STRUCTURES OF COASTAL RESILIENCE: DESIGN STRATEGIES FOR STORM RISK REDUCTION AT JAMAICA BAY, NEW YORK

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1 ABSTRACT
This proposal for enhancing coastal resiliency at Jamaica Bay, New York consists of strategic design recommendations for the Rockaway Peninsula, the central marsh islands, and Back Bay communities. These recommendations, developed in a progressive academic research laboratory with the support of USACE, embrace the vast scale of Jamaica Bay as an asset for exploring USACE’s new focus on developing nature-based features as viable coastal storm risk reduction techniques. The Jamaica Bay resiliency plan includes three strategies developed through field research and modeling, both physical and digital. The first strategy addresses water quality and the reduction of back-bay flooding via a series of over wash plains, tidal inlets, and flushing tunnels at the Rockaway Peninsula and Floyd Bennett Field. The second strategy develops enhanced verges at Robert Moses’ Belt Parkway and elevates of coastal edges at vulnerable back-bay communities, managing flood risk with a layered system of marsh terraces, berms, and sunken attenuation forests. The third strategy develops novel techniques of bay nourishment and marsh island restoration through maximizing the efficacy of minimal quantities of dredged material. This “island motor / atoll terrace” would align with local cycles of maintenance dredging. Dredged material from maintenance dredging may be beneficially reused to nourish the Rockaways’ coastal beaches, enhance the bay’s marsh islands, and create living shorelines at the back-bay perimeter. A resilient marsh ecosystem provides coastal storm risk management services to adjacent communities through wind and wave attenuation, delivering maximum immediate benefits for both vulnerable communities and the disappearing salt marsh islands.

1.1 Keywords
Coastal resiliency, salt marsh islands, dredged material, sediment capture, nature-based features
2 THE STATE OF THE BAY

Since Hurricane Sandy’s landfall along the Atlantic seaboard in October 2013, the word “resilience” has loomed large as coastal communities and government agencies assess their preparedness for the potential of future storm events and the uncertain certainties of climate change and sea level rise (Schultz et al, 2012). Former New York City Mayor Michael Bloomberg was quick to organize the Special Initiative for Risk and Reconstruction (SIRR), with a dedicated team producing a 445-page report and recommendations within during the summer of 2013. At a national level, the United States Army Corps of Engineers, defenders of the nation’s navigable waterways and coastlines, was tasked by Congress in January 2013 to prepare a Comprehensive Study of the eastern seaboard affected by Sandy, a close scrutiny of the possible future of the post-Sandy coastal landscape from Virginia to Maine. This $19.5 million study, led by the North Atlantic Division of USACE and titled the North Atlantic Coast Comprehensive Study (NACCS), was delivered to Congress in January 2015, and review and comment by interested parties on the massive report is ongoing (USACE, 2015).

Structures of Coastal Resilience (SCR) was conceived as a progressive multi-university academic research paradigm, working in parallel with USACE’s Comprehensive Study schedule. This eighteen-month multi-university collaborative study, fully funded by the Rockefeller Foundation, provides a focused look at designing for resilience at four coastal embayment sites along the East Coast within the Corps’ greater study area. The four sites and four university teams, each lead by a landscape architect or architect, are Narragansett Bay, Rhode Island, Harvard University; Jamaica Bay, New York, City College of New York; Atlantic City, New Jersey, Princeton University; and Norfolk, Virginia, University of Pennsylvania. Though the work of SCR is not officially part of USACE’s study, these projects have been reviewed, advised, and informed by continuing discussions with both members of the North Atlantic Division and those in the regional district offices. This direct contact with the Corps has reframed the designers’ resiliency thinking, pushing the limits of comfortable and known niches. The ambition is that these academic studies, and the design thinking they have engendered, might indeed have some impact on the Army Corps as well.

