The Blue Dunes Report

WXY / West8 / Stevens Institute of Technology / AIR Worldwide / Arcadis / **Rebuild by Design**

“But here I’ll stay,
though this stern
strikes rocks; and
they bulge through;
and oysters come
to join me.”

Rebuild by Design, an initiative of the Hurricane Sandy Rebuilding Task Force and the U.S. Department of Housing and Urban Development (HUD), is a competition that focuses on bringing innovation in design to advance resilience in the Sandy-impacted region. Team WXY / West 8 would like to extend their gratitude to Henk Ovink and the Rebuild by Design team form orchestrating this valuable initiative. We also share our appreciation to all participants and colleagues who have offered their time and knowledge to the advancement of this process.

Thank you.

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Paul Salama
B. Tyler Silvestro
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Yeju Choi

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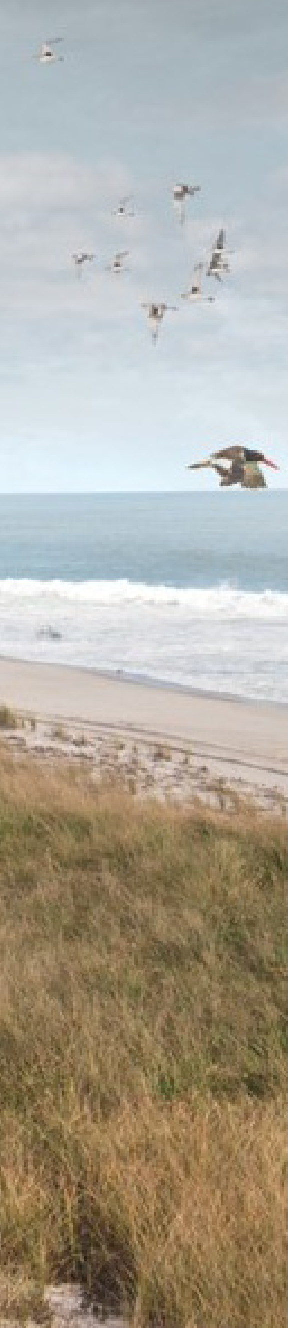
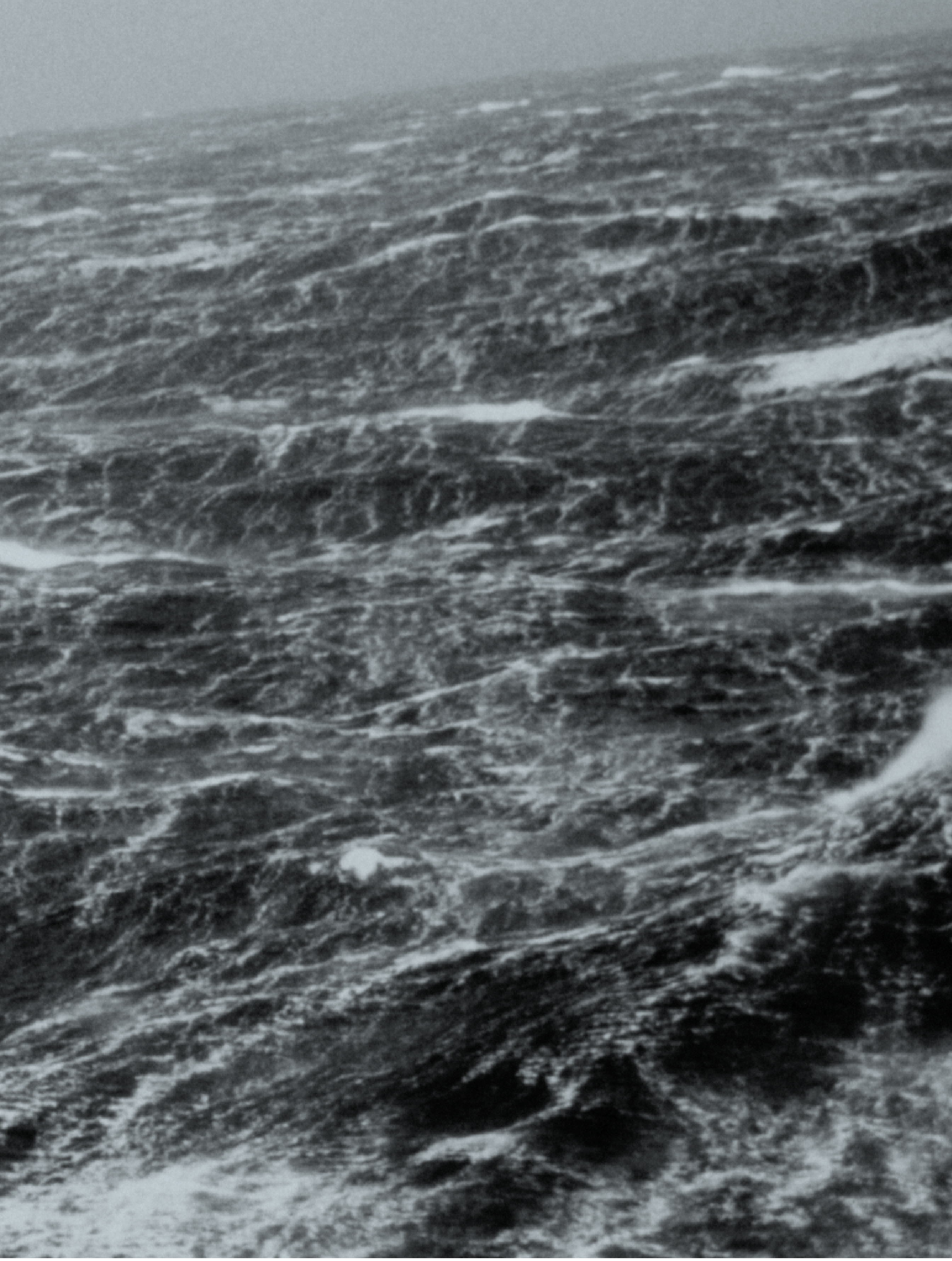
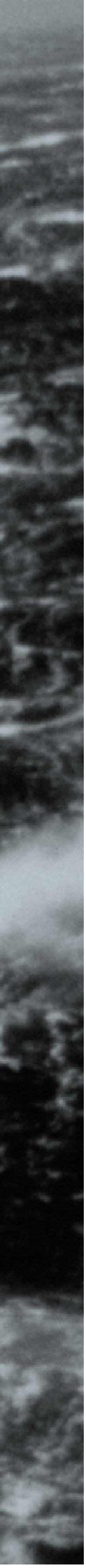
The Blue Dunes Report







I

The Blue Dune Islands

Hurricane Sandy, which hit the Eastern Seaboard in October 2012, reminded the Greater Tri-State Area that coastal storms are among the world's most costly and deadly disasters, capable of causing tens-to-hundreds of billions of dollars in damages and threatening the livelihood of entire neighborhoods. Increased damage can result from storm-driven surges, which are often the greatest threat to life and property from a coastal storm as a result of additional water being pushed along the shoreline. These damages are likely to intensify with a changing climate, as the potential for intensified storms, coupled with rising sea levels, makes storm-driven surges an even greater threat to the region. While atmospheric scientists cannot predict when large storm events will strike or with what force, there is a great likelihood that another major storm event, weather a hurricane or nor'easter, will hit the Mid-Atlantic Coast. There is a 1% chance each year of that major event; now is the time to get better prepared.

While we can't predict when the next storm will come or what it will look like, we are learning about how oceans behave.

The forces shaping our coastline are driven by the energy from the atmosphere and the ocean. Coastal processes are controlled by wind, waves, ocean currents, and the highly predictable tides that move water and sediment day in and day out. The processes are responsible for the landscape changes we see along our coastlines. Dunes, for example, are a result of the movement of sediments that reflect these processes. Theories and models, both conceptual and mathematical, have been developed by scientists to explain how ocean currents and waves create and destroy dunes and create interrelationships between these dynamics, geomorphology, and habitats. Similar models have been developed by the financial industry to predict damages from a range of natural disasters.

"The ocean, our coasts, and the Great Lakes provide jobs, food, energy resources, ecological services, recreation, and tourism opportunities, and play critical roles in our Nation's transportation, economy, and trade, as well as the global mobility of our Armed Forces and the maintenance of international peace and security."

—President Barack Obama

In June 2013, President Barack Obama announced the national competition, Rebuild by Design. The team of WXY/West8 (Team) decided to respond with a new, yet proven approach to coastal protection—offshore islands. The Team collaborated with scientists, engineers and financial analysts capable of developing the models needed to design and verify a worthy system.

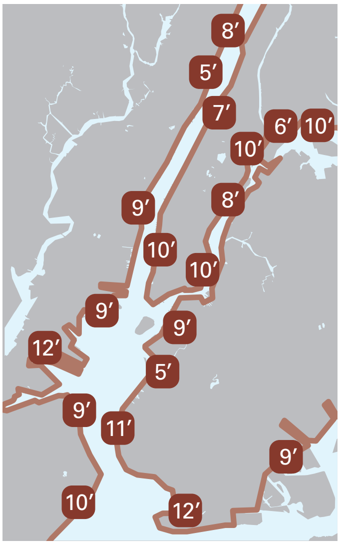
At the beginning of the design process the Team asked, "If we had planned and designed our shorelines with coastal processes in mind, what

could we have done in lieu of constructing walls and berms, or investing in gates to every harbor, to prevent the damage and upheaval caused when Sandy hit?” The Team hypothesized that there could be a way to deflect to storm driven tides with a set of barrier islands ten miles out in the coastal waters. When the financial and

hydrodynamic models were examined, it was clear that there was significant potential for a barrier islands system to save lives and billions of dollars across the region. Additionally, by decreasing the height of storm surge, this system would permit lower, softer, and less disruptive landside storm protections. The resulting proposal to create an offshore barrier island chain centered on the New York Bight is called "The Blue Dunes"—blue indicating their position in the open ocean and

dunes for the natural landforms they mimic. Today the proposal stands at a crossroads. We have investigated a new form of designed coastal protection that would, on a large scale, mitigate risk for life, economy and property within coastal zones. However, much work needs to be done. The scientists, economists and maritime stakeholders that have participated to date in our analyses have identified many of the key issues that need to be addressed, including: water quality, habitats, recreation, navigation, constructability, potential supplemental surge reduction with offshore wind farms, and funding.

Working offshore needs to be considered as it can make more sense than relying exclusively building on land. Due to enormous projected beneficial impacts—the project has the ability to reduce regional damage estimates by tens of billions of dollars from the hundreds of billions of projected damage for future 100-year storms—the offshore physical protection efforts need to be considered as a way to manage catastrophic risk. The project will impact and reinforce benefits of individual property level coastal resiliency measures being considered by other teams in this design contest, but it will also benefit areas more vulnerable to surge due to lack of existing and/or planned



Inflexible Solutions: Severed ecologies cause loss of upland habitat migration and human detachment from the water

localized projects. The New York City coastline alone is 573 miles. Building storm protection on coastal edges alone is, in many respects, an inefficient and unreliable way to address storm surge. Moreover, seawalls of all types higher than 5'-6' negatively impact shoreline communities, public access to the waterfront, and transitional habitat zones. By 2050, these walls would need to be at least 15'-16' high.

The scale that offshore design provides complement local projects and allow, for economies of scale: complex and combined protection systems; physical coupling of on and off-shore systems; and enhanced feasibility of financial risk mitigation efforts through more affordable pricing and more efficient supply of insurance reinsurance and catastrophic bond products. As one of the key beneficiaries, insurance providers and other risk management entities would be structured as funding partners for the project. The offshore islands are physically transformative, but also allow our risk framework to work more effectively and efficiently.

There is a long history in the United States of infrastructure investments driven by national interest. In the face of the complexity of coastline development, the construction of offshore dunes, potentially coupled with offshore wind renewable energy, may be required to prevent larger scale economic losses. This approach has the ability to be an important line of defense for a wide variety of storm types. Building offshore dunes, further out in the ocean than previously considered,

results in the scale of annual savings for flood insurance that can draw on investment nationally and internationally.

Throughout Phase Three, team members have been overwhelmed by the level of support from state, local and federal officials, from private insurance industry partners, from engineering professionals, the finance industry, and very importantly, from the scientific community that studies and fosters coastal and ocean communities. Therefore the Team is proposing the creation of the Blue Dunes Research Initiative (BDRI) to further examine the feasibility of offshore islands. There still remains a critical need for deeper and more sophisticated modeling to explore how offshore dunes could provide protection from the next major hurricane. The Initiative will continue the investigation, collaboration, and communication that the Team


FISHES
RICREATIONAL
FISHERIES
MERGING
VETLANDS
BOATS
SA
MAR
FISHES
BIRDS
SEALS
NATURE ISLAN
WHA
BIRDS
FISHES
SEALS
Hudson Canyon
SALT
MARSHES
NATURE ISLAND
WHALES
1 2 4 6
1 2

has framed throughout the Rebuild by Design process, as well as collaboration and input from communities and organizations. BDRI will be a catalyst for creating a knowledge network.

The proposed multidisciplinary initiative will span five years and become a planning and technology resource for the coastal communities of the Mid-Atlantic. BDRI will develop The Blue Dunes and, in doing so, launch the next generation of science, engineering, and technology that enables us to adapt and respond to the certainty of an uncertain future.


New York
New York City
restoring
Jamaica Bay
emerging wetlands
Lower Bay
Recreational
fisheries
Great South
emerging w
Longshore drift
Windfarm
Hudson Canyon
New Jersey
elphia
Barnegat Bay
Longshore drift
Hudson Canyon


Rhode Island Sou
Block Island Sound
Long Island Sound
Gardiners Bay
Tobaccolot Bay
Peconic Bay
Rhode Island Shelf Valley
wetlands

Appendix A

Collaborative Process

A.1
Participatory Design Process

One of the primary challenges facing the team is the identification of a stakeholder coalition at a regional scale. The key to a participatory design process is the ability to engage your community, and to garner as much input and dialogue from them in order to design effectively and with confidence and for the public good. Without a system set up to deal with regional issues across town, county and state lines, the team focused heavily on the expertise of scientists and economists whose research and work is without geopolitical bounds. A regional strategy requires regional thinking, so the team set out to share this approach through a series of organized colloquia, public lectures and private meetings to steer the design process.

Team WXY/West 8 held it first outreach meeting, a scientific colloquia entitled, "Science Colloquia—Offshore Landscapes in the Mid-Atlantic." Working with team member, Dr. Alan Blumberg, from the Stevens Institute of Technology, the team orchestrated a list of science and engineering experts to give presentations on research relevant to the project. Dr. James O'Donnell of the University of Connecticut discussed storm surge in the Long Island Sound, the role of the East River on dissolved oxygen and salinity exchange, and the stratification cycles of the Long Island Sound. Dr. Robert Chant of Rutgers University spoke of the role of tides and waves on the Hudson River. The Hudson River plume is effectively flushed of its salt levels by river discharge and tidal ranges. Lowering the river discharge would essentially result in deeper salt penetration north in the Hudson River. Dr. Thomas Herrington of Stevens Institute of Technology described the origin of waves in the NY Bight, the typology of regional sediments and sediment transport systems, further enhancing the team's understanding of offshore materiality and the dynamic systems at play.

Dr. Cristina Archer of the University of Delaware gave a talk on wind energy and the potential storm energy dissipation that result with large scale wind-farms. Dr. Olaf Jensen, Rutgers University, spoke of the fisheries and aquatic systems at the regional scale, sensitive ecosystems with massive economic impacts on the coasts of New York and New Jersey. Dr. Klaus Jacob moderated a final discussion looking at the big picture. He challenged all of the Rebuild by Design teams to think about resilience on a much larger scale, and to consider sea-level rise. The ecological concerns addressed throughout the day have been recorded and transcribed and will fold into the considerations for the team's proposal. The scientific community challenged the team's thinking and shaped the direction of the proposed configuration of barrier islands.

The scientific community represented a large swath of regional issues including; hydrodynamics, levels of salinity, coastal fishing economies, energy and wind dissipation of storms, and basic wave physics. The conversation was able to transcend the bounds of political jurisdictions, and speak to the regional issues that are at play in the Mid-Atlantic coastal systems that affect the proposal. Small breakout groups further fostered facilitation of the participatory design process, where attendees were encouraged to speak to their expertise, and share their knowledge through informal discussion.

Aside from demonstrating the ecological participatory design process, the project also has to be addressed by the financial community. Therefore, a second colloquium was held, Risk Economy, which prompted guests to think about the alternative benefits and potential financial feasibility of Blue Dunes. The agenda for the day was for team partners to present the risk modeling data and potential methods of funding to obtain feedback from a robust group of thinkers from leading industries in the purview of regional strategies; insurance, reinsurance, catastrophic bonding, risk modelers, real estate developers, economists, and academic researchers. The coalition of participants engaged heavily on the topics of governance, financing, and legal permitting, all key concepts that drive the process for Team WXY / West 8. The entire event was recorded and transcribed, and the notes of the meeting will fold into the design process and the formation of a coalition.

Team WXY / West 8 continues to engage in the public dialogue about regional resiliency. Team member Alan Blumberg has addressed people in a wide variety of navigational roles in the New York and New Jersey arenas, touting the necessity of large-scale barrier islands for the future and benefit of our coastal communities. Claire Weisz has lectured on numerous occasions on the importance of Rebuild by Design, coastal resiliency, and other issues surrounding the project.

The team is also focused on sharing their findings with state and federal officials who represent various jurisdictions in the Mid-Atlantic coastal region. Team WXY / West 8 has found support from a variety of potential stakeholders and participants who have shared their valuable knowledge and opinions with the team. Also, Team WXY / West 8 has gained the support of Senator Charles Schumer of the State of New York to apply for research funding to continue studying the feasibility of the proposal.

Throughout Phase 3, team members have been overwhelmed by the level of support from state, local and federal officials, from private insurance industry partners, from engineering professionals, the finance industry, and very importantly the scientific community that studies and fosters coastal and ocean communities. The attached engineering design memo provides details regarding the feasibility of the proposal. The high-level value analysis shows the potential damage reduction and new activity benefits of the projects. And finally the presentations of the stakeholders at the science colloquia illustrate the complex, but supportive responses, received thus far from the scientific community. The cost benefit analysis completed to date is partial due to the need to conduct further research into the potential benefits of the project. A highly tailored cost benefit framework is in the process of being constructed for the project due to the large scale, diverse, and multiple stakeholder (public, private, net new economic) framework of the projected benefits. However, even with the partial estimated benefits, the project holds enormous potential to have a net positive impact.

Dr. Alan Blumberg delivers project overview to speakers and participants of NYHOPS steering committee.

Kate John Alder leads a breakout session at Science Colloquium

Dr. Robert Chant presents research on tidal systems in the Hudson River

Dale Morris of the Netherlands Embassy talks about the role of large-scale planning

Dr. Klaus Jacob makes the closing statements at Science Colloquium.

William Morrish discusses the role of marine spatial planning at Science Colloquium.

Claire Weisz presents WXY architecture + urban design projects focused on resiliency.

Tyler Silvestro discusses Rebuild by Design with architecture students from the Oslo School of Architecture and Design, AHO.

“I think that is a huge industrial mission that’s on par with the space program. that this in many ways is the next space program specific to the oceans and I think that’s a huge challenge for everyone and one that certainly can benefit long-term.”

Jesse Keenan, Center for Urban Real Estate

“The predictability of making a shared system by which to measure risk accessible to everyone, that this will ultimately strengthen networks and strengthen social sustainability throughout the region.”

Claire Weisz

“To me, the ocean is the new frontier, there are so many things we don’t know about the ocean. We need to study in great detail, the waves, storm surges, and changes in salinity and temperature especially as climate change comes into place. It is the new frontier and we need to marshall students, faculty, and all of our resources to address it.”

Dr. Alan Blumberg

“The big shore expands our capacity to cohabitate with the coastal plain and the ocean that has shaped our past, and will underpin our capacity to live in the future.”

William Morrish

“What’s being proposed is the need for important physical infrastructure interventions and looking at how those mitigation costs can be offset by savings.”
Ron Shiffman, Pratt Institute

“It really is the entire galaxy of panoply of issues raised… the answers are not as easily fashioned as the questions posed…”

David Paget, Sive, Paget, & Reisel, P.C.

“Opportunities to create new value… how can we create new economic opportunities and new economic value…”

Niek Veraart, Louis Berger Group

“If you built higher in neighborhoods, it would have a greater physcological impact locally... But if you couple that will offshore strategies, the local measures don’t have to be built so high.”

Dr. John Seo

A.2
Science Colloquium Attendees

Brookfield Properties
250 Vesey St.

Rebuild by Design, January 27, 2014

Kjirsten Alexander
Senior Research Associate
Structures of Coastal Resilience

Alec Appelbaum
Writer
The Next City

Cristina L. Archer
Professor
University of Delaware

Genevieve Boehm-Clifton
Manager
NJDOT Office of Maritime Resources

Michael Bruno
Dean, School of Engineering
Stevens Institute of Technology

Robert Chant
Professor
Rutgers University

Amy Chester
Project Manager
Rebuild by Design

Eric R. Daleo
Special Advisor
NJ Governor's Office

Kate Dineen
Special Advisor
NY Rising Communities

Kevin Farley
Professor
Manhattan College

Joanna Field
Biologist
NYS Department of Environmental Conservation

Peter B. Fleischer
Executive Director
Empire State Future

Peter Glus
Vice President
ARCADIS

William Golden
Executive Director
National Institute for Coastal & Harbor Infrastructure

Carrie Grassi
Senior Policy Advisor
NYC Office of the Mayor

Tom Grothues
Professor
Rutgers University

Roselle Henn
Environmental Services
Army Corps of Engineers

Tom Herrington
Director of Research
Stevens Institute of Technology

Richard Isleib
Project Manager General
HDR/HydroQual

Klaus Jacob
Professor
Columbia University

Olaf Jensen
Scientist
Rutgers University

Henry John-Alder
Chair of Ecology Department
Rutgers University

Edward Kelly
Maritime Association of the Port of NY+NJ

Sandra Knight
President
WaterWonks LLC

Captain Gordon Loebl
Commander
Captain of the Port of NY & NJ

Michael Marrella
Director of Waterfront and Open Space
Department of City Planning

Suketu Mehta
Associate Professor
New York University

David Maddox
Founder & Editor
The Nature of Cities

Jon Miller
Scientist
Stevens Institute of Technology

David A. Morris
Special Advisor
NJ Governor's Office

William Morrish
Professor
Parsons The New School

Guy Nordenson
Princeton University

Jim O'Donnell
University of Connecticut

Henk Ovink
Senior Advisor to the Secretary
US Department of Housing and Urban Development

Rob Pirani
Vice President for Environmental and Energy Programs
Regional Planning Association

Enrique Ramirez
Research Assistant
Structures of Coastal Resilience

Denise Reed
Chief Scientist
The Water Institute of the Gulf

Cynthia Rosenzweig
NASA

Mary Rowe
Vice President
Municipal Arts Society

Vincent Saba
Research Fishery Biologist
NOAA

Alexis Taylor
Project Manager
Municipal Arts Society

Laura Tolkoff
Associate Planner
Regional Planning Association

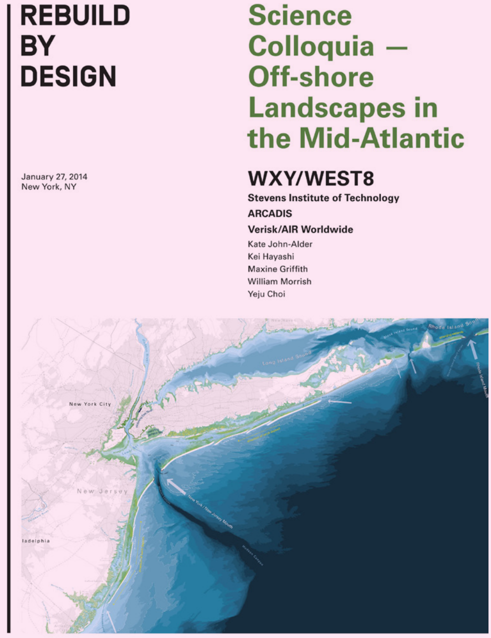
Sergey Vinogradov
Research Scientist
Stevens Institute of Technology, Team WXY/West 8

Alex Washburn
Stevens Institute of Technology

Edgar Westerhof
Senior Planner
ARCADIS

Bob Yaro
President
Regional Planning Association

Dan Zarrilli
Director of Resilience
NYC Office of the Mayor



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Executive Vice President Government & Community Affairs
Columbia University

Kei Hayashi
Founder
BHJ Advisors Team

Daniel Hitchings
Vice President
ARCADIS

Kate John-Alder
Professor
Rutgers University
Team WXY/West 8

Adam Lubinsky
Principal
WXY architecture + urban design

Lauren Micir
Landscape Designer
West 8

Paul Salama
Urban Planner
WXY architecture + urban design

B. Tyler Silvestro
Urban Designer
WXY architecture + urban design

Sergey Vinogradov
Research Scientist
Stevens Institute of Technology

Claire Weisz
Principal
WXY architecture + urban design

A.3
Risk Economy Colloquium Attendees

Institute for Public Knowledge
20 Cooper Square, 5th Floor, NY

Rebuild by Design, March 13, 2014

Ana Baptista
Professor of Environmental Management and Sustainability
The New School

Arjan Braamskamp
UN Procurement Liaison Officer
Netherlands Consulate General New York

Sam Carter
Associate Director for Resilience
Rockefeller Foundation

Jennifer Coghlan
Principal
Sive, Paget, & Riesel, P.C.

Curtis Cravens
Senior Program Manager
Coastal Protection, NYC Mayors Office of Sustainability

Scott Davis
Director
Office of Community Planning and Development, HUD

Michael B. Francois
Chief Real Estate & Development Port Authority of NY NJ

Adam Friedman
Director
Pratt Center for Community Development

Wendi Goldsmith
CEO and Founder
Bioengineering Group

William H. Hanson
Vice President and Manager
U.S. Department for the Great Lakes Dredge & Dock

Klaus Jacob
Adjunct Professor of International and Public Affairs
Columbia University

Jesse Keenan
Research Director
The Center for Urban Real Estate (CURE), Columbia University

Justine Shapiro-Kline
Teaching & Research Assistant
Columbia University

David J. Leach
Director of Programs
North Atlantic Division, USACE

Alice LeBlanc
Director
Environmental and Economic Consulting
Karbone

Georgia Levenson Keohane
Fellow
Roosevelt Institute

Megan Linkin
Atmospheric Perils Specialist
Swiss Re

Paimaan Lodhi
Vice President of Urban Planning
Real Estate Board of New York (REBNY)

Rashid Malik
Program Manager
NY-NJ Harbor Coalition at Metropolitan Waterfront Alliance

Michael Marella
Director of Waterfront and Open Space Planning
NYC Department of City Planning

Nicholas Martin
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Bobby McKinstry
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Tim Mealey
Founder and Senior Partner
Meridian Institute

Lisa Miller
CEO
Lisa Miller Associates

Dale T. Morris
Senior Economist
Royal Netherlands Embassy, Washington DC

David A. Morris
Special Advisor
New Jersey Governor's Office of Recovery and Rebuilding

Dianna Nelson
Assistant Vice President, Atmospheric Specialist
Swiss Re

Juan Camillo Osorio
Director of Research
NYCEJA

David Paget
Principal
Sive, Paget & Riesel, P.C.

