5	25.5	19	13	6	0%	2 Sides	FALSE
6		6/29/2016	Staghorn sumac (Rhus hirta)	Park	4	4.5	TRUE	TRUE	100%	27	27	21.8	11.5	11.5	0%	2 Sides	FALSE
7		6/29/2016	Staghorn sumac (Rhus hirta)	Park	3	4.5	TRUE	TRUE	100%	19.6	19.6	13.5	10.5	10.5	0%	1 Side	FALSE
8		6/29/2016	Staghorn sumac (Rhus hirta)	Park	4.3	4.5	TRUE	TRUE	100%	26.24	26.24	20	13	12.5	0%	2 Sides	FALSE
9		6/29/2016	Staghorn sumac (Rhus hirta)	Park	1.3	4.5	TRUE	TRUE	100%	13	13	10.5	7.5	8.5	0%	1 Side	FALSE
10		6/29/2016	Staghorn sumac (Rhus hirta)	Park	1.5	4.5	TRUE	TRUE	100%	12.5	12.5	10	6	8	0%	1 Side	FALSE
11		6/29/2016	Staghorn sumac (Rhus hirta)	Park	3.8	4.5	TRUE	TRUE	100%	19.2	19.2	9.6	13	7.5	0%	2 Sides	FALSE
12		6/29/2016	Staghorn sumac (Rhus hirta)	Park	4.5	4.5	TRUE	TRUE	100%	20.5	20.5	18	9.5	13	0%	2 Sides	FALSE
13		6/29/2016	Staghorn sumac (Rhus hirta)	Park	4	4.5	TRUE	TRUE	100%	19.04	19.04	10.5	5.5	10	0%	1 Side	FALSE
14		6/29/2016	Pin oak (Quercus palustris)	Park	3	4.5	TRUE	TRUE	100%	31.2	31.2	15.36	7.5	7.3	0%	5 Sides	FALSE

Figure 13. *Sample i-Tree Eco Database Input.*

The *i-Tree Eco* software is often utilized at the scale of community and city, managing large numbers of individual specimens. The results round values to two decimal places and provide results in fixed units. This rounding and the units utilized provide a relatively coarse level of information for the small inventories and tree calipers that the research team encountered in this inventory, and may obscure benefits provided by young individual specimen as present in the surveyed representative quadrats. To increase the resolution of unit measurements, each tree database was duplicated such that 10 multiples of each tree were included in the database for processing.

Once input was complete, each quadrat database was submitted to *i-Tree* servers for processing. Then all results obtained from the *i-Tree* servers were divided by 10 to account for the previous multiplication of the submitted sample; additionally, all results provided in tons were converted to pounds (*tons*2000)*. The results of the two quadrats were averaged to come up with "typical" annual functional benefits per 5 sq. meters.

Annual functional benefits were defined as the sum of the total gross carbon sequestration, avoided runoff and pollution removal. These results were converted to per sq. ft. metrics (*benefits quantity / 269 sf. sample area*). An area takeoff was performed on the planting plans for the areas labelled "managed succession" (25,027 sf.) and this area was multiplied by the *per sf.* metric to quantify the total annual functional benefits afforded by the managed succession areas on Pier 1 (Figure 14).

BBP Quadrat 1

Species	# of trees	Carbon Storage		Gross Carbon Sequestration		Avoided Runoff		Pollution Removal		Structural Value
		Lbs	$	Lbs/Yr	$	ft3/yr	$/yr	lbs/Yr	$/yr	$
Pin Oak	1	16.36364	1.05	7.2727273	0.42	1.505455	0.10	-	0.33	235.41
Staghorn sumac	13	263.6364	17.56	43.636364	2.88	24.57182	1.64	-	5.40	2894.68
Total	**13**	**263.6364**	**17.56**	**43.636364**	**2.88**	**24.57182**	**1.64**	**13.021**	**5.40**	**2894.68**

BBP Quadrat 2

Species	# of trees	Carbon Storage		Gross Carbon Sequestration		Avoided Runoff		Pollution Removal		Structural Value
		Lbs	$	Lbs/Yr	$	ft3/yr	$/yr	lbs/Yr	$/yr	$
Sweetgum	1	56	3.70	4	0.27	4.144	0.28	-	5.43	679.14
Pin Oak	3	48	3.23	12	0.80	4.219	0.28	-	5.53	721.41
Staghorn sumac	7	154	10.22	26	1.71	12.905	0.86	-	16.92	1509.61
Black haw	1	2	13.75	1.04	0.04	0.934	0.06	-	1.23	45.82
Total	**12**	**260**	**30.90**	**43.04**	**2.80**	**22.202**	**1.48**	**7.738**	**29.11**	**2955.97**

BBP Quadrat Average

Species	# of trees	Carbon Storage		Gross Carbon Sequestration		Avoided Runoff		Pollution Removal		Structural Value
		Lbs	$	Lbs/Yr	$	ft3/yr	$/yr	lbs/Yr	$/yr	$
Sweetgum	0.5	28	1.85	2.00	0.13	2.072	0.14	-	2.72	339.57
Pin Oak	2	32.18182	2.14	9.64	0.61	2.862227	0.19	-	2.931955	478.4061818
Staghorn sumac	10	208.8182	13.89	34.82	2.29	18.73841	1.25	-	11.16236	2202.147273
Black haw	0.5	1	6.87	0.52	0.02	0.467	0.03	-	0.61	22.91
Total	**13**	**270**	**24.75**	**46.974545**	**3.05**	**24.13964**	**1.61**	**10.3795**	**17.42**	**3043.03**
Total per sq. ft.	**0.05**	**1.00**	**0.09**	**0.17**	**0.01**	**0.09**	**0.01**	**0.04**	**0.06**	**11.31**
Total $/yr benefits per sq. ft.	**$0.08**									
Total Pier 1 Managed Succession Planting Benefits (25,027 sq. ft.)	**1209.48**	**25120.04**	**2303.06**	**4370.38**	**284.11**	**2245.88**	**150.15**	**965.68**	**1621.06**	**283115.10**
Total $/yr benefits	**$2,055.32**									

Figure 14. *i-Tree benefit summary for BBP Managed Succession Planting Areas*

<u>Reference Site Benefits Quantification</u>
A 5m x 5m quadrat was overlaid on top of an aerial of the double row of monoculture tree planting in East River State Park. It was determined that based on the uniform tree spacing, 1 tree fell within a sampling quadrat. The characteristics of all trees in this planting typology (qty: 20) were averaged to create a "typical" 5m x 5m quadrat measurement. Canopy measurements were taken based on aerials from Google Earth. Heights were estimated based on site photographs.

A separate project was set up for the East River State Park typical quadrat in the *i-Tree Eco v1.6* software and the same procedure was followed as that described above for the Brooklyn Bridge Park "managed succession" quadrats. The results were processed in the same manner described above to identify annual functional benefits per square foot and total annual functional benefits based on area takeoffs (Figure 15).

East River State Park

Species	# of trees	Carbon Storage		Gross Carbon Sequestration		Avoided Runoff		Pollution Removal		Structural Value
		Lbs	$	Lbs/Yr	$/Yr	ft3/yr	$/yr	lbs/Yr	$/Yr	$
Kentucky Coffee Tree	1	206	13.75	14	0.95	13.775	0.95	-	2.23	1050.81
Total	**1**	**206**	**13.75**	**14**	**0.95**	**13.775**	**0.95**	**0.3675**	**2.23**	**1050.81**
Total per sq. ft.	0.003717	0.77	0.05	0.05	0.00	0.05	0.00	0.00	0.01	3.91
Total $/yr benefits per sq. ft.	**$0.02**									
Total East River State Park Entry Tree Benefits (8,921 sq. ft.)	**33.16**	**6831.70**	**455.83**	**464.29**	**31.44**	**456.83**	**31.44**	**12.19**	**73.99**	**34848.61**
Total $/yr benefits	**$136.87**									

Figure 15. *i-Tree benefit summary for East River State Park*

Limitations:

While the "managed succession" planting typology was observed to be relatively uniform in terms of primary woody plant species distribution, composition and vegetative structure, two representative sample quadrats may not account for all species and conditions present within all “managed succession” planting areas.

Carbon storage and structural values are defined as values based on the tree structure itself, while carbon sequestration, avoided runoff and pollutant removals are defined as functional values provided by the trees.

Avoided Runoff value is calculated by the price $0.067/ cu. ft.

Pollution removal accounts for removal of CO, NO2, 03, PM2.5 and SO2 and sums the mean estimated removal of these pollutants. Value is calculated based on the prices of $0.734/lb (CO), $5.170/lb (O3), $5.170/lb (NO2), $1.2660/lb (SO2), $3.452/lb PM2.5.

Sources:

i-tree Eco v1.6
i-tree Eco v1.6 User’s Manual
East River State Park. 40°43’118.29” N 73°57’41.00” W. GOOGLE EARTH. September 9, 2015.
Michael Van Valkenburgh Associates. Brooklyn Bridge Park *100% Construction Documents*. PDF.

Environmental Benefit 3

Provides habitat for 119 species of birds observed on-site. Of these, 11 species were observed to nest on site and 74 use it as a migratory stopover point, including one New York Species of Special Concern.