The Comprehensive Study addresses storm risk reduction strategies and promotes resilient communities along the coast, while considering future climate change and sea level rise scenarios (Figure 1). Perhaps most interestingly, given USACE’s traditional reliance on engineered hard structures for coastal

![Figure 1](image-url). Merged topobathy DEM of Jamaica Bay (left) and the Jamaica Bay resiliency plan (right), showing strategic recommendations for the Rockaway Peninsula, the central salt marsh islands, and the back-bay perimeter. Images courtesy of SCR Jamaica Bay Team

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engineering, the study examines the integration of what USACE has termed natural and nature-based features (NNBF) into their lexicon of risk reduction measures—a radical paradigm shift (Bridges, 2013; USACE, 2013). NNBFs include such features as dunes, oyster and coral reefs, barrier islands, maritime forests, and wetlands (Nature Conservancy, 2013). Often the benefits and performance of these features increase with scale. And that is perhaps the most invaluable quality of Jamaica Bay, New York, the study site of the City College of New York university research team, led by landscape architect Catherine Seavitt Nordenson, with research associates Kjirsten Alexander, Danae Alessi, and Eli Sands.

The Rockaway peninsula and the back bay communities of Jamaica Bay were massively impacted by Hurricane Sandy’s surge and extensive flooding. The bay has been environmentally challenged since its early days as New York City’s dumping ground (Moses, 1938; NYCDEP, 2007; NYCDEP, 2012). Since the 1970s, the reduction of the marsh island footprints within the bay has severely increased, likely due to the combined anthropogenic impacts of poor water quality, nutrification, erosion, and sediment starvation (Hartig, 2002). Yet, given its vast scale, Jamaica Bay has the potential to be recast as an impactful ecological, infrastructural, and community asset, becoming an anchor of the region’s resiliency. And for the Army Corps, it provides an incredible design opportunity for exploring the performance of nature-based features, particularly salt marshes, maritime forests, and dunes. Jamaica Bay is a dynamic ecological entity, an estuarine embayment in a post-glacial outwash plain, a sandy, shifting terrain geologically capable of functioning resiliently during and after disturbance events. The City College of New York’s adaptive resiliency design proposals for Jamaica Bay seek to enhance that capability.

3 EXPERIMENTAL RESEARCH STUDIO

The SCR Jamaica Bay Team is not an academic studio, but an experimental research studio within the academic setting at City College of New York. This grant-funded research studio reflects a distinct shift in the discipline. Recently, several landscape architecture educators and practitioners have argued that the range of the discipline is expanding, and evolving. And several expect that landscape architecture’s range of inquiry in the earth, ocean, and atmospheric sciences is approaching (or perhaps has already become) a STEM / STEAM discipline. In some ways, this Jamaica Bay research studio, and the SCR project in general, may represent another phase shift toward a new model of a research-driven, laboratory-based academy, with work led by principal investigators in the discipline of landscape architecture.

Inspired by interaction with the Army Corps and research into their historic methodologies during a visit to Vicksburg, Mississippi, the Jamaica Bay research studio is modeled as a contemporary version of the Waterways Experiment Station (WES), established by USACE in 1930 in response to the Great Mississippi Flood of 1927. A 673-acre complex in Vicksburg, Mississippi, WES is the Army Corps’ hydraulics research laboratory facility and the site of the Engineer Research and Development Center (ERDC) headquarters. WES built large-scale hydraulic physical models of the Mississippi River, Chesapeake Bay, and the New York Harbor in order to test flood control structures and the effects of longshore drift. While ERDC still works with hydraulic physical models, their research has substantially shifted to digital modeling. Yet the think-tank atmosphere of experimentation is still present, and ERDC’s affiliated engineers and scientists are actively involved with the study of natural and nature-based features that figure prominently in the Comprehensive Study.

At the City College Jamaica Bay lab, a large number of physical models have been produced, from the scale of the watershed to the detailed marsh platform, resulting in a deep understanding of the morphology of the bay. Five of these are water tank models, constructed to test the dynamic conditions of water flow, residence time, overwash, sediment transfer, and surge (Figure 2). The hydrodynamic effects produced are somewhat coarse, but the precision of the Jamaica Bay topobathy model through which the water flows allows for the iterative study of design scenarios with subtle physical transformations. These water tank models are topographic contour models cast in glycerin, a forgiving material which allows for quick transformations and manipulations to the topography during the flow experiments. The empirical results of the water tank experimental studies, captured in video, have provided integral feedback to the design.