Ron Shiffman
Professor
Programs for Sustainable Planning and Development, Pratt Institute

David Rosenblatt
Administrator Office of Engineering & Construction
NJ DEP

Jamie Springer
Partner
HR&A

Chris Tepper
Director of Development and Capital Markets
Jamestown Properties

Niek Veraart
Vice President
Louis Berger Group

John Vickerman
Vickerman & Associates LLC

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Senior Vice President, Head Sustainable Development Americas Hub
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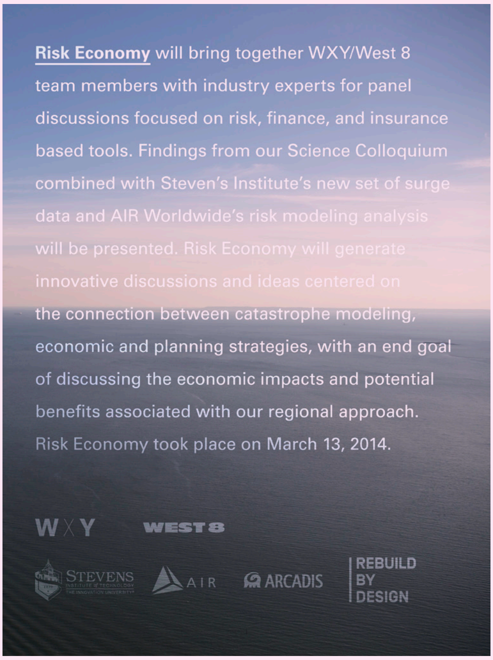
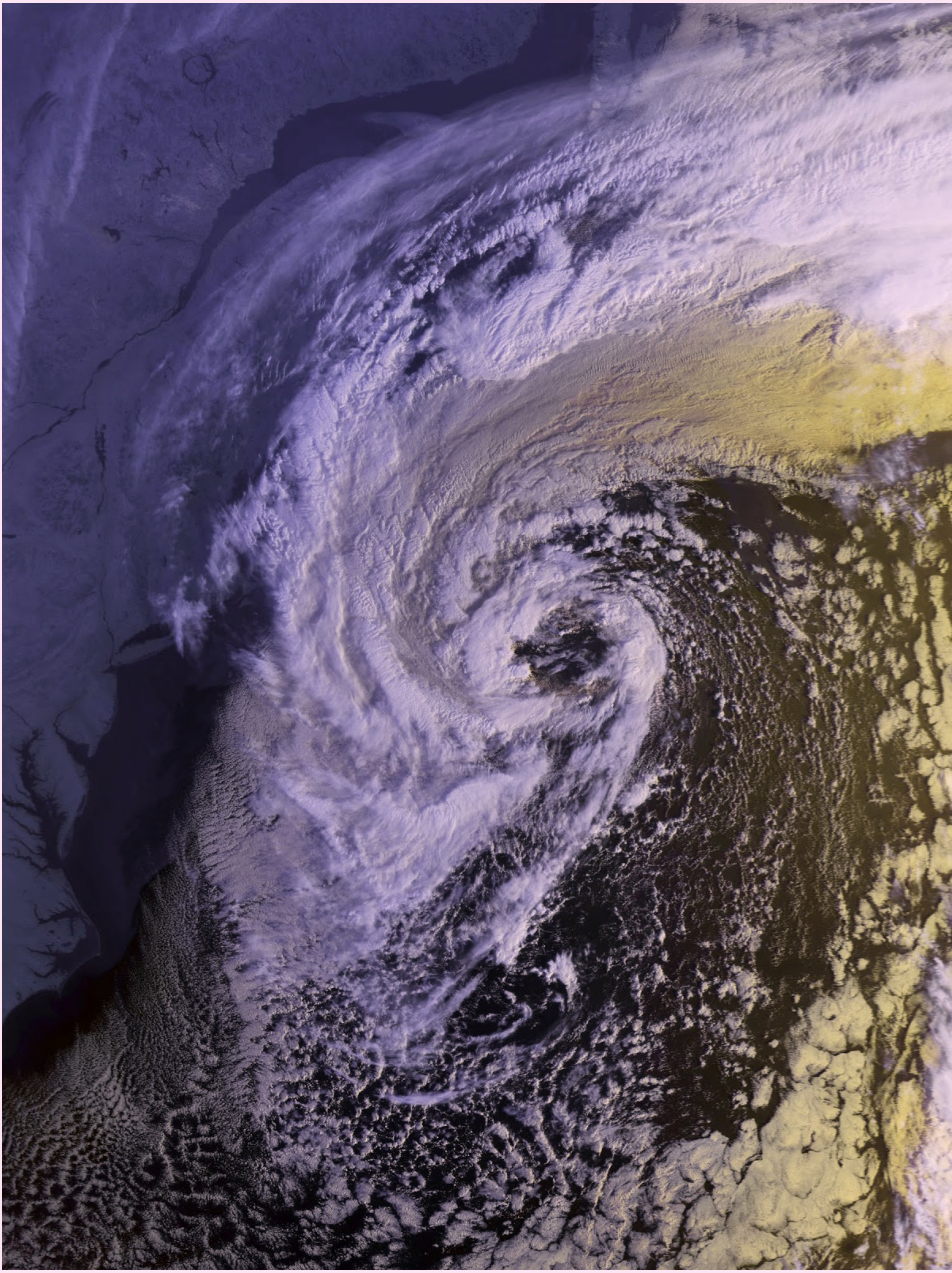




Appendix B

Scientific Research

B.1
Computational Modelling

B.1.0
Objective

Given the technology of today and what is likely to come in the future, it is hypothesized that a set of offshore landscapes (barrier islands) in the coastal waters of the mid Atlantic region could be constructed that would lower storm surges and therefore save lives, reduce damage, and safeguard the environment. To test this hypothesis, a series of hydrodynamic simulations were begun to look at new landscapes without the use of closures or surge gates by using historical storm data in a storm-surge flood. The following describes the first part of the search for the most effective landscapes.

Stevens Institute of Technology

Stevens Institute of Technology, The Innovation University®, is a premier, private research university situated in Hoboken, N.J. overlooking the Manhattan skyline. Founded in 1870, technological innovation has been the hallmark and legacy of Stevens' education and research programs for more than 140 years.

The Davidson Laboratory is Stevens Institute of Technology's renowned marine research laboratory. The Laboratory operates in two primary areas: marine monitoring and forecasting and experimental marine hydrodynamics (ship design and evaluation).

The Davidson Laboratory created and maintains the New York Harbor Observing and Prediction System (NYHOPS), a vital forecasting resource for emergency preparedness in the metro New York City area and coastal New Jersey. In October 2012, the Laboratory's Hurricane Sandy predictions proved accurate and vital, attracting the attention of CNN, The Weather Channel and other national media. Davidson Lab experts also create innovative infrastructure and coastline rebuilding solutions and assess the effectiveness of municipal shore protection initiatives, beach erosion mitigation plans and zoning laws to prepare for future natural disasters.

Experimental Marine Hydrodynamics

For more than 80 years the Davidson Laboratory has conducted physical experiments on marine craft and marine and coastal structures to determine how they interact with their environment. The Laboratory was at the forefront of the combination of numerical and computational experimentation, and Stevens remains at the forefront of expertise and excellence in physical and numerical hydrodynamic modeling. The Lab's unique facilities and special expertise are utilized daily by marine, aerospace and defense industry leaders, federal and municipal agencies, and a host of private and academic research groups both within and outside Stevens.

Experiments at Stevens began in May 1931. A professor of mechanical engineering with a passion for sailing, Kenneth S.M. Davidson, would use the Stevens swimming pool to study scale models of ships. At the time, there were only two tow tank facilities available in the entire U.S. where scale models of maritime vessels could be evaluated.

Today, the laboratory also works closely with the Department of Homeland Security and the National Oceanic and Atmospheric Administration (NOAA) on projects including sophisticated modeling and forecasting of wind, tide, current and wave conditions to better assist preparation for and response to storms, floods, accidents, and other emergencies on water.

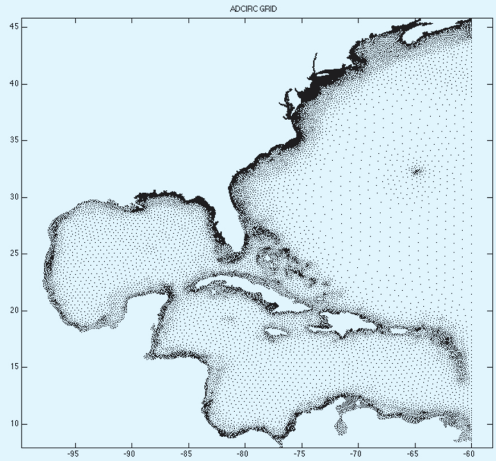
B.1.1
Modeling Approach

Steven's Institute uses the FEMA modeling setup for the New York Bight. This consists of a vertically integrated, two dimensional, coupled modeling system based on ADCIRC (ADvanced CIRCulation model) /SWAN (Simulating Waves Nearshore). The models use an unstructured grid with 604,790 nodes over the Northwestern part of the Atlantic. Spatial resolution is enhanced in the coastal New York/New Jersey regions where the distance between nodes can be as fine as 70m. Floodplains (grid nodes on land which can be flooded) are incorporated with spatially varying bottom friction based on land use. Neither rainfall nor river runoff is included.

ADCIRC/SWAN Version 49 is run on the Cray system Salk at the High-Performance Computing Center (HPCC) at the College of Staten Island, City University of New York (CSI-CUNY). On average, one Hurricane Donna run takes about 4.5 hours of CPU time using 256 processors available to this study.

Acknowledgements

Data for atmospheric pressure and winds provided by OceanWeather, Inc. Model setup is taken from the FEMA/OEM Region II Project. This research was supported, in part, by a grant of computer time from the City University of New York High Performance Computing Center under NSF Grants CNS-0855217, CNS-0958379 and ACI-1126113; We are grateful to Mr. Paul Muzio for making this grant possible.



ADCIRC Grid: FEMA setup ADCIRC/SWAN domain

B.1.2 Model Setup

The three primary input files to the ADCIRC model are the Nodal Attributes File (fort.13), the Grid and Boundary Information File (fort.14), and the Model Parameter and Periodic Boundary Condition File (fort.15). The fort.13 file and the development of nodal attributes are discussed in the Region 2 Storm Surge Project Spatially Varying Land Use Parameters Report (RAMPP, 2013). The fort.14 file and the development of the ADCIRC mesh are discussed in the Region II Storm Surge Project Mesh Development Report (RAMPP, 2013).

The fort.15 file includes parameters affecting model physics and numerics. The parameters used for this study closely match those used other ongoing and previously conducted FEMA studies. The options in the fort.15 file were kept consistent for both the tidal calibration and storm validation simulations, with the exception of parameters controlling the time of tidal forcing and the use of meteorological and radiation stress forces associated with storms. Tidal forcing is applied at the open boundary by eight tidal constituents (K1, K2, M2, N2, O1, Q1, S2, and P1). All tidal forcing constituents are taken from the Eastcoast 2001 tidal database except for P1, which was not modeled in the Eastcoast 2001 model and was taken from the LeProvost tidal database. Because tides vary in time, two parameters representing this variation must be provided—the nodal factor (a multiplier) and the equilibrium argument (a phase).

For the storm simulations, wind and pressure fields developed by Oceanweather, Inc. (OWI)
were used as forcing conditions for the combined surge and wave model. As the OWI-provided winds are 30-minute averages and ADCIRC expects 10-minute average winds, the input winds were increased by 4%. In addition, ADCIRC applies a wind drag coefficient defined by Garratt (1977), and after consultation with the ADCIRC development team, and a review of ongoing and previous FEMA studies, the default cap on the wind drag was utilized for this study ($Cd \leq 0.0035$).

B.1.3 Model Adjustments

Throughout the model calibration and validation process adjustments were made to the model mesh when there were observed instabilities or when it was determined that the model performance could be improved. Adjustments included modifying elevations within the model mesh to ensure correct representation of channels and features. The modifications made to the mesh included:

- Adjustments were made in the offshore bathymetry portion of the mesh where abrupt slope changes were causing erroneously large wave heights
- Modifications were made to bathymetry within Jamaica Bay/Head of the Bay to ensure correct representation and that tidal inundation was occurring in smaller back bay channels and marsh systems
- Modifications were made to bathymetry at the entrance to the Shrewsbury/ Navesink
- Rivers and in back bay channels to ensure correct representation of hydraulic conductivity.

In addition, sensitivity testing was conducted and adjustments were made to the spatial attributes defined for the mesh, including the bottom roughness and the directional surface roughness coefficients. These adjustments were shown to have a minimal effect on the results.

B.1.4 Tidal Calibration

Model calibration involves the adjustment of model inputs and parameters with the goal of obtaining a better match to measured data. To ensure the ADCIRC model is capable of predicting water levels and coastal hydrodynamics during periods of low energy, the model was utilized to predict tidal conditions within the study region for a period of 45 days. The model was forced with tidal constituents at the open ocean boundary in order to simulate water levels which were then compared with known tidal conditions at seven NOAA stations. The seven NOAA stations selected for tidal comparisons are shown in Figure 1. These locations were chosen due to their relevance to the current study and the availability of tidal harmonic data from NOAA CO-OPS .

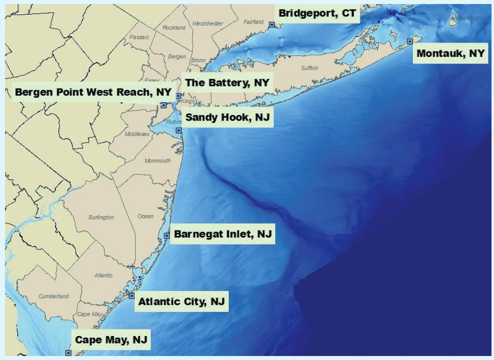


Figure 1: NOAA Water Level Statiojs Used for Modal Validation

The ADCIRC tidal simulations consisted of a 15-day ramping period, allowing the model to enter a steady state, followed by a 30-day period with full tidal forcing. Tidal harmonic analyses were performed using the 30-day model output at the NOAA station locations. Modeled amplitudes and phases for eight predominant tidal constituents (K1, K2, M2, N2, O1, Q1, S2, and P1) were compared with the values reported at each of the stations by NOAA. Figure 2 shows scatter plots comparing modeled and measured amplitudes and phases for all of the NOAA stations.

Overall, there is good agreement between modeled and measured data with differences in amplitude being less than 20% for all significant constituents having amplitudes greater than 0.1 meters. Larger amplitude and phase differences exist for stations outside of the detailed study area, such as Montauk, NY and Bridgeport, CT, where the mesh resolution is not sufficient to fully capture the complexities of the harbor and inlet hydrodynamics at these locations. Based on the results of the tidal simulation where there was reasonable agreement between the modeled and measured data, no further calibration or adjustment of model parameters was warranted.

B.1.5 Model Validation Process

Model validation is a process to measure the performance of the model in replicating historical storm events. Model validation was conducted by comparing the model

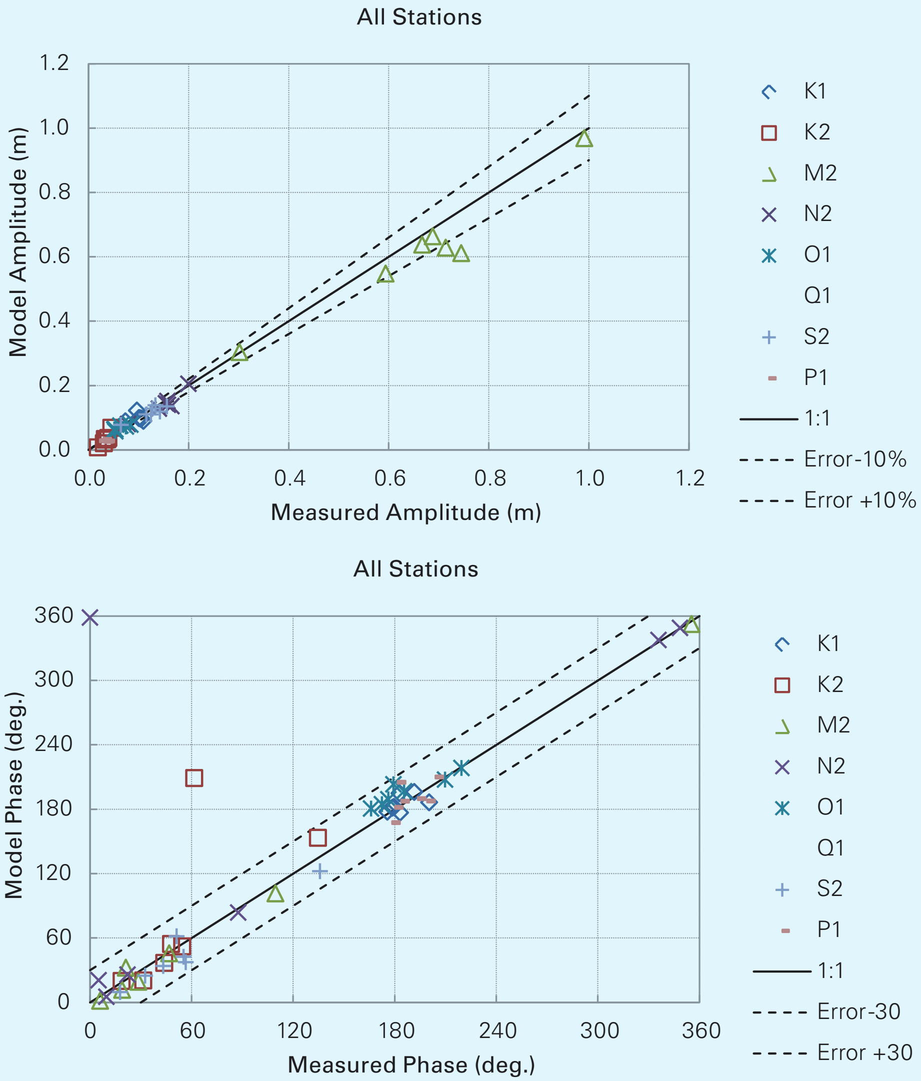


Figure 2 Comparison of Tidal Constituents from Tidal Calibration

output, both maxima and time series of water elevations, with observed data for historical storm events. The UnSWAN model was also validated by comparing the modeled wave heights with available collected wave data. The historical storms selected for validation included both tropical and extratropical events.

The tropical storm events included:

- H1938 – Hurricane of 1938 (Long Island Express)
- H1944 – Great Atlantic Hurricane of 1944
- H1960 – Hurricane Donna
- H1985 – Hurricane Gloria

The extratropical events included Nor'easter storms which impacted the region:

- N1984 – March 28-29, 1984 Nor'easter
- N1991 – October 30-31, 1991 Nor'easter (Perfect Storm or Halloween Storm)
- N1992 – December 11-14, 1992 Nor'easter

These storms were selected for validation as they are well-documented, major storm events affecting the region and based on the availability of observed water level and high water mark (HWM) data. Figure 3 shows the storm tracks for the tropical validation storms. A 15-day ramping period including only tidal forcing was completed prior to each validation storm run to ensure water levels were correctly represented at the start of the ADCIRC-UnSWAN simulations.

Measured Data

For each storm, the modeled water levels were compared with verified water level data obtained at NOAA tidal stations located throughout the study area. Figure 1 shows the locations of the NOAA water level gauges where the modeled water surface elevation was extracted for comparison with observed data. Peak water levels were also extracted from the NOAA measured time series data for each

validation storm event. For some NOAA stations where measured hourly water level data was not available, the monthly means data was utilized which also includes the highest observed water level during the specified month.

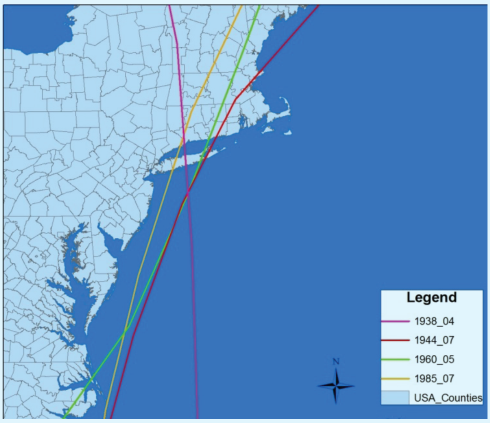


Figure 3: Tracts of Tropical Storms Used for Model Validation

B.1.6 Validation Results NOAA Hydrograph Comparisons

The seven validation storm simulations were conducted and the time series of water elevations were output from the model at locations coinciding with the NOAA water level stations shown in Figure 1. The modeled water levels were then plotted with the observed water levels for the NOAA stations where hourly data were available. The comparisons of the simulated hydrographs with measured NOAA data indicate that the model is capable of simulating water levels attributed to the combined forcing of tides and storm effects. In general, it is shown the modeled and measured water levels are in phase, as the peaks and valleys (highs and lows) are largely coincident. The hydrographs also demonstrate the model's capability in simulating the hydrodynamics of the study area, as the tidal ranges are closely matched prior to the arrival of the storm. This especially can be seen in the extratropical storm hindcasts which are of longer duration. There is an indication from the hydrograph comparisons that, in general, the model is overpredicting the maximum water levels associated with the storm events. It can be seen, however that the maximum water levels may not have been captured at the NOAA stations which recorded water levels at hourly intervals.

Hydrographs for the N1991 indicate that there is good agreement between the modeled and measured data for the first 3 days of the storm simulation, after which there is a gradual increase in the observed water level between days 3 and 6 of the simulation that is not being captured in the model.

This suggested the wind and pressure fields may be a source of error for the N1991 extratropical storm event. capture the meteorological conditions that induced the surge during this large, complex 1991 Nor'easter event.

In consultations with the developers of the wind and pressure fields for the hindcast events, it was determined that the ADCIRC model mesh does not extend far enough east across the Atlantic Basin to fully B.1.6

B.1.7
Description of Experimental Results

New islands are introduced by replacing the depths at corresponding ocean grid nodes in the model with +10m elevation. Reports are provided per each island configuration (grid version). Some configurations have ran with several storms, for each storm the impact maps have been plotted.

First page represents the bathymetry of a configuration on large scale (Mid-Atlantic Bight) and small scale (NY/NJ Harbor area).
For each storm that ran on a modified bathymetry, plotted are: peak flood maps from the base run, modified run, and the reduction of storm peak flood due to modification.

Peak flood maps show maximal sea surface elevation at each wet/flooded grid node during the storm. Plotted ranges are 0..4m (except 0..5m for 2.11 experiment with Sandy)

For the base grid, only peak flood maps for all three storms are shown.
Peak reduction plots show the difference with the base run; positive reduction (decrease in peak flood due to new islands) is shown in red colors, and negative reduction is shown in blue colors. Plotted ranges are -0.5..+0.5m except for -1..+1m for 2.11 experiment with Sandy and Donna). First presented experiment result is the base (FEMA) grid, followed with model validation based on Sandy storm.

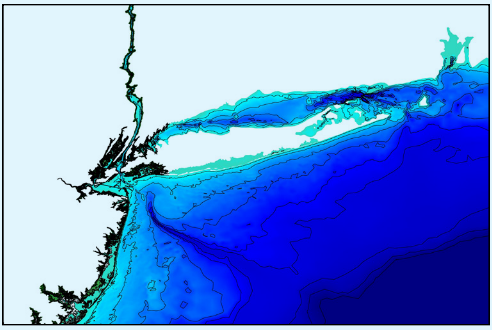
Second shown experiment result corresponds to 2.11 version – configuration recommended for the next stage of the project. It includes verbose analysis of the impact on the coastal areas. Note that ranges for both peak flood and impact plots have been increased for this configuration, and are different from other experiments' reports.

Other experiments results are provided in the order they have been performed. Experiments naming is arbitrary and corresponds to internal logistics.

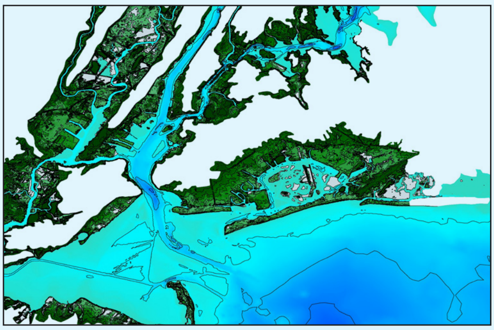
Island Configuratiions	**1960 Donna**	**1992 Nor'Easter**	**2012 Sandy**
Base	•	•	•
2.01	•		
2.04	•		
2.05	•		
2.06	•		
2.07	•		•
2.08	•		•
2.09	•	•	•
2.10			•
2.11	•	•	•
1.clz	•		•
1.cle			•
1.hud	•		
1.rbd	•		
1.sit	•		
1.xxx	•		

B.1.2.0
Base Case

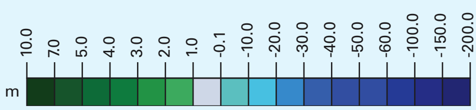
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area



Description

This is the base configuration taken from FEMA/OEM study, representing the unmodified, today's coastline and bathymetry. Impacts of all tested offshore configurations are compared to this case. Bathymetry and flood plains are represented by the unstructured finite element grid in the ocean circulation and wave model, with spatial resolution up to 70m in the NYC area.

Experiments Performed on this Grid

1960 Donna	1960.09.11 – 1960.09.13
1992 N'E	1992.12.06 – 1992.12.14
2012 Sandy	2012.10.25 – 2012.11.01

Validation

The summary of methodologies and results from the storm surge model calibration and validation performed by FEMA/RAMPP is well-represented in Region II Storm Surge Model Calibration and Validation Report (July 2013).

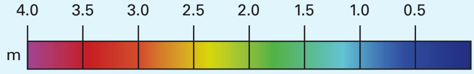
Additional validation of FEMA modeling setup was performed by Stevens Institute of Technology for NYC/OEM project.

Atmospheric winds and pressure by OceanWeather, Inc, come from their proprietary model which assimilates atmospheric data. For this project, there was no separate validation study of atmospheric fields. Instead, the modeled sea levels were compared with data.

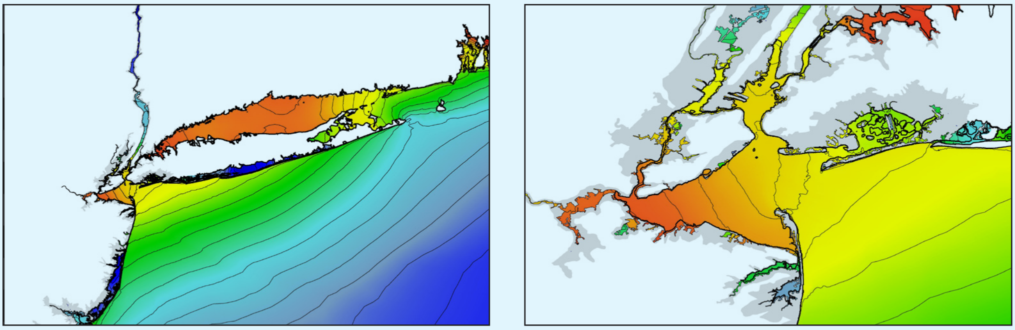
The exact spatial distribution of land flooding from Sandy is still not available at this moment, so the validation focused on sea level time series at NOAA recording buoys. In particular, the Battery location (above) shows generally excellent consistence in timing, amplitude and phase of the surge between the model (black curve) and historical data (green curve) on all stages of the storm (advance, peak and retreat).

The model overestimates the 3.5m flood peak at the Battery by 5% which can be attributed to the up-scaling wind factor of 1.04 inherited from our NYC/OEM work. These discrepancies are clearly not the first order problem for this particular study focusing on the differences in flood due to new islands construction. However, we are currently undertaking a study involving Sandy model/ data comparison, which will also provide the best wind calibration for the next stage of this project.

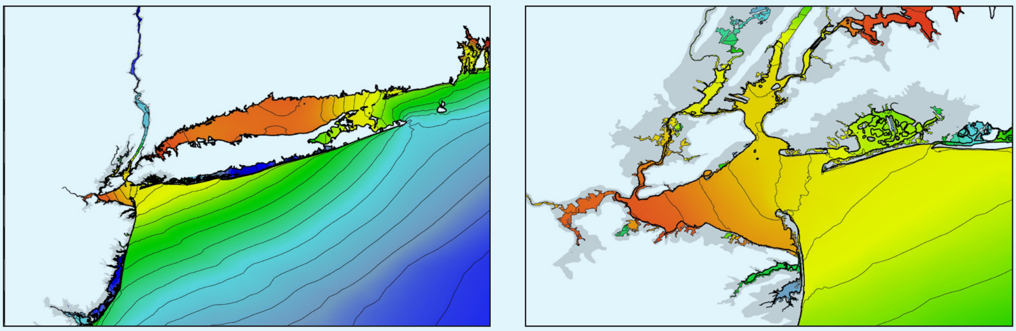
Peak Flood



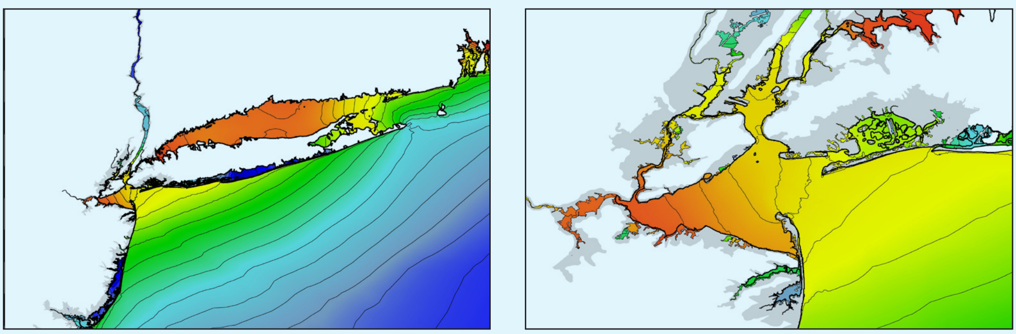
1960 Donna



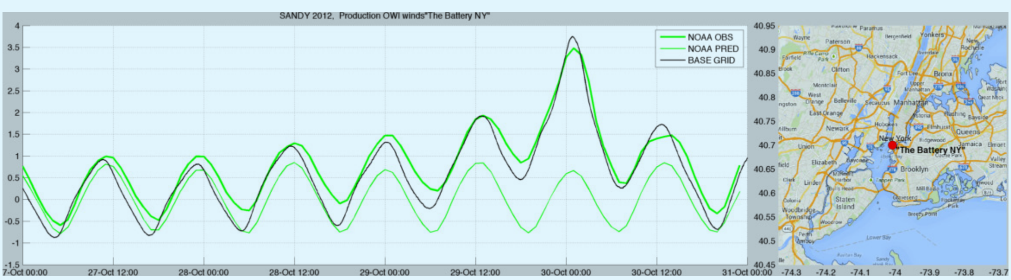
1992 Nor'Easter



2012 Sandy



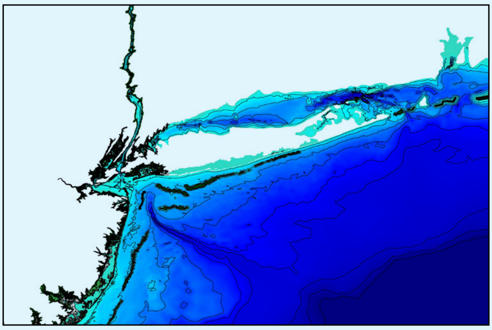
Mid-Atlantic Bight Area   New York Harbor Area



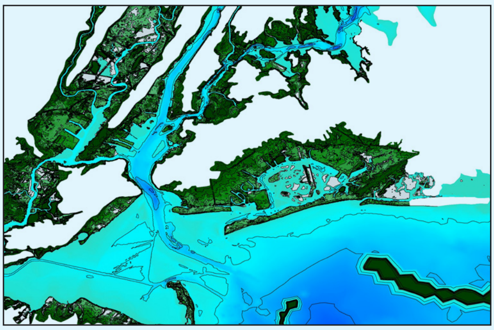
Modeled and observed water level at the Battery, NY, during the 2012 super-storm Sandy.

