A NEW ERA OF RESTORATION AND REDEVELOPMENT IN BAYONNE, NJ:

RECONNECTING COMMUNITY TO UPPER NEW YORK BAY

By

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ABSTRACT

A New Era of Restoration and Redevelopment in Bayonne, NJ:

Reconnecting Community to Upper New York Bay

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Thesis Director:
Dr. Frank Gallagher

This thesis examines an intertidal area and surrounding shoreline along a portion of eastern Bayonne, New Jersey covering approximately 75.4-acres. The site is surrounded by Peninsula at Bayonne Harbor, the new redevelopment zone along the north, Upper New York Bay along the east, South Cove Commons shopping complex and Bayonne Golf Club along the south, and US Highway 440, Rail station, and residential areas along the west portion of the site. Much of the design focus is centered around improving waterfront access, circulation and use, along with water quality, stormwater management, and storm resiliency. This thesis also examines the history of the site and long-lost ecological systems once abundant along Bayonne. A broad analysis of past, present, and future conditions is included, followed by conceptualization, design modeling, and the development of various design proposals that activate, fortify, and rejuvenate this tucked-in intertidal mudflat.

ACKNOWLEDGEMENTS

This design thesis is the result of nearly two years of academic research and professional collaboration. Through the guidance and emotional support of my thesis committee and other contributors, I was able to conceptualize and create a functional and enjoyable park I am proud of.

I want to give special thanks to my wonderful thesis committee for their useful and wise contributions. I am highly grateful for the guidance and support throughout this process. My Thesis Advisor, Dr. Frank Gallagher, provided invaluable guidance through this process, along with thought-provoking design discussion. Dr. Gallagher also provided peace of mind by providing periodic assurances as I struggled through this time-consuming process and with his calm demeanor. Dr. Dan Van Abs also provided a wealth of useful information pertaining to CSOs and wastewater management, along with detailed edits and comments for improving content. Furthermore, Arianna Lindberg provided useful edits, while serving as the "eye" of design throughout this process. Her understanding of space and knack for beautiful composition were highly valuable assets to have while designing this park. Lastly, it was a treat and honor to have Carl Alderson round off the committee as he brought along his keen knowledge of Upper New York Bay, years of wetland restoration experience, and passion to improve the waterway.

Besides my helpful committee, I also give heartfelt thanks to additional folks that assisted in this long process, including:

- Anita Bakshi, Research Methods Professor
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INTRODUCTION

Humans have a deep, intrinsic connection to the coast, with more than 40% of U.S. populations currently living in a coastal county.[1] This is most evident along the New York-New Jersey coastline, where more than 23 million people currently live, work, and socialize. In the heart of this dense coastal population lies the Hudson-Raritan Estuary, a sprawling coastal ecosystem that also includes Upper New York Bay, the multi-functional backbone of New York City (Figure 1).[2]

Figure 1. *2018 aerial photo of the site and surrounding area.* Photograph by Cameron LLC Bayonne. Retrieved March 3, 2020, from http://cameronllc.com/wp-content/uploads/Bayonne_nov_232.jpg.

Global population trends changed around the turn of the 21st century, leading to more than half of global populations living in dense, city environments, rather than rural and small towns, for the first time in recorded history.[3] Migration to cities is also increasing coastal populations, requiring sound design solutions to defend against coastal vulnerability. As metropolitan New York coastal population density increases, many municipalities are rezoning and repurposing old, derelict commercial and industrial parcels that lie unused, oftentimes polluted, along Upper New York Bay. These large infill areas, once vast tidal marsh wetland complexes along the shoreline, are being reimagined and transformed into multi-functional hubs for people to live, work, and interact. To protect new infrastructure while partially restoring the Bay, various forms of green infrastructure and "living shorelines" are also being installed.[4] This natural and semi-natural infrastructure provides increased stormwater management along with protection from tidal surge and flooding brought on by large storm events and rising sea-levels. Green design solutions also have been shown to provide critical wildlife habitat for a broad array of creatures that typically live, breed, and feed in and along the waterway.

Area of Investigation

Although some may see the field of landscape architecture simply as the creation of "pretty places", it can be much more influential, greatly improving how people live and function. Landscape architecture also has a lasting effect on ecological systems, which sometimes is lost in our pursuit to provide places for human use. As sea levels rise and storm frequency and severity increase, adaptive design is required for increased resilience and long-term occupation along the waterway. The art and science of Landscape Architecture can lead to effective land-use changes and social advancements to help facilitate this pursuit. In this way, landscape architecture is a useful tool for improving ecological services, land use, and social issues in our ever-changing world.

Fortunately, societies in many regions of the world are taking the necessary steps to repair and replace some of the landscapes and natural systems left tattered after years of excessive abuse. Many global citizens are finally focused on restoring and protecting the environment, especially coastal ecosystems, wildlife biodiversity, and water resources.[5]

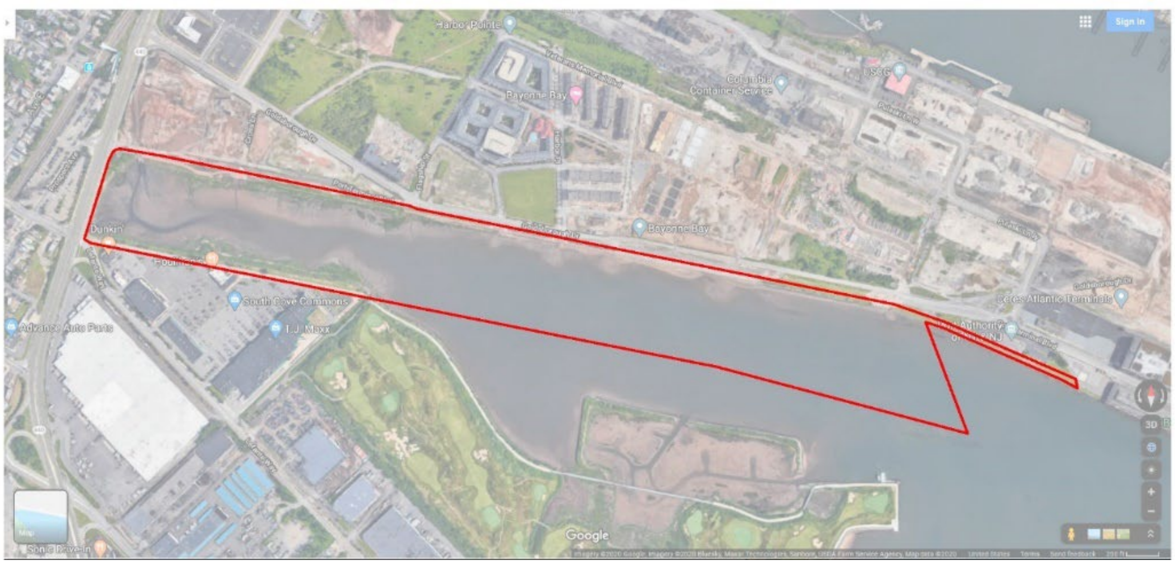

Figure 2: *Contract Limit Line (CLL) for the site.* Illustration by author. March 13, 2020. Aerial photograph: Retrieved February 18, 2020, from https://www.google.com/maps/@40.6690159,-74.0954577,1222m/data=!3m1!1e3.

This thesis examines an intertidal area and surrounding shoreline along a portion of eastern Bayonne, New Jersey covering approximately 75.4-acres (Figure 2). The site is surrounded by Peninsula at Bayonne Harbor, the new redevelopment zone along the north, Upper New York Bay along the east, South Cove Commons shopping complex and Bayonne Golf Club along the south, and Highway NJ440, 34th Street light rail station, and residential areas along the west portion of the site. Much of the design focus is centered around improving waterfront access, circulation and use, along with water quality, stormwater management, and storm resiliency. This thesis also examines the history of the site and long-lost ecological systems once abundant along Bayonne. A broad analysis of past, present, and future conditions is included, followed by conceptualization, design modeling, and the development of various design proposals that activate, fortify, and rejuvenate this tucked-in intertidal mudflat.

Thesis Questions

After conducting a site survey and related analysis, the site and surrounding area presented a variety of issues and challenges relating to stormwater management, waterfront use and access, coastal restoration, and shoreline protection. Environmental degradation was also evident on and around the site, brought on by decades of pollution and long-term neglect during commercial, industrial, and military activities. An example is Peninsula at Bayonne, the former Military Ocean Terminal – Bayonne (MOTBY), a major embarkation facility for military equipment, supplies and troops, operating from World War II (1942) to its closure in 1999.[6] Two Combined Sewer Overflow (CSO) sewer pipes, part of Bayonne's old, outdated Combined Sewer System (CSS), discharge polluted stormwater runoff, along with raw sewage wastewater, through the site and into Upper New York Bay and the Atlantic Ocean. On average, these two CSOs average 36 annual discharge events, releasing nearly two million gallons per event.[7] The site also experiences flooding during large rain and tidal surge events, such as Hurricane Sandy in October 2012, which inundated most of the surrounding landscape under more than six feet of storm surge.[8] Flooding and surge events in the Bay are being exacerbated by rising sea levels as well, predicted to average 1.56 feet by 2050 and 4.16 feet by 2100.[9] Last, the former MOTBY complex directly north of the site is experiencing an influx of more than 10,000 new residents by 2026 who will greatly benefit from improved waterfront access, along with open space for outdoor recreation, relaxation, and community engagement.

With these broad site conditions in mind, various questions are examined, including:

- What design solutions are necessary to ensure minimal environmental risk to people and wildlife that visit the site?
- What engineering solutions need to be applied in order to effectively manage and treat CSO effluent before it enters the waterway?
- What resilience strategy will be most effective in protecting the inlet and surrounding landscape from flooding, erosion, and tidal surge?
- How can this design adapt to sea-level rise (SLR) and increased storm events and what lifespan can be expected as coastal conditions change over time?
- What design components and site programming will be most effective in bringing the community of Bayonne together to mingle and interact in this space?
- What components of design will help ensure community “buy-in”, daily interest, and long-term management of the site?

Background

The site and surrounding area have a long, rich human history, including millennia of native occupation and use, followed by more than five centuries of European settlement and U.S. nation-building. This use, including early settlement, rapid industrialization, and other land uses, are presented wherein to better understand the site's history and how is has changed over time.

The Pre-European Landscape and Early Colonization

Thousands of years before European arrival, native peoples occupied and, by many historical accounts, sustainably managed this landscape.[10] Native tribes, including Mohican, Lenape, and Munsee numbering in the thousands, relied on and managed the resources of the Bay, all while imparting a small footprint on the environment through their daily activities.[11]

Figure 3: *Painting of Henry Hudson first entering Upper New York Bay*. Moran, Edward. "Google Arts and Culture." Google Arts and Culture. Pittsfield, MA. Accessed March 3, 2020. https://artsandculture.google.com/asset/henrik-hudson-entering-new-york-harbor-september-11-1609-edward-moran/RAHWSWctzaI2Mg.

When European explorers came upon the Hudson-Raritan Estuary (Figure 3), they found a place that offered everything a settlement could hope for; a sprawling pristine environment loaded with seemingly endless amounts of food and resources, positioned at the mouth of two rivers emptying into two large protected bays. As a result, European explorers selected this geographic location for settlement, taking advantage of all the goodness that lay before them. The geographic location was ideal for commerce and trade, offering a harbor protected from the harsh Atlantic seas, along with a straight, deep river for inland navigation (Figure 4). As a result, wave-upon-wave of migrants flocked to this area to take advantage of everything it had to offer, arriving in spurts during early colonialization, then in masse throughout the 18^{th}, 19^{th} and 20^{th} Centuries.

Figure 4: *1778 Map of Lower and Upper New York Bay*. New York Bay Antique Map Print (1778). (n.d.). Blue Monocle. Retrieved April 21, 2020, from https://bluemonocle.com/products/new-york-bay-antique-map-print-1778.

The Industrial Transformation

Much of the population boom during the late 18th and early 19th centuries was attributed to the Industrial Revolution, a period of technical advancement that led to large industrial complexes springing up all along the Bay, including the Constable Hook area in what is now southern Bayonne. Smelting and chemical factories, oil refineries, tank farms, coal fields and tanneries were just some of the installations along the waterway, resulting in widespread releases of pollution, waste and toxins. Much of the wildlife and resources once abundant in these locations were decimated by these activities, oftentimes without any concern or penalty.

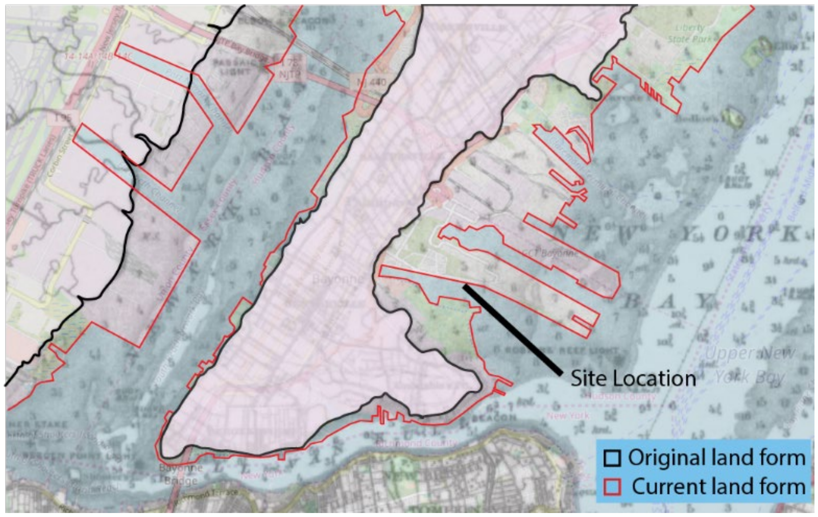

Figure 5: *Illustration of pre-European shoreline vs. modern day shoreline.* Illustration by author. March 13, 2020. Source of base map: ESRI.

As expansion continued into the 20th century, intertidal marsh and coastal wetlands throughout the Bay became targets for dredging, infill and land-forming activities. Thousands of acres of marsh and related tidal flats surrounding the site were covered to accommodate U.S. military operations, port activity, and growing industry (Figure 5). These new landforms were constructed with elevations only a few feet above the mean water line and bulkhead along shorelines. Unfortunately, low-lying and flat design led to vulnerabilities from surge and sea level rise.

20th Century Growth, WWII, and Military Ocean Terminal at Bayonne

With the continued expansion of population and industry, the site and surrounding area continued to experience much change. Residential areas along eastern Bayonne went through drastic zoning changes as they became industrialized. To meet the needs of a growing regional population, the City of Bayonne began developing a new port terminal project in 1932, followed by dredging and infill activities in 1939. After entering WWII, the U.S. Navy acquired the newly formed peninsula and began military cargo operations in 1942. Similar infill activities continued, leading to the formation of hundreds of acres of new coastal property for industrial and commercial use, including space for additional port activities, tank farms, factories, and municipal landfills. The construction of Military Ocean Terminal – Bayonne (MOTBY) in 1943 (left), led to the formation of the inlet. Years later, Port Jersey shipping terminal (right) was constructed, created from the conversion of Jersey City's landfill in 1974 (Figure 6).

Figure 6: *Previous infill projects near the site.* Military Ocean Terminal—Bayonne—Military Railroads of the New York Metropolitan Area. (n.d.). Retrieved March 4, 2020, from http://members.trainweb.com/bedt/milrr/motby.html.