Methodology:

Bird counts are based on data by Heather Wolf, citizen scientist and author of *Birding at the Bridge: In Search of Every Bird On The Brooklyn Waterfront (New York: The Experiment Publishing, 2016)*, who shared her unpublished raw data with the research team. Heather Wolf leads birding tours of the park for the Brooklyn Bridge Park Conservancy and has been tracking birds at Brooklyn Bridge Park since April 2013. She provided the research team with observation data from 4/1/2013 to 6/5/2016, a log of 8,728 individual sightings within the entirety of Brooklyn Bridge Park. For the Pier 1 and Pier 3-4 Uplands habitat benefit described here, Heather Wolf provided a breakdown of the full dataset for the research team, with sighting locations, nesting behavior, and migratory/resident behavior broken out as separate data fields. Heather Wolf’s sightings constitute part of the publicly available *eBird* dataset for Brooklyn Bridge Park.

Total sightings on Pier 1 and Pier 3-4 Uplands included a total of 119 bird species. (19 other species have been observed in other parts of Brooklyn Bridge Park, but not on Pier 1 or Pier 3-4 Uplands, and thus were not included in this benefit.)

Of the 11 species observed to nest on Pier 1 or Pier 3-4 Uplands, 8 are year-round nesters and 3 are summer breeders at the northern end of their migration. All have an IUCN conservation status of “*Least Concern*.”

Of the 6 species observed using Pier 1 or Pier 3-4 Uplands as a summering ground, one (the chimney swift) is listed as “near threatened” by the IUCN[4], and one (the common tern) is a “*threatened species*” in New York (Any native species likely to become an endangered species within the foreseeable future in

[4] BirdLife International. 2012. *Chaetura pelagica*. The IUCN Red List of Threatened Species 2012: e.T22686709A38153976. http://www.iucnredlist.org/details/22686709/0

New York State).[5]

Of the 74 species observed using Pier 1 or Pier 3-4 Uplands as a stopover point on their spring or fall migrations, all have an IUCN conservation status of "*Least Concern,*" and one (the grasshopper sparrow) is a "*species of special concern*" in New York (Any native species for which a welfare concern or risk of endangerment has been documented in New York State).[6]

Limitations:

The number of observed bird species does not differentiate between the commonness or rarity for any particular species, nor the abundance or density of particular species within the study site. The sighting of a particular migrant, breeding, or nesting species does not guarantee that the study area is providing a habitat benefit in a consistent or ongoing manner.

The dataset of observed birds does not describe the sampling methodology, so that a determination of species abundance correlated to geographic area cannot be made. Standard methods for assessing avian abundance are point counts, line transects, spot-mapping, or variable distance methods, with consistent timeframes in place for conducting the census.[7]

Sources:

Heather Wolf. April 2013-June 2016. "*Bird Counts and Field Observations at Brooklyn Bridge Park.*" Unpublished raw data.

Environmental Benefit 4

Increases ecological quality as demonstrated by an increase in Floristic Quality Index (FQI) in "managed succession" areas from 0.0 to 23.1 relative to existing site conditions and to an equivalent "traditional" waterfront park landscape.

Methodology:

The "managed succession areas" on Pier 1 and Pier 3-4 Uplands at Brooklyn Bridge Park are densely planted zones, denoted as "dense hedgerows" and "managed succession areas" by BBP's designers. They are characterized by a mixed planting of shade tree species, understory trees and shrubs, and an herbaceous layer. The design intent of these planting areas was for the structure and character of vegetation to change over time due to plant growth, competition and changing microclimatic conditions. This intent has carried through to the ongoing park maintenance. Maintenance staff regularly culls overly dominant plant material, alters understory plant species as the amount of shade in the dense hedgerows gradually increases, and prunes woody plant material such that long-lived shade tree species are given competitive preference over shorter-lived early successional tree species. (While having different nomenclature, "dense hedgerows" and "managed succession areas" appear visually similar and receive identical maintenance routines and practices, and for the purposes of study, these areas will be collectively referred to as "managed succession" areas) (Figure 2).

Floristic Quality Assessment (FQA) is a method that uses characteristics of a plant community to derive

---

[5] NYS Department of Environmental Conservation. "List of Endangered, Threatened and Special Concern Fish & Wildlife Species of New York State." http://www.dec.ny.gov/animals/7494.html

[6] Ibid.

[7] Nur, N., S.L. Jones, and G.R. Geupel. 1999. A statistical guide to data analysis of avian monitoring programs. U.S. Department of the Interior, Fish and Wildlife Service, BTP-R6001-1999, Washington, D.C. https://nctc.fws.gov/resources/knowledge-resources/Pubs9/avian_monitoring.pdf

an estimate of habitat quality, originally defined by Swink and Wilhelm in *Plants of the Chicago Region*, 1994.[8] The primary unit of measurement for Floristic Quality Assessments is the *Floristic Quality Index* (FQI), with higher scores representing higher quality habitats. The FQI equation utilizes a *Coefficient of Conservatism* (C) value assigned to individual species by a panel of experts with knowledge of a region's native flora. The C value can range from 0-10, with high C values assigned to species typically occurring in high-quality habitats, and low C values assigned to those occurring in a wide variety of conditions and showing a tolerance of disturbance.[9]

The FQI is calculated using the equation $FQI = \bar{C}(\sqrt{N})$ where $\bar{C}$ stands for the Native Mean C (i.e., the average Coefficient of Conservatism for native species) and N is native species richness (i.e., the number of native species).

Floristic Quality Assessment Index metrics were used to compare a portion of the site representative of the "managed succession" conditions *as designed* (Figure 2) to:

- the pre-existing conditions on the same site (Figure 3), and
- the most similar planting typology found at the "traditional" landscape reference site at East River State Park (Figure 4).

For the condition *as designed*, plant species were obtained from the planting plans and plant schedules included in the Issued for Bid Construction Documents by Michael Van Valkenburgh Associates (MVVA).

Figure 2. *Pier 1 Managed Succession/Dense Hedgerow Areas.*

[8] F. Swink and G. Wilhelm. *Plants of the Chicago Region, 4th ed.* Indianapolis: Indiana Academy of Science, 1994.

[9] Mid-Atlantic Wetlands Workgroup. "Floristic Quality Assessment Index (FQAI)". http://www.mawwg.psu.edu/tools/detail/floristic-quality-assessment-index-fqai

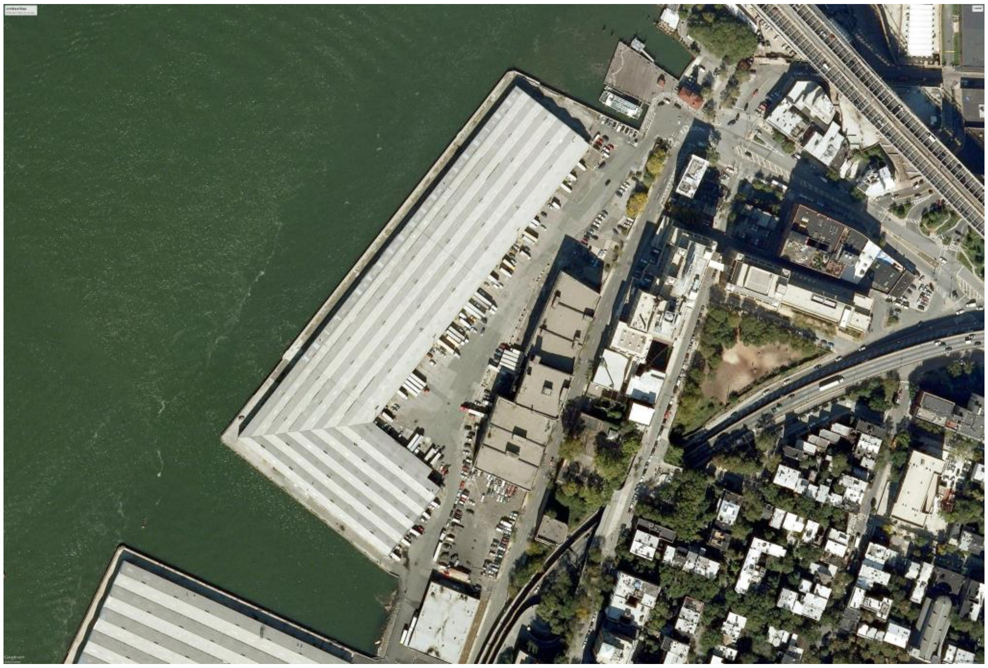


Figure 3. *Pier 1 Pre-existing condition. 40°42'06.02" N 73°59'46.85" W. GOOGLE EARTH. September 30, 2006.*

For the pre-existing condition, based on historic site photographs and historical aerials (Figure 3), the areas constituting the managed succession study areas is assumed to be unvegetated in the pre-existing industrial warehouse and parking lot condition. The pre-existing conditions FQI is assumed to be 0.

For the "traditional" park reference site, the managed succession FQI at BBP was compared to the most similar planting typology found at East River State Park. Since the managed succession areas at BBP are typically located along paths with the primary design intent of structuring spaces and framing views[10], the closest equivalent use at East River State Park is a double row of monocultural shade trees planted along the main entry path (Figure 4). The vegetation at East River State Park was inventoried on-site by the research team and utilized for the vegetative comparisons found within this document.

[10] Nik Elkovitch, MVVA Senior Associate. Interview with UPenn research team. New York, April 13, 2016.

Figure 4. *East River State Park Reference Planting: double row of monocultural shade trees. Landscape Architecture Foundation (Sean McKay, CSI 2016)*

The species lists for Brooklyn Bridge Park and East River State Park were entered into the online Universal FQA Calculator[11] using the New Jersey Region database, the most geographically accurate database available for the study site. Species that were present on site but not present in the database were excluded from the FQI calculations (Figures 5,6).