B.1.2.1
Model 2.01

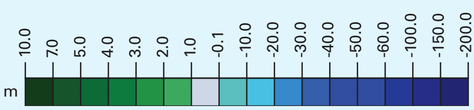
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

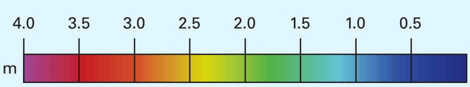


Description

Large-scale modification. Refining the NY Harbor protection; reducing exposure to the open ocean.

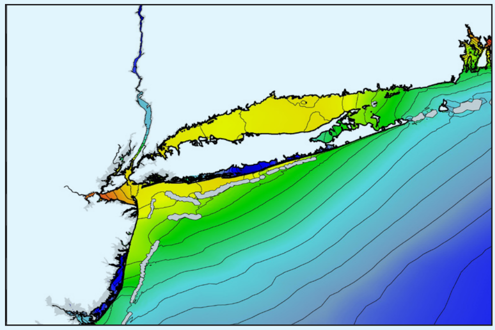
Experiments Performed on this Grid

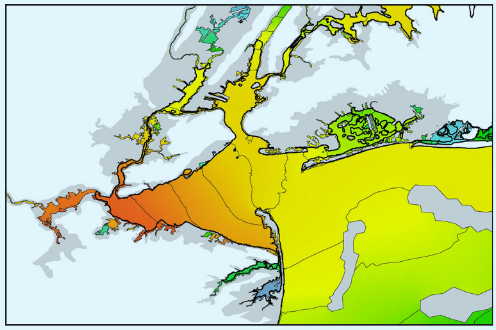
1960 Donna 1960.09.11 – 1960.09.13



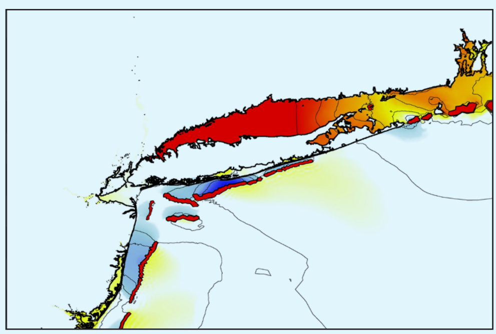
1960 Donna

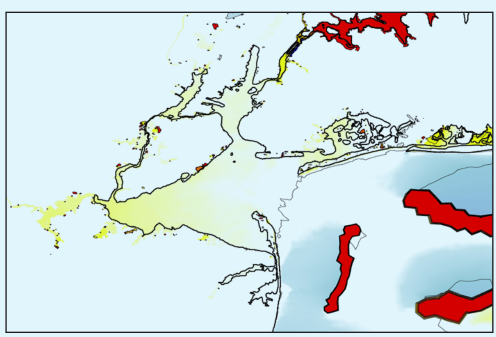
Peak Flood





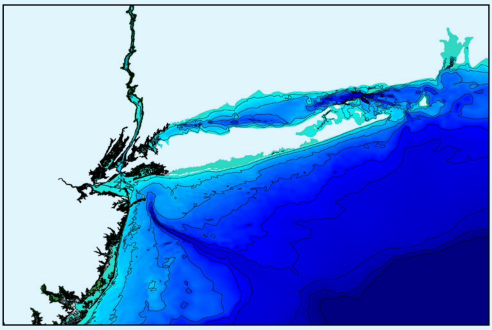
Peak Reduction



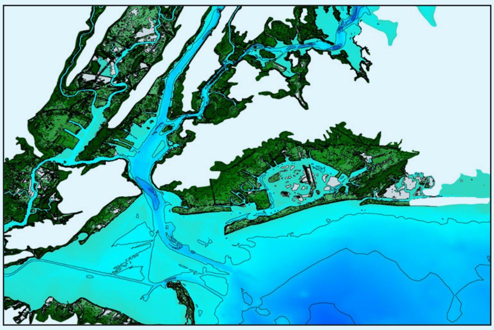


B.1.2.2
Model 2.04

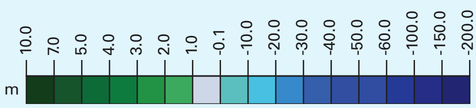
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area



Description

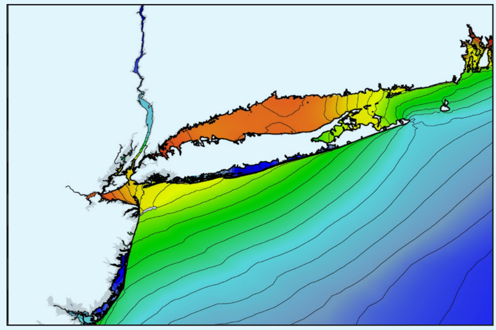
Small-scale modification. Checking the effect of blocking the transport along the NJ coast.

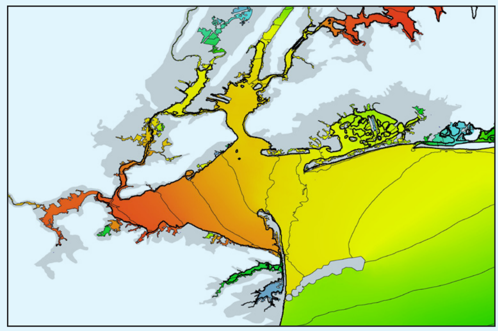
Experiments Performed on this Grid

1960 Donna 1960.09.11 – 1960.09.13

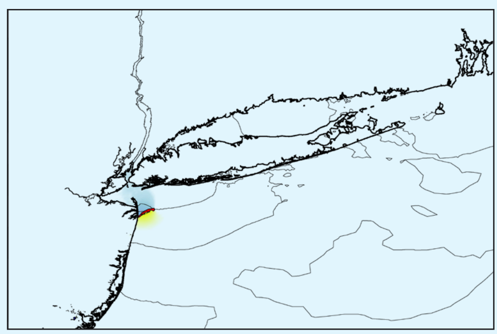
1960 Donna

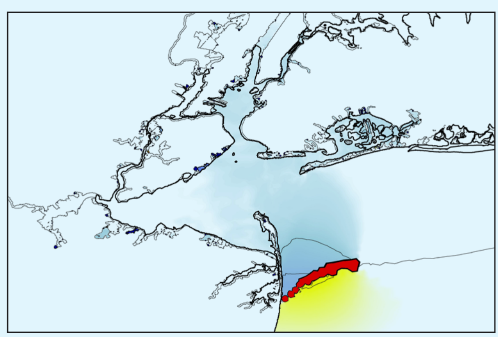
Peak Flood





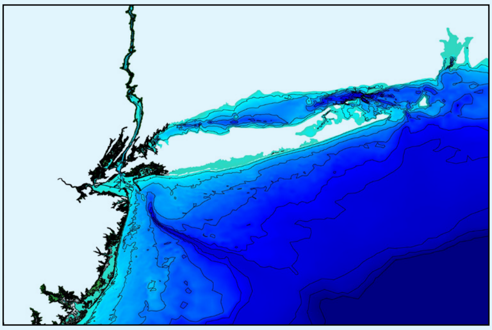
Peak Reduction



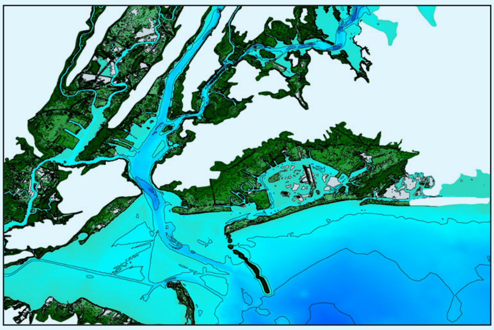


B.1.2.3
Model 2.05

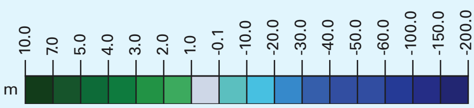
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

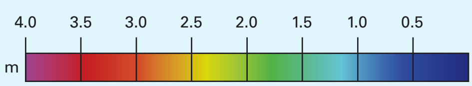


Description

Small-scale modification. Checking the effect of blocking the transport along the Long Island coast.

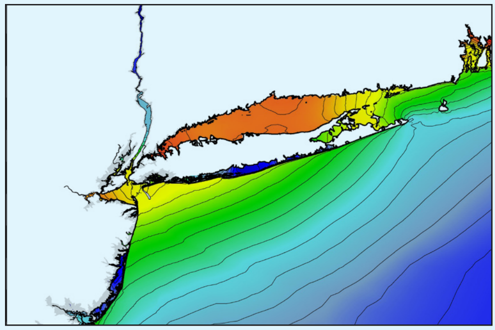
Experiments Performed on this Grid

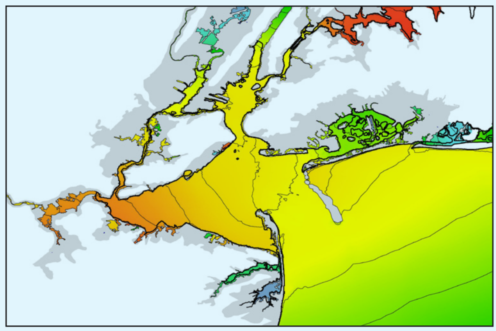
1960 Donna 1960.09.11 – 1960.09.13



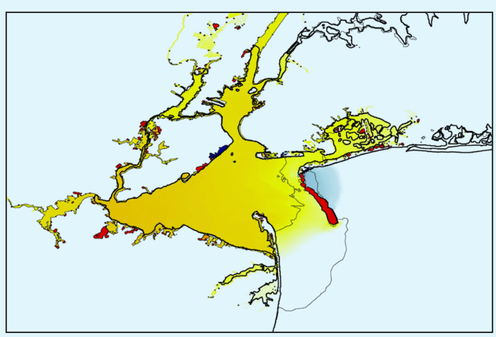
1960 Donna

Peak Flood



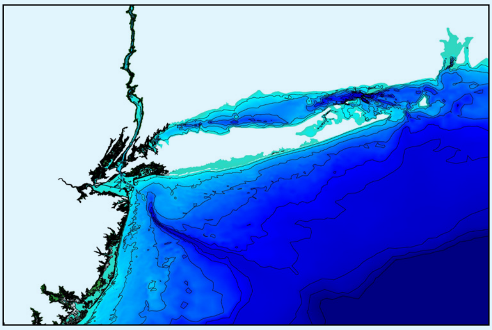


Peak Reduction

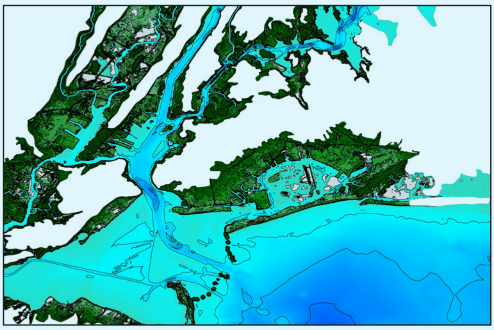


B.1.2.4
Model 2.06

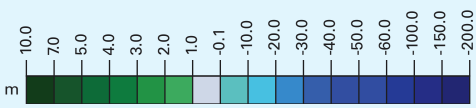
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

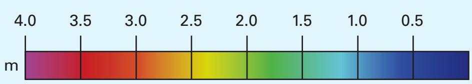


Description

Small-scale modification. Checking the effect of blocking the transport along the NJ coast.

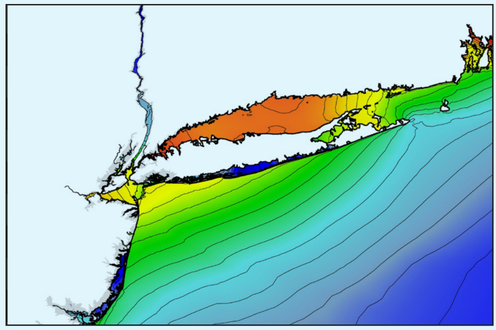
Experiments Performed on this Grid

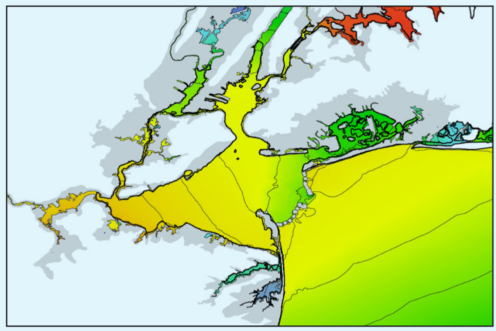
1960 Donna 1960.09.11 – 1960.09.13



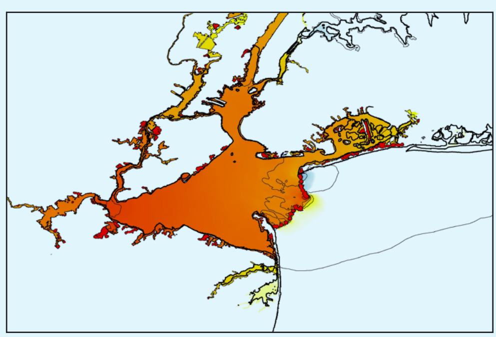
1960 Donna

Peak Flood



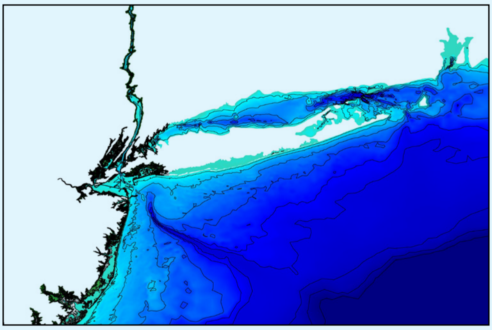


Peak Reduction

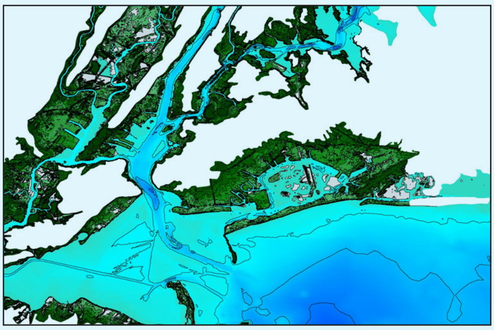


B.1.2.5
Model 2.07

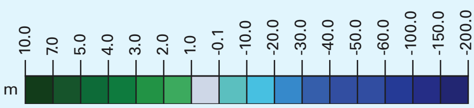
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area



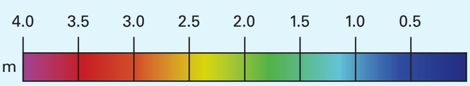
Description

Small-scale modification. Checking the effect of blocking the transport along the Long Island coast.

Experiments Performed on this Grid

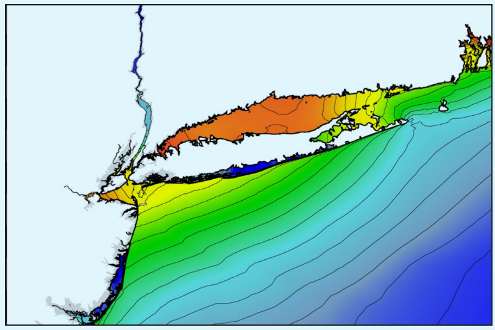
1960 Donna 1960.09.11 – 1960.09.13

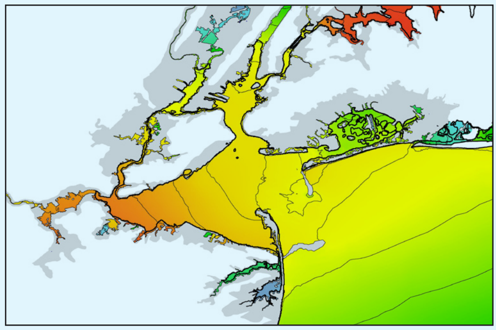
2012 Sandy 2012.10.25 – 2012.11.01



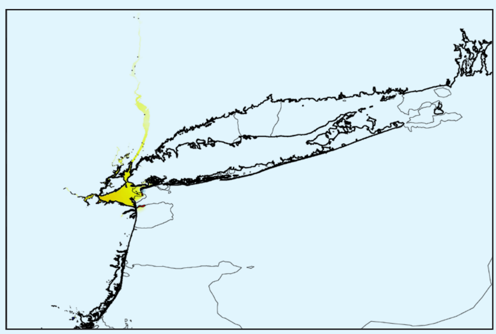
1960 Donna

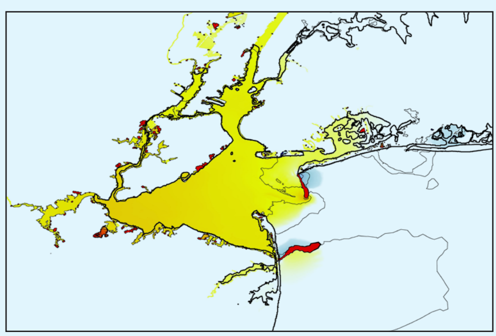
Peak Flood





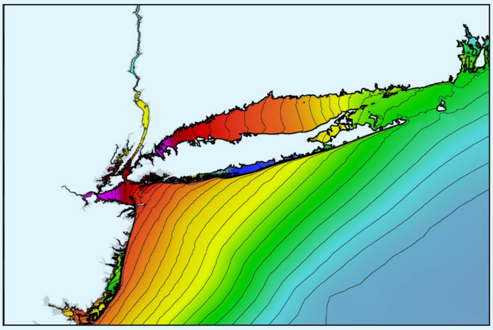
Peak Reduction

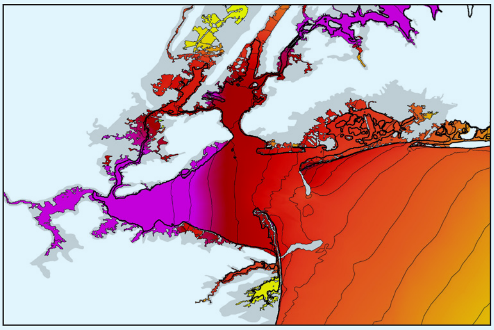




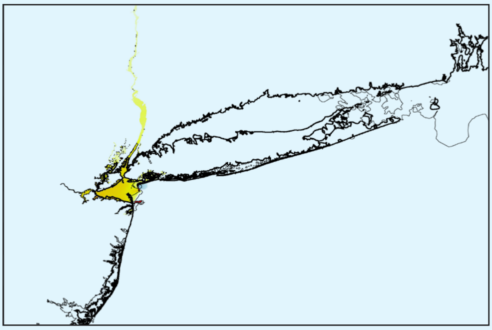
2012 Sandy

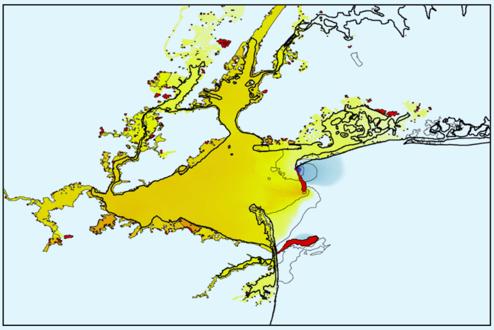
Peak Flood





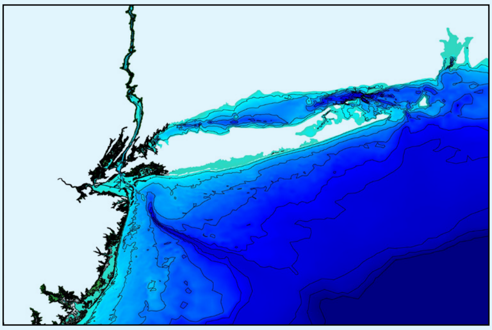
Peak Reduction



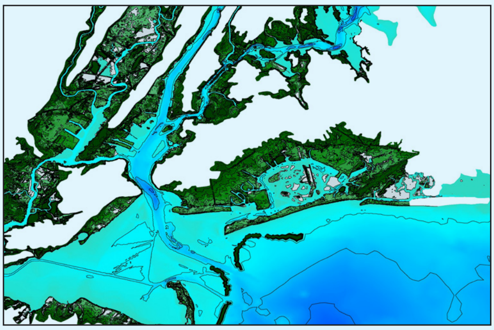


B.1.2.6
Model 2.08

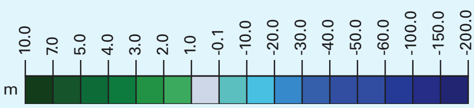
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

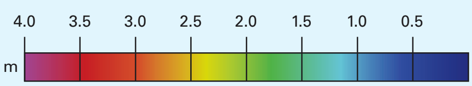


Description

Small-scale modification. Deflecting the surge with a chain of small block islands.

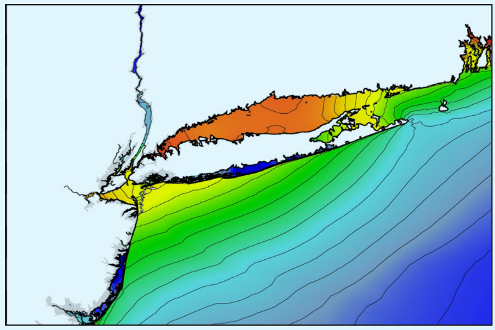
Experiments Performed on this Grid

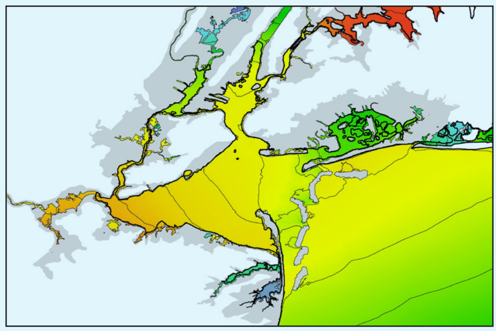
1960 Donna 1960.09.11 – 1960.09.13
2012 Sandy 2012.10.25 – 2012.11.01



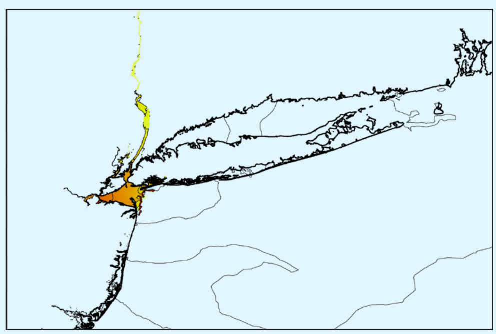
1960 Donna

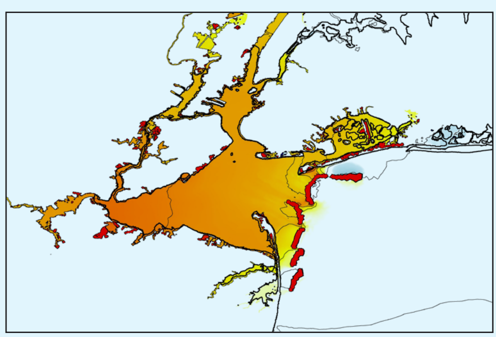
Peak Flood





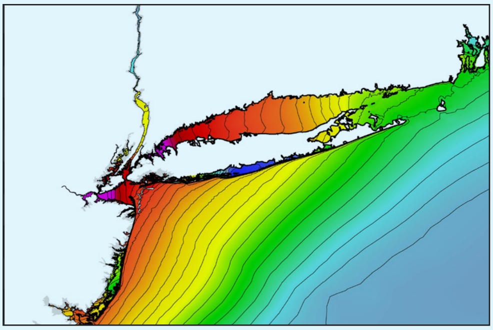
Peak Reduction

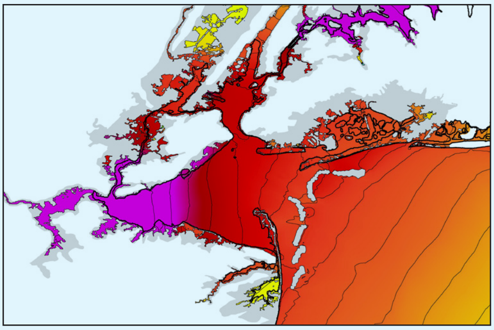




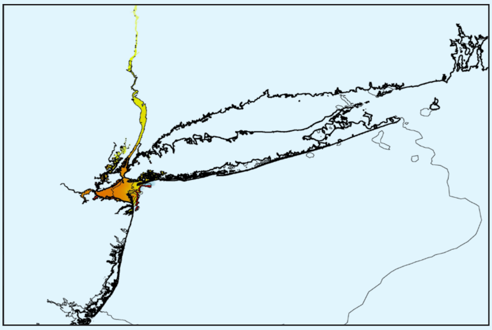
2012 Sandy

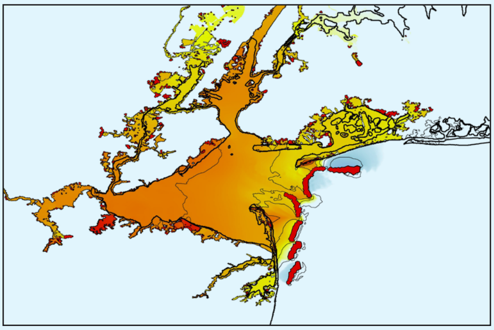
Peak Flood





Peak Reduction

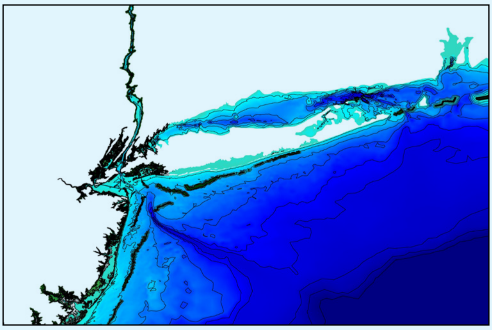




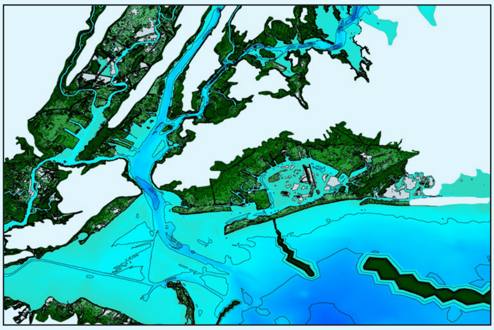
B.1.2.7
Model 2.09

1960 Donna

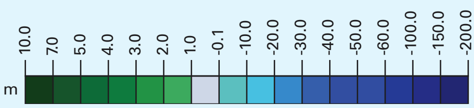
Bathymetry



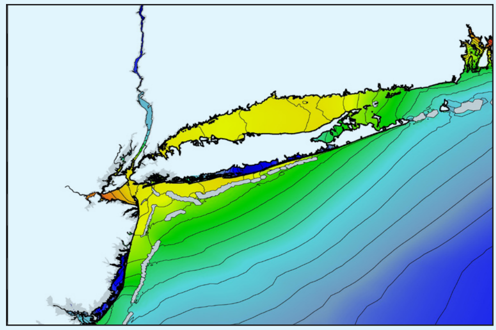
Mid-Atlantic Bight Area

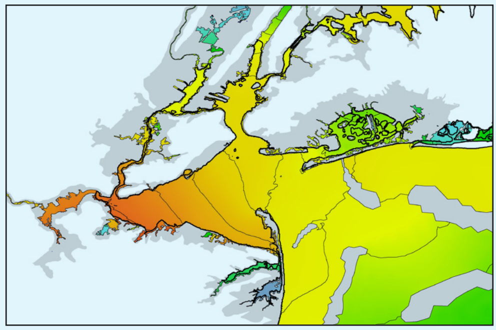


New York Harbor Area

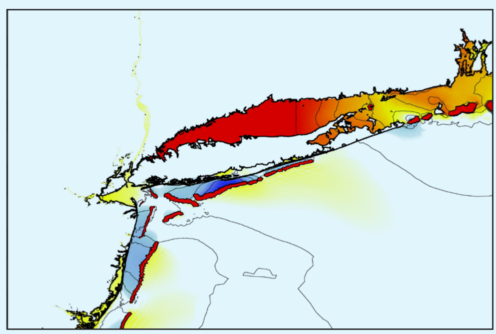


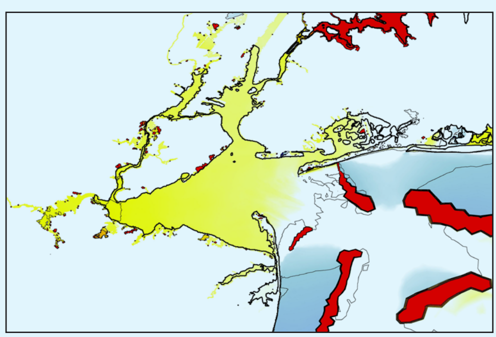
Peak Flood





Peak Reduction



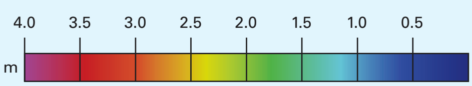


Description

Large-scale modification coupled with another configuration for NY Harbor offshore protection.