In the digital realm, a highly refined digital elevation model (DEM) of the topobathy of Jamaica Bay has been built, seamlessly merging topographic (land) and bathymetric (water depth) data. This continuous surface is integral to the conceptual understanding of terrain as a gradient surface, a
transformable basin containing the dynamic medium of water. The DEM is used in both its existing condition and with proposed design modifications to create comparative analyses of the efficacy of the design proposals using digital hydrodynamic modeling tools such as the SLOSH (Sea, Lake and Overland Surges from Hurricanes) model, SLAMM (Sea Level Affecting Marshes Model), and the wind fetch raster generator WAVES2012, an ArcGIS toolbox plug-in.

Figure 2. CNC-milled topobathy model of Jamaica Bay with watertank flow and residence time test. Image courtesy of SCR Jamaica Bay Team

But getting out of the lab in order to ground-truth in the field is critical. Broad Channel, Queens, is an unexpected community on a marsh island in the middle of the bay. Like Jorge Luis Borges' fabled one-to-one map of the kingdom, Jamaica Bay itself is a full-scale research lab. Friendships have been forged with local environmentalists in Broad Channel. The EcoWatchers (Dan Mundy, Jr. and Dan Mundy, Sr.) have been an incredible source of knowledge, particularly regarding marsh island restoration. Don Riepe, the Jamaica Bay Guardian and director of the American Littoral Society's Northeast Chapter, has provided support and access to over thirty years of his photographic archive of Jamaica Bay imagery. Current observation and the mapping of both low and high tide lines in the marshes have been critical for locating the proposed placement of elevated terraces for sediment traps. Data collection and ground-truthing is done in tall rubber boots, Trimble in hand, Avenza tracking on NOAA's chart 12350 enabled on iPhones. Tide charts are critical. The research team walks to islands during extreme low tides. Visits are timed with the incoming tides to access the back bay inlets in Don Riepe's boat, with mean tides for quad copter overflights, and with unnaturally high tides for surveying flooded streetscapes in Howard Beach.

Another resource developed as part of the work in the research studio is the Pamphlet Library, consisting of sixteen topical pamphlets and three reference manuals, which are compiled as a structured repository for accumulated data. Inspirations include by the "semiotext(e)" model of carefully curated translations of French philosophy for an American pocket, and the low-tech hand-printed-and-folded "cordel" literature and poetry of the northeastern Brazilian troubadours, self-published pamphlets hung from a cord with clothespins and sold in town squares.

Each pamphlet is a both a reference and a tool. Some compile aerial imagery, some are photographic field notebooks, some contain collections of coastal infrastructural inventions. Most address in some way the complex cultural, ecological, and infrastructural systems at this complex embayment. (Black, 1981). As a set, the pamphlets comprise the thoughts and research that influenced and informed the team's resiliency strategies and designs for Jamaica Bay. They are also intended to be a resource for others, and may lead to future research directions.

"Experimental Marsh Island Restoration at Jamaica Bay" was the first pamphlet, evolving from a need to understand the techniques, processes, locations, and lessons learned from USACE New York
District’s innovative and unprecedented island restorations at the bay. Another pamphlet, “The Air above Jamaica Bay” explores the conflicts between the marsh restoration initiative and FAA-controlled airspace, given that high marsh provides a fantastic breeding habitat for birds that can potentially take down an aircraft. The Port Authority of New York and New Jersey’s bird depredation techniques are examined and quantified—the FAA’s most-wanted. “The Bottom of Jamaica Bay” showcases bathymetric scans and video stills of benthic habitat, providing a fascinating look at those otherwise unseen species floating in the water column and crawling around on the bottom.