[11] Freyman, William A. "Universal FQA Calculator". http://universalfqa.org/

Brooklyn Bridge Park Dense Hedgerow: Designed Conditions

Conservatism-Based Metrics:

Total Mean C:	3.6	
Native Mean C:	4	
Total FQI:	23.1	
Species Richness:		
Total Species:	41	
Native Species:	35	85.40%
Non-native Species:	6	14.60%

Scientific Name	Native?	C	Common Name
Aronia arbutifolia	native	5	chokeberry, red
Asclepias tuberosa	native	1	butterfly-weed
Baccharis halimifolia	native	4	groundsel-tree
Clethra alnifolia	native	5	pepperbush, sweet
Comptonia peregrina	native	3	sweet-fern
Cornus racemosa	native	3	dogwood, gray; swamp
Cornus sericea	native	7	dogwood, red-osier
Distichlis spicata	native	9	marsh spike-grass
Gleditsia triacanthos	non-native	0	honey-locust
Ilex verticillata	native	5	winterberry
Liatris spicata	native	8	blazing-star, dense
Liquidambar styraciflua	native	1	sweet-gum
Magnolia virginiana	native	5	magnolia, sweetbay
Myrica pensylvanica	non-native	0	bayberry
Panicum virgatum	native	3	grass, switch
Prunus maritima	native	7	plum, beach
Prunus serotina	native	1	cherry, wild black
Prunus virginiana	native	2	cherry, choke
Quercus bicolor	native	7	oak, swamp white
Quercus coccinea	native	6	oak, scarlet
Quercus palustris	native	3	oak, pin
Quercus prinus	native	4	oak, chestnut
Rhus aromatica	native	4	fragrant sumac
Rhus copallina var. copallina	native	2	shining sumac
Rhus glabra	native	2	sumac, smooth
Rhus typhina	native	2	sumac, staghorn
Ribes hirtellum	native	10	northern wild gooseberry
Robinia pseudoacacia	native	0	black locust
Rosa blanda var blanda	native	5	meadow rose/ smooth rose
Rosa carolina	native	4	rose, pasture
Rosa rugosa	non-native	0	rugosa rose
Rubus allegheniensis	native	3	blackberry, common
Rubus idaeus var. strigosus	native	2	red raspberry
Rudbeckia hirta var. hirta	non-native	0	black-eyed-susan
Sassafras albidum	native	2	sassafras
Spiraea tomentosa	native	5	steeple-bush
Symphoricarpos albus var. albus	native	0	snowberry
Viburnum dentatum	native	5	arrowwood, southern
Viburnum opulus	non-native	0	guelder-rose
Viburnum prunifolium	native	5	viburnum, blackhaw
Viburnum trilobum	non-native	9	cranberry, highbush

Figure 5. *Brooklyn Bridge Park Designed Dense Hedgerow FQI.*

East River State Park Entry Row Monoculture

Conservatism-Based Metrics:

Total Mean C:	0	
Native Mean C:	0	
Total FQI:	0	

Species Richness:

Total Species:	1	
Native Species:	0	0%
Non-native Species:	1	100%

Scientific Name	Native?	C	Common Name
Gymnocladus dioica	non-native	0	kentucky coffee-tree

Figure 6. *East River State Park FQI.*

Limitations:

Turfgrass understory at East River State Park was excluded from FQI calculations. Typical turfgrass species used on New York State projects[12] such as Kentucky bluegrass (*Poa pratensis)* and perennial ryegrass (*Lolium perenne*) are not native and have a C value of 0, therefore not contributing to the FQI.

FQI calculation for Managed succession initial conditions at Brooklyn Bridge Park is based on 100% CD design drawings rather than installed material. Based on interviews with MVVA staff, specified plant material availability was confirmed during design so that few species substitutions were needed during construction, so the difference in FQI calculations is assumed to be minimal. In cases where a species was not present in the FQI database, it was excluded from the calculation.

Sources:

Interviews and email correspondence with MVVA Staff. Conducted between 03/16 and 05/16.
Michael Van Valkenburgh Associates. Brooklyn Bridge Park *100% Construction Documents*. PDF.
Existing Site Photography Provided by MVVA.
On-site vegetation inventory at East River State Park conducted by the research team on 5/17/16.

Environmental Benefit 5

Increased Biomass Density Index from 0.15 to an estimated 2.43 relative to existing site conditions. This BDI is nearly three times greater than that of a nearby traditionally designed waterfront park (0.84).

Methodology:

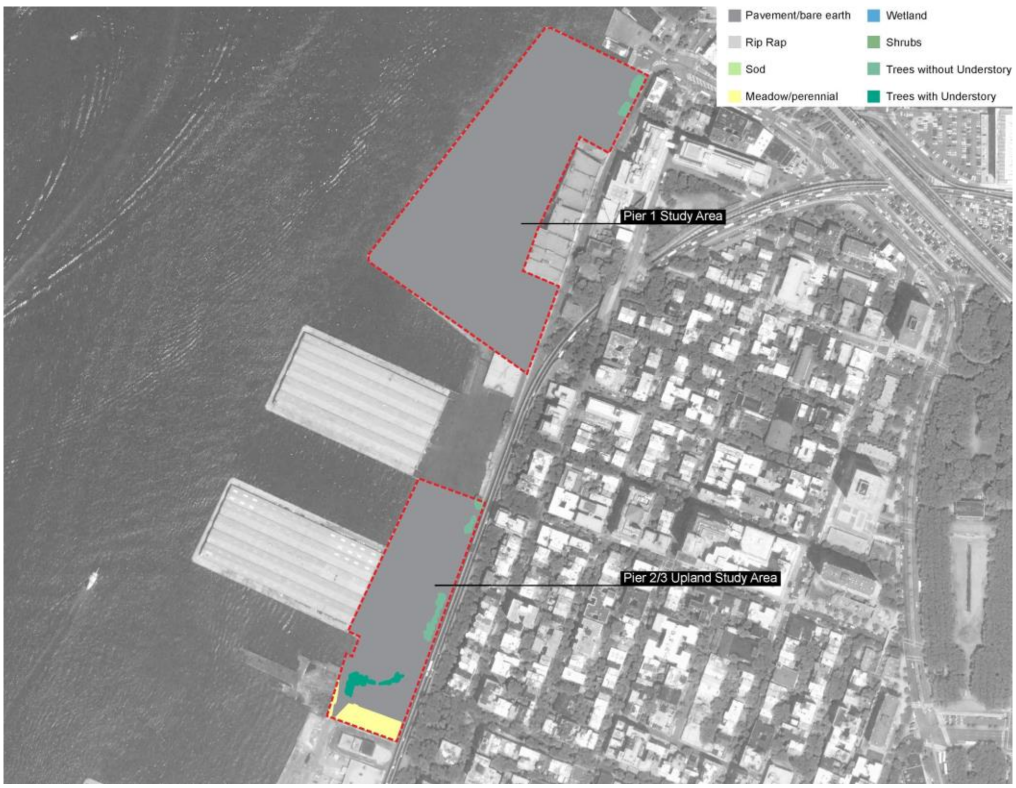
Biomass density is used as an indicator of ecosystem services provided by vegetation with higher vegetative biomass being generally indicative of greater number and quality of ecosystem services.[13] The Biomass Density Index (BDI) is the primary metric used by SITES to quantify ecosystem services provided by vegetation. BDI assigns coefficient constants to general vegetative coverage categories and accounts for percentage of site area for each coverage type. A higher BDI value is indicative of greater biomass density.

[12] Based on New York State Standard and Specification for Recreation Area Improvement. http://www.dec.ny.gov/docs/water_pdf/sec3part2sub1.pdf

[13] Calkins, Meg. *The Sustainable Sites Handbook: A Complete Guide to the Principles, Strategies and Best Practices for Sustainable Landscapes.* Wiley. 2012.

The BDI was calculated for 1) the pre-existing landscape condition and 2) the designed landscape condition for Pier 1 and Pier 3-4 Uplands, as well as 3) the traditional reference waterfront park landscape at East River State Park. BDI was calculated in accordance with the methodology outlined by SITES credit 4.6: *Preserve or Restore Appropriate Plant Biomass on Site*. Area takeoffs for each of the 3 calculations were based on the following, respectively:

1) Site aerials obtained from Google Earth Pro dated 3/31/2006 and site photographs obtained from MVVA depicting the pre-existing condition. The pre-existing site conditions were primarily unvegetated, with small areas of volunteer vegetation. These areas were characterized for calculation purposes based on the available photography and historic aerials. (Figure 7)
2) 100% Construction Documents provided to the research team by MVVA. (Figure 8)
3) Site aerials from Google Earth Pro dated 9/6/2015, on-site photography and verification, and on-site vegetation survey conducted on 5/17/16. (Figure 9)



