Resiliency|Massport

A pathway to a more resilient future

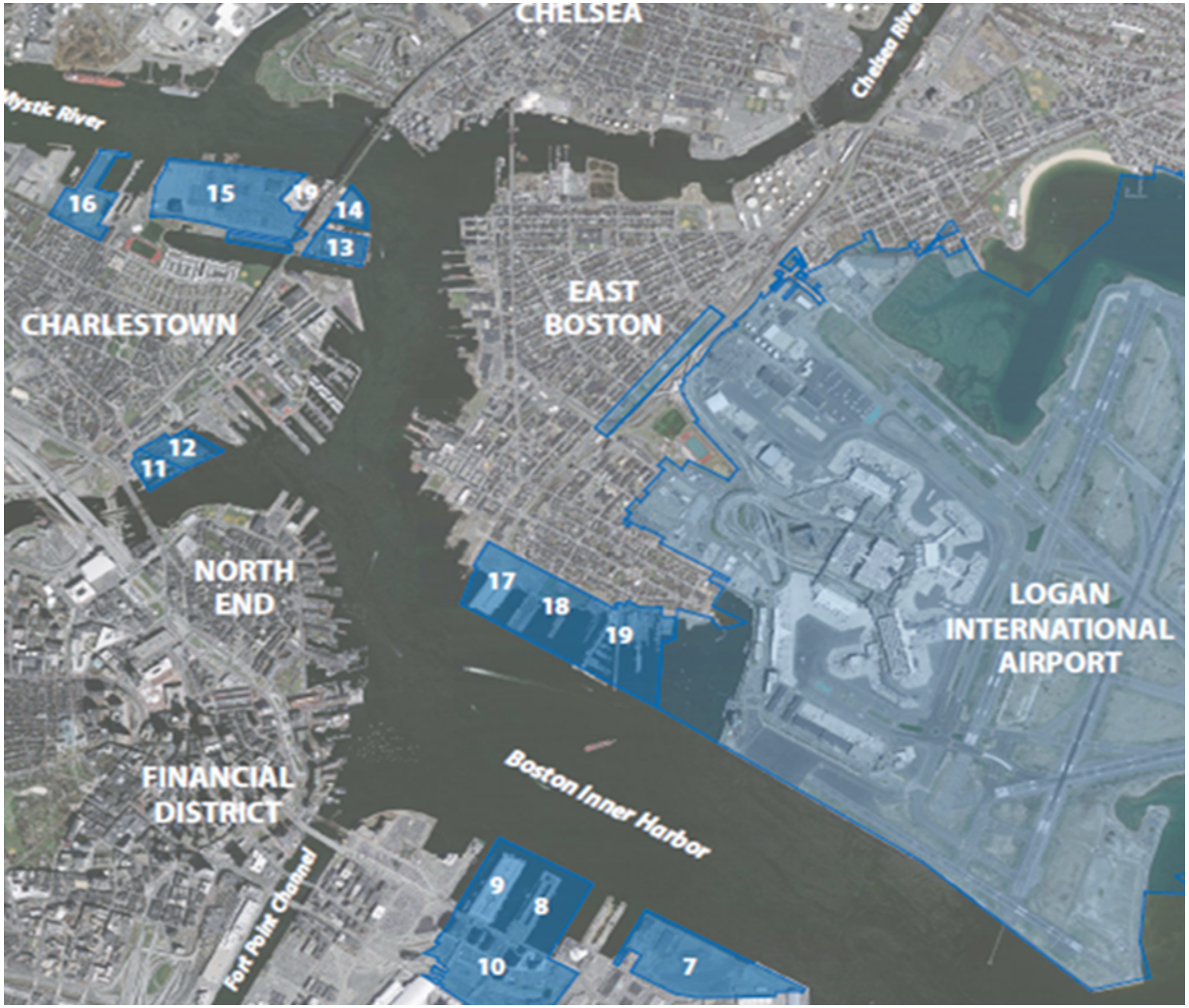
massport

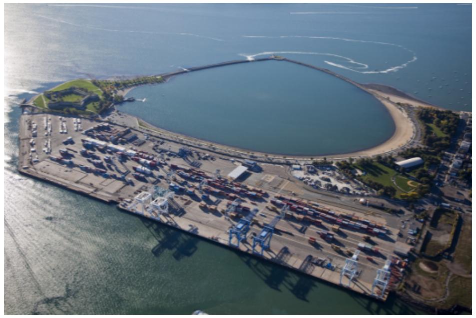
URI 4.5.16

Overview of Massport

- Massport is an independent authority governed by a board of directors, appointed by the state's governor
- Massport owns and operates
  - Boston-Logan International Airport
  - Hanscom Field, Bedford, MA
  - Worcester Airport
  - Conley Container Terminal
  - Black Falcon Cruiseport
  - Various real estate assets

Secure and Resilient Massport on Boston Harbor



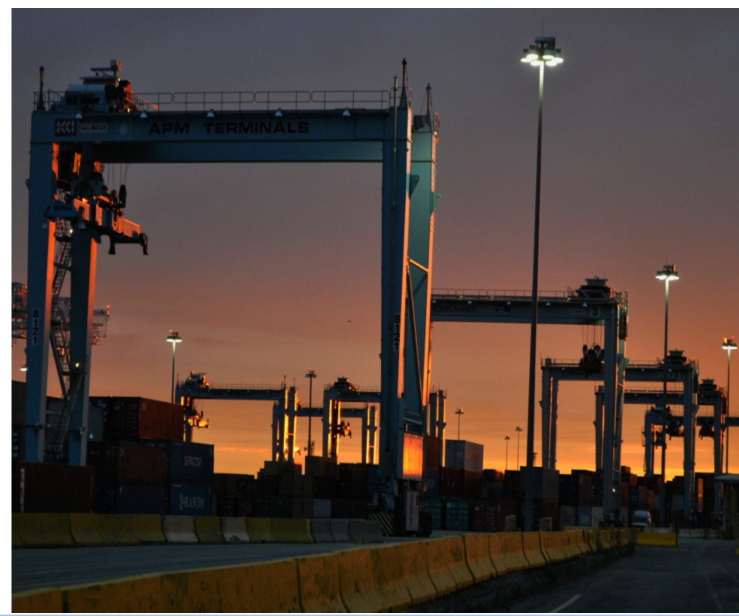


Port of Boston

- Oldest continually active port in Western Hemisphere (400 years)
- New England’s maritime hub
- Supports 34,000 jobs
- $2 billion to local, regional,
- and national economies

Paul W. Conley Container Terminal

- Serves three of the world's top 10 container lines.
- Handles nearly 1.5 million metric tons of cargo each year.

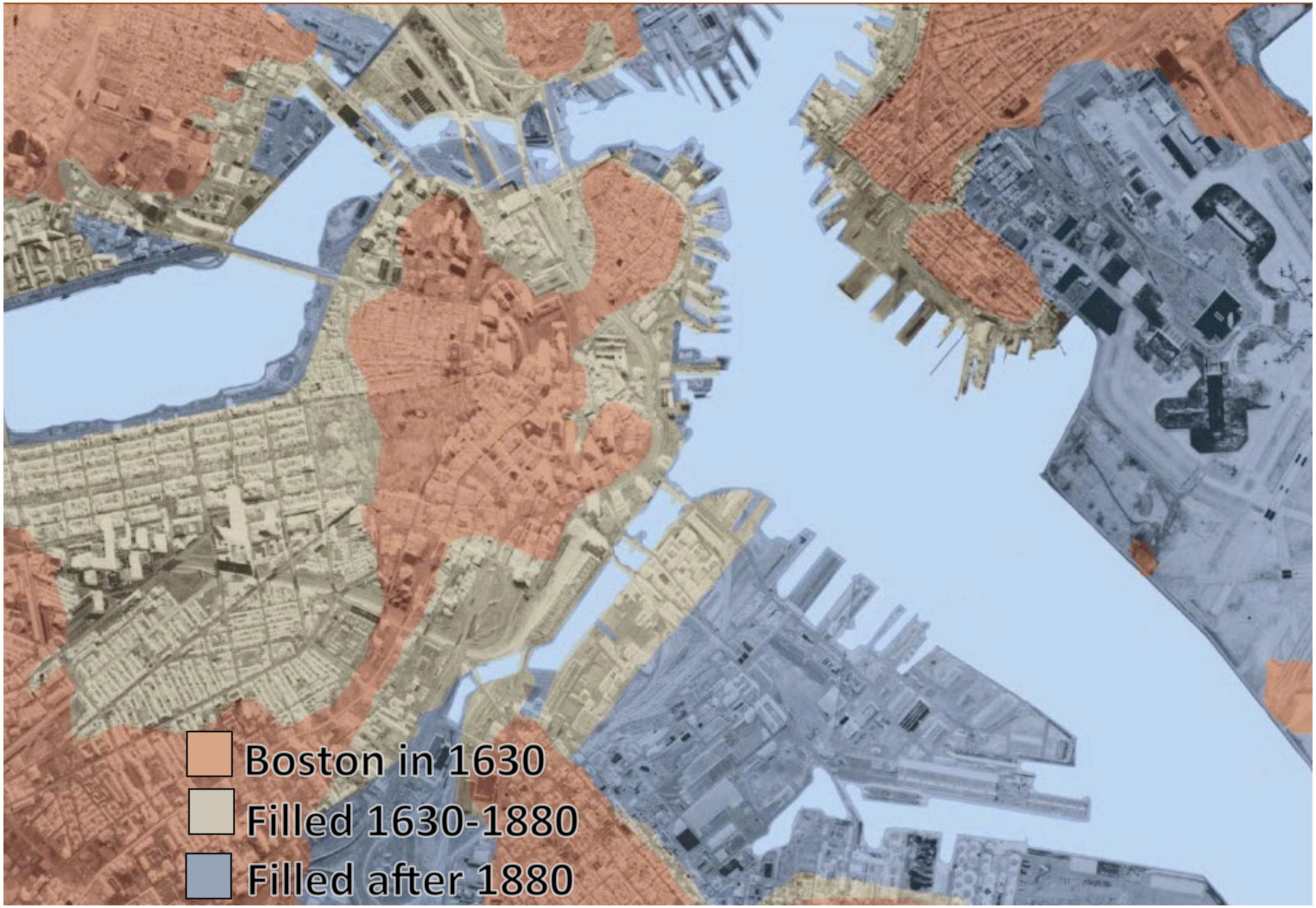


- Privately owned petroleum and liquefied natural gas terminals
- Supplies more than 90% of Massachusetts' heating and fossil fuel needs.
- Two ship repair yards,
- Public and private ferry operations,
- Marinas,
- Coast Guard’s Sector Boston

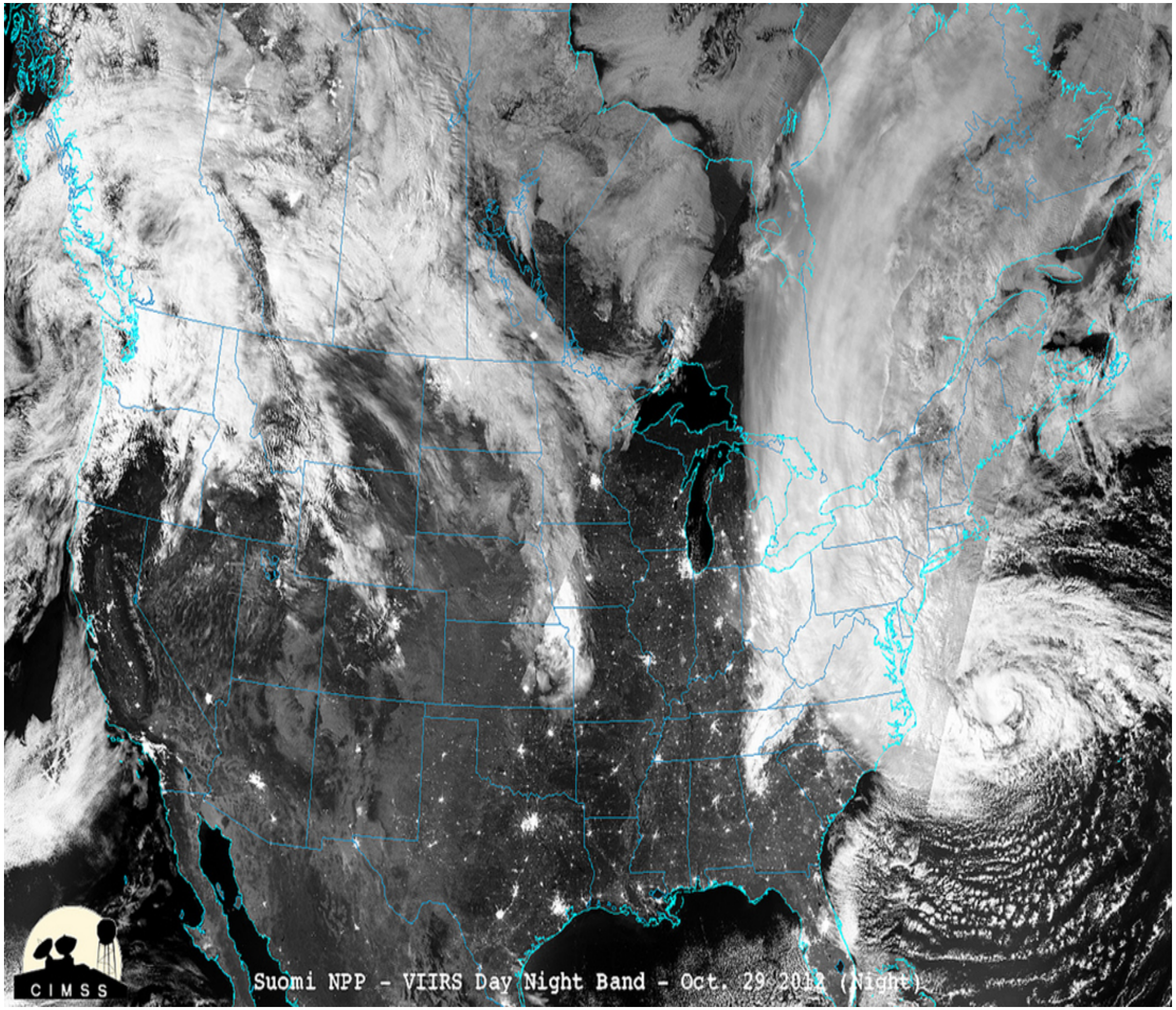
Cruiseport Boston

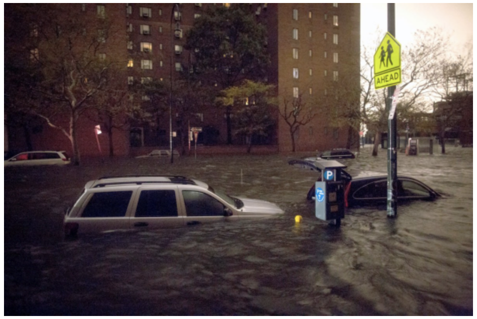
Context for our resiliency work

A City Built on Fill



Drivers for Action





Monitoring

- Massport essential personnel
  - Fire
  - Safety
  - Operations
  - Resident Engineers

- Term-contractors on-site
  - Roofing
  - Electrical
  - Mechanical
  - Pumping
  - Cleaning

Hazardous Waste

Hazardous waste moved inside

Hazardous waste moved inside

Assessing Damage

- Solar panels destroyed
- Terminals flooded
- Standards and signs blown over
- Vehicles destroyed
- Roofing membranes peeled off

Possible Impacts

- **Airports**
  - Logan Airport prolonged closure – regional/national, international transportation/ economic impacts
  - Passenger, business, critical goods, and commerce disruption
  - Lack of ability to serve area-wide storm recovery efforts
- **Maritime**
  - Major facility and equipment loss leading to long term closure
  - Loss of cruise & container business
- **Real Estate**
  - Financial risks associated with tenant disruptions/recovery
  - Disruptions to local/regional transportation system
- **Agency-wide**
  - Loss of human resources
  - Greater recovery cost

Massport Resiliency

Addressing Impacts

- Hardening critical Infrastructure, retrofitting existing facilities
- Providing redundant facilities
- Incorporating resiliency into new projects
- Workforce cross training

Reducing Impacts Through Sustainability

- GHG reduction
  - Leading by Example
- Sustainability Management Plan
- Sustainable Design Guidelines
- MEPA/NEPA compliance and project mitigation
- Collaboration with agencies and institutions

Program Manager of Resiliency

- First position of its kind at Massport and possibly at any national port authority.
- Directs and coordinates resilience assessment and adaptation preparedness activities of Massport.