Experiments Performed on this Grid

1960 Donna	1960.09.11 – 1960.09.13
1992 N'E	1992.12.06 – 1992.12.14
2012 Sandy	2012.10.25 – 2012.11.01

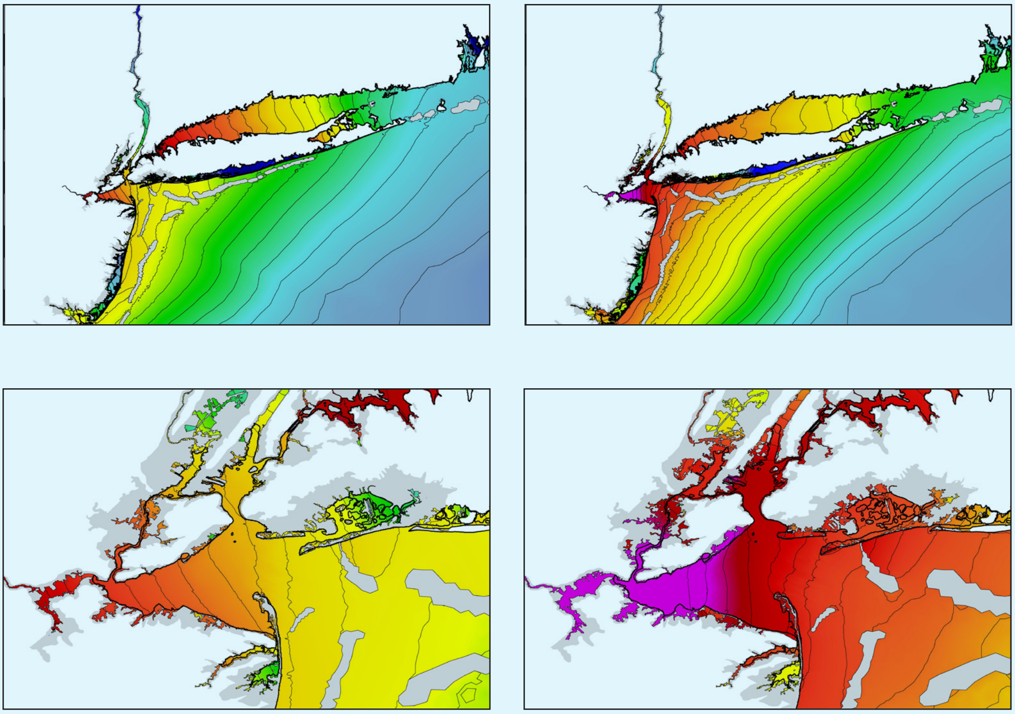


1992 Nor'Easter

2012 Sandy

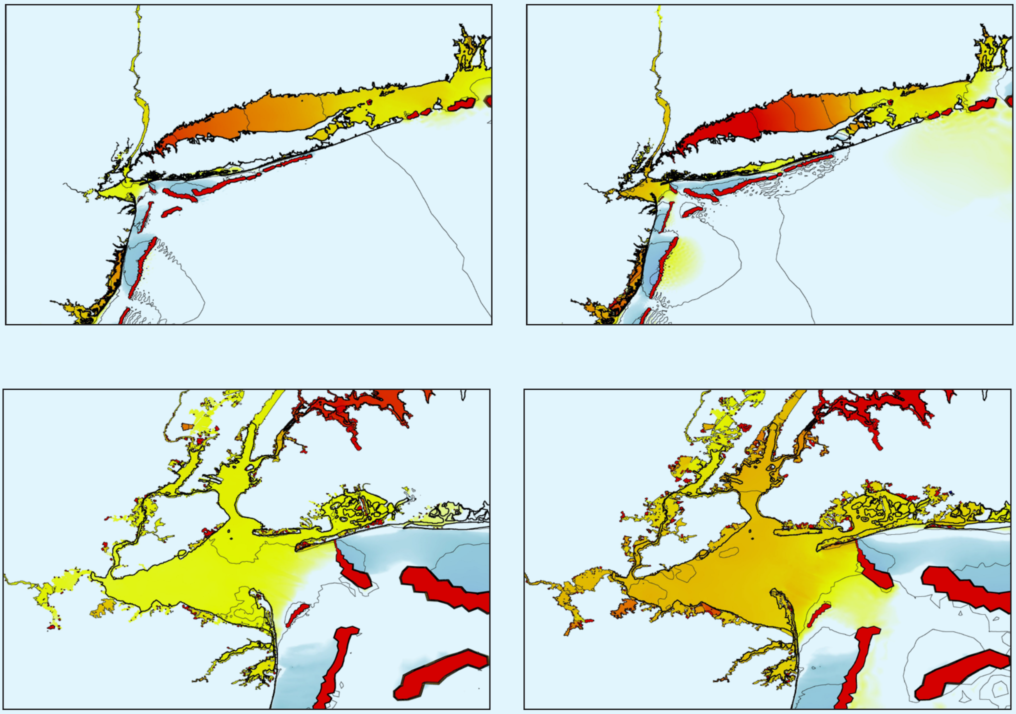
Peak Flood

Peak Flood



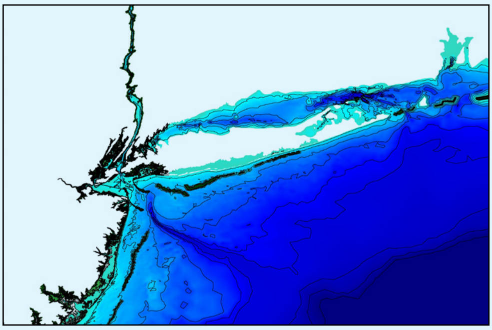
Peak Reduction

Peak Reduction

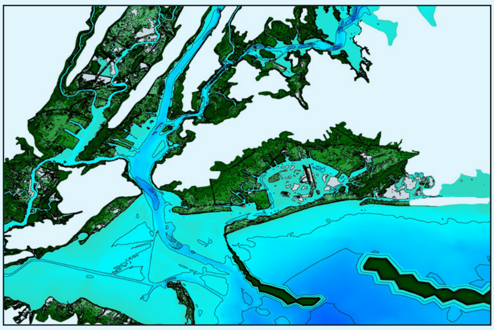


B.1.2.8
Model 2.10

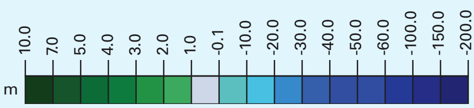
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area



Description

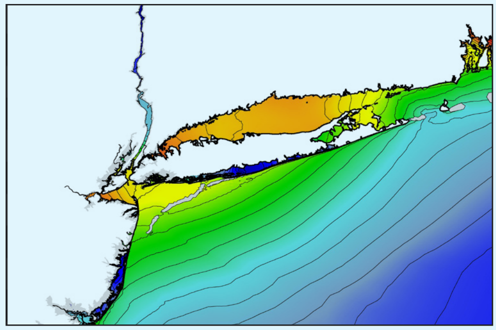
Large-scale modification coupled with another configuration for NY Harbor offshore protection.

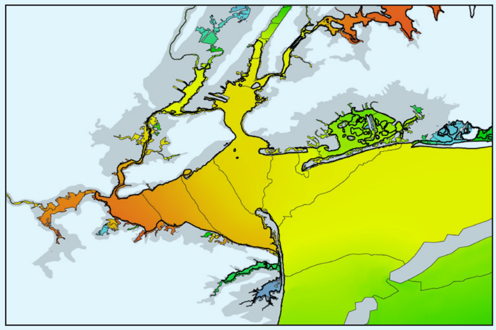
Experiments Performed on this Grid

1960 Donna	1960.09.11 – 1960.09.13
2012 Sandy	2012.10.25 – 2012.11.01

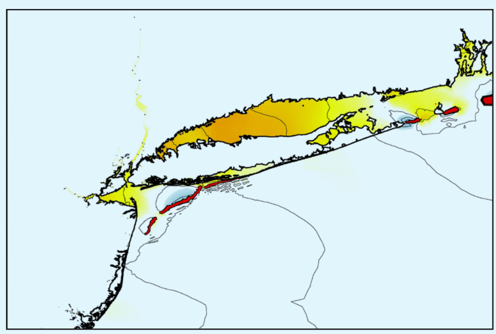
1960 Donna

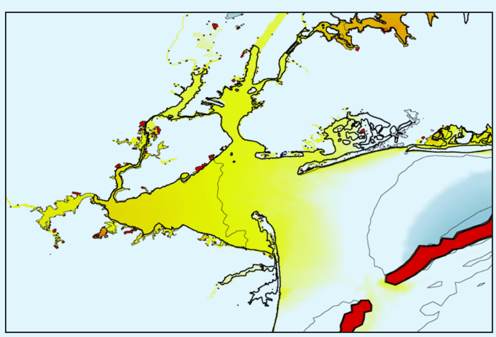
Peak Flood





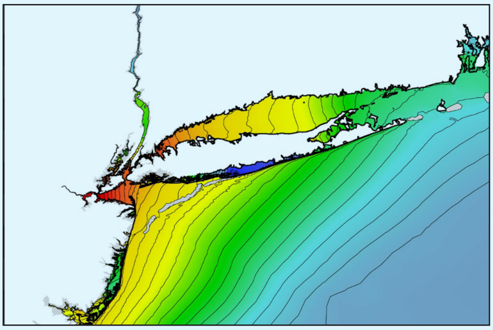
Peak Reduction

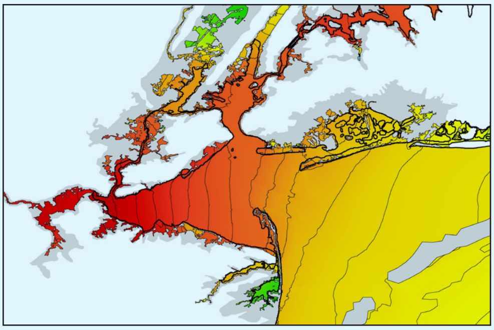




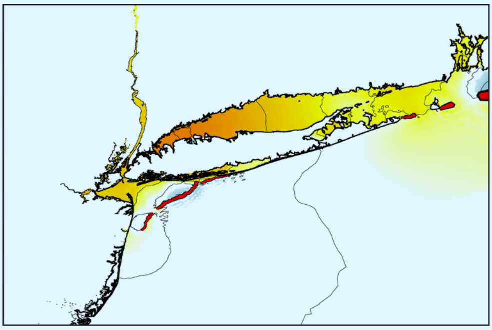
2012 Sandy

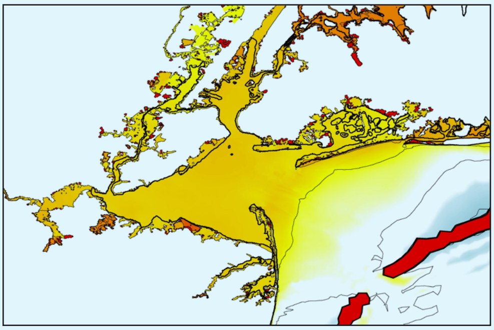
Peak Flood





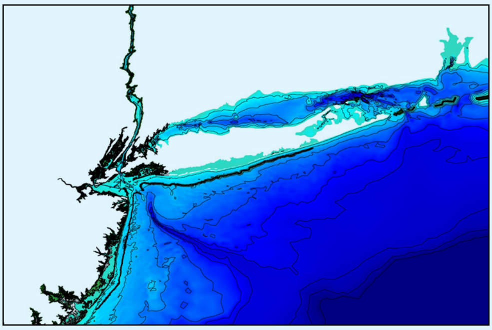
Peak Reduction



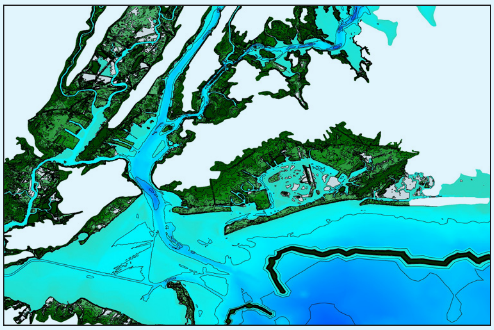


B.1.2.9
Model 2.11

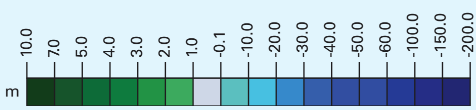
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

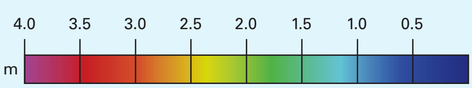


Description

Large-scale coastal lagoon-style modification, a result of analyzing all the cases to date. Model 2.11 is the most effective configuration without considering financial or ecological considerations.

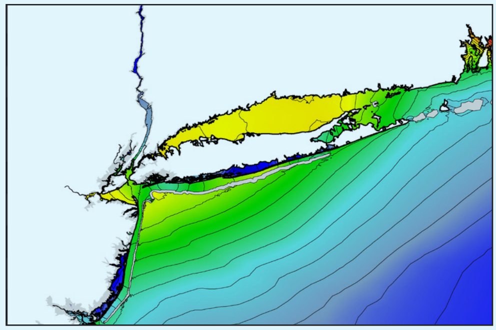
Experiments Performed on this Grid

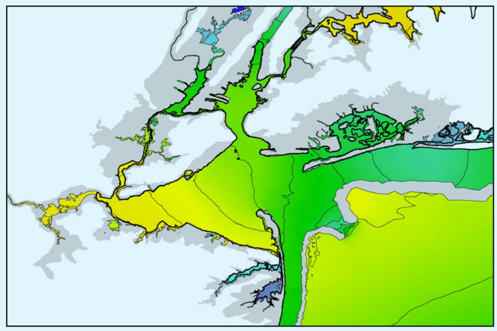
1960 Donna	1960.09.11 – 1960.09.13
1992 N'E	1992.12.06 – 1992.12.14
2012 Sandy	2012.10.25 – 2012.11.01



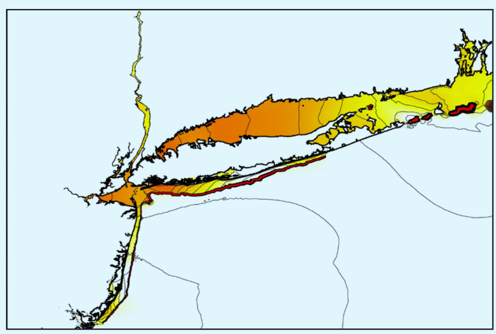
1960 Donna

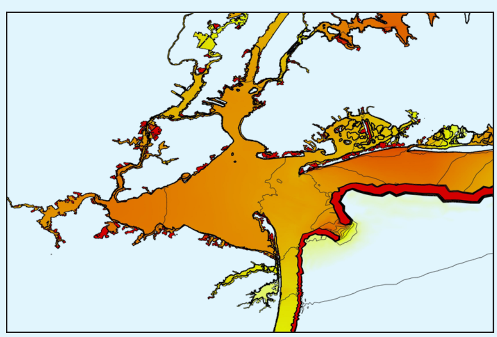
Peak Flood





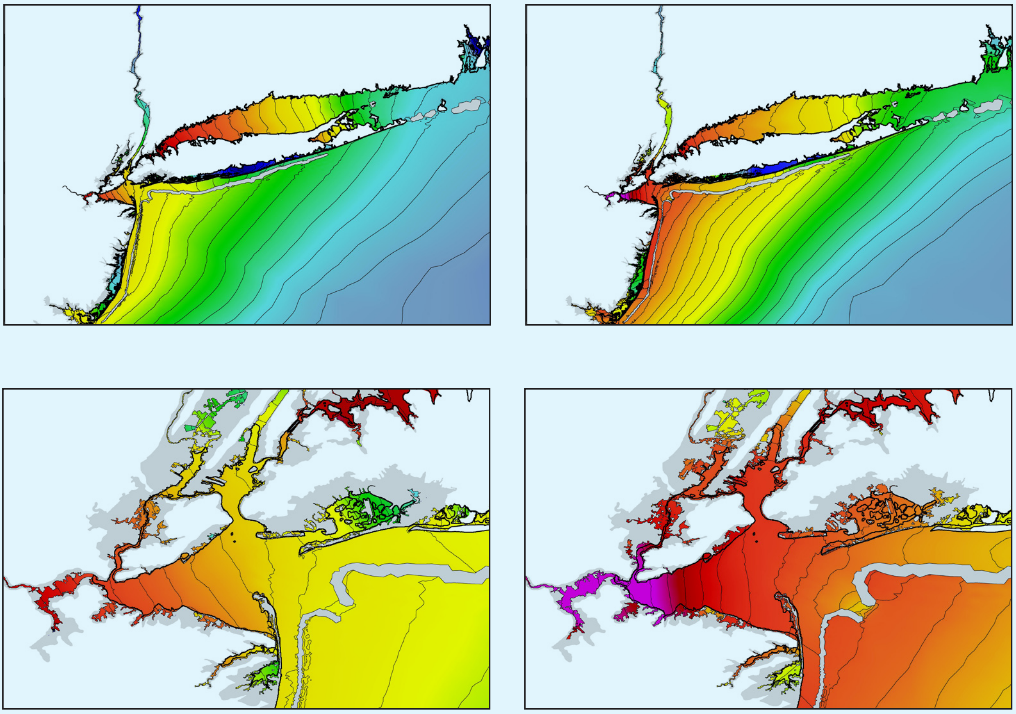
Peak Reduction



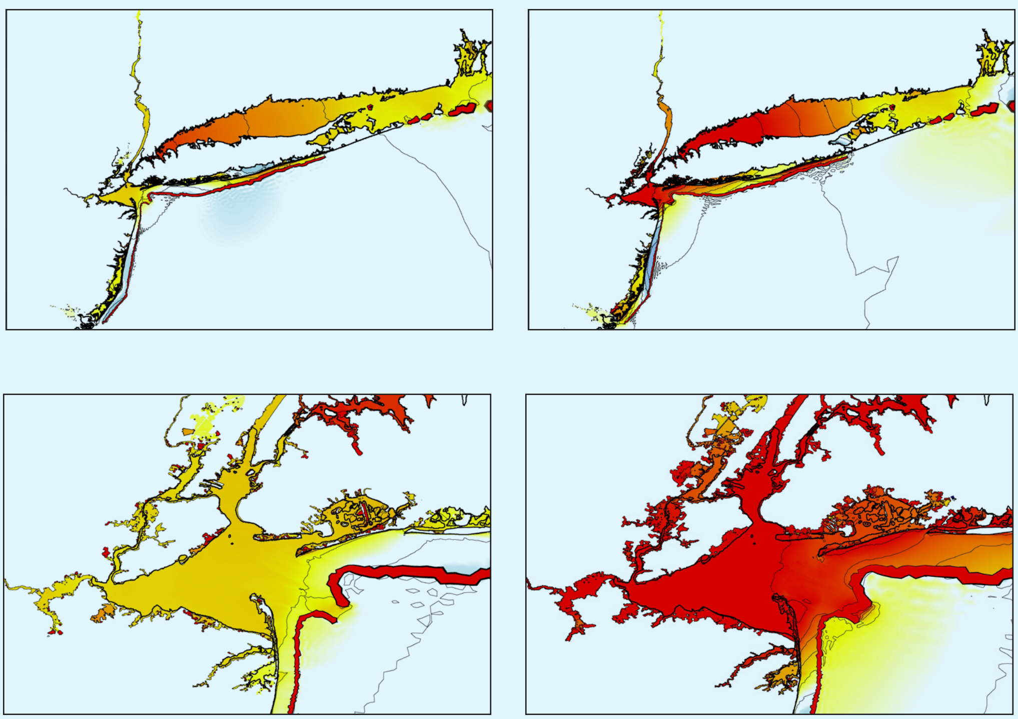


1992 Nor'Easter | **2012 Sandy**

Peak Flood | Peak Flood



Peak Reduction | Peak Reduction



Results

This configuration of barrier islands results in the following changes in flood peak pattern for the 1960 hurricane Donna:

- New York/New Jersey Harbor storm surge reduced by 0.6m
- Long Island Sound surge reduced by 0.6m
- South shore of the Long Island surge decreased by up to 0.9m
- Coastal flooding reduced in Compton Creek area (Raritan Bayshore), Gravesend (Brooklyn), Rockaway Beach area, Midland Beach (Staten Island)

This configuration of barrier islands results in the following changes in flood peak pattern for the December 1992 Nor'easter:

- New York/New Jersey Harbor storm surge reduced by 0.2m
- Long Island Sound surge reduced by 0.5m
- Coastal flooding reduced in some areas along Raritan Bayshore, Rockaway Beach and Jamaica Bay areas, Midland Beach (Staten Island)

This configuration of barrier islands results in the following changes in flood peak pattern for the 2012 super-storm Sandy:

With high confidence:

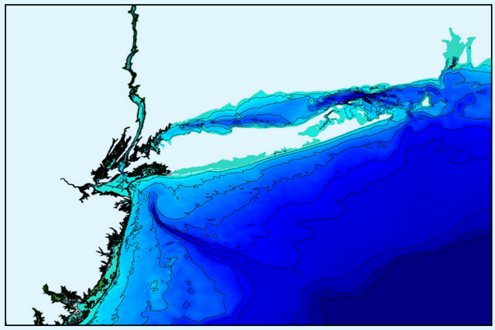
- New York/New Jersey Harbor storm surge reduced by 0.7m
- Long Island Sound surge reduced by 1m
- Island Beach State Park area of NJ coast surge decreased by 0.2m
- Maximal Sandy surge at Keyport Harbor reduced by more than 1m
- Coastal flooding stopped in Compton Creek area (Raritan Bayshore), Flushing Meadows Corona Park (Queens).

With less confidence:

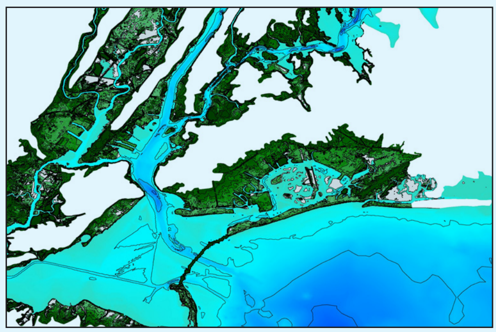
- Coastal flooding practically stopped in Hoboken, NJ, Newark Airport, Gravesend (Brooklyn)
- Midland Beach area of Staten Island surge reduced by 0.8m
- Rockaway surge reduced by 1m
- Union Beach surge reduced by 1m.

This coastal lagoon-style configuration provided one of the most drastic reductions of the Sandy's storm surge in the study area. One recommendation for improvement can be widening of the central inlet into the lagoon leading to the NY/NJ Harbor, in order to let more water from Hudson River plume flow out into the Atlantic. However, actual width and geometry of the inlet can be determined in a more realistic modeling which will involve Hudson River dynamics.

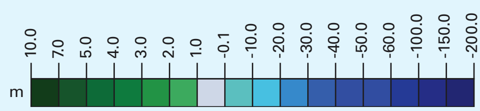
B.1.2.10
Model 1.clz
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

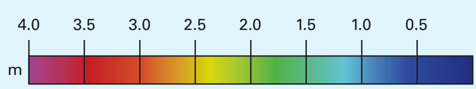


Description

Sandy Hook – Rockaway transect completely closed, allowing to study how much of the storm surge is coming into the Lower Bay directly from the Atlantic.

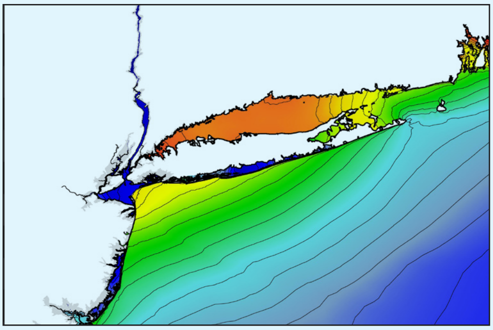
Experiments Performed on this Grid

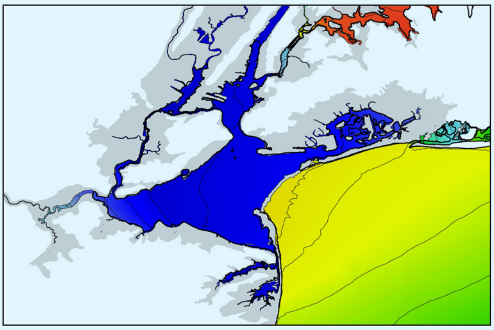
1960 Donna	1960.09.11 – 1960.09.13
2012 Sandy	2012.10.25 – 2012.11.01



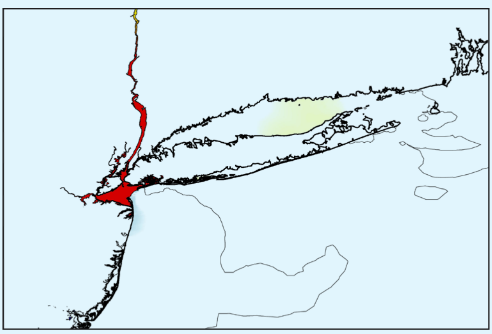
1960 Donna

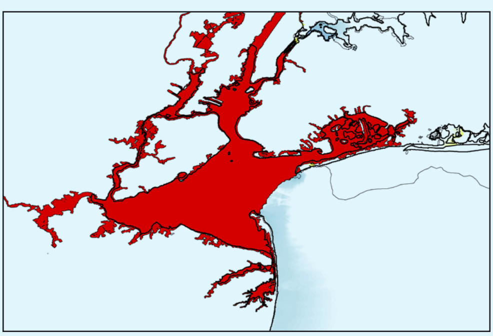
Peak Flood





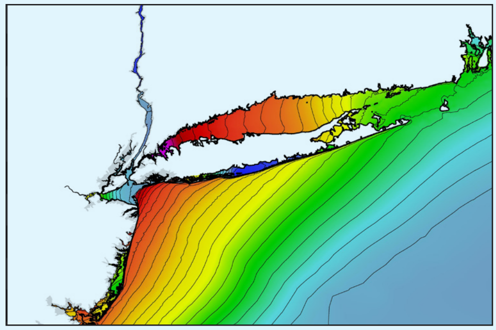
Peak Reduction

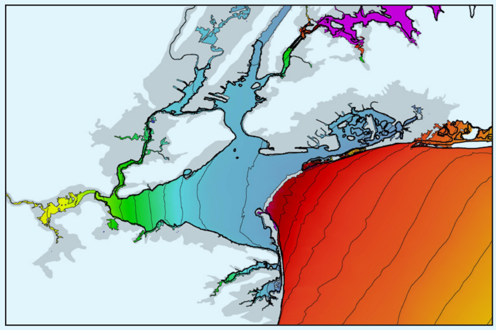




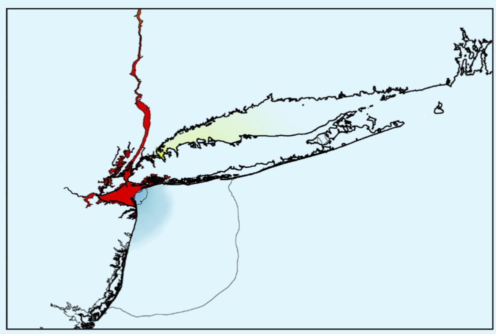
2012 Sandy

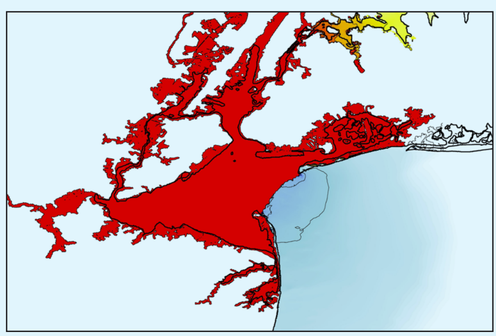
Peak Flood



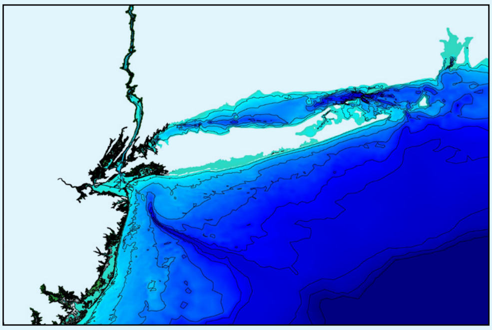


Peak Reduction



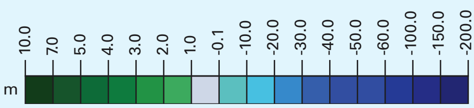


B.1.2.11
Model 1.cle
Bathymetry



Mid-Atlantic Bight Area

New York Harbor Area

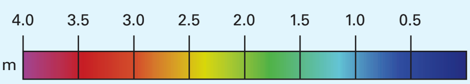


Description

Sandy Hook – Rockaway transect completely closed, allowing to study how much of the storm surge is coming into the Lower Bay directly from the Atlantic.