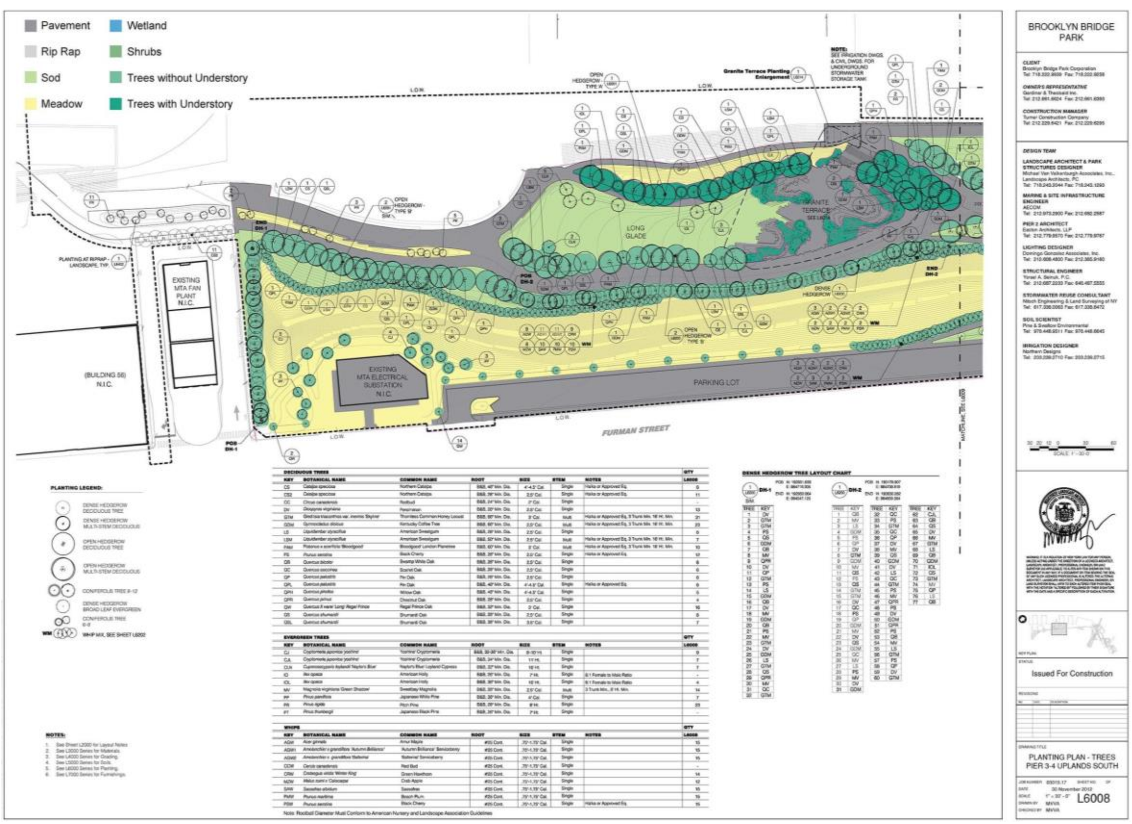
Brooklyn Bridge Park Pre-existing Conditions BDI

Land Cover/vegetation type zones	Biomass density index for this zone	Area (sq. ft.)	Percent of total site area for this zone	Biomass density value x % of total site area
Trees w/understory	6	7165.80	0.82	0.05
Trees w/out understory	4	72393.35	8.27	0.33
Shrubs	3		0.00	0.00
Annual plantings	1.5		0.00	0.00
Grasslands and turfgrass	2	109680.61	12.53	0.25
Wetlands	6		0.00	0.00
Impervious cover	0	685849.76	78.37	0.00

Total BDI	**0.63**

Figure 7. *Brooklyn Bridge Park Pre-existing Conditions BDI*


Pavement
Wetland
Rip Rap
Shrubs
Sod
Trees without Understory
Meadow
Trees with Understory
HARBOR VIEW MEADOW
NORTH SALT MARSH
WETLAND TERRACES
BRIDGE VIEW MEADOW
OPEN WATER
PIER 1
EAST RIVER
PIER ONE PARCEL A
BROOKLYN BRIDGE PARK
100% Construction Documents
PLANTING PLAN - PIER 1 - TREES
L6005


Pavement
Wetland
Rip Rap
Shrubs
Sod
Trees without Understory
Meadow
Trees with Understory
EXISTING MTA FAN PLANT N.I.C.
(BUILDING 56) N.I.C.
EXISTING MTA ELECTRICAL SUBSTATION N.I.C.
LONG GLADE
PARKING LOT
FURMAN STREET
BROOKLYN BRIDGE PARK
Issued For Construction
PLANTING PLAN - TREES PIER 3-4 UPLANDS SOUTH
L6008

Brooklyn Bridge Park Pier 1 + 2/3 upland BDI

Land Cover/vegetation type zones	Biomass density index for this zone	Area (sq. ft.)	Percent of total site area for this zone	Biomass density value x % of total site area
Trees w/understory	6	112282.21	17.95	1.08
Trees w/out understory	4	59420.84	9.50	0.38
Shrubs	3	9161.61	1.46	0.04
Annual plantings	1.5	0.00	0.00	0.00
Grasslands and turfgrass	2	198541.05	31.73	0.63
Wetlands	6	30478.44	4.87	0.29
Impervious cover	0	215758.77	34.49	0.00

Total BDI	**2.43**

Figure 8. *Brooklyn Bridge Park Design Conditions BDI.*

East River State Park BDI

Land Cover/vegetation type zones	Biomass density index for this zone	Area (sq. ft.)	Percent of total site area for this zone	Biomass density value x % of total site area
Trees w/understory	6	1044.54	0.26	0.02
Trees w/out understory	4	20048.68	5.04	0.20
Shrubs	3	2210.69	0.56	0.02
Annual plantings	1.5	0.00	0.00	0.00
Grasslands and turfgrass	2	119961.12	30.17	0.60
Wetlands	6	0.00	0.00	0.00
Impervious cover	0	254312.01	63.97	0.00
			Total BDI	**0.84**

Figure 9. *East River State Park BDI*

Limitations: BDI was based on general area of the planting indicated on the landscape plan. On-site observation revealed that species, quantity and location of vegetation has shifted relative to landscape plans provided by MVVA. Such shifts include differing tree species and locations due to tree mortality, relocated and replaced material, maintenance practices and appearance and propagation of introduced tree, shrub and perennial species. Given the coarse categorization of vegetation and reliance on area takeoffs for the calculations, it is unlikely that these shifts would have had a significant impact on the BDI calculations.

Sources:

Brooklyn Bridge Park. 40°42’05.11” N 73°59’44.21” W. GOOGLE EARTH. March 31, 2008.
East River State Park. 40°43’118.29” N 73°57’41.00” W. GOOGLE EARTH. September 9,2015.
Michael Van Valkenburgh Associates. Brooklyn Bridge Park *100% Construction Documents*. PDF.

Environmental Benefit 6

Diverted over 90,000 cu yds of material from landfills by using salvaged fill material for the creation of the Pier 1 and sound berm topography. This represented a cost savings of roughly $2.88 million in comparison to provision of traditional sources of fill material.

Methodology:

The substantial topographic variation on Pier 1 and the construction of the sound berm were made more financially feasible through the salvage of base clean fill material. Fill material was sourced from tunneling operations for the New York Metropolitan Transit Authority (MTA)'s Long Island Railroad Eastside Access Project.

40,000 cubic yards of this clean bulk fill underlies Pier 1 topography while an additional 50,000 cubic yards underlies the sound berm on Pier 2/3 uplands. According to designers at MVVA, typical sources of fill for projects in New York City cost roughly $32 per cu. yd.
90,000 cu. yds. of fill would cost $2,880,000 at this unit cost.

Limitations:

The quantities of fill provided are ballpark figures and may not reflect the precise quantity of fill used during construction. Savings estimate does not include any costs associated with shipping or placement of clean fill material.

Cost of typical sources of fill is a rough figure based on MVVA's local construction experience and expertise.

Sources:

http://www.brooklynbridgepark.org/pages/sustainability
Interviews and email correspondence with MVVA Staff. Conducted between 07/05 and 07/12.

SOCIAL BENEFITS

Social Benefit 1

Attracts an average of 127,307 weekend and 25,789 weekday visitors during summer months. 18.84% of 2015 users were from adjacent neighborhoods, and 63.54% were from other parts of New York City.

Methodology:
Brooklyn Bridge Park Conservancy conducts annual surveying and visitor counts in Brooklyn Bridge Park every summer. The Conservancy shared their most recent surveying results and visitor counts with the research team. These counts are included below as Appendix (A)

Limitations:
User counts and residence location represent parkwide totals and may include persons within the park but outside the defined study area.

Sources:
Brooklyn Bridge Park Conservancy. *2015 Usership Results*. PDF.

Social Benefit 2

Hosts over 664 programs and events annually.

Methodology:
Brooklyn Bridge Park Conservancy is responsible for all park programming and events within Brooklyn Bridge Park; the park's event calendar is available online. Events within the park are broken into 6 general categories:

- Arts and Culture
- Education and Environment
- Recreation
- Volunteer
- Fundraiser/Membership
- Kid Approved

The total number of events posted to the Park's event calendar were summed for calendar year 2016.

Limitations:
The events calendar does not categorize events by area of the park in which they are taking place, so total number of events for this benefit include all events taking place in the entirety of the park, and not just in the Pier 1 and Pier 3-4 Uplands study area. Some of these events may be occurring entirely in areas of the park outside the defined study area, or partially within and partially outside the defined study area.

Sources: http://www.brooklynbridgepark.org/events/

Social Benefit 3

Reduces noise levels by 10.4 dB, with sound levels from Brooklyn-Queens Expressway traffic averaging 64.1dB behind the sound berm as compared to an average of 74.9dB where no sound berm is present. A 10 dB reduction reduces perceived sound levels by half.

Methodology:

Because BBP is located directly adjacent to the Brooklyn-Queens Expressway (BQE), a heavily-trafficked double-decker cantilevered interstate highway built into the steep slope above the park, noise pollution and its potential adverse effects on social experience was a major concern for the design team. Because of the particular geometry of the cantilevered highway (designed to take advantage of the steep slope and provide a cantilevered pedestrian promenade above it), traffic sound is reflected and concentrated in the direction of the park. The relatively constant stream of traffic on both levels of the highway, plus occasionally loud traffic on Furman Street below, results in omnipresent traffic noise in a large portion of the park with direct line-of-sight of the BQE, making normal conversations difficult (normal conversations take place between 50-65 dB while typical New York traffic is in the 70-85 dB range[14]). BBP's sound berm was a design move intended to buffer the sound of the BQE in order to provide a quieter park experience.