- Pursues two complementary objectives:
  - Making the resilience plan and its principles part of business strategy and operations everywhere;
  - Facilitating cooperation among internal staff
  - External stakeholders promoting partnership &collective action.

Defining Resiliency

"Resiliency is the ability of a system to withstand a major disruption within acceptable degradation parameters, recover within an acceptable time, and balance composite costs and risks."

- How to protect Massport facilities against long-term sea-level rise, storm surges, intense storm events, other unplanned events and threats?
- How to maintain and restore operational capabilities during and after disruptive events?
- How to implement a balanced composite cost and risk plan?

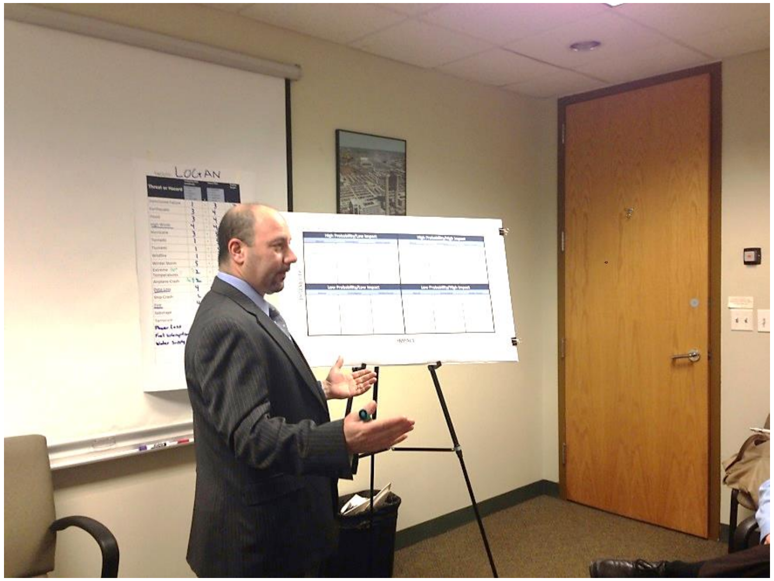
Resiliency Program Goals

- Become an innovative and national model for resiliency planning and implementation within the port authority.
- Take responsibility for improving our overall infrastructure and operational resilience.
- Increase our business value and (contextual community responsibilities) through improved resiliency.
- Engage our stakeholders to better understand and address their concerns.
- Incorporate resilient design and construction practices in the development of our airports, maritime systems, and real estate.
- Monitor, measure, and adapt/modify our progress.

OUR

PROCESS

Resiliency Working Group



- Logan
- Maritime
- Worcester
- Hanscom
- Corporate

Working Group Charge

- Identification
  - Threat event
  - Threat level
  - Impacted facilities
  - Effect of impact
  - Critical facilities needing protection
- Devise a Plan
  - Avoid, minimize, recover
  - Short term
  - Long term

Methodology

Modified DHS Threat and Hazard Identification and Risk Assessment (THIRA) Model

Step 1: Identify Threats and Hazards

- Natural
- Technological
- Human Caused
- Based on historical occurrences and probability models.
- Assess Probability and Impact of each threat/ hazard

Step 2: Identify Critical Infrastructure and Key Resources (CI/KR)

- What the CI/KR is required to do
- Identify dependencies and interrelationships

Step 3: Assess Vulnerabilities

- Functionality
- Structural Integrity
- Environmental Considerations
- Accessibility

Step 4: Current and Planned Activities

- Vulnerabilities already being addressed
- External coordination
- Short –range and Capital Improvement plans

Step 5: Gap Analysis

- Gap between CI/KR requirement and existing or planned capability

Step 6: Findings

- Identify resolutions to minimize or eliminate the gap
  - ✓ Resiliency
  - ✓ Redundancy
  - ✓ Development

Threats & Hazards to Critical Infrastructure

NATURAL	TECHNOLOGICAL	HUMAN-CAUSED
Resulting from acts of nature	Involves accidents or the failures of systems and structures	Caused by the intentional actions of an adversary
• Earthquake • **Flood*** • **High winds*** • **Hurricane*** • **Sea Level Rise*** • Tornado • Tsunami • Fire • **Winter Storm*** *** Addressed in Kleinfelder Study for Logan and Maritime**	• Data Loss • Power Loss	• Fire/Accident • Sabotage • Terrorism Acts (Bomb Blast)

Critical Infrastructure/Key Resources

Utilities	Transportation	
Electrical/Vaults/Sub Stations/Distribution etc. Drainage Generators Water	Parking Surface Roads Elevated Roads Tunnels Bridges	Transit Taxi Shuttle Rental Car
Fuel Systems	**Human Capital**	
Aviation Fuel Ground Fuel Generator Fuel	Workforce HR Functions Qualified Maintenance Security	
IT	**Equipment/Buildings**	
ATC – Tower Telecommunications Network Software Hardware Enterprise	Terminals Runway/Taxiway Apron Tower Security Gates Berths	Operating Cranes Processing Gates

Probability

High Probability/High Impact		
Natural	**Technological**	**Human-Caused**
Flood High Winds Hurricane Fire Extreme Temps	Data Loss	
Low Probability/High Impact		
Natural	**Technological**	**Human-Caused**
Tsunami Tornado Earthquake		Terrorism Sabotage Epidemic

Disaster Infrastructure Resiliency Planning (DIRP)

Goals of the project:

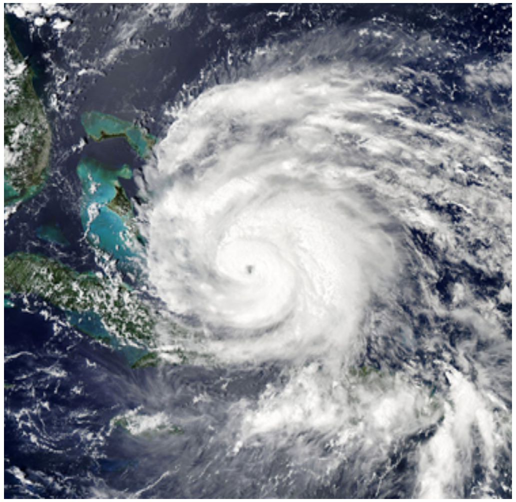
- Understand Massport's vulnerability to climate impacts
- Develop short-term and long-term resiliency strategies

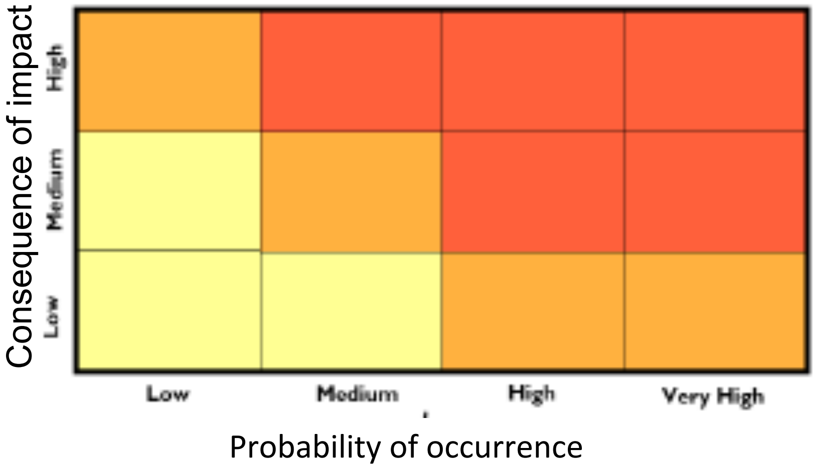
Project approach:

Climate projections

Vulnerability and risk assessment

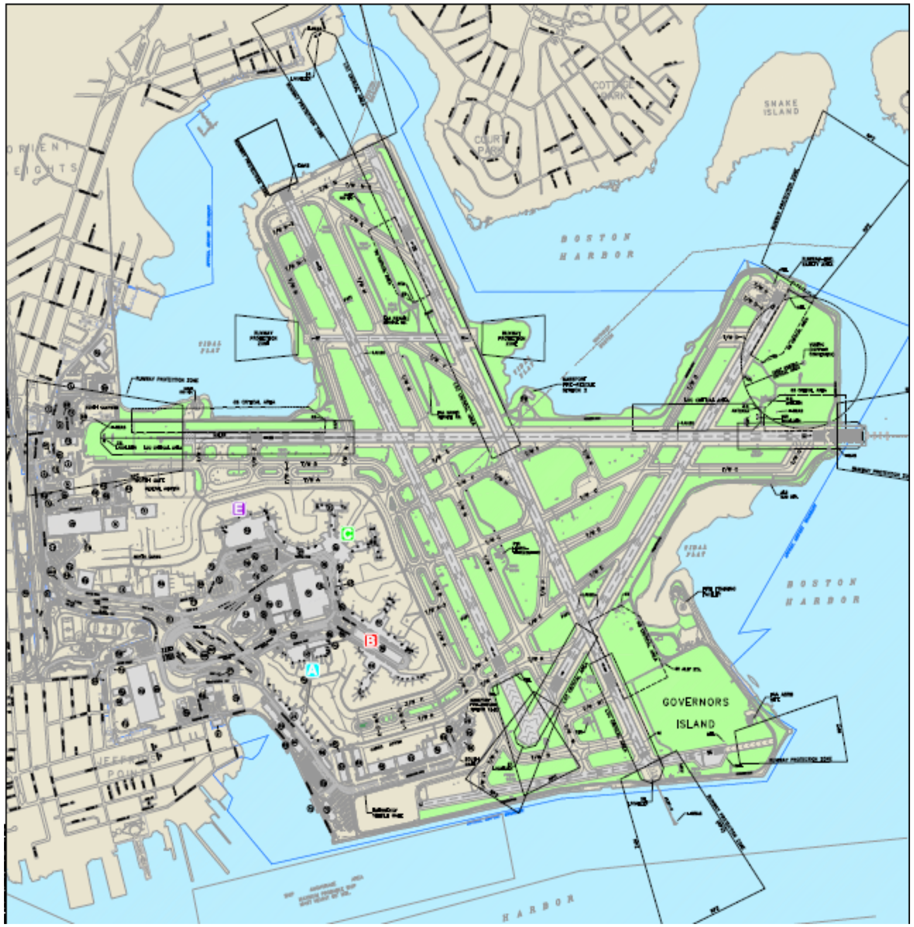
Adaptation planning & design



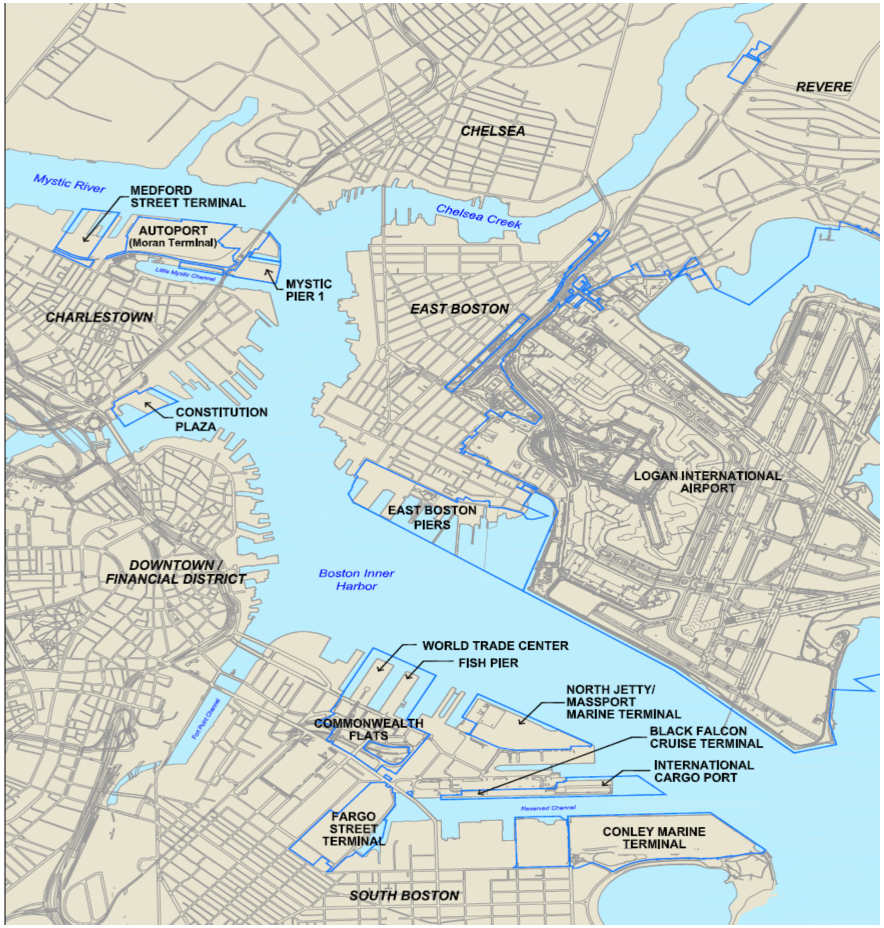


Climate Study Area

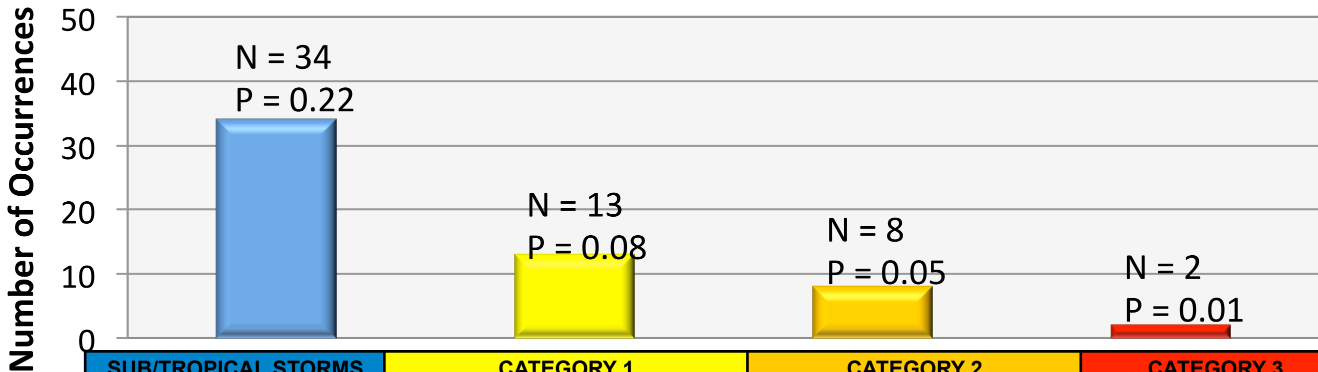
Logan Airport



Maritime Facilities



Historic Occurrence of Hurricanes – Boston (1858-2013)