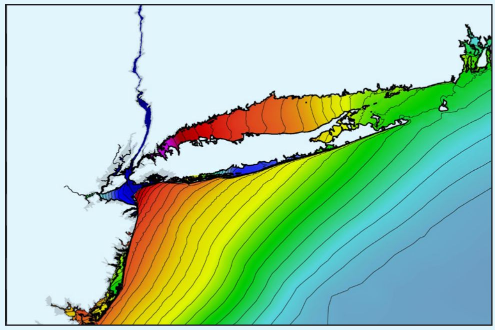
Experiments Performed on this Grid

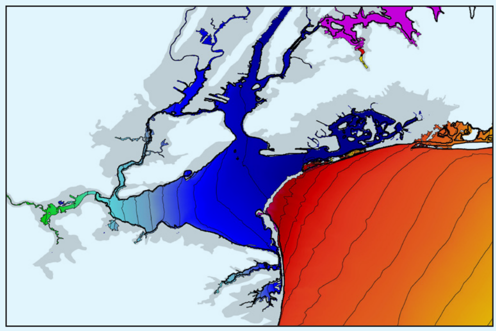
2012 Sandy 2012.10.25 – 2012.11.01



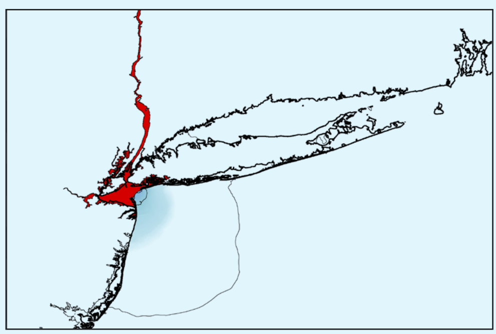
2012 Sandy

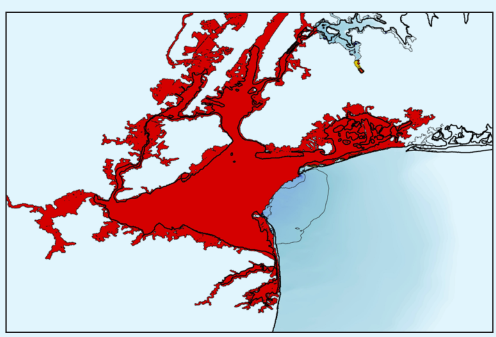
Peak Flood



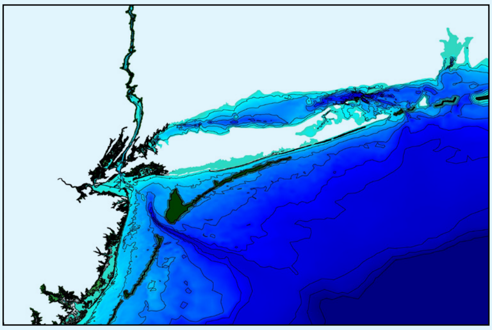


Peak Reduction

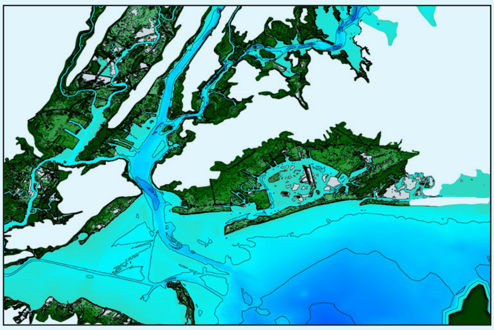




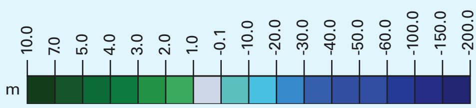
B.1.2.12
Model 1.hud
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area

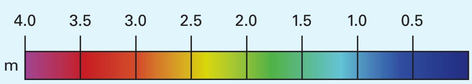


Description

Initial large-scale design.

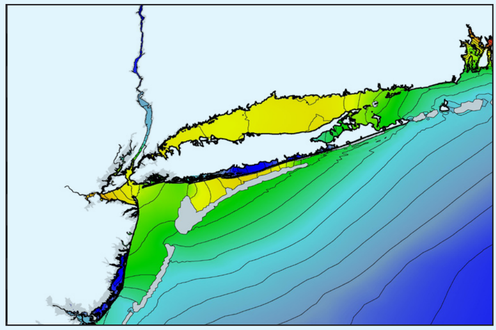
Experiments Performed on this Grid

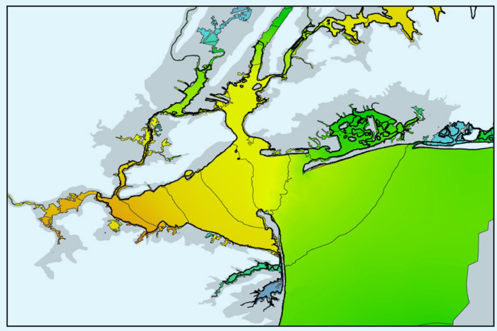
1960 Donna 1960.09.11 – 1960.09.13



1960 Donna

Peak Flood





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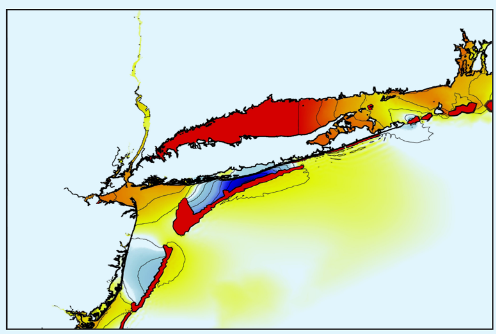
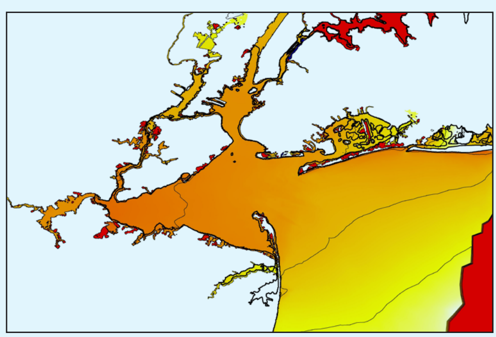
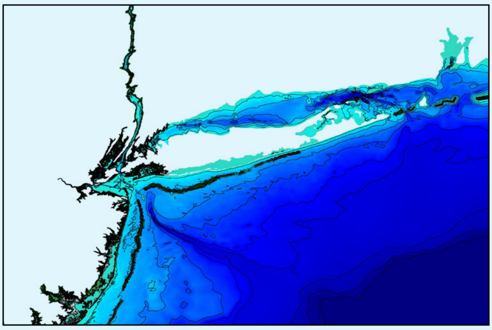


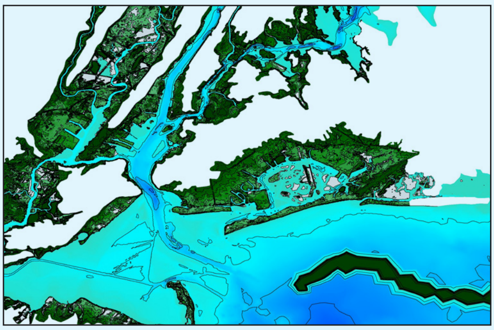


B.1.2.13
Model 1.rbd

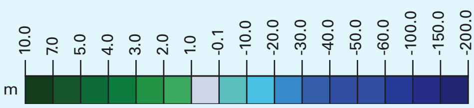
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area



Description

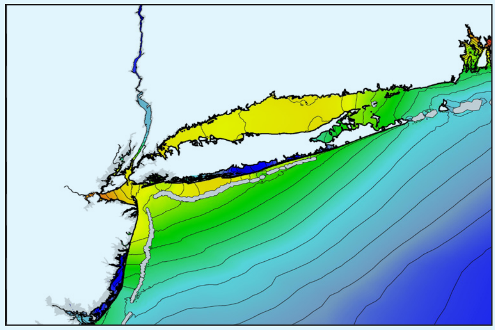
Large-scale modification; refining the NY Harbor protection.

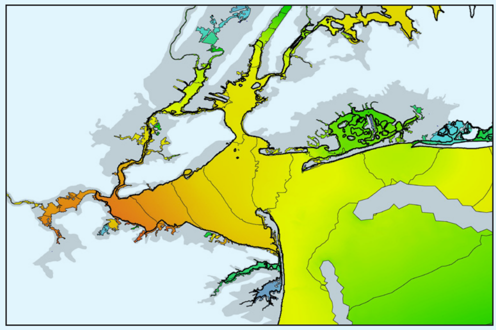
Experiments Performed on this Grid

2012 Sandy 2012.10.25 – 2012.11.01

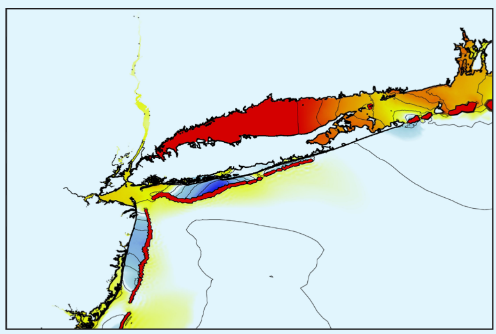
1960 Donna

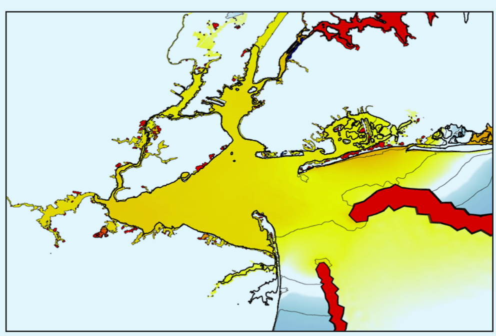
Peak Flood





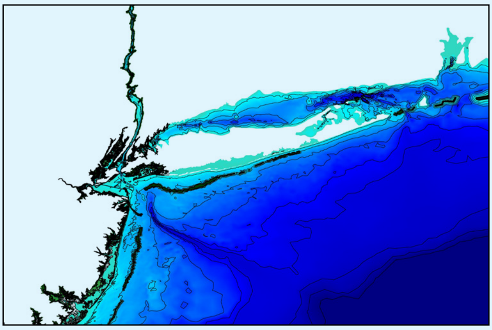
Peak Reduction



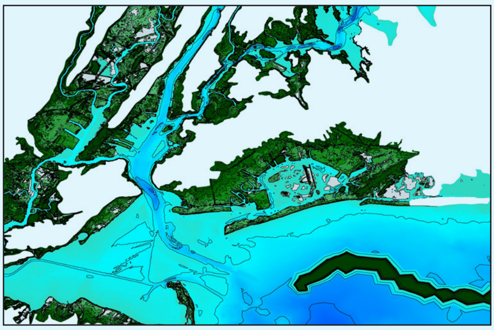


B.1.2.14
Model 1.sit

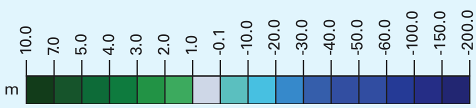
Bathymetry



Mid-Atlantic Bight Area



New York Harbor Area



Description

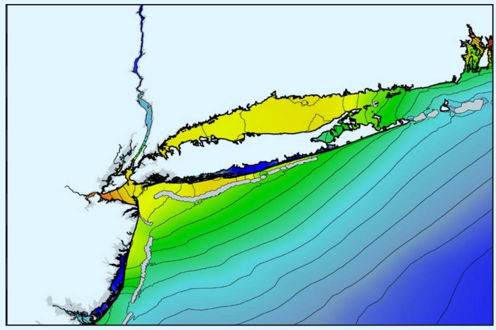
Large-scale modification. Refining the NY Harbor protection; blocking the along-NJ shore surge pathway.

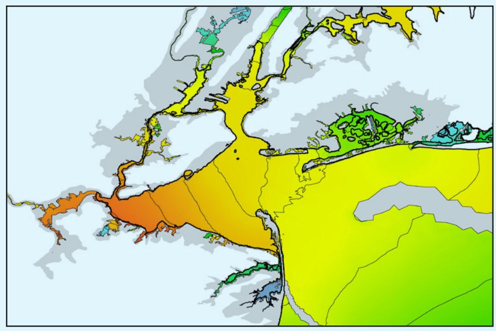
Experiments Performed on this Grid

2012 Sandy 2012.10.25 – 2012.11.01

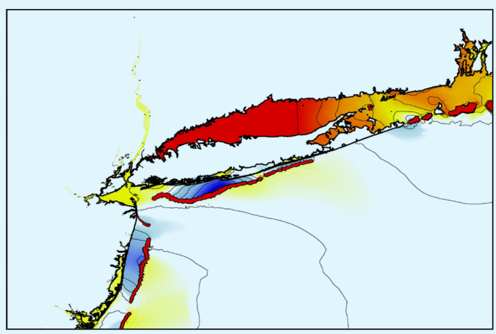
1960 Donna

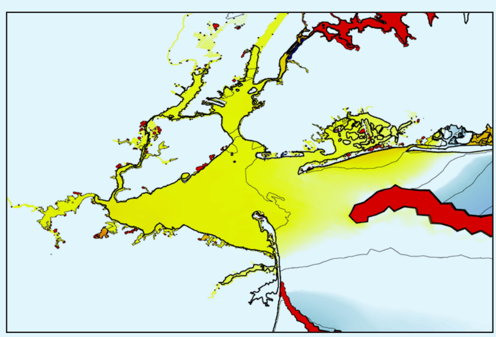
Peak Flood





Peak Reduction

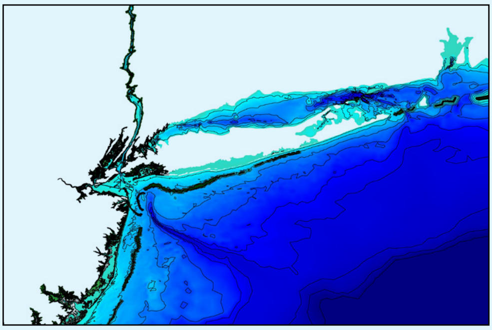




B.1.2.15
Model 1.xxx

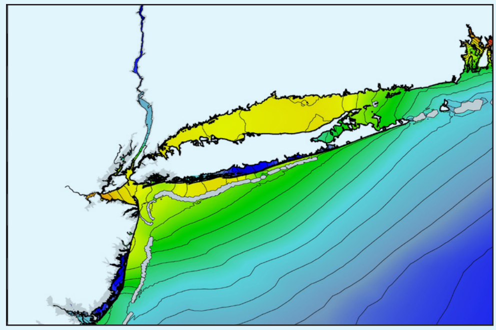
1960 Donna

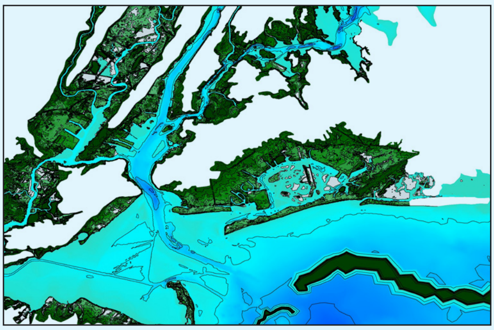
Bathymetry



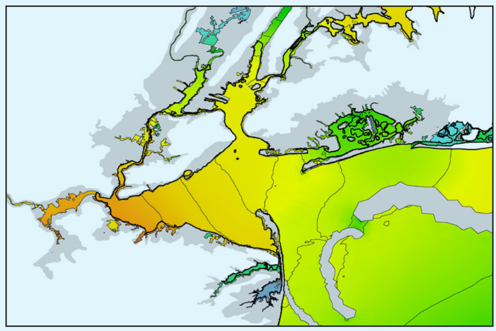
Mid-Atlantic Bight Area

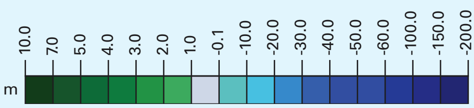
Peak Flood



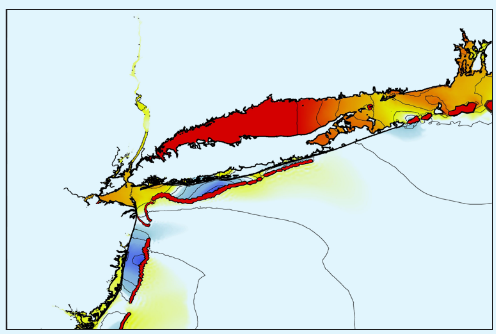


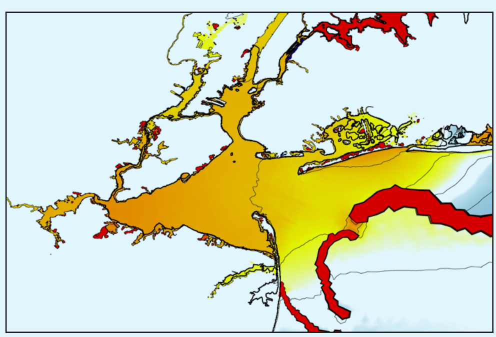
New York Harbor Area





Peak Reduction





Description

Large-scale modification. Refining the NY Harbor protection; blocking the along-NJ shore surge pathway; reducing the exposure to the open ocean.

Experiments Performed on this Grid

2012 Sandy 2012.10.25 – 2012.11.01

B.2

Marine Coastal Mapping

B.2.0
Introduction

Our proposal rests on several key assumptions. The first is that people enjoy living by the ocean and they will continue to do so. The second is that humanity has historically exploited ocean resources, and will continue to do. The third is that it is possible to redirect both of these energies away from damaging levels of disturbance, and toward a more sustainable future even in the face of rising water levels and extreme weather events. There is no doubt that our response to these assumptions is audacious, but our team has conducted a series of preliminary studies that indicate our proposal is less extreme, and much more conservation than it at first seems; especially when considered within the larger context of the urban history of New York City waterfront. These preliminary studies also reveal the revolutionary potential of our project to ecologically recreate at a grand scale, a complete natural system.

To date our team has selected three significant storm events (two hurricanes and one nor'easter) to model how a new string of offshore islands approximately 10 miles off-shore and extending from the mouth of the New York Harbor outward along the coast of northern New Jersey and western Long Island impact storm surge. These models indicate a significant reduction in storm surge. Though not within the scope of this study, future work proposes to increase the number of storms modeled in order to verify results, and to model the impact of the proposed islands upon the flow of the Hudson River plume.

In addition, our team's scientific advisors have noted that any offshore island proposal has to take into account physical disturbance to the ocean floor caused by large-scale marine sand mining, including the subsequent impacts of the mining activity upon species diversity. To help understand the impact of sand mining upon the surrounding marine environment our team has begun to compile a multi-layered marine coastal map. This map draws from many sources includes topography, ocean floor geology and sand deposits, locations were sand is currently mined, and former garbage dumping zones; the distribution of commercial and recreational fish and marine mollusks (scallops, clams, mussels, cod and sea bass – check this against the slide show); the distribution of endangered species such as the Piping Plover, and migratory pathways for fish, birds and marine mammals; the location of marinas, boat channels, telecommunication installations and wind farms; and regulatory oversight and control.

Once the different layers of the marine coastal map are compiled, they will help determine the optimum location, size and configuration of the proposed islands. The intent is to avoid environmentally sensitive areas and minimize detrimental environmental impacts. Additionally, and though outside the scope of the current study, the marine coastal map will form the basis of explorations into the potential of these islands - as opposed to hardened barrier systems - to foster a more diverse marine and barrier island ecology than currently exists.

But perhaps most critical of all, the marine coastal map allows our team to define the key features of a comprehensive inland-beach-island-marine section, and then tie these physical characteristics to our team's economic, social and political analysis of the benefits obtained from soft-edged storm surge risk reduction. Our ultimate goal is not the mastery of nature, or the avoidance of sea level rise. Instead we seek to understand and work with the processes of nature to create a multi-layered system with the inherent capacity to adapt and change over time. In this sense, we do not see our barrier island proposal as a finished solution with a neatly wrapped outcome. Rather, we see it as a sort of unending dialectic in which people and the shoreline continue to make and remake each other in response to the fluid nature of their interactions.

B.2.1
Mid-Atlantic Regional Council (MARCO) Data Portal

The Mid-Atlantic Regional Council on the Ocean (MARCO), a collaboration among the states of New York, New Jersey, Delaware, Maryland, and Virginia. As part of their 2009 action plan, the five MARCO states agreed to develop a regional, web-based portal for ocean planning. The MARCO Portal Project team develops and improves this portal using funds provided by the National Oceanic and Atmospheric Administration's (NOAA) Regional Ocean Partnership funding program. The team is represented by Monmouth University Urban Coast Institute, Rutgers University's Edward J. Bloustein School and Center for Remote Sensing and Spatial Analysis, The Nature Conservancy, The University of Delaware's Gerard J. Mangone Center for Marine Policy, and Ecotrust.

Through the MARCO Data the following data sets were downloaded to create Marine Spatial Maps:

All Gear Types

This is an extract of Fishing Vessel Trip Report (FVTR) data that The Nature Conservancy compiled from raw data received from the National Marine Fisheries Service (NMFS).
Source: National Marine Fisheries Service

Notes: The owner/operator of a vessel issued a federal fishery permit with FVTR requirements is required to submit FVTRs for each trip taken. The National Marine Fisheries Service requires this information for the conservation and management of marine fishery resources in accordance with the Magnuson-Stevens Fishery Conservation and Management Act. The data reported are used to develop, implement, and monitor fishery management strategies and for a variety of other uses. These data are sufficient for general planning purposes but errors in reporting or in transferring the paper reports to a digital format are not uncommon.

Benthic Habitats (North)

Benthic habitats are based on Ecological Marine Units (EMUs), which represent the three-way combination of depth, sediment grain size and seabed forms based on the ecological thresholds revealed by the organism relationships. Benthic habitats are combinations of EMUs considered with their species assemblages. Thresholds were created by classifying grab samples into organism groups based on similarities in the composition and abundance of the benthic species using hierarchical cluster analysis. To perform this analysis, each grab sample was classified to an organism group, then overlaid on standardized base maps of depth, sediment grain size and seabed forms, and attributed with the information taken from the classified data. Regression trees were built individually for each physical variable to identify critical thresholds that separated sets of organism groups from each other. Regression trees were also built using all variables collectively to identify which variables were driving the organism differences. Each analysis was performed separately by ecological subregion after data exploration revealed that the relationships between genera and physical factors differed markedly among subregions.

Source: USGS, NOAA; analysis by TNC

Notes: This data product was created as part of the Northwest Atlantic Marine Ecoregional Assessment. The Nature Conservancy developed this science-based ecoregional assessment for the Northwest Atlantic Marine region (Bay of Fundy to Cape Hatteras, North Carolina). This assessment synthesizes information on oceanography, chemistry, geology, biology, and social science to inform decisions about coastal and marine ecosystems. The ten categories of targets identified as the primary structure for the marine ecoregional assessment are: coastal and estuarine habitats, benthic habitats, diadromous fish, demersal fish, pelagic fish, forage fish, nearshore shellfish, shorebirds and seabirds, marine mammals, and sea turtles. For more information and a detailed report, please visit http://nature.org/namera/.

Benthic Habitats (South)

Benthic habitats are based on Ecological Marine Units (EMUs), which represent the three-way combination of depth, sediment grain size and seabed forms based on the ecological thresholds revealed by the organism relationships. Benthic habitats are combinations of EMUs considered with their species assemblages. Thresholds were created by classifying grab samples into organism groups based on similarities in the composition and abundance of the benthic species using hierarchical cluster analysis. To perform this analysis, each grab sample was classified to an organism group, then overlaid on standardized base maps of depth, sediment grain size and seabed forms, and attributed with the information taken from the classified data. Regression trees were built individually for each physical variable to identify critical thresholds that separated sets of organism groups from each other. Regression trees were also built using all variables collectively to identify which variables were driving the organism differences. Each analysis was performed separately by ecological subregion after data exploration revealed that the relationships between genera and physical factors differed markedly among subregions.

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Seabed Forms

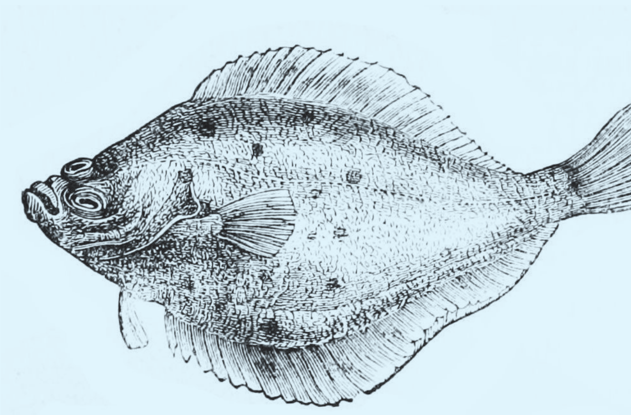
Seabed forms classify seafloor topography into discrete units. Derived from The Nature Conservancy's digital bathymetry, seabed forms can be described by a combination of just two variables: seabed position and slope. Seabed position (also referred to as topographic position or slope position) describes the topography of the area surrounding a particular cell. We based our seabed position calculations on Fels and Zobel's (1995) method, which evaluates the elevation differences between the model cell and the surrounding cells within a specified distance.

Source: NOAA; analysis by TNC

Notes: This data product was created as part of the Northwest Atlantic Marine Ecoregional Assessment. The Nature Conservancy developed this science-based ecoregional assessment for the Northwest Atlantic Marine region (Bay of Fundy to Cape Hatteras, North Carolina). This assessment synthesizes information on oceanography, chemistry, geology, biology, and social science to inform decisions about coastal and marine ecosystems. The ten categories of targets identified as the primary structure for the marine ecoregional assessment are: coastal and estuarine habitats, benthic habitats, diadromous fish, demersal fish, pelagic fish, forage fish, nearshore shellfish, shorebirds and seabirds, marine mammals, and sea turtles. For more information and a detailed report, please visit http://nature.org/namera/.

Sea Level Rise Vulnerability

The goal of this project is to provide a preliminary overview of the relative susceptibility of the Nation's coast to sea-level rise through the use of a coastal vulnerability index (CVI). This initial classification is based upon the variables geomorphology, regional coastal slope, tide range, wave height, relative sea-level rise and shoreline erosion and accretion rates. The combination of these variables and their association to each other furnish a broad overview of regions where physical changes are likely to occur due to sea-level rise. The purpose of this data layer is to allow the user to view both the coastal vulnerability index (CVI) and the data from which the CVI is calculated (tides, wave height, relative sea-level rise, coastal slope, geomorphology, and shoreline erosion and accretion rate) for the U.S. Atlantic Coast. The CVI provides insight into the relative potential for coastal change due to future sea-level rise.



Source: U.S. Geological Survey

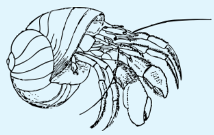
Notes: These data were created to be used for planning purposes only. They are designed to give a broad overview of vulnerability to sea level rise at a National scale.

All Vessels

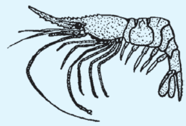
Automatic Identification System (AIS) data are collected by the U.S. Coast Guard using automated two-way radio transmissions to track real-time vessel information such as ship identity, purpose, course, and speed, primarily in coastal U.S. waters. These data layers are derived from archived 2011 AIS data and are intended to be used by the ocean planning community to better understand vessel traffic patterns. The density grids shown here depict the concentration of a majority of commercial shipping traffic within U.S. coastal and offshore waters, though it should be noted that certain vessel types (i.e., fishing, military) are underrepresented. A track line was generated for each unique vessel from a "raw" AIS point database and these track lines were then used to create density grids.

Source: USGS, NOAA; analysis by TNC

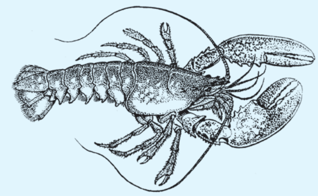
Notes: This is a simplified view of a very complex and detailed data set. Hundreds of millions of individual points were processed and condensed into generalized density grids. These grids show a good overview of the density of most commercial shipping traffic but do not necessarily represent all shipping traffic at a fine level of detail.