The pre-existing site noise levels were measured by acoustic consultant Cerami & Associates at 82dB adjacent to the Brooklyn Queens Expressway and 75dB at the waterfront. Their acoustical analysis of the proposed sound berm prior to construction estimated a reduction to 68dB along the waterfront (Figure 20).

85dB	*Level at which hearing damage begins with 8 hour exposure.*
82dB	*Roughly equivalent to a diesel train at 45mph at 100' away*
75dB	*Roughly equivalent to music in a living room; Roughly equivalent to a dishwasher; Above the threshold at which interference with a telephone conversation occurs*
68dB	*Roughly equivalent to a central air conditioner at 20' away*

Figure 19: *Selected Examples of Sound Equivalents*
Sources: Industrial Noise Control. "Comparative Examples of Noise Levels." http://www.industrialnoisecontrol.com/comparative-noise-examples.htm; Bureau of Land Reclamation. "Apprendix E: Noise," Navajo Reservoir RMP/FEA. June 2008. https://www.usbr.gov/uc/envdocs/ea/navajo/appdx-E.pdf; Norwall Power Systems. "Generator Noise Levels - How Loud Are They." http://www.norwall.com/blog/generator-information/generator-noise-levels-how-loud-are-they-2/

[14] New York City Department of Environmental Protection. *A Guide to New York City's Noise Code*. http://www.nyc.gov/html/dep/pdf/noise_code_guide.pdf

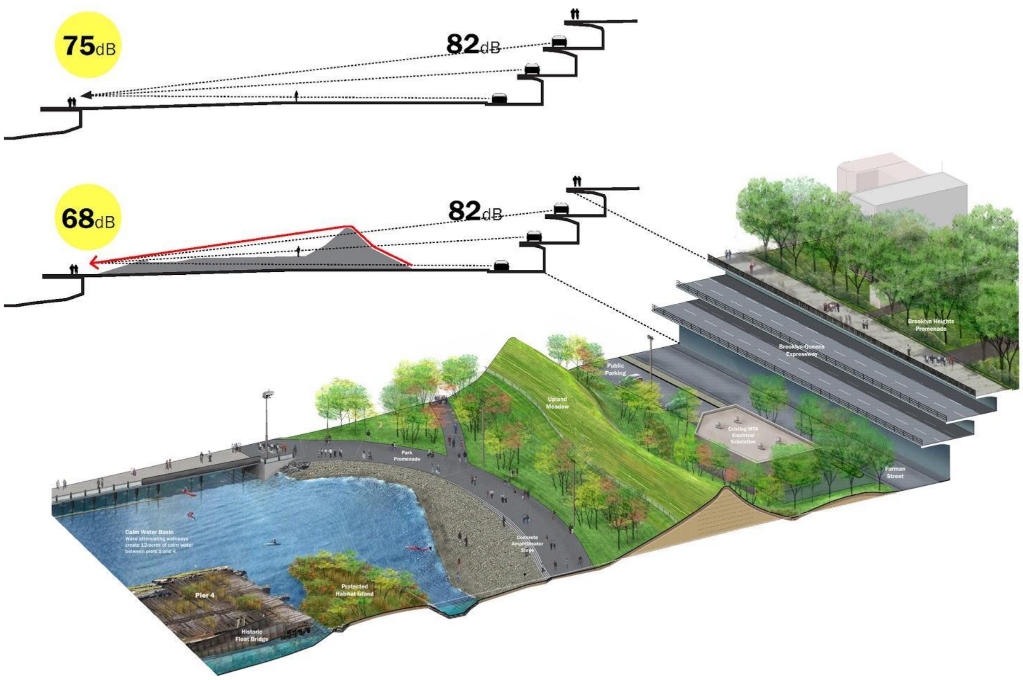


Figure 20. *Noise Attenuation Landscape. Brooklyn Bridge Park Primer. (Source: MVVA)*

The research team measured sound levels on-site at a number of at regularly spaced locations along to the sound berm on the BQE side, adjacent to the sound berm on the Brooklyn Bridge Park side, and along the waterfront (Figure 21). Due to on-site construction and maintenance, certain areas of the park were closed off during data collection, mandating some adjustment in the field to sampling locations, as indicated.

Figure 21. *On-Site Site Sound Measurement Location Plan*

Sound levels were measured on June 29, 2016 using an Apple iPhone 4s smartphone with a MicW i436 external microphone, employing the SoundMeter 8.3.2 iOS application by

Faber Acoustical. The SoundMeter app and microphone were selected because of their superior accuracy based on a third-party comparative study of smartphone sound measurement applications for iOS and Android devices.[15]

Sound measurements were taken at 2 times during the day: once during a period a freely flowing traffic on the BQE (between 10:30am-11:15am), and once during slow-moving rush hour traffic on the BQE (between 5:30pm-6:05pm). For each study, a 30-second sample was recorded at each sampling location and the average dB volume noted. Sound recordings were taken with the goal of capturing the baseline background sound conditions. If any sonic disturbances diverging from the typical sound condition (airplane and helicopter flyovers, emergency vehicle sirens) occurred during a recording, the recording was stopped and restarted once the abnormal disturbance sound had subsided.

The average dB reading at each sample point during free flowing traffic periods (Figure 22) and rush hour traffic (Figure 23) are presented below. Rush-hour traffic moves more slowly than freely flowing traffic, and is typically quieter because tire-pavement noise and engine/exhaust noise of traffic increases with speed. The research team also found that the sound measurement of freely flowing traffic was much more consistent over time, as it was not subject to random starts and stops.

For measuring the social benefit of traffic noise reduction, the research team used freely flowing traffic.

Figure 22. *Freely flowing traffic noise levels*

---

[15] Kardous, Chucri and Shaw, Peter. *Evaluation of Smartphone Sound Measurement Applications.* National Institute for Occupational Safety and Health. Published online 21 March 2014. http://scitation.aip.org/content/asa/journal/jasa/135/4/10.1121/1.4865269

Figure 23. *Rush hour traffic noise levels*

xx.x Avg. dB over 30 sec. sample period

To calculate the benefit, the logarithmic average of the 4 sampling positions directly behind the sound berm (**64.6**dB, as the average of 61.3 + 66.6 + 63.0 + 65.6) during freely flowing traffic was compared to the logarithmic average of the 3 sampling positions along the same transect where no sound berm was present (**75**dB, as the average of 75.6 + 73.1 + 75.9).

The research team also calculated the benefit at the water's edge by comparing the logarithmic average of the 3 sampling positions along the waterfront that were behind the sound berm (**67.9**dB, as the average of 61.2 + 69.9 + 68.8), the logarithmic average of the 3 sampling positions along the waterfront where no sound berm was present (**72.7**dB, as the average of 65.5 + 75.4 + 72.5). The observed noise reduction at the waterfront can thus be said to be a logarithmic average of 4.8dB. The research team believes that the waterfront was considerably louder than the observed levels immediately behind the sound berm because of an array of ambient environmental sounds coming from the river and from Manhattan -- most notably, the sound of lapping waves breaking against the shoreline, the sound of boats and ferries on the river, and the sound of helicopters flying over the river and taking off/landing at the Wall Street heliport in Manhattan -- and not due to traffic noise from the BQE.

Limitations:

The sample size for the calculation is small, as it is based on a single day of measurement. Given the number of factors that affect volume levels, and the inability to isolate the sound measurement to traffic *only*, it is not possible to determine how much of the observed sound reduction is directly attributable to the sound berm.

Sound levels also fluctuate in response to traffic pulses and chance events, and thus may fluctuate based on date and time of day at which they are recorded. However, the observed consistency in sound readings, especially during periods of freely flowing traffic, indicate that an average sound measurement for a consistent nuissance traffic noise can indeed be discerned, and suggests a strong relationship between the presence of the sound berm and the observed reduction in noise levels behind it.

Finally, it should be noted that the research team only measured overall sound *intensity*, and did not differentiate between sound *quality*. While it generally holds true that louder sounds will constitute larger annoyances and disruptions, individual observers will have differing and subjective thresholds, and some sounds may be relatively loud yet be perceived positively or neutrally (water, waves, bird calls, music, children, etc.) by observers, rather than as nuisance disturbances.

Sources:

MVVA. *Brooklyn Bridge Park Primer*. PDF.
MVVA. "Sound". *Brooklyn Bridge Park*. PDF. Unpublished draft of forthcoming publication.

ECONOMIC BENEFITS

Economic Benefit 1

Generates revenues to cover 100% of costs, approximately $10.9 million, for park maintenance and operations.

Methodology:

The Brooklyn Bridge Park Corporation (BBPC) is the not-for-profit entity responsible for park financing, operations and maintenance. BBPC originally developed a financial model in 2005 during the park's planning, and annually updates the financial model, refining projections for anticipated future revenues and expenses. The park's annual revenues, expenditures and model updates are released annually and are publicly accessible through the Brooklyn Bridge Park website.[16] [17] The research team reviewed available financial records and conducted an interview with David Lowin, BBPC's Vice President, Real Estate. The park's current annual operating expenditures are approximately $10 million. Future expenditures are projected for the financial model through 2064 (Figure 25).

