Brooklyn Bridge Park:
Storm Resilience through Design

During the early stages of the Brooklyn Bridge Park design process, careful thought was given to shoreline conditions and site location. Due to BBP's waterfront location and the consideration of climate change and rising sea levels, Michael Van Valkenburgh Associates (MVVA), the park's landscape architect, made a conscious effort to design a park capable of withstanding the impact of storms and major floods. With this thinking in mind, the park's elevation, soil types, vegetation and edge design were all carefully selected and constructed. This past autumn's Super Storm Sandy was the first true test as to whether these design elements were successful in protecting the Brooklyn Bridge Park during extreme weather incidents.

Topography

Brooklyn Bridge Park's topography helped to protect the park, and its plants and trees from sea level rise during the storm surge.

During the design process, MVVA took into consideration the NOAA water level predictions for 2045. With a predicted mean high water level increase of +1.32' and a 100 year storm surge of +7.80', an +8' elevation was selected. To be responsive to the predicted water levels, all of the park's tree root balls have been planted at or above +8' to protect from the vast majority of storm surges.

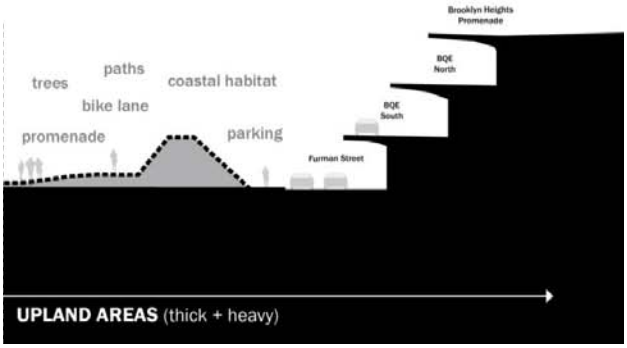

Figure 1. Landforms throughout the park uplands.

Furthermore, the park design employs dramatic increases in topography to transform the site. By using hundreds of thousands cubic yards of imported fill from the East Side access excavation in Sunnyside Yards, the park's elevation is increased at Pier 1 and throughout the park's uplands to reach as high as 30 feet. This new topography acts as barriers to impending water level rise.

Figure 2. Pier 1 topography. Credit: Julienne Schaer.

This design element was identified as successful in the wake of Super Storm Sandy, since much of the debris and floodwaters were blocked by these new land formations.

Horticulture

Salt tolerant species hold up against flood waters and river spray.

The plants at Brooklyn Bridge Park appear to be doing well in the months after the flooding from Super Storm Sandy. Thoughtful design placement and post storm management contribute to BBP's optimism that the park's horticultural losses will be minimal.

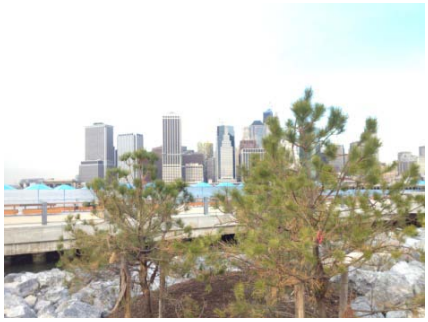

Figure 3. Pitch pines along the BBP's stabilized edge, one of several species of salt-tolerant plants in the Park.

In addition to strategic placement discussed above, the plant palette at the park was specifically selected for salt tolerance. Plants such as Rosa rogusa, pitch pine, and cottonwood are coastal plants that evolved in high salt environments. They have fared well against spray from the East River in the past and BBP expects to see their healthy growth in the upcoming spring season.

While the long term affects of the salt water inundation remains to be seen, our hope is that proper post-storm management following the storm will contribute to the survival of the park's horticulture. Immediately following the storm, BBP's horticulture team began flushing salt from the soils using the park's irrigation system. While salinity levels were high immediately following the storm, these levels quickly declined and it appears that Super Storm Sandy was a good test of the resilience of these grasses, plants, and trees.

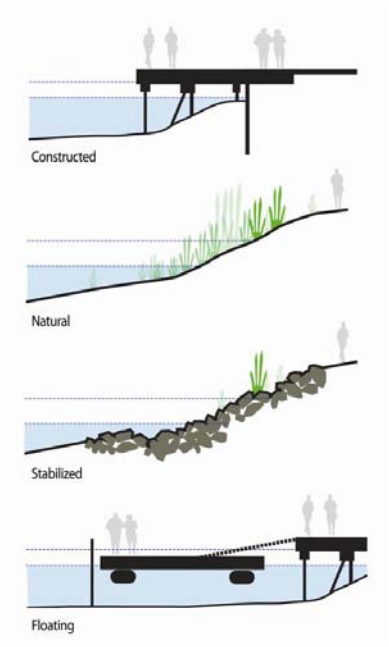

Figure 4. BBP's various edge types. Credit: MVVA.

Several other factors can contribute to the survival of BBP's plants. The soil profile selected for park use has a high sand content, which helped salts drain exceptionally quickly. Further, the nor'easter that followed Super Storm Sandy was a benefit for the park's plants, as the rain facilitated the flush of salt out of the soils.