Acadian Hermit Crab
(*Pagurus acadianus***)**



Aesop Shrimp
(Pandalus montagui)

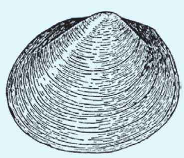


American Lobster
(Homarus americanus)

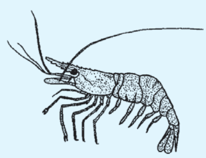
Atlantic Rock Crab
(Cancer irroratus)

Longnose Spider Crab
(Libinia dubia)

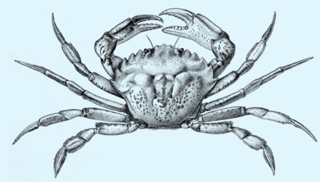
Calcareous coral



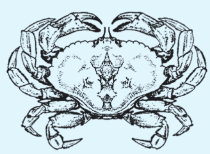
Atlantic Surf Clam
(Spisula solidissima)



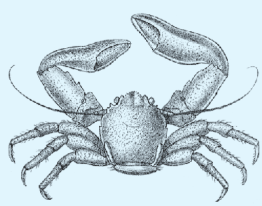
Glass Shrimp
(Palaemonetes paludosus)



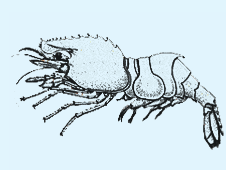
Green Crab
(Carcinus maenas)



Jonah Crab
(Cancer borealis)

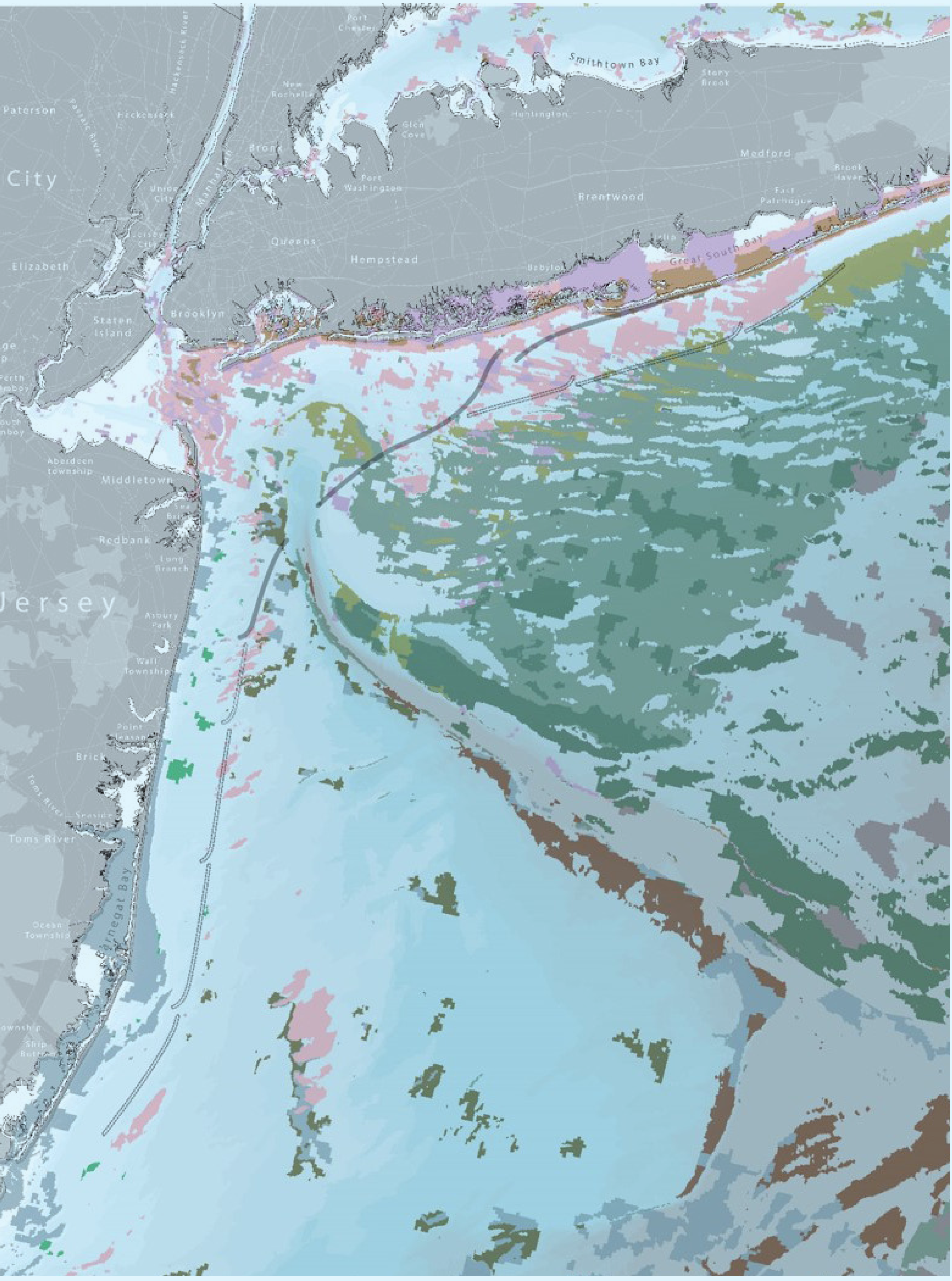


Olive-pit Poreclain Crab
(*Euceramus praelongus)*



Parrot Shrimp
(Spirontocaris spinus)

Sea Scallop


Port Chester
Smithtown Bay
Stony Brook
New Rochelle
Paterson
Hackensack
Glen Cove
Huntington
Bronx
Medford
City
Manhattan
Port Washington
Brentwood
East Patchogue
Queens
Elizabeth
Hempstead
Babylon
Great South Bay
Staten Island
Brooklyn
Aberdeen township
Middletown
Redbank
Long Branch
Jersey
Asbury Park
Wall Township
Brick
Toms River
Seaside
Toms River
Ocean Township
Ship Bottom

B.3
Wave Hazards

B.3.0
Introduction

The size and intensity of storm-generated waves depend on the magnitude of the storm, its sustained wind speeds and the duration of the storm. In general, the maximum breaking wave height at any point along the coast is a function of the water depth at that particular location. When a wave reaches a height equal to three-quarters of the water depth, the wave will break (Figure 6). During calm weather, large waves typically reach breaking depths a few thousand feet from the shoreline. During storm conditions, however, the elevated water levels generated by storm surge allow waves to penetrate much closer to the shoreline, exposing coastal structures to direct wave attack, wave runup and wave-induced scour and erosion (Figure 7).

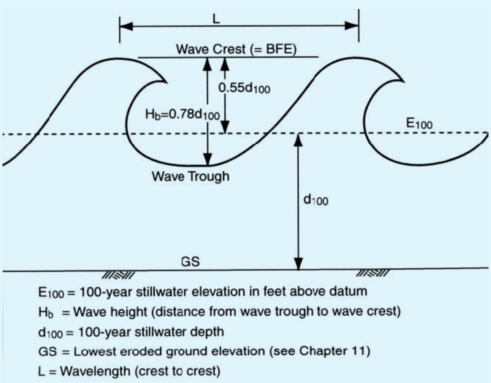


Figure 6: Determination of the Base Flood Elevation (BFE) for regions exposed to wave attack. A wave breaks when it reaches a height equal to 78% of the water depth. At breaking 75% of the wave height is above the still water level and must be added to the flood level. Reprinted with permission from the FEMA Coastal Construction Manual (FEMA, 2000).

B.3.1
Non-breaking Waves

A wave can impact a structure prior to breaking, during breaking, and after breaking. If a wave strikes a solid structure prior to breaking, the wave energy is reflected back

Figure 7: Extensively damaged home south of Litchfield Camp, South Carolina as a result of Hurricane Hugo. In addition to the heavy damage to the structure of the building itself from wind and wave damage, note evidence of wave-induced erosion and scour under the house and around pilings and creation of channels toward the viewer (Photo courtesy of Dr. MaryJo Hall).

toward the ocean. If the incoming wave approaches the structure at an angle, the reflected wave will travel away from the wall at the same angle. Reflected waves apply two times the amount of wave-induced stress on the seabed as a single shoreward propagating wave. The increased bottom stress generates increased erosion and scour at the base of the structure, potentially leading to undermining and collapse (Figure 8).

Figure 8: Brant Beach section of Long Beach Island, New Jersey after the March, 1962 storm. Houses with regular foundations undermined by wave scour on the oceanfront, cinder blocks failed and houses tipped down the scarp (cliff) toward the ocean. The number of damaged homes from this storm led to FEMA subsequently requiring houses in specific zones to be built on pilings (Photo by Al Chance, courtesy of Dr. Susan D. Halsey).

B.3.2
Breaking Waves

The most extreme wave hazard to the built environment occurs when a wave breaks on a structure. As the crest of a breaking wave strikes a solid structure, wave forces 4 to 5 times greater than that from a non-breaking wave are measured. An air pocket formed between the wave crest and trough at impact, compresses during breaking (Figure 9). As the air pocket collapses, the structure is exposed to an exceedingly high-pressure burst of energy. Peak pressures from a 5-foot high breaking wave can exceed 2,000 pounds per square foot (FEMA, 1999). Post storm damage inspections have shown that breaking waves are capable of destroying all wood-frame or unreinforced masonry walls (FEMA, 2000).

As a breaking or non-breaking wave passes under an open foundation, such as the pilings below a fishing pier, the structure experiences an oscillating, high-velocity horizontal flow that peaks under the crest and trough of the wave. Because there is ample open space below pile supported structures the wave energy is allowed to pass through the structure, eliminating any severe loading on the foundation (Figure 10). Maximum vertical velocities occur at the still water level, midway between the wave crest and trough. If the distance between the water level and the bottom of the structure is about ½ the wave height, the horizontal members of the structure, floor or decking, can experience significant uplift forces. Uplift damage frequently occurs to piers (Figure 11) and boardwalks (Figure 12) as waves lift the decking from the pilings and beams.

B.3.2
Wave Runup

Wave run-up refers to the distance a non-breaking or broken wave will travel up a sloped surface or vertical wall. Wave run-up can drive large volumes of water and debris against coastal structures. Strong currents associated with run-up can cause localized erosion and scour (Figure 13). Wave run-up can extend up to the top of bulkheads, seawalls and revetments, allowing a significant volume of water to overtop the structure, causing localized flooding even in protected areas. Uplift forces generated by wave run-up are capable of destroying overhanging decks and porches, as well as flooring under pilesupported buildings (Figure 14).

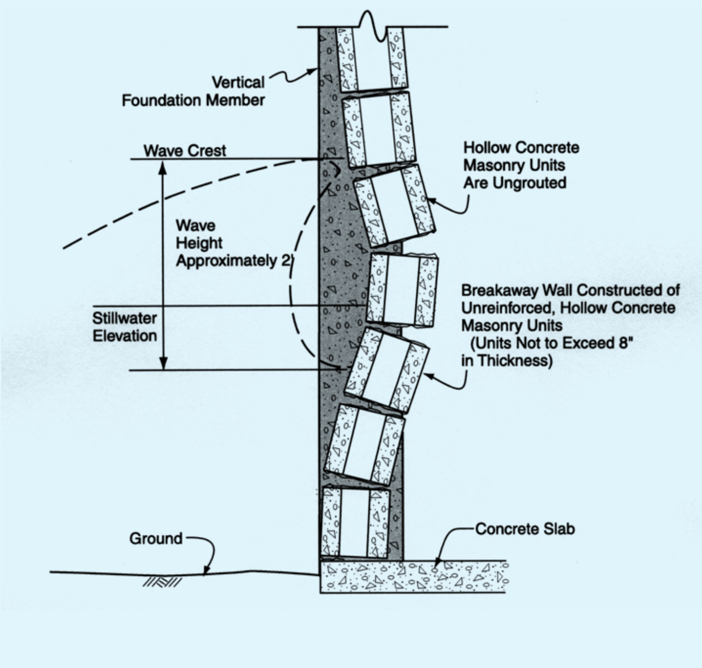


Figure 9: Compressed air trapped between a breaking wave and a vertical wall generates extreme horizontal pressure, often leading to structural failure. Reprinted with permission from the FEMA Technical Bulletin 9-99 (FEMA, 1999).

Figure 10: Large waves passing under a piling supported pier in Ocean Grove, New Jersey (Photograph by Dr. Thomas O. Herrington).

Figure 11: Damage to Atlantic City's Steel Pier from the March, 1962 storm. Note missing center portion removed by wave uplift during the height of the storm (Photo courtesy of Dr. Susan D. Halsey). 22

Figure 12: Damage to the Ocean City, NJ boardwalk from Hurricane Gloria, September 1985. This damage was caused by waves reflecting off the adjacent bulkhead, lifting up sections of the boardwalk and moving the loosened section landward (Photo courtesy of Dr. Susan D. Halsey).

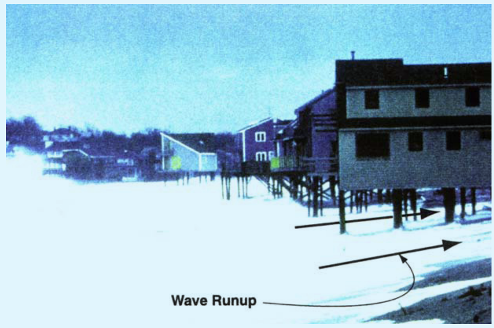


Figure 13. Erosion due to wave runup under elevated buildings in Scituate, Massachusetts (Photograph by Jim O'Connell).

Figure 14a. Brighton Beach Condominiums with decks overhanging primary bulkhead, 5th Street, Ocean City, New Jersey prior to March 28-29, 1984 northeaster. Storm waves lifted up the decks that had been tied into the interior of the house damaging the entire living rooms. The City condemned the buildings until the structure of the units were repaired, and passed an ordinance that prohibited decks to be tied into the main part of the house. Decks now have to be freestanding (Photo courtesy of Dr. Susan D. Halsey).

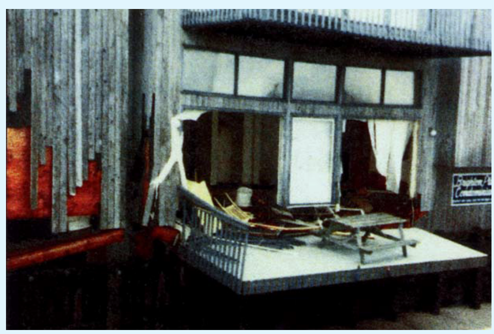


Figure 14b. Damage to an oceanfront residence in Ocean City, New Jersey due to wave run-up on a timber bulkhead (Photograph by Mark Mauriello).

B.3.3
Non-traditional Shore Protection Structures

Responsible Agency/ Party:	• Federal and/or state sponsored projects • Municipal or community initiated • Homeowner or industry initiated
Mitigation for:	• Long– and short-term erosion • Flood hazards • Wave hazards
Management Effort:	• Low to High

As research and experimentation continue, new techniques for shoreline stabilization will be proposed and developed (Herrington et al., 1998). In many instances, these approaches "work with nature" rather than simply constructing a barrier as a solution to erosion or wave attack. Increasingly, a shoreline stabilization structure can be hidden in the natural environment and only exposed, if at all, during severe storm events.

Dewatering Systems

Dewatering refers to the drawdown of the water table under the beach foreshore by a system of perforated pipes and pumps. By lowering the natural water table, the porosity of the beach is increased allowing water that would normally run up and down the foreshore slope to percolate down through the sand. Any sediment being carried by the water is deposited on the beach creating a zone of sand deposition (Figure 15). The beach response to a dewatering unit is similar to that of an offshore breakwater system however, in the absence of wave energy reduction, sediment is more easily eroded during storm events. The effectiveness of the system is also dependent on the reliability of the pumps, the maintenance of the pipes and the availability of sand.

Hardened Dunes

Dune hardening refers to the process of constructing a solid core in the center of a manmade dune system to act as a shore-parallel barrier to wave attack during severe storms. The dune core can be constructed of clay berms, rock revetments or seawalls, pre-cast concrete units or sand filled geotextile tubes. In all cases, the core is designed to promote the development of a natural dune on top of, and around the structure and can include appropriate drainage and soil conditions for the establishment of dune grasses and other plants. Some pre-cast concrete units include hollow interiors to promote sand deposition and plant establishment. Once exposed during a storm, the core of the dune acts as a traditional shore protection structure and must be re-covered with sand after the storm event.

Hardened dunes have been used extensively in New Jersey. Sand filled geotubes have been used in Whale Beach, Avalon, and Atlantic City. Clay berms have been used in Long Beach Township on Long Beach Island. Many relict rubble mound seawalls have also become the core of natural dune systems over time (Figure 16).

Figure 15: STABEACH dewatering system in Cod Fish Park, Nantucket. Dashed line indicates the location of the buried dewatering pipe. Note the bulge in the shoreline generated by the deposition of sediment in the swash zone over the pipe (Photograph courtesy of Coastal Stabilization, Inc.).

Figure 16: Exhumed portion of small rock seawall under dunes in northern section of Bay Head, New Jersey after a severe storm. Many residents were unaware that this seawall existed because it was completely covered by extensive dunes (Photograph by Dr. Susan D. Halsey).

Viscous Drag Mats

Sometimes refereed to as artificial seaweed, viscous drag mats are comprised of buoyant, high-strength plastic fronds woven into a weighted or anchored mat that is placed on the seabed. The fronds create a high-density, vertical lattice that interrupts fluid flow and decreases the velocity of near bottom currents. By interrupting currents, the mat promotes the deposition of sand thereby reducing erosion. Viscous drag mats have worked extremely well in deep water applications, by reducing scour around submerged pipelines and the bottom of drilling rigs. In coastal environments, the mats are only effective in low wave energy environments and are well suited to use in front of bulkheads and revetments where scour is a problem or the re-establishment of a more natural shoreline is desired.

Geotubes

Geotubes are porous textile tubes designed to hold sand but allow water to percolate through. Although geotubes are not in themselves a shore protection device, they are commonly used in shore protection structures. When filled, geotubes are as hard as traditional shore protection structures, but their use is considered by many as a “soft solution” to shore protection as the tubes can be easily removed by cutting the geotextile and pulling the bag out, leaving the sand fill on the beach. Geotubes have been used to create hardened dunes, revetments, groins

Figure 17: Sand filled geotube used to create the core of a protective dune line (Photograph by Dr. Michael S. Bruno).

and submerged sills (Figure 17). However, geotubes have a tendency to degrade over time and are prone to tearing, punctures and settlement. Proper maintenance and foundation preparation is required.

B.3.4
Coastal Resource Management

Along most coasts, sand is a finite resource that is always in motion in response to waves, currents and wind climate. In regions where the net yearly transport of sand is in one direction along the coast, coastal managers can use techniques to re-circulate the sand in the system, bypass or back-pass obstructions to sediment transport and redistribute sand across the beach profile. In addition, coastal managers can take steps to insure that sediment sources remain unconstrained (not encased behind bulkheads or similar structures) and that sediment sinks, such as inlets and offshore canyons, are avoided. By carefully managing our sand resources, the existing long- and short-term erosion, flood

Responsible Agency/ Party:	• Municipal or community initiated • Homeowner or industry initiated
Mitigation for:	• Long– and short-term erosion • Flood hazards • Wave hazards
Management Effort	• Moderate

and wave hazard levels can be maintained and perhaps slightly reduced over time.

Regional Sediment Management

Regional sediment management refers to the process of recirculating sediment along specific reaches of coast with similar sediment transport patterns. The process may include the impoundment and mining of sand at the updrift end of the coastal reach and the transport and redistribution of that sediment along the downdrift beaches. Mechanical scraping and movement of sand by pan scrapers or front-end loaders can achieve similar results on smaller scales. By returning the sand to the beginning of the coastal reach, sand is conserved and long-term erosion is reduced. However, the amount of material removed from the updrift limit of a coastal reach should not, of course, exceed the volume of material expected to replenish the area between mining operations.

Sand Bypassing

Where a natural coastal feature or structure completely blocks the transport of sand, several techniques can be used to transfer (bypass) the sediment around the obstruction. Natural sand bypassing can be used to divert sand from the updrift shoreline out onto a natural bar or ebb shoal feature that extends around coastal headlands or inlets. This allows natural transport mechanisms to continue the motion of the sand down the coast.
Forced sand bypassing employs mechanical methods such as mining and hauling to move sand around a barrier or pump sand across it. The volume, rate and frequency of sand bypassing are determined by the natural net sediment transport rate along the coast. At stabilized inlets, it is common to delineate an impoundment area that is mined once a specific volume of sand is deposited within it. In some instances, updrift jetties have been constructed with weir sections that allow sand to cross into the inlet and settle into a deposition basin (Weggel, 1981). At specific intervals the basin is dredged and the sand placed on the downdrift side.

Beach Scraping

Beach scraping is a technique used to move small volumes of sand that have accumulated in the intertidal zone to a beach berm or dune area during accretionary periods (Herrington, 1994). Bulldozers, pan scrapers or front-end loaders remove a veneer (< 6 inches) of sand from the low water line at low tide. The goal is to remove only that quantity of sand that can be replenished during the following tidal cycle. If repeated over a prolonged period of accretionary conditions, the technique can increase the volume of the dry beach, providing some mitigation for short-term erosion. Beach scraping in New Jersey has often been used to build a protective dune immediately prior to the arrival of a coastal storm. Large volumes of sand are moved from the beach foreshore into the dune. Scraping in this manner actually makes the beach more vulnerable to severe erosion by steepening the slope of the dry beach and allowing the larger storm waves to undermine the lower beach foreshore (Herrington, 1994). To be effective mitigation, beach scraping must be conducted over a prolonged period of calm weather conditions.

B.3.5
Natural Resource Restoration

Responsible Agency/ Party:	• Municipal or community initiated • Homeowner or industry initiated
Mitigation for:	• Long– and short-term erosion • Flood hazards • Wave hazards • Wind hazards
Management Effort	• Low to Moderate

Most coastal landscapes are composed of two types of geologic features; loose granular soils and eroding headlands. This composition allows the land to rapidly adjust to varying amounts of wave and wind energy and reach equilibrium between the amount of incident energy and the amount of energy dissipated along the coast. In addition to the physical forces in the environment, saltwater flooding and salt spray creates an extremely harsh environment for plants and animals. The rather unique diversity of plant and animal life along our coastal margins is the result of millions of years of adaptation to these harsh conditions. As communities work toward mitigating hazards along the coast, careful consideration should be given to restoring the natural features of the coastal environment. Features such as dunes and coastal marshes naturally mitigate coastal erosion and flood hazards.

Dunes provide a buffer between the ocean and the most seaward buildings and infrastructure along the coast. In addition, dunes store a significant volume of sand that can be released during extreme storm surges and wave events, providing the eroding beach with an additional layer of protection. They can be easily created by placing obstructions along the backshore to trap windborne sand and other particles. Wooden dune fencing or natural vegetation, such as American beach grass, will quickly begin to accrete sand. As the dune grows horizontally and vertically, additional layers of fencing or plantings can be used to incrementally increase the volume of the dune and the level of protection it provides. Although dunes grow and migrate in response to the wind, a properly vegetated dune provides a windbreak for down-wind structures and reduces the amount of sand blown landward of the beach.

Dunes are a unique and valuable coastal resource, providing habitat and protection for a number of endangered and threatened species including shore birds, small mammals (e.g., red fox) and crustaceans. As beach restoration projects continue to recreate lost shoreline many of these species are returning to the New Jersey coast and consideration should be given to enhancing their habitat. Dunes are also a component of the natural landscape adding to the aesthetic beauty and value of the coast. As coastal communities work to restore coastal resources lost to development and natural processes, private and municipal shorefront property owners should consider allowing the establishment or preservation of coastal dunes as a way to enhance the natural environment as well as mitigate the level of flood and wave hazards. If planned correctly, buffer areas can be left on oceanfront lots that will accommodate the growth and potential migration of the dune.

Coastal wetlands provide a buffer between bays or sounds and coastal uplands. Wetlands dissipate wave energy, trap sediments, and via their storage capacity, reduce the velocity of floodwaters during storm events. Coastal wetlands are also extremely productive coastal habitats, providing nutrients, shelter and nurseries to the young of a multitude of species. As the coastal zones were developed, many wetlands were dredged, filled or bordered by bulkheads. An unintended consequence of these construction practices was the erosion and degradation of the surrounding wetlands. Increased wave energy from pleasure boats, or reflected waves (e.g., from bulkheads) and the subsidence of marshlands due to reduced sediment supply has lead to a rapid loss of coastal wetlands and a higher susceptibility of the bay shore to flood and wave damage. As development and redevelopment occurs along the coast, mangers should consider construction techniques that will reduce the rate of surrounding wetland loss. Shore protection measures that dissipate instead of reflect wave energy should be encouraged. Similarly, strong consideration should be given to restoring and conserving wetlands along the coast. Best management practices include planting marsh vegetation, shoreline nourishment and planting, creation of perched sills seaward of wetlands, and the deployment of temporary wave attenuation barriers along eroding wetlands. Although too voluminous to list here, a tremendous amount of useful information for coastal marsh and bay shore restoration and protection practices can be found in the Soundfront Series, published by North Carolina (e.g., Rodgers and Skrabal, 2001; Clark, 2001).

Coastal property owners considering landscaping alternatives should give thought to planting native species. Not only are these forms uniquely adapted to the coastal environment, proper landscaping also acts to reduce flood hazards by decreasing runoff and high velocity flood waters. Given the unique environment of the coast, property owners should be encouraged to plant natural vegetation rather than recreate suburban landscapes.

As a community seeks to restore the natural resources of the coastal environment, the dynamic nature of the coastal environment must not be forgotten. Our coastal margins are uniquely adapted to rapid changes in landform and climatic conditions. One significant storm event can radically alter the geography and distribution of native species for years. Restoring, manicuring, and building beaches, dunes and marshes through filling, scraping, grading, staking, planting and fencing can camouflage the mobility of the natural environment and convey a false sense of stability and permanence. Stability is not a natural attribute of the coastal zone and should not be depended upon for long-term mitigation. A truly functional and natural coastal ecosystem is highly variable.

B.3.6
Building Techniques

Responsible Agency/ Party:	• Homeowner or industry initiated
Mitigation for:	• Flood hazards • Wave hazards • Wind hazards
Management Effort	• Low

Over the latter half of the 20th century, great strides have been made in the design and construction of residential buildings to withstand the extreme forces that occasionally occur in the coastal zone. Many best management practices have been derived from the analysis of structural failures during coastal storms. As a result, homeowners and builders now have a variety of low-cost building materials, building techniques, and design options to mitigate potential storm damage. Architects and engineers should ensure that all loads (wind and water) have a direct path from each structural member to the foundation. In more contemporary structures with large open interiors, the inclusion of appropriate interior shear walls should not be overlooked. Large windows should be surrounded by appropriate framing to reduce side loads. Gable roofs and porch overhangs should be properly designed to resist uplift forces from strong winds. Proper nailing patterns should be applied to sheathing and framing to reduce the chance of uplift. Deck and porch overhangs exposed to wave forces should be properly anchored to prevent uplift. FEMA's coastal construction manual provides design details for those wishing to minimize hazards to their dwellings and businesses (FEMA, 2000).

Inexpensive approaches to reducing hazards to existing buildings include window shutters, hurricane straps placed on roof framing, unbreakable shingles and proper door connections. For flood and wave protection, enclosed areas under the base flood elevation should be constructed with breakaway walls, proper connections between pilings and floor framing should be used and maintained, and proper cross-bracing (perpendicular to the water motion) should employed. All connectors, fixtures and coatings should be constructed of anticorrosive materials and the regularly inspected and maintained over the life of the structure.

Homeowners should be aware of external utilities, tanks and furniture that are not part of the existing structure, or affixed to it. Propane, oil, gas and water tanks that can be lifted by floodwaters should be anchored to concrete pads or held in place with anchoring straps and earth anchors. Outside utilities, including air-conditioning units and electrical boxes should be elevated above the base flood elevation. Carports or storage areas under buildings should not have poured concrete pads or grade beams attached to support pilings. Also, outdoor furniture, decoration or anything that can be lifted by wind or water should be properly stored prior to a storm to eliminate the potential of those items becoming wind or water borne debris.

Appendix C

Financial Modelling

C.1
Catastrophe Risk Engineering

C.1.0
Catastrophe Modeling and Why it Matters

AIR Worldwide (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 90 countries. More than 400 insurance, reinsurance, financial, corporate, and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, detailed site-specific wind and seismic engineering analyses, and agricultural risk management.

So how do these models work? AIR models are based on sophisticated simulation methods and powerful computer programs that capture how catastrophes—both natural and man-made—behave and impact the built environment. AIR scientists and engineers combine simulations of the natural occurrence patterns and characteristics of hurricanes, tornadoes, severe winter storms, earthquakes, and other catastrophes, with information on property values, construction types, and occupancy classes. Model output provides information concerning the potential for large losses before they occur so companies can prepare for their financial impact.

C.1.1
Risk Assessment and Catastrophe Models

Catastrophe models provide detailed output from which various measures of loss potential and risk can be derived. One example is the average annual loss (AAL), which refers to the loss that can be expected to occur per year, on average, over a period of many years. Another important output is the exceedance probability (EP) curve, which reveals the probability that a loss of any given size (or greater) will occur in the coming year. Today, catastrophe model output is the basis for understanding and quantifying catastrophe risk. It is the "currency" by which risk is priced, transferred and traded. AIR modeling is used extensively for pricing, risk selection and underwriting, loss mitigation activities, reinsurance decision-making and overall portfolio management. But it is not just the insurance industry that looks to AIR for help. Applications of the technology have broadened to serve the needs of corporate risk managers, government agencies, investors, hedge funds and other financial institutions, and a wide variety of other stakeholders exposed to catastrophe risk.

While catastrophe models begin with the same historical data, different assumptions used in the model development can lead to differences in model output. To ensure that final model results are both realistic and robust, AIR builds its models from the ground up, validating each component independently. Critically, we also validate the models from the top down to ensure that final model results make sense.

Economic and Financing Considerations Modeling Sandy with and without the Offshore Dunes

The model developed by AIR, shows a damage reduction projection based on the effects of the offshore dunes, under conditions from a storm like Sandy, and gives figures based only on damage to private property and contents, both residential and commercial, for that storm. The scope of this analysis thus far does not take into account the great savings potential of this project when considering risk exposure from other types of storm paths, the damage to public infrastructure, business interruption, and impact reductions to less fiscally visible yet vulnerable communities. In addition measuring the value to the insurance industry has historically been double these figures.