[16] http://www.brooklynbridgepark.org/pages/project-approvals-and-presentations
[17] http://www.brooklynbridgepark.org/pages/financial-information

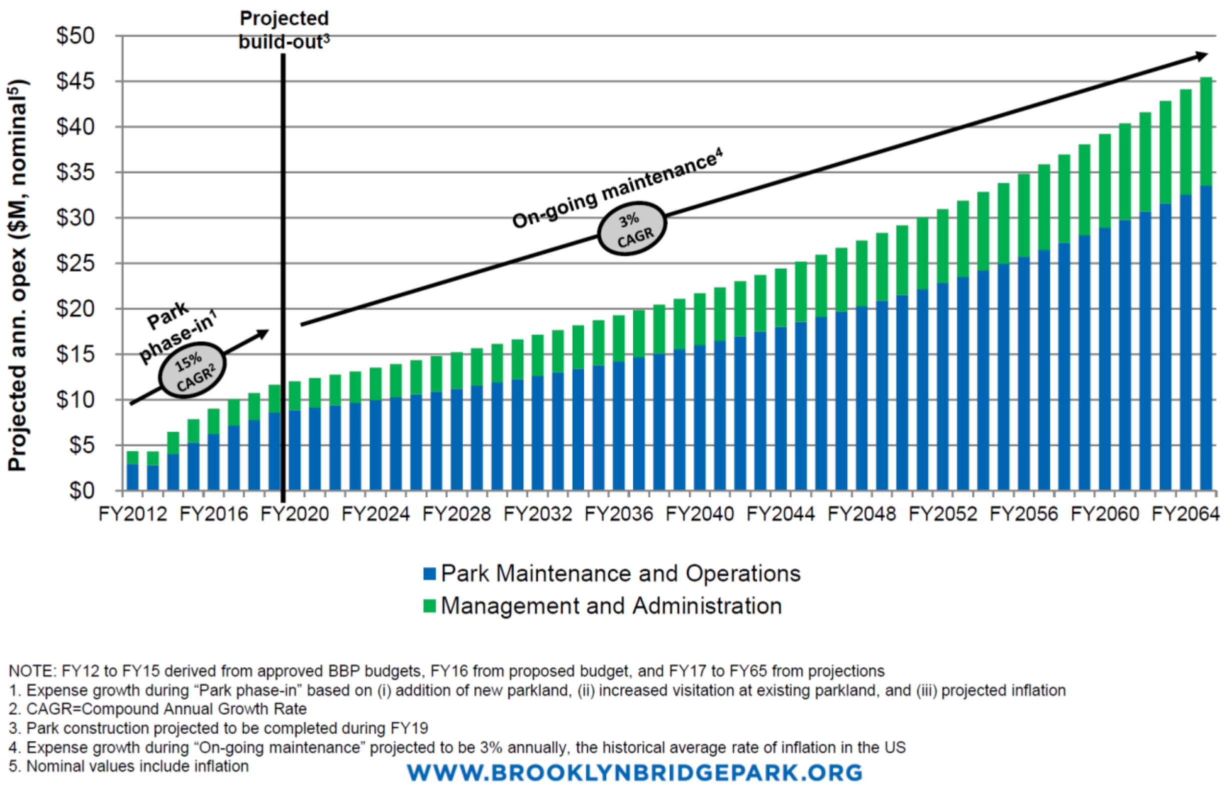


Figure 25. *Brooklyn Bridge Park Operating Expenses. (Source: Brooklyn Bridge Park Corporation)*

A major additional expenditure for the park as a whole moving forward is the repair of the marine infrastructure -- timber piles, concrete extensions, bulkheads, concrete pier decks and rip-rap and natural shorelines -- that make up large portions of the park (Figure 26).

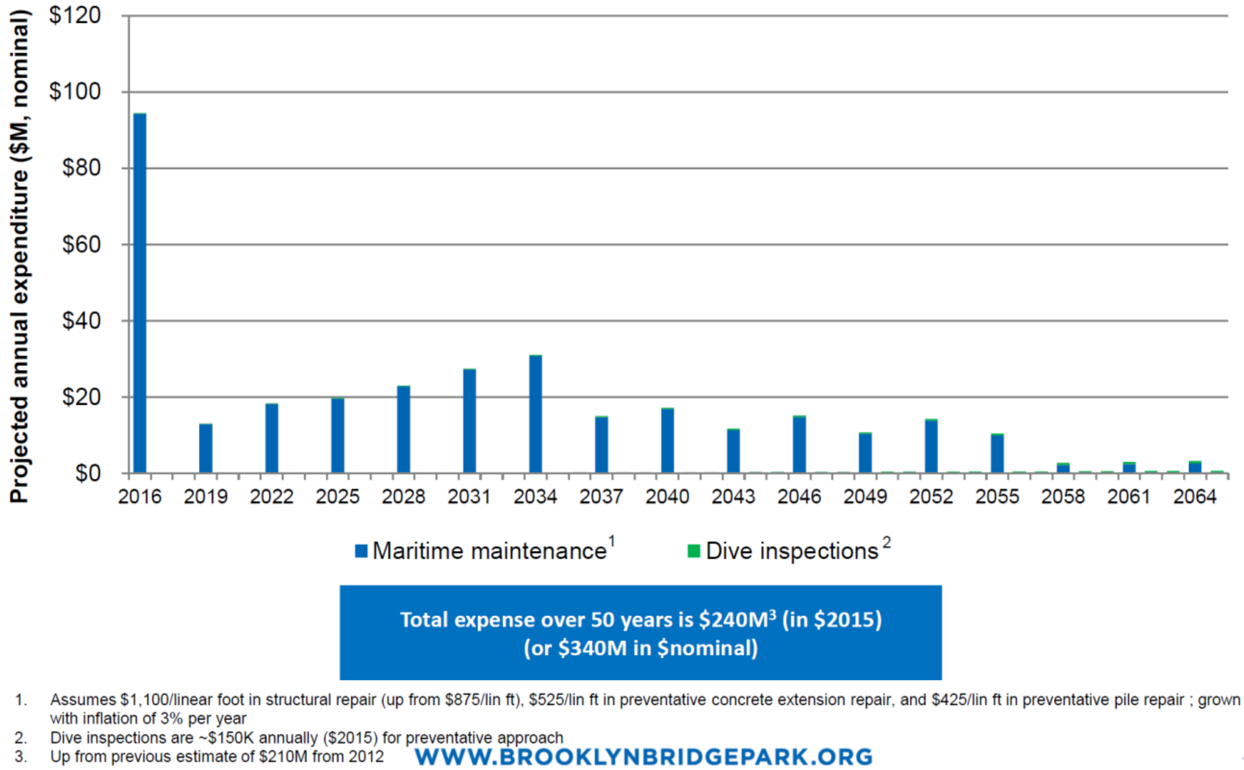


Figure 26. *Brooklyn Bridge Park Marine Infrastructure Expenditures. Brooklyn Bridge Park Corporation*

Park revenues are generated through a number of sources but the primary source is real estate development within the park. This generates one-time revenues in the form of upfront rent, payment in lieu of sales tax (PILOT) and payment in lieu of mortgage recording tax (PILOMRT) (Figure 27), and recurring revenues primarily in the form of annual rents from the development sites (approximately 84% of recurring annual revenue). Additional revenue sources include concessions, parking, permits, events and a marina (noted as "Other" revenues in financial models) (Figure 28). Future recurring revenues are projected for the financial model through 2064 (Figure 29).

Site	One-time rev ($M)
One Brooklyn Bridge Park	$4
Pier 1	$27
John Street[3]	$31
Empire Stores	$32
TOTAL	**$93**

Figure 27. *Development Parcel One-time Revenue Generation. Brooklyn Bridge Park Corporation*

	Rev. per year ($2015 in M)[5]
OBBP	$2.3
Pier 1[6]	$3.2
John St.[7]	$1.0
Empire Stores[6]	$2.7
Other[8]	$1.7
TOTAL	**$10.9**

Figure 28. *Annual Revenue Generation. Brooklyn Bridge Park Corporation*

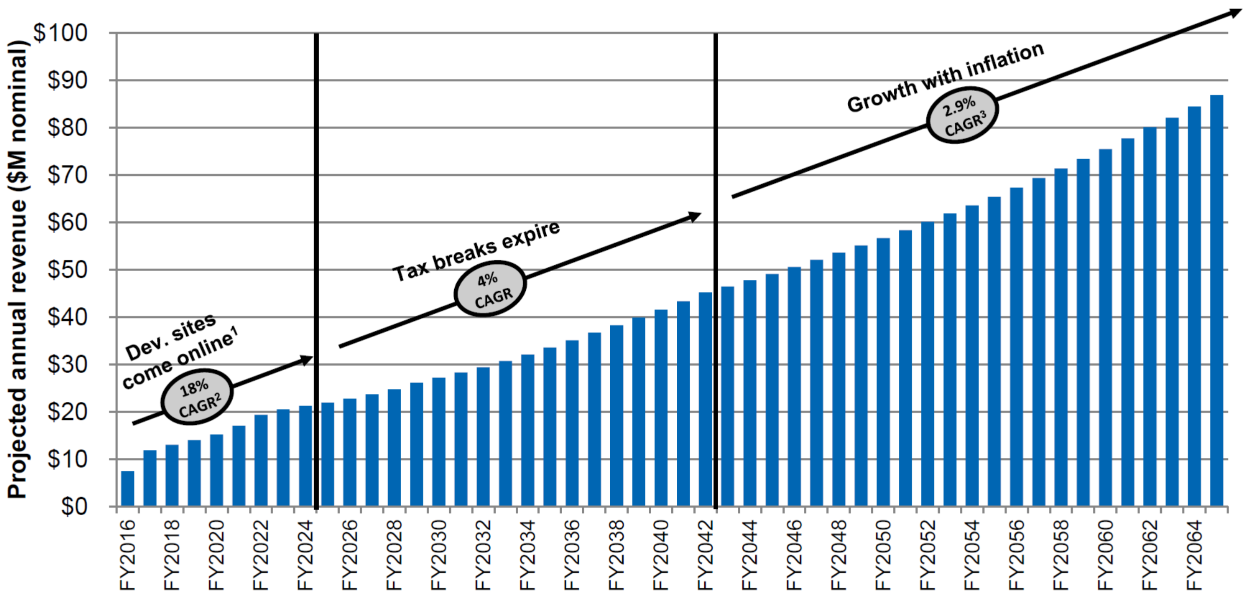


Figure 29. *Annual Revenue Generation. Brooklyn Bridge Park Corporation*

The financial modelling considers these expenditures and revenues as well as costs of future park project phases and additional revenues from future development parcels to project future cash balance and income. Based on these inputs, current financial modelling shows the park to be financially self sustaining through 2064 (Figure 30).