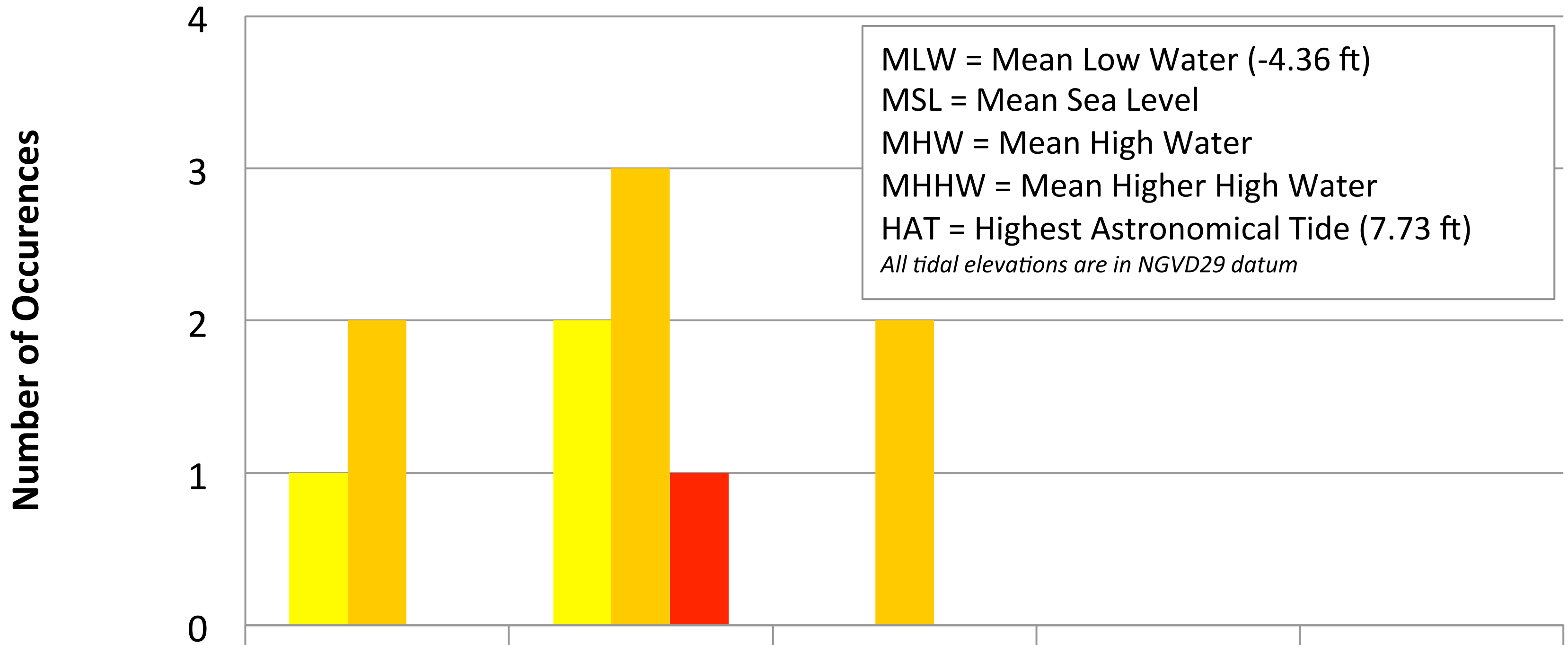


N = Number of Occurrences
P = Annual Probability

SUB/TROPICAL STORMS & DEPRESSIONS	CATEGORY 1 HURRICANE	CATEGORY 2 HURRICANES	CATEGORY 3 HURRICANES
	Hurricane Sandy [1]: October 29-30, 2012	**Hurricane Bob:** August 16 - 29, 1991	**Hurricane Esther:** September 10 - 27, 1961
	Great Atlantic Hurricane of 1944: September 9 - 16, 1944	**Hurricane Gloria:** September 27,1985	**Hurricane of 1869:** September 7 – 9, 1869
	Unnamed (1936): September 8 - 25, 1936	**Hurricane Donna**: September 12, 1960	
	Unnamed (1924): September 27 - 30, 1924	**Hurricane Edna**: September 11, 1954	
	Hurricane of 1916: July 10 - 22, 1916	**Hurricane Carol**: August 31, 1954	
	Unnamed (1904): September 8 - 15, 1904	**Great New England Hurricane**: September 21, 1938	
	Unnamed (1896): August 30 - September 11, 1896	**Unnamed** (1924): August 16 - 28, 1924	
	Unnamed (1894): October 1 - 12, 1894	**Unnamed (1869)**: October 4 - 5, 1869	
	Unnamed (1893): August 15 - 26, 1893		
	Unnamed (1888): September 23 - 27, 1888		
	Unnamed (1885): September 17 - 23, 1885		
	Unnamed (1879): August 13 - 20, 1879		
	Unnamed (1858): September 14 - 17, 1858		

[1] All storms listed above tracked within 150 miles of Boston, except Hurricane Sandy.

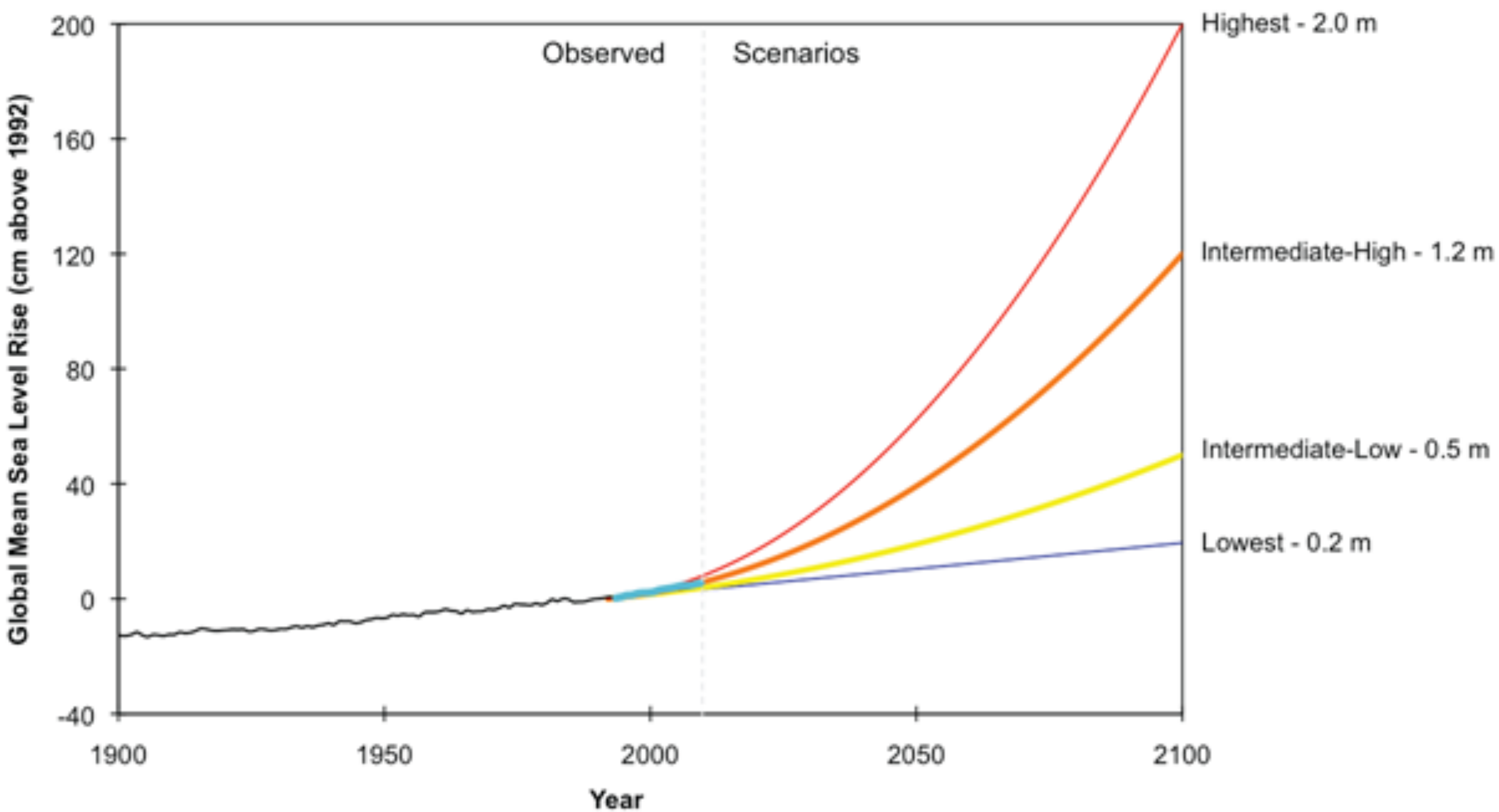
Tide Levels at Peak Hurricane Storm Surge - Boston (1923-2013)



	MLW	MSL	MHW	MHHW	HAT
Category 1	1	2	0	0	0
Category 2	2	3	2	0	0
Category 3	0	1	0	0	0

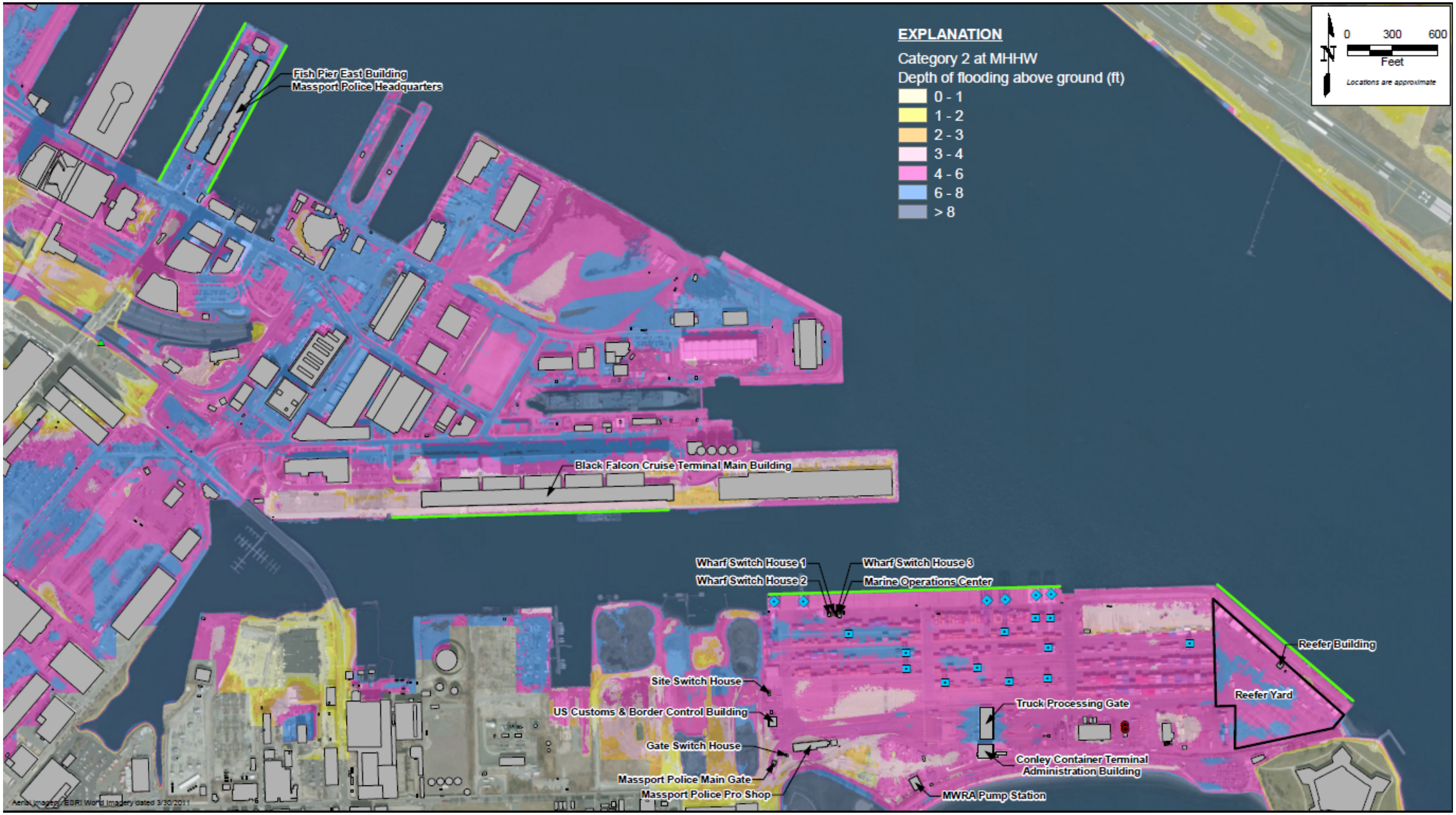
Sandy made final landfall near Atlantic City, NJ on 10/30/2012 00:00 GMT as a Category 1 hurricane at MHW (NOAA, 2013)

Sea Level Rise Projections

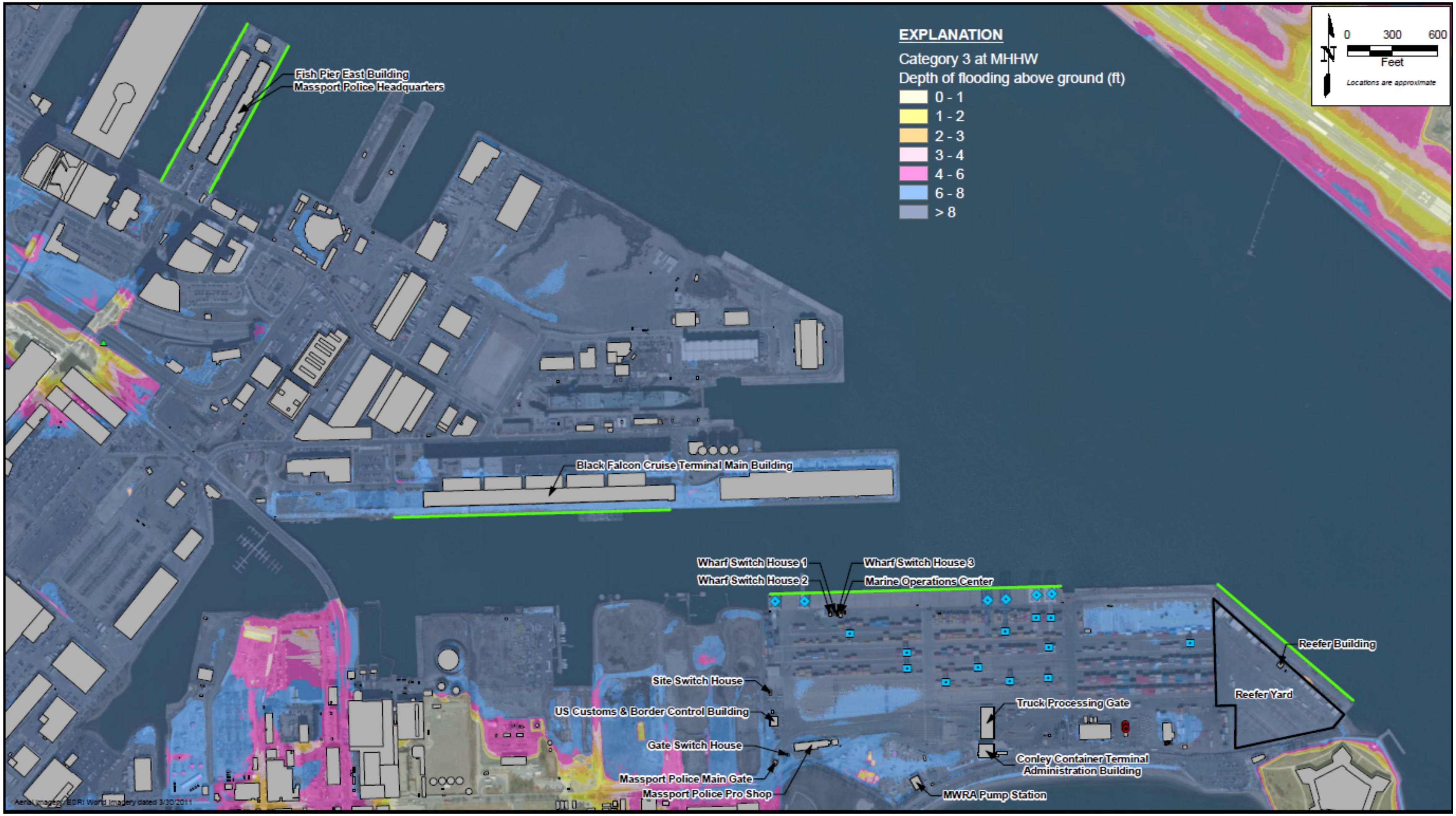


Global mean sea level rise scenarios provided by NOAA as part of the National Climate Assessment report published in December 2012.

