Sustainability Management Capstone - Summer 2018

Project: Enhancing Climate Resilience in Long Island State Parks, Orient Beach State Park Case Study

Client: New York State Office of Parks, Recreation and Historic Preservation

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Table of Contents

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Key Terms

Adaptation: A change or the process of change by which an organism or species becomes better suited to its environment.

Adaptation Strategy: A framework for managing future climate risk, prioritizing and coordinating action.

Barrier Island: A detached portion of a barrier beach between two inlets.

Beach Erosion: The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.

Beach Nourishment: Material placed on a beach to re-nourish eroding shores, usually sand pumped by dredging but sometimes delivered by trucks.

Beach Width: The horizontal dimension of the beach measured normal to the shoreline and landward of the higher-high tide line (on oceanic coasts) or from the still water level (on lake fronts).

Biodiversity: The variety of life in the world or in a particular habitat or ecosystem buffers.

Causeway: A raised road across wet or marshy ground, or across water that allows access to facilities and physical infrastructure.

Climate Change: A term used for the change in global or regional climate patterns, associated with an increase in global average temperatures.

Climate Change Impacts: This term refers to how climate change can alter rainfall and temperature influence crop yields, affect human health, cause changes to vegetation and other ecosystems.

Climate Models: Systems of differential equations concerning the interactions and reactions of climate drivers such as atmosphere, oceans, ice, and land, based on the basic laws of physics, fluid motion, and chemistry.

Climate Projections: The simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases and aerosols, generally derived using climate models.

Coast: A strip of land of indefinite width that extends from the shoreline inland to the first major change in terrain features.

Coastal Area: The land and sea area bordering the shoreline.

Coastal Communities: People living on the thin strip of land or on the water along the fluctuating line where the sea meets the land.

Coastal Ecosystems: The collection of organisms that are found on the boundaries of oceans, lakes, rivers, and other forms of liquid water.

Coastal Morphology: Refers to geomorphology of the coast.

Coastal Protection: Measures aimed at protecting the shoreline against coastal erosion, thus protecting coastal ecosystems, housing, and infrastructure from erosion.

Coastal Resilience: Refers to enhancing the ability of a community to accommodate and bounce back after major climate events such as hurricanes, coastal storms, and flooding.

Coastal Resource Management (CRM): Refers to the sustainable use and management of coastal resources. It also involves capacity building of national and local governments along with communities to manage marine and coastal ecosystems.

Coastal Vulnerability Assessment: Research and data collection applied to vulnerable coastal areas with projections and analyses on how to best tailor solutions for response.

Dredging: The act of removing silt or sediments from the bottom of bodies of water.

Dunes: Ridges or mounds of loose, wind-blown material, usually sand.

Ecosystem Services: The benefits that an ecosystem derives from healthily functioning systems, such as flood protection, water purification, etc.

Ecosystem Based Adaptation (EBA): Is a nature-based solution that harnesses biodiversity and ecosystem services to reduce vulnerability and build resilience to climate change.

Erosion: The carrying away of beach material by wave action, tidal currents, or littoral currents.

Fauna: This describes animals of a particular region, habitat, or geological period.

Flora: This describes plants of a particular region, habitat, or geological period.

Geomorphology: Refers to the branch of physical geography which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.

Habitat: Refers to the natural home or environment of an animal, plant, or other organism.

Hurricane: A severe tropical storm with high winds and heavy rain.

Inundate: This is a term used to describe flooding, cover or overspread with water.

Integrated Coastal Zone Management (ICM): A dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio-cultural and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone.

Maritime Red Cedar Forest: Refers to the number of juniper trees or shrubs with bluish, berry-like fruit and red wood.
Marsh: A tract of soft, wet land, usually vegetated by reeds, grasses and occasionally small shrubs.

Modeling: The creation of a physical or computer analogy to understand a particular phenomenon.

Natural Infrastructure: This term refers to a strategically planned and managed network of natural lands, such as forests and wetlands, working landscapes, and other open spaces that conserves or enhances ecosystem values and functions, and provides associated benefits to human populations.

Oyster Reefs: The term refers to dense aggregations of oysters that form large colonial communities.

Peninsula: A tract of land surrounded by water or projecting out into a body of water while being connected to the mainland from which it extends.

Preservation: The act of keeping something as it is, especially in order to prevent it from decaying or to protect it from being damaged or destroyed.

Restoration: Refers to the act of returning something to its original form or condition.

Salt Marsh: Refers to the area of coastal grassland that is regularly flooded by seawater.

Sea Grass: Refers to the members of marine seed plants that grow chiefly on sand or in mud.

Sea Level Rise: An increase in global mean sea level as a result of an increase in the volume of water in the world's oceans.

Seawall: A structure, often concrete or stone, built along a portion of a coast to prevent erosion and other damage by wave action.

Sediment: It is loose, fragments of rocks, minerals or organic material, which are transported from their source over varying distances and deposited by air, wind, or water.

Sediment Supply: The transport of sediment to the beach environment by both fluvial and aeolian transport.

Sediment Transport: Refers to the main agencies by which sedimentary materials are moved.

Shoreline Armoring: It is the use of groins, jetties, offshore breakwaters, sea walls, tombolos or other engineering solutions to protect the shoreline.

Storm Surge: A rising of the sea as a result of atmospheric pressure changes and wind associated with a storm.

Tombolos: A special type of groin built perpendicular to the shore to trap sand, but with an end parallel to the shore designed to reduce wave energy.

Tropical Storms: Refers to a localized, very intense low-pressure wind system, forming over tropical oceans and with winds of hurricane force.

Undercurrent Stabilizer System: An erosion control technology that uses geotextile tubes filled with concrete to protect shorelines from damage and loss during storms. It also encourages beach nourishment.

Wave Attenuation: This term refers to the lessening of the amplitude of a wave.

Wetlands: Areas of land covered by water all or part of the time, which can support both aquatic and terrestrial species.

Executive Summary

As sea levels continue to rise, and storms increase in frequency and intensity, dramatic alterations to coastal landscapes widen the flood-prone footprint, placing more buildings and infrastructure at risk. Orient Beach State Park, a peninsula accessible by a causeway, is located in the town of Southold, Hamlet of Orient, in Suffolk County, on the North Fork of Long Island. The Park was selected as a case study to better understand the challenges, risks, and unique characteristics of coastal parks in New York State and how to better adapt to climate change, sea level rise, and projected storm activity.

The scope of this report is to provide recommendations for adaptation and response, conduct cost-benefit analysis and risk assessment to advise on project feasibility and prioritization, and finally to suggest Best Management Practices (BMPs) for adaptation. The four main objectives for this investigation were to research climate change, sea level rise, storm projections; study the existing wildlife, aquaculture and natural infrastructure; identify and characterize risks; and evaluate potential opportunities to develop a multidisciplinary adaptation approach. Our analysis investigates how to best prioritize these issues and determine some preliminary costing assumptions. An ecosystem-based management approach was adopted in framing future improvements.

The key park features we identified were its function as physical protection to the Hamlet of Orient and surrounding areas from waves, storm surges, and adverse weather impacts; the wetlands which reduces flooding; the Maritime Red Cedar Forest which acts as a wind breaker and is a habitat for most of the avian species on the peninsula, the causeway which acts as the only point of entry and exit by land and the rapidly declining sandy shoreline which has serious implications for wildlife and marine life if climate change adaptation is not implemented.

Ultimately, Orient Beach State Park serves as a case study for how to drive resiliency planning along New York coastal parks, Long Island, and similarly vulnerable areas. A menu of different options is proposed, as well as the feasibility and cost-effectiveness of each of these projects. The most comprehensive solution is very likely a hybrid of engineering and natural infrastructure solutions.

It should be recognized that this paper in no way commits the Office of Parks, Recreation and Historic Preservation (OPRHP) to ultimately implement any approach we discuss. This capstone project is to assist OPRHP with making the challenging decisions that revolve around resiliency and sustainability.

Research and Data Collection Methodology

Our team focused on collecting information and gathering data from secondary data sources, interviews with various stakeholders, analyzed relevant case studies and utilized G.I.S. methodology to assess exposure to storm surges and sea-level rise; in order to better understand impacts of climate change while providing adaptation strategies and recommendations for Orient Beach State Park.

Assumptions, Considerations and Parameters of the Report

Our primary focus for this report is to explore practical and actionable opportunities as part of a multidisciplinary adaptation plan to preserve park facilities and conserve the peninsula. Furthermore, we seek solutions that will stabilize the shoreline, encourage stormwater management, as well as protect and reinforce existing natural infrastructure and ecosystems.

The first area of concern is the causeway to Orient Beach State Park, which is currently the only way to access park facilities and physical infrastructure. Our recommendations will consider other alternatives to the causeway, should preservation prove to be the least suitable alternative. It should also be noted that the electrical service to the park is buried underneath the causeway, as such the relocation of the primary electrical feeder will be considered an infrastructure upgrade project later in the report.

We relied on studies, research, and framework already established by the New York State Parks system as well as predictive models and tools set forth by Columbia University's Earth Institute Center for Climate Research. We recognize that the 2011 ClimAID report governs New York State Parks; understanding that estimations and conclusions may differ from those published by Columbia University, and will cite them as such in the following report.

Making the distinction between adaptation and mitigation helps us to identify where climate change is of greatest concern in contrast with areas where humans may be able to adapt to its impacts. Furthermore, "adaptation" refers to the process of changing behavior to better suit one's environment. We believe that given the risks and uncertainty that sea level rise and big storm events pose, adaptation is more appropriate in the context of this project.

Established Items Beyond Scope of Project

Due to time and resource constraints surrounding the execution of this report, there were certain, non-exhaustive items excluded from the scope of the project. For instance, our assessment is founded largely on the basis of information gathered through informational interviews, desktop research, meetings and correspondence with the client, and observations made during site visits. Due to limited inventories and outdated databases, it was difficult to ascertain the accuracy of information regarding existing flora and fauna, marine, plant, avian, and animal life at the park. There was an observed lack of science-based data collection, record keeping methodology for erosion and flooding measurements, and other noticeable gaps in park-specific data. Therefore, the following estimates and recommendations reflect our best guess estimates and projections.

Project Scope and Baseline

Overview of Orient Beach State Park

Orient Beach State Park is located on the far eastern edge of Long Island in New York. Orient Beach State Park was studied as part of preliminary internal 2014 Long Island Coastal Vulnerability Assessment by New York Parks in response to major storm events and hurricanes. The Long Island area was targeted as part of the assessment due to its vulnerability to large storm events and historical damage to infrastructure and resources. Among a myriad of climate change impacts to State Parks, coastal topography will be subject to changes due to coastal and inland flooding, a predicted sea level rise of 17 to 29 inches by 2050, and increased storm intensity with an unknown but wide-ranging impact on plant, marine and animal species (NYSOPRHP Coastal Vulnerability Assessment, 2014).

Orient Beach State Park is a 4-mile long peninsula and was opened in 1934. Of the ~190 acres surveyed by the NY Natural Heritage Program, about 40% consists of maritime forest, 22% salt marsh, 37% beach, and 1% pond. This coastal park has endured storms, seasonal flooding, and the inevitable effects of climate change and sea level rise. The park's strategic geographical location allows it to provide ecosystem services, and recreational and economic value. It was reported that 350,000 people visit the park each year. The park is open 7 days a week and is a destination for tourists, runners, bicyclists, boaters, fishermen, naturists, picnickers, and beachgoers.

Relevant Policy Framework and Existing Management Plan

At the time that this report was researched, compiled and finalized, there was no knowledge of a site-specific management plan in place at Orient Beach State Park. Therefore, based on general management practices and existing policy framework as governed by the New York State Parks system, the following federal, state, and local level policies were assumed to be in effect, thus this collective framework was instrumental in establishing a baseline upon which future endeavors would be built.

The National Oceanic and Atmospheric Administration (NOAA) facilitates a voluntary partnership between the federal government and U.S. Coastal and Great Lakes States and Territories through the Coastal Zone Management Act (CZMA) of 1972. The legislation aims to "protect, restore and responsibly develop our nation's diverse coastal communities and resources."[i] The comprehensive program's approach to coastal resource management recognizes that natural resources need protection, high hazard areas need to be managed responsibly, and that public access to recreation should be provided. The act recognizes these coastal-dependent uses as sometimes in competition with one another, and works to identify programs that both address local challenges while addressing coastal issues such as marine debris, aquaculture and nonpoint source pollution control and runoff.

The New York Ocean and Great Lakes Ecosystem Conservation Act was established in 2006 by the New York Legislature and Governor. The Act later established a Conservation Council consisting of the Department of State (DOS) and eight other state agencies. The end goal was to ensure that coastal ecosystems were being utilized in a sustainable way and that complex problems associated with land use, planning, and management were approached systematically. Further, the Ocean and Great Lakes Program was designed to better understand how human behavior could impact the "ecological health and integrity of coastal ecosystems," and incorporate science into their decision-making[ii]. The Ocean and Great Lakes Ecosystem Conservation Act provides an important ecosystems management approach to analyzing the adaptation efforts required at Orient Beach State Park in the wake of historical storm events and lingering effects of climate change. Similarly to how human activities and advancements in manufacturing industry are linked to the rise in greenhouse gas emissions and CO_2 levels, the Act recognizes the link between climate change and how our coasts and lakes are being impacted especially as vulnerable areas.

In 2014 Governor Andrew Cuomo signed the Community Risk and Resiliency Act (CRRA) to ensure that specific state funding was allocated for facility-siting regulations and permits that would consider "effects of climate risk and extreme-weather events."[iii] CRRA includes five major provisions, centered around the official sea-level rise projections from 2020 to 2100 which are used in later sections of this report to project the sea level rise at Orient Beach State Park based on low, low-medium, medium, high-medium and high probabilities of sea-level rise. These sea-level rise projections along with NYSERDA's Responding to Climate Change in New York State (ClimAID), identifies coastal zones and their vulnerability as regards storm surges, flooding, and coastal erosion. Various adaptation strategies are set forth in ClimAID, which was established based on the premise that, "it is difficult to determine an effective course of action, since natural processes within these dynamic systems operate on different time scales and are poorly understood. Implementation of adaptation strategies are further complicated by the division of power and jurisdiction in the coastal zone between various levels of government and different agencies." [iv]

Furthermore, the concept of Stewardship Responsibility (SR) rankings was introduced by Bunnell et al. in 2009 as a method for conservation planning, using British Columbia as its backdrop for global rankings, and then later adapted to biodiversity distribution assessments in NY State Parks. As such, species within New York were ranked similarly for geographic rarity, endemic species ranking the highest (SR1) and widespread rankings the lowest (SR5). Based on the analysis, Long Island was identified as home to the most SR1 rankings, totaling 87 species. State parks are in the position to carry on important stewards of biodiversity and "it is clear that no single management category will suffice to protect the full complement of rare species and significant communities for the state and that state parks are critical and irreplaceable stewards of its biological resources."[v] The SR rankings are important in assigning both scientific and economic value in approaching the concept of biodiversity conservation as it relates to Orient Beach State Park.

Environmental, Social, Economic, Geographic, Biodiversity Issues

This section will study the plants, wildlife, and natural habitats and ecosystems at Orient Beach and seek to understand the implications when climate change resilience provisions are not implemented. There are many forms of plant and animal life on Orient Beach State Park, but this report will focus on a few specific features. For plants, the focus will be on the Maritime Red Cedar Forest, for its rarity, Eelgrass and the Spartina Salt Marsh for its environmental importance. Birds, shellfish, and sea turtles are of particular note for animal biodiversity.

Plants

The landscape of Orient Beach State Park is generally divided into beach, brush, maritime forest, and marsh[vi]. The vegetation communities can be further broken down into maritime beach and swale, maritime forest, and coastal salt marsh[vii]. The Long Beach area of Orient Beach State Park was designated as a National Natural Landmark in 1980 because it was recognized as an excellent example of a sand gravel spit that shows the succession from a saltmarsh to maritime forest[viii].

A 1991 species richness study at Orient Beach State Park conducted by Eric Lamont, compared the existing Vascular Flora with the first known study of Orient Beach State Park, conducted by Roy Latham in 1934. Lamont found that in the nearly 60 years that had passed since the last study was conducted, many species recorded at the time of the first study were no longer observable on Orient Beach State Park and that while only 8% of the vegetation was believed to be non-native in 1934, over half was identified as being non-native in 1991.

The 1938 and 1944 hurricanes flooded the area, submerging the peninsula 4-6 feet underwater and swept the beach clean of vegetation. The 1938 hurricane turned Orient Beach State Park into an island until the causeway was re-built[ix]. Mary Laura Lamont, a naturalist and Park Ranger at Orient Beach State Park from 1998-2007, whose research was also listed in the 2004 New York Natural Heritage Program report on Rare Species and Ecological Communities at Orient Beach State Park[x] offered her observations for this project. Lamont recorded that since the 1991 report, at least one plant species, Scots lovage (*Ligusticum scothicum*), was no longer found at Orient Beach State Park by 2004 and that it is possible that other plant species have since been extirpated as well.

Eelgrass (Zostera marina)

Eelgrass is an angiosperm, which grows below water.[xi] Sometimes it is visible at low tide at Orient Beach State Park. Eelgrass is a habitat for animals and is important to shellfish operations, particularly Bay Scallops.[xii] It is the best type of vegetation for a bay scallop nursery, because living in eelgrass meadows makes predation more difficult. Although scallops adapt to other marine plants, as do clams,[xiii] most marine animals will not create their habitat where there is no eelgrass or rocks are available, even if the depth of water is 6-15 ft.[xiv] This is because it is too difficult for juvenile fish and marine animals to survive in open water. A fairly healthy eelgrass meadow extends from the pavilion at Orient Beach State Park down the beach, about three-quarters of the way to the lighthouse. That meadow has been used to harvest seeds as part of restoration projects, which replant the seeds in other locations.[xv] There is not much eelgrass left in New York waters: In less than a century, eelgrass meadows have declined by 90% to roughly 1,000 acres in the Peconic Estuary as of 2014, and this decline trend is global.[xvi] [xvii] Aerial surveys for the Peconic Estuary Program have recorded eelgrass decline in the area but the surveys are not conducted annually which has left gaps in information at times.[xviii]

Eelgrass replanting projects have been attempted for over 20 years and while planting in the Peconic has not yielded much success locally, it has been a testing ground and has shown some success elsewhere, including Tampa Bay and the Chesapeake Bay.[xix],[xx] One method is to deploy buoyed nets with adult shoots, which has worked in San Francisco Bay. Replanting helps with water temperature and photosynthesis.[xxi]

A "Wasting disease" has been steadily killing eelgrass for roughly 100 years and lately anthropogenic factors like sea temperature rise have compounded that effect.[xxii] Eelgrass can "grow itself to death" from too much nitrogen, which occurs in water most frequently as a by-product from agriculture in the Peconic area.[xxiii] Additionally, a water temperature increase to 25 degrees Celsius or more for over 30 days in summer usually results in an eelgrass die off.

Ecosystem services of eelgrass:

SeagrassLI.org, an online resource provided by the Cornell Cooperative Extension, provides detailed information on the ecosystem services of Eelgrass. We were also able to gain valuable insights from local specialist, Stephen Schott. Eelgrass is important in balancing ocean acidity and for carbon sequestration. It also plays an important role in coastal resilience. Spartina and eelgrass are buffers that reduce erosion, ensure sediment stabilization and protect land from energetic waves in a storm. Eelgrass is a primary producer and the base of a marine food chain. A very recent study shows that where seagrass meadows exist, potential pathogens are reduced by 50% in invertebrates like scallops leading to fewer diseases in humans and animals.[xxiv]

Spartina Marsh (Spartina Alterniflora and Spartina Patens)

Low salt marsh at Orient Beach State Park is almost exclusively *Spartina alterniflora a*nd high salt marsh is *Spartina patens*.[xxv] Reports in 1974 and 1982 attempted to assign monetary value to the 'net product' of coastal marshes and valued them at over $10,000 per hectare, or roughly $54,000 per hectare today.[xxvi] Another report in 2000 assigned an ecosystem-service value of $14, 785 per hectare per year to wetlands; 64 times that of comparably sized grassland.[xxvii]

A Spartina Marsh provides valuable ecosystem services. It protects shorelines from erosion, cleans the water, and provides habitat for wildlife and shellfish. These ecosystem services are critical to the survival of oysters and scallop farms.[xxviii] It also acts as a nursery for Diamondback Terrapin (*Malaclemys terrapin*) sea turtles.[xxix]

The decline of the Spartina salt marsh is occurring throughout the east coast and the gulf coast. The low salt marsh is threatened by sea level rise as well as Phragmites (*Phragmites australis*), an invasive species.[xxx] Interesting and innovative projects are currently taking place to prevent wetland decline, including a shoreline restoration project in nearby Greenport which received a permit in June of 2018.[xxxi]

Maritime Red Cedar Forest (Juniperus Virginiana)

A Maritime Red Cedar Forest exists on the southern part of Orient Beach State Park. Red cedar is not only the dominant maritime forest vegetation but it is also the dominant vegetation in Orient Beach State Park, 97% of the maritime forest and 75% of all trees in the Park are red cedar.[xxxii] There are only five examples of Maritime Red Cedar Forest in New York State and all of them are in Suffolk County. Orient Beach State Park and Fire Island are considered the two best examples of this community type in New York.[xxxiii] Sections of the forest were cleared in the creation of the park, and the first species richness study done of the Park in 1934 by Roy Latham noted the rarity of this type of forest even at that time.

The maritime forest helps to stabilize soil, prevent erosion and provide a buffer for storms as well as wildlife habitats. The red cedar forest at Orient Beach State Park is comprised of an eastern red cedar species (*Juniperus virginina*) that resourcefully uses and recycles nutrients in high-salinity environments.[xxxiv]

According to Brooke Lauro, an ecologist from St. John's University who conducted a species richness test at Orient Beach State Park in 2016, there were more dead trees in the maritime forest than on any other part of the peninsula because of the constant flooding. Salinity is detrimental to their health.[xxxv] Since the forest accommodates habitat for bird species such as the Prairie Warblers and various song sparrows, the decline in the forest has resulted in a decline in the population of these birds.[xxxvi]

Animals

Orient Beach State Park is home to many avian species, as well as deer and marine life, including Diamondback Terrapin turtles. Although Orient Beach State Park hosts a variety of animals, it is a particularly special haven for avian life. Brook Lauro, and Amanda Pachomski, an Audubon Society specialist, offered their expertise and familiarity with avian life at Orient Beach State Park. The Audubon Society has designated Orient Beach State Park as an Important Bird Area; it is recognized as a location that has high bird visitations in the Spring. This includes the federally threatened bird Piping Plover (*Charadrius melodus*), and the New York State threatened Least Tern (*Sterna antillarum*). Least Terns and Piping Plovers prefer to nest in beach areas. Another species, which is in decline, is the Prairie Warbler. It prefers to nest in less dense, scrubby forest and can be found nesting in the Maritime Red Cedar Forest at the park.

Avian

50 species were recorded at Orient Beach State Park in 2018. A full list can be found on page 24 of Lauro's 2018 report. The Audubon Society has monitored beach-nesting birds at Orient Beach State Park for 10 years, with the help of staff and volunteers from other organizations, including the North Fork branch of the Audubon Society, and found it to be the most significant of the six Audubon-monitored sites on Long Island. [xxxvii] It is considered

significant because of the amount of suitable bird habitats. Species monitored at Orient Beach State Park by Audubon, include American Oystercatchers (*Haematopus palliates*), Least Terns, and Piping Plovers. Their nests are monitored twice per week from April through August.

Plovers: Last year there were nine pairs of breeding plovers on OBSP, which had a higher than average productivity (chicks per pair) when compared to the other five monitored sites on Long Island. The USFWS Atlantic Coast Recovery Plan has a goal of 575 breeding pairs of Piping Plover for the New York and Jew Jersey recovery unit and there are currently approximately 400 in New York and 100 in New Jersey, according to one survey. Pachomski observed that plovers favor the beach at Orient Beach State Park because the nesting area has water on both sides and a more accessible foraging habitat. Plovers like sandy and over washed habitat. Although flooding erodes habitat, and from several "naked eye" accounts, it appears that the width of the beach has reduced, resulting in less habitat than the year before; specialists have observed that beach stabilization and dune construction could be potentially destructive to plover conservation, as plovers won't nest on dunes but prefer flat, open sand beaches.

American oystercatchers: the population is declining in other areas of the US and considered threatened by climate change by the Audubon Society, but is not considered an endangered species and not yet under particular threat at Orient Beach State Park.[xxxviii] The Audubon Society is taking a proactive measure by monitoring these birds. The current population on Orient Beach State Park should continue to be monitored although their decline is more significant in other parts of the country.

Least Terns: Considered Threatened in New York State and Endangered in interior parts of the US, these birds are monitored by Audubon at OBSP.[xxxix] Outreach efforts such as the Be a Good Egg program have been attempted in order to raise awareness and increase environmental stewardship towards these birds among beachgoers.[xl]

The main threat to avian species on Orient Beach State Park is the possible loss of habitat due to flooding and erosion. The birds have also become more vulnerable to predators such as raccoons, squirrels and crows who ravage their nests in the Park.