The Great Divide: When a Road Acts as a Wall

With 20th century national growth came a massive post-war Federal push for a network of rapid transit roadways.[12] As a result, the national interstate highway system was constructed, along with similar state highway systems. These broad, fast-moving roadways provide many benefits to our daily lives, but also have negative aspects, including various social justice issues associated with road placement, such as eminent domain mandates, racial segregation, and classism. Bayonne experienced a decline in population during this post-war period. Besides social issues, many of these roadways also act as physical barriers, impeding pedestrian and wildlife access and circulation. One such example is highway NJ440, a busy, four-lane State Highway with high volumes of commuter and commercial traffic directly along the western boundary of the design site (Figure 7). This roadway acts as a formidable barrier, disconnecting most Bayonne residents from the waterway, while also causing an ecological divide between the waterway and surrounding landscape.

Figure 7: *Area along west site boundary.* Source: Photo taken by author (2019).

CSOs and a Neglected Inlet

As populations grew through the 19th and 20th centuries, sewage management became an increasing concern. Open sewage ditches, septic pits, and leach fields were the norm for centuries, but had drawbacks in populated areas of fouls smells, rodents, and a number of deadly diseases. The Combined Sewer System (CSS) was an “all-in-one” solution designed to capture residential sewage, commercial wastewater, and stormwater runoff in one system, then transport it underground to a nearby treatment plant before reintroducing it back to the environment. This collection network provided cleaner neighborhoods and safer sanitary conditions, but still discharged raw and partially treated sewage into waterways after heavy rain events.

Bayonne populations boomed during the start of the 20th century, growing from 9,372 in 1880 to 55,545 by1910. The 1880's also saw the introduction of a CSS in Bayonne, a welcome, innovative advancement for managing stormwater, sewage, and industrial wastewater (for those industries that did not discharge directly into Bay waters). The system includes 30 Combined Sewer Overflow (CSO) discharge points, the highest number for all New Jersey municipalities, including BA006 and BA007, two CSO discharge points located along western portion of the design site that release effluent across the site and into Upper New York Bay (Figure 8).[13] Although the original CSS does dot connect to MOTBY and other surrounding industrial areas, new residential and commercial development will contribute additional sewer and stormwater volumes into Bayonne's CSS discharging into the surrounding waterway.

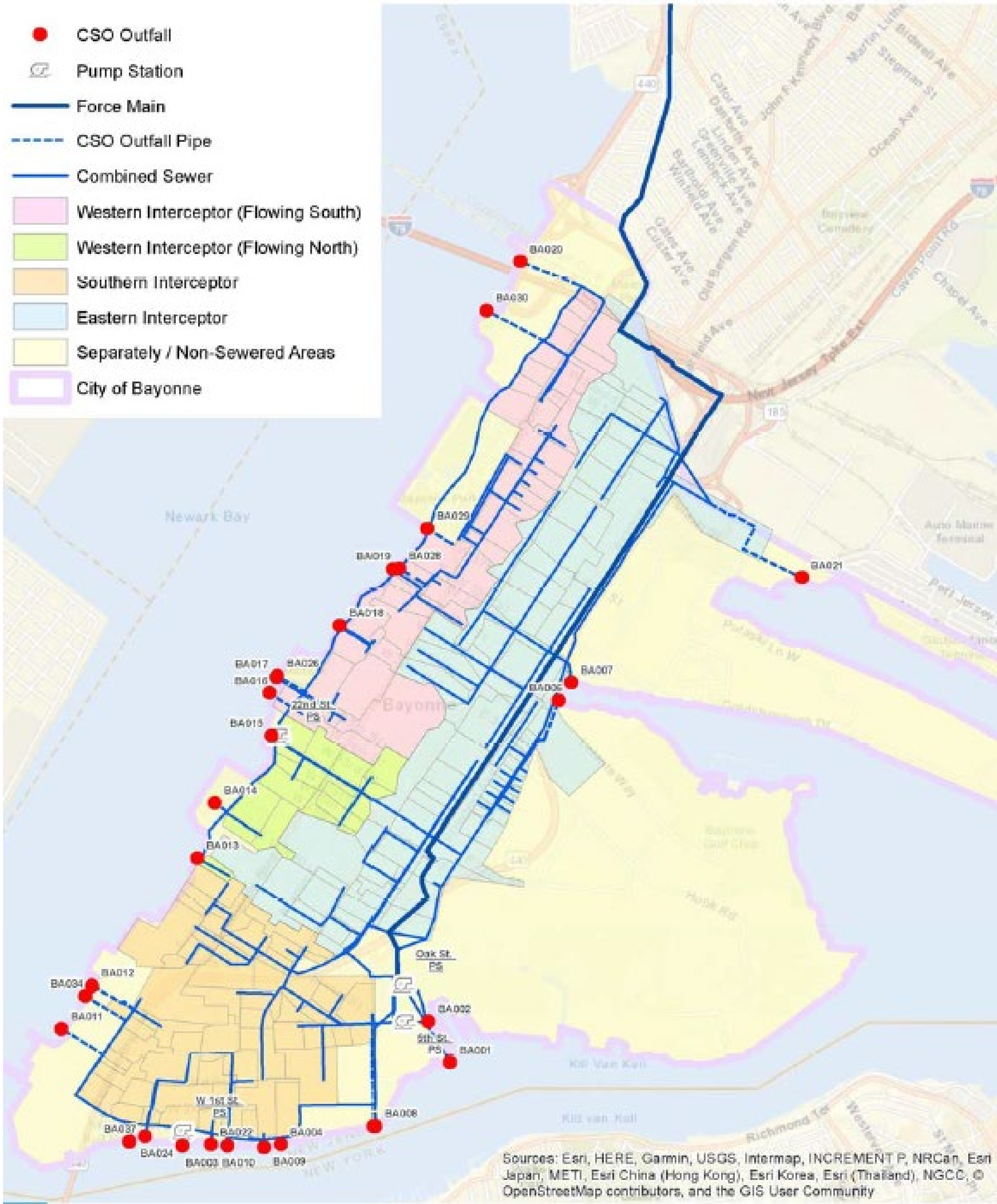

Figure 8: *Map of Bayonne's Combined Sewer System and Combined Sewer Overflow discharge points.* CSO_DEAR_PVSCRegional_Appendix_20190628.pdf. (n.d.). Retrieved Sept. 15, 2019, from https://www.nj.gov/dep/dwq/pdf/CSO_DEAR_PVSCRegional_Appendix_20190628.pdf.

Unfortunately, continued population and industrial growth in Bayonne has led to larger releases of sewage and wastewater, along with increased stormwater runoff brought on by high levels of impervious surfaces, such as roadways, parking areas, and building rooftops. These combined volumes exceed sewer capacity more frequently each year, discharging more than 80 million gallons of effluent annually from the two CSO discharge pipes located along the west site boundary, across the site, and into surrounding waterways (Figure 9).

Figure 9: *Location of two onsite CSOs.* Source of image: Google Maps. Accessed November 24, 2019. https://www.google.com/maps/@40.6699753,-74.1060008,306m/data=!3m1!1e3.

Besides a brief period in the late 19th century (during the Romantic Era), American sentiment and policy towards the environment was highly lacking. Fortunately, widespread environmental abuse and neglect became a social concern, leading to a series of new policies and protections after World War II, with the Federal Water Pollution Control Act of 1948, which was greatly reorganized and expanded through the Federal

Water Pollution Control Act Amendments of 1972 (in part as a reaction to fires on the Cuyahoga River in Cleveland, Ohio), and then rebranded as the Clean Water Act in 1977. New policies were implemented in response to an environmental movement spawned in part by Rachel Carson's *Silent Spring* in 1962 and from public discord throughout the late 1960s. These newfound thoughts and actions spawned new environmental policy, including the National Environmental Policy Act of 1969 and Environmental Quality Improvement Act of 1970. With these policies came the formation of the Council on Environmental Quality and subsequent formation of the United States Environmental Protection Agency in 1970 by Executive Order.

Site Analysis / Data Collection

The eastern shores of Bayonne offer a unique landscape for design intervention, but it comes with a variety of issues and challenges.[14] A coastal location such as this, with more than three centuries of use and change, requires extensive site analysis and data collection in order to better understand the dynamics of the site. Furthermore, obtaining the most current data available is important when designing spaces in high-impact zones that experience frequent change. Initial site analysis was conducted in 2019 while participating in two Bayonne studies, a spring praxis design studio and separate summer coastal design project.

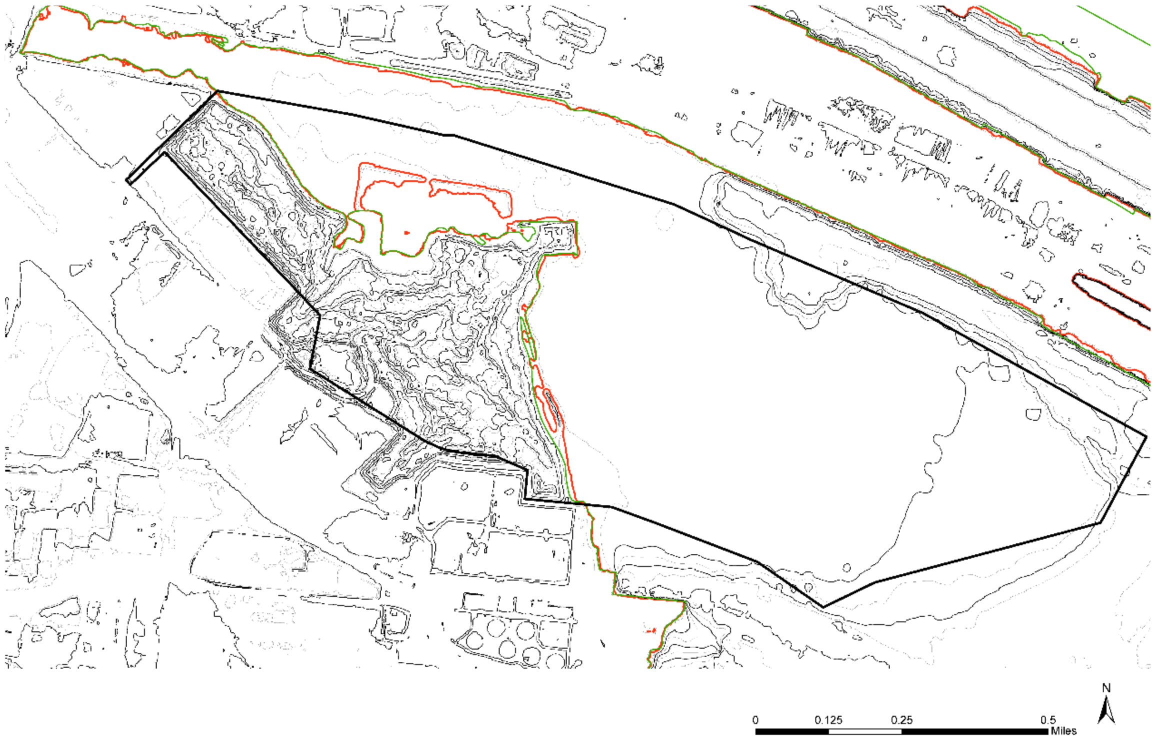

Figure 10: *Contract Limit Line for the adjacent Bayonne Golf Course property.* Source of image: ESRI.

Initial analysis began with a praxis design studio exploring the possibilities of developing 309-riparian acres for the Bayonne Golf Course, near the design site (Figure 10). The private golf course was interested in adding new coastal features in the waterway as part of their long-term management plan. A broad study of conditions occurred over a period of many months, helping contribute to many different design solutions for the area. These designs were well received by Bayonne Golf Course, leading to a continued exploration of the idea. Over the summer of 2019, Rutgers' Center for Urban Environmental Sustainability (CUES) and Stevens Institute of Technology were contracted to conduct more extensive research and deliver three separate design solutions for the riparian zone jutting out into Upper New York Bay.[15]

Geology – Bedrock and Surficial

The site sits along the edge of the Newark Basin geologic province, in an area where the Manhattan Prong and Atlantic Coastal Plain provinces converge (Figure 11).[16] Within the Newark Basin, a stratified line of geologic formations transect north-south across the site along a narrow zone, with most of the site within the Stockton Formation (Figure 12).[17] Approximately 100 feet west of the site boundary, the Diabase layer (depicted in pink in Fig. 12), part of the Jurassic formation, increases in elevation (Figure 13). This long, elevated layer provides protection from coastal surge and flooding making it ideal for residential and commercial development; it is the high ground historically in Bayonne. As a result, generations of residents have occupied this area, now covered primarily in older, single family and subdivided homes. Although this elevated area provides protection for these homes, it also causes surge and flood waters to divert north and south, leading to flooding of adjacent lands.

Figure 11: Geologic Provinces of the Hudson River Valley. Regional Geology—NJ_NY_08.pdf. (n.d.). Retrieved February 20, 2019, from https://people.hofstra.edu/j_b_bennington/field_trips/Southeastern_NY_Guide_08.pdf

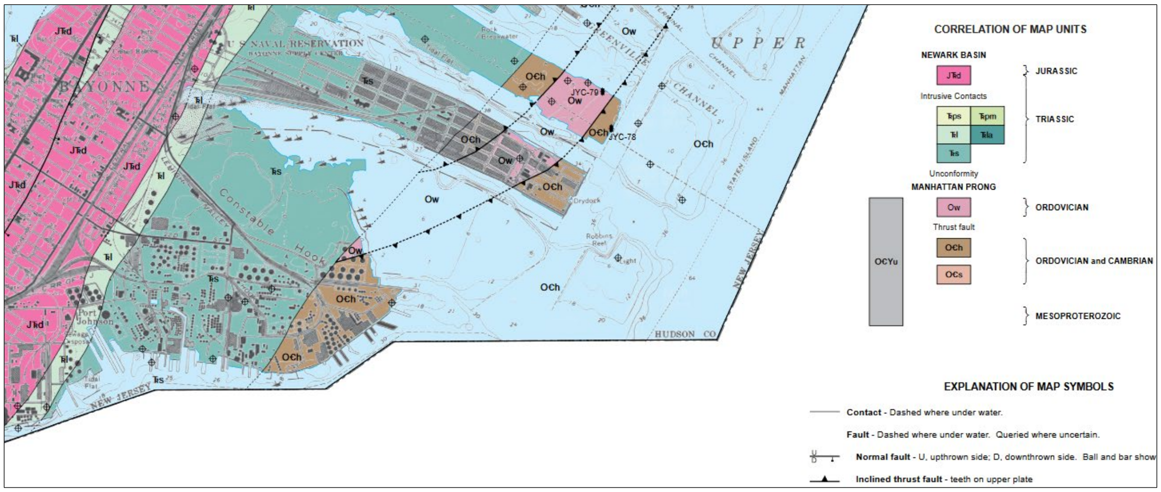

Figure 12: *Map of geologic bedrock.* Ofm110.pdf. (n.d.). Retrieved April 5, 2020, from https://www.state.nj.us/dep/njgs/pricelst/ofmap/ofm110.pdf.

Figure 13: *Photo showing the Jurassic formation boundary.* Source of image: Google Maps. Created October 2018. Accessed October 27, 2019.

The surficial conditions of the site include artificial fill typically less than 20' in depth and Estuarine and Salt-marsh postglacial deposits ranging from 50'-65' in depth. Artificial fill deposits are defined as, "artificially placed sand, gravel, silt, clay, and rock; and man-made materials including cider block, ash, brick, concrete, wood, slag, metal, glass, and trash". Estuarine and Salt-marsh deposits include primarily organic silt and clay, along with salt-marsh peat, black, dark brown, and dark grey sand, and shell material. [18]

Topography and Bathymetry

Coastal areas experience considerable topographic and bathymetric changes over geologic time as a result of constant exposure to wind and wave forces. These forces originate from up the Hudson River and across Upper New York Bay, causing subtle surficial and aquatic changes to the landscape.