South Boston - Flooding from Category 2 Hurricane at MHHW



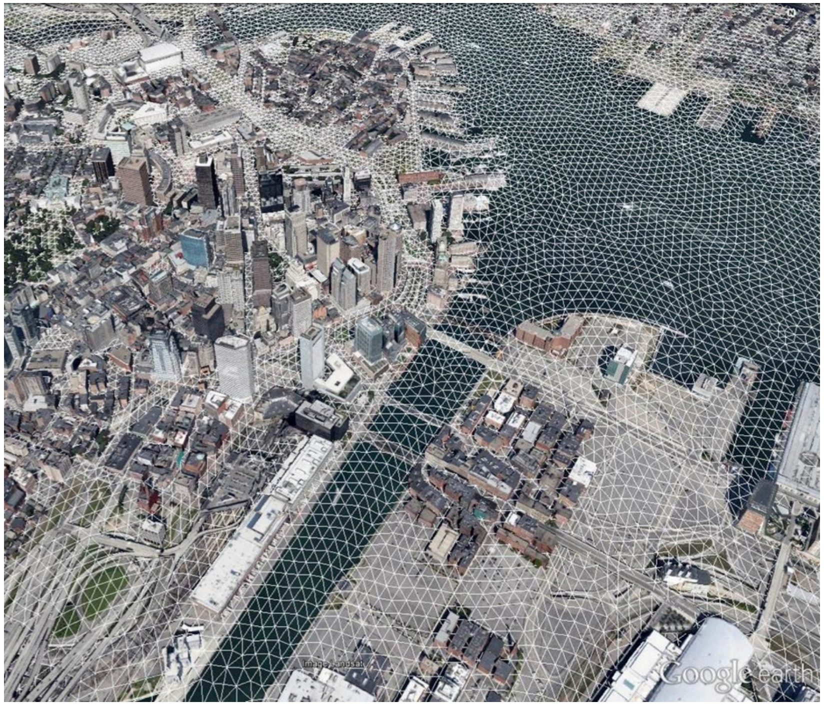
South Boston - Flooding from Category 3 Hurricane at MHHW

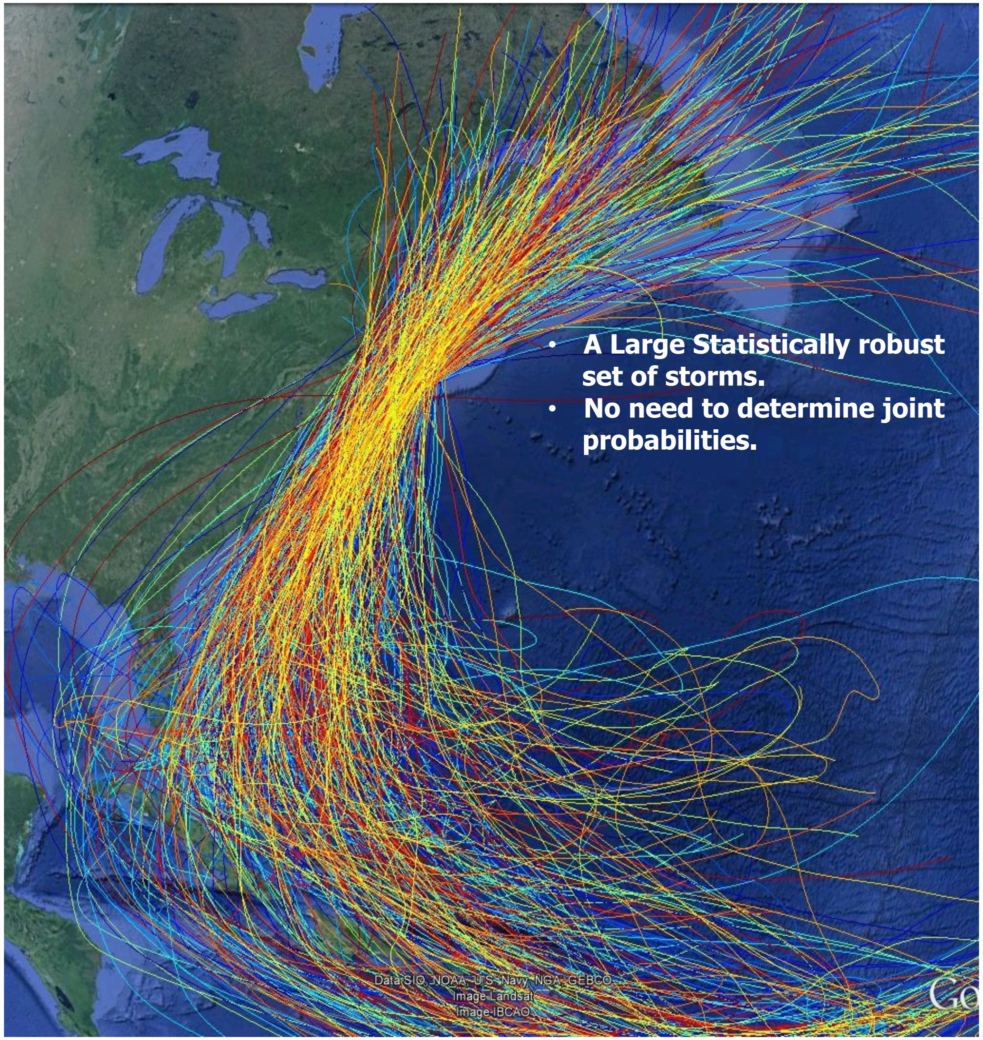


Storm Climatology

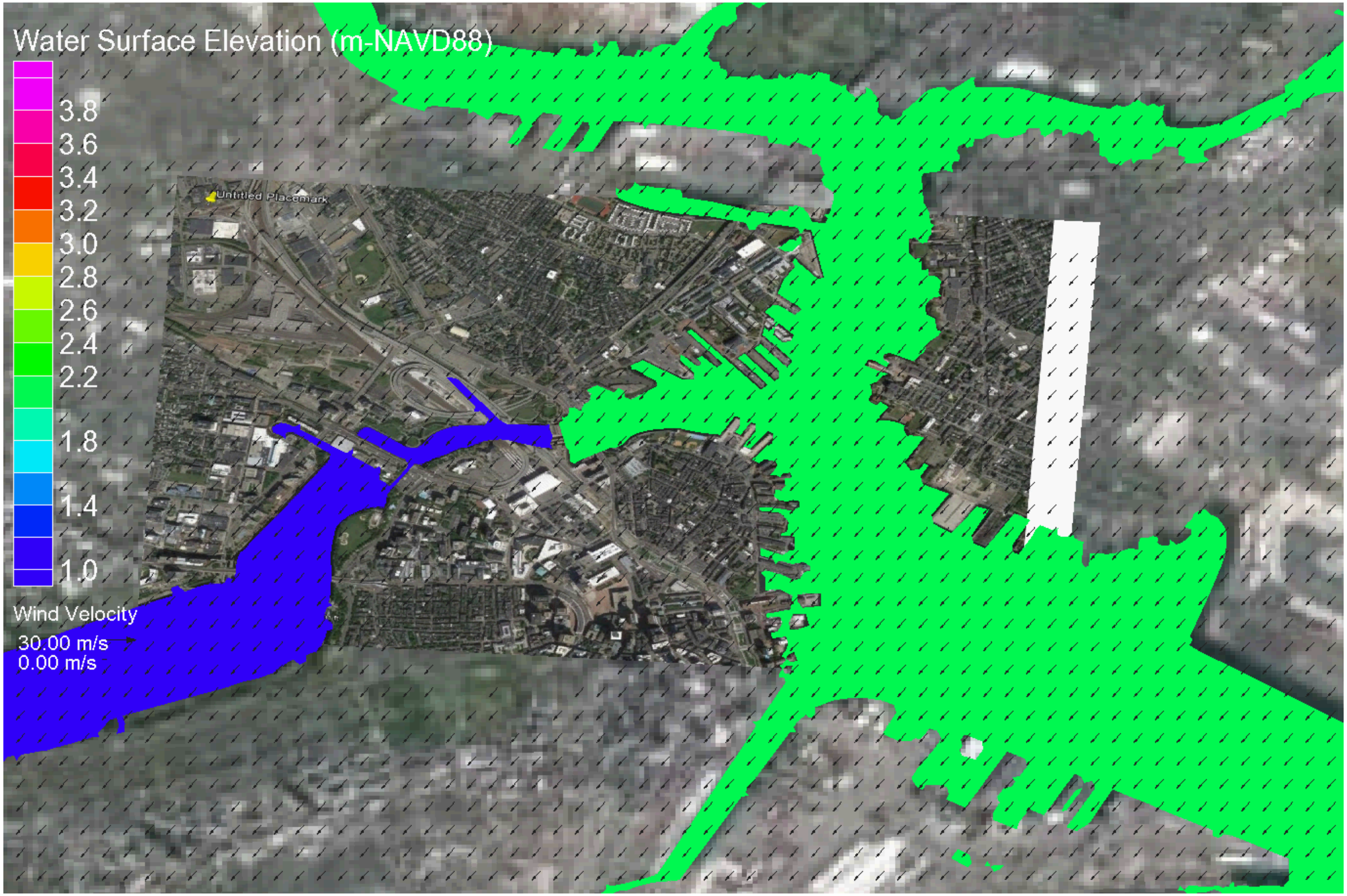
- Includes both tropical and extra-tropical storm sets

- Present and future climate change scenarios



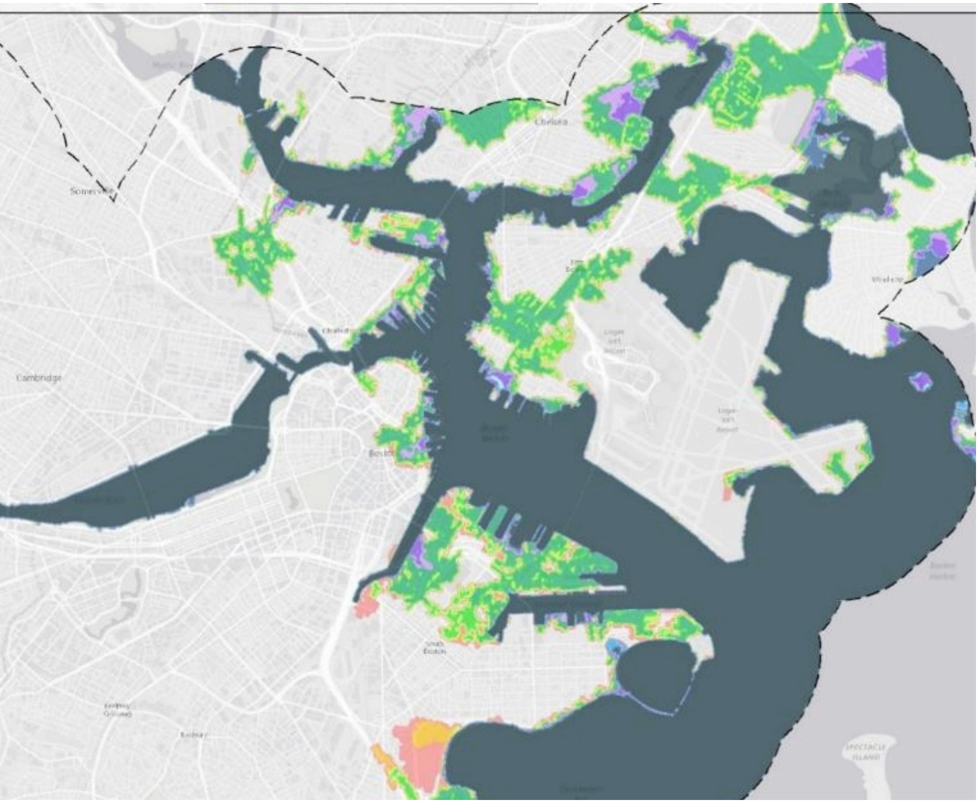


Source: Woods Hole Group

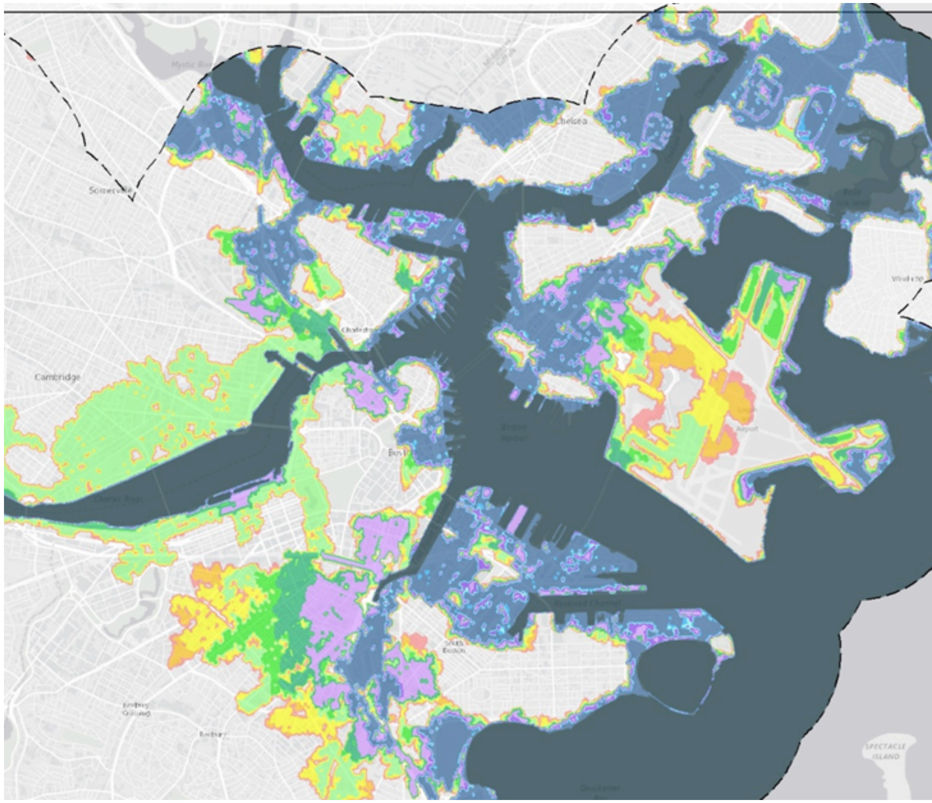

Water Surface Elevation (m-NAVD88)
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
1.8
1.4
1.0
Wind Velocity
30.00 m/s
0.00 m/s
Untitled Placemark

Flood Risk Model

- 2030



- 2070



Design Flood Elevations (Probabilistic Model)

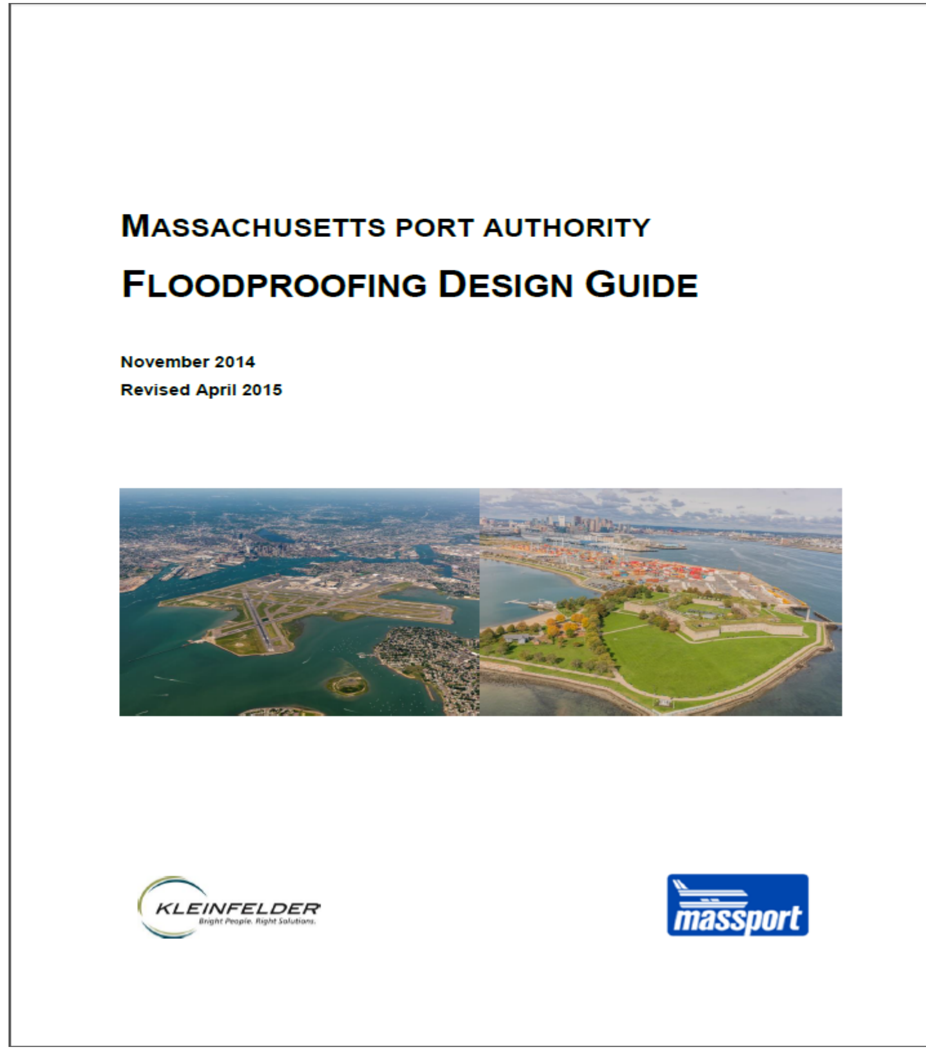
20	
	OLD - Logan DFE New Facilities: Cat 3 MHW = 19.5 ft (SLOSH)
18	OLD - Maritime DFE New Facilities: Cat 3 MHW = 19.3 ft (SLOSH)
16	NEW – MPA DFE New Facilities: 0.2% 2070 +3 ft freeboard = 17 ft (BH-FRM)
	OLD - Logan DFE Existing Facilities: Cat 2 MHW = 15.4 ft (SLOSH)
14	OLD - Maritime DFE Existing Facilities: Cat 2 MHW = 15 ft (SLOSH)
	NEW – MPA DFE Existing Facilities: 0.2% 2030 +3 ft freeboard = 13.7 ft (BH-FRM)
12	AE 1% 2013 = 10 to 13 ft (FEMA*)
10	AE 1% 2009 = 9 to 11 ft (FEMA)