One concern specific to Orient Beach State Park is how boats gain access to land near Long Beach Point, which usually has nesting Least Terns and Piping Plovers; as this could potentially disturb the nesting process.

Diamondback Terrapins (Malaclemys terrapin)

Terrapins are a keystone species in many saltmarshes in New York and serve as a top-down predator control for Spartina herbivores as well as a seed-disperser for both Spartina and Eelgrass.[xli] Terrapins nest at Orient Beach State Park and are experiencing a decline in population from habitat loss, overharvesting and bycatch issues, pollution and predation. Victoria O'Neill, an Environmental Analyst for the New York State Department of Environmental Conservation (NYSDEC), explained that measures had recently been taken to keep terrapins out of crab traps as bycatch.

Marine life

Aquaculture in Orient Harbor (P5 in Charts) and Gardiners Bay (G in Charts) is a significant industry. The main types of shellfish harvested (clams, oysters, mussels, bay scallops, and whelk) in just these two areas were worth nearly a million dollars wholesale in 2017 alone and contributed to significant job creation in the area. The NYSDEC Shellfish Landing Data illustrates that oysters are the most lucrative shellfish business in the area and that Peconic Bay Scallops are considered by some to be a delicacy only harvested in a very small geographic area.

The quantity of shellfish harvested has ebbed and flowed overtime, and conservation regulations have been instituted when some species, particularly the Peconic Bay Scallop, had been overharvested. Healthy estuaries are vital for shellfish production and climate related changes to their habitat, as well as anthropogenic factors like agricultural run-off, take a toll on their vitality. There are numerous fish and shellfish species that are dependent on Orient Beach State Park for survival and while there is a thriving recreational fishing community in this area, this section will focus on two especially interesting species of the growing commercial shellfish industry of the North Fork.

Oysters

Area P5 of the New York State Shellfish Harvest Areas provided by the DEC, which represents the area where Orient Harbor, the Shelter Island Sound, and Southold Bay converge, is home to nine commercial aquaculture operations, as well as some wild harvest landings.[xlii] This relatively small area produced roughly 8% of all Peconic Bay Scallops and 13% of Oyster commercially harvested in New York in 2017. Gardiners Bay (area G) contributed 2% and 1% respectively to these numbers. G and P5 are the harvest areas closest to Orient Beach State Park. The interconnectivity between habitat and the ecosystem health of the entire area was evident throughout this study. Clean water and ample wetlands are crucial for shellfish survival and numerous businesses which harvest oysters, scallops, and other mollusks, depend at least partially upon the ecosystem health of Orient Beach State Park.

One of the premier shellfish enterprises in New York, Oysterponds Shellfish Company (one of the main providers to the iconic Grand Central Oyster Bar) operates immediately across Orient Harbor from Orient Beach State Park, and relies on the water health of that bay, which is directly tied to functioning wetlands.[xliii] As of May of this year, the Department of Environmental Conservation has mandated that Oysterponds Shellfish Company close for at least the next six months, because the DEC determined that water quality conditions were no longer safe to harvest oysters for human consumption due to fecal coliform contamination.[xliv] In 2015, Oysterponds applied for a permit to dredge the opening of their creek in order to improve the quality of their water and move sediment to a nearby eroding shoreline. For the purposes of this report, we reached out to the proprietor of the company who did not respond to our inquiries. Litigation is currently ongoing regarding this issue.[xlv]

Eelgrass and Spartina aid in filtering the water, as do some shellfish. Orient Beach State Park has one of the only healthy eelgrass meadows in the area, and as explored in the Plants section of this report, this meadow has been used for replanting eelgrass in places where it has been degraded.[xlvi]

Some local oyster farmers, including Little Creek Oyster Farm and Market, have expressed interest in restoration projects and used proceeds from oyster sales to fund projects related to the Peconic Estuary Environmental Projects.[xlvii] Governor Cuomo has announced a Shellfish Restoration Project though no Peconic sites have been selected for funds thus far.[xlviii][xlix]

Bay Scallops

One of the undeniable delicacies of Long Island is the Peconic Bay Scallop (*Argopecten irradians*). Though they are technically the same species as typical Bay Scallops, the scallops from the very small Peconic Estuary area are thought to be especially flavorful. Bay Scallops thrive in eelgrass, which is a diminishing resource in the area. According to data collected from the DEC, in 1995, 4,324 bushels of Peconic Bay scallop were harvested in New York and in 1996, 9 bushels in total were harvested because of harmful algal blooms, which also is detrimental to eelgrass. Harvesting these scallops by dredging can be damaging to eelgrass, because dredging is disruptive to very habitat in which they thrive. There are regulations in place to limit the timing and scallop harvesting methodology to prevent extinction.[l] However, accurate data on Peconic Bay Scallops, particularly those caught by recreational fishers, is very difficult to gather and thus the health of the population residing in the meadow adjacent to Orient Beach State Park is under-assessed.

Threats to Shellfish Farming: Storms, Agriculture and Humans

Super Storm Sandy was not as bad for oyster culture as it was for wild harvesters because there was much warning given prior to the storm.[li] However, heavy rain and flooding due to storms always closes some fisheries because of runoff issues.[lii] Peconic area fisheries, which rarely close had closures after Super Storm Sandy.

Harmful algal blooms resulting from nitrogen runoff from nearby agricultural operations have been detrimental to shellfish populations, in two ways: the chemicals harm the shellfish and destroy their habitat.[liii] In other parts of Long Island, septic systems and lawn care contribute to Nitrogen pollution in water, but in the Peconic Estuary, agriculture is a primary polluting culprit.[liv]

With the growing aquaculture industry in the North Fork area beginning to reach its limits, user conflicts are one of the biggest issues plaguing the industry. At the time of this report, litigation was underway between shellfish harvesters and a yacht club in the area, which found the increased boat activity from the harvesting to be a disturbance to their guests.[lv] There have also been complaints from private landowners about the gear in the water in close proximity to houses.

As we conclude the section on biodiversity we would like to reiterate that all species at Orient Beach State Park face the same challenges: habitat loss and degradation from climate-related events as well as anthropogenic causes, especially in relation to agricultural runoff and water quality. For shellfish this has particularly grave consequences. Shellfish are beneficial to a habitat because of their ability to filter water while their habitat also serves to protect the surrounding land by acting as wave breakers.

Figure 1. The Red, Yellow, and Green areas show Eelgrass Meadows of varying health. Source: https://www.peconicestuary.org/threats-to-the-peconic/habitat-loss/

Figure 2 lays out the shellfish harvest areas within New York State.

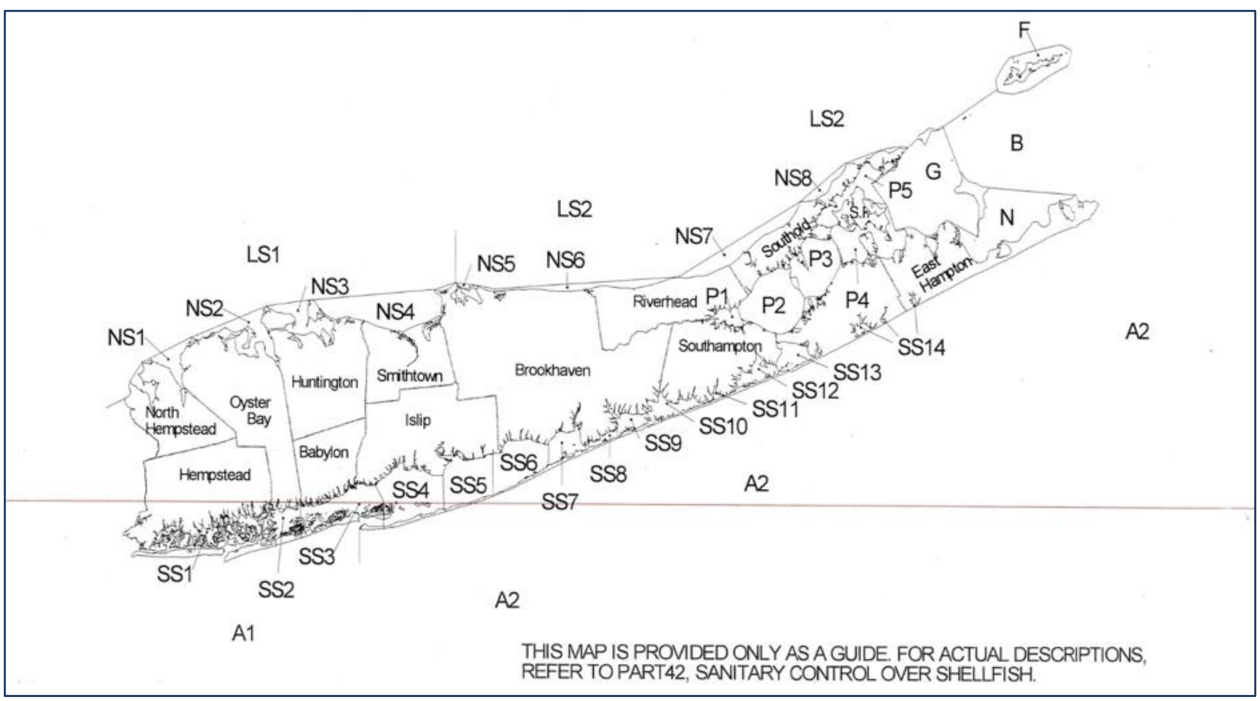


Figure 2. NYS Shellfish Landing Map of Shellfish Harvested in NY State Landings P5 and G (extracted from a larger data source provided by the DEC).

Beach Morphology and Impacts of Storm Surges

Alterations to Coastal Topography

Coastal topography is particularly vulnerable to climate change because of the direct physical effects it has on shorelines. Climate change is linked to extreme weather events exacerbating coastal erosion and has the potential to eliminate beaches entirely. Orient Beach State Park has already begun to experience some of the impacts of climate change, particularly in the aftermath of recent storms like Super Storm Sandy. The storm ravaged Orient Beach State Park extensively, causing physical damage to Orient Beach's coastline, inland ecosystems, infrastructure and wetlands.

Given future scenarios of anticipated climatic events, Orient Beach State Park is undoubtedly in a vulnerable position. As the planet continues to get warmer due to the relentless increase of greenhouse gases in the atmosphere, the consequential expansion of the oceans and the melting of sea ice will lead to a rise in sea level.

Sea level rise is partly responsible for some of the visible physical changes taking place at Orient Beach State Park and is projected to further impact the peninsula according to the ClimAid report. Already, the width of the beach has significantly reduced since the establishment of the park in 1929. In accordance with the ClimAid report, at the most extreme rate of sea level rise, barrier islands could potentially be washed away if the rate of the rise in sea level outpaces the ability of the system to replenish sediment naturally[lvi]. This could potentially be the fate of Orient Beach if measures are not taken to make the Park resilient.

Impact of Storms – Super Storm Sandy

According to Sue Wuehler, Park Manager at Orient Beach State Park, during Super Storm Sandy, along with the storm surge came powerful waves that broke over the rocks and the causeway, resulting in the collapse of the road as sediment was washed out and undermined the road[lvii]. In the event of another severe storm the causeway could be eliminated completely, preventing access to the park by land.

The ClimAid report anticipates coastal flooding associated with storms will increase in intensity, frequency, and duration; with these storms introducing stronger winds, higher waves, and heavier rainfall that could increase runoff, and flooding. [lviii]Orient Park has already experienced its share of flooding from past storm events and given future flood projections and scenarios, a coastal resilience plan would help provide a roadmap for actions to help enhance the resiliency of Orient Beach State Park.

Super Storm Sandy was responsible for the most recent flooding event on Orient Beach; the peninsula was submerged under several feet of water, causing damage to the shoreline, causeway, marine forest and inland buildings. (See Figure 3)

During Super Storm Sandy, Orient Beach suffered a great deal of vegetation loss, with trees visibly dying from high concentrations of salt water as a result of flooding from storm surge.

Orient Beach Park provides the first line of defense for the Hamlet of Orient, the wetlands, terrestrial habitats and some marine life, it should therefore not be left vulnerable to erosion and other extreme future climate events.

Impact of Super Storm Sandy on Orient Beach State Park


Dying forest & broken causeway


Flooding of Maritime Red Cedar Forest


Erosion of Shoreline & Causeway


Broken Causeway


Dying vegetation alongside causeway


Disruption to utilities under causeway

Other Benefits of Orient Beach State Park

As we reviewed potential impacts from storm surges and sea level rise at Orient Beach State Park, it became important to assess the current value of the park in order to lay the foundation for decision-making regarding the type of interventions to implement in the protection of the park. In addition to the obvious fiscal benefits from the park, we must also recognize added value the park creates for recreation, tourism, and building community. Orient Beach State Park delivers many intangible benefits to nearby residents and visitors. Not only does the park contribute to the physical health of its visitors, but also to their cognitive performance and psychological well-being.

Health benefits associated with engaging natural environments are quite difficult to quantify. However, research studies have shown the correlation between human exposure to nature and mental health. These studies conclude that interactions with the natural environment could help with cognitive development within children, coping with anxiety and stress, crime reduction strategies and the treatment of dementia.[lix]

However, benefits of physical exercises and activities, according to the National Institute for Health and Clinical Excellence, could be quantified using Quality Adjusted Life Year (QALY), which measures the quantity and quality of a person's life. These estimates were converted into avoided health care costs - representing savings that would be made from not having to treat health related illnesses associated with a lack of physical activity.[lx]

Furthermore, the park offers a place for families, friends, and neighbors to gather and socialize in a lesser-known and more closely acquainted open space than nearby coastal parks. Orient Beach State Park acts as the de facto community space for nearby residents. In line with Commissioner of the New York State Office of Parks, Recreation and Historic Preservation, Rose Harvey, stresses the importance of building community "where New Yorkers of all ages and backgrounds come together for fun and friendship, learning and healing, to experience New York's great outdoors and history, and build mind and muscle," in her testimony before the Joint Budget Hearing of the State Legislature FY 2017-2018 Executive Budget.

Tangible Benefits of Orient Beach

Real economic value of Orient Beach is also realized in the protective services it provides in its function as a barrier island. Although currently sparsely populated, Orient, as well as all of North Fork, has become a place of interest for land and real estate due to the migration of high net worth individuals into the area responding to saturation in the Hamptons. In recent years, the North Fork has experienced steadily rising home prices, as more buyers have been drawn to the bucolic setting and its relative value compared with the Hamptons.[lxi] This has the potential to significantly drive up the economic value of Orient within a few years.

As a result, this value estimate should be based not only on current land and real estate value but also on potential value based on growth projections by the real estate industry. Estimates of Orient Beach's economic value should also reflect value or wealth of the Shellfish industry, farming community, as well as economic opportunities provided by the park.

The Value of Orient Beach State Park

Techniques for quantifying the economic value of natural resources are imprecise and subjective. However they largely rely on common sense, so observers can draw their own conclusions.

The major values Orient Beach State Park are:

- Protection of the Hamlet of Orient
- Protection of bays rich in marine life
- Beach recreation for hundreds of thousands each year
- Rich biodiversity

Protection of the Hamlet of Orient – almost an island itself, Orient is about 6 square miles with roughly 700 people. With 600 houses worth an average of $ 500,000, the real estate values alone are $ 300,000,000. There is substantial agricultural production. OBSP does not totally protect the town, sea level rise will eventually submerge it, but it provides substantial storm wave protection at present.

The shellfish industries are clearly producing tens of millions annually. We were unable to precisely quantify this due to ongoing litigation. However, without the barrier island, there would be no bays and the shellfish industries would be greatly diminished.

NYDOP estimates 300,000 visitors per year. What is that recreation worth? Economists usually approach this by estimating what the public would pay for this, or would pay to keep it from disappearing. $ 10 per person per visit seems conservative and reasonable, giving a public value of $ 3,000,000 per year. Incidentally, it appears that about $ 1 million of this could be recovered with judicious entrance fee collection.
Biodiversity is the value most difficult to quantify. But the value is substantial given the salt marshes and eel grass beds that are marine nurseries and the endangered bird species.

One can see that the value of Orient Beach State Park is certainly in the many millions of dollars. This may be appreciated when deciding upon the funding of resiliency measures suggested in this report. Resiliency only goes so far. Within a lifetime from today, sea level rise may seriously undermine, if not obliterate, the Park. Only reductions of emissions could possibly address that eventuality.

This section was contibuted by Ralph Schmidt, Faculty Advisor

The shellfish industries in New York (Long Island) do produce millions of dollars. According to the DEC, New York produced roughly 17 million dollars of shellfish at wholesale (so not counting retail or any additional value produced like jobs) last year (2017). Those are aggregate numbers from vendors and dealers. That value has been as high as $20 million in the last couple of decades. For the area around Orient Beach State Park specifically, the value is probably somewhere around one million dollars annually. The Shelter Island Sound/Southold Bay/Orient Harbor and Gardiners Bay, the areas most immediate to Orient Beach State Park (shown in the shellfish map in the Marine Life of the report), recorded ~$700,000 wholesale, excluding at least one species which is likely to be harvested there.

Oysters are harvested for $82.58 a bushel (roughly 100 pieces in a bushel so 83 cents per oyster-going rate as of 2017). However, 83 cents per oyster does not include the added value that the restaurants bring to bear on the product, the number of waiters who serve it and are able to share the provenance of the shellfish with diners, nor the transport industry that ensures its distribution, among other factors. This confirms Professor Schmidt's submission that the shellfish producers of New York are producing tens of millions of dollars each year. Technically, the actual wholesale revenue is 17 million for New York and between 700,000-1,000,000 for the area directly adjacent to Orient Beach State Park.

Risk Assessment

In this section, we discuss how future sea level rise and larger storm surges amplified by sea level rise will impact the Park. Due to unavailability of current site-specific scientific records and analysis (climatology, biophysics and geomorphic study etc.), the probability and magnitude of risk that is unique to Orient Beach is uncertain, however projections can be made based on model forecasts regarding the general New York or Long Island area. We recognize the importance of identifying all potential risks in order to work towards mitigating any potential disasters or permanent harm to the Park.

Risk Analysis

Understanding the factors impacting the morphology of Orient Beach State Park today is very important to the development of a coastal resilience plan for the Park. As seen in Figure 4 below, due to the low elevation of the park, Orient Beach State Park is especially vulnerable to hurricane inundation.[lxii] Frequent immersion of the Park in seawater threatens the Maritime Red Cedar Forest, wildlife habitat and existing park infrastructure. There has been a significant increase in the number of tropical storms and hurricanes in the Atlantic since the late-1980s.[lxiii] Therefore, inundation caused by extreme weather may progressively become more of a regular event than before, thereby exacerbating the erosion of the shoreline and threatening the very existence of the park.

Figure 4. Hurricane inundation Zone at Orient Beach State Park. Source: NYSOPRHP LI Coastal Vulnerability Assessment, 2014.

Forecast of Storm Frequency and Changes in Sea Level

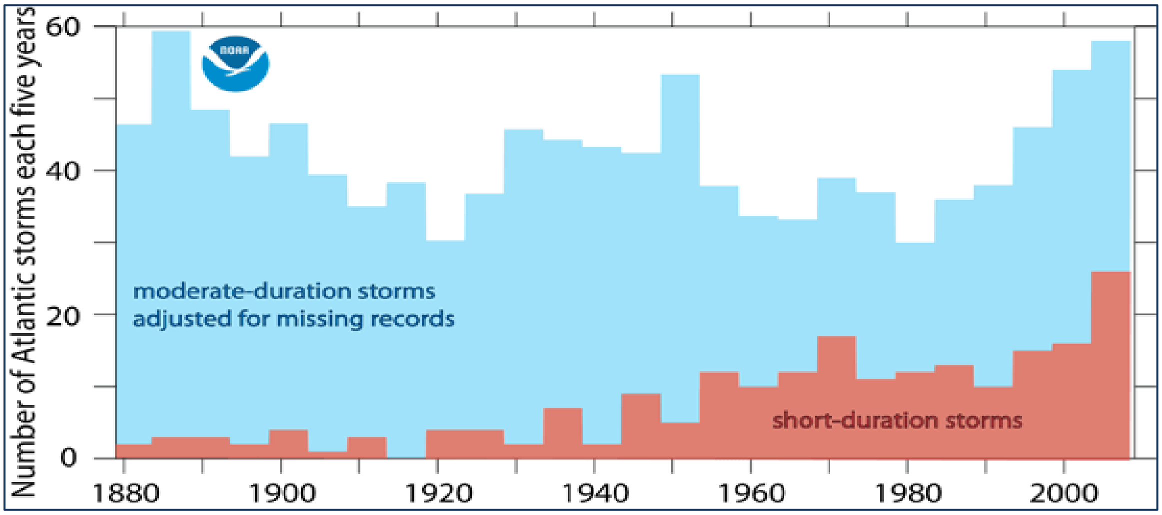


Figure 5. Number of Atlantic Storms every five years from 1880-2010. Source: Christopher W. Landsea, Impact of Duration Thresholds on Atlantic Tropical Cyclone Counts, American Meteorological Society. Source: NOAA.

According to Figure 5 (above), the number of short-duration storms have increased about 25% since 2010, and sea level has risen by .26 feet from 1993 to 2018, which confirms that climate change is the prime factor influencing the physical changes on Orient Beach State Park.[lxiv] Therefore, understanding the implications of future storm projections and the potential changes in sea level would be very helpful for park managers as they draw up comprehensive plans to ensure resilience in coastal park development.

Measurement of Risk

Risk is evaluated by probability of occurrence and magnitude of the impact in United States Dollars (USD) on major assets in the Park.

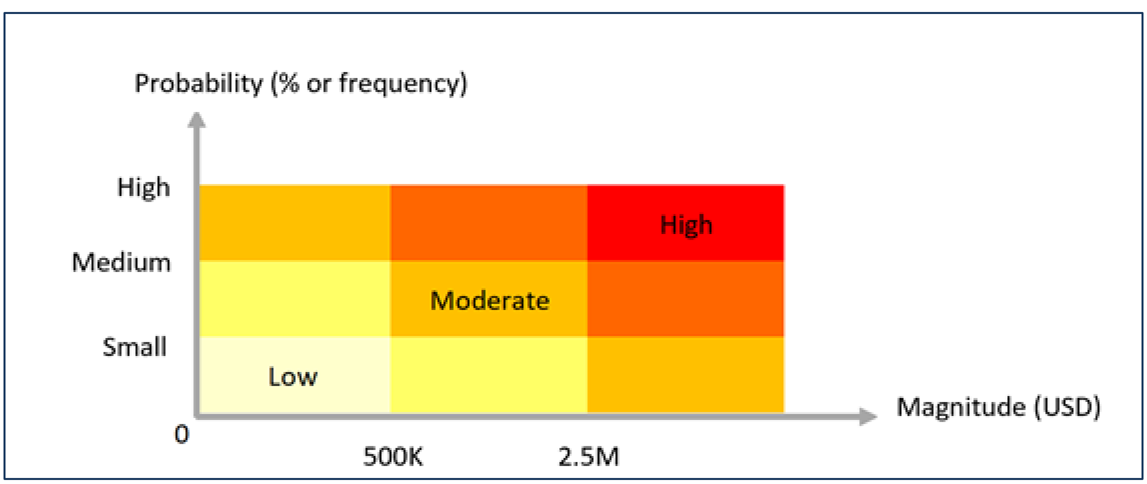


Figure 6. Risk is calculated by the frequency of its occurrence (small, medium, high probability) and magnitude of that impact in USD.

Future sea level rise and extreme storms are considered risk variance for risk assessment. For sea level rise, the probability of occurrence (from 10% to 90%) and the magnitude of the impact, which is measured in monetary value are set as determinant of the scale of the risk. In other words, the higher the probability of occurrence and/or the greater the economic loss or replacement cost; the greater the risk.

In the 2014 climate impact assessment for the Long Island Region, sea level is predicted to rise 17-29 inches (1.4-2.4 feet) by 2050.[lxv] In addition to this projection, Figure 7, was developed to demonstrate a scientifically-based projection of the rise in sea level for Long Island, including the marine coasts of Nassau, Suffolk, and Westchester counties.[lxvi] These values were adopted from Part 490, Projected Sea-level Rise - Express Terms, Regulations and Enforcement, of the New York State Department of Environmental Conservation.