Stone Shoreline Stabilization

Brooklyn Bridge Park incorporates several edge types into its design. The park's natural and stabilized rip rap edge types were major factors in its ability to diminish the force of waves and withstand the storm.

The stabilized edges and revetment slopes greatly contributed to Brooklyn Bridge Park's resilience during the storm. Stone rip rap acted as a buffer for the violent wave action produced by the storm and provided significant protection of the shoreline. These

rocky edges are much more durable than solid walls and do not fracture or break the way vertical-wall bulkheads do. During park construction, the original relieving platforms were removed and replaced with the more durable rip rap. Once complete, Brooklyn Bridge Park will stretch 1.3 miles along the East River, and of this length roughly 4,045 linear feet will be revetment slope with stabilized rip rap edge.

BBP also uses natural edges in its design. The Salt Marsh at the southern edge of Pier 1 was built to mimic a naturally occurring edge and played an important role in helping to protect the Park during the storm surge. In addition to protecting the upland area, the Salt Marsh played an important role in filtering the storm water.

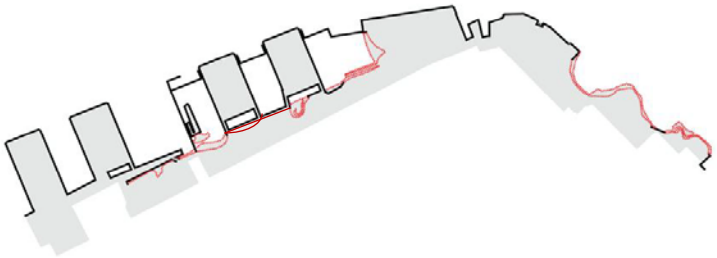

Figure 5. BBP's constructed rip rap edges. Credit: MVVA.

Sustainable Materials

The use of salvaged materials directly contributed to the resilience of Brooklyn Bridge Park during the storm.

Longleaf yellow pine wood salvaged during the deconstruction of the Cold Storage Warehouses on the uplands of Pier 1 was used to build park benches and cladding for park buildings. Longleaf Yellow Pine is known for its incredible tensile strength. Other sustainable materials,

Figure 6. From left, park benches constructed from Salvaged Longleaf Yellow Pine, Willis Avenue Bridge granite. Credit: Julienne Schaer.

such as salvaged granite from nearby bridge reconstruction projects, were used in the park's design and proved successful in protecting and stabilizing the landscape against storm impacts. In addition, as part of the park's sustainable design, BBP uses salvaged materials from the original Port Authority site. Mast lighting, mooring cleats, steel frame sheds and pier signs all survived the storm.

Structural Stability

All of the Brooklyn Bridge Park's piers remained stable despite the storm surge and wave action produced by the storm.

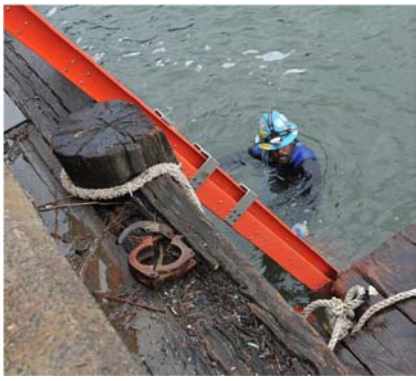

Figure 7. Marine engineers performing pile repairs. Credit: Julienne Schaer.

Brooklyn Bridge Park's piers are the original structures built by the Port Authority in the 1950s. In order to extend the life of the piers, BBP restores the structures through pile encapsulation. Due to the constant tidal action, overtime, dry rot fungus has degraded the timber piles. By encapsulating the timber piles with concrete, they are protected from tidal shifts so that the fungus cannot survive and further deteriorate the piles. To date, BBP has encapsulated over 1,900 timber piles, and through this work, BBP has been able to greatly extend the life of these piers by reinforcing the piles and increasing stabilization. BBP's maintenance of the piles may have contributed to the piers' ability to withstand the storm and will likely aid in their long-term durability.

Development Sites

The park plan also includes a handful of residential and commercial development sites along the park's urban edge to generate funds that will fulfill BBP's mandate to be financially self-sufficient for park maintenance and operations expenses. Many of the development sites are located at, or slightly below, the 100-year flood plain and experienced flooding during Superstorm Sandy. In addition to the park design elements already discussed, BBP will be working with the selected developers of these sites to ensure that each of these projects incorporates the most up-to-date flood protection measures in their design to further enhance the park's flood resiliency.

Working together with the City of New York and the development community, BBP has been closely monitoring waterfront developments around the City and has identified a series of flood prevention measures that have been most effective in minimizing any negative impacts of the recent storm. BBP is encouraging all developers of park development sites to incorporate as many of these measures into their designs as is feasible. These flood prevention measures include:

- Raising the ground elevation above and beyond the flood plain levels;
- Placing mechanical and electrical equipment on higher floors;
- Adding redundant mechanical and electric systems;
- Adding flood proof enclosures to minimize the penetration of water;
- Using damage resistant materials on ground floor and basement.

The design for the Pier 1 hotel and residential development, recently awarded to Toll Brothers City Living and Starwood Capital Group, has already incorporated many of these measures. Going forward, BBP will continue to track the latest building technology improvements to ensure that development projects in the park are among the forefront of flood resiliency.