(Feet NAVD88)

Floodproofing Design Guidelines

Floodproofing Design Guide:

- Design Flood Elevations
  - New Facilities
  - Existing Facilities
- Floodproofing Strategies
  - Wet Floodproofing
  - Dry Floodproofing
- Performance Standards
- Reviews and Approvals



MASSACHUSETTS PORT AUTHORITY

FLOODPROOFING DESIGN GUIDE

November 2014

Revised April 2015

KLEINFELDER

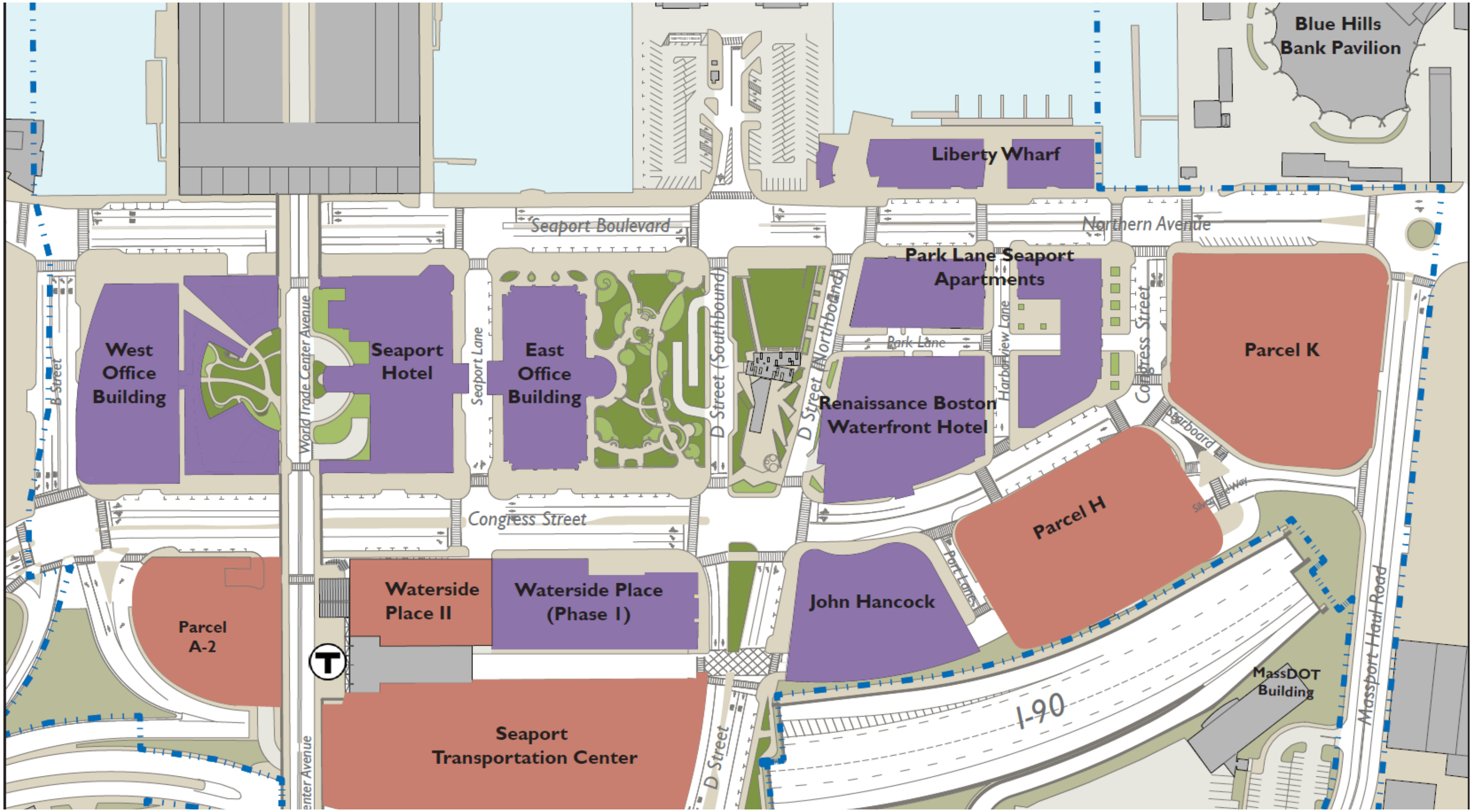
Bright People. Right Solutions.

massport

New Construction

New Construction

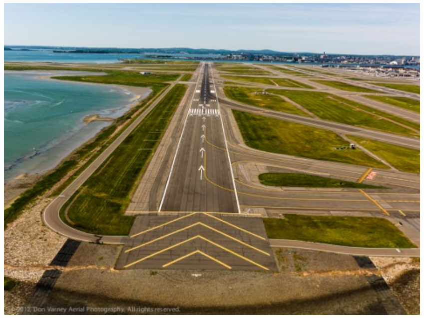
Real Estate and tenants



South Boston Maritime – Critical Facilities

Consequence: Criticality Score

Description	Criticality Score
Assets required for **bare-bones functionality** for disaster preparedness, response, and recovery	**3**
Assets required for **disaster response** in the immediate aftermath of a flood event	**2**
Assets required for facility to **recover to acceptable level of service**	**1**




Risk-Based Prioritization

Probability of Flooding

Determined based on Inundation Model results

Flooded in more storm scenarios → higher probability, higher priority

Consequence of Flooding

Criticality Score X Occupancy Category

Criticality Score	Occupancy Category
Based on role in disaster preparedness, response, recovery	Based on ASCE/SEI 24-05 Standard for Flood Resistant Design and Construction

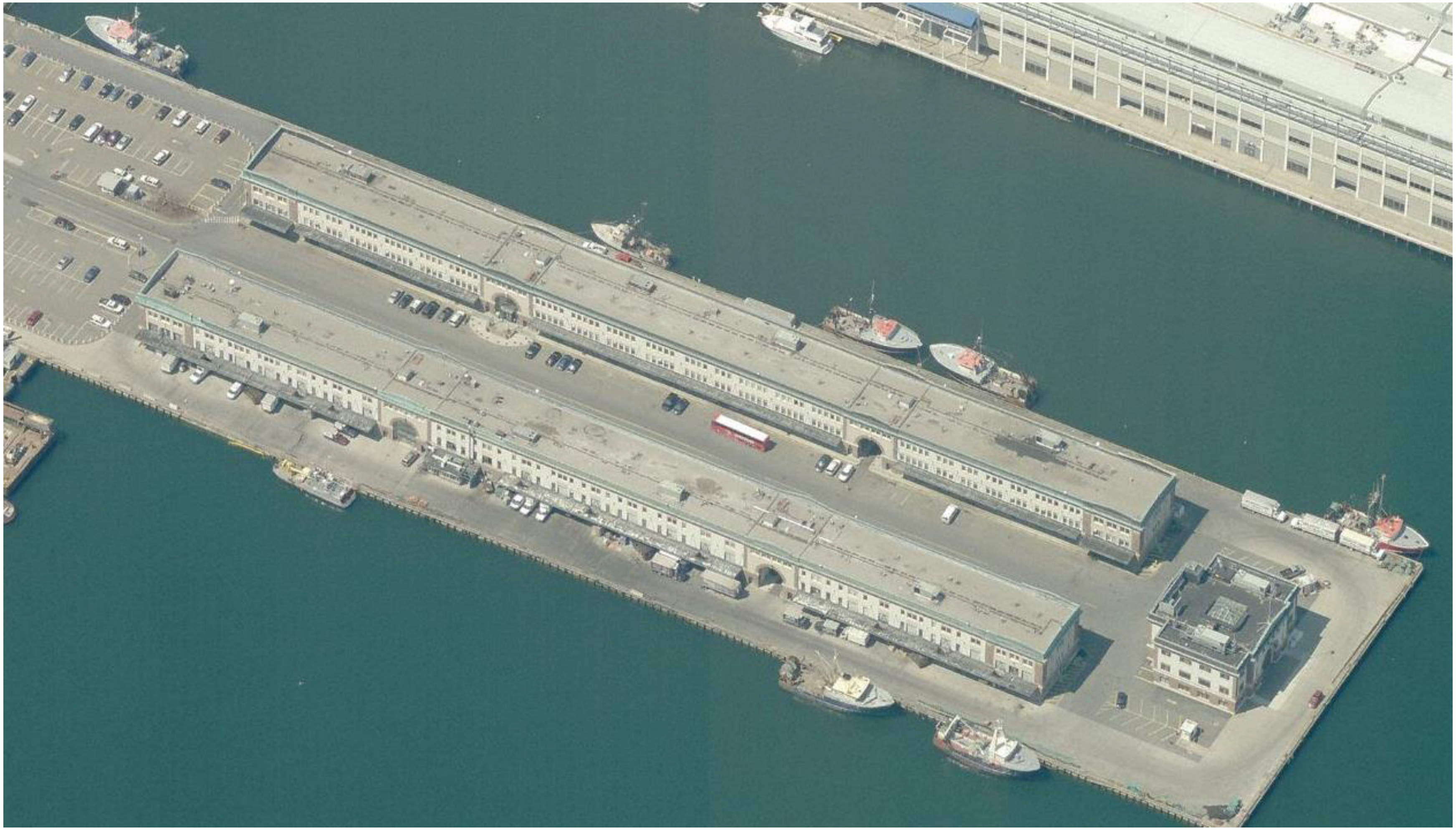
Higher consequence → higher priority

Depth of Flooding

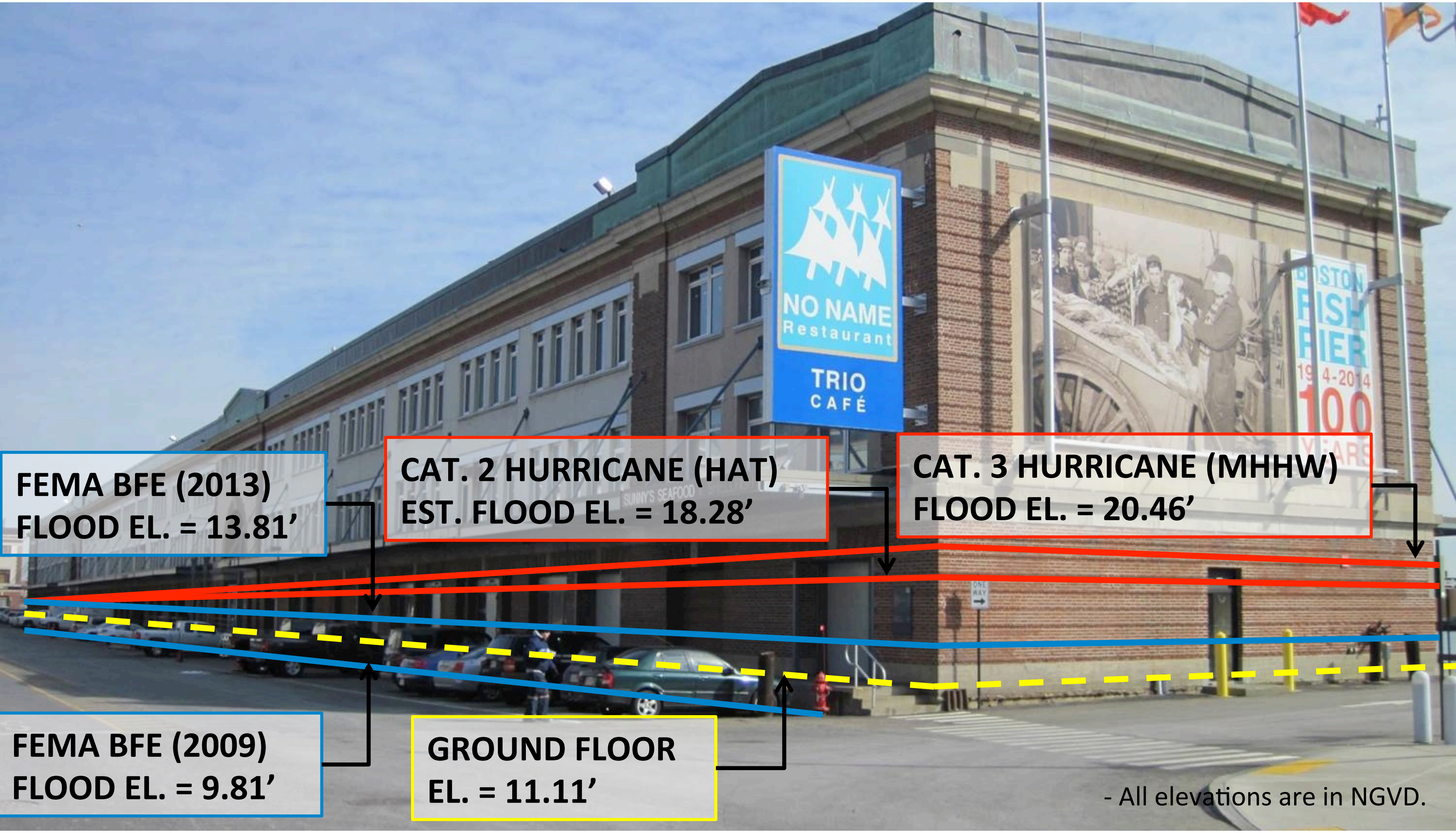
Further distinguish among assets with same Probability and Consequence