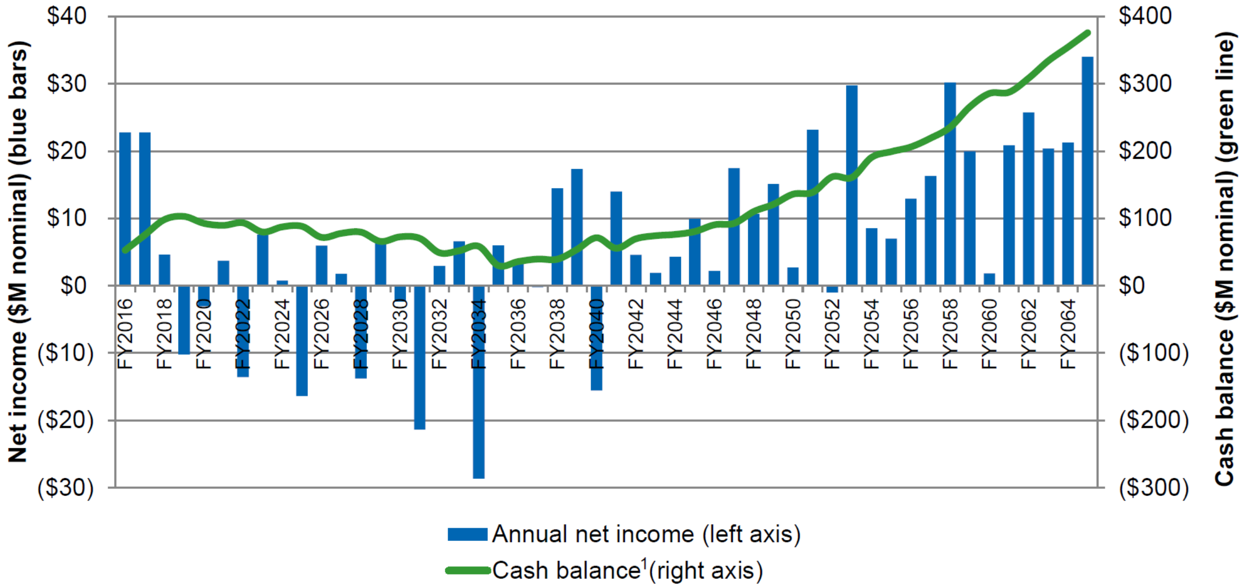


Figure 30. *Projected Net Income and Cash Balance. Brooklyn Bridge Park Corporation*

Limitations:

Benefit quantification is based on financial model reports provided to the research team by Brooklyn Bridge Park Corporation. The precise modelling inputs and many of the assumptions made within the model were not explicitly stated to the research team.

Sources:

Brooklyn Bridge Park Corporation. *Financial Model Update: Public Presentation*. 07/9/16. PDF. https://brooklynbridgepark.s3.amazonaws.com/p/2925/BBP%20Financial%20model%20for%20July%20Public%20Presentation%2007%2009%2015b.pdf

Brooklyn Bridge Park Corporation. *Brooklyn Bridge Park Financial Statements*: Years Ended June 30, 2015 and 2014. PDF. https://brooklynbridgepark.s3.amazonaws.com/p/3508/FY15%20Audited%20Financial%20Statements.pdf

Appendix

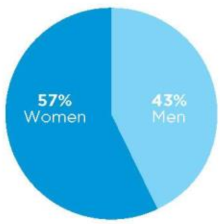
Appendix A

Brooklyn Bridge Park Conservancy Survey Information

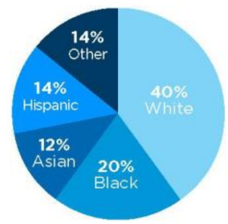
Parkwide | Usership Profile Summer 2015

Average Attendance: Weekend 127,307 | Weekday 25,789

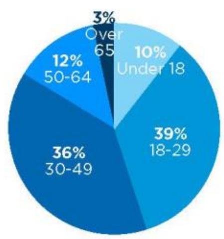
Gender



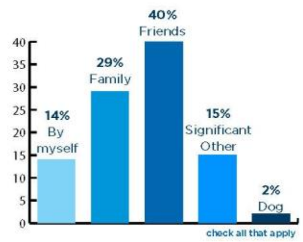
Ethnicity



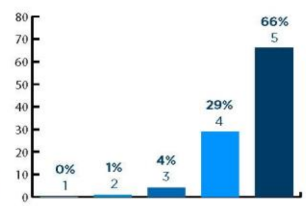
Age



Who did you visit with?