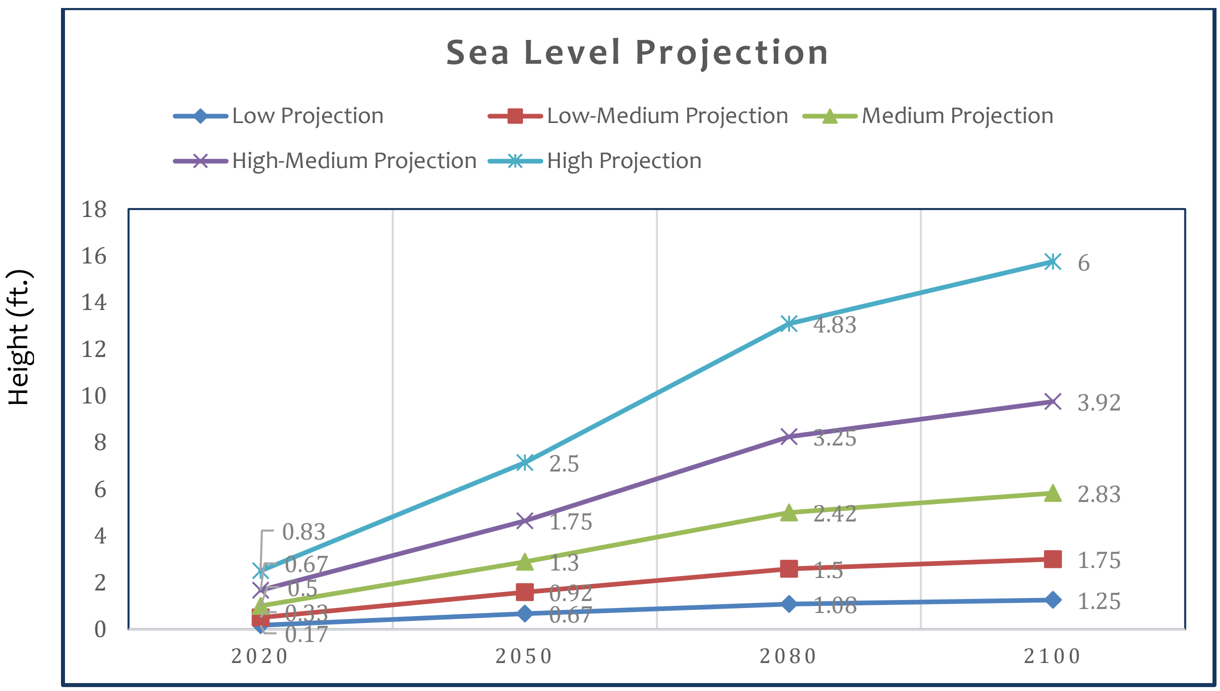


Figure 7. Sea level projection of Long Island Area[lxvii]. Source: Part 490, Projected Sea-level Rise – Express Terms, 6 NYCRR, Chapter IV Quality Services, Subchapter I Climate Change, NY State Department of Environmental Conservation.

Storm Frequency

For extreme storms, probability is measured by projected frequency of 100-year and 500-year storms by 2050 and the magnitude of cost incurred. In spite of the uncertainties about future hurricane intensity and frequency, NOAA and IPCC (2014) generally assume that storms will reduce in frequency while increasing in scale.

The 2011 ClimAID report predicts that at least two 100-year storms plus one 500-year storm could occur before 2050.

A 2015 study from Geophysical Fluid Dynamics Laboratory (GFDL) of the National Oceanic and Atmospheric Administration (NOAA) estimated the impact of projected climate changes on some tropical cyclone metrics with a GFDL hurricane model regarding the late 21st century.[lxviii] According to this study, there will be fewer tropical cyclones globally in a warm late 21st century climate (See Figure 8), but the intensity of tropical cyclones will increase in most basins, whilst category 4 and 5 storms also increase in occurrence. However, it's worth noting that by the latest report, GFDL is still not confident that such an increase will occur in the Atlantic basin because the increase would not be detectable until the end of the 21st century.[lxix] (See Figure 9)

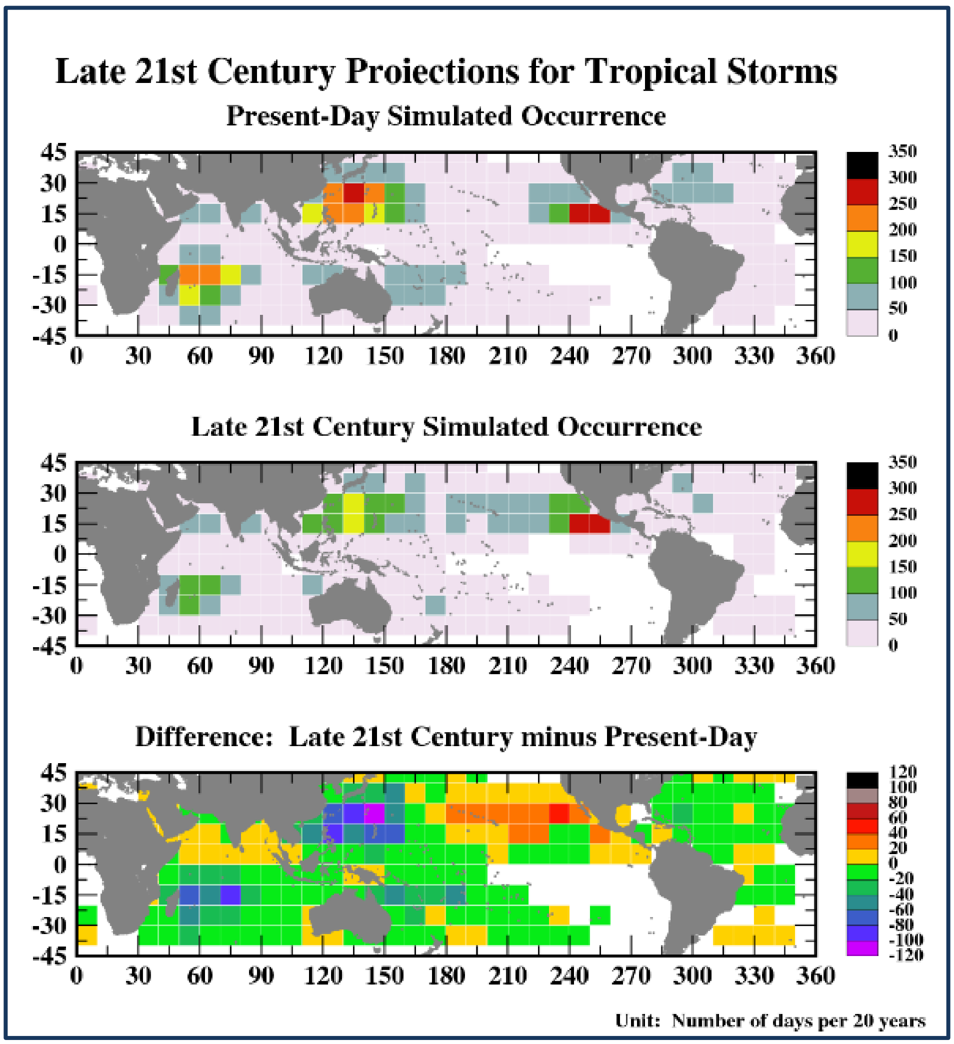


Figure 8. Global Tropical Storms Projections between present-day and late 21st century[lxx]

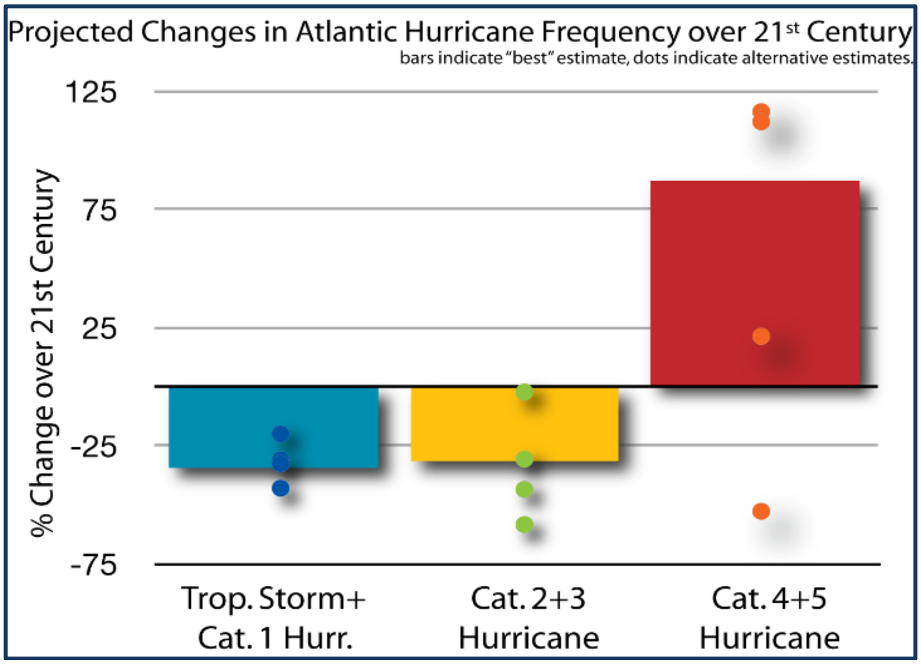


Figure 9. Atlantic Hurricane Frequency Projection[lxxi]

The list of potential risks, adaptive management and cost estimates are displayed as Table 1 in the Appendix.

The Next Big Storm

The risks associated with the next big storm will have huge environmental impacts on Orient Beach State Park. According to Nicholas Coch, a professor of coastal geology at Queens College, "Super Storm Sandy was just a primer for extreme weather events to come." Based on Figure 10 (below) there could be 9 to 13 named storms in the Atlantic area during the hurricane season in 2018, which on average could last about six months ending November 30, 2018. Among these storms, there could be 4 to 7 named storms evolving into hurricanes (with winds of 74 mph or greater) including 0 to 2 major hurricanes of a category 3 or above (with winds of 111 mph or greater). Up until August 2018, the season has seen 4 named storms including 2 hurricanes.

It is worth noting that the prediction is in regards to overall seasonal activity instead of landfall prediction.[lxxii] According to the United States Landfalling Hurricane Probability Project, there is a 3.7% probability that 1 or more named storms will occur at the Suffolk county (where Orient Beach State Park is located) by the end of 2018, At the same time, there is a 2.2% probability that 1 or more hurricanes will make landfall in Suffolk. In the next 50 years, there is a 94.6% probability of 1 or more named storms making landfall in Suffolk, including an 81.1% probability of 1 or more hurricanes and 53.7% probability of 1 or more major hurricanes in this county. [lxxiii]

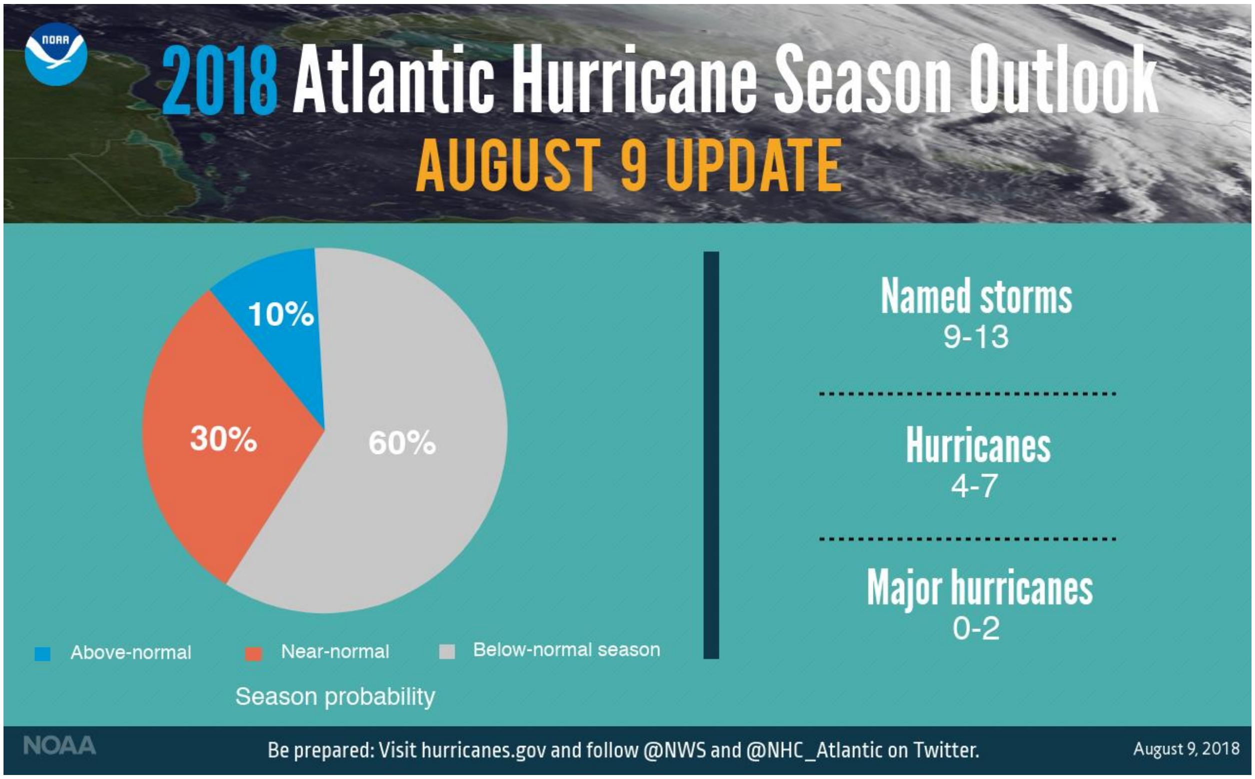


Figure 10. 2018 Atlantic Hurricane Season Outlook

Based on the climate analysis detailed above and in accordance with the United States Landfalling Probability Project, the climate projections predict a range of probable outcomes for the region, as mentioned throughout the report. It also points to the probability of the next big storm occurring in the near future.

Ecosystem and Environmental Impact on Orient Beach State Park

When considering ecosystem and environmental impacts, it is key to understand the value of each habitat and how future sea level rise and storm surges could potentially affect their functions as well as their physical existence. The major coastal ecosystems within the park, which have been identified as being at risk, are Maritime Red Cedar Forest, saltmarshes, seagrass beds, sand beaches and dunes.

Maritime Red Cedar Forest

After consulting with Adjunct Professor and Faculty Advisor Ralph Schmidt, who holds a Masters of Forest Science from Yale School of Forestry and Environmental Studies, and a long-time expert in sustainable forest management, it was concluded that the replanting and restoration of other at-risk coastal ecosystems would provide more benefit to halt the rate of erosion than the replanting of the Maritime Red Cedar Forest. The Maritime Red Cedar Forest has helped to put Orient Beach State Park on the map as it is a rare species, and garnered awareness for the complex issues that coastal parks face with erosion. However, due to the slower rate of development for seedlings and the expense for replanting the eastern red cedars, it would be more cost-effective and timely to focus on the other at-risk coastal habitats. Therefore, the Maritime Red Cedar Forest is a lesser priority than the following ecosystems.

Saltmarshes

Almost half of the Park is covered by wetlands. The salt marshes provide invaluable benefits to Orient and Orient Beach State Park. These include coastal protection, erosion control, water purification, maintenance of fisheries, tourism, recreation, contributions to education and research as indicated in Appendix A. Based on climate projections, the majority of the saltmarshes are expected to be eroded or inundated in the future.

Sediment and marsh plant material must accumulate at an equal or greater rate to build up vertical elevation so that the marshes can keep pace with sea level rise. With sea level rising faster and faster every year, salt marshes that cannot outpace the rate of sea level rise will drown[lxxiv] In the absence of site specific data from Orient Beach State Park regarding the conversion rate of marsh to ocean, we consulted wetland trends for the larger Long Island Region. According to the DEC, Long Island's estuaries have lost 13.1% of native intertidal (IM) High Marsh and coastal fresh marsh communities between 1974 and 2005/2008. Collectively Long Island' three estuary complexes have, on average, lost 85 acres of native marsh annually over time[lxxv]. The U.S. Department of the Interior Fish and Wildlife Service (2015) also indicated in their 130-year assessment of the Status and Trends in the Long Island Sound

Area, there was an estimated 48% loss in tidal wetland acreage (approximately 7,841 acres) within the Long Island coastal boundary between the 1880s and 2000s.

Since saltmarshes provides coastal protection from energetic waves, storm surges as well as coastal erosion, its obliteration will result in the loss of these regulating functions. The loss of the salt marshes will make the town of Orient even more vulnerable to the imminent harsh weather events anticipated by all the risk and vulnerability assessment reports.

Sea grass Bed (Eelgrass)
Eelgrass extends as far south as North Carolina, though eelgrass has been in decline across the Atlantic coast. Some of the most successful restoration projects using Eelgrass have been in the Chesapeake Bay in Virginia.

Like saltmarsh, the eelgrass provides a variety of ecosystem services (see Appendix B). The eelgrass functions as a wave attenuator whilst providing habitat for ecologically and economically important species such as oysters, scallops and other species of shellfish. As a result, the risk of coastal erosion represents a real threat as well as the changing temperature of the ocean, which negatively impacts the growth of eelgrass. While further research is required to establish how eelgrass can be adapted to survive the imminent increase in ocean temperatures, sea level rise and stronger storm surges; the current strain on existing eelgrass beds could result in its extinction leading to even more devastating beach erosion at the Park.

Sand Beach and Dune
Sand beaches and dunes form at low-lying coastal margins where sand transported by oceanic waves and wind combine with vegetation to produce dynamic geomorphic structures. Beaches and vegetated sand dunes provide sediment stabilization and soil retention in vegetation root structure, thus controlling coastal erosion and protecting recreational beaches, land for aquaculture and wildlife habitat (see Appendix C). The erosion of the sand beach and the dunes will impact tourist visits to the park whilst making the peninsular and its infrastructure even more vulnerable to storm surges and sea level rise.

Rare Flora and Fauna
As discussed previously in this report, there is a variety of rare flora and fauna, which have been identified on the Park but the Maritime Red Cedar Forest, must be highlighted here in terms of rarity. During our visit to the Park, Sue Wuehler, the Park Manager, indicated that there had been an increase in tree deaths with the recent increase in the flooding of the

cedar forest. Rising sea levels and damaging storm surges will only worsen an already unfortunate situation.

Socio-Economic Impact

Infrastructure

The risk to Orient Beach's infrastructure became even more apparent after Super Storm Sandy, as demonstrated in the section on the Impact of Storms on Orient Beach State Park. The two-mile-long causeway and Gardiner Bay shoreline suffered serious erosion, and four asphalt roads were destroyed. All of the buildings in the park were flooded as well.[lxxvi] After Sandy, the causeway needed to be rebuilt and park staff installed a layer of stone along the shoreline to protect it. However, erosion continued during less significant storms in 2017.[lxxvii] The Park experienced erosion along one and a half miles of the Gardiner Bay shoreline during what was considered minor storms in 2017.

During Super Storm Sandy, the powerful winds and high-energy waves destroyed dozens of trees along the causeway, the lifeguards' shack and picnic tables were washed away from the beachfront. The unfixed equipment in the park suffered enormous damage during Super Storm Sandy.[lxxviii]

Sea Level Rise and future hurricanes with stronger intensity and higher frequency will have direct negative impacts on both natural and gray infrastructures within the Park. According to Resources for the Future, "natural or "green" infrastructure projects rely on services produced by ecosystems, often utilizing natural landscapes to minimize flood damages, purify and store water, and reduce urban stormwater runoff." Gray infrastructure refers to man-made infrastructures, such as building levees and dredging rivers to manage flood risks[lxxix].

In order to visualize the change in loss of land and reshaping of coastlines, figure 13 was created based on GIS data and mapping tools provided by the NY State Office of Planning and Development, through the Geographic Information Gateway[lxxx]. As seen below, projections based on a 2.5foot increase in sea level was mapped to demonstrate the infrastructure at risk in 2050. According to these projections in sea level rise (excluding storm surge impact), almost half of all the natural infrastructure and physical structures currently in place are in a flood-prone zone and could be damaged or destroyed by 2050 if countermeasures are not taken.

Based on the line graph included in the Department of State Coastal Risk Model showing the Physical Environment and Climate Change by increments of 1 foot in -Sea level Rise, we can forecast the potential changes in Orient Beach State Park (See Figure 14)[lxxxi]. From the series of maps below, it is clear that the rise in sea level will negatively impact the park. The changes are most significant to occur in the middle and southern parts of the park, where the elevation is low. Because these two parts consist of the Maritime Red Cedar Forest and other rare species, it is necessary to boost resilience in these areas to protect the forest and the habitat of resident species from inundation.

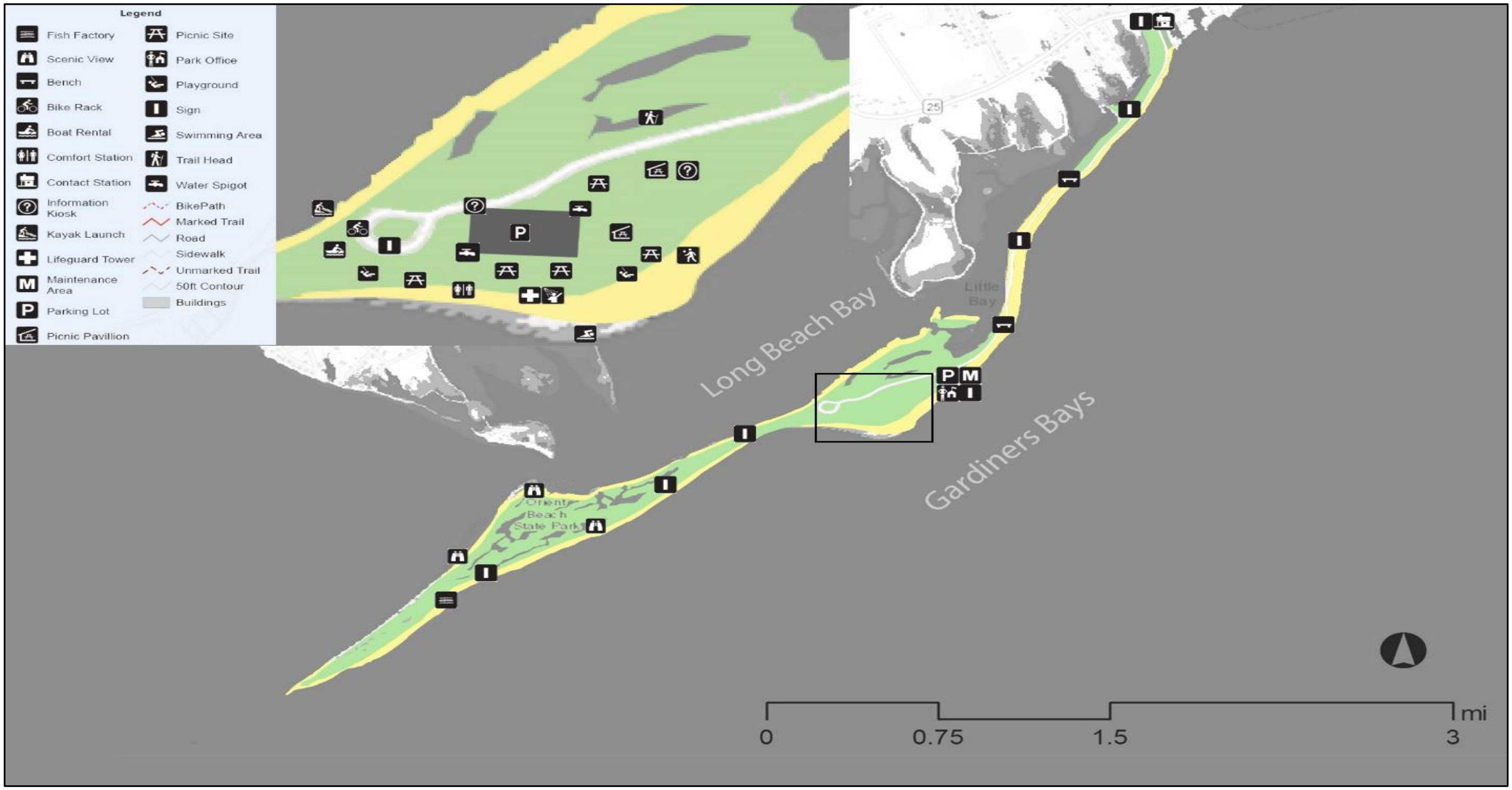


Figure 13. The Park infrastructures with high projection probability applied (assuming 2.5 feet SLR) by 2020

Potential Changes in Orient Beach State Park (2020 – 2100)

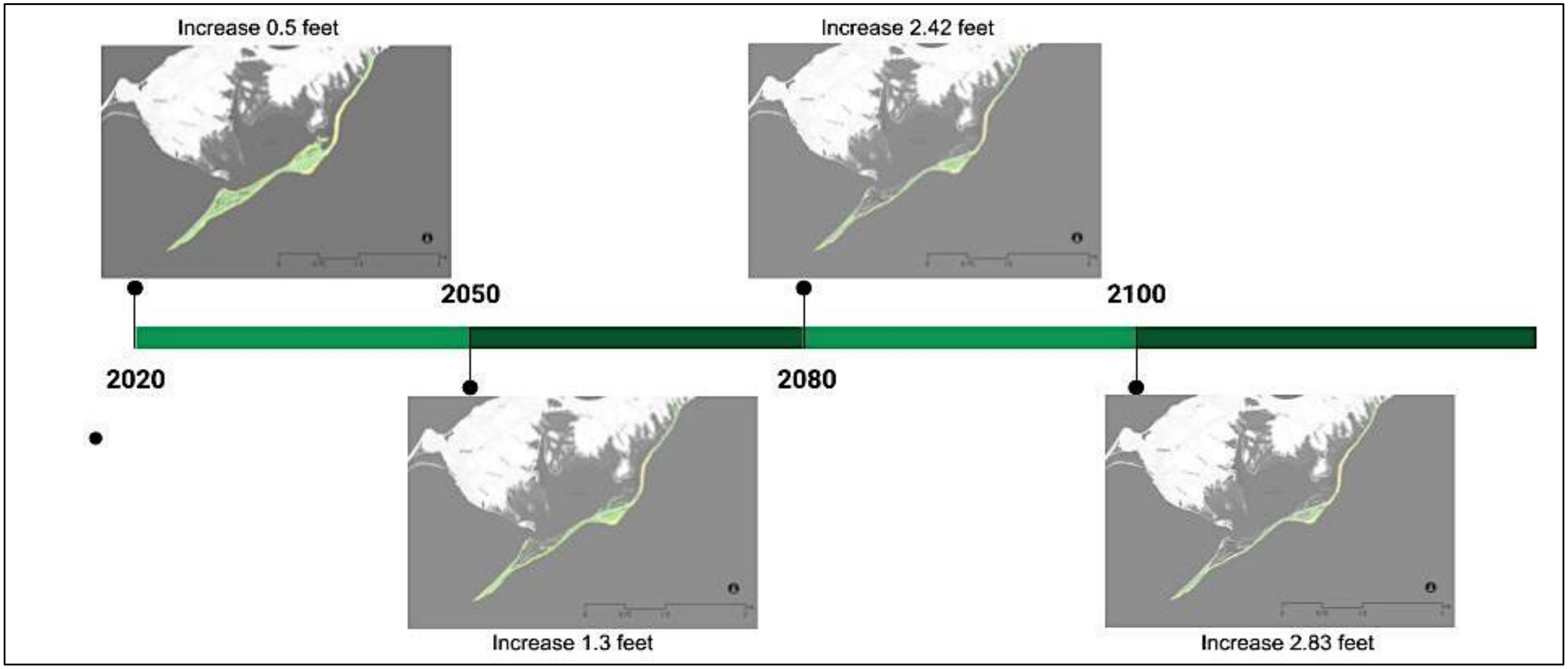


Figure 14. Morphology change corresponding to the medium projection on the line graph at Orient Beach State Park from 2020 to 2100, where maps 1, 2, 3, and 4 correspond to the years 2020, 2050, 2080, and 2100, respectively. Source: DOS Coastal Risk Model

Adaptive Management

There has been a growing body of research on coastal zone management as the world struggles to deal with the swift and relentless impacts of climate change on coastal systems. Research in the area of coastal zone management has led to the development of three generic response strategies for coastal resilience or restoration; Protection, Accommodation, and Managed Retreat (UNDP, 1998).