Anthropogenic influences, on the other hand, are more dramatic and abrupt. The site and surrounding area experienced a rapid human-induced transformation over the past century, dramatic changing landform, elevation, and hydrology. Shipping activities also led to major alterations of the Bay, with navigation channels and port inlets dug out of the Bay floor all throughout the waterway. These ports and channels are routinely dredged, with periodic deepening as new, bigger freight ships require deeper drafts. (Figure 14).

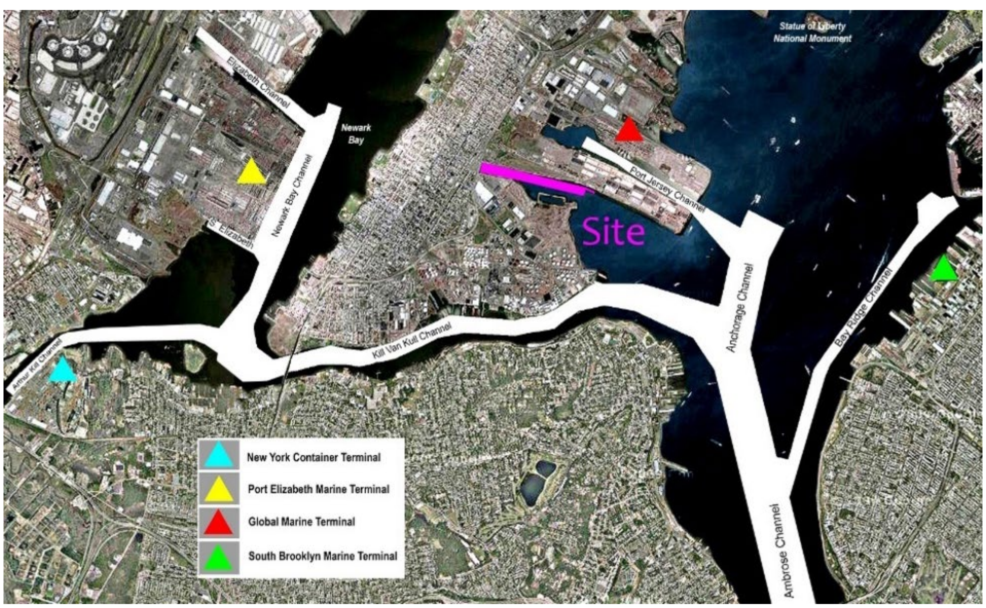

Figure 14: *Map of maintained navigation channels surrounding the site.* Technical Information and Team Operations. (n.d.). Retrieved April 22, 2020, from http://www.nyc-arecs.org/ops.html.

Land Use, Rezoning and Redevelopment

For more than a century, eastern Bayonne was used almost exclusively for commercial and industrial purposes. By the late part of the 20th century, enhanced environmental regulations, overseas industrial competition, and new industrial site needs led to significant closure and abandonment of industrial properties. In particular, the Department of Defense chose to decommission the MOTBY federal facility in the 1990s, leaving nearly 700 acres vacant. Then, roughly two decades ago, rezoning and redevelopment started to become the new initiative for expansive sections of these degraded spaces, primarily the result of growing housing needs within the NY-NJ Metro area.

Changes began with widespread removal of abandoned structures, hazardous soils, and unwanted infrastructure, flotsam left over from large-scale rail, military, and industrial activities. This was followed by years of soil, groundwater, and shoreline remediation activities.[19] While clean-up was occurring, Bayonne implemented new redevelopment initiatives, with the intent to convert large, unsightly and underutilized areas into completely transformed, medium and high-density mixed-use, community-oriented spaces.

The first conversions came in the form of a large shopping complex directly south of the design site. It was constructed on vacant industrial land sitting nearly fourteen feet below mean sea level, requiring 1.5 million tons of fill material during construction.[20] Next came Bayonne Golf Club, a world-class, “Scottish Links” style private golf club constructed on 160-acres alongside the shopping complex that offered wonderful coastal recreation and panoramic Bay views. This project was an example of savvy land-use development as the developers decided to use a city landfill at full capacity needing to be sealed and a derelict site formally envisioned in the late 1960s as the location of a nuclear power plant (cancelled after community outcry). Rather than simply installing a traditional cap, they opted to cap the landfill with a beautiful, rolling golf course, using 4.5 million tons of amended dredge material to seal the site, avoiding future toxic leaching and related environmental degradation.[21] Portions of the Hudson River Waterfront Walkway (HRWW) were also constructed during this period, providing over a mile of public waterfront access along the scenic inlet (Figure 15).

Figure 15: *Aerial depiction of current infrastructure surrounding the site.* Illustration by author. Source of aerial: Google Ma*ps. Retrieved February 18, 2020, from* https://www.google.com/maps/@40.6690159,-74.0954577,1222m/data=!3m1!1e3.

Large-scale redevelopment of Military Ocean Terminal - Bayonne began after Federal decommissioning of the peninsula in 1999 and final acquisition by the city of Bayonne in 2002. City acquisition of the property included riparian rights along the entirety of the peninsula, extending approximately 500 feet into the waterway. Much of the peninsula was resurveyed, leading to new roadways and parcels along the entire northern portion of the design site, covering hundreds of acres. The area was divided into sections for redevelopment and to celebrate different architectural styles. The space is planned to accommodate a broad array of uses, including various retail options, light commercial businesses, hotel accommodations, medium and high-density housing for 10,000 new Bayonne residents, and a ferry terminal servicing lower Manhattan (Figure 16).[22] The eastern, outermost portion of the peninsula currently includes Bayonne Dry Dock and Repair, a massive commercial dry dock facility, Cape Liberty Cruise Port, a modern passenger terminal for overseas cruises, and Harbor View Park, a two-acre memorial park featuring a 9/11 monument standing 100 feet high, gifted by Russia in 2006. Construction of a sprawling 4-million square foot storage facility is planned for northern portions of the peninsula, which will require extensive infill material in order to construct at elevations suitable to rising sea levels and larger flood events.

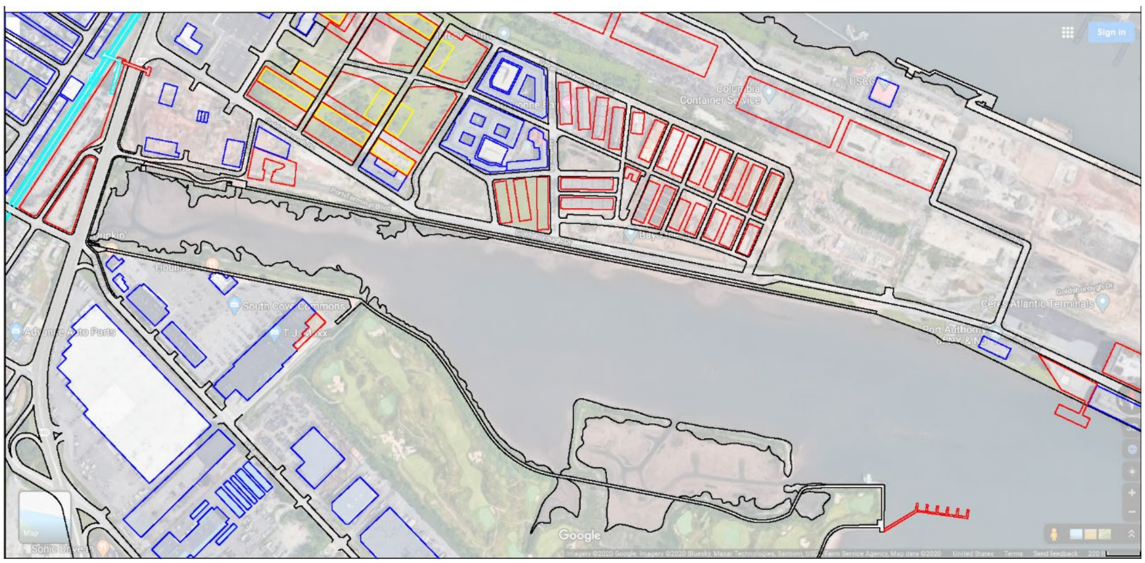

Figure 16: *Aerial depiction of current (blue) and planned (red) development surrounding the site.* Illustration by Brady Smith. Aerial courtesy of Google Ma*ps. Retrieved February 18, 2020, from* https://www.google.com/maps/@40.6690159,-74.0954577,1222m/data=!3m1!1e3.

Public Access, Circulation, and Gathering Spaces

Pedestrian access and circulation around the design site are restricted by a number of physical limitations. One primary limitation to movement around the site lies in its shoreline position, with Upper New York Bay along the east side of the site impeding full pedestrian circulation. Additional obstacles exist along the west side of the site as well, in the form of multi-lane Highway NJ440 and NJ Transit's Light Rail corridor. These large transportation systems create a divide, making pedestrian access difficult for residents living west of the site. Fortunately, portions of the HRWW run the full length of the north and south portions of the site, offering waterfront access and miles of scenic waterfront pathways. Although current use of pathways is minimal, they will become greater destinations as additional residential development and the ferry terminal are completed near the site. Unfortunately, the HRWW lacks full circulation, requiring users to walk out to the terminus of the pathway, then turn around and return.

The HRWW was created as a multi-county, continuous linear pathway along New Jersey's "Gold Coast", providing widescale public waterfront access. The pathway begins at the George Washington Bridge in the lower Hudson River, averaging 16 feet in width. It continues, albeit incomplete, south along the river, down along the bay, all the way down to the southern tip of Bayonne, terminating at the Bayonne Bridge. Creating a continuous pathway directly along the shoreline is ambitious, but nearly impossible as large sections of the pathway transect through restricted areas such as shipping terminals, oil/chemical tank farms, and other "High-risk" spaces prohibited for public access (Figure 17). A few small gathering spaces are present along the pathways, but none of them offer programming options or services to facilitate prolonged gathering of users.

Figure 17: *Illustration showing pathway limitations (red) along this section of Hudson River Waterfront Walkway.* Peros, S. (n.d.). Hudson River Waterfront Walkway Southern section map. 1.

CSOs and Contaminants

Decades of industrial activity and subsequent environmental contamination have resulted in ecological damage to the site and surrounding area. During rain events, stormwater runoff is collected in combined sewers from defined drainage areas referred to as “CSO-sheds”. The two onsite CSOs collect runoff from industrial and commercial lands south of the site along with residential lands to the west covering 202.4 and 230.4 acres, respectively. Both CSO-sheds are areas of heavy use and include high levels of impervious surfaces associated with residential, commercial, light/heavy industrial, and transportation uses.[23] During normal, mild rain events, stormwater runoff drains from these areas into the CSS, then directly to nearby wastewater treatment facilities for processing before entering the waterway. During heavier rain events, large volumes of stormwater runoff overfill the CSS, causing overflows of residential sewage, commercial wastewater, and stormwater runoff to discharge directly into the waterway, across the entire site, and into the Bay. Historically, this effluent has contained various contaminants and pathogens that pose a threat to wildlife and human health (Figure 18). Based on a New Jersey Integrated Water Quality Monitoring and Assessment Report, Upper New York Bay is impaired with a host of pollutants, including:[24]

- ☐ Benzo(a)pyrene (PAHs)
- ☐ Chlordane in Fish Tissue
- ☐ DDT & its metabolites in Fish Tissue
- ☐ Dieldrin
- ☐ Dioxin (including 2, 3, 7, 8-TCDD)
- ☐ Heptachlor epoxide
- ☐ Hexachlorobenzene
- ☐ Mercury in Fish Tissue
- ☐ PCB in Fish Tissue
- ☐ Phosphorus (Total)

Figure 18: *Photo of onsite water use advisory.* Source: Photo taken by author (2019).

In 1936, the Interstate Environmental Commission (IEC) was established, a tri-state air and water pollution control agency serving New York, New Jersey, and Connecticut.

This agency created water quality classifications for Hudson-Raritan Estuary waters, including Class A, Class B1, and Class B2 waters (Figure 19). The site and surrounding waters of Upper New York Bay are classified as Class B1 waters. These waters should remain of a quality suitable for fishing and secondary contact recreation, along with provide standards suitable for growth and maintenance of fish life and other forms of marine life naturally occurring in the waterway, but *not* suitable for fish propagation.[25]

Figure 19: *IEC water classification map for Hudson-Raritan Estuary.* CSO_SystemCharacterization_PVSC_8_20180629.pdf. (n.d.). Retrieved April 22, 2019, from https://www.state.nj.us/dep/dwq/pdf/CSO_SystemCharacterization_PVSC_8_20180629.pdf.

Plant Transect Study and Soil Survey

Field studies were conducted to identify and document the various plant species growing on the site. Nearly the entire inlet is dominated by intertidal mudflat, bordered by fragmented marsh habitat on three sides. Flora observed and identified include native species such as smooth cordgrass (*Spartina alterniflora*) and switchgrass (*Panicum virgatum*), along with non-natives such as common glasswort (*Salicornia europaea*) and common reed (*Phragmites australis*).

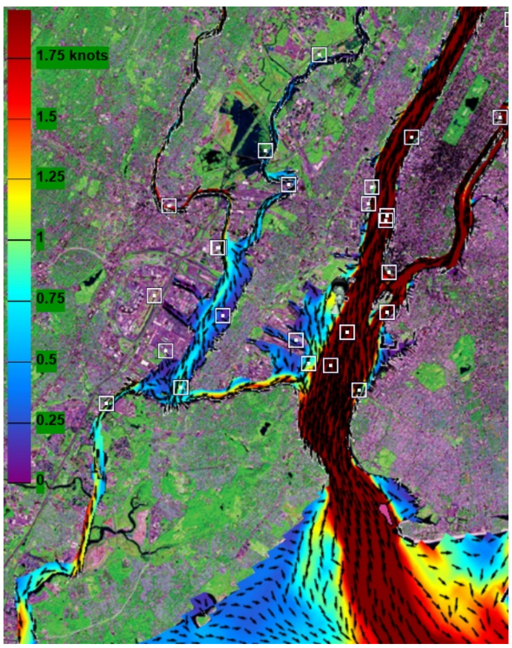

Figure 20: *Illustration of channelized current through the Bay during outgoing tide.* NYHOPS: Urban Ocean Observatory at Davidson Laboratory. (n.d.). Retrieved April 2, 2019, from http://hudson.dl.stevens-tech.edu/maritimeforecast/maincontrol.shtml.

Sedimentation and Water Quality

Land-fill activities, extensive bulkhead, and shipping activities over the past century have greatly reduced natural sediment flow to and within the site. Construction of MOTBY and the Port Jersey Terminal formation cut off natural sediment flow from the Hudson River (Figure 20). Natural sedimentation processes are also disrupted by shipping activities through the Bay, which requiring 50-meter navigation channels. These deep, dredged areas cause channelization of sediments away from the site.[26] This rapid transportation of sediments perpendicular to the inlet decreases the potential for natural accretion within the site. [27]

Without sufficient accretion (Figure 21), marsh systems at the site will struggle to persist as sea levels rise. Natural marsh migration is also hindered by minimal inland space for marshes to shift as seas rise. These constraints require novel solutions to keep marsh systems intact, such as periodic thin-layer sediment applications.[28] Mechanical application mimics natural accretion processes and is becoming a solution for a number of similar coastal zones that struggle with insufficient accretion levels.[29] Current and future development of surrounding areas may lead to increased localized sediment entering the inlet as twelve separate stormwater drains empty across the site.