Higher depth → higher priority

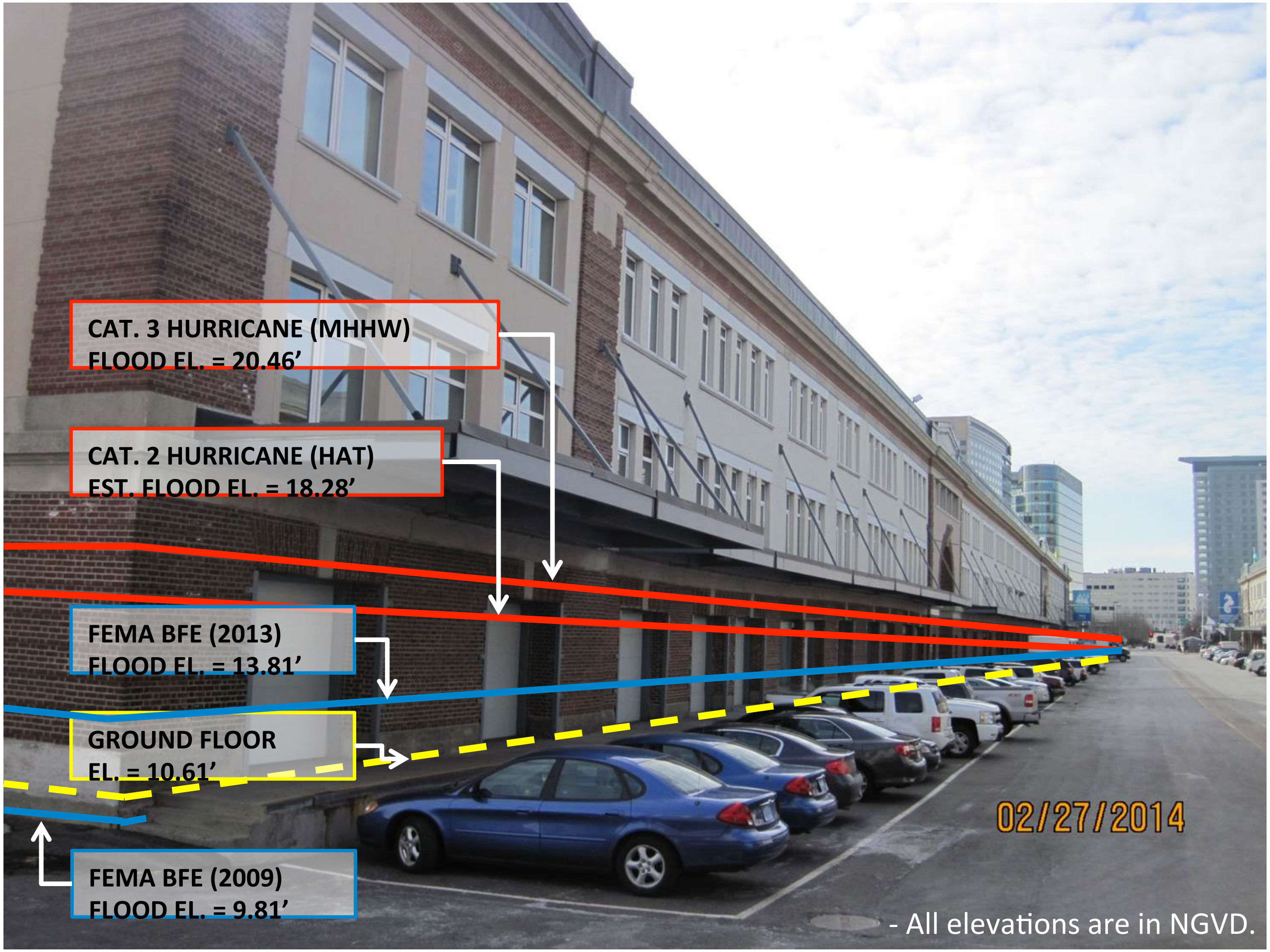
Fish Pier



Fish Pier East – Design Flood Elevations



Fish Pier East – Design Flood Elevations



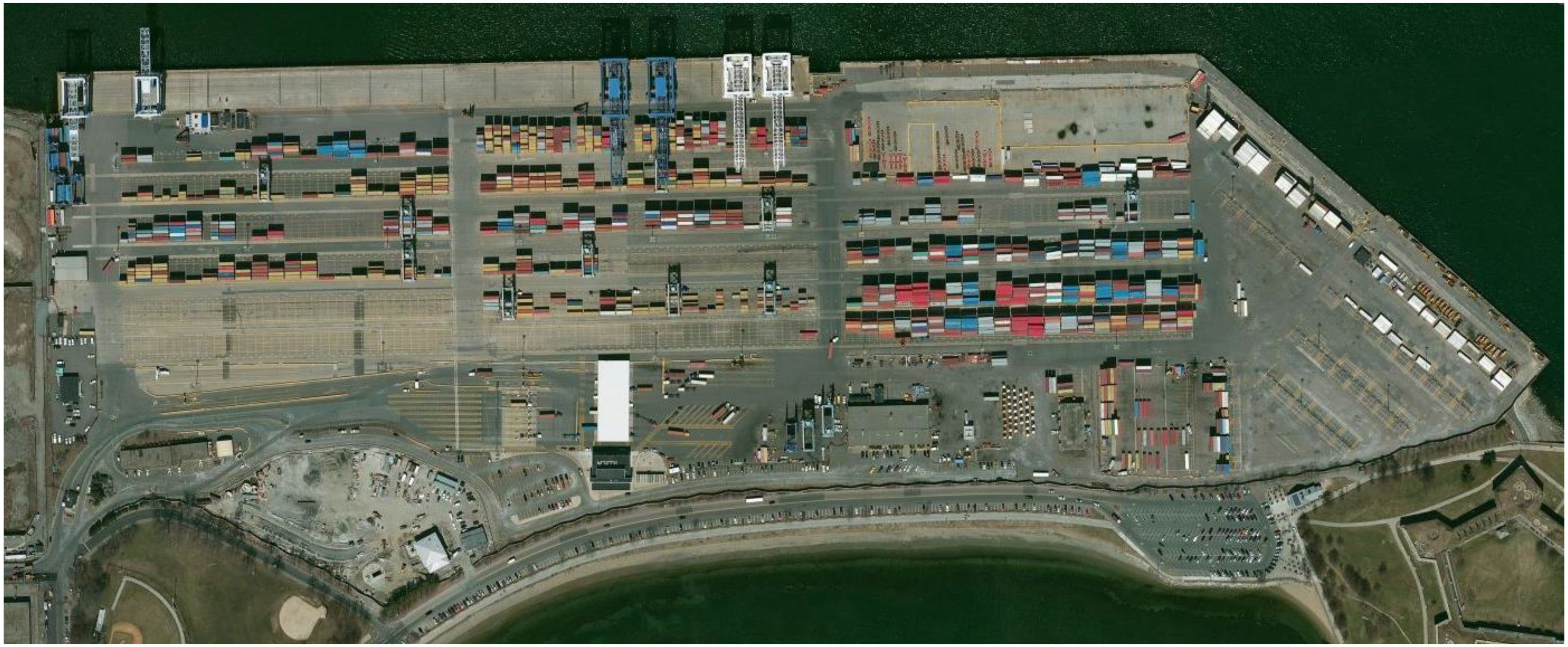
Fish Pier – Design Flood Elevations

Fish Pier – Resiliency Objectives

Resiliency Performance Objectives:

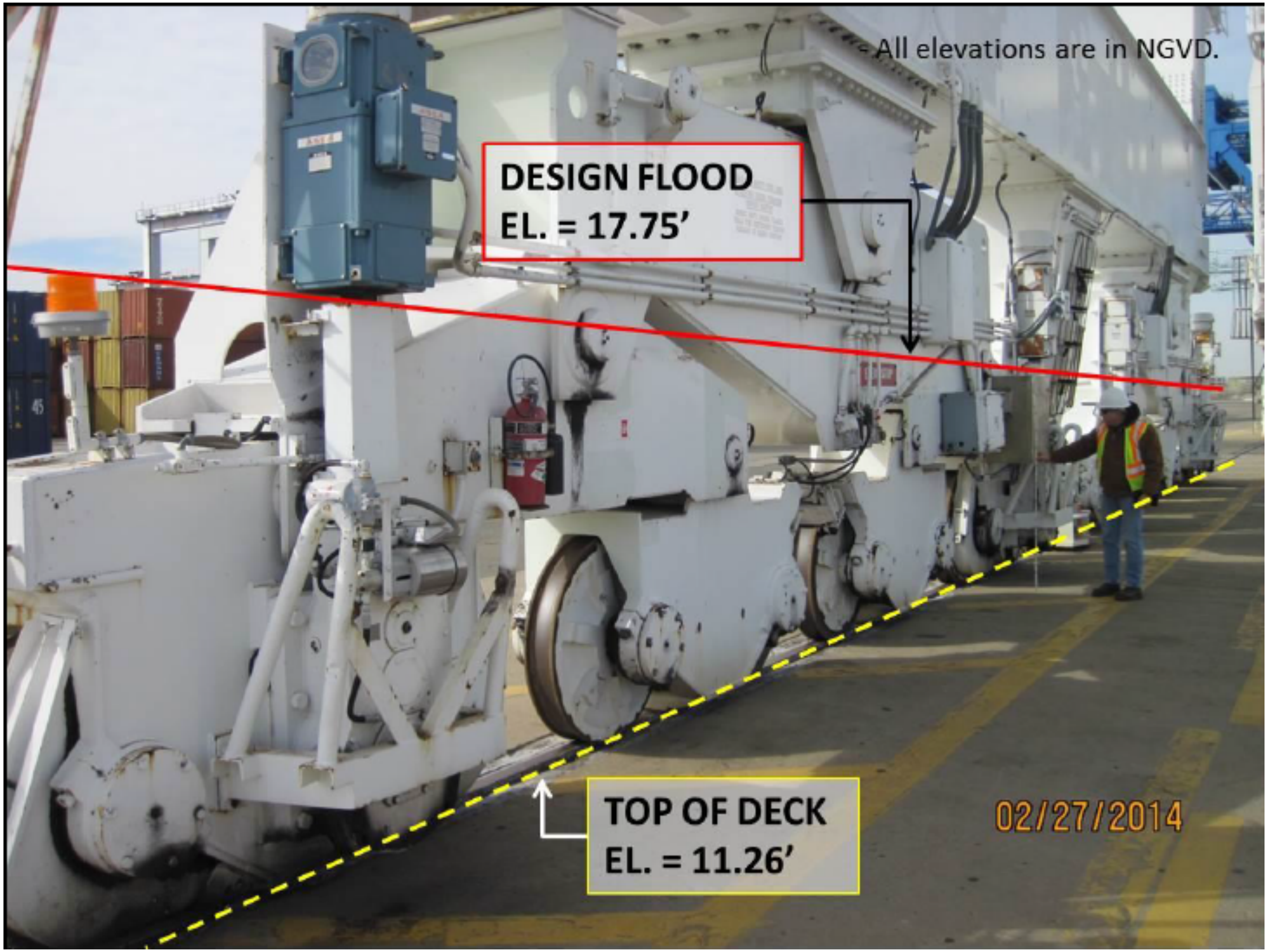
- Allow the first floors of buildings to flood
- Prevent damage to critical electrical and fire protection systems and building elevator machinery
- Prevent flooding of underground waste storage tanks and associated pump systems
- Prevent structural failure of the building due to flooding

Conley Terminal



Conley Terminal - Vessel Berths

Conley Terminal – Vessel Cranes



Adaptation Planning & Design

2015 Resiliency Work Plan for Critical MPA Assets at Logan and Maritime

- *Task 1 - ADCIRC Model*
- *Task 2 - Re-Review Tier 1 Facilities*
- **Task 3 - Temporary Measures Procurement/Demonstration**
- **Task 4 - A/E Services for the Permanent Flood Control at Tier 1 Facilities**
- **Task 5 - Operational Plan**

Common Adaptation Recommendations – Temporary Flood Walls

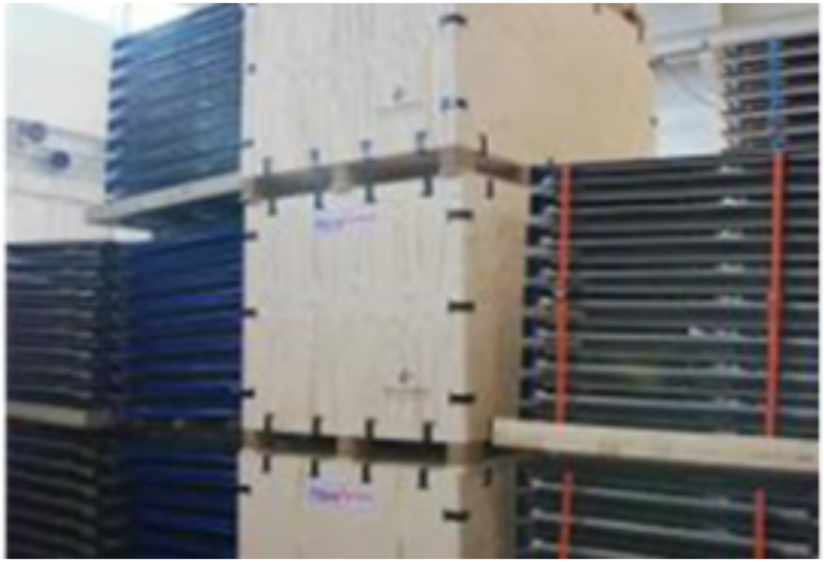
Inflated Height in Feet	Maximum Controllable Water/Sediment Depth in Inches*	Inflated Volume in Gal. per liner Foot	Inflated Width in Feet	Connection Overlap Requirements in Feet
3	27	131	7	4.5
4	36	225	9	6
5	45	352	11.25	7.5
6	54	506	13.5	9
8	72	901	18	12

* The depth of water represents 75% of the inflated height of a fully inflated Aqua-Barrier™. It is required that a minimum 25% freeboard (portion of barrier above water level) inflated capacity be maintained during all phases of a project. Excess slopes and grades, soil composition, moving water, and other related hydrological criteria may increase or decrease the ability of the Aqua-Barrier™ to perform as projected.

Procure Temporary Flood Barriers

- AquaFence successful bidder
  - Logan Airport – 4 facilities
  - Conley Terminal - 2 facilities
  - Fish Pier – 3 Facilities
- Ready for deployment in September 2015

Access Stairs



Stored Barriers

Deployed Barriers

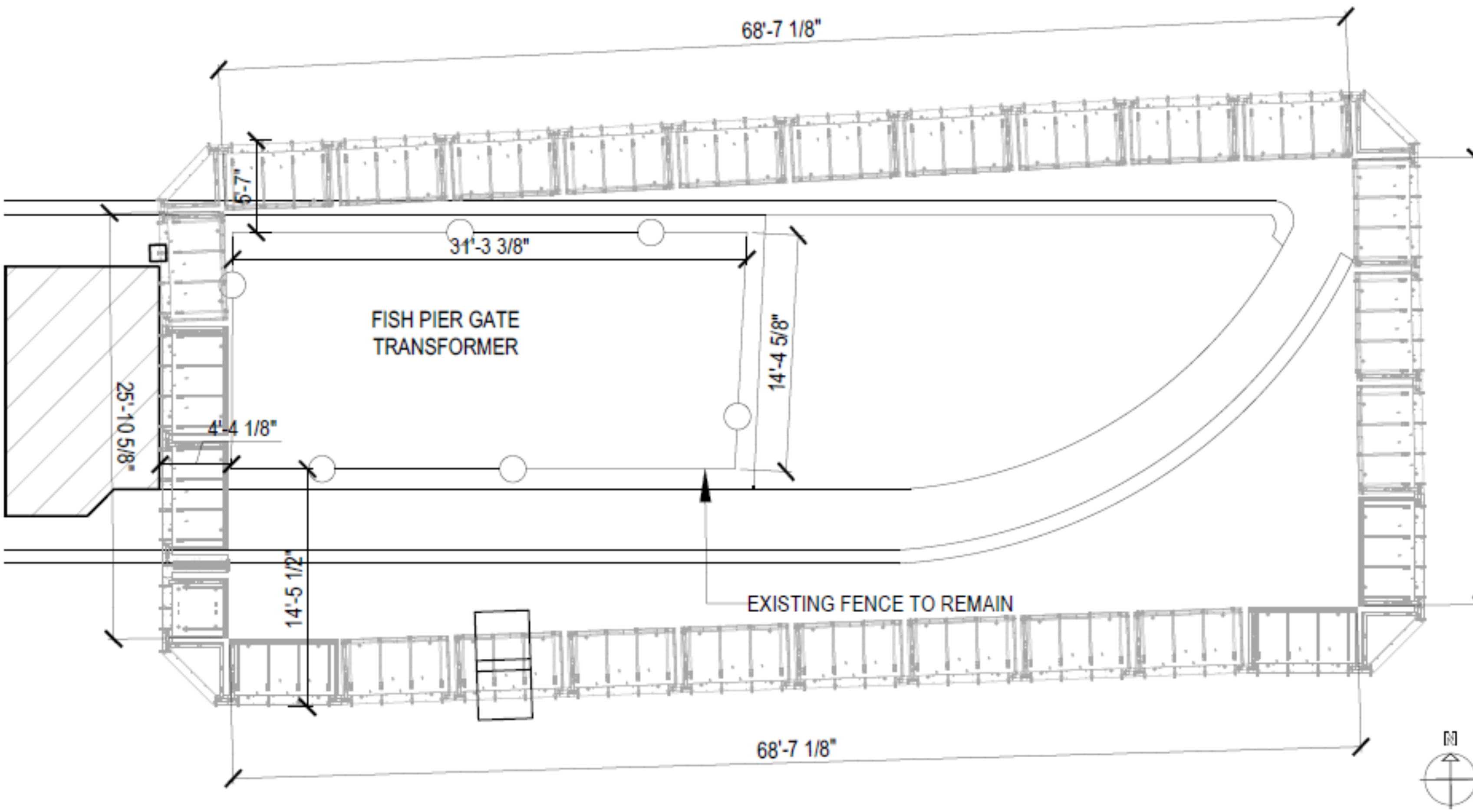
Temporary Flood Barriers

AquaFence Storage in Fumigation Building on 12/29/2015

A310-S2 Resiliency – Fish Pier – Gate Transformer

- Seal electrical conduits
- Purchase temporary water pump
- Install water level sensors
- Install ground anchors for AquaFence