The Managed Retreat strategy is to progressively abandon threatened land when the cost of resilience building outweighs Managed Retreat.

The Three Generic Response Strategies for Coastal Resilience or Restoration

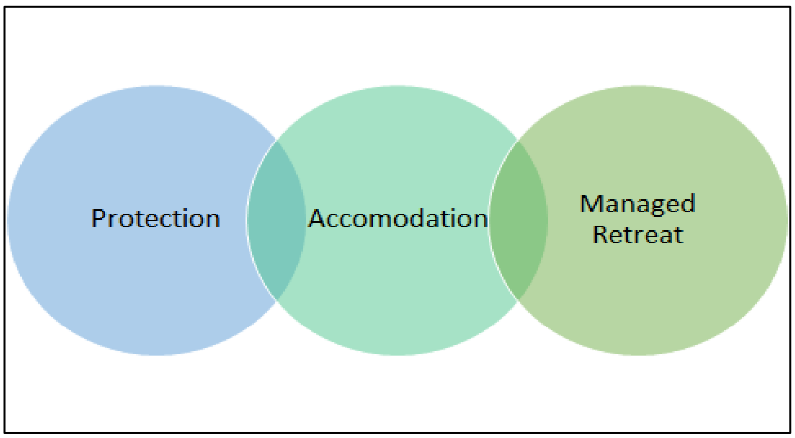


Figure 15. Accommodation is a mix of Protection and Managed Retreat.

The Accommodation strategy involves continued but altered utilization of land, which includes measures such as the elevation of buildings above flood levels, modification of drainage systems and changes in land-use. Together with Managed Retreat, these two strategies are based on the acceptance that increases in land loss and coastal flooding are inevitable and that some coastal functions and values will change or be completely lost. These strategies, particularly when developed around natural infrastructure, are usually not disruptive and help to maintain the integrity of geological processes such as beach nourishment, enabling the peninsula to move and shift in sync with the elements.

The Protection strategy usually involves engineering solutions, which will attempt to maintain shorelines in their existing condition either by strengthening or building defensive structures to protect shorelines and coastal property. This strategy often results in the loss of some of the natural functions of beaches. As a result, the selection of appropriate options requires the consideration of critical trade-offs, which need to be carefully evaluated.

A coastal resilience plan needs to consider the following:

- Ecosystem-based adaptation measures
- Engineered and technological measures
- Institutional and social measures

Ecosystem-based adaptation (EBA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to adjust to the adverse effects of climate change. It is often the case that initial consideration is given to engineering and technological approaches to adaptation when dealing with climate-related threats. However, incorporating natural infrastructure such as living shorelines, wetlands, or vegetated sand dunes helps to minimize the impact of climate change in a variety of ways. In the Park's case, the use of salt marshes as a buffer against damage to coastal communities and infrastructure have been well researched and found to be effective both physically and financially in appropriate locations (Day et al., 2007; Morris, 2007).

Examples of engineering solutions include management of storm surges, energetic waves and flooding with flood levees, seawalls, and infrastructure upgrades to existing facilities and buildings to improve wind and flood resilience. It is important to note that most engineering options are expert driven, capital-intensive, usually large-scale and complex.

Technological applications range from soft to hard, conventional to the non-conventional. Information and Communication Technology (ICT) could, for example, be helpful in involving local communities in the tracking and monitoring of information such as local flood levels and impact. Such information could be critical in the development of disaster management and response programs.

Integrated Coastal Zone Management (ICZM)

The Rupprecht Consult & International Ocean Institute, in 2006, comprehensively describes Integrated Coastal Zone Management as "a strategy for an integrated approach to planning and management, in which all policies, sectors and, to the highest possible extent, individual interests are properly taken into account, with the proper consideration given to the full range of temporal and spatial scales, and involving stakeholders in a participative way. It demands good communication among governing authorities (local, regional and national), and promises to address all three dimensions of sustainability: socio/cultural, economic and environmental. It thus provides management instruments that are not per se included or foreseen in the different policies and directives in such comprehensiveness."

The concept of integrated Coastal Zone Management was borne in 1992 during the Earth Summit at Rio de Janeiro and has often been applied in coastal management programs to date. ICZM uses the informed participation and cooperation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting those objectives.

Although ICZM has been seen as the most robust approach in history, a recent review of ICZM in Europe concluded that the complexity of coastal regulations, lack of sustainable finance and a failure of certain stakeholders to accept a bottom up approach, as opposed to the traditional top down approach hinders its implementation (Shipman and Stojanovic, 2007). As a result, it is important that an active participatory process with local stakeholders be ensured in the Park's future adaptive management program.

Collaborations with other parks facing similar risks could also be instructive and useful for developing a more robust coastal resilience template, which could be shared with coastal areas with similar problems.

Case Studies

As part of our research we explored several case studies in order to find real life applications of best practice for coastal resilience, and ultimately focused on successful examples such as the Surfers' Point Managed Shoreline Retreat Project and the San Francisco Bay Living Shorelines: Nearshore Linkages Project

Surfers' Point Managed Shoreline Retreat Project

Figure 16. The beach at Surfers' Point, with the county fairgrounds just inland. The restoration plan had to accommodate the diverse interests of the public, the city, and the county fair operators, while meeting natural resource protection laws. Image by Wikimedia user Jimwmurphy.[lxxxii]

Project Detail		Strategies
Location	Seaside Park, City of Ventura, Ventura County	– Managed Retreat – Vegetated Dunes – Cobble Berm – Beach nourishment – Bio swales for stormwater retention and filtration – Permeable Parking Lot
Setting	Open Coast, river mouth delta, sandy beach and dunes over cobble substrate with backshore infrastructure	
Project size	1,800 feet of shoreline	**Benefits**
Land owner/managers	Ventura County Fairgrounds and City of Ventura	✓ Flood protection ✓ Recreation ✓ Habitat Restoration ✓ Water Quality ✓ Lower Erosion Risk ✓ Coastal Access ✓ Aesthetic Benefits

Figure 17. Surfers' Point Managed Shoreline Retreat Project details.

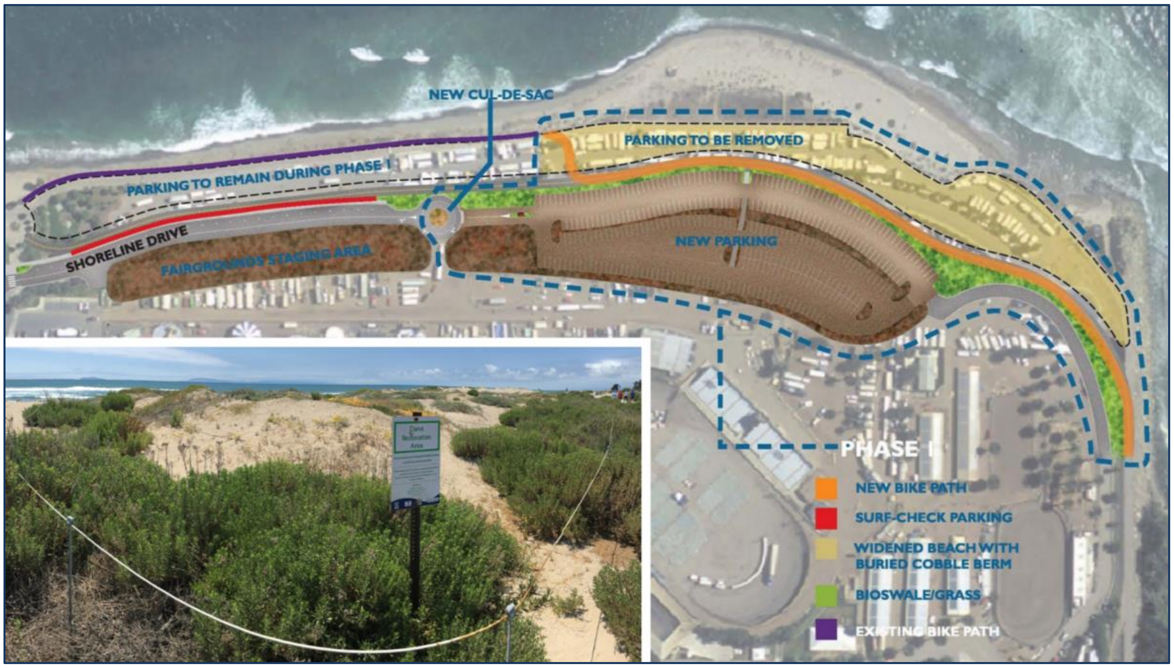


Figure 18. A 2010 map showing elements of the Surfers' Point Managed Shoreline Retreat Project.

Cost of Project	
Total Cost	$10.9M
Planning/Design	$2.2M
Construction	$3.6 Million comprised of 3.4 M (2010) plus $0.2 M (2013) for dunes.
Monitoring	$130,000 through spring 2017.
Maintenance	No known maintenances costs

Figure 19. Surfers' Point Managed Shoreline Retreat Project Costs.

Project Performance

1. This Surfers' Point Managed Shoreline Retreat project has performed as intended. According to the US Climate Resilience Toolkit, as of 2014, the beach at Surfers' Point had a 70-foot wide buffer zone and a significant sediment reservoir. Thereby successfully preventing erosion and increasing dune elevation.
2. The areas of the beach backed by dunes vegetated quickly and protected the area behind them from flooding during large storms
3. While other coastal areas were damaged, during high wave conditions in the 2015-2016 winter, no damage was experienced at the Surfers' Point Retreat project.

San Francisco Bay Living Shorelines: Nearshore Linkages Project

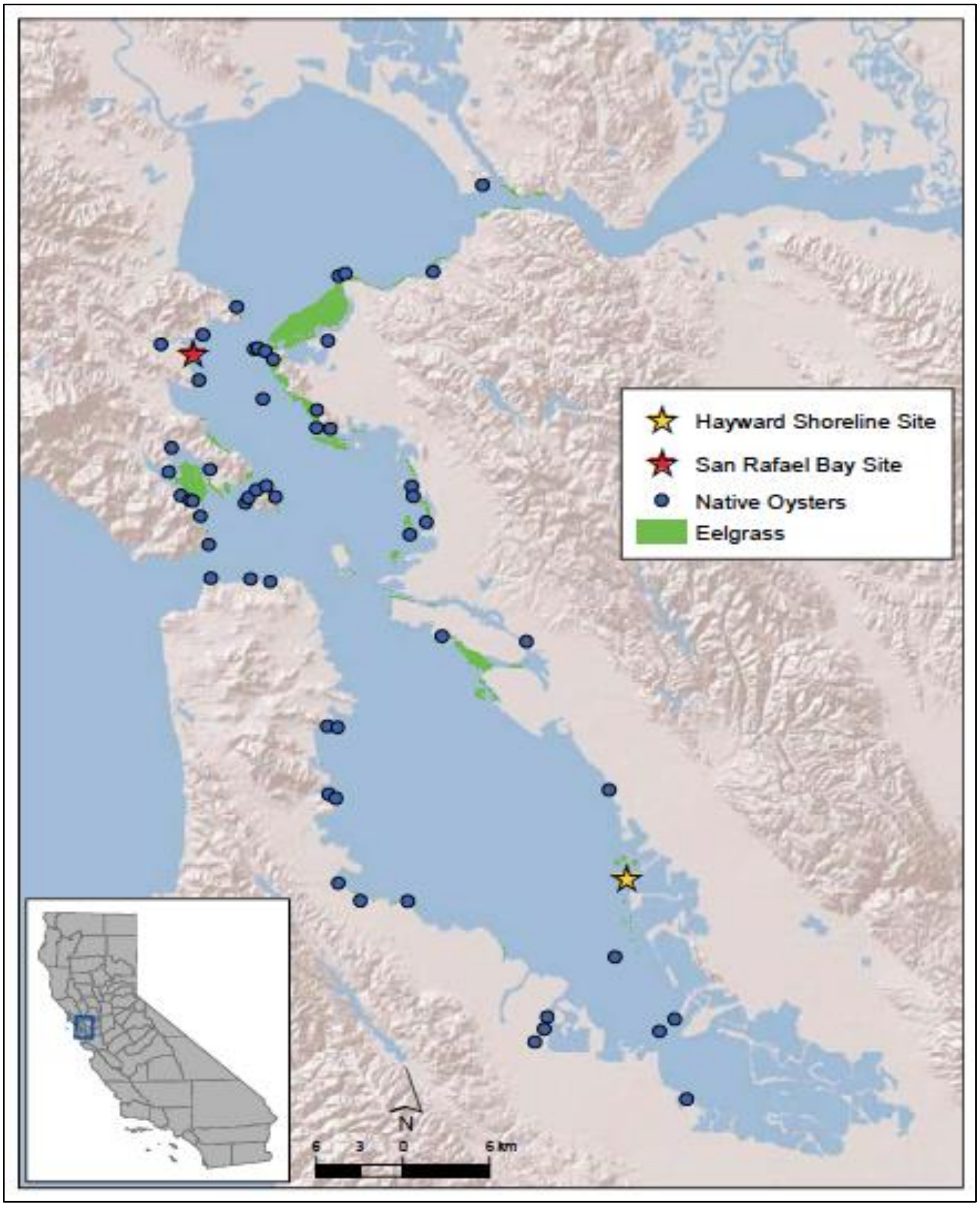


Figure 20. Using a pilot-scale, experimental approach to establish native oysters and eelgrass at multiple locations in San Francisco Bay [lxxxiii]

Project Details		Benefits
Location	San Francisco Bay, City of San Rafael shoreline	– Habitat Restoration – Food and nesting resources for aquatic and bird species – Erosion Prevention – Accretion of sediment – Reduced wave energy
Setting	Deep intertidal, shallow subtidal, nearshore, soft bottom	
Project Size	One acre, 200 meters offshore	
Strategies	– Eelgrass bed restoration – Olympia oyster (Ostrea lurida) reef restoration – Living Shorelines Approach (i.e., using natural habitats to soften and protect the shoreline)	

Figure 21. San Francisco Bay Living Shorelines: Nearshore Linkages Project Details.

Cost of Project	
Total for first five years	$2.5 M
Design and permitting	$450 k
Construction	$350 k
One year pre-construction and five year post-construction with high frequency monitoring	$1.7 M

Figure 22. San Francisco Bay Living Shorelines: Nearshore Linkages Project Costs.

Project Performance

1. The oyster–eelgrass plot dissipated approximately 30% more wave energy than the control at mean tide level.
2. Olympia oysters recruited quickly to both shell bag mounds and the baycrete structures, with an estimated peak of more than three million recruits in spring 2013
3. Eelgrass density reached 200% above initial planted densities when planted alone and just under 100% density when planted amongst oyster shell mounds, which can be abrasive to shoots and restricted the available space where eelgrass could expand.
4. Sediment core sampling of infaunal invertebrates showed a significant increase in density where eelgrass and oyster bags were installed, potentially due to the detritus and biological material coming off the reefs and enhancing food resources for species in benthic sediments.

Orient Beach State Park - Coastal Resilience Efforts to Date

The Shoreline

Figure 23 displays the four shoreline types in Orient Beach State Park. These are the armored shoreline, the shoreline with sand and gravel, the flat shoreline and the vegetated shoreline, which belonging to categories 1, 3, 4, and 5, respectively (see figure 23). The armored shoreline, describes the shoreline being protected from coastal erosion by bulkheads. This is the area in the north-eastern side of the park.[lxxxiv]

The beachfront, which covers approximately two-thirds of the eastern and southwestern shoreline of the park,[lxxxv] consists of sand and gravel, as well as small shells. The widest part of the beach is located in the center, facing Gardiner Bay, which is about 156 feet across.[lxxxvi] Majority of the recreational facilities and buildings are concentrated in the center of the park, behind the widest part of the beach. The park has, in the past, made efforts to manually nourish the beach; unfortunately, the rate of erosion was faster than the rate of replenishment.

Apart from a recent reforestation project by Park officials and volunteering members of the Orient community, there are no records of any restorative interventions made towards the third and fourth shorelines, which mostly consists of marshlands located in the southern and northern part respectively (see Figure 23).[lxxxvii]

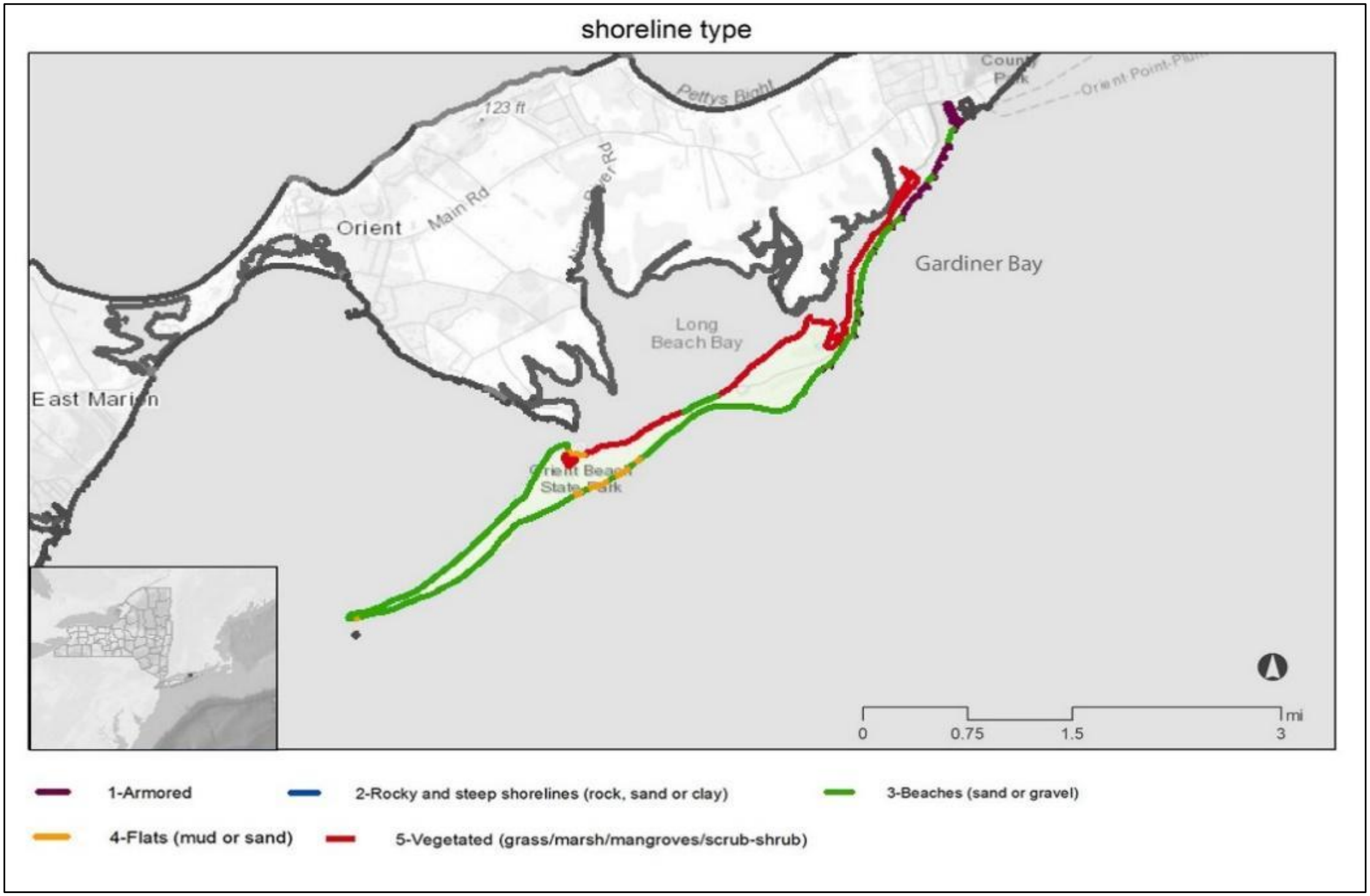


Figure 23. Shoreline types at Orient Beach State Park. Source: DOS Coastal Risk Model.

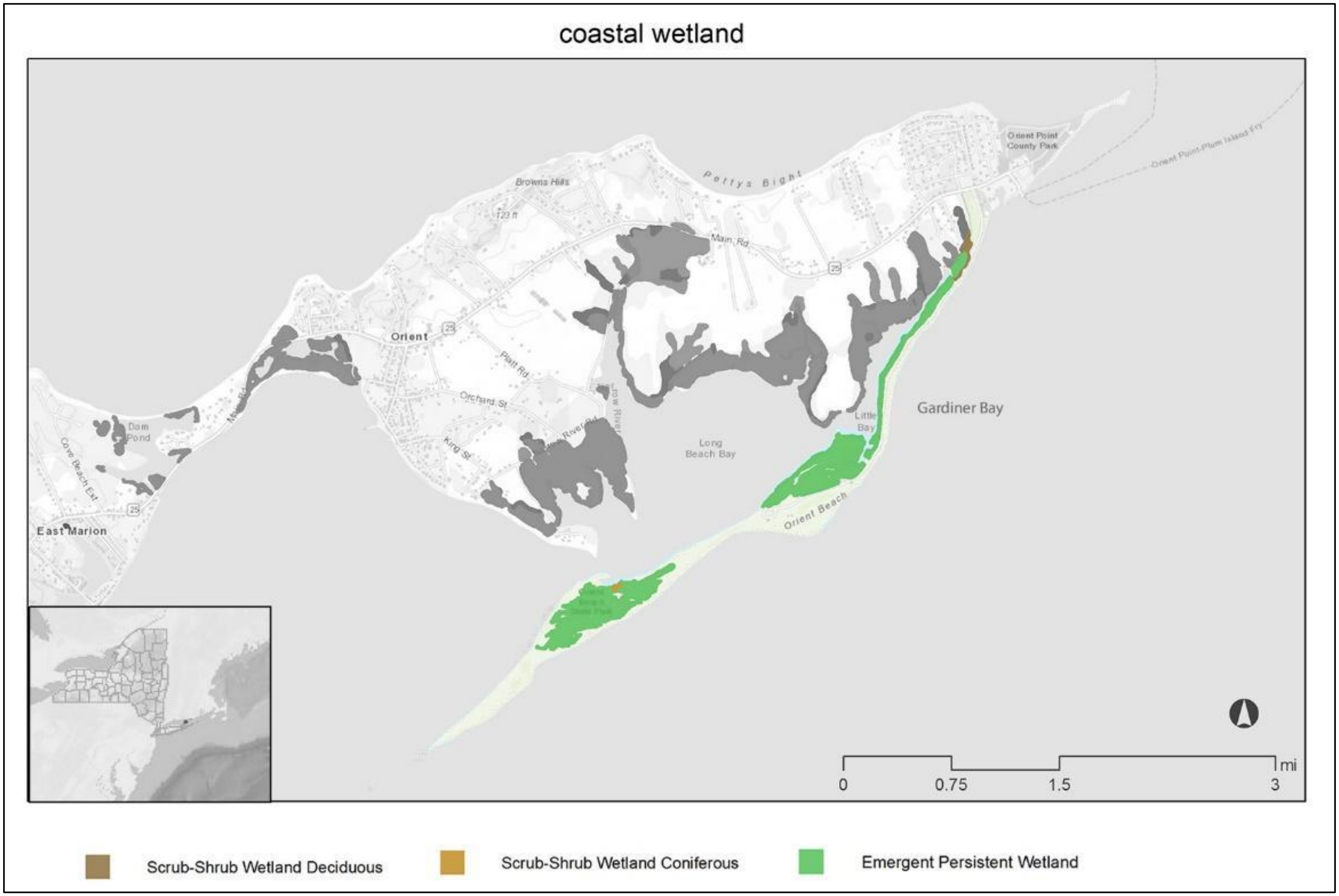


Figure 24. Coastal wetland at Orient Beach State Park. Source: DOS Coastal Risk Model.