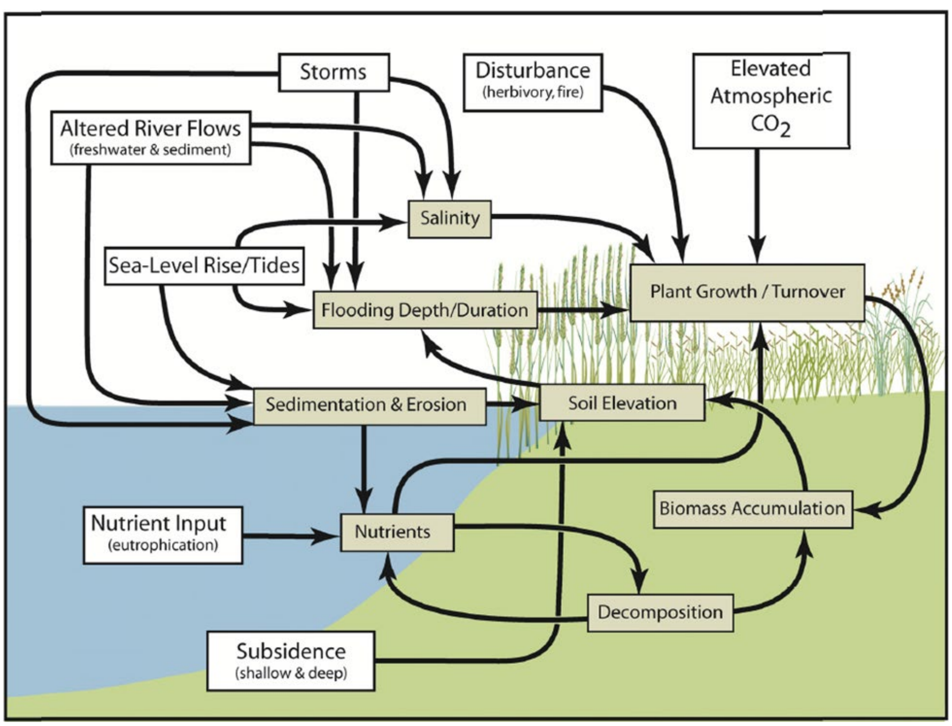

Figure 21: *Conceptual model of a tidal marsh in salt marshes with substantial tidal inputs of mineral sediment. Read* "Effective Monitoring to Evaluate Ecological Restoration in the Gulf of Mexico" *at NAP.edu*. (n.d.). https://doi.org/10.17226/23476.

Tides, Hydrology, and Currents

Water is the highlight of this site and dictates nearly every aspect of design and development. Tidal range plays a major role in the design of the site, especially as it relates to low-marsh and high-marsh placement. Plants in these habitats have a narrow range they can successfully grow in, so the elevation they are planted dictates overall plant performance and persistence over time. The tidal range at the site averages 4.53 feet during normal tide cycles, increasing to 5.06 feet during lunar tide events.[30] The site lies within a coastal inlet, with the western portion classified as tidal flat on the USGS topographic map. This tidal flat area is covered almost entirely by intertidal mudflat, which is non-vegetated, submerged areas consisting of fine sediments that are exposed twice daily during low tide periods. Although mudflat is an important component of a tidal flat, it should only make up a fraction of a healthy tidal zone. Typically, healthy tidal flats are made up of mostly low-marsh plant complexes, with smaller portions of high-marsh present along slightly elevated margins (and coastal shrub/upland zones, where topography allows). Unfortunately, coastal development and environmental degradation have led to extensive losses of low-marsh and high-marsh throughout the site, both critical components of healthy tidal flats.

Tide and flood data, available through multiple data sources, was examined to understand impacts to the site. National Oceanic and Atmospheric Administration (NOAA) collects a wide range of data, including tide data (using the NAVD88 datum) for the U.S. and partnering territories. Daily high tides at the site average 1.96 feet (MHW), increasing to 2.28 feet during monthly diurnal tides (MHHW), and 2.57 feet (MHWS) during annual "Spring Tide" periods when the moon orbits closer to the Earth, exerting greater gravitational forces (Figure 22). Higher water levels also occur during storm events. As a result, flood zones around the site are monitored by Federal Emergency Management Administration (FEMA), the government arm responsible for storm response and management. FEMA's storm surge analysis is used to monitor risks from projected water elevation data based on different storm levels, including projected flood heights (also known as starting stillwater elevations) for 50-year, 100-year, and 500-year storm events, which were projected at 10.5', 11.9', and 15.5', respectively for the site location.[31]

Elevations on NAVD88

Station: 8518750, The Battery, NY
Status: Accepted (Nov 19 2012)
Units: Feet
Control Station:
T.M.: 0
Epoch: 1983-2001
Datum: NAVD88

Datum	Value	Description
MHHW	2.28	Mean Higher-High Water
MHW	1.96	Mean High Water
MTL	-0.30	Mean Tide Level
MSL	-0.20	Mean Sea Level
DTL	-0.24	Mean Diurnal Tide Level
MLW	-2.57	Mean Low Water
MLLW	-2.77	Mean Lower-Low Water
NAVD88	0.00	North American Vertical Datum of 1988
STND	-6.06	Station Datum
GT	5.06	Great Diurnal Range
MN	4.53	Mean Range of Tide
DHQ	0.32	Mean Diurnal High Water Inequality
DLQ	0.21	Mean Diurnal Low Water Inequality
HWI	0.84	Greenwich High Water Interval (in hours)
LWI	7.21	Greenwich Low Water Interval (in hours)
Max Tide	11.27	Highest Observed Tide
Max Tide Date & Time	10/30/2012 01:12	Highest Observed Tide Date & Time
Min Tide	-7.06	Lowest Observed Tide
Min Tide Date & Time	02/02/1976 21:30	Lowest Observed Tide Date & Time

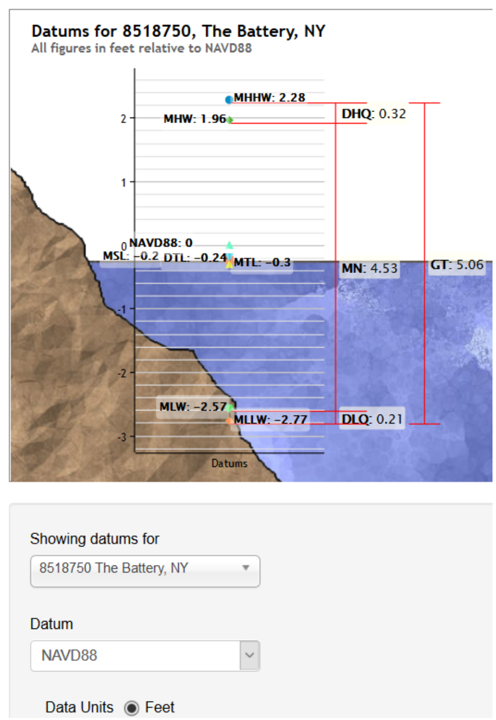

Figure 22: *Average tide and storm elevations using NAVD88 Datum.* Datums—NOAA Tides & Currents. (n.d.). Retrieved April 22, 2020, from https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=0&epoch=0&id=8518750&name=The+Battery&state=NY

The hydrology of the site plays a key role in plant selection and placement. Besides the two CSO discharge points, the site has twelve additional stormwater discharge points. During heavy rain events, salinity levels fluctuate considerably across the site.

Freshwater sources draining onto the site can lead to the introduction and potential proliferation of common reed (*Phragmites australis*), an invasive species to lower-salinity tidal systems.

Wind Dynamics and Fetch

The site is positioned along the western edge of Upper New York Bay, making it susceptible to high levels of fetch. Fetch refers to the distance wind travels over water in a single direction. The further wind travels across water, the more potential for wind-generated waves. Surface winds travel many miles across the top of the Bay leading to strong fetch in and around the site, bringing high erosion potential along silty or sandy shorelines. Fetch-related erosion is considerably less when healthy low-marsh systems are present in tidal zones as they hold sand and sediment in place. Fetch impacts the site differently from season-to-season as a result of changing wind directions and storm severity.

Climate Change, Sea-level Rise, and Coastal Resilience

In the 21st century, some things have become clear; human activities since the Industrial Revolution are having a direct impact on Earth's climate. Global changes are occurring, in part, because of extraction and combustion of non-renewable resources, such as coal, oil, shale, and natural gas, along with widespread deforestation and large-scale farming and agri-business. Examples of human's global influence include rising ocean and atmospheric temperatures, increased glacial and polar melting, above-average increases in global sea-levels, larger and more frequent storm events, persistent regional drought periods, and continual “record-breaking” events relating to temperature, precipitation, snowfall, winds, tornadoes, hurricane/cyclone pressures, storm surges, and flooding.[32]

Higher levels of resilience are being required to ensure long-term functionality and occupation of coastline as issues and threats become more commonplace. Novel, large-scale solutions are being devised and implemented, providing increased safety and well-being for coastal occupants that remain deeply connected to the coast. Coastal residents love coastal living, making retreat unfathomable to some. Instead, many residents remain committed to adaptation and doing everything possible to ensure coastal infrastructure remains intact and functional over the long term. Some who occupy the coast are economically “trapped”, unable to relocate, left susceptible to coastal threats as they increase. Unfortunately, most resiliency projects are costly, ecologically intrusive and time-consuming, making their implementation a challenge.

HRE Comprehensive Restoration Plan and Target Ecosystem Characteristics

The Hudson-Raritan Estuary spans nearly 100 miles from north-to-south and includes numerous municipalities throughout various counties across two states. Historically, the HRE has been managed at the local level, with many sections being damaged simultaneously via infill activities of coastal wetland and marsh, leading to major decreases in wildlife. To better manage all the ecological resources across the entire Hudson-Raritan Estuary, a large group of stakeholders was brought together. The result was the identification and classification of various Target Ecological Characteristics (TECs), along with the beginning of a long-term restoration plan for the waterway.

Based on this plan, the design site was chosen as a TEC site that provided restoration opportunities for improving shorelines and shallows (Figure 23).

Figure 23: *HRE-CRP graphic of restoration opportunities.* Hudson-Raritan Estuary CRP - Final Ver 2016-06-27_v1.0.pdf. (n.d.). Retrieved January 10, 2019, from https://www.nan.usace.army.mil/Portals/37/docs/harbor/Final%20CRP_2016-06-27_v1.0.pdf?ver=2016-06-29-170128-157

METHODS

Good coastal design requires understanding the flux of a coastal setting, where seemingly constant celestial rhythms and tidal norms are disrupted by erratic weather events, changing climate trends, and persistent Anthropogenic activities. The Bayonne site is influenced by all these forces along with a host of other human factors.

Taking this into account, different methodologies were applied during analysis and design to accomplish overall design goals and objectives. Some methodologies served as primary drivers of design, while others were used to accomplish more specific design objectives. System Modeling serves as the primary methodology for design, taking into account system-wide functionality as design solutions are integrated into the system. Additional secondary methodologies that play a role in site design include "Environmental Relations", which looks at design materiality, "Structure of the Problem", which focuses on solving site issues, "Optimization Essential Function", which identifies key functions as a base for design, and "Disaggregation", which breaks down site conditions to inform design (Figure 24). All of these selected methodologies take in to account the dynamics of the landscape and the varying processes that alter it.

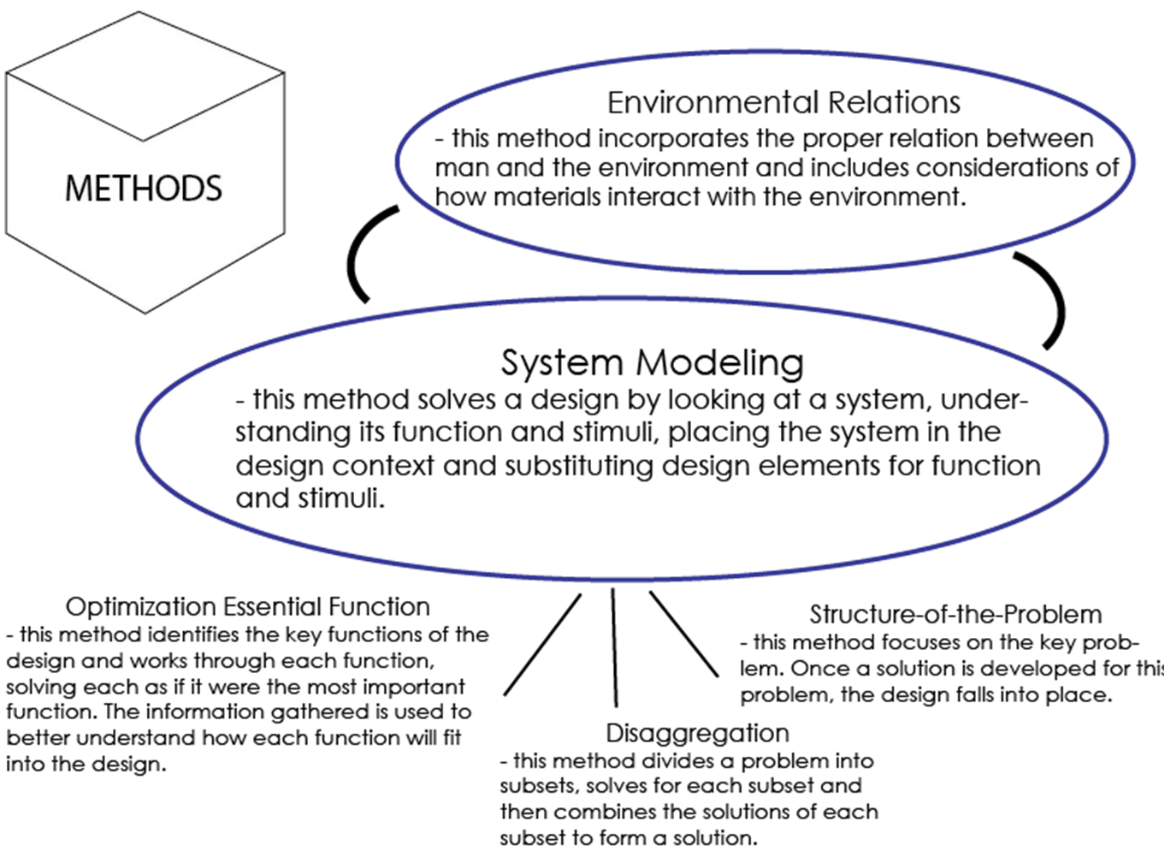

Figure 24: *Illustration of applied design methodologies.* Graphic created by author. 2019.

Visits to the site and surrounding area were conducted throughout the analysis. As a result, the site was observed during different seasons and tidal periods, including a high “Spring Tide”. Visits included transecting the site and neighboring parcels, making observations, looking especially for noticeable issues or concerns. Besides observations, general rough site sketches and notes were taken during site visits, including impressions generated by aromatic and audible influences. Last, site visits included photographic and video documentation throughout the site and surrounding area. This material was especially helpful for reference during analysis and design, while also serving as useful base material for rendering of design proposals.

Some analysis was conducted during a praxis studio and summer “spin-off” project, both for Bayonne Golf Club, a Bayonne, NJ client adjacent to the design site, occupying 482 coastal acres, including 309-acres of riparian rights (more than any private entity on New York Bay). The site and surrounding area were examined through a series of studies, including past, current, and projected topography, land-use, environmental conditions, plant communities, wildlife (especially waterfowl), transportation, sanitation, waterway access, and related terrestrial data, along with general water data such as tides, hydrology, bathymetry, plant communities, aquatic wildlife, salinity, dissolved oxygen, suspended solids, accretion, fetch and storm surge potential. Historical and projected weather conditions and patterns were also important factors in design, including wind, flood, and hurricane data.

Many questions about the site and surrounding area were derived from site observations and this broad collection of material. Issues with ecological services, pedestrian access, and community engagement were focal points during the formation of design solutions. Over the past century, human activity heavily altered the eastern Bayonne landscape, leading to dramatic changes in topography and land-use. In a more positive direction, new alterations of the landscape are continuing to greatly influence the site. As a result, these changes were also taken into account during this design process.