A310-S2 Resiliency – Fish Pier – Gate Transformer



Permanent AquaFence Layout

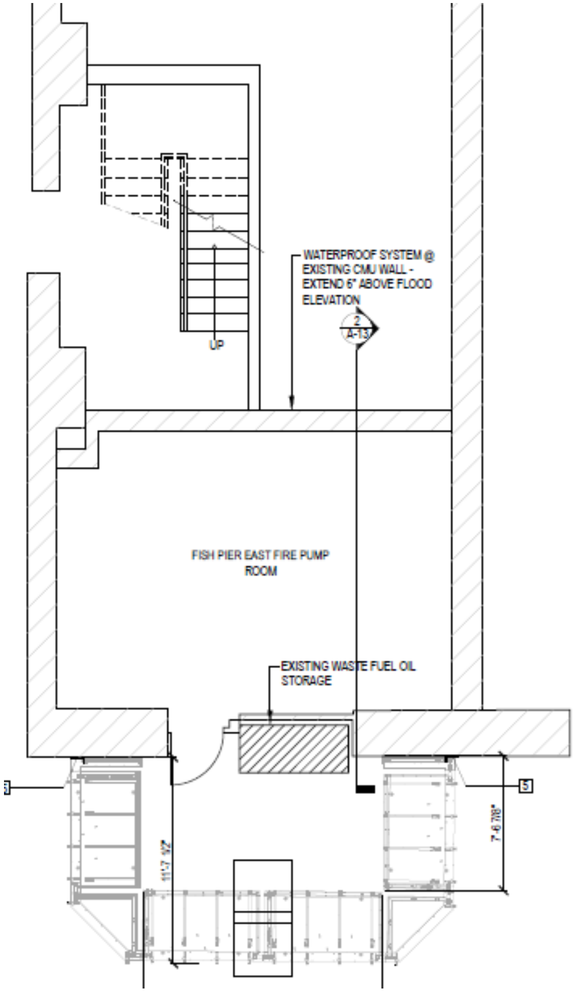
A310-S2 Resiliency – Common resiliency

Sealing Electrical Conduits

Water Level Sensors

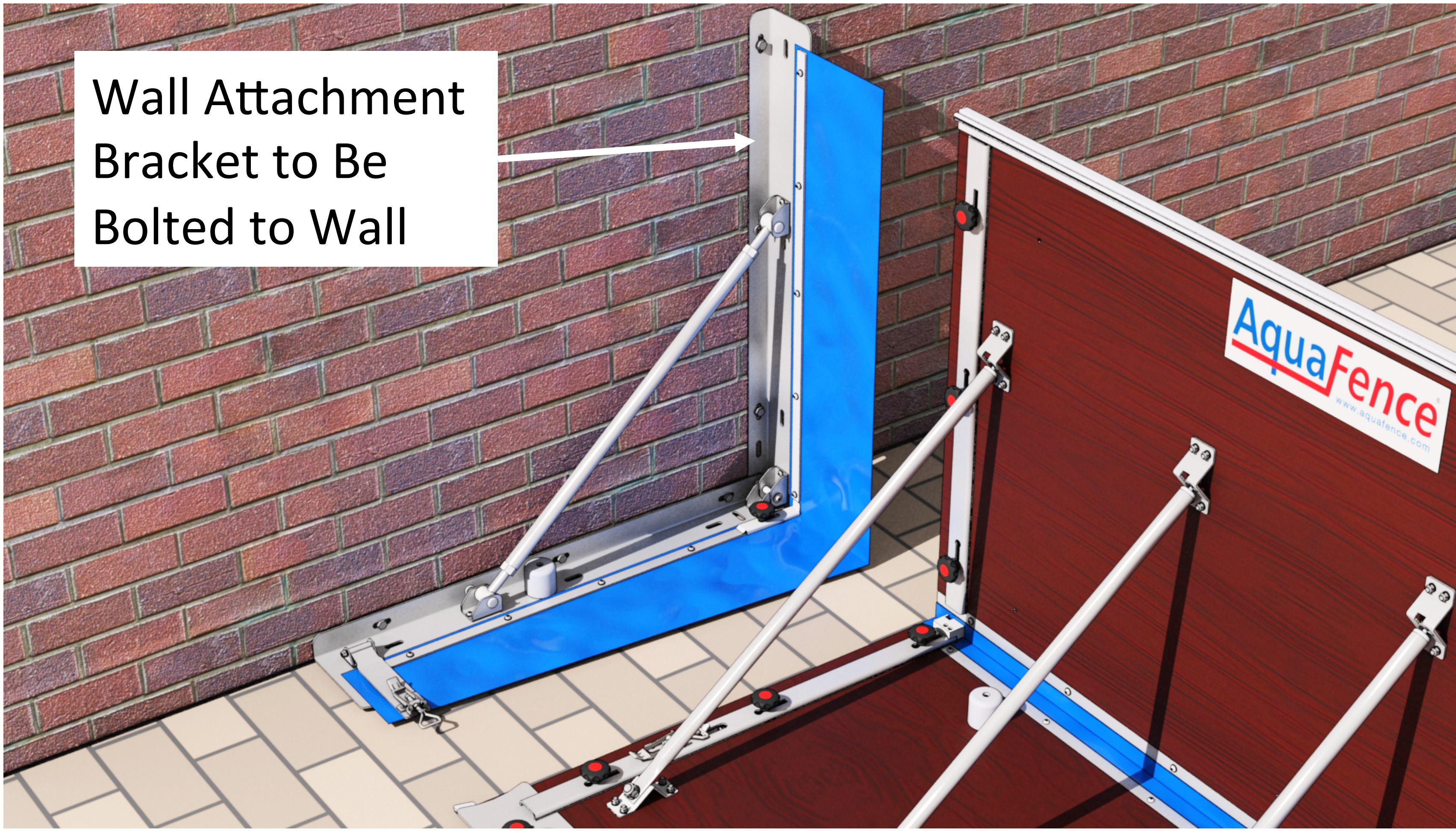
Temporary Water Pump

- Seal electrical conduits
- Purchase temporary water pump
- Install water level sensors
- Install ground anchors for AquaFence
- Waterproof interior CMU wall

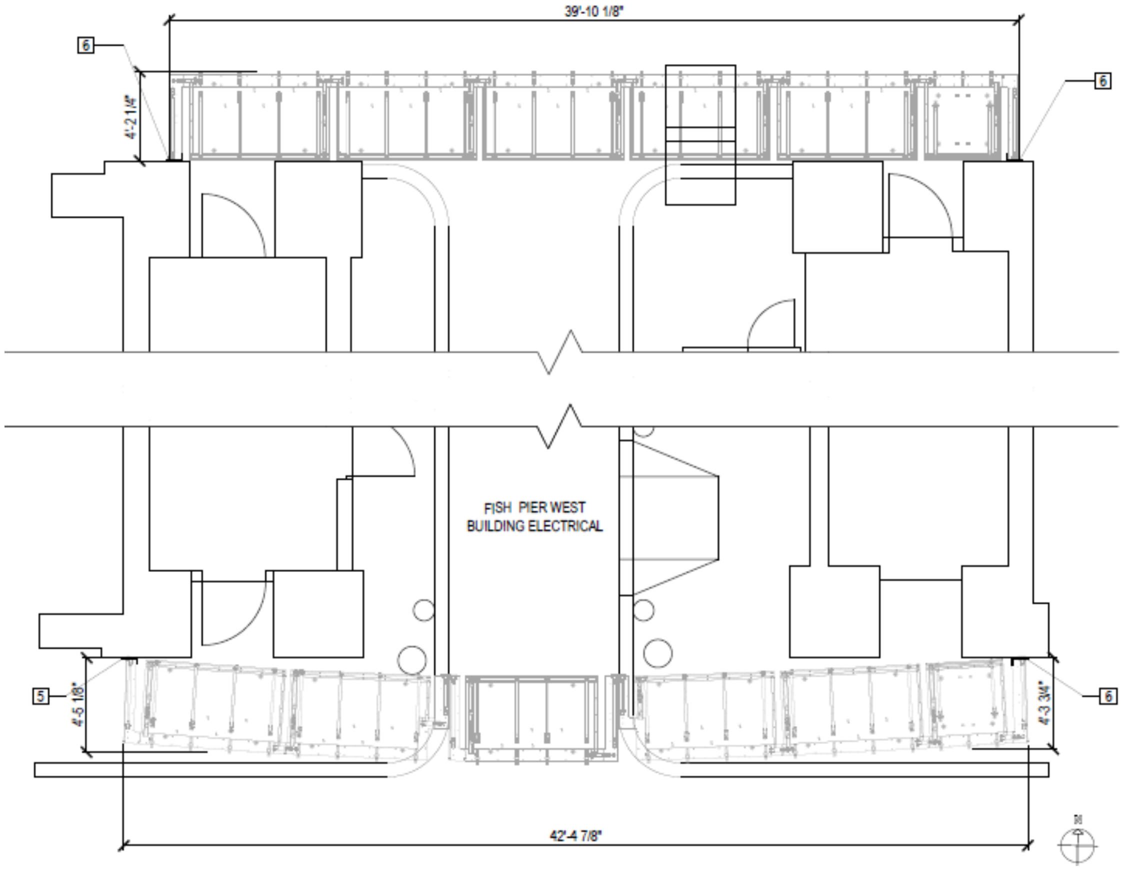


Permanent AquaFence Layout

A310-S2 Resiliency – Wall attachment



A310-S2 Resiliency – Fish Pier West– Electrical Room

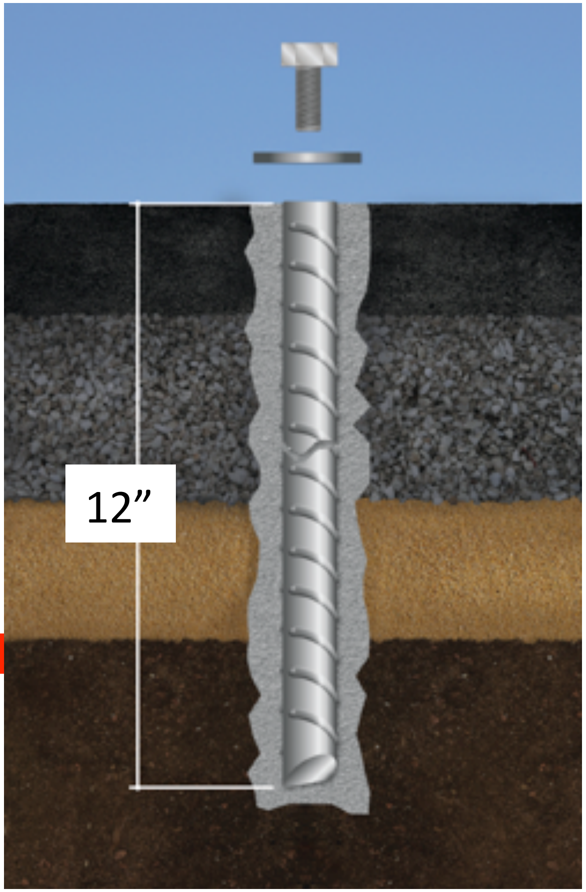


Permanent AquaFence Layout

- **Seal electrical conduits**
- **Purchase temporary water pump**
- **Install water level sensors**
- **Install ground anchors for AquaFence**
- **Install wall anchors at 4 AquaFence wall brackets**

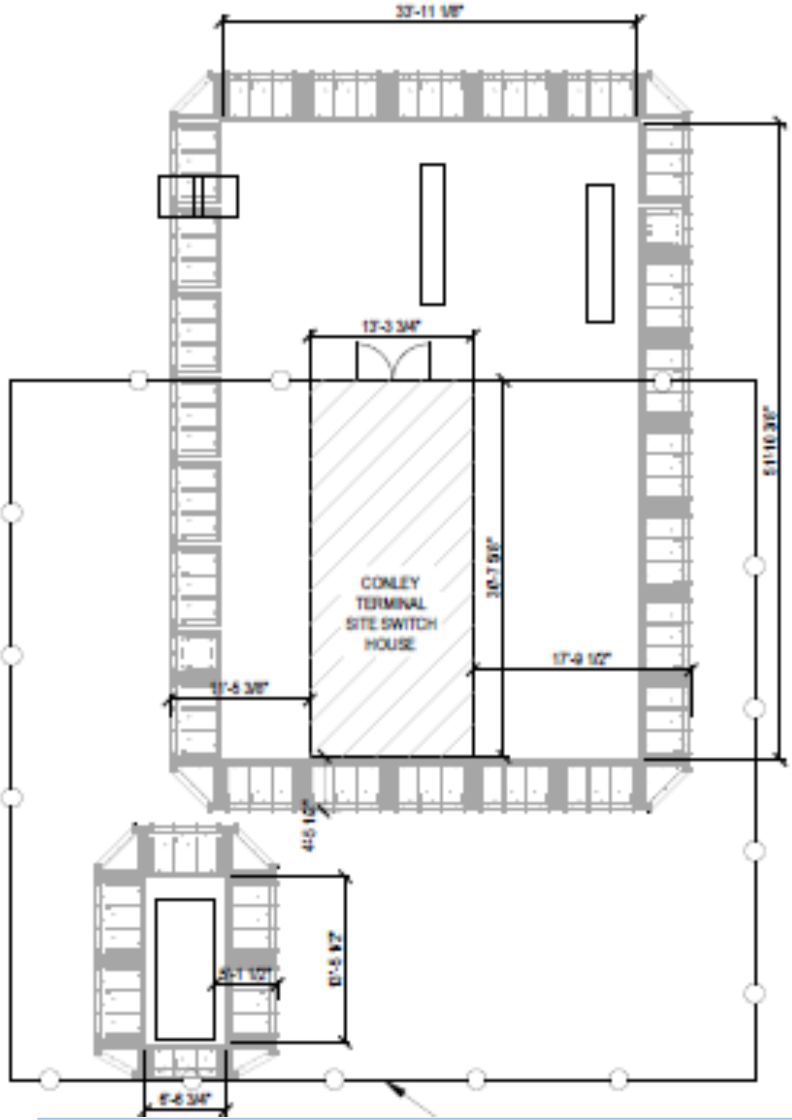
A310-S2 Resiliency – Ground acnhors

Typical AquaFence Panels



AquaFence Pavement Anchors

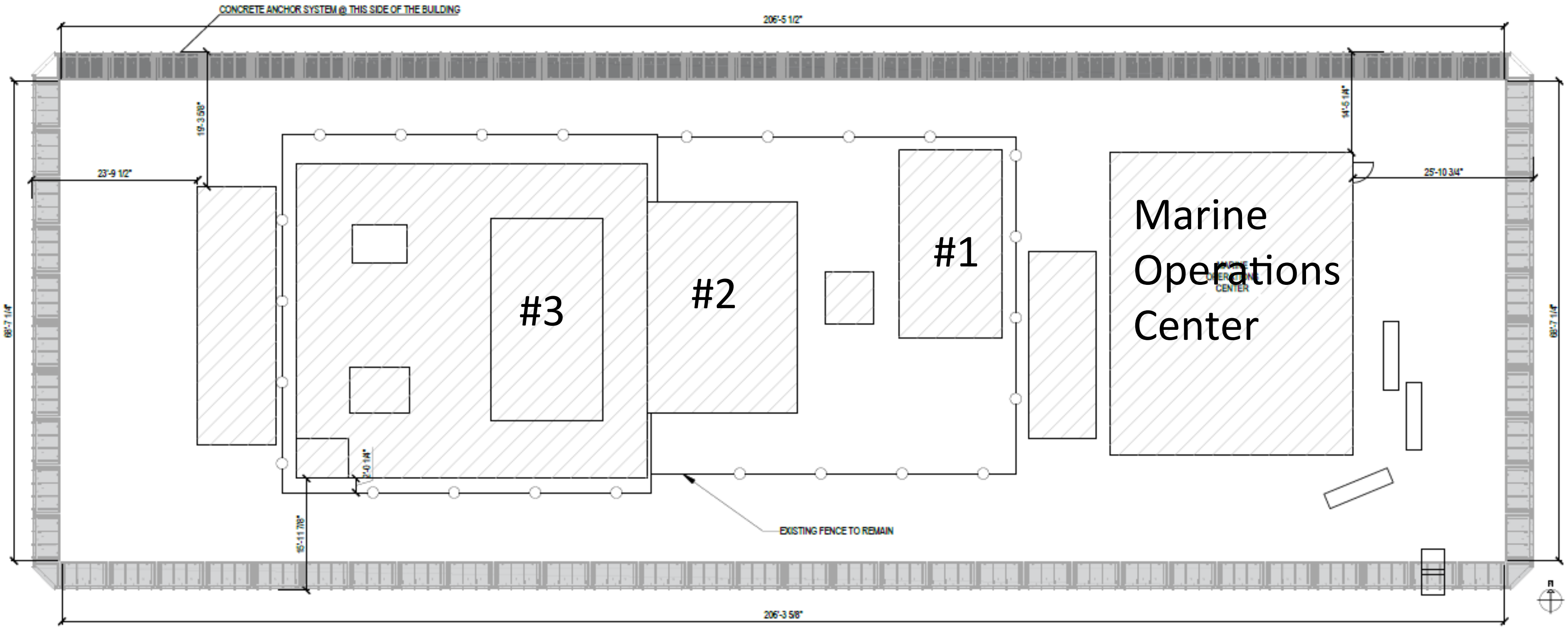
A310-S2 Resiliency – Conley – Site Switch House