4 ADAPTIVE DESIGN STRATEGIES FOR JAMAICA BAY

The SCR Jamaica Bay team has identified a holistic set of strategic design recommendations supporting coastal resiliency at Jamaica Bay, inclusive of the Rockaway Peninsula, the central marsh islands, and the tributary inlets at the ay’s interior perimeter. The project seeks to address social, environmental, and infrastructural vulnerability, with the goal of enhancing the overall resiliency of Jamaica Bay. These proposals reflect a set of ideas emerging from USACE that attempt to merge its more recent environmental restoration projects with traditional flood protection and erosion control practices.(USACE, 2013). The Army Corps is a large bureaucratic ocean liner of an organization, but the Comprehensive Study is the beginning of a paradigm shift. For USACE, it’s not about flood control any more, nor is it flood protection. It’s about the management of risk. The new terminology at the Army Corps is coastal storm risk management (CSRM). And now ecosystems are included in this thinking—ERDC produced a post-Sandy study arguing that salt marsh island restoration projects at Jamaica Bay effectively reduced wind fetch, and thereby the potential for erosive undermining of the Cross Bay Boulevard North Channel Bridge, a critical infrastructural evacuation route for Broad Channel and the Rockaway Peninsula (Burks-Copes, 2013).

The Jamaica Bay-wide resiliency master plan includes three strategies, merging novel techniques of ecosystem restoration with layered nature-based features (Figure 3). First, the improvement of water quality and the reduction of residence time and back-bay flooding via a series of overwash plains, tidal inlets, and flushing tunnels at the Rockaway Peninsula and Floyd Bennett Field. Second, the strategic verge enhancement of the Belt Parkway and elevation of coastal edges at vulnerable back-bay communities to manage flood risk via a layered system of marsh terraces, berms, and sunken attenuation forests. Third, the development of novel strategies of bay nourishment and salt marsh island restoration

Figure 3. The “island motor” concept uses natural processes to capture sediment through the use of an “atoll terrace” perimeter ridge at the marsh islands. Images courtesy of SCR Jamaica Bay Team
through maximizing the effects of the strategic placement of minimal quantities of dredged material. This feature, dubbed the “island motor / atoll terrace,” would align with local cycles of maintenance dredging.

### 4.1 Flow and Circulation

An important consideration in the design strategy is the improvement of both water quality and hydrologic flow throughout Jamaica Bay. Reducing residence time, particularly in the easternmost reaches of the Bay, will support ecological and benthic health as well as ensure the success of restoration projects within the bay. Improving flushing through the introduction of tidal inlets, overwash plains, and flushing tunnels may also reduce impacts from surge by providing additional outlets for the retreat of floodwaters. In addition, reintroducing sediment sources from the ocean to the bay will support the nourishment and accretion of the wetland marsh islands.

At Edgemere, near the eastern end of the Rockaway Peninsula, with its relatively dense building footprint, both below-grade flushing tunnels and above-grade flow paths are included to improve bay-to-ocean circulation as well as provide a controlled trajectory for periodic floodwaters. At the western end of the Rockaway Peninsula, near Jacob Riis Park and Fort Tilden, there is much more open space. Here, tidal inlets and overwash plains are proposed as very shallow topographic modifications allowing for sediment delivery from ocean to bay. Low earthen berms limit the extents of the overwash plains and serve to protect the adjacent communities to the east (Figure 4).

![Figure 4](image-url) Design proposal for a tidal inlet and overwash plain at Jacob Riis Park at the western edge of the Rockaway Peninsula. Images courtesy of SCR Jamaica Bay Team

### 4.2 Verge Enhancement

Strategic gradient enhancement through the elevation of coastal edges at the vulnerable back-bay communities of Jamaica Bay is addressed through a layered system of marsh terraces, earthen berms, and attenuation forests, defined in sum as “verge enhancement.” The project also seeks to connect elevated earthen berms with existing high ground and the linear infrastructure of the Belt Parkway, recasting the verges of this transportation network as a continuous elevated buffer from Mill Creek to Canarsie and Howard Beach. These enhanced verges are foregrounded by low marsh, high marsh, and
upland planting zones, providing additional mitigation of wave energy as well as public space at the waterfront. Densely planted sunken maritime forests are established behind the berm.