Literature Review

Numerous similar spaces were identified and studied to gain a broader understanding of coastal design options. Some design solutions appeared to be lasting, functional interventions while others left the impression of being less successful. Regardless of the results, the extensive review process provided useful data and information to better understand the challenges and complexities that come with coastal design. Although not included as detailed case studies, some additional locations provided useful design solutions as well. Bob Kerrey Pedestrian Bridge, a large, multi-purpose pedestrian bridge spanning the Missouri River between Nebraska and Iowa, served as inspiration for pedestrian circulation (Figure 25).

Figure 25: *Bob Kerrey Pedestrian Bridge, Omaha, NE.* Bob Kerrey Pedestrian Bridge | Stanleyisms. (n.d.). Retrieved April 23, 2020, from http://stanleyquan.com/omaha-nebraska/bob-kerrey-pedestrian-bridge/

A number of community swimming complexes were also studied, including Allas Sea Pool in Helsinki, Finland, Bassin de la Villette in Paris, France, and Piscine Joesphine Baker, also in Paris, France (Figure 26).

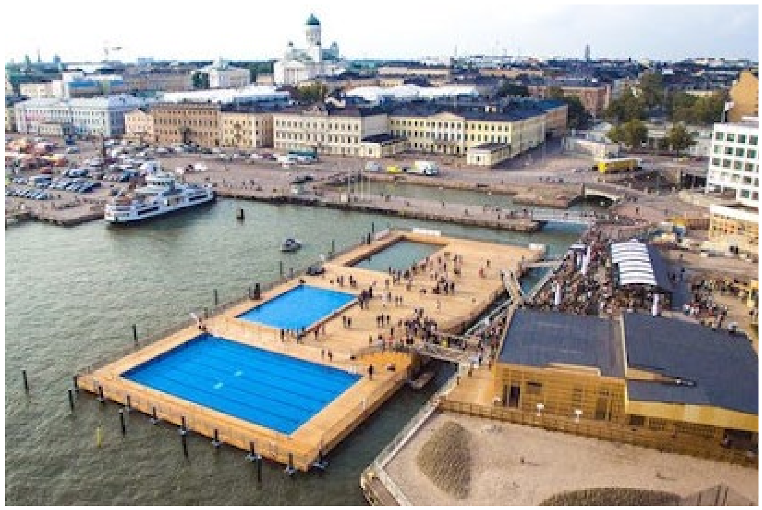

Figure 26: *Allas Sea Pool complex, Helsinki, Finland.* Hurst, S. (2016, November 28). Helsinki's Allas Sea Pool Spa Seeks €400,000 on Invesdor. Crowdfund Insider. https://www.crowdfundinsider.com/2016/11/93066-allas-sea-pool-spa-seeks-e400000-invesdor/.

Case Studies

After reviewing the literature, three locations were chosen as case studies for informing site design solutions, including the Gowanus Canal, located across the Bay in Brooklyn, NY, Hunter's Point Park, located along the East River in nearby Long Island City, NY, and Houtan Park, a far-off park located in Shanghai, China. These locations were selected because of similar issues and design solutions associated with waterfront access, storm protection, and wildlife habitat, which is described in more detail below.

Case Study 1 – Gowanus Lowlands, Brooklyn, NY

In an attempt to bring local residents and wildlife back to the area, SCAPE, a New York-based Landscape Architecture firm, conducted the Gowanus Lowlands project.

This complex project includes a framework plan (completed in 2017) and draft master plan (completed in 2019) to serve as guides for clean-up procedures, restoration initiatives, and long-term management of the canal.

The Gowanus Canal is located east of the site, directly across Upper New York Bay in Brooklyn, New York. It was chosen because of its similar waterfront location across the bay, along with the fact it's also a highly manipulated coastal feature that has experienced drastic topographic changes over time. Like the design site, this location has a history of environmental degradation, brought on by years of industrial use along the waterway and CSO releases from multiple discharge points. This location was chosen because of the unique design solutions proposed for improving environmental function of the canal and increasing pedestrian waterfront access and use (Figure 27).[33]

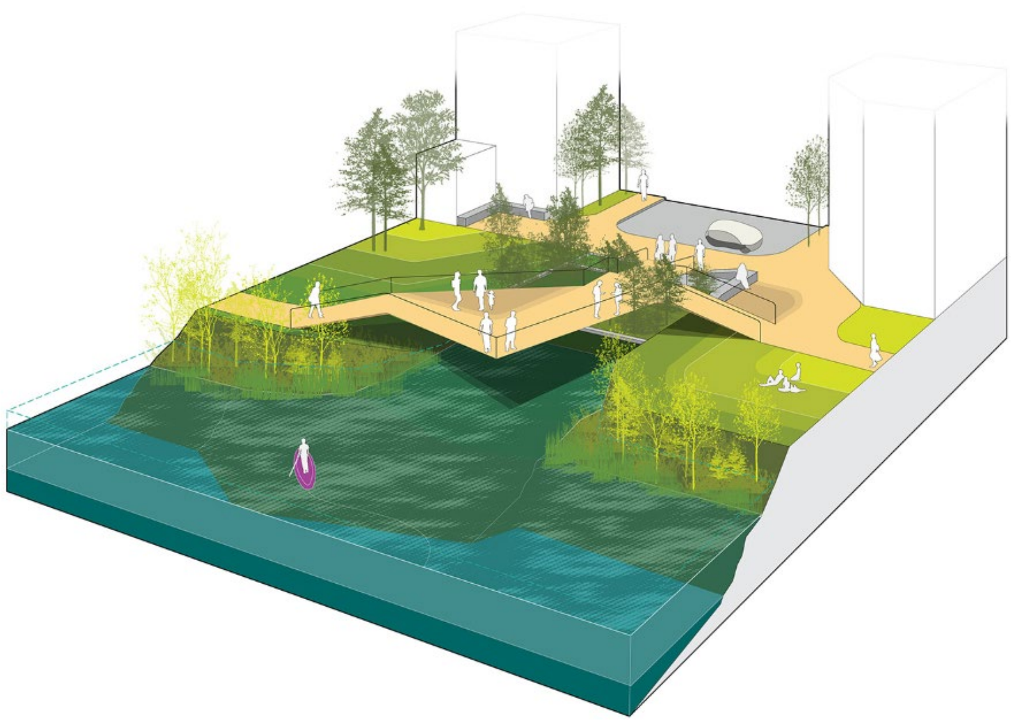

Figure 27: *Rendering of shoreline activation using pathways and living shoreline.* Gowanus Lowlands. (n.d.). SCAPE. Retrieved September 25, 2019, from https://www.scapestudio.com/projects/the-gowanus-lowlands/

Case Study 2 – Hunter's Point Park, Long Island City, NY

A great example of 21st century coastal park design can be found at Hunter's Point Park, which uses blue-green infrastructure to protect from surge and flooding during storm events and generous native plantings for increased ecological services.[34] The overall design intention centers around ecological restoration and function through the incorporation of high volumes of constructed wetland and native upland plantings, while still providing pedestrian waterfront access and traditional park use (Figure 28). Constructed tidal marsh was installed along the shoreline to serve many functions, including providing wildlife habitat, flood and surge resilience during storm events, erosion control from plant roots and mussels, and nutrient sinks for reduction of algae blooms in the waterway. As sea levels rise and storms become more frequent and severe, resilient blue-green infrastructure is becoming an important design component.

Figure 28: *Hunter's Point Park constructed wetland along the East River in New York City.* Newly expanded Hunter's Point South Park highlights a greener future for NYC parks. (2018, June 29). Archpaper.Com. https://archpaper.com/2018/06/newly-expanded-hunters-point-south-park-highlights-a-greener-future-for-nyc-parks/

Case Study 3 – Houtan Park, Shanghai, China

Houtan Park is an example of an inviting, riverside park that also functions as a phytoremediation powerhouse. The long, narrow park is designed to naturally filter wastewater through a series of linear plant complexes before releasing the clean effluent into the waterway (Figure 29). This system cleans more than 600,000 gallons daily of highly contaminated sewage and industrial wastewater that was historically released directly into the waterway. Phytoremediation offers an effective alternative to traditional chemical treatment systems for a variety of wastewater. These systems also provide a host of ecological services, especially as wildlife habitat for shore birds, while also offering beautiful spaces for park visitors to enjoy passive recreation.

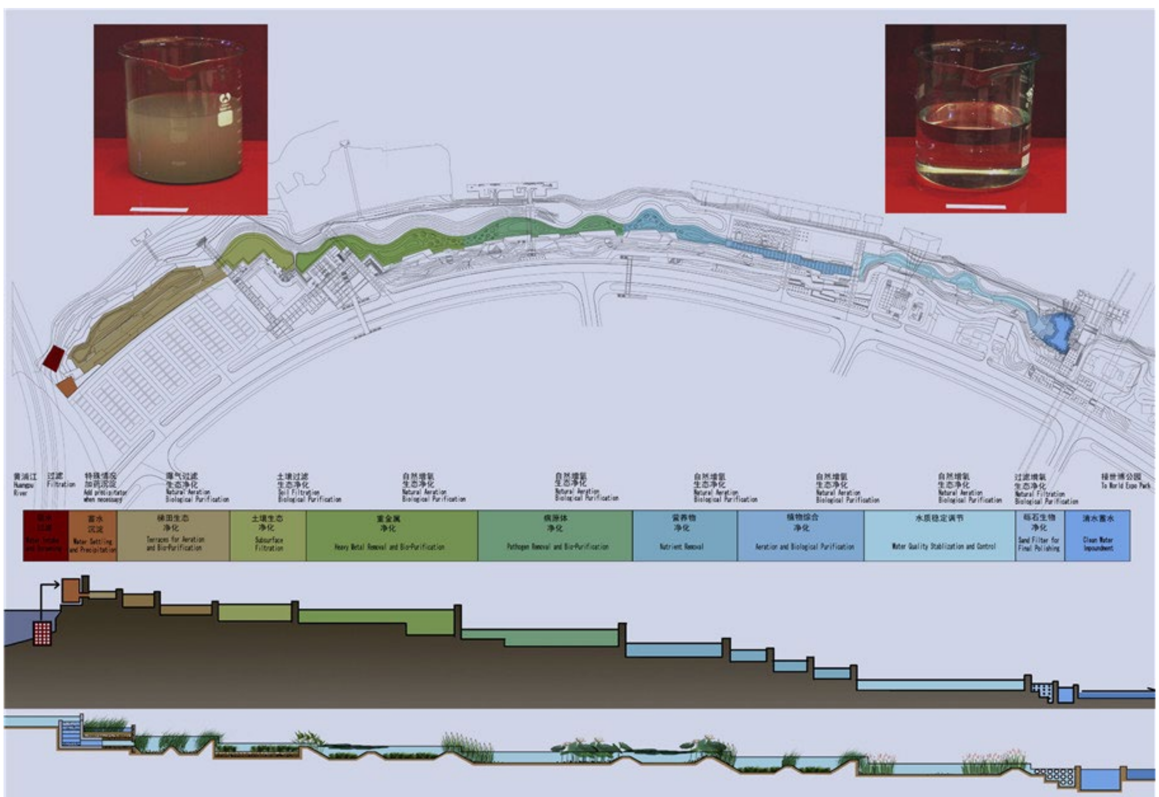

Figure 29: *Houtan Park illustration of phytoremediation process.* Pudong, S. A. it. (2011, December 1). Shanghai Houtan Park. Landscape Performance Series. https://www.landscapeperformance.org/case-study-briefs/shanghai-houtan-park.

DISCUSSION / SITE DESIGN

This long, narrow tidal flat along eastern Bayonne has been an overlooked relic of industry and growth, a by-product from centuries of development. After multiple site observations, thorough literature review, and broad analysis of conditions, a variety of design solutions are proposed to activate this space and connect residents of Bayonne to the waterfront and Upper New York Bay.

Design solutions begin with effective CSO management, including treatment of CSO discharge effluent and the reduction of overflow events triggered by moderate-to-heavy rainfall. Effective management of CSOs then serves as the foundation for increased site use and improved ecological services. Focus is placed on providing scenic waterfront access and circulation for nearby residents, more improved and resilient surge and flood protection, and much-needed wildlife habitat for the broad range of flora and fauna that frequent the Bay. Last, these design solutions provide the framework for a broad variety of proposed programming, intended primarily to promote community interaction along the waterfront, health and well-being, coastal education, research and preservation and maximum use of space within the site (Figure 30).

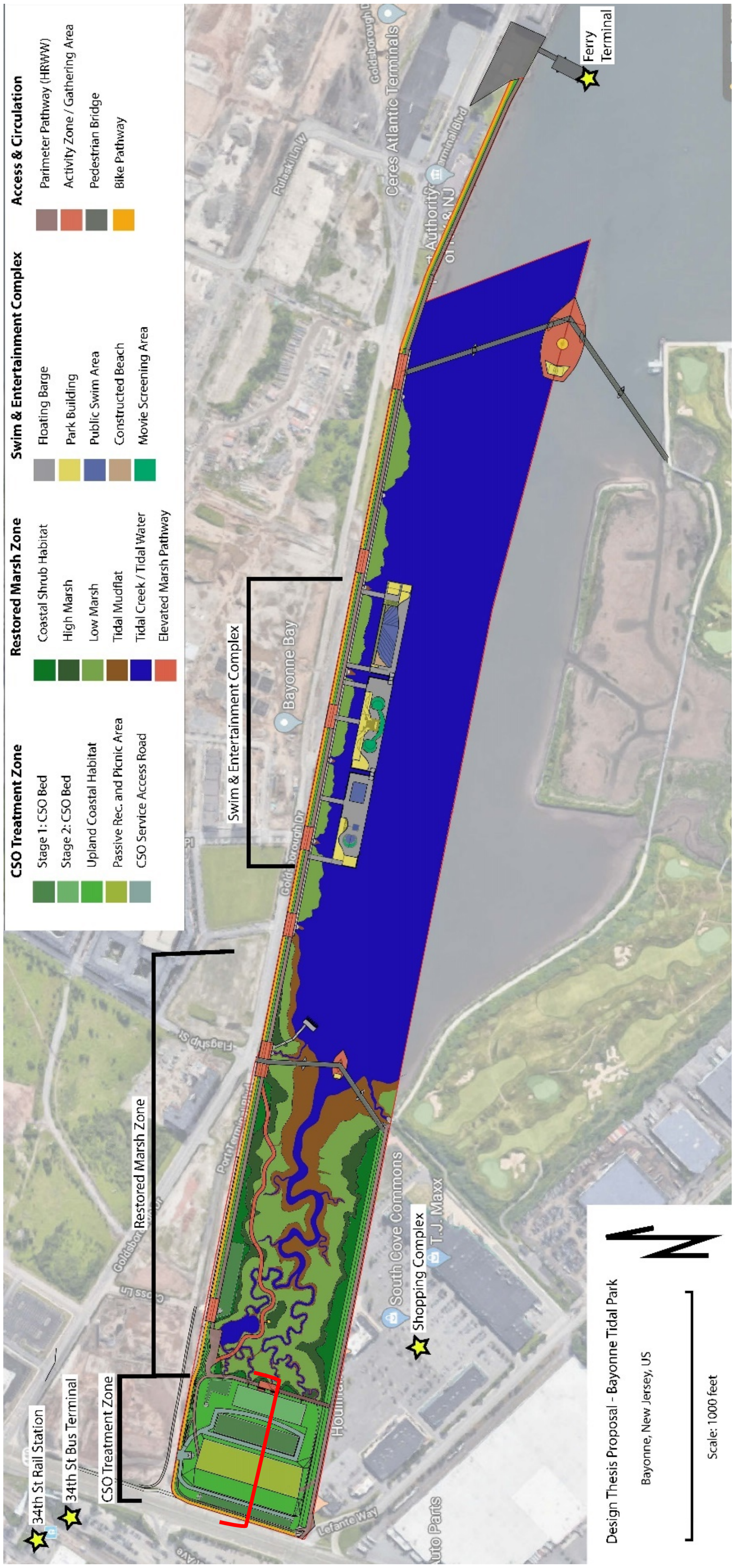

Figure 30: Site design base plan. Illustration by author. Source of aerial: Google Maps. (2019).