Furthermore, this project has great potential to be an economic engine for a relatively untapped ocean based market; one that could generate construction, engineering, and other technical employment, and drive a renewed agenda for the exploration of ocean based planning, physics, chemistry, biological and energy-based systems.

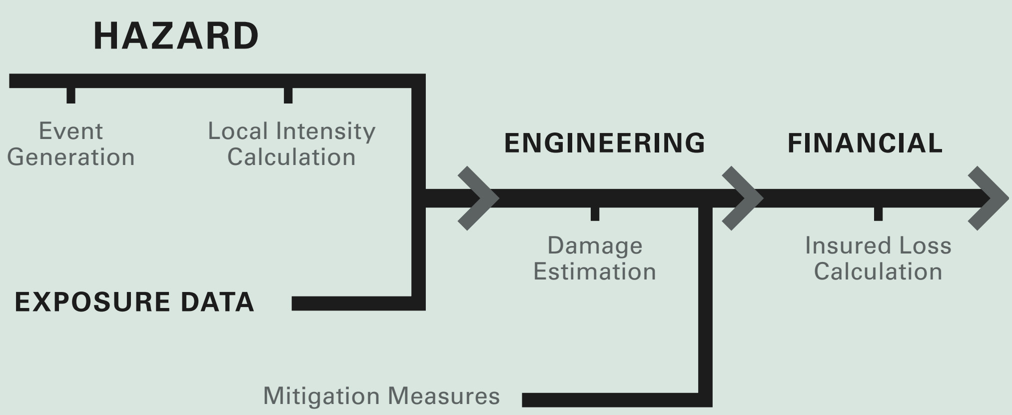
In terms of financing, the goal is to create a structure whereby debt to fund the construction would be repaid out of a portion of the savings from reduced future damage costs, either directly or indirectly, in the form of lower insurance premiums or other risk pooling or shifting payments. Financing is likely to come about through the use of some form of municipal bond structure that could be a combination of revenue based with appropriation back-stop mechanisms.

C.1.2
AIR Methodology

As storms become more catastrophic, here measured in billions lost in USD, the probability of them occurring also drops. AIR estimates the Insured Losses for Sandy are between $16 and $22 Billion. Measuring the value to the insurance industry has historically been double these figures and is currently higher than this. A loss event of the size of Sandy falls just below the 1% annual probability or 1-in-100 year return period event. Note: AIR's estimates include both wind and surge damage.

CAT models produce a risk profile in the form of an Exceedance Probability (EP) Curve. Different size losses along the EP Curve are associated with different annual probabilities. By introducing mitigation measures, the risk profile changes - ideally reducing the losses. By integrating between the original curve and the reduced curve, the benefit of the mitigation measures may be quantified.

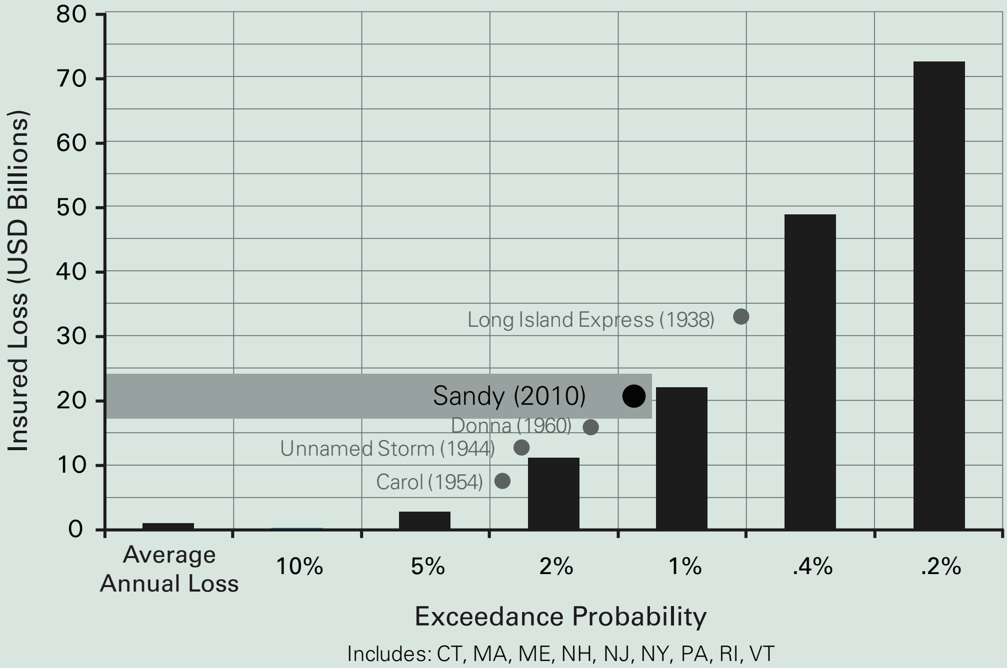
By utilizing AIR's catastrophe modeling framework with Stevens Institute's two surge foot prints, we can estimate the reduction in losses based on the reduced surge intensity due to EPIC. The following slides show an overview of the estimated loss reduction for the entire region and particular sub-areas that comprise the Rebuild By Design competition. Note: Each component of AIR's models is developed, calibrated, and validated as a cohesive whole. By decoupling the hazard model from the other components, uncertainty is introduced to the catastrophe



Hazard: AIR utilizes large catalogs of simulated catastrophes to represent the entire spectrum of plausible events. These catalogs answer the questions: Where are future events likely to occur? How large or severe are they likely to be? And how frequently are they likely to occur? For each simulated event, the model calculates the intensity at each location. Note: AIR's stochastic catalogs were replaced with the single event surge data provided by Stevens Institute.

Engineering: Measures of intensity—wind speed, ground shaking, flood depth—are then applied to highly detailed information about the properties that are exposed to them. Estimates of physical damage are translated into estimates of monetary damage.

Financial: For each simulated event, insured losses are calculated by applying mitigation measures to the total damage estimates (e.g. – policy conditions, physical mitigation, or emergency business continuity plans).



As storms become more catasrophic, here measured in billions lost in USD, the probability of them occuring also drops. AIR estimates the Insured Losses for Sandy are between $16 and $22 Billion. A loss event of the size of Sandy falls just below the 1% annual probability or 1-in-100 year return period event. Note: AIR's estimates include both wind and surge damage.

risk assessment. Consequently, direct comparisons should not be made between AIR's industry loss estimates and the estimates obtained using Stevens' surge data.

For RBD, AIR decoupled the modules of its catastrophe modeling framework in order to utilize the Stevens' Institute's Sandy surge inundation data.

Stevens developed two inundation files.

1. Sandy as it occurred
2. Sandy as mitigated by the full island EPIC proposal.

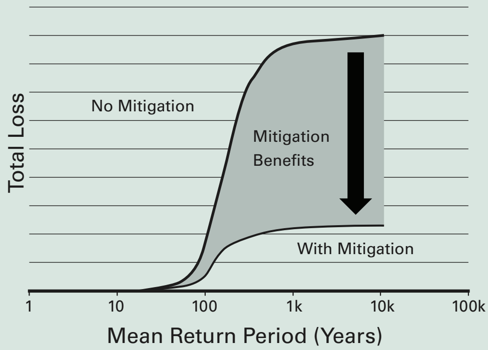
Stevens' surge data was combined with AIR's high resolution Industry Exposure Database (IED).

The IED contains:

- Property locations for individual commercial properties
- Census block aggregated residential properties.
- Property counts (residential and commercial)
- Replacement values
- Occupancy
- Physical characteristics
- Standard insurance policy conditions (limits and deductibles)

Each exposure in the IED is represented by a combination of occupancy, construction, and other physical characteristics that aid the selection of the most appropriate damage function.

Each Stevens Institutes' Sandy surge inundation footprint was overlaid with the IED to obtain an estimate of the Total Exposed Values. By taking a difference between the Total Exposed Value of each footprint, we can estimate the reduction in Total Exposed Values resulting from the EPIC proposal for a single event (Sandy) With this analysis of Sandy by the Stevens Institute and AIR, we have assessed the impact of EPIC on the Northeast region for a single point on each EP Curve. As there are a multitude of potential storm intensities, landfall locations, and landfall angles (among many other event characteristics), a more thorough assessment of the storm surge potential and the EPIC impact across many more potential events and obtain a more robust risk assessment and mitigation study.



CAT models produce a risk profile in the form of an Exceedance Probability (EP) Curve. Different size losses along the EP Curve are associated with different annual probabilities.

By introducing mitigation measures, the risk profile changes - ideally reducing the losses. By integrating between the original curve and the reduced curve, the benefit of the mitigation measures may be quantified.

	Ground Loss ($B)	Insured Loss* ($B)
Before Mitigation	81.73	44.78
After Mitigation	63.05	33.45
Total Δ	18.68	11.33

By utilizing AIR's catastrophe modeling framework with Stevens Institute's two surge foot prints, we can estimate the reduction in losses based on the reduced surge intensity due to EPIC. The following slides show an overview of the estimated loss reduction for the entire region and particular sub-areas that comprise the Rebuild By Design competition.

Note: Each component of AIR's models is developed, calibrated, and validated as a cohesive whole. By decoupling the hazard model from the other components, uncertainty is introduced to the catastrophe risk assessment. Consequently, direct comparisons should not be made between AIR's industry loss estimates and the estimates obtained using Stevens' surge data.

C.2
Economic and Financing Considerations

C.2.0
Introduction

The model, developed by Stevens Institute and AIR Worldwide, shows damage reduction projections based on the effects of the offshore structures under conditions from a single storm event, like Sandy, and gives figures based only on the storm surge damage to private property and contents, both residential and commercial, for that storm. The scope of this analysis thus far does not take into account the great savings potential of this project when considering risk exposure from other types of storm paths, the impacts from business interruption, and the damage to public/private infrastructure and less fiscally visible yet vulnerable communities.

C.2.1
Initial Valuation Analysis

Timing and funding constraints limited the team's ability to undertake a full cost-benefit analysis, however the team understood the need to have a high-level, order of magnitude estimate of benefits or "value" for the project. In order to advance this discussion, the team leveraged the report "A Stronger More Resilient New York" released in 2013 to consider the potential benefits to just New York City, which would correspond to a majority portion of the Phase 1 project benefit (off-shore structures placed at the New York Harbor entrance). The estimated benefits were calculated by multiplying the average percentage benefit found through the team's modeling (approximately 15%) by $3 billion, the median of New York City's average annual expected storm loss today ($1.7 billion) and in 2050 ($4.4 billion with the increase attributable to sea level rise and changing hurricane patterns) . The New York City analysis takes into account damage from tropical cyclone impacts (both wind and storm surge), which may be mitigated by the offshore structures, as well as other factors such as height and placement of infrastructure on the offshore structures, such as wind turbines (see Science Colloquia presentations), but which have not yet been studied through the Team's work. This methodology results in an annual average loss savings of approximately $450 million. From this, the operation and maintenance of the structures, estimated at approximately $125 million annually, was subtracted, for a net annual savings of $325 million.

The benefit analysis also includes an estimate of possible "new activity" value from the offshore structures, which could include airport uses, fees related to energy generation from wind turbines, and recreation related income. In this estimate, all of the annual "new activity" value, taken together, is less than 20% of the total value of the structures; however, in future analysis, the value of new activity would be studied more closely to ensure all feasible and community supported uses that could be of economic and financial value to the project were included. Furthermore, this project has great potential to be an economic engine for a relatively untapped ocean based market; one that could generate construction, engineering, and other technical employment, and drive a renewed agenda for the exploration of ocean based planning, physics, chemistry, biological and energy-based systems, which has yet to be built into the comprehensive cost-benefit analysis/valuation discussions.

A growth factor of 10% was applied to the value from reduced damages, or savings, to account for the increasing costs of vulnerable assets on the coastline, as well as new development/assets that would be placed in flood plains. Due to further study required in the "new activity" area, no growth factor was assumed for this annual income stream. The two annual benefit streams were then discounted at 5%. The time period considered was 40 years, which corresponds to a long-term financial bond instrument. The net present value of the savings and new activity income is approximately $37 billion. If a capital charge of two times is applied to the reduced damage figure, the benefit rises to $72 billion, which is more than 2 times Arcadis' cost to construct estimates.

As mentioned above, this analysis does not yet take into account the potential economic and fiscal impacts that such a large-scale infrastructure project would have on the regional and national economies, providing thousands of temporary construction jobs, and hundreds if not thousands of ongoing maintenance jobs as well as spawning a new coastal planning and infrastructure sector which would itself create other new economic activity.

C.2.1 Financing

In terms of financing, the goal is to create a structure whereby debt to fund the construction would be repaid out of a portion of the savings from reduced future damage costs, either directly or indirectly, in the form of federal savings from disaster relief appropriations or from reduced need for subsidies to the National Flood Insurance Program, and/or lower insurance premiums or other risk pooling or shifting payments that could be captured at the point of purchase or through a federal/regional capture intermediary. For the "new activity" financing, a more straightforward public-private partnership funding mechanism would be possible. Depending upon final structure, from initial conversations the team has had with financial experts in the risk field, it is reasonable to assume that pension funds and other infrastructure investors would find this an attractive investment.

C.3

Cost/Benefit Analysis

a. Based on National Flood Insurance Program premium growth rates for policies written after 10/1/13
b. AIR estimates from Sandy run across region
c. Based on "NYC: A Stronger More Resilient NY" midpoint estimate (bet. current and 2050) NYC annual average loss
d. Assumes efficiency based public financing structure, with possible segmented issuance tied to private insurance savings
e. Licensing/rental, annual—needs research
f. Licensing/rental, annual—needs research
g. Rental/taxes/PILOT/other fees, annual—needs research
h. Assumes public-private financing structure based on new income from islands as repayment source
i. Capital charge reflects insurers charges above ave. loss as well as costs of reserving funds for self-insurance activities

Offshore Wave Mitigation - Phase 1, NYC Harbor	
High-Level Value Analysis	
A. Value from Savings	
5.00%	Discount rate
15%	Percent of reduced damages (a)
10%	Growth factor (b)
40	Period, years
$ 3,000,000,000	Ave Annual Loss (c)
$ 450,000,000	Ave Annual Savings
$ -125,000,000	O&M for Offshore Structures (just Phase 1)
$ 325,000,000	Remaining for Debt Service (d)
$ 35,287,731,944	A. NPV, Amount that could be raised to pay for Construction from Savings
B. Value from New Activity	
$ 20,000,000	Recreation (e)
$ 20,000,000	Wind Turbines (f)
$ 40,000,000	Other - including regional airport, other transit depot (g)
$ 80,000,000	Remaining for Debt Service (h)
$ 1,372,726,908	B. NPV, Amount that could be raised to pay for Construction from New Activity
$ 36,660,458,853	A + B, Total NPV
$ 1,948,190,797	Applying Capital Charge to "A" Savings Value (2x) (i)

Sensitivity Analysis	
Discount Rate	**Total NPV of Savings and New Activity Revenue Streams**
3%	$61,623,805,771
4%	$47,229,710,393
5%	$36,660,458,853
6%	$27,626,656,203
7%	$21,909,661,923

As mentioned above, this analysis does not yet take into account the potential economic and fiscal impacts that such a large-scale infrastructure project would have on the regional and national economies, providing thousands of temporary construction jobs, and hundreds if not thousands of ongoing maintenance jobs as well as spawning a new coastal planning and infrastructure sector which would itself create other new economic activity.


Hudson Canyon
BOATS
EMERGING
WETLANDS
SEALS
FISHES
RICREATIONAL
FISHERIES
BIRDS
NATURE ISLAND
BIRDS
WHALES
FISHES
FISHES
SALT
MARSHES
SEALS

Appendix D

Technical Feasibility

D.1
Implementation Strategy

D.1.0
Introduction

The Offshore Landscapes in the Mid Atlantic are a long-term and grand-scale plan to decrease the impact of storm surges on the greater New-Jersey-New-York area and the Long Island Sound. The plan encompasses the construction of a chain of barrier islands seaward of today's shoreline. Creating such a chain of barrier islands requires the redistribution of unprecedented billions of cubic yards of sand, clay and rock.

In this stage the plan is a sketch design and (technical) details are not yet available. In this memo basic questions regarding the technical feasibility and the costs are addressed. Furthermore elements for an implementation plan are presented.

D.1.1
Technical Feasibility

D.1.1.0
The Logic of a Sandy (Soft) Line of Defence

The offshore landscapes in the Mid Atlantic are envisaged as a chain of sandy barrier islands, with a beach, shoreface and dunes. These islands resemble their natural equivalents on today's Atlantic coast. An obvious question is why the barrier islands are sandy ? Rock and concrete seem to be more obvious materials to withstand the immense forces that batter this first line of coastal defence during storms. The answer lies in 'adaptation'. A sandy coast will adapt to the conditions of a storm through changes of the profile. Sand will be transported from the dunes and the beach and the shore face until an equilibrium profile is formed that absorbs and reflects the storms energy. Adaptation continues after the storm, when regular waves will return at least part of the sand back to beach and the wind will redevelop some of the dunes.

A dam or dike of stone and concrete is not an adaptive structure. The hard structure has to designed to withstand the tremendous forces. The design conditions for the offshore Atlantic are extreme and will require large and heavy elements. If, despite all efforts, the structure is damaged during a storm it is, the damage is permanent and repairs are required.

"Studies are how we move resiliency forward, USACE uses the term Reconnaissance Study for their work that has to proceed any implementable project. So we look at this the same way and understand that the results show that the idea is viable and implementable but what comes next; studies in a variety of disciplines to refining and optimizing the design to provide benefits and lessen adverse impacts is critically important to the field of engineering and to American industry."

Maintenance of a sandy barrier is relatively simple. Sand nourishments restore the volume of the barrier and thus bring the strength of the barrier up to standards. Adaptation to sea-level rise or an increase in storm-intensity also takes the form of nourishments, to increase the volume of the barrier. A dam or dike will require more specific work. And adapting a hard structure to changing conditions is a challenge.

D.1.1.1
Can it be Made?

The next question to be answered is the achievability: Can a chain of barrier islands be constructed? Or will the ocean currents, tides and waves wash the sand away before the island emerge? The answer to these questions is: Yes, it can be constructed, if a sufficient amount material (sand, clay, rocks) is deposited per unit time. This is a question of balance: if more material is dumped than the transported away by natural processes a structure will develop. It will require detailed simulations of the currents and waves and the resulting sediment transport to determine the needed rate of material delivery. And with a smart design the sediment that is transported away from the disposal site can form the fundament for further construction.

D.1.1.2
Sediment Availability

Construction and maintenance of a chain of barrier islands will require large volumes of material. This material has to be present (5-10 kilometres) nearby on the sea floor, so dredgers can transport the material over relatively short distances and with relative ease. Alternative land-based sources of material are not considered because of the complexity of the transport and the resulting costs. A primary requirement is therefore the availability of construction material on the sea floor. The New York bight has been surveyed intensively by the USGS and the knowledge of the sea-floor composition and subsurface stratigraphy is good. It shows that there is sediment present at minable water depths, but not everywhere and with varying thicknesses. At this stage the conclusion is that the volume of sediment nearby will be sufficient for the construction and maintenance of the barrier-island chain.

D.1.2
Outline of the designs

D.1.2.0
Schematic Cross Section of the Barrier Islands

In a schematic cross section (Figure 1) of the barrier islands is presented, with the lengths, height and slopes. Please note that these slopes are used for calculation purposes only; during and after construction different slopes will develop. Specifically the 1/30 slope on the seaward side is steeper than the natural slope and offshore redistribution may be significant. The cross section of the barrier determines with the total length of the barrier islands the sediment volume.
The volume per m of the barrier island follows from:

VTotal = V1 + V2+ V3+V4

With:

V1=H1 x W1
V2=H2 x (W1/2)
V3=H3 x (W3/2) = H3 x ((H1 x Slope3)/2)
V4=H4 x (W4/2) = H4 x ((H1 x Slope4)/2)

For the sedimentvolume the most important variables are:

Water depth H1
Barrier width W1

Variables of lesser importance for the sediment volume are:

Dune height
Dune slope

The underwater slopes are design variables when combined with measures likes revetments, artificial reefs or support berms (Figure 2).

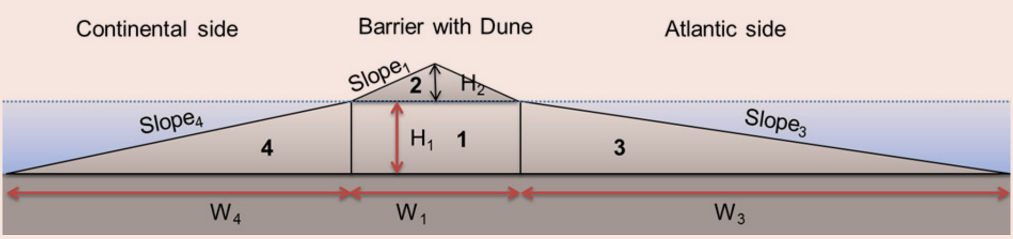


Figure 1: Schematic cross section

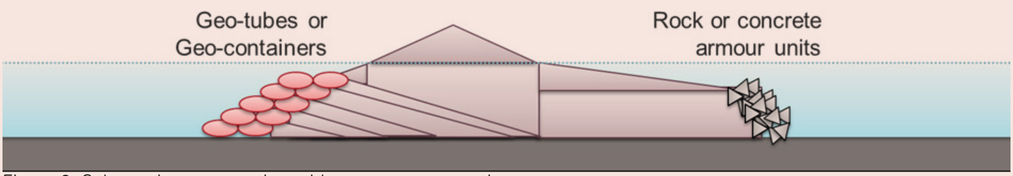


Figure 2: Schematic cross section with support constructions.

D.1.2.1 Water Depth

The average water depth on the New York bight transects is 20 m (Figure 3). With an additional 1 m to count for the accuracy of the data a water depth of 21 m is used in the caluclations.

For comparison a wide and a narrow barrier have been used. The dimensions are in shown below (Table 1).

D.1.2.2 Length of the Barrier Island Configuration

Full Barrier-Islands chain (Stephens)

The Full barrier-island chains covers the original configuration that was used the Stevens Institute of Technology to calculate the reduction of the storm-surges. It consists of barrier island on the New Jersey and New York shores in the New York Bight and on the

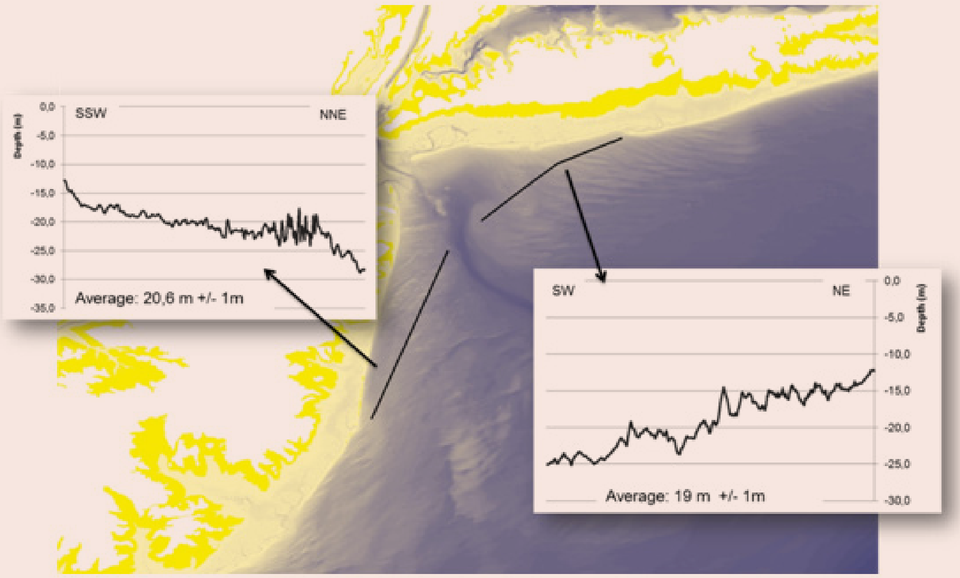


Figure 3: Water depths along transects from the New York bight (data: NOAA)

	Units: Meters	Narrow	Wide
H1	Height of barrier from sea floor to sea level	21m	21m
H2	Height of dune barrier	10m	10m
W1	**Width of beach barrier**	**250m**	**500m**
Slope1	Slope of dune	1:12.5	1:12.5
Slope3	Underwater slope at Atlantic side	1:30	1:30
Slope 4	Underwater slope at Continental side	1:30	1:30
V total	**per meter of island**	**19,730 m²**	**26,230 m²**

Table 1: Dimensions of the two schematic cross sections.

entrance to the Long island Sound. The total length of the barrier islands (without inlets) is 170 kilometres.

Phase 1 & 2

Phase 1 and 2 are part of a barrier-island chain in the New York bight. The total length of the Phase 1 chain is 65 kilometres and of the Phase 2 island chain is 75 kilometres.

D.1.2.3
Sediment volumes

The dimensions of the wide and narrow cross sections and the lengths of the Barier-Island chains have used to calculate their total sediment volumes (Table 2).

Full barrier-island chain		
Lenght	170 km	
Width of the islands	Narrow (250 m)	Wide (500 m)
Volume	3.354 B m³	4.459 B m³
Phase 1		
Lenght	65 km	
Width of the islands	Narrow (250 m)	Wide (500 m)
Volume	1.282 B m³	1.705 B m³
Phase 2		
Lenght	75 km	
Width of the islands	Narrow (250 m)	Wide (500 m)
Volume	1.480 B m³	1.967 B m³

Table 2. Dimensions of the two schematic cross sections.

D.1.3
Construction

The essential element of the construction of a barrier-island chain is the delivery of sediment via dredgers. Given the immense sediment volumes two type of dredgers are the seen as the principal contributors to the construction:

1. Trailing Suction-Hopper Dredgers
2. Cutter Suction Dregders & Pipelines.

Other types of dredgers and transportation means (barges, …) have capacities that limit their contribution and are therefore not considered.

Trailing suction-hopper dredgers are self-propelled dredgers that use their suction arm to mine sediment on the sea floor into their hold (the actual "hopper"). In the construction site the sediment is deposited through the doors at the base of the ship, pumped over the bow ("rainbowing") or the vessel hooks up to a pipeline and pumps the material onto the island (Figure 4). Hopper dredgers can cover long distances between borrow area and the construction site. Hopper dredgers can work relatively severe conditions on the ocean. Furthermore hoppers are flexible and can temporarily move to different borrow and construction locations if the weather conditions require this.

Cutter-suction dredgers use a an arm so the mine he material from the sea-floor. The sediment is then pumped tot the construction site through a pipeline. The pipeline can extend to several kilometres (this may require additional pumps – booster stations). Cutter-suction dredgers temporarily fix their position on the sea-floor with a (spud-)pole. By retracting their spudpole and applying their other spudpole they gradually move through the burrowing area. Cutter-suction dredgers and their pipelines are more susceptible for waves. They are not very flexible. Deployment in full ocean conditions may result in frequent down time.

A combination of trailing-suction hopper dredgers working on the Atlantic side and cutter-suction dredgers working in the lee-side of the proto-islands can be envisaged (Figure 5).

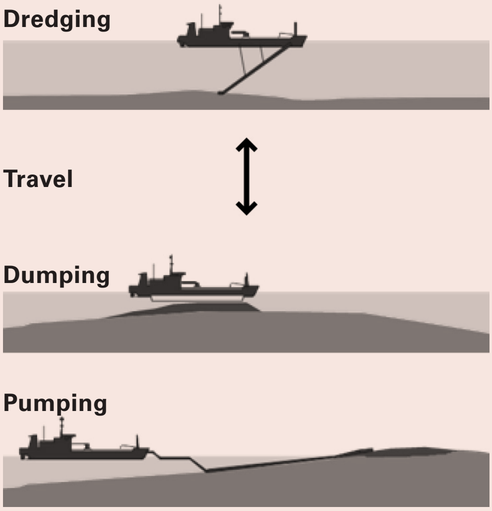


Figure 4: Schematic diagram of trailing suction-hopper dredgers.

Figure 5: Schematic diagram of cutter-suction dregders & pipelines.

D.1.4 Budget-estimate

D.1.4.0 Assumptions

The estimate budget is based on a dredge & dump scheme for sand-only designs.

No hard structures (breakwaters, deep water harbours & terminals) are envisaged in this stage of the design and they are not considered in the budget.

Support constructions (Figure 2) could be used to decrease the required sediment volume, but their construction is more complex and require more expensive materials. The savings from the reduced sediment volume may easily be lost through the additional construction costs . In stage of the design support constructions are not considered.

No specific rate for cutter dredgers has been used.

The range presented in the construction is very large. This is justified, not only because of the sketch status the design, but also because the sediment volume involved is immense. The plan has the potential to disrupt the entire US dredging market. This could lead to immense increases in costs (on the entire US-market), but alternatively it may lead to investments in very large dredgers and lower costs.

Two pathways are followed to determine the costs per m^3.

1. Going Dutch

The Dutch (2010) price relation between travel distance and price per m3 for small and average trailing suction-hopper dredges (3.500 m^3 and 7.700 m^3) and average travel distances of 5, 10 and 15 km (visa versa) between the dredge location and the dump sites. No relation has been implemented between dredge depth and price. Euro prices per m3 have been converted to dollars using a factor 2, to include the conversion rate and the differences in the dredge market. This is a very optimistic scenario). This results in prices per m3 from $3.29 to $6.65.