Howard Beach is very low-lying back bay community that was extensively flooded during Sandy, and even experiences street flooding during high tidal cycles. Here, a continuous connection is created from existing high ground at the southwest to the launching of the Belt Parkway’s bridge over Spring Creek. A continuous elevated verge is created from the Spring Creek bridge at the west to the Bergen Basin and Lefferts Boulevard at the east. By providing closure structures below the Belt Parkway at Spring Creek and near the mouths of Shellbank and Hawtree Basins at 165th Avenue, this continuous enhanced verge has the capacity to provide the entire community with the equivalent protection of FEMA’s current 100-year base-flood elevation plus two feet of “freeboard” (Figure 5).

Figure 5. Design proposal for Howard Beach at Spring Creek, Shellbank Basin, and Hawthorne Creek, establishing a continuous earthen berm tying into high ground at the verges of the Belt Parkway. Images courtesy of SCR Jamaica Bay Team

4.3 Atoll Terrace / Island Motor

Salt marsh loss at Jamaica Bay is a paradigmatic example of environmental vulnerability, particularly given future sea level rise. A resilient marsh ecosystem provides coastal storm risk management services to adjacent communities through wind fetch reduction and wave attenuation. After assessing the methods and results of the innovative marsh island restorations at Jamaica Bay undertaken in partnership with the National Park Service, USACE, and local environmental NGOs, the project proposes novel strategies of bay nourishment and salt marsh island restoration through an “island motor,” maximizing the effects of the strategic placement of minimal quantities of dredged material as a perimeter “atoll terrace.” This elevated marsh terrace, formed specifically to reduce wave energy and encourage sediment deposition, provides an ideal slope for the upward migration of low marsh grass (Spartina alterniflora) and allows the natural processes of current-driven sediment capture and deposition to nourish the marsh, thus allowing it to accrete upward with sea level rise. Atoll terraces are arrayed at the perimeter of the marsh island footprints, positioned to best capture sediment given predominant current speeds, tidal flows, and sedimentary transport. The construction of the atoll terraces would be aligned with the availability of local dredged material and sequenced to provide maximum immediate benefits for the most vulnerable communities and marsh islands (Figure 6).
Figure 6. The “atoll terraces,” formed specifically to reduce wave energy and encourage sediment deposition, provide an ideal slope for the establishment and upward migration of low marsh grasses. Image courtesy of SCR Jamaica Bay Team

The atoll terraces, formed specifically to reduce wave energy and turbidity as well as encourage sediment deposition, will provide both an ideal slope for the establishment and upward migration of low marsh grasses (Spartina alterniflora) as well as conditions for achieving the water clarity and light penetration required for the successful establishment of submerged aquatic vegetation (Zostera marina). The team is also examining resilient plant selections for the marsh islands given climate change, such as SAVs that tolerate warmer waters and low marsh / high marsh species that are adaptive to wetter and warmer climates. Ensuring the future success (and indeed, the continued existence) of the salt marsh islands at Jamaica Bay requires the strategic use of dredged material resources, the improvement of water quality at the Bay, and a robust palette of plant material.

5 AN ADAPTABLE FRAMEWORK FOR JAMAICA BAY

The three proposed design strategies for coastal resilience at Jamaica Bay, developed through iterative research using physical and digital modeling as well as field investigations, are conceived as complementary and developed as an adaptable framework. Each of the three elements combines with the others, creating an enhanced, and resilient, Jamaica Bay, capable of responding to future sea level rise and storm risks over time while supporting the continued co-existence of nature and culture at the bay (Figure 7).
Figure 7. Resiliency Plan for Jamaica Bay, New York. Image courtesy of SCR Jamaica Bay Team

6 REFERENCES