CSO Management

The city is pursuing a long-term management plan to meet federally-mandated CSO reduction requirements for the CSS, but proposed solutions will be costly, time-consuming, and highly disruptive to daily activity, requiring a multi-phased approach spanning decades. Based on their research, EPA determined that water-quality standards are accomplished when the total CSO discharge effluent volume from the system is reduced by 85% either captured for wastewater treatment elsewhere or reduced through redirection of the stormwater from the CSS.[35] Further research by the Passaic Valley Sewerage Commission (PVSC), the leading planning agency, determined the need for Bayonne to capture or reduce their CSO volumes by 59% (thought to be a conservative estimate based on future weather trends) to accomplish the overall 85% benchmark set by the EPA. Current city plans include an offsite storage tank to collect and hold CSO effluent, then redirect it back to the PVSC treatment facility before discharging into the Bay. This plan would have a considerable impact on commercial and commuter activity common in the area as a result of extensive construction activities.

A more efficient onsite approach to CSO management was chosen that offers multiple functions and better use of site space by using a combination of subterranean storage and phytoremediation (Figure 31). This combination eliminates harmful CSO releases, while also helping avoid the need for costly off-site management of wastewater.[36] These design solutions also help meet CSO reduction requirements set by the EPA by reducing CSO events as much as 96%.

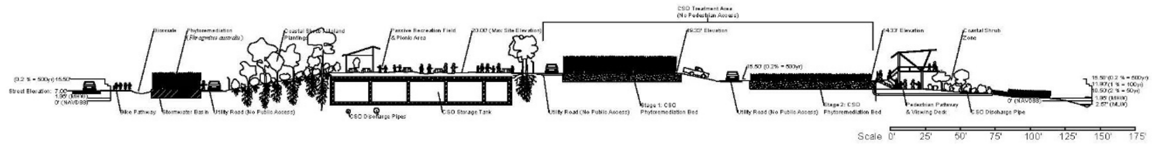

Figure 31: *Section cut of CSO design solution.* Illustration by author. (2019).

A reinforced concrete CSO storage tank buried beneath aggregate and engineered soils on the western portion of the site serves as the heart of this design, providing adequate storage during CSO events. With a capacity of approximately 6.6MG and measurements of 450’(L)x130’(W)x15’(H), the tank is designed to contain three times the average volume for a CSO event. This sizing is based on average CSO discharges of 2.2MG per event and the possibility of overlapping events requiring storage. Strategic placement of the massive structure along the western site boundary, between Highway NJ440 and a restored tidal flat, allows the storage facility to function as a physical buffer between waterway and roadway. The tank includes a non-permeable liner for protection, aggregates and anchoring for additional stabilization, and engineered soils on side slopes and above for various plant assemblies. During overflow events, CSO discharge effluent would be pumped into the storage tank, then gravity fed through phytoremediation beds, and finally discharged from multiple outlets located above seasonal tidal levels along the eastern edge of the design segment, where constructed tidal flat begins (Figure 32).

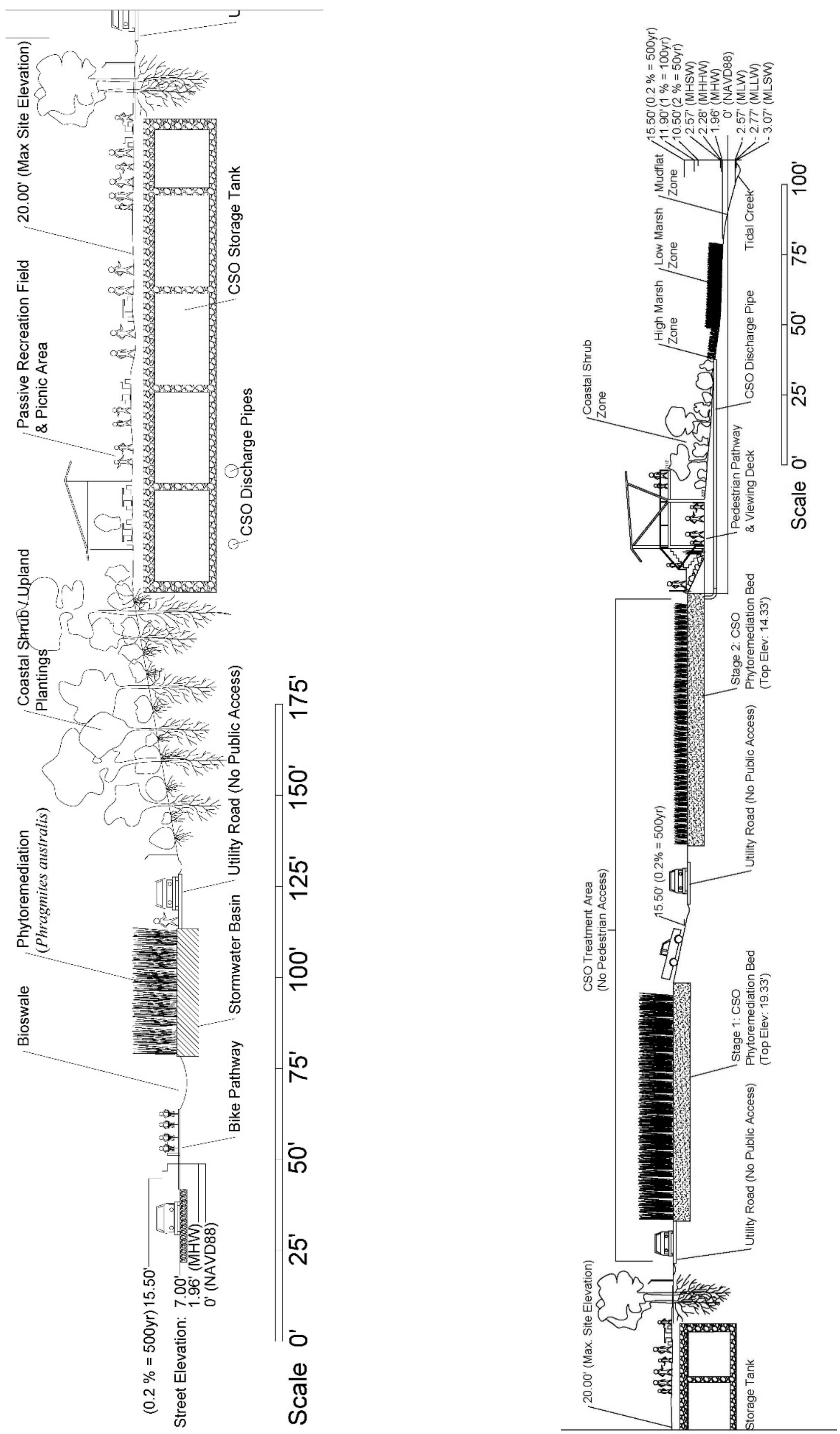

Figure 32: *Section cuts of western CSO treatment portion of the site design.* Illustration by author. (2020).

Effective CSO management is possible through onsite storage and the use of simple biological processes involving multi-stage phytoremediation technologies developed by Naturally Wallace, FBA™, a U.S. water treatment consultant.[37] Sizing of the proposed treatment area is based on average CSO discharge volumes, effluent flow rates, and percolation rates through phytoremediation beds.

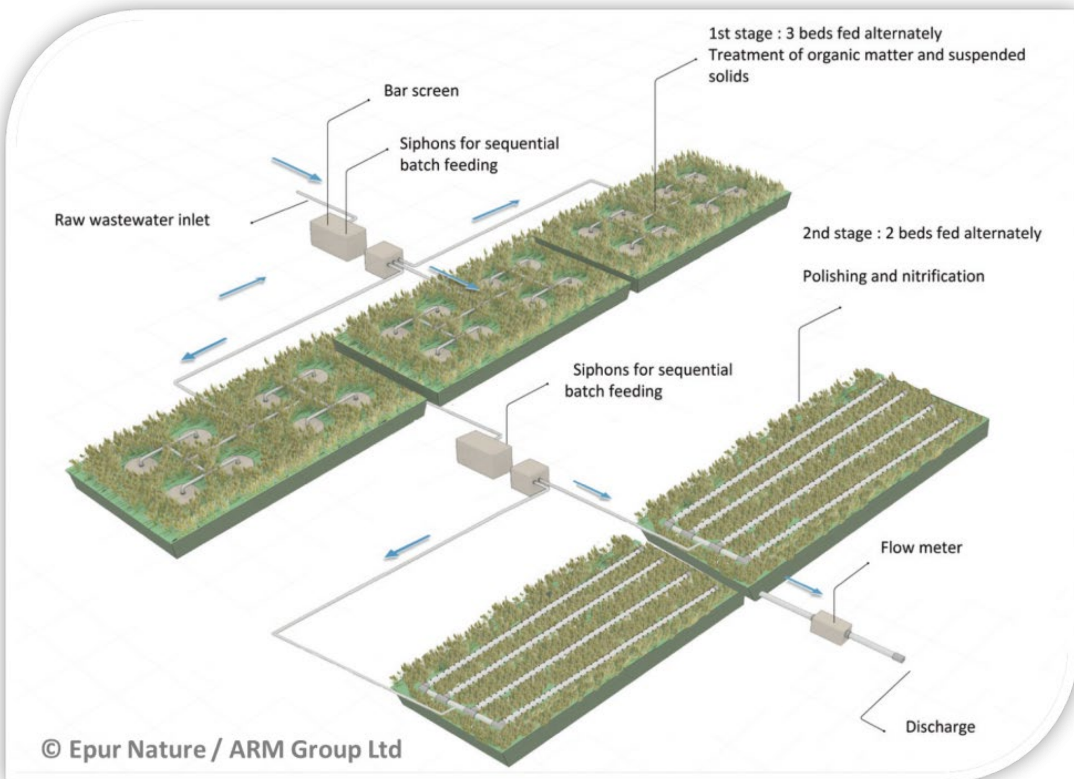

Figure 33: *Two-stage CSO phytoremedation system.* Constructed Wetlands / Reedbeds. (n.d.). ARM Reedbeds. Retrieved April 23, 2020, from https://armreedbeds.co.uk/constructed-wetlands/.

The straightforward treatment process begins with the collection of effluent in the storage tank during CSO discharge events. Once collected, effluent is dispersed at a prescribed rate across the surface of the first stage of constructed wetland for treatment of organic matter and suspended solids (Figure 33). Surface dispersal increases surface interactions and microbial processes within the root matrix as the effluent percolates through six vertical feet of root mass and plant medium. The first stage consists of common reed (*Phragmites australis*) beds, which provide effective, long-term treatment of wastewaters high in BOD, SS, NH4-N, and other organic contaminants.[38] Treatment of affluent continues in the second stage of constructed wetland, where final polishing and nitrification occurs via dispersal of affluent across the surface and through six feet of roots and medium. The second stage consists of smooth cordgrass (*Spartina alterniflora*), providing effective CSO treatment while also being tolerant to higher salt concentrations from salt spray and surge events.

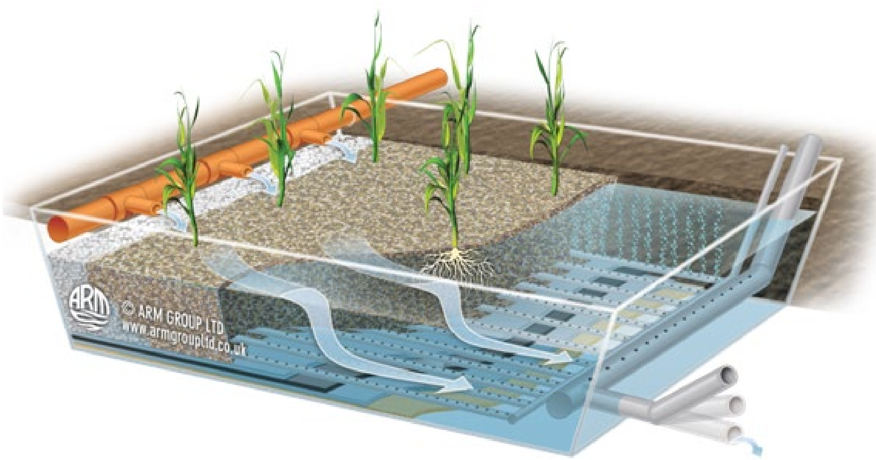

Figure 34: *Phytoremediation diagram of Forced Bed Aeration and water flow.* Constructed Wetlands / Reedbeds. (n.d.). ARM Reedbeds. Retrieved April 23, 2020, from https://armreedbeds.co.uk/constructed-wetlands/.

For maximum bioreactivity, forced air is added to the phytoremediation system. Forced Bed Aeration (FBA) is a recently developed wastewater treatment process designed to enhance constructed wetland treatment performance.[39] This process involves injecting air up from the base of treatment beds through the growing medium and root zone of plants (Figure 34), which accelerates the remediation process by 15 times compared to non-FBA systems.[40] Once cleaned through this process, processed effluent is discharged into the waterway and across the site.

This design solution requires only minimal oversight and periodic maintenance, along with small amounts of electricity for operating water and air pumps. Besides effectively processing CSO discharges, this plant-based approach also provides beautiful plantings to view, while also offering valuable ecological services, including ideal nesting habitat for local and migratory shorebirds that frequent the Bay.

Resiliency and Restoration

As noted in previous analysis, coastal location and narrow configuration of the site make it highly vulnerable to erosion, flooding, and wind damage, which will be exacerbated by sea level rise. Surrounding development, including Highway NJ440 and South Cove Commons shopping complex, experience periodic flooding during large storm events. Protecting current and upcoming residential, retail and commercial construction is paramount if eastern Bayonne is to be effectively used and occupied for the long term. Based on recent climate patterns and weather predictions, future use and occupation of coastal environments will require new and novel protection measures. This design proposes the use of low and high marsh habitat, along with other blue-green infrastructure, such as living shoreline, to provide additional coastal resiliency against storm surge, flooding and rising sea levels (Figure 35).[41] [42]Besides providing added protection, restored tidal flat and living shoreline bring ecologically rich marsh habitat back into this portion of Bayonne and Upper New York Bay, where it has been depleted for decades.

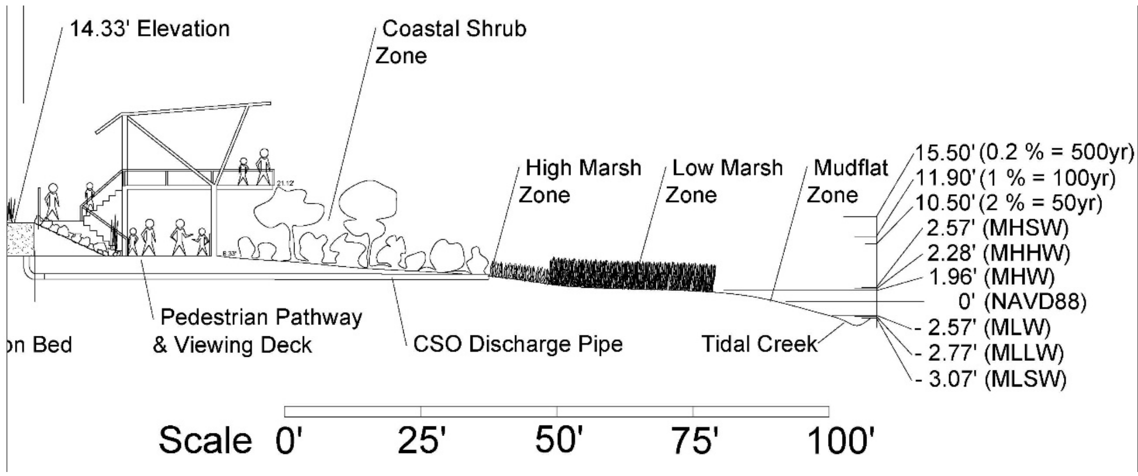

Figure 35: *Shoreline and various site water levels.* Illustration by author. (2020).