The Causeway

In 1984, a major storm event destroyed 8,600 linear feet of the causeway. A project commenced to repair the roadway in-kind; the project cost $275K, which would be equivalent to $667K today (According to the Bureau of Labor Statistics consumer price index, the dollar experienced an average inflation rate of 2.64% per year over the past 34 years). A multi-phased capital project was designed and built by the Park to help prevent erosion along the causeway by creating an armored shoreline using boulder riprap, and gabion baskets. The four phases of the $2 Million project armored approximately 1,000 linear feet of some of the most vulnerable sections of the roadway. The project commenced in 2002 and was completed in 2008. The roadway was damaged again in 2012 when super-storm Sandy struck the northeast, land-locking and closing the park to the public for 6 months. Under a New York State Office of General Services (OGS) emergency contract, a $461,811 in-kind repair was made to the causeway. These emergency contracts managed by OGS are charged back to the Park's annual capital appropriations. The aggregate of costs between 2002 and 2012 for shoreline protection and roadway repair totaled approximately $2.5 Million.

Recommendations

Barrier Islands are complex and dynamic Islands that are influenced by waves, currents, tides, winds, storms, and sea level rise. They serve a critically important ecological purpose, and act as a first line of defense to the coasts of main lands by preventing ocean swells and other storm events from destroying property or disrupting water systems on the mainland sides. Orient Beach State Park provides these services to the town of Orient. The objective of this project is to enable Orient Beach State Park to continue to provide these services, whilst ensuring a safe environment for outdoor recreation for neighboring communities.

A positive note about the Park's current situation is the lack of real estate development on the beach and the significantly low inhabiting population. This means that the constant changeability of the beach, which is a natural part of beach morphology, can be maintained without any real endangerment to human life or significant property.

Our proposed solutions will seek to minimize erosion/loss of sediment, by mimicking the natural delivery of sediments to the beach, ensuring the attenuation of wave energy, managing the exit of water from the beach to minimize damage to dunes and vegetation, as well as protecting and reinforcing existing natural infrastructure and ecosystems on Orient Beach State Park.

Our recommendations will also look into redesigning existing physical infrastructure to withstand the natural forces that are characteristic of barriers islands by ensuring that the winds and water coming into the park leave with minimal resistance.

Given that Orient Beach State Park is open to the public, and given the current condition of the causeway, our recommendations will also provide access options to the Park

The recommendation section will cover the following areas:

- The Beach & Existing Natural Infrastructure
- Wildlife & Ecosystem Conservation
- Pre and Post Storm Protocols
- The Causeway (Engineered Solutions)
- Facilities Upgrade
- Renewable Electricity Generation
- Funding Recommendations

The Beach

In order to fortify the beach and make it resilient to coastal erosion and future storm surges a combination of grey and green infrastructure solutions will have to be employed in order to realize the project objectives.

Beach Reclamation and Dune Building

The erosion of Orient Beach's shoreline has increased partly due to a reduction of sediment supply, and the net result has been a narrowing of the island[lxxxviii].

The objective of this first step is to increase beach width and elevation. Recognizing that traditional beach nourishment usually involves dredging which is disruptive to existing ecosystems, the project proposes the use of Undercurrent Stabilizer Systems. Undercurrent Stabilizers are custom-designed modular fingers of concrete-slurry-filled geotextile fabric that project outward into the ocean perpendicular to the shore, depending on the local currents. Each stabilizer array can consist of two to five of these fingers, usually spaced about 70 feet apart and projecting 250 – 350 feet outward on the ocean floor[lxxxix]. By altering the dynamics of the currents, the stabilizers encourage sand deposition to rebuild the eroding beach or lakeshore. The coastlines eventually become restored to a self-building capacity, which simulates the geological function of beach nourishment or sand replacement[xc]. Undercurrent Stabilizers are successful at retaining the natural slope of the beach platform. Unlike traditional groins, undercurrent stabilizers taper as they get farther from shore. The stabilizers are designed to reduce wave reflection and turbulence to create a "low-energy beach." Calmer waters allow more sand to be deposited, and as sand accumulates and the near-shore areas become shallower, wave energy is lessened even more[xci].

According to Holmberg Technologies, undercurrent stabilizers have been successful in ensuring the expansion of the width of beaches in the following locations:

1982-Manasota Key, FL
1983 – Michigan near Buffalo; Captiva, FL and Ogden Dunes, (See Figure 1).
2000 – Najmah Beach, Ras Tanura, Saudi Arabia [xcii] (See Figure 2).

Before | After

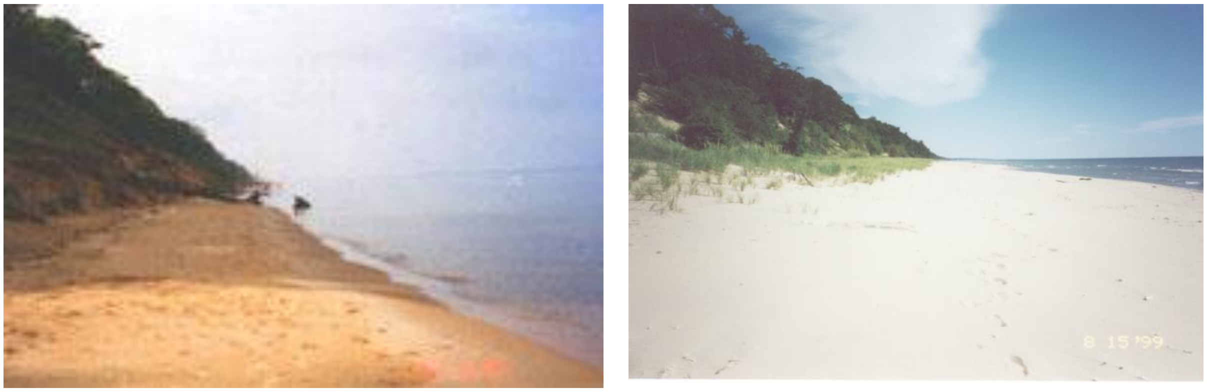


Figure 26: Holmberg Technologies' Undercurrent stabilizer system employed along lake Michigan at Orchard Beach[xciii]

December 1991 | May 2001

Figure 27: Holmberg Technologies' Undercurrent stabilizer system employed at Ras Tanura, Saudi Arabia[xciv]

Over the years, Orient Beach has progressively lost unrecorded expanses of shoreline to erosion and sea level rise, as a result, the width of the beach has reduced, and the Red Cedar Forest is more frequently threatened by flooding from salt water. The successful reclamation of the beach will provide sediments needed for creating more vegetated dunes. This ensures continuous nourishment of the beach with dune grass can encourage dune growth by trapping and stabilizing sand deposited by incoming waves.

The establishment of the dune-building grass (Ammophila breviligulata) is critical since their guerilla root morphology and high tolerance to sand burial initiates the formation of a continuous line of protective dunes along coastlines[xcv]"

Living Shorelines

In an effort to reduce wave energy responsible for beach erosion and causeway destruction, the project will establish, along the beach, a living shoreline made up of eelgrass beds, Spartina marshes and oyster reefs. These will also stabilize the shoreline by encouraging re-sedimentation. Living shorelines also trap sand brought in by waves and minimize the loss of beach sand as well.

Figure 21 simulates the location and phases for the installation of gray and natural infrastructure and how they will protect the Island from high wave energy and erosion whilst ensuring re-sedimentation of the beach.

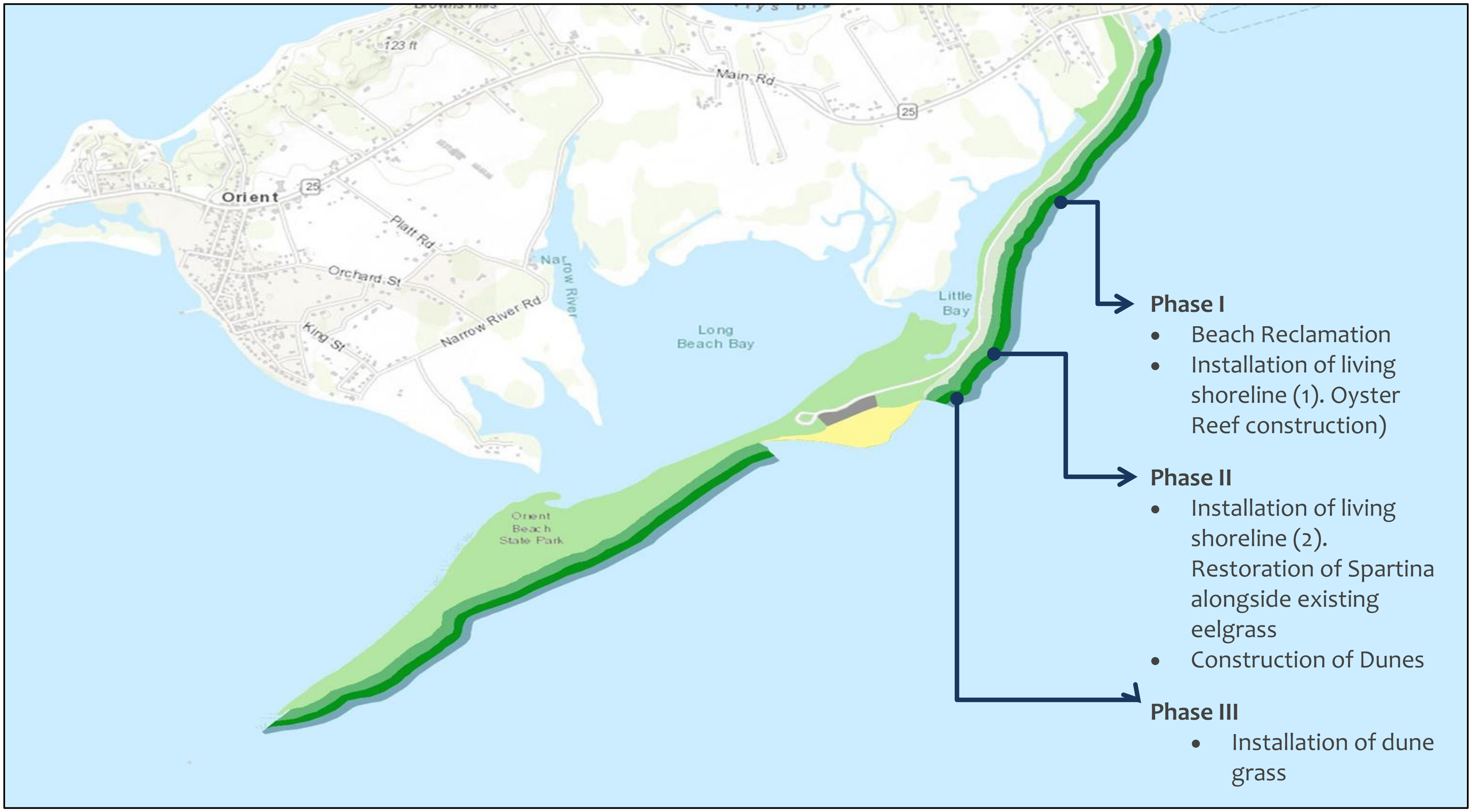


Figure 28. Three-phase living shoreline plan

Phase I: The objective of this phase is to increase beach width and elevation. Undercurrent Stabilizer Systems will be installed to ensure beach nourishment or sand replacement.

This phase also includes the construction of oyster reefs which are part of the living shoreline and will be established to reduce the energy of the waves that crash on the beach, The intention is to have the oyster reefs attenuate wave energy to aid with re-sedimentation whilst reducing erosion as the undercurrent stabilizer progressively increases the width of the beach through nourishment.

Phase II: The objective of this phase involves the further development of the living shoreline to include vegetation. It is envisaged that the living shoreline will comprise of eelgrass beds, Spartina marshes and oyster reefs (Phase I). Since the frontier already has healthy eelgrass, they will be maintained, while the Spartina marshes are restored and established alongside the eelgrass. This combination of vegetation and oyster reefs will stabilize the shoreline by breaking strong waves to minimize erosion whilst the beach is nourished by sand brought in by the waves. More dunes will be built from the sediments to create an elevated topography, which will facilitate draining after a storm.

Phase III: The objective of this phase involves the establishment of dune-building grass American Beachgrass (Ammophila breviligulata), which will ensure continuous nourishment of the beach because of its ability to encourage dune growth by trapping and stabilizing sand brought in by waves.

Revival of Maritime Red Cedar Forest

This project seeks to restore the Maritime Red Cedar Forest by creating conditions that would provide reprieve from the saltwater floods, which kill the trees. Through the process of beach reclamation and the construction of vegetated dunes, the project hopes to increase the distance between the forest and the ocean and create a raised topography that encourages quick drainage after an overwash.

Pre and Post Storm Protocols

We recommend that Orient Beach State Park develops protocol and restoration plans for dealing with the impact of storm damage of various categories.

Guided by the hazard scale developed by the U.S. Geological Survey (USGS[xcvi]), there are four possible storm impacts based on the strength of the storm; and procedures to protect and restore existing facilities need to be established and applied appropriately.

According to the USGS, in the case of an Impact 1 storm situation: “Wave erosion is confined to beach area. The eroded sands will be replenished in a few weeks to months and no significant change occurs in the system.”

Impact 2: “Waves erode the dune and cause the dune to retreat. This is a semi-permanent or permanent change to the system.”

Impact 3: “Wave action exceeds the dune's elevation, destroys the dune and pushes sediment from the dune landward (approximately 300 yards [sic] /100 m), thereby creating overwash. This change in the system pushes the barrier island landward”

Impact 4: “The storm surge completely covers the barrier island, destroys the dune system and pushes sediments landward (approximately 0.6 miles/1 km). This is a permanent change to the Barrier Island or portions of it.”

In order to ensure the continued existence of Orient Beach while sustaining all the ecological and economic benefits it provides, the following information must be collected, and acted on in a timely and efficient manner, as referenced by Protocol developed by the United States Department of Agriculture Forest Service and University of Massachusetts, Amherst[xcvii]:

1. **Pre-Storm Data Collection** (e.g. obtain scaled maps and street information for sampling of existing trees, field survey of permanent plots, estimate total cleanup costs and damage potential, summarize pre-storm cleanup and amount of debris damaged, archive assessment protocol and train assessor(s) to complete post-storm surveys)
2. **Post-Storm Data Collection** (e.g. complete survey within 12 hours after a storm passes, re-sample permanent plots, estimate tree removals, rate of beach erosion, hazard pruning and canopy loss, summarize plot data and estimate cleanup cost, report damage assessment to appropriate agencies)
3. **Data Analyses/Assessment**
4. **Emergency Response and Recovery** (e.g. Evacuation Plan, maintain a special needs database, identify redevelopment opportunities outside of flood hazard areas etc.)

Relevant coastal protection professionals must be engaged to provide training to staff and volunteers of Orient Beach State Park in best practices regarding coastal resilience as it pertains to pre and post storm protocols. This program shall include specific training for data collection and analyses, response protocol as well as the development of recovery programs for specific impact situations as outlined above.

Physical Infrastructure of Orient Beach State Park

As we evaluate the effects of climate change on our planetary oceans, we must contemplate the feasibility of adaptation for developed coastal regions. As sea levels continue to rise, and storms increase in frequency and intensity, geomorphological transformation and coastal erosion will accelerate. Dramatic alterations to coastal landscape from storm activities widen the flood prone footprint placing more buildings and infrastructure at risk. A deliberate and comprehensive program for climate adaptation should be created for the coastal locations within New York State's portfolio of parks.

To consider feasibility for adaptation, we must assess the cost effectiveness of the project in terms of probability and magnitude of loss. These elements of risk are moving targets, as climate change increases both the frequency and intensity of major storm events and sea levels. The element of time, in this scenario, plays a crucial role as justification for implementation increases as time moves forward. Likewise, as probability and magnitude of loss increases, projects prove more likely to be cost effective.

Likelihood of Cost Effectiveness of Flood proofing Project:

Magnitude of Potential Loss (S)	Probability of Loss		
	Low	Medium	High
Low	Unlikely	Unlikely	Likely
Medium	Unlikely	Likely	Highly Likely
High	Likely	Likely	Highly Likely

Figure 29. *(Source: FEMA p-936)*

The case study for Orient Beach State Park reveals overwhelming vulnerability of the Park's physical facilities and infrastructure. The entrance to the park follows an 8,000-foot causeway with partial revetment, which evinces exposure and defenselessness. This roadway is the only access to the park for ingress, egress and regress; and has a long history of destruction. As the ocean rises from major storm surge, waves crash over the low-sloped beach and begin to undermine the soft sand sub-base causing the asphaltic road surface to collapse.

Access to the park depends on the existence of the causeway, which continues to be threatened by each storm with increased risk as erosion of the earthen shoulder marches on toward the road. Solutions to protect the causeway are complex, costly, impermanent, and cannot guarantee effectiveness.

Alternatives – The Island Concept

The island concept is a solution, which abandons the causeway permanently; severing the land based umbilical connection. The Park would continue to operate, but would no longer have vehicular passage. A ferry system would provide admittance, and a pier with an accessible gangway would have to be constructed to land the ferry at the park. The ferry dock at Orient Point could serve as the launch point for the Orient Beach State Park destination. Approximate cost for the ferry dock build-out is $3.5 Million.

Alternatives – The Bridge

An alternate connection to the mainland may be a plausible solution if the causeway is to be abandoned and a ferry pier is not desired. In this scenario, a bridge is constructed over the Peconic River to the southwest point where the causeway meets the Park's greater peninsula 1,000 feet east of the Park Office (Figure R-1). Land acquisition or an access easement would be required to build a road from Route 25 through the property located at Eagles Neck Point. The bridge would be designed for pre-cast concrete roadway panels sitting atop pre-case concrete pile caps (Figure R-2). The only penetration through the water and wetlands would be steel pipe piles to minimize impact to the river floor and surrounding habitat. Approximate cost for the new land based connection is $6.4 Million.

Figure 30. Physical routing for concept access road and bridge to OBSP. (Source: Map data; Google)

Figure 31. Concept bridge constructed of precast girders and panels installed on mini-pipe piles. (Source: Link Projekt)

Preservation of the Causeway

Preservation of the existing causeway will require significant and capital intensive upgrades, building onto the initial 4-phase Shoreline Protection project in the Park's 2002-2008 capital program. The alternates identified in the Phase 4 bid documents were apparently never awarded. The design for these additional shoreline armored areas are shovel ready and should be considered ready for immediate implementation. The Phase 4 bid tabulation will reveal actual 2008 pricing for these alternates, however in the absence of these documents, we can use the unit pricing of the average awarded contracts ($2,079 per Linear Foot) for all 4 completed phases. The approximate cost for the completion of the 887 linear feet of armor stone revetment identified as Alternate A & B identified in the engineered bid documents is $1.85 Million.

It is recommendation for future installations that material selection and technical specifications for gabion baskets call for zinc coated wire which has demonstrable resistance to corrosion in coastal environments where systems are exposed to constant sun and salt sea spray with occasional submersion. In 2001, the State of California Department of Transportation, in cooperation with the Federal Highway Administration conducted a comprehensive study on the corrosion resistance of gabion mesh. One of the sites observed over the 16-year study is identified as Site 7; a stretch of roadway with comparable threats from erosion and storm damage to Orient Beach State Park. We look to this study to demonstrate the resilience of such systems and the appropriateness of their inclusion in our recommendations.

Figure 32. Pacific Coast Highway location of 2001 State of California Department of Transportation study of corrosive resistance for gabion systems Site 7, mile 8.1. (Source: Racin and Hoover)

Figure 33. Box showing normal high tide level, circle showing a camper on the roadway and arrow showing the gabion assembly at Site 7, mile 7.7. Box (Source: Racin and Hoover)

Racin and Hoover (2001) describe the findings at Site 7:

Near Alder Creek along the Pacific Coast Highway, gabion walls (PVC-coated mesh) were built beyond the wave height and run-up limit of normal daily, high tide waves.

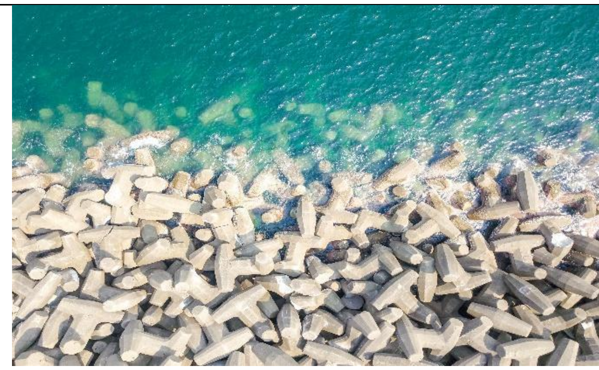
Walls are protected by a rocky beach, they were exposed directly to sunlight and wave splash, and during storms they were submerged by above-normal tides and waves. While PVC has delayed and protected the underlying coatings and wire, it was susceptible to photo-degradation by ultraviolet (UV) light of the sun and got chalky and cracked. Rock impacts abraded PVC and often broke wires on the steps of the step-faced wall. Where PVC was nicked, wire corroded and lost about 35 percent of its tensile strength after about 13 years. Mattresses (PVC-coated mesh) under 8-ton riprap were protected from breaking waves and from abrasive particles. Rock shades the mattresses. Zinc-coated test panels lost nearly 15 percent of tensile strength after about 12 years. As reported in mid-May 2001, the Caltrans Willow Springs Maintenance staff said there was one storm during the 2000-2001 wet season, that washed-away riprap and exposed some gabion mattresses along the north RSP (north of Shale Point). Their assessment indicated that the 4 gabion facilities (2 walls and 2 rock revetments) at site 7 are performing "OK" so far, about 16 years after they were built. (pg. 98)

In addition to the wire type, thickness and coating, the study reveals that a major contributing factor for gabion corrosion is the local soil characteristics. To preserve the containment baskets, it is recommended that geotextile fabric be installed between the soil and the gabion system (as was done in previous phases of the armored shoreline project). Clearly, stone filled gabion systems and armored shorelines are designed to shield the causeway from erosion.

While these systems are quite effective at doing just that, major storms with significant surge will amplify wave energy and hydrodynamic action against the revetment assembly far beyond the capabilities of gabions or riprap. Mooney (2018) explains, "A 620-ton boulder equivalent in mass to about 90 large African elephants moved several meters on the island of Inshore in the winter of 2013-2014 after being slammed by powerful coastal storm waves, according to the research led by Rónadh Cox, a geoscientist at Williams College." We must begin to recognize the impact of storm intensified wave energy even on armored shorelines and separate systems that protect against erosion from conceptual solutions aimed at reducing wave energy forces.

Offshore Breakwater System

To defend Orient Beach State Park's causeway against the next several major storms, we must look to various technologies to provide improved wave attenuation. An offshore breakwater system is perhaps the most effective method to de-risk storm impact from intense wave energy and reduce the storm's ability to pull apart the gabion revetment. One such system that provides dramatic reduction in wave energy is massive concrete structures such as tetrapods or dolosse.

	
Figure 34. A defensive lineup of Dolosse ready for deployment. (source: T.)	**Figure 35**. Dolosse interlocking to create a breakwater system in Hong Kong. (source: Cypang)

These engineered systems are designed to break up wave forces effectively. A single 30-40 ton Dolos (plural: dolosse) or Tetrapod would cost approximately $1,800 to install. Each assembly of interlocking tetrapods or dolosse is a unique and engineered system making costing assumptions difficult without securing hydrographic, wave and storm data. Based on a typical installation of strategically placed, interconnecting concrete wave break structures; protecting the 8,000-foot causeway with this technology would cost approximately $54.8M.

Tetrapod/Dolos Breakwater System

OPINION OF PROBABLE COST FOR SITE CONSTRUCTION					
Item #	Description	QTY	Unit	Material & Labor Unit Price	Material & Labor Cost
Tetrapods/Dolos					
	Precast reinforced concrete Tetrapods or Dolos (3 units per Ln. Ft.)	24,000	EA	$1,800.00	$43,200,000.00
Total for concrete structures				**Sub-Total**	**$43,200,000.00**
SITE WORK					
	Mobilzation/Demobilization	1	EA	$35,000.00	$35,000.00
	Temporary Access	1	EA	$15,000.00	$15,000.00
	Excavation & Backfill	300	CY	$25.00	$7,500.00
	Crane and Rigging	1	EA	$155,000.00	$155,000.00
	Site Restoration (sand, topsoil, landscaping)	1	EA	$25,000.00	$25,000.00
Total for Site Work				**Sub-Total**	**$237,500.00**
				Constuction Estimate Subtotal	**$43,437,500.00**
				Field Order Allowance (5% of Construction Costs)	$2,171,900.00
				Construction Estimate Total	**$45,609,400.00**
				Design Contingency (20% of Construction Costs)	$9,121,900.00
Figure 36.				**A/E Bidding & Construction Administration/Inspection Services**	$75,000.00
				Site Construction Total	**$54,806,300.00**

This Opinion of Probable Cost is intended to give order of magnitude pricing information and is not intended to give final pricing information.