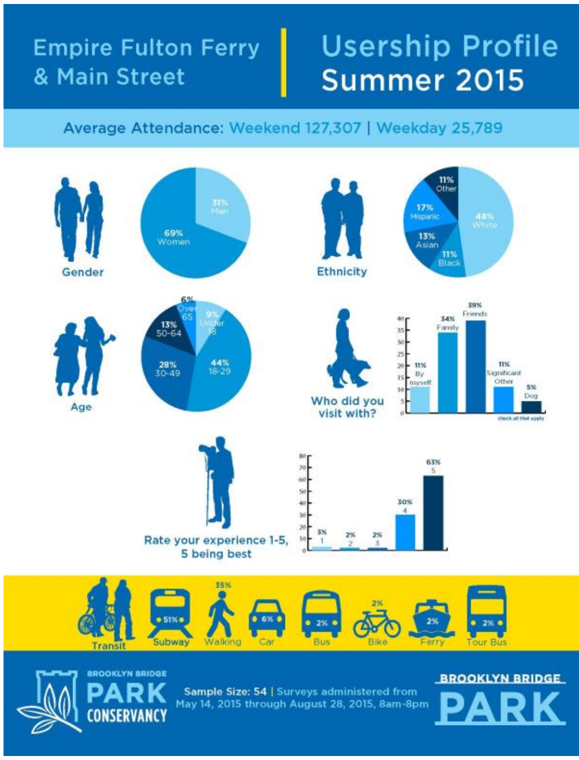
Rate your experience 1-5, 5 being best

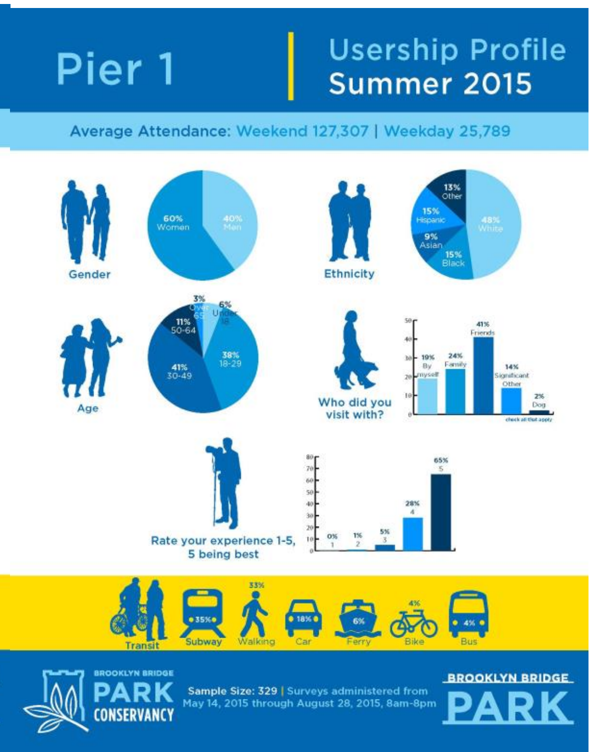


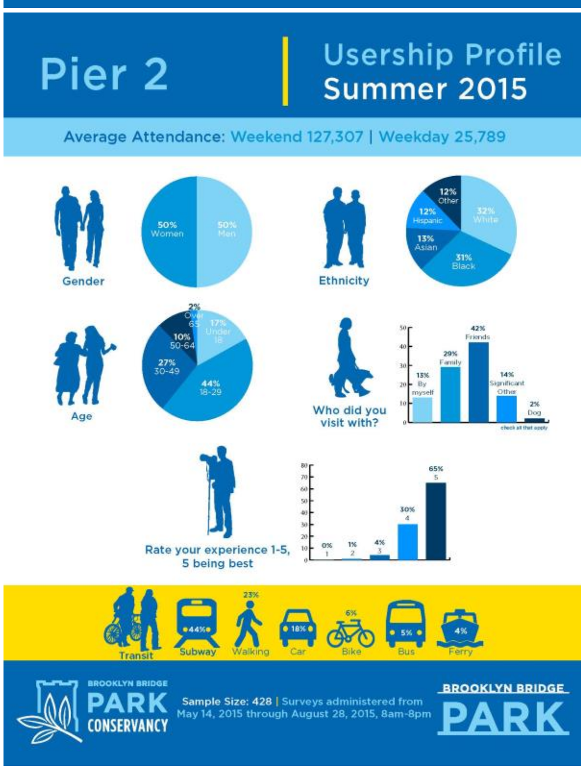
BROOKLYN BRIDGE PARK CONSERVANCY

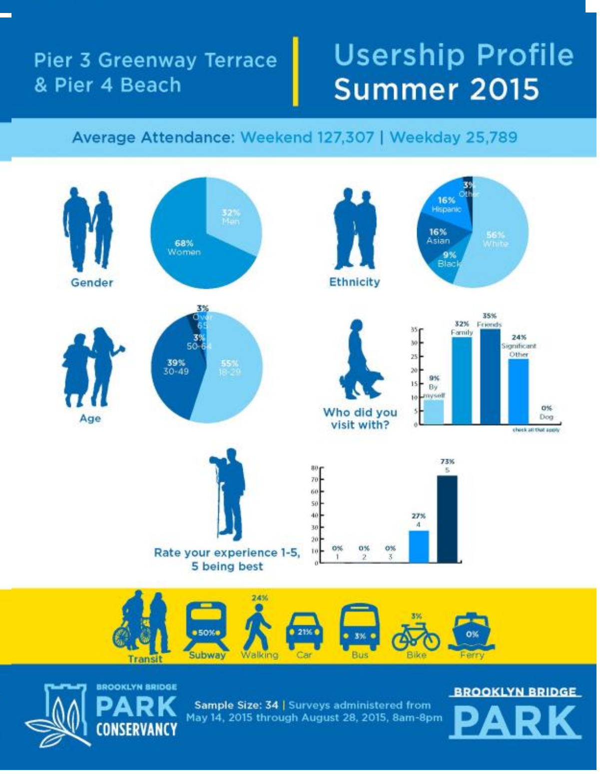
Sample Size: 1,253 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm

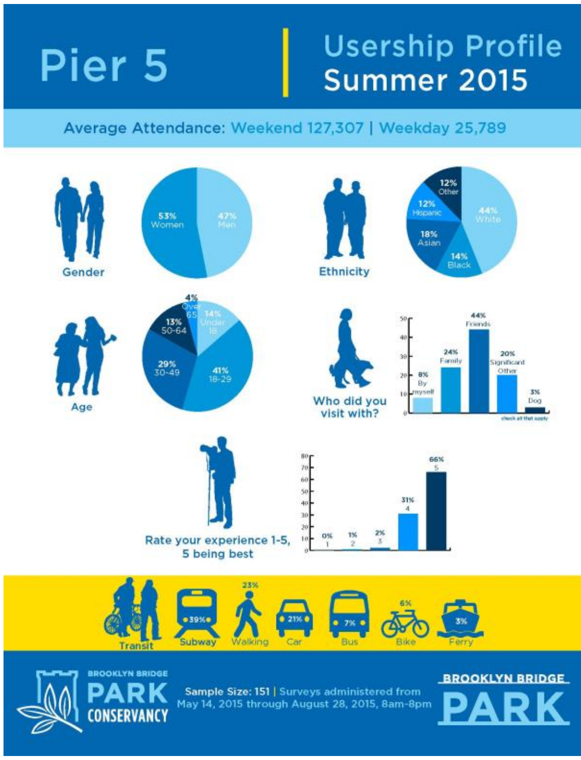
BROOKLYN BRIDGE PARK

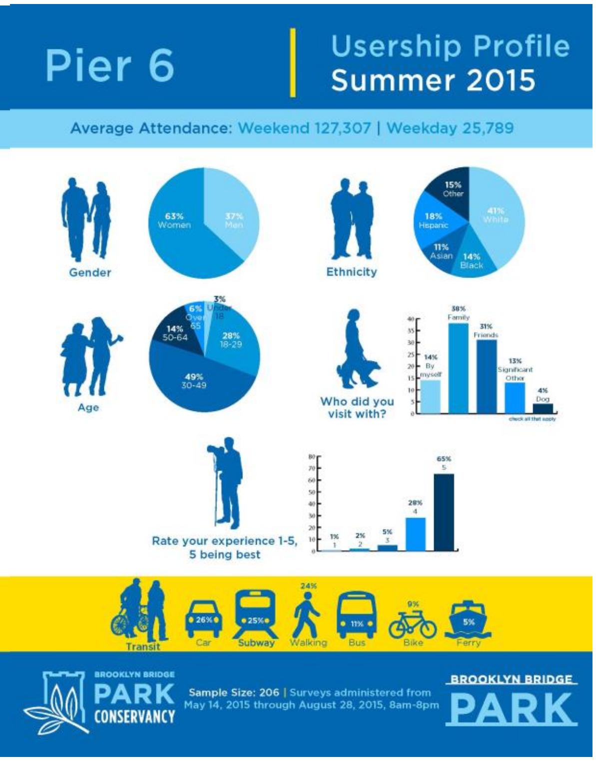

Empire Fulton Ferry & Main Street
Usership Profile Summer 2015
Average Attendance: Weekend 127,307 | Weekday 25,789
Gender
31% Men
69% Women
Ethnicity
11% Other
17% Hispanic
13% Asian
11% Black
48% White
Age
6% Over 65
9% Under 18
13% 50-64
28% 30-49
44% 18-29
Who did you visit with?
11% By myself
34% Family
39% Friends
11% Significant Other
5% Dog
check all that apply
Rate your experience 1-5, 5 being best
3% 1
2% 2
2% 3
30% 4
63% 5
Transit
51% Subway
35% Walking
6% Car
2% Bus
2% Bike
2% Ferry
2% Tour Bus
BROOKLYN BRIDGE PARK CONSERVANCY
Sample Size: 54 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm
BROOKLYN BRIDGE PARK


Pier 1
Usership Profile Summer 2015
Average Attendance: Weekend 127,307 | Weekday 25,789
Gender
60% Women
40% Men
Ethnicity
13% Other
15% Hispanic
9% Asian
15% Black
48% White
Age
3% Over 65
6% Under 18
11% 50-64
41% 30-49
38% 18-29
Who did you visit with?
19% By myself
24% Family
41% Friends
14% Significant Other
2% Dog
check all that apply
Rate your experience 1-5, 5 being best
0% 1
1% 2
5% 3
28% 4
65% 5
Transit
35% Subway
33% Walking
18% Car
6% Ferry
4% Bike
4% Bus
BROOKLYN BRIDGE PARK CONSERVANCY
Sample Size: 329 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm
BROOKLYN BRIDGE PARK


Pier 2
Usership Profile Summer 2015
Average Attendance: Weekend 127,307 | Weekday 25,789
Gender
50% Women
50% Men
Ethnicity
12% Other
12% Hispanic
13% Asian
31% Black
32% White
Age
2% Over 65
17% Under 18
10% 50-64
27% 30-49
44% 18-29
Who did you visit with?
13% By myself
29% Family
42% Friends
14% Significant Other
2% Dog
check all that apply
Rate your experience 1-5, 5 being best
0% 1
1% 2
4% 3
30% 4
65% 5
Transit
44% Subway
23% Walking
18% Car
6% Bike
5% Bus
4% Ferry
BROOKLYN BRIDGE PARK CONSERVANCY
Sample Size: 428 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm
BROOKLYN BRIDGE PARK


Pier 3 Greenway Terrace & Pier 4 Beach
Usership Profile Summer 2015
Average Attendance: Weekend 127,307 | Weekday 25,789
Gender
32% Men
68% Women
Ethnicity
3% Other
16% Hispanic
16% Asian
9% Black
56% White
Age
3% Over 65
3% 50-64
39% 30-49
55% 18-29
Who did you visit with?
9% By myself
32% Family
35% Friends
24% Significant Other
0% Dog
check all that apply
Rate your experience 1-5, 5 being best
0% 1
0% 2
0% 3
27% 4
73% 5
Transit
50% Subway
24% Walking
21% Car
3% Bus
3% Bike
0% Ferry
BROOKLYN BRIDGE PARK CONSERVANCY
Sample Size: 34 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm
BROOKLYN BRIDGE PARK


Pier 5
Usership Profile
Summer 2015
Average Attendance: Weekend 127,307 | Weekday 25,789
Gender
53% Women
47% Men
Ethnicity
12% Other
12% Hispanic
18% Asian
14% Black
44% White
Age
4% Over 65
14% Under 18
13% 50-64
29% 30-49
41% 18-29
Who did you visit with?
8% By myself
24% Family
44% Friends
20% Significant Other
3% Dog
check all that apply
Rate your experience 1-5, 5 being best
0% 1
1% 2
2% 3
31% 4
66% 5
Transit
39% Subway
23% Walking
21% Car
7% Bus
6% Bike
3% Ferry
BROOKLYN BRIDGE PARK CONSERVANCY
Sample Size: 151 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm
BROOKLYN BRIDGE PARK


Pier 6
Usership Profile
Summer 2015
Average Attendance: Weekend 127,307 | Weekday 25,789
Gender
63% Women
37% Men
Ethnicity
15% Other
18% Hispanic
11% Asian
14% Black
41% White
Age
3% Under 18
6% Over 65
14% 50-64
28% 18-29
49% 30-49
Who did you visit with?
14% By myself
38% Family
31% Friends
13% Significant Other
4% Dog
check all that apply
Rate your experience 1-5, 5 being best
1% 1
2% 2
5% 3
28% 4
65% 5
Transit
26% Car
25% Subway
24% Walking
11% Bus
9% Bike
5% Ferry
BROOKLYN BRIDGE PARK CONSERVANCY
Sample Size: 206 | Surveys administered from May 14, 2015 through August 28, 2015, 8am-8pm
BROOKLYN BRIDGE PARK