Restoration of approximately fifteen acres of tidal flat area is proposed for western portions of the site, currently consisting of vast mudflat and scoured "tidal creeks" (Figure 36), formed from rapidly released effluent discharging from different CSO and stormwater points throughout the site.

Figure 36: *Aerial of scoured mudflat conditions across western portions of the site.* Source of aerial: Google Maps (2019).

Mimicking natural form and proportion (Figure 37), the tidal flat restoration of this design includes winding, slow-flowing tidal creeks (shown below in blue) flanked by narrow bands of mudflat (between blue and yellow). This engineered sinuous creek is surrounded by extensive low marsh (between yellow and green), planted with smooth cordgrass (*Spartina alterniflora*) covering the majority of tidal area. Less abundant high marsh (between green and purple) is also part of the design, consisting mainly of saltmeadow cordgrass (*Spartina patens*) and spike grass (*Distichlis spicata*) plantings. Last, the upper fringes of high marsh (purple) will include black grass (*Juncus gerardii*) and marsh elder (*Iva frutescens L.*) plantings for erosion control along edges of the inlet. Site design for this portion of the site posed the greatest challenges as a result of changing climate, rising sea-levels, and persistent water quality issues.

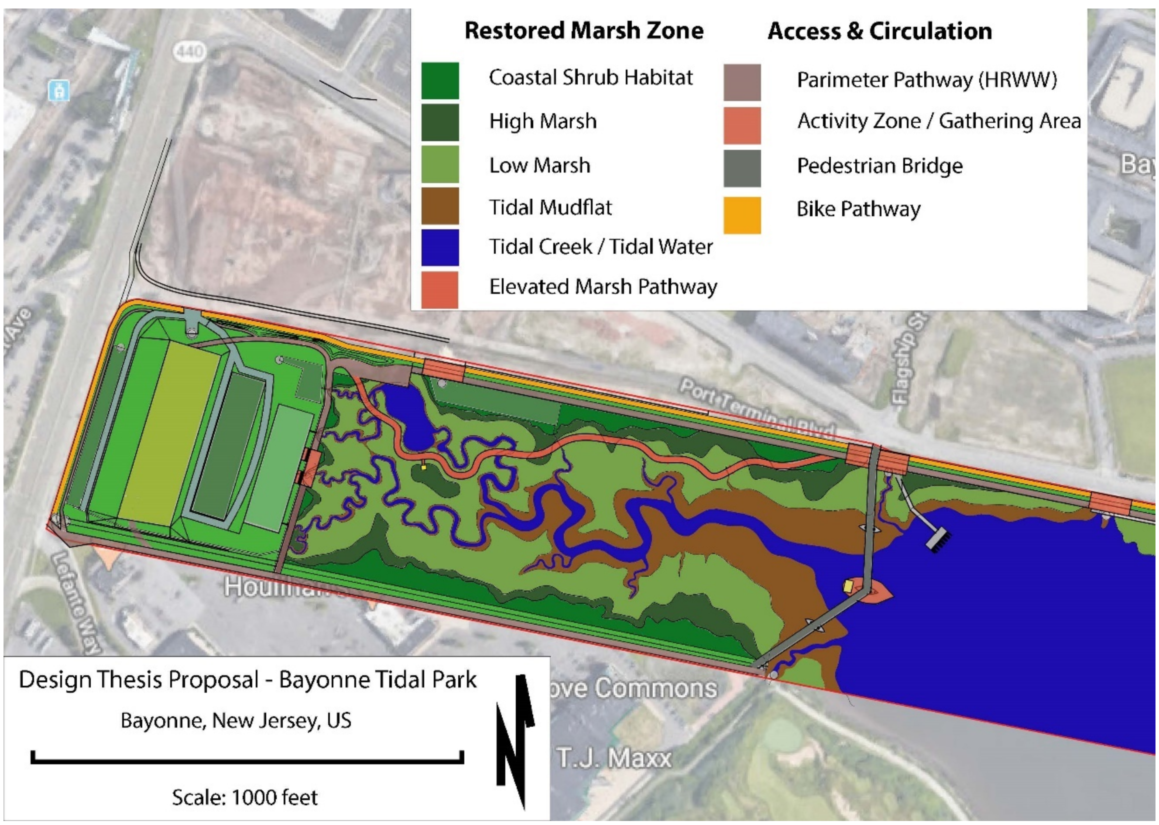

Figure 37: *Tidal flat restoration plan including tidal creeks, mudflat, low marsh, high marsh, and coastal shrub zones.* Illustration by author. 2020. Source of aerial: Google Maps. (2019).

Public Access and the Hudson River Waterfront Walkway (HRWW)

To provide adequate pedestrian circulation, additional pathways are proposed, along with two pedestrian bridges, one transecting near the middle of the site and the other near the eastern edge of the site, close to the soon-to-be-constructed Bayonne Golf Course marina and Bayonne ferry terminal (Figure 38). Additional pathways will facilitate circulation that currently is lacking on and around the site.

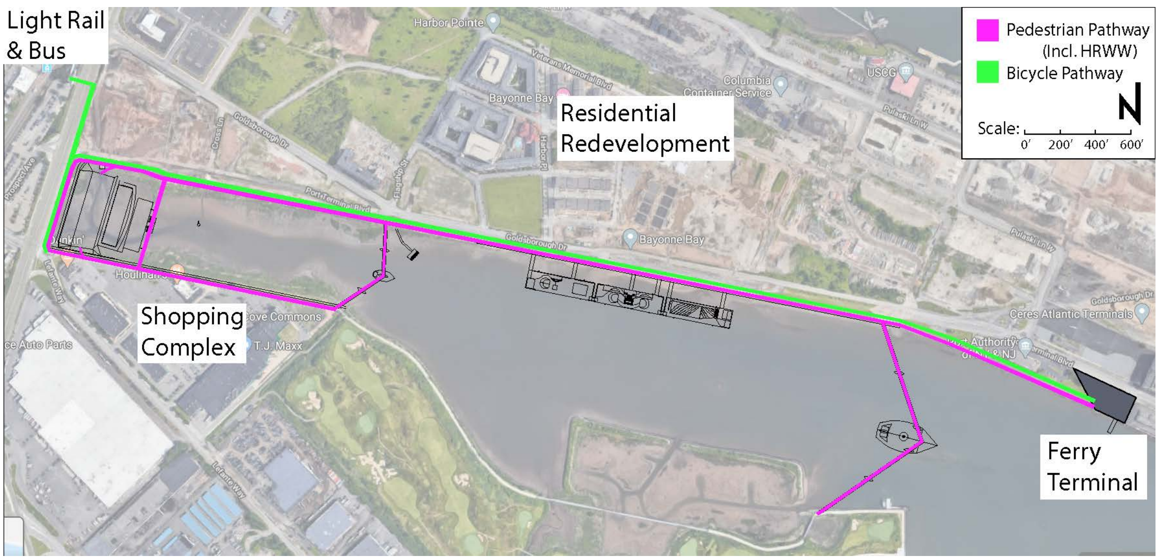

Figure 38: *Multi-pathway design solution providing full access around and through the site.* Illustration by author. 2020. Source of aerial: Google Maps. (2019).

New north-south sections of pathway are proposed to connect long, linear stretches of east-west oriented Hudson River Waterfront Walkway along portions of the site boundary. These proposed design solutions ensure proper circulation throughout the site. Since 1988, the HRWW have been sporadically installing (or accepting from developers, as applicable) a multi-purpose, linear pathway along the New Jersey waterfront. The mission of the HRWW Conservancy has been to provide continuous pedestrian waterfront access from the lower Hudson River at the George Washington Bridge south along the Hudson River and Upper New York Bay, then along Kill Van Kull to terminate at Bayonne Bridge. This lofty goal is problematic because of restricted areas along the waterway which prohibit public access, such as shipping ports, industrial facilities, and chemical/oil tank farms. Use of the HRWW along the site would increase with the addition of new pathways and bridges as they would provide better connectivity and full circulation of the site via multiple routes, eliminating restrictive and unappealing out-and-back path usage.

A sinuous pedestrian pathway through the tidal flat is also proposed, passing over tidal creeks and mudflat and through low and high-marsh habitat. This pathway would provide a juxtaposition to the straight, level pathways of the HRWW, bringing the user along the winding path through natural tidal systems where the pulse of the tides can be experienced more intimately. Besides providing a unique user experience, the pathway will also provide easy access for "living lab" activities such as water and sediment sampling, plant and animal surveys, and similar coastal research. Furthermore, the site will be ideal for primary and secondary school field trips, along with more advanced study by academic institutions and research organizations.

Site Uses and Programming

Primary design goals included improving water quality, adding storm protection and habitat, and providing yearlong waterfront access to residents of Bayonne and neighboring communities. A number of secondary design objectives, such as site programming, is accomplished through the inclusion of activity zones, gathering spaces, and recreational infrastructure. These spaces help facilitate various passive and active uses of the park, both land-based and aquatic.

Land-Based Design

With most of the site comprised of tidal flat, considerable effort was placed on providing passive and active land-based uses across a variety of settings. A network of more than three miles of pedestrian pathways is proposed, forming the “nervous system” of the park by providing useful circulation for visitors to flow in and around the site. Pathways are proposed alongside, among, and across the tidal flat, allowing for extensive waterfront access and unique experiences throughout the park.

The HRWW makes up portions of the pathway system, providing opportunities for users to venture northward beyond the park, along the “Gold Coast” of New Jersey. This walkway also allows visitors to travel south to explore and enjoy this site, making it an ideal destination along the HRWW. Besides offering extensive waterfront access, park pathways also offer opportunities for passive recreation, such as exercise walking, dog walking, sightseeing, and bird watching. A number of activation zones are included along northern portions of pathway to promote social engagement and break up the mile-long corridor. These zones are designed as pocket parks for gathering and interaction through different uses, including table clusters for table-oriented gaming, lawn game pads for enjoying cornhole, horseshoes, or shuffleboard, and table tennis assemblies.

Four transecting pathways are included in the design, offering maximum circulation within the site, including two along the western portion of the site, straddling the CSO treatment system, and two in the form of pedestrian bridges that cross the waterway. Each of them offers different experiences and are meant to be used in different ways.

The westernmost pathway is straight and simple, designed for rapid movement as it is positioned close to the hustle and bustle of Highway NJ440. The other western pathway is positioned between the elevated CSO treatment system and restored tidal flat, where diffused, phytoremediated effluent is discharged from multiple points into the marsh area. This pathway includes an elevated, covered viewing deck at the midpoint, offering views of the treatment beds to the west and big, scenic views east across the site's proposed marsh and pedestrian bridges, along with connecting Bay (Figure 39).

Figure 39: *Looking east from western-most viewing deck at proposed pedestrian bridges.* Photo by author. (2020).

Both bridges include gathering platforms in the shape of broad sailing ships, positioned at the center-point of each bridge. These platforms offer ideal space for relaxing along the pathway, plus inviting space for a variety of activities. The western pedestrian bridge platform is designed to resemble a ship and measures 60'W x 130'L. The smaller of the two, this platform is best suited for stopping to view lush marsh-laden tidal flat to the west and long, grand views east over the inlet and across Upper New York Bay. This platform also offers ideal space for outdoor recreation, such as fishing and birdwatching, along with programmed, group-oriented activities such as yoga, cross-fit, and sketching/painting classes. The larger, eastern pedestrian bridge platform, also shaped like a ship, measures 175'W x 360'L. This bridge platform is designed as the primary gathering place along the walkway where most site programming is proposed. A multi-use stage area is included, providing space for annual and seasonal events, such as concerts, performances, and festivals. The highlight of the platform is a 360-degree "bird's nest" viewing deck located 80' above the base of the platform (Figure 40). This perspective offers expansive views of popular spots, such as One World Trade and lower Manhattan, Statue of Liberty, sprawling Port Jersey shipping terminal, The Narrows and Verrazzano Bridge, plus a host of other surrounding sights.

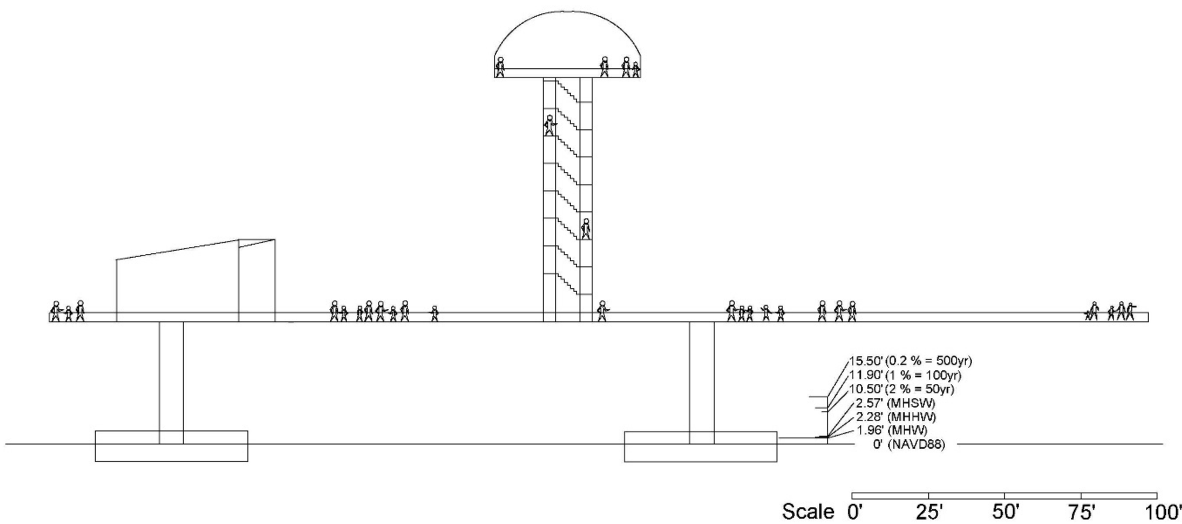

Figure 40: *East pedestrian bridge platform and 360-degree viewing deck.* Illustration by author. (2020).

A dedicated multi-lane bike path is also included around the park perimeter for more rapid circulation between the ferry terminal, train station and shopping complexes surrounding the site. This "non-motorized transportation corridor" is designed for visitors using bicycles, skateboards, and in-line skates, along with electric scooters, e-bikes, and e-boards. Besides being a quick corridor, this dedicated pathway is also designed to separate visitors using mobility equipment from pedestrians walking along pathways and across bridges in the park. This separation is to increase park safety along pathways and help ensure a smooth and relaxing experience for visitors.

Aquatic Design

Floating structures are included in the design, allowing visitors more intimate interaction with the waterway. Although the Class B waters of the waterway prohibit prolonged human contact or consumption, making them unsuitable for swimming, they are recommended for fishing activities (primarily non-consumption, due to fish contamination, such as PCBs) and watercraft use, both popular local activities and important components of this design. A floating dock allows visitors direct access to the waterway from the north side of the inlet, near the mouth of the restored tidal flat and alongside the central pedestrian bridge (Figure 41). The floating structure is designed for launching various non-motorized watercraft, such as kayaks, canoes, paddle-boards, and even small sailing vessels, using specialized slips for making water transfer easier.