One disadvantage for fixed wave break systems such as tetrapods or dolosse is that over time, the bottom units will embed into the mudline and the top units will often shift and slide around following major storms. They require a crane to setup and reset/restack following each event.

Floating Concrete Systems

Alternatively, floating concrete systems may provide equivalent wave attenuation without these disadvantages or required maintenance. Floating concrete structures riding on steel pipe piles could be set 60 to 80 feet offshore to absorb the wave energy before it reaches the vulnerable shoreline. The piles allow the buoyant wave break system to rise and fall with each passing tide and storm swell. Undercurrents and the sea floor are generally unaffected. The 8,000-foot causeway protection would require 96,000 square feet (134 units measuring 12' wide x 60'long) of floating wave attenuators installed on driven steel piles would be expected to cost $40M.

Offshore Floating Concrete Wave Attenuators					
OPINION OF PROBABLE COST FOR SITE CONSTRUCTION					
Item #	Description	QTY	Unit	Material & Labor Unit Price	Material & Labor Cost
Concrete wave attenuators					
	Precast reinforced concrete floating wave attenuators (12'x60' each)	96,000	Sq.Ft.	$118.00	$11,328,000.00
Total for concrete structures				**Sub-Total**	**$11,328,000.00**
SITE WORK					
	Mobilzation/Demobilization	1	EA	$115,000.00	$115,000.00
	Launch, plce and Installation of floats	96,000	Sq.Ft.	$185.00	$17,760,000.00
	Pile Driving Steel Pipe Piles (266 Piles x 80 Ln.Ft. each)	21,280	Ln.Ft.	$110.00	$2,340,800.00
	Crane and Rigging	1	EA	$165,000.00	$165,000.00
	Site Restoration of laydown and staging (sand, topsoil, landscaping)	1	EA	$85,000.00	$85,000.00
Total for Site Work				**Sub-Total**	**$20,465,800.00**
				Constuction Estimate Subtotal	**$31,793,800.00**
				Field Order Allowance (5% of Construction Costs)	$1,589,700.00
				Construction Estimate Total	**$33,383,500.00**
				Design Contingency (20% of Construction Costs)	$6,676,700.00
				A/E Bidding & Construction Administration/Inspection Services	$185,000.00
				Site Construction Total	**$40,245,200.00**
This Opinion of Probable Cost is intended to give order of magnitude pricing information and is not intended to give final pricing information.					

Figure 37.

Sacrificial Corridors

Another strategy to protect the causeway would involve alternating between armored coastline and the creation of sacrificial corridors along the roadway. These corridors could be strategically placed along the entrance roadway. In these sections, the roadway would be designed as a haunched, reinforced structural slab (thickened edge), with helical piles to underpin the edge. When storm events overtake the causeway the road may be undermined, but will never collapse. Rather, the road will bridge over the collapsed sections of the causeway. This approach would provide continued access to the park while ensuring continuity of business and services following a significant and damaging storm event. Costing for this option would be entirely dependent upon the sections that would be targeted as sacrificial corridors. For the purposes of this study, we will assume 3% of the causeway be dedicated for structural buildout with underpinned structural slab. Costs to build this concept would be approximately $1.3M.

Reinforced Causeway Sacrificial Corridors

Item #	Description	QTY	Unit	Material & Labor Unit Price	Material & Labor Cost
OPINION OF PROBABLE COST FOR SITE CONSTRUCTION					
Reinforced structural mat slab system					
	Steel reinforced concrete haunched mat slab (3% of causeway)	5,280	Sq.Ft.	$120.00	$633,600.00
Total for concrete structures				**Sub-Total**	**$633,600.00**
SITE WORK					
	Mobilzation/Demobilization	1	EA	$95,000.00	$95,000.00
	Helical pile underpin installation (48 pile locations/ 40' depth)	1,920	Ln.Ft.	$95.00	$182,400.00
	Site Restoration of laydown and staging (sand, topsoil, landscaping)	1	EA	$55,000.00	$55,000.00
Total for Site Work				**Sub-Total**	**$332,400.00**
				Constuction Estimate Subtotal	**$966,000.00**
				Field Order Allowance (5% of Construction Costs)	$48,300.00
				Construction Estimate Total	**$1,014,300.00**
				Design Contingency (20% of Construction Costs)	$202,900.00
				A/E Bidding & Construction Administration/Inspection Services	$85,000.00
				Site Construction Total	**$1,302,200.00**

This Opinion of Probable Cost is intended to give order of magnitude pricing information and is not intended to give final pricing information.

Figure 38.

Seawall (with a re-curve wave wall)

A seawall is perhaps the most effective long-term solution to defend the causeway against erosion and destructive storm events. A seawall should be planned with the inclusion of a recurve wave wall, which is designed to return the incoming energy from a wave by rolling it back onto itself.

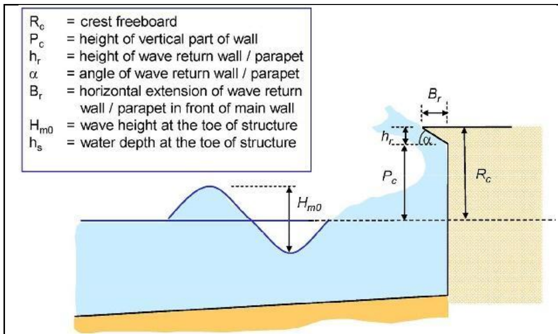


Figure 39. Parapet Wave Recurve Wall detail. (Source: Castellino et al.)

Figure 40. Example: Recurve-wave wall flood and coastal defense designed to return incoming wave energy back onto itself– (Source: Moore Concrete)

A seawall will mitigate persistent erosion and the slow abolition of the causeway. However, it will also forever change the landscape and the relationship between the park and the ocean. A seawall is also one of the costliest options; base costs for a concrete seawall structure can vary widely and are dependent on local conditions. An industry acceptable range of costs for these projects can range from $2,250 to over $8,000 per lineal foot.

In 2017, The Navy Operating Support Center New York City (NYC-NOSC) awarded a project to replace a seawall in the Bronx. Govtribe (2015) details the project scope, "The work includes all labor, materials equipment, transportation, supervision and incidental work related to the replacement of existing seawall with a new cast-in-place concrete seawall. Also included is restoration of the stone revetment shoreline protection, relocation of underground utilities, and ancillary site improvements."

The 160-foot seawall project was awarded under a federal contract for $1. 3M with a unit cost of $8,125 per Lineal Foot. (Change orders from unknown field conditions and project delays drove the actual project over $3M). There is typically a significant economic advantage to larger projects; it should be assumed the high range is based on a much smaller seawall project than that of OBSP. Additionally, the NYC-NOSC project included the demolition of an existing, dilapidated concrete seawall structure and relocation of 3 high voltage electrical manholes. Unfortunately, park documents seem to be lacking topographical and storm impact data for much of the causeway.

Costing consideration for this option along Orient Beach State Park's causeway, for example, would widely range between $24M and $83M depending on soil conditions and design load considerations for the structure. If the Park wishes to consider a seawall as an option it is recommended that a detailed survey be conducted of the area including geotechnical investigations, soil borings and underground utility surveys. This information is needed to inform the design of the architectural and engineering (A/E) unit, and will help to narrow costing estimates.

Masonry Seawall With Concrete Wave Wall

OPINION OF PROBABLE COST FOR SITE CONSTRUCTION					
Item #	Description	QTY	Unit	Material & Labor Unit Price	Material & Labor Cost
Reinforced structural mat slab system					
	Masonry sea wall structure along causeway (Low)	8,000	Ln.Ft.	$2,250.00	$18,000,000.00
	Masonry sea wall structure along causeway (High)	8,000	Ln.Ft.	$8,125.00	$65,000,000.00
Total for concrete structures (Low)				Sub-Total (Low)	$18,000,000.00
Total for concrete structures (High)				Sub-Total (High)	$65,000,000.00
SITE WORK					
	Mobilzation/Demobilization	1	EA	$178,000.00	$178,000.00
	Demolition	8,000	Ln.Ft.	$56.00	$448,000.00
	Temporary Access	1	EA	$75,000.00	$75,000.00
	Excavation & Backfill	3,800	CY	$25.00	$95,000.00
	Site Restoration of laydown and staging (sand, topsoil, landscaping)	1	EA	$172,000.00	$172,000.00
Total for Site Work				Sub-Total	$968,000.00
				Constuction Estimate Subtotal	$18,968,000.00
				Field Order Allowance (5% of Construction Costs)	$948,400.00
				Construction Estimate Total	$19,916,400.00
				Design Contingency (20% of Construction Costs)	$3,983,300.00
				A/E Bidding & Construction Administration/Inspection Services	$192,000.00
				Site Construction Total (Low)	$24,091,700.00
				Constuction Estimate Subtotal	$65,968,000.00
				Field Order Allowance (5% of Construction Costs)	$3,298,400.00
				Construction Estimate Total	$69,266,400.00
				Design Contingency (20% of Construction Costs)	$13,853,300.00
				A/E Bidding & Construction Administration/Inspection Services	$192,000.00
				Site Construction Total (High)	$83,311,700.00

This Opinion of Probable Cost is intended to give order of magnitude pricing information and is not intended to give final pricing information.

Figure 41.

Park Buildings and Physical Assets

Adaptation planning at Orient Beach State Park must also recognize preservation of facilities. Certainly, the park has been entirely inundated with floodwaters several times over the years and the park buildings and physical assets have been submerged, displaced, or destroyed multiple times. Of particular importance and critical for business continuity is the Park's Main office. This building has been inundated so many times that the building now has removable wall panels along the lower 4 feet of each interior wall and all electrical appliances have all been elevated. The recommendation from this study is specifically targeted at this facility, although it may easily be applied to the other buildings at the park. As the park's main office is the central command post during and following disastrous times, it is imperative that it be protected from floodwaters.

Floodwall

Normally, it would be recommended that this structure be elevated on piles above the mean flood level. However, this building is a slab-on-grade structure and it would not be plausible to get below the surface to establish lift points. Rather, this recommendation seeks to create a levee system around the park's critical facilities. A 6-foot above grade wall would be positioned over a spread footing and will encircle the park office and adjoining maintenance buildings. A deliberate opening at the driveway entrance would be fitted with an Aquafragma system or similar self-activating flood barrier (SAFB) to seal off the opening during a flood event.

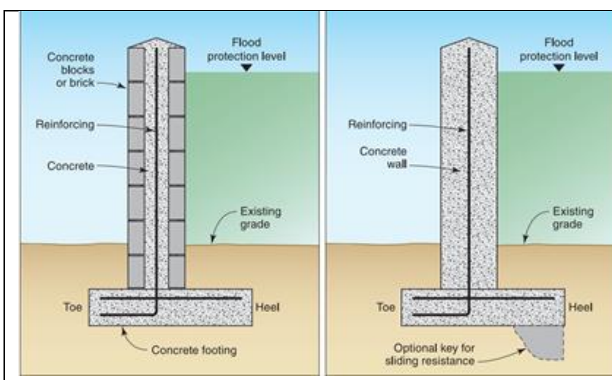


Figure 42. Concrete cantilever floodwall reinforcement (Source: FEMA P-936)

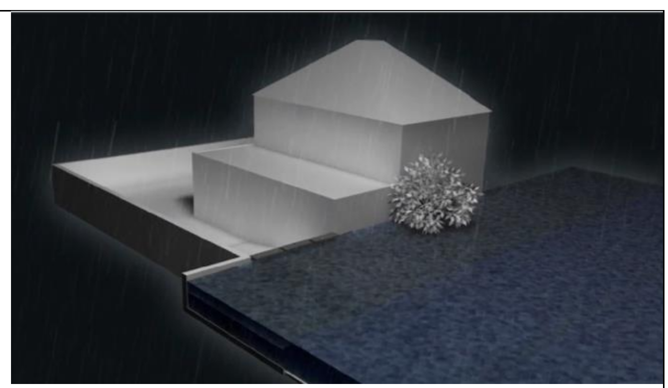


Figure 43. Self Activated Flood Barrier in fully engaged position. (Source: Aquafragma Performance)

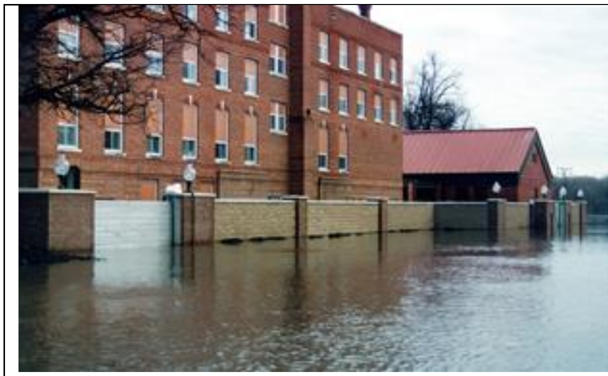


Figure 44. Typical masonry floodwall with engineered closures, which protected the Oak Grove Lutheran School in Fargo, ND, from flooding in 2001 (Source: Flood Control America, LLC, as cited in FEMA P-936)

Figure 45. The Art Building West at the University of Iowa experienced heavy damage from [a] 2008 flood. The Invisible Flood Control Wall now protects the building. The height of the flood wall ranges from about 9'-13' (Source: Flood Control America)

FEMA P-936 states, "A floodwall is a freestanding, permanent, engineered structure designed to prevent encroachment of floodwaters. Floodwalls, which are typically constructed of reinforced concrete or masonry, provide a barrier against inundation, protect structures from hydrostatic and hydrodynamic loads, and may deflect flood-borne debris and ice away from the building." According to FEMA-551 (2007), the cost for a permanent, 2,000-foot floodwall built to 6-feet above ground to surround the Park's main office and maintenance buildings is approximately $390K.

Levee/Berm	
2 feet above ground	$60/linear foot
4 feet above ground	$106/ linear foot
6 feet above ground	$170/ linear foot
Floodwalls	
2 feet above ground	$92/linear foot
4 feet above ground	$140/linear foot
6 feet above ground	$195/linear foot

Figure 46. Source: FEMA 551

Invisible Flood Control Wall

If a permanent or restricting masonry wall surround is not desired, an alternative, removable, panelized system may provide adequate fortification from flooding during an anticipated storm event. Flood Control America offers a lightweight, Invisible Flood Control Wall system utilizing aluminium columns and panels that can be installed quickly with a small workforce. FEMA 551(2007) explains, "IFCW is the first major installation in the United States accepted by the Army Corps of Engineers. The IFCW is the most proactive means of protecting communities and property from the ravages of floods" Rather than a permanent floodwall, this scheme would involve a grade level, reinforced, keyed concrete sidewalk or foundation surrounding the building. Permanent, flush base plates are poured into the concrete acting as permanent anchors. The Park manager could direct the installation of the system for an approaching storm. According to the manufacturer, 3 workers can erect 1200 square feet in about 2 hours for a typical installation. The system can be dismantled, stacked and stored in a garage when not in use. A sagacious strategy may include the precautionary installation of many of the vertical columns at the beginning of each storm season. This way, the Park could be ready to drop in the panels at any time. The cost of the 2,000-foot Invisible Flood Control Wall to surround the Park's main office and Maintenance buildings would be approximately $256,000. Of course, either system is scalable and could be designed to equally fortify the bathhouse, the manager's residence, the lifeguard station and other Park facilities.

Utilities

Regardless of which schemes and scenarios the Park decides to further develop; special consideration ought to be focused on the Park's electrical service. The park receives its electricity from Long Island Power Authority (LIPA) through a primary electrical feeder buried directly below the causeway road surface. This arrangement reveals a distinctive vulnerability in that the Park's main (and only) umbilical source of power is an unprotected shallow cable. If the park's transformer and secondary distribution was closer to the connection in Route 25, we may recommend the installation of a reinforced concrete electrical duct bank. However, the distance from this cross-connection makes this concept cost prohibitive and therefore not recommended.

Alternatively, the Park has unrestricted and constant access to renewable energy from sources such as solar, wind, tidal and current. Environmental regulations may impede planning efforts to develop ocean-based systems, and a windmill may face opposition from the neighboring communities. However, the coastal park has an abundance of unobstructed access to the southern sky and solar exposure. The development of an off-grid system or an established island type micro-grid to connect the park facilities to photovoltaic panels and a bank of batteries would ensure consistent and clean power for the park. Based on a National Renewable Energy Laboratory (NREL) PV Watts calculation for annual solar radiation at Orient Beach State Park's Latitude (41.17° N) and Longitude (72.26° W), a standard PV module will generate 1,373 kWh/Year of electricity for each 1 kW of DC system size. A schedule of assumed electrical loads and energy consumption estimates based on the size, type and use of the park structures and facilities, calculates the park electrical requirements to be approximately 6,585 kWh/Month. This value may be adjusted to reflect actual consumption data from past utility records.

Schedule of Assumed Electrical Loads for Orient Beach State Park									
Area (ft) Overall	6250								
Area (ft) Climatized	2500								
Motor Loads	Item		Quantity		HP	V		A(3-Ph)	kW
	Pump		4		3	208		6.91	**5.75**
AC Loads	Assumption		Quantity	Tons	BTUs	V		A (3-Ph)	kW
	1 Ton Per 500 sq ft		1	5	60,000	208	min	14.00	**4.29**
							max	20.00	**6.12**
Lighting Load	Item		Quantity			V		A	kW
	Interior (3.6k Lumens)		28			120		0.42	**1.40**
	Exterior (5k Lumes)		25			120		0.38	**1.13**
	Emergency		9			120		0.12	**0.13**
	Exit Signs		7			120		0.12	**0.10**
Working Load	Item		Quantity			V		A	kW
	Exhaust Hood		1			208		5.00	**1.04**
	Convenience Outlets		25			120		5.00	**15.00**
	Dishwasher		1			208		12.00	**2.50**
	Computers		7			120		3.00	**2.52**
	Computer Switch / Server		1			208		30.00	**6.24**
	Refrigerator		3			120		6.50	**2.34**
Total					kw/sq ft			A	kW
					0.017		min	**126.69**	**42.43**
					0.018		max	**132.69**	**44.27**

Figure 47

Energy Consumption Estimate - Orient Beach State Park								
Area (ft) Overall	6250							
Area (ft) Climatized	2500							
Motor Loads	Item	Quantity			kW/Hr	Hrs/Day	Days/Month	kWh Total
	Pump	4			5.75	2	20	**460**
AC Loads	Assumption	Quantity			kW/Hr	Hrs/Day	Days/Month	kWh Total
	1 Ton Per 500 sq ft	1		min	4.29	6	20	**514**
				max	6.12	6	20	**735**
Lighting Load	Item	Quantity			kW/Hr	Hrs/Day	Days/Month	kWh Total
	Interior (3.6k Lumens)	28			1.40	12	20	**336**
	Exterior (5k Lumes)	25			1.13	12	20	**270**
	Emergency	9			0.13	24	30	**93**
	Exit Signs	7			0.10	24	30	**73**
Working Load	Item	Quantity			kW/Hr	Hrs/Day	Days/Month	kWh Total
	Exhaust Hood	1			1.04	2	20	**42**
	Convenience Outlets	25			15.00	4	20	**1,200**
	Dishwasher	1			2.50	1	20	**50**
	Computers	7			2.52	10	20	**504**
	Computer Switch / Server	1			6.24	10	20	**1,248**
	Refrigerator	3			2.34	24	30	**1,685**
Total								kWh/Month
							min	**6,475**
							max	**6,695**
							avg	**6,585**

Figure 48.

The cost of the renewable sourced micro grid will be determined based on designed parameters for the system, the electrical demands, storage capacity and distribution infrastructure. Based on average installed costs for the region, capital costing expectations of $2.65 per Watt for an appropriately sized (based on the energy consumption estimate above) 58 kW system would cost approximately $153,700. To limit financial risk to the Park, the Office of Parks and Recreation should consider the installation of the system while Orient Beach State Park is grid connected to pursue a Power Purchase Agreement (PPA).

We have calculated the system to have a 10-year payback based on a PPA rate of $0.10 ($/kW) with 2.5% escalation and a merchant rate set currently at $0.13 ($/kW) also with 2.5% escalation while eliminating 1.3 million pounds of CO^2 emissions avoided over the system lifetime. Under the PPA scenario, this project has a NPV of $51,120.00 and a Project IRR of 10%. (See Finance Model in Appendix)

7/30/2018 PVWatts Calculator

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

79,633 kWh/Year*

System output may range from 77,762 to 81,640 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	2.96	4,582	731
February	4.05	5,581	890
March	4.90	7,335	1,170
April	5.67	7,809	1,246
May	5.85	8,187	1,306
June	6.26	8,184	1,305
July	6.48	8,599	1,372
August	6.11	8,099	1,292
September	5.46	7,147	1,140
October	3.97	5,680	906
November	3.19	4,514	720
December	2.58	3,916	625
Annual	**4.79**	**79,633**	**$ 12,703**

Location and Station Identification

Requested Location	40000 Main Rd Orient, NY
Weather Data Source	Lat, Lon: 41.17, -72.26 1.3 mi
Latitude	41.17° N
Longitude	72.26° W

PV System Specifications *(Commercial)*

DC System Size	58 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.160 $/kWh

Performance Metrics

Capacity Factor	15.7%

Figure 49.

Implementation of any of the recommended solutions in this study requires deliberate and careful planning and prioritization. It is therefore strongly recommended the Park conducts a comprehensive Facilities Master Plan prior to programming any of these initiatives. Costs associated with many of the projects required for Orient Beach State Park to adequately adapt to the effects of climate change far exceed available funding the Park has in its current capital plan. Capital funds are distributed regionally, and Orient Beach State Park will compete with other parks in the Long Island region for these funds. Many of the other coastal parks in this region will be looking to begin projects focused on climate change adaptation, simultaneously increasing the Parks capital program deficit making it more difficult for individual parks to make meaningful and appropriate long term improvements. Proper planning and prioritization for these projects will be critical for achieving a successful and financially viable program at OBSP. The Agency's state-wide annual capital appropriation is approximately $91M for capital improvements and critical maintenance renovations. If these appropriations were distributed evenly over the 350,000 acres managed by the agency, Orient Beach State Park would expect an annual appropriation of $94K. A multi-year capital program should be developed to record the Park's priority projects and to communicate to regional administrators' clear justification for project support.

Funding Recommendations

Orient Beach State Park will have to seek alternative funding opportunities if they are to advance many of the projects or concepts discussed. There are numerous grant opportunities, we would recommend. By registering with the New York State Grants Gateway, Orient Beach State Park will be able to qualify and apply for several grants to support its future development. The New York State Energy Research and Development Authority (NYSERDA, 2018) website explains,

> *"As part of Governor Cuomo's transformative plan to improve the state's economic development model, a New York State Consolidated Funding Application (CFA) has been created that will streamline and expedite the grant application process. The CFA process marks a fundamental shift in the way state resources are allocated, ensuring less bureaucracy and greater efficiency to fulfill local economic development needs".*

The CFA allows a single grant application to request multiple grants from NYSERDA as well as many other sources. Specifically, the 2018 Climate Smart Communities Grant, which the program selection page within the NYSERDA (2018) CFA Portal describes as:

"…a competitive grant program to conduct climate adaptation and mitigation actions across the state. Projects eligible under the CSC Grants Program include: flood risk reduction, especially with natural resiliency measures; adaptation of climate vulnerable facilities and natural systems…"

Other examples of grant opportunities that the NYS Parks agency would be eligible for include: Empire State Development Grant Funds, Green Innovation Grant Program, Local Government Efficiency Program, Net Zero Energy for Economic Development, NYSERDA Energy Efficiency Projects, and Recharge New York. Additionally, Resilience Fund's Low-cost Financing programs are available for the construction or restoration of wetlands, floodplains and riparian buffers and there are also Community Development Block Grants specifically for protecting and preserving public Infrastructure and public facilities. Dedicated funds are also available for program studies and feasibility planning to help advance conceptual models into design. Bearing in mind, annual capital fund scarcities for NYS Parks, we strongly recommend the routine application for additional grant funds using NYSERDA's CFA to support the multi-year capital plan in development.