2. US-average

An average price for post-Sandy dredging operations on the US-east coast surrounding the New York bight of $ 17, - has been used.

The results of the cost estimates are presented in Table 4. Detailed numbers are presented in Table 4a, 4b, and 4c.

Configuration	Cost Estimate ($B)		
	Dutch	US	For Report
Full Island Concept (170km)	16	46	31
Phase 1 (65km)	6	18	12
Phase 2 (75 km)	7	20	14

Table 3: Prices are an average of the narrow and wide barriers from Tables 4a, 4b, and 4c

Phase 1 (75 km)	Narrow Barrier	Wide barrier
1. Going Dutch		
Full Barrier-Islands chain (Stevens) 170 km	$11-22 B	$15-30 B
Phase 1- 65 km	$4-9 B	$6-11 B
Phase 2 75 km	$5-10 B	$6-13 B
2. US average		
Full Barrier-Islands chain (Stevens) 170 km	$57 B	$76 B
Phase 1- 65 km	$22 B	$29 B
Phase 2 75 km	$25 B	$33 B

Table 4: Cost estimates of the Full Barrier-Islands chain (Stevens).

Full Barrier-Islands chain (Stevens 170 km)	Narrow Barrier	Wide barrier
1. Going Dutch		
Average distance 5 km & Hopper dredge 3,500 m^3	$14.971.360.760	$19.903.638.760
Average distance 5 km & Hopper dredge 7,700 m^3	$11.043.709.660	$14.682.032.660
Average distance 10 km & Hopper dredge 3,500 m^3	$18.634.037.960	$24.772.975.960
Average distance 10 km & Hopper dredge 7,700 m^3	$13.669.969.960	$18.173.507.960
Average distance 15 km & Hopper dredge 3,500 m^3	$22.296.715.160	$29.642.313.160
Average distance 15 km & Hopper dredge 7,700 m^3	$16.296.230.260	$21.664.983.260
2. US average		
	$ 57.019.700.000	$ 75.804.700.000

Table 4a: Cost estimates of the Full Barrier-Islands chain (Stevens)

Phase 1 (65 km)	Narrow Barrier	Wide barrier
1. Going Dutch		
Average distance 5 km & Hopper dredge 3,500 m³	$5,724,343,820	$7.610.214.820
Average distance 5 km & Hopper dredge 7,700 m³	$4,222,594,870	$5.613.718.370
Average distance 10 km & Hopper dredge 3,500 m³	$7,124,779,220	$9.472.020.220
Average distance 10 km & Hopper dredge 7,700 m³	$5,226,753,220	$6.948.694.220
Average distance 15 km & Hopper dredge 3,500 m³	$8,525,214,620	$11.333.825.620
Average distance 15 km & Hopper dredge 7,700 m³	$6,230,911,570	$8.283.670.070
2. US average		
	$21.801.650.000	$28.984.150.000

Table 4b: Cost estimates of Phase 1 Barrier-Islands chain

Phase 2 (75 km)	Narrow Barrier	Wide barrier
1. Going Dutch		
Average distance 5 km & Hopper dredge 3,500 m3	$6.605.012.100	$8.781.017.100
Average distance 5 km & Hopper dredge 7,700 m3	$4.872.224.850	$6.477.367.350
Average distance 10 km & Hopper dredge 3,500 m3	$8.220.899.100	$10.929.254.100
Average distance 10 km & Hopper dredge 7,700 m3	$6.030.869.100	$8.017.724.100
Average distance 15 km & Hopper dredge 3,500 m3	$9.836.786.100	$13.077.491.100
Average distance 15 km & Hopper dredge 7,700 m3	$7.189.513.350	$9.558.080.850
2. US average		
	$25.155.750.000	$33.443.250.000

Table 4c: Cost estimates of Phase 2 Barrier-Islands chain

In addition to the budget the number of ships required to complete Full Barrier-Islands chain with a narrow cross section in 20 years has been calculated. Depending on the size of the dredges and the distance between dredge site and construction location between 2 (dredge of 7,700 m3 and average 5 km distance) and 13 (dredge of 3,500 m3 and average 15 km distance) will be fully employed for the entire 20 years.

Barrier-island management

The management of the barrier islands consists of sand nourishments and sediment redistribution to keep the sediment volume up to standards. A need for sand nourishments of 10% of the initial yearly volume is envisaged. The yearly budget for the management ranges from tens of millions to several hundreds of millions.

D.1.5
Sediment Availability

D.1.5.0
Seafloor Sediments

Several studies available on the presence, composition and thickness of the sea-floor sediment in the New-York bight. Amongst others:

- Schwab, W.C., Denny, J.F., Butman, B., Danforth, W.W., Foster, D.S., Swift, B.A., Lotto, L.L., Allison, M.A., and Thieler, E.R.(2000. Seafloor Characterization Offshore of the New York-New Jersey Metropolitan Area using Sidescan-Sonar: U.S. Geological Survey Open-File Report 00-295) present data on sea-floor composition of the entire New-York bight.
- Schwab, W.C., Thieler, E.R., Denny, J.F., Danforth, W.W. (2000. Seafloor Sediment Distribution Off Southern Long Island, New York: U.S. Geological Survey Open-File Report 00-243) give detailed insight in the presence of sediment along the Long Islands shoreline.

Some images from these studioes are shown here to give insight in the type and detail of information that is available. The map with side-scan sonar and bathymetry in figure 6 gives indications on depth and sea-bed composition (high backscatter – light tones equals sand, gravel or rock; low –backscatter -dark tones equals fine sand/mud). This type of map does not provide information on the actual sediment composition (samples are required) and neither does it provide information on the layer thickness (a thin layer of sand will give a similar result as a thick layer).

Information on the thickness of the sediment can be obtained from seismic lines, as the one shown in Figure 7. The Quaternary sediment can be mined. The composition of this material has to be checked in situ with samples from cores.

Ideally the available sand or other sediments is presented in maps, similar to the one in Figure 8.

The available reports and the information in it show that pronounced variations in sea floor and in the subsurface composition occur in the New-York bight. Local outcrops of Cretaceous rocks are present on the sea floor in some locations, meaning the absence of minable sediment. Part of the area has been influenced by of ice-age activity. In certain areas reworking of sediments on the sea floor has been taking place, leaving the sediment in in ridges with varying sediment composition.
In general, sediment is available in the vicinity of the barrier island chain, the actual thickness and proximity varies. The mining of sediment in range from 5 to 15 kilometres of the barrier islands seems feasible.

Establishing the areas that are suitable for mining and determining the sediment composition will require detailed geological investigations. Ecological, archaeological – shipping artefacts- and environmental (historical pollution) aspects should be incorporated in the search for sediment.

D.1.5.1
Environmental Aspects

Studies show that contaminated sediments are present on the sea-floor in the New-York bight:

- Mecray, E.L., M. Buchholtz ten Brink &B. Butman, 1999 (Contaminants and Marine Geology in the New York Bight: Modern

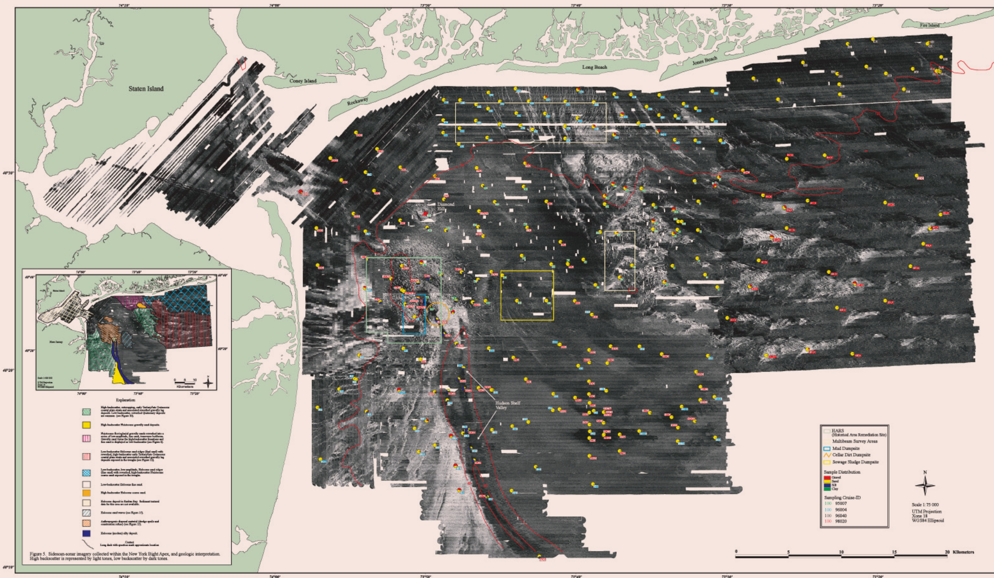


Figure 6: Map of the New York bight sea floor from side-scan sonar (from Schwab et al., 2000).

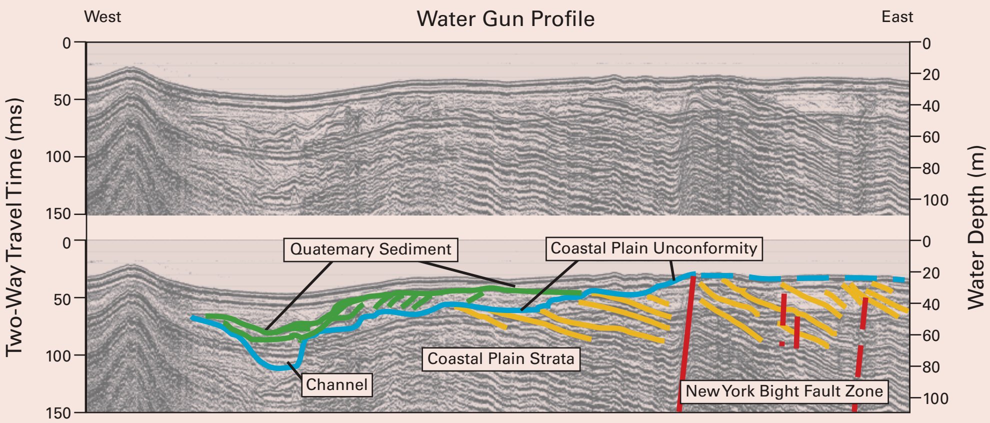


Figure 7: Seismic line from the New York bight sea (from Schwab et al., 2000).

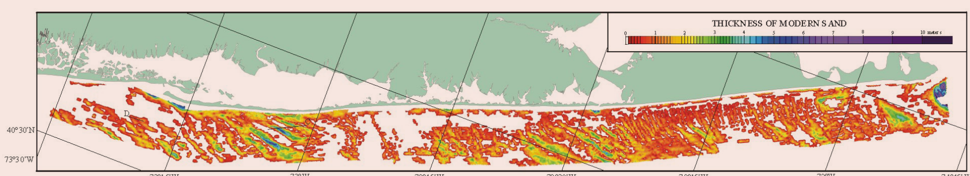


Figure 8: Map of the sand thickness offshore Long island (from Foster et .al, 1999).

Sediment Dynamics and a Legacy for the Future, U.S. Geological Survey Fact Sheet 114-99 Version 1.0

- Butman, B., 2001 (Mapping the Sea Floor of the Historic Area Remediation Site (HARS) Offshore of New York City, U.S. Geological Survey Fact Sheet 001-02 Online Version 1.0)
- Some of the contaminated sediment is present on the sea floor, especially near the Hudson shelf valley. Other contaminants have been capped with sediment to prevent redistribution.

The presence of contaminated sediment presents constraints, because sediment should not be mined from these areas. However the barrier island may serve as a safety measure. Capping the sites with a barrier island may be a long-term solution for some sites. Furthermore thee presence and evolution of dump sites may be used for verification of geomorphological models.

D.1.6
Examples

The scale of the Barrier-island surpasses all examples of offshore island construction and land reclamation. Typical sediment volumes in such schemes amount to 200 x 106 m3 and take 2-5 years for completion. World-wide examples include:

- Hong Kong Chek Lap Kok Airport ~200 x 106 m3 Landfill completed: 1992-1996
- Dubai Artificial islands (Palm Jumeirah, 90-110 x 106 m3; Palm Jebel Ali final design volume 172 -200 x 106 m3; Palm Deirah final design volume 200 x 106 m3 The World final design volume 300 x 106 m3.
- Rotterdam Harbour Extension (Maasvlakte II 200 x 106 m3 ; Landfill completed: 2008-2012)

In the USA the examples that resemble the complexity of the barrier-island construction are the artificial islands along Prudhoe bay, Alaska. The islands have constructed for hydrocarbon exploration and exploitation. Their complexity lies in the design and working conditions of the arctic.

D.1.7
Implementation strategy

Further development of the plans for a barrier-island chain to provide a shelter against storm surges for the New Jersey, New York and Long-Island sound areas will require much more information. Part of that information will be gathered in a feasibility study. For the aspects addressed in this memo a number of questions arise that should be answered. An overview of these questions and an approach is presented here.

What are the requisites for the barrier-islands: should they withstand surges?, is local washover development allowed?, may the island breach?

An optimization of these requirements follows from:

1. Storm-surge modelling
2. Morphological modelling of the development of the islands;
3. A discussion on the outcomes of the two modelling exercises.

What are the construction options ?

4. Overview of construction techniques, with clear insight into the conditions (waterdepths, wave height, subsoil conditions,…) under which these have/can be applied, insight in the costs, in the foreseen life time and in the effects. To be obtained from literature and dialogues with experts.
5. Overview of the innovation needs (new techniques, new construction vessels,…). To be obtained from literature and dialogues with experts.

Where is the sediment, what is its composition and what are the impacts of mining?

6. Insight in the sea bed composition and thickness of the sediment, specifically in the area surrounding the Phase 1 barrier-island-chain. To be obtained from available data (USGS) and additional field data (seismic survey, cores, lab. analysis).
7. Overview of the ecological and archaeological values of the sea floor, insight in contaminated areas. To be obtained from available studies and

dialogues with experts (fisheries, wildlife, …).

8. Insight in the impacted area (surface area, depth after mining, change in composition of the sea bed)

How will the barrier islands develop morphologically?

9. Morphological modelling of along shore and cross shore developments.

What will be the impact during construction on the environment?

10. Numerical model study on the release and dispersal of mud near the borrow-sites and on the construction site.
11. Analysis of the effects of the dredging operations: disturbance through vessel traffic, (underwater) sound, light, etc.: Overview and expert assessment.

What will be the long-term impact on the environment?

12. Overview of the in- and outflow of water from various sources; overview of the sediment budgets (mud and sand) in new and old situations.
13. Numerical model study of the water quality.
14. Numerical model of the morphology.

These questions and the activities that results in answers are part of the larger implementation scheme.

What	Who	Estimated costs
1. Storm-surge modelling	Stevens	
2. Morphological modelling of the development of the islands during storm surges	ARCADIS	$ 75,000.-
3. A discussion on the outcomes of the two modelling exercises	ARCADIS	$ 7,500.-
4. Overview of construction techniques from literature and dialogues with experts	ARCADIS	$ 30,000.-
5. Overview of the innovation needs from literature and dialogues with experts	ARCADIS	$ 30,000.-
6. Insight in the sea bed composition and thickness of the sediment from available data (USGS) and additional field data	Specialized institute (USGS) or firm (Fugro)	$ 500,000.-
7. Overview of ecological, archaeological values and contamination from available studies and dialogues with experts	ARCADIS	$ 60,000.-
8. Insight in the impacted area on the sea floor	ARCADIS	$ 30,000.-
9. Morphological modelling of along shore and cross shore developments.	ARCADIS	$ 75,000.-
10. Numerical model study on the release and dispersal of mud	ARCADIS	$ 75,000.-
11. Analysis of disturbance due to the dredging operations: Overview and expert assessment.	ARCADIS	$ 75,000.-
12. Overview of water budgets and sediment budgets (mud and sand) in new and old situations	ARCADIS	$ 30,000.-
13. Numerical model study of the water quality,	ARCADIS	$ 75,000.-
14. Numerical model of the morphology	ARCADIS	$ 45,000.-

D.2
Global Precedents

D.2.0
Introduction

Global precedents of island creation and capital dredging projects were researched to help inform our storm surge barrier island proposal. We looked into why projects were initiated, how they were funded, who manages them, costs, materials and equipment used, and the economic impacts of the project to surrounding communities. The examples we examined include Manhattan's street grid, the California Channel Islands, the Hong Kong's International Airport, the Atlantic Intracoastal Waterway, the London Crossrail, and Delta Works in the Netherlands. The precedents that follow were suggested by jurors and collaborators throughout the Rebuild by Design process, and have remained invaluable in our team's effort to understand the validity and method of large-scale thinking.

D.2.1
Manhattan Grid, USA

In the early 1800's, much of Manhattan was made up of expansive estates and winding roads. In 1811, New York's commissioners' developed a rigid grid for Manhattan north of 14th street, which cut through the island's hilly and rugged landscape. Incensed by the division of their sprawling estates, many landowners, including poet Clement Clarke Moore denounced the plan. In protest, Moore wrote a 60- page protest of the plan to other land owners. "Our public authorities seem unwilling to depart from leveling propensities, but proceed to cut up and tear down the face of the earth without least remorse." Going on to say that the commissioners, "would have cut down the Seven Hills of Rome". Despite the protests, the city moved forward with their plans, and over time, land owners and developers began to realize the profitability of the 200 by 800 foot lots, which maximized the number of streets and lots.

City Commissioners predicted in 1811 that the population of New York would be on par with that of Paris by 1860 (500,000), instead the population exploded nearly six fold to 800,000 people, cementing New York as one

Figure 9: Manhattan Grid

of the world's biggest and most important cities. Today, Manhattan is the most densely populated borough in New York City- with an average of 12 people for every 5,000 square feet of space.

D.2.2
California Channel Islands, USA

The California Channel Islands are naturally occurring formations located off the coast of California and is a good example of how recreation, educational programming, research, tourism, and fishing has benefitted from the islands and how Federal and State Agencies work together to manage public lands. Five of the Islands are owned and

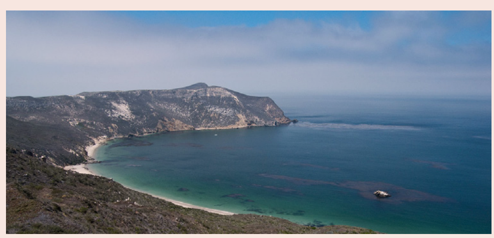


Figure 10: California Channal Islands, San Miguel (Photo by: Mike Baird, 2009

managed by the National Park Service, while 2 are owned by the U.S. Navy. The Channel Islands National Park was set aside to protect the nationally significant natural, scenic, wildlife, marine, ecological, historical, archeological, cultural, and scientific values of the Channel Islands in the state of California.[1] The California Department of Fish and Game has jurisdiction and management over the living marine resources in the water column and sea bed surrounding the park islands, starting at the mean high tide. In particular, commercial and sport fishing are regulated by the agency. The California Channel Islands provide mainland visitors and tourists with recreational and educational experiences. The Park has camping facilities and hiking trails on each of the islands, as well as infrastructure in support of visitation. In addition to coming to one of the islands on scheduled and chartered boats from Ventura and Santa Barbara harbors, many visitors also come to the islands on their pleasure boats. [2]

D.2.3
Hong Kong International Airport, Hong Kong

The Hong Kong International Airport is a government funded direct capital project located on the island of Chek Lap Kok. The airport platform was constructed from 250 million cubic yards of dredged sand and clay, creating "new land" that did not exist before the early 1990s. The 1,248-hectare platform is comprised of 938 hectares of reclaimed land and 310 hectares from the two original islands of Chek Lap Kok and Lam Chau. The materials came from dredging mud from the sea floor, constructing seawalls to maintain structural integrity, excavating and flattening the existing headlands of Chek Lap Kok and Lam Chau islands, and introducing offsite marine sand for land reclamation.[3] From

Figure 10: Aerial view of Hong Kong International Airport. (Photo by Wylkie Chan, 2009)

2012-2013, Hong Kong International Airport hosted 57.2 million passengers, handled 4.04 million tonnes of cargo and connected to 176 destinations worldwide.[4]

D.2.4
Atlantic Intracoastal Waterway, USA

The Atlantic Intracoastal Waterway is a continuous sheltered waterway used by commercial and private shallow draft vessels. The US Army Corps of Engineers maintains the Waterway for 1,088 miles between Norfolk, Virginia and Miami Florida. The AIWW is authorized to 12 feet deep with widths of 90 feet through land cuts and 150 feet in open water areas. For most of its length, the system consists of naturally deep estuaries, rivers and sounds. However, these natural stretches are connected by man-made "cuts" through land areas and shallows, many of which require periodic dredging to maintain their depths. Despite the federally authorized 12'project depth along most of the AIWW, actual depths vary from 5' to 12'.[5] The AIWW serves 10 Ports, 14 Military Bases, 4 US Coast Guard Bases and is used by tugs, barges, passenger vessels (ferries, cruise ships), the fishing industry, construction vessels, marine businesses, shipyards and recreational boaters. The USACE receives its annual funding from the Energy and Water

1 Draft General Management Plan / Wilderness Management Study / Environmental Impact Statement Channel Islands National Park Ventura and Santa Barbara Counties, California. National Park Service U.S. Department of the Interior Channel Islands National Park California, November, 2013.

2 Glassow, Michael A, CHANNEL ISLANDS NATIONAL PARK ARCHAEOLOGICAL OVERVIEW AND ASSESSMENT. Department of the Interior, NationalPark Service. December, 2010.

3 Terminal 1, HKIA The world's single largest building project. Building Journal. Hong Kong. August 2011

Mayer, Brantz von Dredging the Hong Kong International Airport

4 SUSTAINING OUR CAPACITY: Our Blueprint for Shared Growth." Sustainability Report. Hong Kong International Airport. 2012/13.

5 Atlantic Intracoastal Waterway Presentation. Atlantic Intracoastal Waterway Association. http://www.capca.net/PDF/AIWA%20Presentation.pdf

Figure 11: Atlantic Intracoastal Waterway, Galveston Bay (U.S. Army Corps of Engineers Digital Visual Library, 1999)

Development Appropriations subcommittee. The federal budget becomes more challenging every year and studies have been conducted to determine recreational boater willingness to pay for an Atlantic Intracoastal Waterway Dredging and Maintenance Program.[6]

D.2.5 Crossrail, London UK

Crossrail is the largest infrastructure project in Europe and forms a major part of the Mayor of London's Transport Strategy. 4.5 million tonnes of excavated material from the tunnels will be shipped to Wallasea Island in Essex where it will be used to create a new 1,500 acre RSPB nature reserve. The reserve is planned to be in development until around 2019. Over the coming years, the scheme will create a varied wetland landscape with more than nine miles (15 km) of new and improved access routes, and eventually a range of visitor facilities. It will be home to tens of thousands of migratory birds, and combat the threats from climate change and coastal flooding.

Figure 12: Crossrail Tunnel Royal Oak Portal Construction (Marcus Rowland, 2011)

D.2.6 Delta Works, Netherlands

Delta Works is a massive chain of flood protection structures that were constructed after the occurrence of the North Sea flood of 1953. The flood led to 8,361 fatalities and flooded nine percent of the farmland in the Netherlands. The project comprised of laying 13 dams, including barriers, sluices, locks, dikes and levees, to reduce the Dutch coastline's size and protect the areas within and around the Rhine-Meuse-Scheldt delta from North Sea floods. The project was finally completed in 1997, at a cost of $5B. The project was undertaken by the Department of Waterways and Public Works. The infrastructure provides flood protection, fresh drinking water and irrigation. The risk of flooding was reduced to one in 4,000 years.[7]

Figure 13: Maeslant Barrier, Rotterdam (Photo: Beeldbankvenw)

6 Whitehead, John C. et al. "Recreational Boater Willingness to Pay for an Atlantic Intracoastal Waterway Dredging and Maintenance Program"
Department of Economics. Appalachian State University. Boone, North Carolina 28608

7 Delta Works Flood Protection, Rhine-Meuse-Scheldt Delta, Netherlands. Website.http://www.water-technology.net/projects/delta-works-flood-netherlands/

D.2.7
Conclusion

All of these precedents are grounded in their defiance of conventions as a means to achieve great feats of planning and architecture, working as regional alternatives to large scale issues. Like any project at this scale, we must learn from and improve upon, not only the technical prowess or beauty of these precedents, but also their societal implications, creating infrastructure that defies our often arbitrary political boundaries as a means to create a social infrastructure.

Long Island Sound
Peconic Bay
Great South Bay
restoring
Jamaica Bay
emerging wetlands
Longshore drift
emerging wetlands
Lower Bay
Recreational
fisheries
Windfarm
Hudson Canyon
Hudson Canyon
Barnegat Bay
Longshore drift

Appendix E

Acknowledgements

Acknowledgements

Institute for Public Knowledge

The Institute selects and develops topics for consideration and discussion in an effort to bring together academics, social researchers, and organizational leaders around issues of public concern. To further these investigations, the Institute forms working groups, which include organizational representatives, graduate students, faculty, and IPK Visiting Scholars from various organizations and academic institutions who share interest in IPK's topics and concerns. The IPK has a core administrative unit comprised of the Director, Eric Klinenberg; the Program Manager, Jessica Coffey and an Administrative Aide, Siera Dissmore.

MAS | NYC

The Municipal Art Society (MAS) is New York's leading advocacy organization dedicated to creating a more livable and resilient city. For 120 years, MAS, a nonprofit membership organization, promotes policies and programs that support New York City's economic vitality, cultural vibrancy, environmental sustainability, and social diversity. In the wake of Hurricane Sandy, MAS hosted a series of multi-stakeholder convenings, assisting the City's Special Initiative on Rebuilding and Resilience process in public workshops across the five districts, and providing community resilience trainings. Throughout its resilience programming and events, MAS advocates for a Resiliency Framework that integrates economic, environmental, cultural, and social considerations, and equips a diverse mix of New Yorkers and neighborhoods in developing local solutions and approaches that can potentially be scaled across the city and region.

Van Alen Institute

(VAI) is an independent architectural organization that promotes inquiry into the processes that shape the design of the public realm. For over a century, VAI has cultivated a fellowship of design practitioners and scholars, awarded excellence in design, and fostered dialogue about the evolving role of architecture in the public realm. Since 1894, VAI has managed 2,400 design competitions, and from the mid-1990s onward, has played an important role in identifying key projects in New York City for public use, such as Times Square, Governors Island, and Queens Plaza, among others. Beyond its extensive competition experience, the Institute's expertise spans exhibitions, public programs, research, and consultancy. VAI often translates complex design questions so that they can easily be understood by parties from different backgrounds and professional fields.

Rebuild by Design

Rebuild by Design, an initiative of the Hurricane Sandy Rebuilding Task Force and HUD, is aimed at addressing structural and environmental vulnerabilities that Hurricane Sandy exposed in communities throughout the region and developing fundable solutions to better protect residents from future climate events. Because of the enormity of this challenge, the Rebuild by Design process was developed to find better ways of implementing designs and informing policy.

Each of the ten participating design teams, selected by the President's Hurricane Sandy Rebuilding Task Force, brings together experts from across planning, design, engineering and science to critically consider the task of rebuilding. They will carry out an extensive research process involving local community input and fieldwork. Teams will visit locations in the region severely impacted by Hurricane Sandy, hearing from residents, business owners and community groups about the problems they faced during and after the storm. Because of the far-reaching nature of the challenge, the Institute for Public Knowledge assembled a Research Advisory Group and coordinated a series of targeted discussions with other outside experts as a way of addressing a broad range of issues. Once teams present regional research identifying places and opportunities that are key to the rebuilding process, each team will then work on a single project, selected by

HUD, aimed at addressing problems identified during the research phase.

Regional Plan Association

The Regional Plan Association (RPA) brings extensive experience in community design, infrastructure planning, and waterfront and natural resource advocacy to our collaborative team. RPA has led dozens of projects for municipal, state, and federal clients including the Port Authority of New York & New Jersey, National Park Service, Metropolitan Transportation Authority, and other agencies that have successfully blended community aspirations, design excellence, innovative policies, and long-term capital investments to meet local and regional needs. RPA has a unique ability to convene the planning and design community across the New York–New Jersey–Connecticut metropolitan area. RPA will focus on bringing together stakeholders across political and sectoral boundaries to ensure that Design Teams engage with environmental, waterfront, energy, and transportation decision makers and experts, as well as communities throughout the region.

The Rockefeller Foundation

For more than 100 years, The Rockefeller Foundation's mission has been to promote the well-being of humanity throughout the world. Today, we pursue this mission through dual goals: advancing inclusive economies that expand opportunities for more broadly shared prosperity, and building resilience by helping people, communities and institutions prepare

The Foundation operates both within the United States and around the world. The Foundation's efforts are overseen by an independent Board of Trustees and managed by its president through a leadership team drawn from scholarly, scientific, and professional disciplines.

Rebuild by Design Partners

U.S. Department of Housing and Urban Development
Institute for Public Knowledge
The Municipal Arts Society, NY
Regional Plan Association
Van Alen Institute
National Endowment for the Arts

Contributing Stakeholders

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National Institute for Coastal Harbor & Infrastructure
Sandyhook Pilots
Stonybrook
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