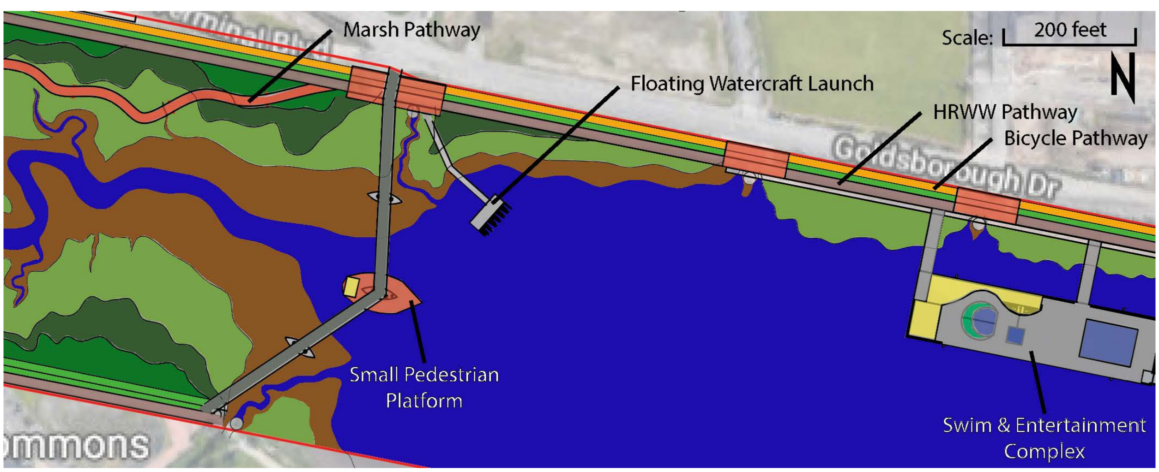

Figure 41: *Floating watercraft launch and surrounding access points.* Illustration by author. (2020).

Upper New York Bay has a long, interesting history of barge use, including famous late 19th century oyster houses, freight car and coal shuttles, and municipal waste transporters.[43] Current uses range from a massive New York City prison facility housing up to 800 inmates to an Olympic-size community pool in the Bronx.[44,45] Other community-oriented uses include The Science Barge, a sustainable urban farm and agricultural center currently docked in downtown Yonkers, and Swale, a public artwork and floating edible landscape currently undergoing renovations to become a permanent floating park in Brooklyn, New York (Figure 42).

Figure 42: *Current examples of community-centric barge use.* Science Barge. (n.d.). Groundwork Hudson Valley. Retrieved April 23, 2020, from http://www.groundworkhv.org/programs/science-barge/. Our Vision. (n.d.). SWALE NYC. Retrieved April 23, 2020, from https://www.swalenyc.org/our-vision.

These examples helped inspire the design of a multi-barge swimming and entertainment complex, moored along the north pathway, between proposed pedestrian bridges. Consisting of three 400'L x 100'W barges, this proposed complex serves as a novel solution for residents to enjoy safe use and activation of the inlet. The complex offers many options for Bayonne residents to enjoy waterfront recreation, including a ten-lane Olympic size pool, children's pool and splash zone, and unique natural swimming pool. The natural swimming pool is a chemical-free option that relies on plant assemblies that provide effective water treatment as the water circulates in a closed-loop system. The pool is lined in sand and includes a sprawling sandy beach for sunbathing that slopes down giving the feeling of a natural sloping shoreline. Other services proposed include various food offerings, washing/changing facilities, workout facilities, and an outdoor space for movie showings and live performances (Figure 43).

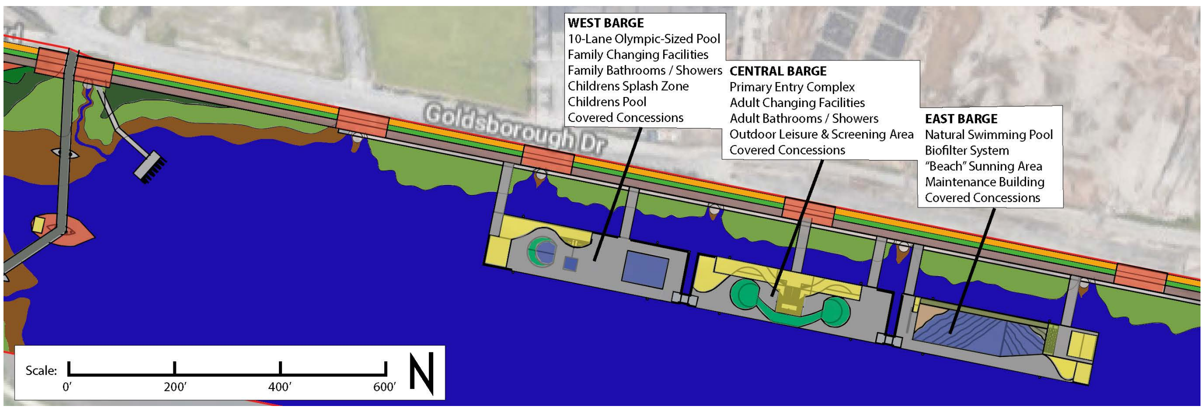

Figure 43: *Proposed barge-based swim and entertainment complex.* Illustration by author. 2020. Source of aerial: Google Maps. (2020.

CONCLUSION

Upper New York Bay and the landscape that surrounds it have gone through immense changes over the past few centuries. This design thesis focuses on a distressed inlet and tidal flat along eastern Bayonne, New Jersey. Primary design goals included CSO management, coastal restoration and resilience, and public waterfront access. Secondary goals, such as circulation, activation of underutilized coastal space, providing fun and engaging programming, and promoting citizen science, were also included to elevate the park visitor experience. This tidal park design is meant to be a beacon for Bayonne residents to reconnect to Upper New York Bay. The design solutions recommended wherein offer insights for future coastal management and restoration efforts. Many coastal areas face a number of human and environmental threats, requiring similar coastal design strategies.

Social Benefits

The communities in and around the site will greatly benefit from this design in a number of ways, ranging from added storm protection to lively spaces for accessing and enjoying the waterfront.

Environmental Benefits

This design will provide a wide variety of environmental benefits, ranging from improving water quality in the surrounding waterway to providing large swaths of habitat for a host of birds, benthic organisms, fish.

Resilient Benefits

It is only after major storm events and our greater understanding of coastal systems that we realize and appreciate the protective potential of natural marsh systems along settled shorelines.

Endnotes

[1] *NOAA Stats—Economics and Demographics*. (n.d.). Retrieved January 28, 2020, from https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html

[2] *NOAA Stats—Economics and Demographics*. (n.d.). Retrieved January 28, 2020, from https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html

[3] Science, A. A. for the A. of. (2016). Rise of the City. *Science*, *352*(6288), 906–907. https://doi.org/10.1126/science.352.6288.906

[4] *Coastal Green Infrastructure Research Plan for New York City*. (n.d.). 157.

[5] *Billion Oyster Project*. (n.d.). Retrieved January 21, 2020, from https://billionoysterproject.org/#

[6] *Military Ocean Terminal—Bayonne—Military Railroads of the New York Metropolitan Area*. (n.d.). Retrieved March 4, 2020, from http://members.trainweb.com/bedt/milrr/motby.html

[7] *CSO_DEAR_PVSCRegional_Appendix_20190628.pdf*. (n.d.). Retrieved September 15, 2019, from https://www.nj.gov/dep/dwq/pdf/CSO_DEAR_PVSCRegional_Appendix_20190628.pdf

[8] *Flood Event Viewer*. (n.d.). Retrieved March 20, 2020, from https://stn.wim.usgs.gov/FEV/#Sandy

[9] *Sea-Level Curve Calculator (Version 2019.21)*. (n.d.). Retrieved April 21, 2020, from http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html

[10] Sanderson, E. (2013). *Mannahatta: A Natural History of New York City*. Harry N. Abrams.

[11] Discover the Hudson Valley's Tribal History. (2016, June 23). *Hudson Valley Magazine*. https://hvmag.com/life-style/history/discover-the-hudson-valleys-tribal-history/

[12] *History of the Interstate Highway System—50th Anniversary—Interstate System—Highway History—Federal Highway Administration*. (n.d.). Retrieved April 16, 2020, from https://www.fhwa.dot.gov/interstate/history.cfm

[13] *New-Jersey-Combined-Sewer-System-by-the-Numbers-New-Jersey-Future.pdf*. (n.d.). Retrieved April 13, 2020, from https://www.njfuture.org/wp-content/uploads/2015/03/New-Jersey-Combined-Sewer-System-by-the-Numbers-New-Jersey-Future.pdf

[14] *Bayonne.pdf*. (n.d.). Retrieved March 5, 2020, from https://www.nj.gov/dep/cmp/access/docs/draftmpaps/bayonne.pdf

[15] *Bayonne Urban Coastal Design: An Integrated Approach, Report of August 30, 2019*. (n.d.). 76.

[16] *Regional Geology—NJ_NY_08.pdf*. (n.d.). Retrieved February 20, 2019, from https://people.hofstra.edu/j_b_bennington/field_trips/Southeastern_NY_Guide_08.pdf

[17] *Ofm110.pdf*. (n.d.). Retrieved April 5, 2020, from https://www.state.nj.us/dep/njgs/pricelst/ofmap/ofm110.pdf

[18] *Surficial Geology Map.pdf*. (n.d.). Retrieved February 26, 2019, from https://www.state.nj.us/dep/njgs/pricelst/ofmap/ofm20.pdf

[19] US EPA, O. (2017, August 22). *Hazardous Waste Cleanup: Military Ocean Terminal in Bayonne, New Jersey* (New Jersey) [Overviews and Factsheets]. US EPA. https://www.epa.gov/hwcorrectiveactionsites/hazardous-waste-cleanup-military-ocean-terminal-bayonne-new-jersey

[20] South Cove Commons. (n.d.). *South Cove Commons*. Retrieved April 2, 2020, from http://www.southcovebayonne.com/the-company/

[21] *Bayonne Golf Club Waterfront Development and Wetland MItigation » Princeton Hydro*. (n.d.). Retrieved December 7, 2018, from http://www.princetonhydro.com/projects/natural-resource-management-projects/coastal/bayonne-golf-club/

[22] *Bayonne-Master-Plan.pdf*. (n.d.). Retrieved February 26, 2019, from http://www.bayonnenj.org/web_content/pdf/plans/Bayonne-Master-Plan.pdf?v=2017

[23] *VanAbs_Urban-Water-Infrastructure-Report-Revised-Final-June-2014.pdf*. (n.d.). Retrieved February 26, 2019, from https://www.njfuture.org/wp-content/uploads/2014/04/VanAbs_Urban-Water-Infrastructure-Report-Revised-Final-June-2014.pdf

[24] *CSO_SystemCharacterization_PVSC_8_20180629.pdf*. (n.d.). Retrieved April 22, 2019, from https://www.state.nj.us/dep/dwq/pdf/CSO_SystemCharacterization_PVSC_8_20180629.pdf

[25] *CSO_SystemCharacterization_PVSC_8_20180629.pdf*. (n.d.). Retrieved April 22, 2019, from https://www.state.nj.us/dep/dwq/pdf/CSO_SystemCharacterization_PVSC_8_20180629.pdf

[26] *NYHOPS: Urban Ocean Observatory at Davidson Laboratory*. (n.d.). Retrieved April 2, 2019, from http://hudson.dl.stevens-tech.edu/maritimeforecast/maincontrol.shtml

[27] Coch, N. K. (2016). Sediment Dynamics in the Upper and Lower Bays of New York Harbor. *Journal of Coastal Research*, *32*(4), 756–767. https://doi.org/10.2112/JCOASTRES-D-15-00133.1

[28] Thin-Layer Placement of Sediment. (n.d.). *NERRA*. Retrieved April 22, 2020, from https://www.nerra.org/reserves/science-tools/tlp/

[29] *DNREC's first beneficial-reuse marsh restoration project succeeds with thin-layer spray application*. (n.d.). Retrieved December 6, 2018, from http://www.dnrec.delaware.gov/News/Pages/DNRECs-first-beneficial-reuse-marsh-restoration-project-succeeds-with-thin-layer-spray-application.aspx

[30] *Datums—NOAA Tides & Currents*. (n.d.). Retrieved April 22, 2020, from https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=0&epoch=0&id=8518750&name=The+Battery&state=NY

[31] *FEMA Flood Map Service Center | Search By Address*. (n.d.). Retrieved March 24, 2020, from https://msc.fema.gov/portal/search?AddressQuery=croton%20point#searchresultsanchor

[32] *State of the Climate | National Centers for Environmental Information (NCEI)*. (n.d.). Retrieved April 16, 2020, from https://www.ncdc.noaa.gov/sotc/

[33] *Gowanus Lowlands*. (n.d.). SCAPE. Retrieved September 25, 2019, from https://www.scapestudio.com/projects/the-gowanus-lowlands/

[34] *Hunters Point Parks Conservancy—Park Features*. (n.d.). Hunters Point Parks Conservancy. Retrieved September 7, 2019, from https://www.hunterspointparks.org/resiliency

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[35] *CSO_DEAR_PVSCRegional_Appendix_20190628.pdf*. (n.d.). Retrieved September 15, 2019, from https://www.nj.gov/dep/dwq/pdf/CSO_DEAR_PVSCRegional_Appendix_20190628.pdf

[36] *Constructed Wetlands for CSO Treatment—Lochmueller Group*. (n.d.). Retrieved January 10, 2020, from http://lochgroup.com/project/constructed-wetlands-for-cso-treatment/

[37] *NaturallyWallace: Wetlands consulting to treat wastewater streams.* (n.d.). Retrieved January 10, 2020, from http://www.naturallywallace.com/

[38] Phragmifiltre. (n.d.). *ARM Reedbeds*. Retrieved April 23, 2020, from https://armreedbeds.co.uk/projects/phragmifiltre/

[39] Forced Bed Aeration. (n.d.). *ARM Reedbeds*. Retrieved April 23, 2020, from https://armreedbeds.co.uk/projects/forced-bed-aeration/

[40] *Forced Bed Aeration—Can Wetlands Tackle CSOs?* (n.d.). Retrieved January 12, 2020, from http://fliphtml5.com/zboo/kjjj

[41] Narayan, S., Beck, M. W., Wilson, P., Thomas, C. J., Guerrero, A., Shepard, C. C., Reguero, B. G., Franco, G., Ingram, J. C., & Trespalacios, D. (2017). The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Scientific Reports*, *7*(1), 9463. https://doi.org/10.1038/s41598-017-09269-z

[42] *Living-shorelines-engineering-guidelines-final.pdf*. (n.d.). Retrieved January 17, 2020, from https://www.nj.gov/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf

[43] *History on the Half-Shell: The Story of New York City and Its Oysters*. (n.d.). The New York Public Library. Retrieved June 19, 2019, from https://www.nypl.org/blog/2011/06/01/history-half-shell-intertwined-story-new-york-city-and-its-oysters

[44] Haag, M. (2019, October 10). A Floating Jail Was Supposed to Be Temporary. That Was 27 Years Ago. *The New York Times*. https://www.nytimes.com/2019/10/10/nyregion/nyc-jail-barge-rikers.html

[45] *Floating Pool: NYC Parks*. (n.d.). Retrieved April 23, 2020, from https://www.nycgovparks.org/facility/pools/floating-pool?wptouch_preview_theme=enabled