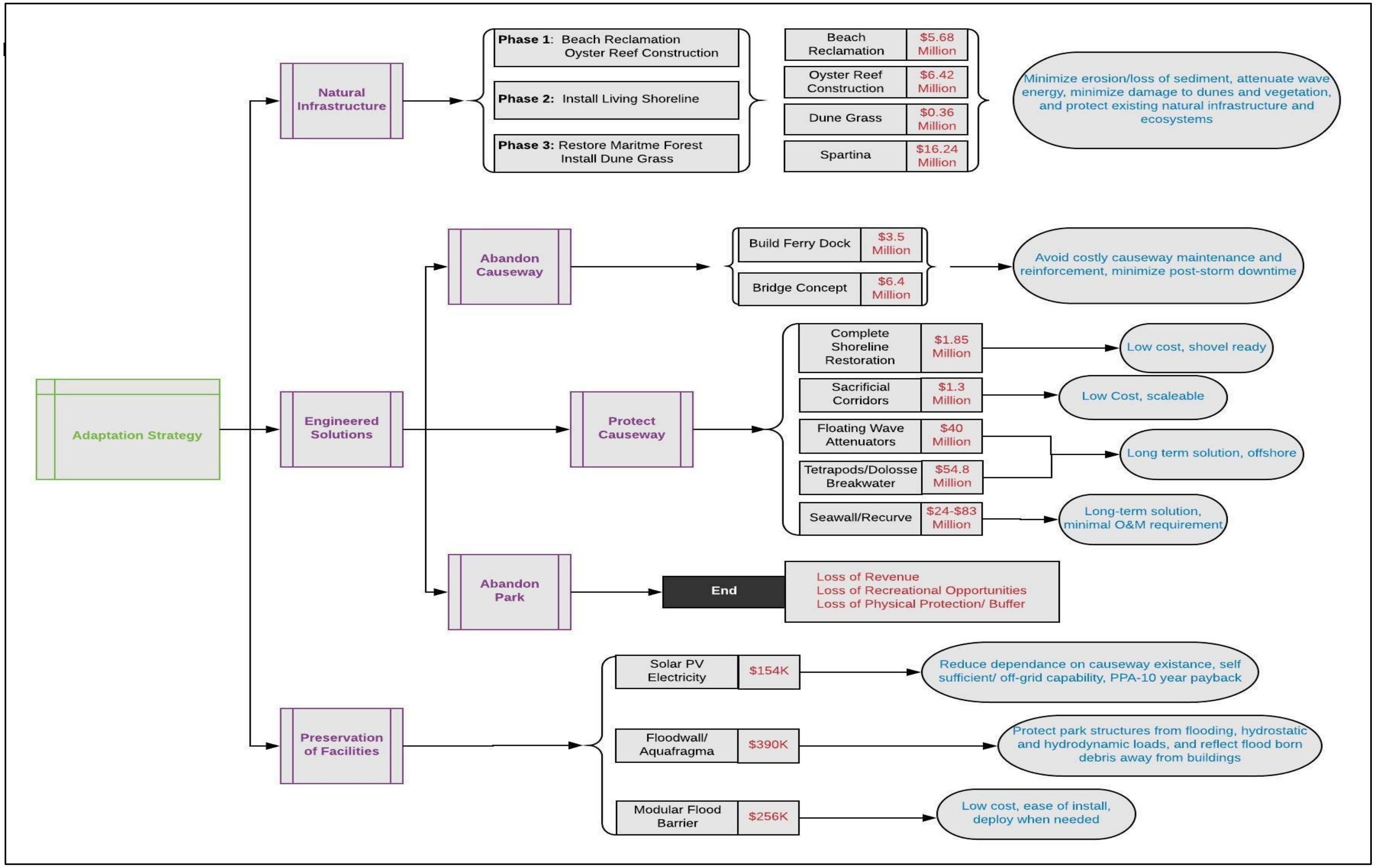
Opportunities for Community Engagement

Each year Orient Beach State Park has over 350,000 visitors, a key resource in providing a strong public outreach component that can help Orient Park implement and promote community engagement opportunities and education initiatives. With the help of local organizations, the Park can solidify partnerships that foster collaborative efforts with community stakeholders, including local businesses, community schools, conservation groups and volunteers to help support local restoration and protective efforts while maximizing opportunities to implement adaptation strategies.

Bob Deluca, President of The Group for the East End has been very active in engaging with the community within the region of Orient by establishing educational initiatives regarding the protection of the natural environment. Mr. Deluca spearheaded sustainability water initiatives, informing local business of the dangers of plastic straws and educating the community of the importance of water quality[xcviii]. Maintaining water quality within the beach is crucial for marine environments, maintaining terrestrial habitats and provide ecosystem services which act as a first line of defense against erosion and impacts from climate change. This organization fosters the exchange of ideas, information and resources to engage the community and ensure everyone in Orient can participate and contribute to efforts aimed at improving sustainability and local aquatic systems.

Cost Benefit Analysis Decision Tree

Below is a Decision tree, which outlines all the recommended interventions and the potential cost for implementation. This diagram is to assist the Office of Parks and Recreation evaluate the various solutions and decide on the best way forward.



Conclusion and Next Steps

The ecosystem-based adaptation recommendations provided in this investigation are suited to address the overwhelming vulnerability of Orient Beach State Park's natural habitats, physical facilities and infrastructure. Recognizing the peninsula's primary function for protecting the Hamlet of Orient and surrounding areas, and its importance in the region for recreation, fishing, and building community, we recommend that New York State Office of Parks and Recreation commit to further investigation in order to ensure the conservation of the Park and the ecosystem services it provides. The possibility that the causeway may need to be abandoned rather than repaired in the event of the next major storm event is also a harsh reality that needs to be contended with.

By continuing to engage community members and non-profits, future partnerships and collaborative efforts could foster awareness and educational initiatives. In response to storm projections and forecasts of sea level rise, a response plan and emergency preparedness protocols need to be established for Orient Beach State Park to ensure better resource management. As indicated in our recommendations, the park is in a favorable position to access financial support for the recommended solutions by exploiting state and federal grants set aside for coastal protection and related matters.

Due to the uncertainties outlined by the various climate models it is difficult to determine or establish a reliable timeline particularly when natural processes within these dynamic systems operate on different time scales. Our recommendation is that the coastal resilience program be implemented as soon as possible to protect Orient Beach State Park from the inevitable impacts of climate change.

The integration of sustainability is critical to enhance resilience for coastal parks in New York State. Fundamentally, New York State Parks must develop a management plan for the Park, maintain a multi-year capital plan which includes Orient Beach State Park, and improve data collection as well as the monitoring of operational and response initiatives to determine a true baseline and path forward. In doing so, New York State Parks will be better equipped to help Orient Beach State Park and other similar coastal parks to adapt to climate change and its inevitable impacts.

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2014 Long Island Coastal Vulnerability Assessment

Appendix

Appendix A. Ecosystem services, process and functions, important components, examples of values, and human drivers of ecosystem change for salt marshes[xcix]

Salt marshes				
Ecosytem service	Ecosytem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials and food	generates biological productivity and diversity	vegetation type and density, habitat quality, inundation depth, habitat quality, healthy predator populations	Euro15.27 *ha-1*yr-1 net income from livestock grazing, UK (King and Lester 1995)	marsh reclamation, vegetation disturbance, climate change, sea level rise, pollution, altered hydrological regimes, biological invasion
Coastal protection	attenuates and/or dissipates waves	tidal heights wave height and length, water depth in or above canopy, marsh area and width, wind climate, marsh species and density, local geomorphology	in reduced hurricane damages, USA (Costanza et al. 2008)	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, tidal stage, coastal geomorphology, subsidence, fluvial sediment deposition and load, marsh grass species and density, distance from sea edge	estimates unavailable	
Water purification	provides nutrient and pollution uptake, as well as retention, particle deposition	marsh grass species and density, marsh quality and area, nutrient and sediment load, water supply and quality, healthy predator populations	USS785-15000/acre capitalized cost savings over traditional waste treatment, USA (Breaux et al. 1995)	
Maintenance of fisheries	provides suitable reproductive habitat and nursery grounds, sheltered living space	marsh grass species and density, marsh quality and area. primary productivity, healthy predator populations	USS6471/acre and S981/ acre capitalized value for recreational fishing for the east and west coasts, respectively, of Florida, USA (Bell 1997) and SO. 19—1.89/acre marginal value product in GulfmCoast blue crab	
Carbon sequestration	generates biogeochemical activity, sedimentation, biological productivity	marsh grass species and density, sediment type, primary productivity, healthy predator populations	US$30.50 *ha-1*yr-1	
Tourism, recreation, education, and research	provides unique and aesthetic landscape, suitable habitat for diverse fauna and flora	marsh grass species and density, habitat quality and area, prey species availability, healthy predator populations	Euro 31.60/person for otter habitat creation and Euro 1.20/person for protecting birds, UK (Birl and cox 2007)	

Appendix B. Ecosystem services, process and functions, important controlling components, examples of values, and human drivers of ecosystem change for seagrass[c]

Seagrasses				
Ecosytem service	Ecosytem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials and food	generates biological productivity and diversity	vegetation type and density, habitat quality	estimates unavailable	eutrophication, overharvesting, coastal development, vegetation disturbance, dredging, aquaculture, climate change, sea level rise
Coastal protection	attenuates and/or dissipates waves	wave height and length, water depth above canopy, seagrass bed size and distance from shore, wind climate. beach slope, seagrass species and density, reproductive Stage	estimates unavailable	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, subsidence, tidal stage, wave climate, coastal geomorphology, seagrass species and density	estimates unavailable	
Water purification	provides nutrient and pollution uptake, as well as retention, particle deposition	seagrass species and density, nutrient load, water residence time, hydrodynamic conditions, light availability	estimates unavailable	
Maintenance of fisheries	provides suitable reproductive habitat and nursery grounds, sheltered living space	seagrass species and density, habitat quality, food sources, hydrodynamic conditions	loss of 12 700 ha of seagrasses in Australia; associated with lost fishery production of AUS235 OOO (McArthur and Boland 2006)	
Carbon sequestration	generates biogeochemical activity, sedimentation, biological productivity	seagrass species and density, water depth, light availability, burial rates, biomass export	estimates unavailable	
Tourism, recreation, education, and research	provides unique and aesthetic submerged vegetated landscape, suitable habitat for diverse flora and fauna	biological productivity, storm events, habitat quality, seagrass species and density, diversity	estimates unavailable	

Appendix C. Ecosystem services, process and functions, important controlling components, examples of values, and human drivers of ecosystem change for sand beaches and dunes[ci]

Beaches and Dunes				
Ecosytem service	Ecosytem processes and functions	Important controlling components	Ecosystem service value examples	Human drivers of ecosystem change
Raw materials	provides sand of particular grain size, proportion of minerals	dune and beach area, sand supply, grain size, proportion of desired minerals (e.g., silica, feldspar)	estimates unavailable for sustainable extraction	loss of sand through mining. development and coastal structures (e.g., jetties), vegetation disturbance, overuse of water, pollution, biological invasion
Coastal protection	attenuates and/or dissipates waves and reduces flooding and spray from sea	wave height and length, beach slope, tidal height, dune height, vegetation type and density. sand supply	estimates unavailable	
Erosion control	provides sediment stabilization and soil retention in vegetation root structure	sea level rise, subsidence, tidal stage, wave climate, coastal geomorphology, beach grass species and density	USS4.45/household for an erosion control program to preserve 8 km of beach, for Maine and New Hampshire beaches, USA (Huang et al. 2007)	
Water catchment and purification	stores and filters water through sand; raises water table	dune area, dune height, sand and water supply	estimates unavailable	
Maintenance of wildlife	biological productivity and diversity, habitat for wild and cultivated animal and plant species	dune and beach area, water and nutrient supply, vegetation and prey biomass and density	estimates unavailable	
Carbon sequestration	generates biological productivity, biogeochemical activity	vegetative type and density, fluvial sediment deposition, subsidence, coastal geomorphology	estimates unavailable US$166/trip or S1574 per visiting household per year for North Carolina	
Tourism, recreation, education, and research	provides unique and aesthetic landscapes. suitable habitat for diverse fauna and flora	dune and beach area, sand supply, wave height, grain size, habitat quality, wildlife species, density and diversity, desirable shells and rocks	beaches, USA (Landry and Liu 2009)	

Table 1. Risk Adaptation Strategy.

Specific Asset at Risk	*Climate Variable*	*Description of Consequences of an Impact Occurring*	*Probability*1*	*Magnitude of Impact *2*	*Time scale*3*	*Potential adaptive management*	*Est. Cost of Strategy (USD million)*	*Strategy Type*
Causeway	Sea level rise	Causeway erosion	High	Large	2020	Island concept by ferry	3.5	Retreat
	100-year storm	Flooding and damage to the causeway	High	Large	2050	Island concept with bridge construction	6.4	Retreat
	500-year storm	Flooding and damage to the causeway	Low	Large	2050	Preserve the island by zinc coated gabion basket with geotextile fabric	1.85	Accommodation
						Install breakwater system	54.8	Accommodation
						Install floating concrete structure	40	Accommodation
						Build sacrificial corridors	1.3	Accommodation
						Build seawalls	24-83	Protection
Other infrastructure including amenity facilities	Sea level rise	Erode the structure	High	Medium	2050	Build floodwall	0.39 for the main office	Protection
	100-year storm	Flooding and damage to the structure	High	Medium	2050	Install invisible flood control wall	0.25 for the main office and maintenance office	Accommodation
	500-year storm	Flooding and damage to the structure	Low	Large	2050			
Buried utility lines	Sea level rise	Causeway erosion	High	Small	2020	Install solar PV (does not include storage)	0.15	Accommodation
	100-year storm	Flooding and damage to the causeway and the utility	High	Small	2050			
	500-year storm	Flooding and damage to the causeway and the utility	Low	Small	2050			
Salt marsh	Sea level rise	Damage and loss of habitat	High	Large	2050	Utilize undercurrent stabilizer system	14.1	Accommodation
	100-year storm	Damage and loss of habitat	High	Large	2050	Establish living shoreline (eelgrass, saltmarsh and oyster)	9.2	Accommodation
	500-year storm	Damage and loss of habitat	Low	Large	2050			
Eelgrass	Sea level rise	Damage and loss of habitat	High	Large	2050	Utilize undercurrent stabilizer system	7.05	Accommodation
	100-year storm	Damage and loss of habitat	High	Large	2050	Establish living shoreline (eelgrass, saltmarsh and oyster)	7.36	Accommodation
	500-year storm	Damage and loss of habitat	Low	Large	2050			
Maritime Red Cedar Forest	Sea level rise	Damage and loss of habitat due to saltwater intrusion	High	Large	2050	Utilize undercurrent stabilizer system	9.4	Accommodation
	100-year Storm	Damage and loss of habitat due to flood and seawater intrusion	High	Large	2050	Establish living shoreline (eelgrass, saltmarsh and oyster)	9.2	Accommodation
	500-year storm	Damage and loss of habitat	Low	Large	2050			
Beach and dune	Sea level rise	Erosion and loss of beach	High	Large	2020	Utilize undercurrent stabilizer system	14.1	Accommodation
	100-year Storm	Flooding and loss beach	High	Large	2050	Establish living shoreline (eelgrass, saltmarsh and oyster)	9.2	Accommodation
	500-year storm	Damage and loss of habitat due to flood and seawater intrusion	Low	Large	2050			
Rare flora and fauna*	Sea level rise	Damage and loss of habitat due to seawater intrusion	High	Large	2050	Utilize undercurrent stabilizer system	14.1	Accommodation
	100-year Storm	Damage and loss of habitat due to flood and seawater intrusion	High	Large	2050	Establish living shoreline (eelgrass, saltmarsh and oyster)	9.2	Accommodation
	500-year storm	Damage and loss of habitat due to flood and seawater intrusion	Low	Large	2050			

*1 For sea level rise, the probability is set to 10% (Low), 50% (Medium) and 90% (High) for evaluating impact. For storm, frequency of occurrence toward set timescale is used for each level storm. For example, 100-year storm is forecasted to occur once in 3-20 years; anticipate 10 occurances in next 30 years (2050 conservatively). Accordingly, this value is established as High.

*2 Magnitude of impact is measured in monetary value for each adaptation measure. < 500K is small, 500K - 2.5M is medium, and 2.5M < is large.

*3 Time scale for storm reflects anticipated frequency of each level storm **by that year**.

Table 2. Solar PV Finance Model.

Arrangement #1: 100% Ownership.

System Assumptions	
Capacity (kW)	58
Insolation (kWh/kW)	1207
Initial Production (kWh)	70,006
Degradation	0.5%
Cost Assumptions	
CAPEX ($/W)	$2.65
CAPEX	$153,700.00
Rate Assumptions	
PPA Rate ($/kWh)	$0.10
PPA Escalation	2.5%
Merchant Rate	$0.13
Merchant Rate Escalation	2.5%
Opex Assumptions	
O&M ($/kw)	$18.00
Initial O&M	$1,044
O&M Escalation	2.5%
Insurance (% of CAPEX)	0.2%
Initial Insurance	$307
Insurance Escalation	0%
REC/SREC Valuation	
NY SunCash ($/kWh)-1st 3 yrs	$0.204
NYSERDA Tier 1 REC ($/MWh)	$-
Duration (years)	10
Compared to ACP value	$23.28
Tax Rate	0%
Discount Rate (WACC)	2%
ITC & Depreciation	
ITC - (Parks does not qualify)	0
Depreciable Basis	153,700
Year 1	52.0%
Year 2	19.2%
Year 3	11.5%
Year 4	6.9%
Year 5	6.9%
Year 6	3.5%
Debt Assumptions	
Leverage %	80%
Principal Amount	$122,960.00
Interest Rate (Interest-Free OGS Loan)	0%
Term (years)	10

$193,576.32

Year	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Production (kWh)		70,006	69,656	69,308	68,961	68,616	68,273	67,932	67,592	67,254	66,918	66,583	66,250	65,919	65,590	65,262
Merchant Rate		$0.13	$0.13	$0.14	$0.14	$0.14	$0.15	$0.15	$0.15	$0.16	$0.16	$0.17	$0.17	$0.17	$0.18	$0.18
Merchant Cost		$9,101	$9,282	$9,466	$9,654	$9,846	$10,042	$10,241	$10,445	$10,653	$10,864	$11,080	$11,300	$11,525	$11,754	$11,988
PPA Rate		$0.10	$0.10	$0.11	$0.11	$0.11	$0.11	$0.12	$0.12	$0.12	$0.12	$0.13	$0.13	$0.13	$0.14	$0.14
PPA Revenue		**$7,001**	**$7,140**	**$7,282**	**$7,426**	**$7,574**	**$7,724**	**$7,878**	**$8,035**	**$8,194**	**$8,357**	**$8,523**	**$8,693**	**$8,865**	**$9,042**	**$9,221**
Gross Savings		$2,100	$2,142	$2,184	$2,228	$2,272	$2,317	$2,363	$2,410	$2,458	$2,507	$2,557	$2,608	$2,660	$2,712	$2,766
NY SunCash Incentive	$31,972	$10,657	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
SREC Revenue (NYSERDA Tier 1 REC)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Revenue	**$31,972**	**$17,658**	**$7,140**	**$7,282**	**$7,426**	**$7,574**	**$7,724**	**$7,878**	**$8,035**	**$8,194**	**$8,357**	**$8,523**	**$8,693**	**$8,865**	**$9,042**	**$9,221**
O&M Expenses		($1,044)	($1,070)	($1,097)	($1,124)	($1,152)	($1,181)	($1,211)	($1,241)	($1,272)	($1,304)	($1,336)	($1,370)	($1,404)	($1,439)	($1,475)
Insurance Expense		($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense		**($1,351)**	**($1,378)**	**($1,404)**	**($1,432)**	**($1,460)**	**($1,489)**	**($1,518)**	**($1,548)**	**($1,579)**	**($1,611)**	**($1,644)**	**($1,677)**	**($1,711)**	**($1,747)**	**($1,783)**
EBITDA	**$31,972**	**$19,009**	**$8,517**	**$8,686**	**$8,858**	**$9,034**	**$9,213**	**$9,396**	**$9,583**	**$9,774**	**$9,968**	**$10,167**	**$10,370**	**$10,577**	**$10,788**	**$11,004**
NOTE: Parks is Tax Exempt																
Principal Balance		$122,960	$110,664	$98,368	$86,072	$73,776	$61,480	$49,184	$36,888	$24,592	$12,296	$0				
Principal Payment		($12,296)	($12,296)	($12,296)	($12,296)	($12,296)	($12,296)	($12,296)	($12,296)	($12,296)	($12,296)	$0	$0	$0	$0	$0
CAPEX	($153,700)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Tax Benefit / (Expense)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow/CADS	**($121,728)**	**$6,713**	**($3,779)**	**($3,610)**	**($3,438)**	**($3,647)**	**($3,083)**	**($2,900)**	**($2,713)**	**($2,522)**	**($2,712)**	**$10,167**	**$10,370**	**$10,577**	**$10,788**	**$10,620**

Year	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Production (kWh)	64,935	64,611	64,288	63,966	63,646	63,328	63,012	62,696	62,383	62,071	61,761	61,452	61,145	60,839	60,535
Merchant Rate	$0.19	$0.19	$0.20	$0.20	$0.21	$0.21	$0.22	$0.22	$0.23	$0.24	$0.24	$0.25	$0.25	$0.26	$0.27
Merchant Cost	$12,226	$12,469	$12,717	$12,970	$13,227	$13,490	$13,758	$14,032	$14,311	$14,595	$14,885	$15,181	$15,483	$15,790	$16,104
PPA Rate	$0.14	$0.15	$0.15	$0.16	$0.16	$0.16	$0.17	$0.17	$0.18	$0.18	$0.19	$0.19	$0.19	$0.20	$0.20
PPA Revenue	**$9,405**	**$9,591**	**$9,782**	**$9,977**	**$10,175**	**$10,377**	**$10,583**	**$10,794**	**$11,008**	**$11,227**	**$11,450**	**$11,678**	**$11,910**	**$12,146**	**$12,388**
Gross Savings	$2,821	$2,877	$2,935	$2,993	$3,052	$3,113	$3,175	$3,238	$3,302	$3,368	$3,435	$3,503	$3,573	$3,644	$3,716
NY SunCash Incentive	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
SREC Revenue (NYSERDA Tier 1 REC)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Revenue	**$9,405**	**$9,591**	**$9,782**	**$9,977**	**$10,175**	**$10,377**	**$10,583**	**$10,794**	**$11,008**	**$11,227**	**$11,450**	**$11,678**	**$11,910**	**$12,146**	**$12,388**
O&M Expenses	($1,512)	($1,550)	($1,589)	($1,628)	($1,669)	($1,711)	($1,753)	($1,797)	($1,842)	($1,888)	($1,936)	($1,984)	($2,034)	($2,084)	($2,136)
Insurance Expense	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense	**($1,819)**	**($1,857)**	**($1,896)**	**($1,936)**	**($1,976)**	**($2,018)**	**($2,061)**	**($2,105)**	**($2,150)**	**($2,196)**	**($2,243)**	**($2,291)**	**($2,341)**	**($2,392)**	**($2,444)**
EBITDA	**$11,224**	**$11,449**	**$11,678**	**$11,912**	**$12,151**	**$12,395**	**$12,644**	**$12,898**	**$13,158**	**$13,423**	**$13,693**	**$13,969**	**$14,251**	**$14,538**	**$14,832**
Principal Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
CAPEX	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Tax Benefit / (Expense)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Free Cash Flow/CADS	**$11,224**	**$11,449**	**$11,678**	**$11,912**	**$11,767**	**$12,395**	**$12,644**	**$12,898**	**$13,158**	**$13,038**	**$13,693**	**$13,969**	**$14,251**	**$14,538**	**$14,447**

NPV	$22,028.16
Project IRR	**3%**

Arrangement #2: Operating Lease.

Year	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Production (kWh)		70,006	69,656	69,308	68,961	68,616	68,273	67,932	67,592	67,254	66,918	66,583	66,250	65,919	65,590	65,262	64,935	64,611	64,288	63,966	63,646	63,328	63,012	62,696	62,383	62,071	61,761	61,452	61,145	60,839	60,535
Energy Rate		$0.13	$0.13	$0.14	$0.14	$0.14	$0.15	$0.15	$0.15	$0.16	$0.16	$0.17	$0.17	$0.17	$0.18	$0.18	$0.19	$0.19	$0.20	$0.20	$0.21	$0.21	$0.22	$0.22	$0.23	$0.24	$0.24	$0.25	$0.25	$0.26	$0.27
SREC Rate (NYSERDA Tier 1 REC)		$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160																				
Energy Revenue		$9,101	$9,282	$9,466	$9,654	$9,846	$10,042	$10,241	$10,445	$10,653	$10,864	$11,080	$11,300	$11,525	$11,754	$11,988	$12,226	$12,469	$12,717	$12,970	$13,227	$13,490	$13,758	$14,032	$14,311	$14,595	$14,885	$15,181	$15,483	$15,790	$16,104
SREC Revenue		$1,481	$1,474	$1,467	$1,459	$1,452	$1,445	$1,437	$1,430	$1,423	$1,416	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Revenue		$10,582	$10,756	$10,933	$11,113	$11,298	$11,487	$11,679	$11,875	$12,076	$12,280	$11,080	$11,300	$11,525	$11,754	$11,988	$12,226	$12,469	$12,717	$12,970	$13,227	$13,490	$13,758	$14,032	$14,311	$14,595	$14,885	$15,181	$15,483	$15,790	$16,104
O&M Expenses		($1,044)	($1,070)	($1,097)	($1,124)	($1,152)	($1,181)	($1,211)	($1,241)	($1,272)	($1,304)	($1,336)	($1,370)	($1,404)	($1,439)	($1,475)	($1,512)	($1,550)	($1,589)	($1,628)	($1,669)	($1,711)	($1,753)	($1,797)	($1,842)	($1,888)	($1,936)	($1,984)	($2,034)	($2,084)	($2,136)
Insurance Expense		($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense		**($1,351)**	**($1,378)**	**($1,404)**	**($1,432)**	**($1,460)**	**($1,489)**	**($1,518)**	**($1,548)**	**($1,579)**	**($1,611)**	**($1,644)**	**($1,677)**	**($1,711)**	**($1,747)**	**($1,783)**	**($1,819)**	**($1,857)**	**($1,896)**	**($1,936)**	**($1,976)**	**($2,018)**	**($2,061)**	**($2,105)**	**($2,150)**	**($2,196)**	**($2,243)**	**($2,291)**	**($2,341)**	**($2,392)**	**($2,444)**
EBITDA		**$9,231**	**$9,378**	**$9,528**	**$9,682**	**$9,838**	**$9,998**	**$10,161**	**$10,327**	**$10,496**	**$10,669**	**$9,436**	**$9,623**	**$9,814**	**$10,008**	**$10,205**	**$10,407**	**$10,612**	**$10,821**	**$11,034**	**$11,251**	**$11,472**	**$11,697**	**$11,927**	**$12,161**	**$12,399**	**$12,642**	**$12,890**	**$13,142**	**$13,399**	**$13,660**
Operating Lease Proceeds / (Payment)	$153,700	($10,144)	($10,144)	($10,144)	($10,144)	($10,144)	($10,144)	($10,144)	($10,144)	($10,144)	($10,144)																				
Estimated Buyout Value											($30,740)																				
CAPEX	$(153,700.00)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384.25)	$0	$0	$0	$0	($384.25)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Free Cash Flow	$0	($913)	($766)	($616)	($462)	($690)	($146)	$17	$183	$352	($30,599)	$9,436.40	$9,623.21	$9,813.56	$10,007.52	$9,820.91	$10,406.53	$10,611.72	$10,821	$11,034	$10,867	$11,472	$11,697	$11,927	$12,161	$12,015	$12,642	$12,890	$13,142	$13,399	$13,276
		($3,448)																													
NPV	$62,669.71																														

System Assumptions	
Capacity (kW)	58
Insolation (kWh/kW)	1207
Initial Production (kWh)	70,006
Degradation	0.5%
Cost Assumptions	
CAPEX ($/W)	$2.65
CAPEX	$153,700.00
Rate Assumptions	
Energy Rate ($/kWh)	$0.13
Rate Escalation	2.5%
Opex Assumptions	
O&M ($/kw)	$18.00
Initial O&M	$1,044
O&M Escalation	2.5%
Insurance (% of CAPEX)	0.2%
Initial Insurance	$307
Insurance Escalation	0%
REC/SREC Valuation	
NYSERDA Tier 1 REC ($/MWh)	$21.16
Duration (years)	10
Compared to ACP value	$23.28
ITC & Depreciation	
ITC	46,110
Depreciable Basis	130,645
Year 1	52.0%
Year 2	19.2%
Year 3	11.5%
Year 4	6.9%
Year 5	6.9%
Year 6	3.5%
Lease Pricing	
Monthly Lease Factor	0.550%
Discount Rate	
WACC	5%

Arrangement #3: PPA.

System Assumptions	
Capacity (kW)	58
Insolation (kWh/kW)	1207
Initial Production (kWh)	70,006
Degradation	0.5%
Cost Assumptions	
CAPEX ($/W)	$2.65
CAPEX	$153,700.00
Rate Assumptions	
PPA Rate ($/kWh)	$0.10
PPA Escalation	2.5%
Merchant Rate	$0.13
Merchant Rate Escalation	2.5%
Opex Assumptions	
O&M ($/kw)	$18.00
Initial O&M	$1,044
O&M Escalation	2.5%
Insurance (% of CAPEX)	0.2%
Initial Insurance	$307
Insurance Escalation	0%
REC/SREC Valuation	
NYSERDA Tier 1 REC ($/MWh)	$21.16
Duration (years)	10
Compared to ACP value	$23.28
Tax Rate	35%
Discount Rate (WACC)	5%
ITC & Depreciation	
ITC	$46,110.00
Depreciable Basis	130,645
Year 1	52.0%
Year 2	19.2%
Year 3	11.5%
Year 4	6.9%
Year 5	6.9%
Year 6	3.5%

Year	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Production (kWh)		70,006	69,656	69,308	68,961	68,616	68,273	67,932	67,592	67,254	66,918	66,583	66,250	65,919	65,590	65,262
Merchant Rate ($/kWh)		$0.13	$0.13	$0.14	$0.14	$0.14	$0.15	$0.15	$0.15	$0.16	$0.16	$0.17	$0.17	$0.17	$0.18	$0.18
Merchant Cost		$9,101	$9,282	$9,466	$9,654	$9,846	$10,042	$10,241	$10,445	$10,653	$10,864	$11,080	$11,300	$11,525	$11,754	$11,988
PPA Rate ($/kWh)		$0.10	$0.10	$0.11	$0.11	$0.11	$0.11	$0.12	$0.12	$0.12	$0.12	$0.13	$0.13	$0.13	$0.14	$0.14
PPA Revenue		**$7,001**	**$7,140**	**$7,282**	**$7,426**	**$7,574**	**$7,724**	**$7,878**	**$8,035**	**$8,194**	**$8,357**	**$8,523**	**$8,693**	**$8,865**	**$9,042**	**$9,221**
Gross Savings		$2,100	$2,142	$2,184	$2,228	$2,272	$2,317	$2,363	$2,410	$2,458	$2,507	$2,557	$2,608	$2,660	$2,712	$2,766
SREC Revenue (NYSERDA Tier 1 REC)		$1,481	$1,474	$1,467	$1,459	$1,452	$1,445	$1,437	$1,430	$1,423	$1,416	-	-	-	-	-
Total Revenue		**8,481.93**	**8,613.66**	**8,748.19**	**8,885.58**	**9,025.88**	**9,169.16**	**9,315.46**	**9,464.84**	**9,617.38**	**9,773.13**	**8,523.24**	**8,692.64**	**8,865.41**	**9,041.61**	**9,221.31**
O&M Expenses		($1,044)	($1,070)	($1,097)	($1,124)	($1,152)	($1,181)	($1,211)	($1,241)	($1,272)	($1,304)	($1,336)	($1,370)	($1,404)	($1,439)	($1,475)
Insurance Expense		($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense		**($1,351)**	**($1,378)**	**($1,404)**	**($1,432)**	**($1,460)**	**($1,489)**	**($1,518)**	**($1,548)**	**($1,579)**	**($1,611)**	**($1,644)**	**($1,677)**	**($1,711)**	**($1,747)**	**($1,783)**
EBITDA		**$9,833**	**$9,991**	**$10,152**	**$10,317**	**$10,486**	**$10,658**	**$10,834**	**$11,013**	**$11,197**	**$11,384**	**$10,167**	**$10,370**	**$10,577**	**$10,788**	**$11,004**
Depreciation %		$0.52	$0.19	$0.12	$0.07	$0.07	$0.04									
Depreciation ($)		($67,935.40)	($25,083.84)	($15,024.18)	($9,014.51)	($9,014.51)	($4,572.58)									
Net Operating Income		($58,102.07)	($15,092.68)	($4,871.73)	$1,302.75	$1,471.16	$6,085.17	$10,833.58	$11,013.23	$11,196.79	$11,384.34	$10,167.05	$10,369.86	$10,576.87	$10,788.17	$11,003.85
Interest Expense		($4,918.40)	($4,508.74)	($4,082.70)	($3,639.61)	($3,178.80)	($2,699.56)	($2,201.15)	($1,682.80)	($1,143.72)	($583.07)	$0	$0	$0	$0	$0
Earnings Before Taxes		($63,020.47)	($19,601.42)	($8,954.43)	($2,336.86)	($1,707.64)	$3,385.61	$8,632.43	$9,330.43	$10,053.08	$10,801.27	$10,167.05	$10,369.86	$10,576.87	$10,788.17	$11,003.85
Income Tax Expense		$22,057.17	$6,860.50	$3,134.05	$817.90	$597.68	($1,184.96)	($3,021.35)	($3,265.65)	($3,518.58)	($3,780.44)	($3,558.47)	($3,629.45)	($3,701.90)	($3,775.86)	($3,851.35)
Income Tax Credits		$46,110.00														
Tax Benefit / (Expense)		$68,167.17	$6,860.50	$3,134.05	$817.90	$597.68	($1,184.96)	($3,021.35)	($3,265.65)	($3,518.58)	($3,780.44)	($3,558.47)	($3,629.45)	($3,701.90)	($3,775.86)	($3,851.35)
CAPEX	($153,700)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Free Cash Flow	**($153,700)**	**$78,000**	**$16,852**	**$13,286**	**$11,135**	**$10,699**	**$9,473**	**$7,812**	**$7,748**	**$7,678**	**$7,220**	**$6,609**	**$6,740**	**$6,875**	**$7,012**	**$6,768**
NPV	$51,119.98															
IRR	**10%**															
Total Savings		$2,100	$2,142	$2,184	$2,228	$2,272	$2,317	$2,363	$2,410	$2,458	$2,507	$2,557	$2,608	$2,660	$2,712	$2,766

Year	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Production (kWh)	64,935	64,611	64,288	63,966	63,646	63,328	63,012	62,696	62,383	62,071	61,761	61,452	61,145	60,839	60,535
Merchant Rate ($/kWh)	$0.19	$0.19	$0.20	$0.20	$0.21	$0.21	$0.22	$0.22	$0.23	$0.24	$0.24	$0.25	$0.25	$0.26	$0.27
Merchant Cost	$12,226	$12,469	$12,717	$12,970	$13,227	$13,490	$13,758	$14,032	$14,311	$14,595	$14,885	$15,181	$15,483	$15,790	$16,104
PPA Rate ($/kWh)	$0.14	$0.15	$0.15	$0.16	$0.16	$0.16	$0.17	$0.17	$0.18	$0.18	$0.19	$0.19	$0.19	$0.20	$0.20
PPA Revenue	**$9,405**	**$9,591**	**$9,782**	**$9,977**	**$10,175**	**$10,377**	**$10,583**	**$10,794**	**$11,008**	**$11,227**	**$11,450**	**$11,678**	**$11,910**	**$12,146**	**$12,388**
Gross Savings	$2,821	$2,877	$2,935	$2,993	$3,052	$3,113	$3,175	$3,238	$3,302	$3,368	$3,435	$3,503	$3,573	$3,644	$3,716
SREC Revenue (NYSERDA Tier 1 REC)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Revenue	**9,404.58**	**9,591.50**	**9,782.13**	**9,976.55**	**10,174.83**	**10,377.06**	**10,583.30**	**10,793.64**	**11,008.17**	**11,226.95**	**11,450.09**	**11,677.66**	**11,909.75**	**12,146.46**	**12,387.87**
O&M Expenses	($1,512)	($1,550)	($1,589)	($1,628)	($1,669)	($1,711)	($1,753)	($1,797)	($1,842)	($1,888)	($1,936)	($1,984)	($2,034)	($2,084)	($2,136)
Insurance Expense	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense	**($1,819)**	**($1,857)**	**($1,896)**	**($1,936)**	**($1,976)**	**($2,018)**	**($2,061)**	**($2,105)**	**($2,150)**	**($2,196)**	**($2,243)**	**($2,291)**	**($2,341)**	**($2,392)**	**($2,444)**
EBITDA	**$11,224**	**$11,449**	**$11,678**	**$11,912**	**$12,151**	**$12,395**	**$12,644**	**$12,898**	**$13,158**	**$13,423**	**$13,693**	**$13,969**	**$14,251**	**$14,538**	**$14,832**
Depreciation %															
Depreciation ($)															
Net Operating Income	$11,224.00	$11,448.72	$11,678.10	$11,912.23	$12,151.22	$12,395.17	$12,644.18	$12,898.36	$13,157.82	$13,422.66	$13,693.01	$13,968.97	$14,250.66	$14,538.20	$14,831.72
Interest Expense	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Earnings Before Taxes	$11,224.00	$11,448.72	$11,678.10	$11,912.23	$12,151.22	$12,395.17	$12,644.18	$12,898.36	$13,157.82	$13,422.66	$13,693.01	$13,968.97	$14,250.66	$14,538.20	$14,831.72
Income Tax Expense	($3,928.40)	($4,007.05)	($4,087.33)	($4,169.28)	($4,252.93)	($4,338.31)	($4,425.46)	($4,514.43)	($4,605.24)	($4,697.93)	($4,792.55)	($4,889.14)	($4,987.73)	($5,088.37)	($5,191.10)
Income Tax Credits															
Tax Benefit / (Expense)	($3,928.40)	($4,007.05)	($4,087.33)	($4,169.28)	($4,252.93)	($4,338.31)	($4,425.46)	($4,514.43)	($4,605.24)	($4,697.93)	($4,792.55)	($4,889.14)	($4,987.73)	($5,088.37)	($5,191.10)
CAPEX	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Free Cash Flow	**$7,296**	**$7,442**	**$7,591**	**$7,743**	**$7,514**	**$8,057**	**$8,219**	**$8,384**	**$8,553**	**$8,340**	**$8,900**	**$9,080**	**$9,263**	**$9,450**	**$9,256**
Total Savings	$2,821	$2,877	$2,935	$2,993	$3,052	$3,113	$3,175	$3,238	$3,302	$3,368	$3,435	$3,503	$3,573	$3,644	$3,716

Debt Assumptions	
Leverage %	80%
Principal Amount	$122,960.00
Interest Rate	4%
Term (years)	10

Debt Payment Structure:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Principal Payment		($10,241.45)	($10,651.11)	($11,077.16)	($11,520.24)	($11,981.05)	($12,460.30)	($12,958.71)	($13,477.06)	($14,016.14)	($14,576.78)
Interest Payment		($4,918.40)	($4,508.74)	($4,082.70)	($3,639.61)	($3,178.80)	($2,699.56)	($2,201.15)	($1,682.80)	($1,143.72)	($583.07)
Debt Service		($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)	($15,159.85)

Arrangement #4: Partnership Flip.

System Assumptions	
Capacity (kW)	58
Insolation (kWh/kW)	1207
Initial Production (kWh)	70,006
Degradation	0.5%
Cost Assumptions	
CAPEX ($/W)	$2.65
CAPEX	$153,700.00
Rate Assumptions	
PPA Rate ($/kWh)	$0.10
PPA Escalation	2.5%
Merchant Rate	$0.13
Merchant Rate Escalation	2.5%
Opex Assumptions	
O&M ($/kw)	$18.00
Initial O&M	$1,044
O&M Escalation	2.5%
Insurance (% of CAPEX)	0.2%
Initial Insurance	$307
Insurance Escalation	0%
REC/SREC Valuation	
NYSERDA Tier 1 REC ($/MWh)	$21.16
Duration (years)	10
Compared to ACP value	$23.28
Tax Rate	35%
Discount Rate (WACC)	5%
ITC & Depreciation	
ITC	$46,110.00
Depreciable Basis	130,645
Year 1	52.0%
Year 2	19.2%
Year 3	11.5%
Year 4	6.9%
Year 5	6.9%
Year 6	3.5%

Year	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Production (kWh)		70,006	69,656	69,308	68,961	68,616	68,273	67,932	67,592	67,254	66,918	66,583	66,250	65,919	65,590	65,262
Energy Rate		$0.10	$0.10	$0.11	$0.11	$0.11	$0.11	$0.12	$0.12	$0.12	$0.12	$0.13	$0.13	$0.13	$0.14	$0.14
SREC Rate (NYSERDA Tier 1 REC)		$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160	$0.021160					
Energy Revenue		$7,001	$7,140	$7,282	$7,426	$7,574	$7,724	$7,878	$8,035	$8,194	$8,357	$8,523	$8,693	$8,865	$9,042	$9,221
SREC Revenue		$1,481	$1,474	$1,467	$1,459	$1,452	$1,445	$1,437	$1,430	$1,423	$1,416	$0	$0	$0	$0	$0
Total Revenue		$8,482	$8,614	$8,748	$8,886	$9,026	$9,169	$9,315	$9,465	$9,617	$9,773	$8,523	$8,693	$8,865	$9,042	$9,221
O&M Expenses		($1,044)	($1,070)	($1,097)	($1,124)	($1,152)	($1,181)	($1,211)	($1,241)	($1,272)	($1,304)	($1,336)	($1,370)	($1,404)	($1,439)	($1,475)
Insurance Expense		($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense		($1,351)	($1,378)	($1,404)	($1,432)	($1,460)	($1,489)	($1,518)	($1,548)	($1,579)	($1,611)	($1,644)	($1,677)	($1,711)	($1,747)	($1,783)
EBITDA		$7,131	$7,236	$7,344	$7,454	$7,566	$7,681	$7,797	$7,916	$8,038	$8,162	$6,879	$7,015	$7,154	$7,295	$7,439
Depreciation %		$0.52	$0.19	$0.12	$0.07	$0.07	$0.04									
Depreciation ($)		($67,935.40)	($25,083.84)	($15,024.18)	($9,014.51)	($9,014.51)	($4,572.58)									
Net Operating Income		($60,804.87)	($17,847.68)	($7,680.24)	($1,560.60)	($1,448.40)	$3,107.99	$7,797.34	$7,916.46	$8,037.97	$8,161.91	$6,879.43	$7,015.42	$7,153.94	$7,295.04	$7,438.76
Earnings Before Taxes		($60,804.87)	($17,847.68)	($7,680.24)	($1,560.60)	($1,448.40)	$3,107.99	$7,797.34	$7,916.46	$8,037.97	$8,161.91	$6,879.43	$7,015.42	$7,153.94	$7,295.04	$7,438.76
Income Tax Expense		$21,281.71	$6,246.69	$2,688.08	$546.21	$506.94	($1,087.80)	($2,729.07)	($2,770.76)	($2,813.29)	($2,856.67)	($2,407.80)	($2,455.40)	($2,503.88)	($2,553.26)	($2,603.57)
Income Tax Credits		$46,110.00														
Tax Benefit / (Expense)		$67,391.71	$6,246.69	$2,688.08	$546.21	$506.94	($1,087.80)	($2,729.07)	($2,770.76)	($2,813.29)	($2,856.67)	($2,407.80)	($2,455.40)	($2,503.88)	($2,553.26)	($2,603.57)
CAPEX	($153,700)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Free Cash Flow	($153,700)	$74,522	$13,483	$10,032	$8,000	$7,689	$6,593	$5,068	$5,146	$5,225	$4,921	$4,472	$4,560	$4,650	$4,742	$4,451

Year	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Production (kWh)	64,935	64,611	64,288	63,966	63,646	63,328	63,012	62,696	62,383	62,071	61,761	61,452	61,145	60,839	60,535
Energy Rate	$0.14	$0.15	$0.15	$0.16	$0.16	$0.16	$0.17	$0.17	$0.18	$0.18	$0.19	$0.19	$0.19	$0.20	$0.20
SREC Rate (NYSERDA Tier 1 REC)															
Energy Revenue	$9,405	$9,591	$9,782	$9,977	$10,175	$10,377	$10,583	$10,794	$11,008	$11,227	$11,450	$11,678	$11,910	$12,146	$12,388
SREC Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Revenue	$9,405	$9,591	$9,782	$9,977	$10,175	$10,377	$10,583	$10,794	$11,008	$11,227	$11,450	$11,678	$11,910	$12,146	$12,388
O&M Expenses	($1,512)	($1,550)	($1,589)	($1,628)	($1,669)	($1,711)	($1,753)	($1,797)	($1,842)	($1,888)	($1,936)	($1,984)	($2,034)	($2,084)	($2,136)
Insurance Expense	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)	($307)
Total Expense	($1,819)	($1,857)	($1,896)	($1,936)	($1,976)	($2,018)	($2,061)	($2,105)	($2,150)	($2,196)	($2,243)	($2,291)	($2,341)	($2,392)	($2,444)
EBITDA	$7,585	$7,734	$7,886	$8,041	$8,198	$8,359	$8,522	$8,689	$8,859	$9,031	$9,207	$9,386	$9,569	$9,755	$9,944
Depreciation %															
Depreciation ($)															
Net Operating Income	$7,585.16	$7,734.27	$7,886.16	$8,040.86	$8,198.44	$8,358.94	$8,522.42	$8,688.92	$8,858.51	$9,031.24	$9,207.17	$9,386.36	$9,568.85	$9,754.72	$9,944.02
Earnings Before Taxes	$7,585.16	$7,734.27	$7,886.16	$8,040.86	$8,198.44	$8,358.94	$8,522.42	$8,688.92	$8,858.51	$9,031.24	$9,207.17	$9,386.36	$9,568.85	$9,754.72	$9,944.02
Income Tax Expense	($2,654.81)	($2,707.00)	($2,760.16)	($2,814.30)	($2,869.45)	($2,925.63)	($2,982.85)	($3,041.12)	($3,100.48)	($3,160.94)	($3,222.51)	($3,285.22)	($3,349.10)	($3,414.15)	($3,480.41)
Income Tax Credits															
Tax Benefit / (Expense)	($2,654.81)	($2,707.00)	($2,760.16)	($2,814.30)	($2,869.45)	($2,925.63)	($2,982.85)	($3,041.12)	($3,100.48)	($3,160.94)	($3,222.51)	($3,285.22)	($3,349.10)	($3,414.15)	($3,480.41)
CAPEX	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)	$0	$0	$0	$0	($384)
Free Cash Flow	$4,930	$5,027	$5,126	$5,227	$4,945	$5,433	$5,540	$5,648	$5,758	$5,486	$5,985	$6,101	$6,220	$6,341	$6,079

IRR	6%
NPV	$8,776.96

Tax Benefits	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
ITC	$46,110														
Benefits of Depreciation	$23,777	$8,779	$5,258	$3,155	$3,155	$1,600	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Tax Benefits	$69,887	$8,779	$5,258	$3,155	$3,155	$1,600	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cash Benefits	$4,635	$4,704	$4,774	$4,845	$4,534	$4,992	$5,068	$5,146	$5,225	$4,921	$4,472	$4,560	$4,650	$4,742	$4,451

Tax Benefits	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
ITC															
Benefits of Depreciation	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Tax Benefits	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cash Benefits	$4,930	$5,027	$5,126	$5,227	$4,945	$5,433	$5,540	$5,648	$5,758	$5,486	$5,985	$6,101	$6,220	$6,341	$6,079

Pre Flip

Debt Assumptions	
Leverage %	80%
Principal Amount	$122,960.00
Interest Rate	4%
Term (years)	10

99 %	Tax Equity		$73,777	$13,348	$9,932	$7,920	$7,612	$6,527																								
1%	Common Equity		$745	$135	$100	$80	$77	$66																								
	Post Flip																															
5%	Tax Equity								$253	$257	$261	$246	$224	$228	$233	$237	$223	$247	$251	$256	$261	$247	$272	$277	$282	$288	$274	$299	$305	$311	$317	$304
95 %	Common Equity								$4,815	$4,888	$4,963	$4,675	$4,248	$4,332	$4,418	$4,505	$4,228	$4,684	$4,776	$4,870	$4,965	$4,697	$5,162	$5,263	$5,365	$5,470	$5,212	$5,685	$5,796	$5,909	$6,024	$5,775
	Returns to Tax Equity	($130,645)	$73,777	$13,348	$9,932	$7,920	$7,612	$6,527	$253	$257	$261	$246	$224	$228	$233	$237	$223	$247	$251	$256	$261	$247	$272	$277	$282	$288	$274	$299	$305	$311	$317	$304
	IRR	-1.3%																														
	Returns to Common Equity	($23,055)	$745	$135	$100	$80	$77	$66	$4,815	$4,888	$4,963	$4,675	$4,248	$4,332	$4,418	$4,505	$4,228	$4,684	$4,776	$4,870	$4,965	$4,697	$5,162	$5,263	$5,365	$5,470	$5,212	$5,685	$5,796	$5,909	$6,024	$5,775
	IRR	10.8%																														
	With Buyout: Return to Tax Equity	($130,645)	$73,777	$13,348	$9,932	$7,920	$7,612	$8,620																								
	IRR	-3.5%																														
	Cash Flows to Common	($23,055)	$745	$135	$100	$80	$77	$66	$5,068	$5,146	$5,225	$4,921	$4,472	$4,560	$4,650	$4,742	$4,451	$4,930	$5,027	$5,126	$5,227	$4,945	$5,433	$5,540	$5,648	$5,758	$5,486	$5,985	$6,101	$6,220	$6,341	$6,079
	Buyout Value							($3,221)																								
	Debt on Buyout							$3,221	($723)	($723)	($723)	($723)	($723)																			
	Cash Flows to Common	($23,055)	$745	$135	$100	$80	$77	$66	$4,345	$4,422	$4,501	$4,198	$3,748	$4,560	$4,650	$4,742	$4,451	$4,930	$5,027	$5,126	$5,227	$4,945	$5,433	$5,540	$5,648	$5,758	$5,486	$5,985	$6,101	$6,220	$6,341	$6,079
	IRR	10.7%																														

Endnotes

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