- Seal electrical conduits
- Purchase temporary water pump
- Install water level sensors
- Install ground anchors for AquaFence

Permanent AquaFence Layout

A310-S2 Resiliency – Conley – Wharf Switch Houses



Permanent AquaFence Layout

- Install water level sensors
- Install ground anchors for AquaFence
- Install sewer shut-off valve
- Seal electrical conduits
- Purchase temporary water pump

A310-S2 Resiliency – Schedule

Milestone	Date
60 % Submission	January 15, 2016
Final Bid Documents for Bidding	March 3, 2016
Pre-Bid Conference	March 15, 2016
Filed Sub-Bid Opening	March 30, 2016
General Contractor Bid Opening	April 13, 2016
Contract Award	May 4, 2016
Notice-to-Proceed	May 11, 2016
Construction Complete (9 weeks)	August 12, 2016

June 3. 2014 HEAVY WEATHER PLAN

Revised 11/14/2015

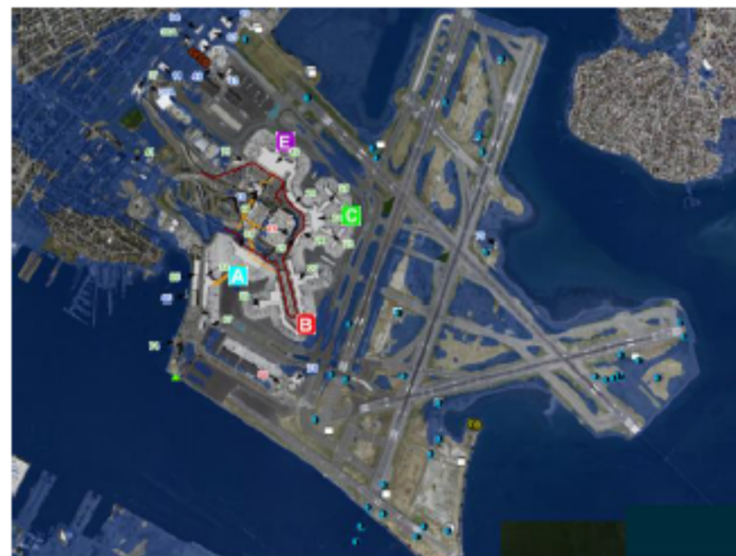
HEAVY WEATHER AND FLOOD OPERATIONS PLAN

FOR MASSPORT'S MARITIME FACILITIES

Massachusetts Port Authority

LOGAN INTERNATIONAL AIRPORT

COASTAL FLOOD OPERATIONS PLAN



November 2015

Guiding Principles

- Safety is #1
- Stakeholder-driven
- Integrated in all-hazards planning
- Minimize disruptions & speed recovery
- Realistically reflect available resources
- More than a document

Airport Coastal Flood Operations Plan - Timelines

Pre-Flood
72, 48, 24, 12, 6 hours

During Flood

Post-Flood
12 hours & 12+ hours

New Flood Preparedness Actions & Timelines

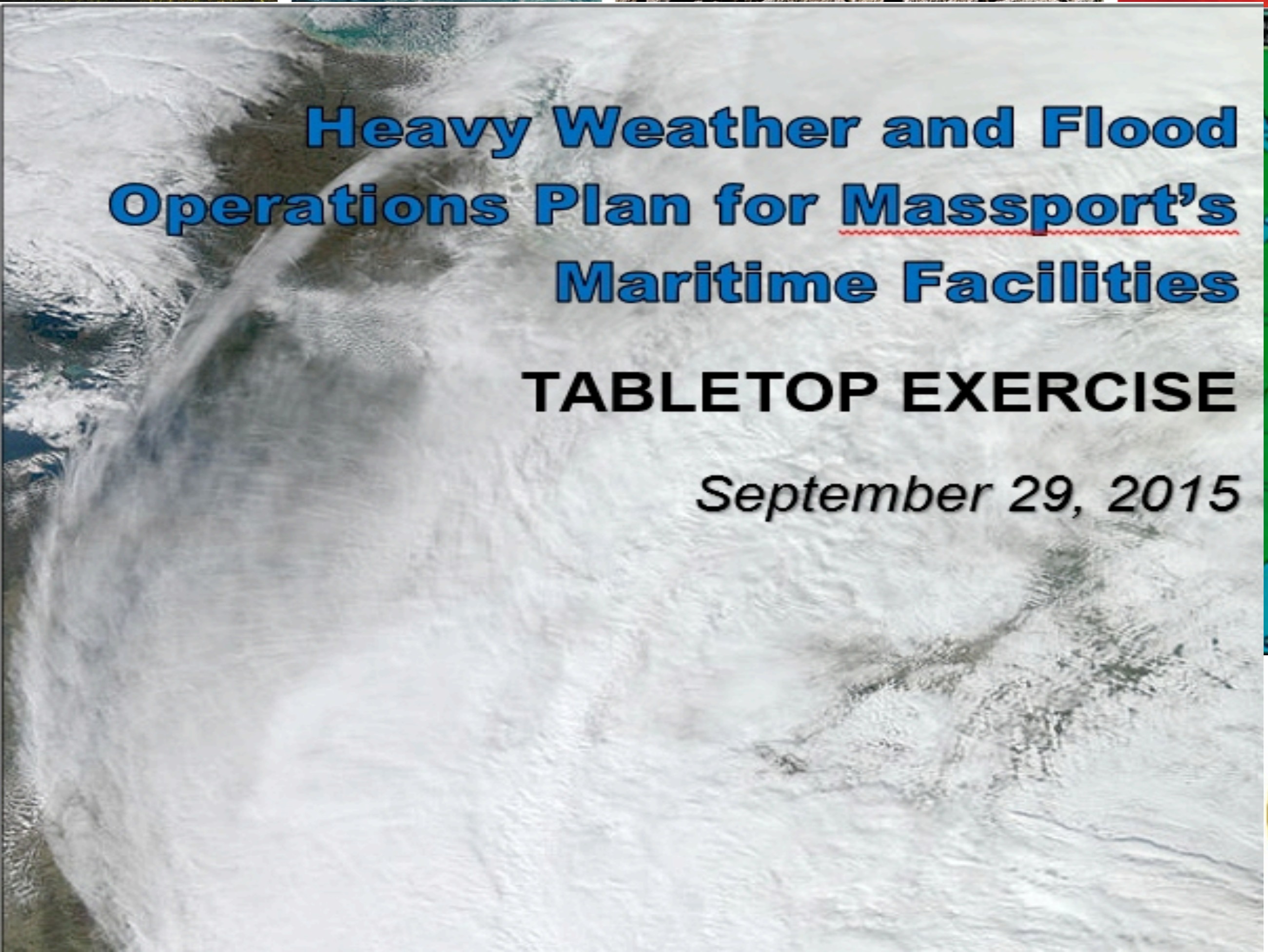
- Flood forecasting and decision framework
- Temporary flood barrier system deployments
- Preventative electrical and IT measures
- Elevating critical stock, equipment, materials
- Relocating fleet out of harms way
- Requiring berthed vessels to leave dock
- Preventative evacuations of at risk buildings
- Debris and waste management planning

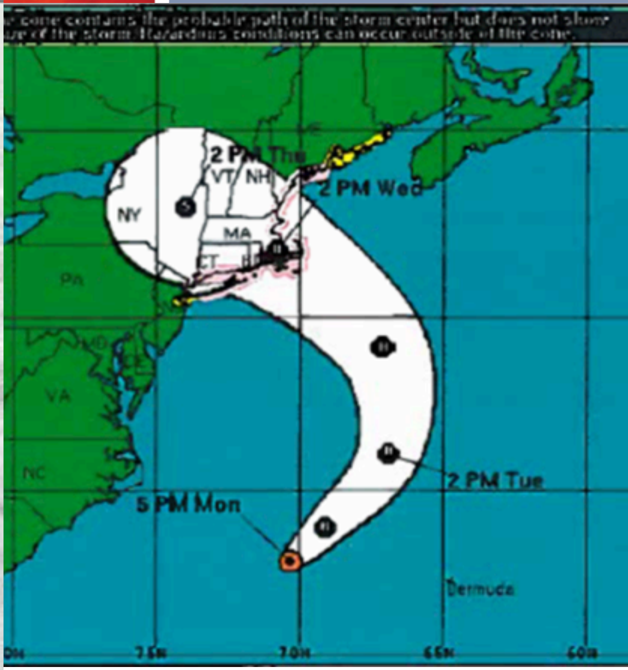
Tabletop Exercises

massport

U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA

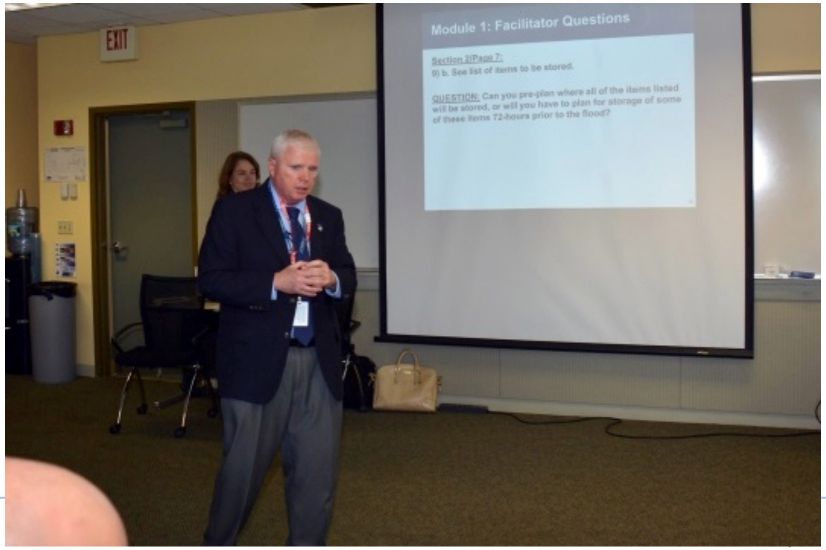




MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY

KLEINFELDER
Bright People. Right Solutions.

Highly Participatory



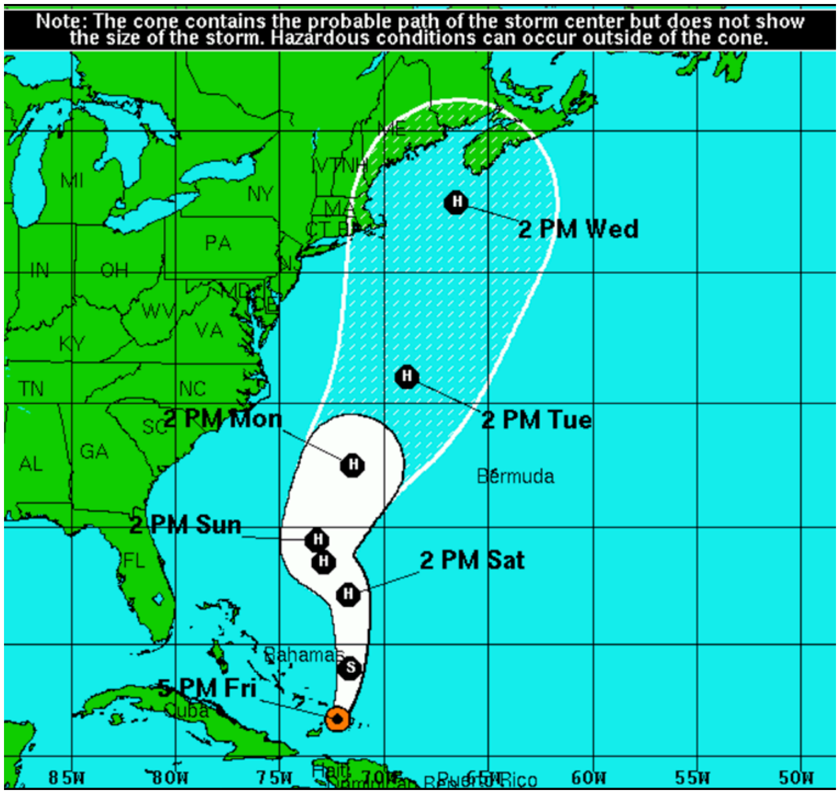
Tough Questions

- Who is responsible for flood monitoring?
- How soon do we activate?
- Who is the “decider”?
- When do we notify contractors?
- Where do we operate from during the event?
- Where is the safest place to shelter people?
- Where is safest place to move vehicles?
- Do essential employees live in impacted areas?

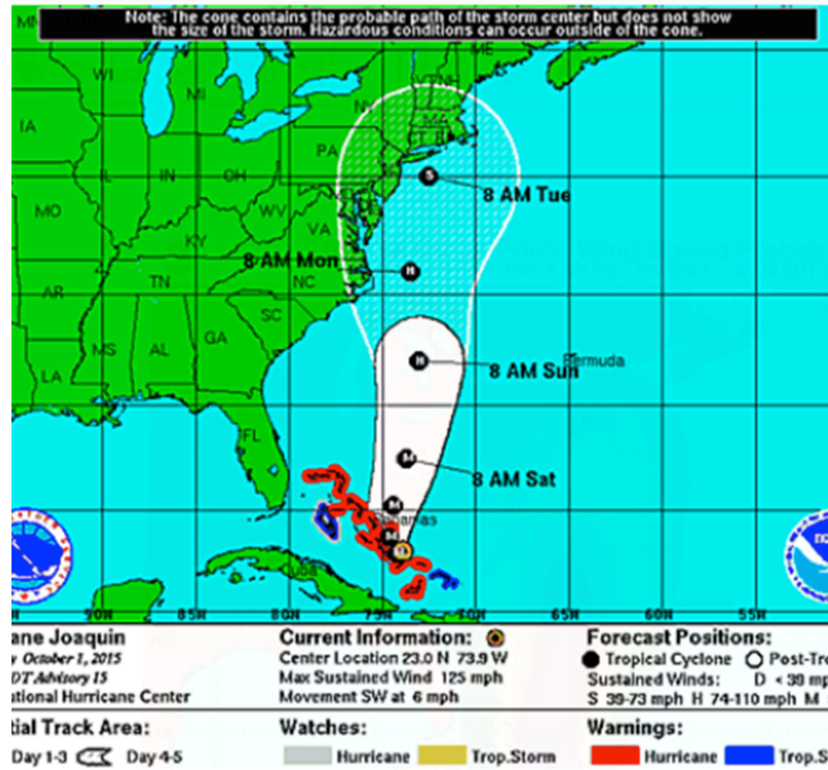
Flood Forecast Reports

DESCRIPTION	FLOOD FORECAST DATA
Date and time of arrival of flood elevation greater than or equal to 9.0 ft. NAVD88	N/A (2)
Maximum flood elevation forecasted (ft. NAVD88 vertical datum)	7.6 ft. NAVD88 (3) (a) 7.5 ft. NAVD88 (3) (b)
Anticipated wave height at time of maximum flood elevation (ft.) (if available)	Harbor: 2- 3 ft.
Date and time of maximum flood elevation	(a) 10/1/15 @ 1400 (b) 10/2/2015 @ 1500
Date and time of recession of flood to elevation below 9.0 ft. NAVD88	N/A (2)
Duration of predicted flooding above elevation 9.0 ft. NAVD88 from start to recession	N/A (2)
Forecasted maximum wind gust speed and direction	NE - Up to 30 kt(4) Small Craft Advisory until 2000 Friday 10/1/2015
Forecasted maximum sustained wind speed and direction	NE - 15 - 25 kt(4) Small Craft Advisory until 2000 Friday 10/1/2015

TTX to Reality

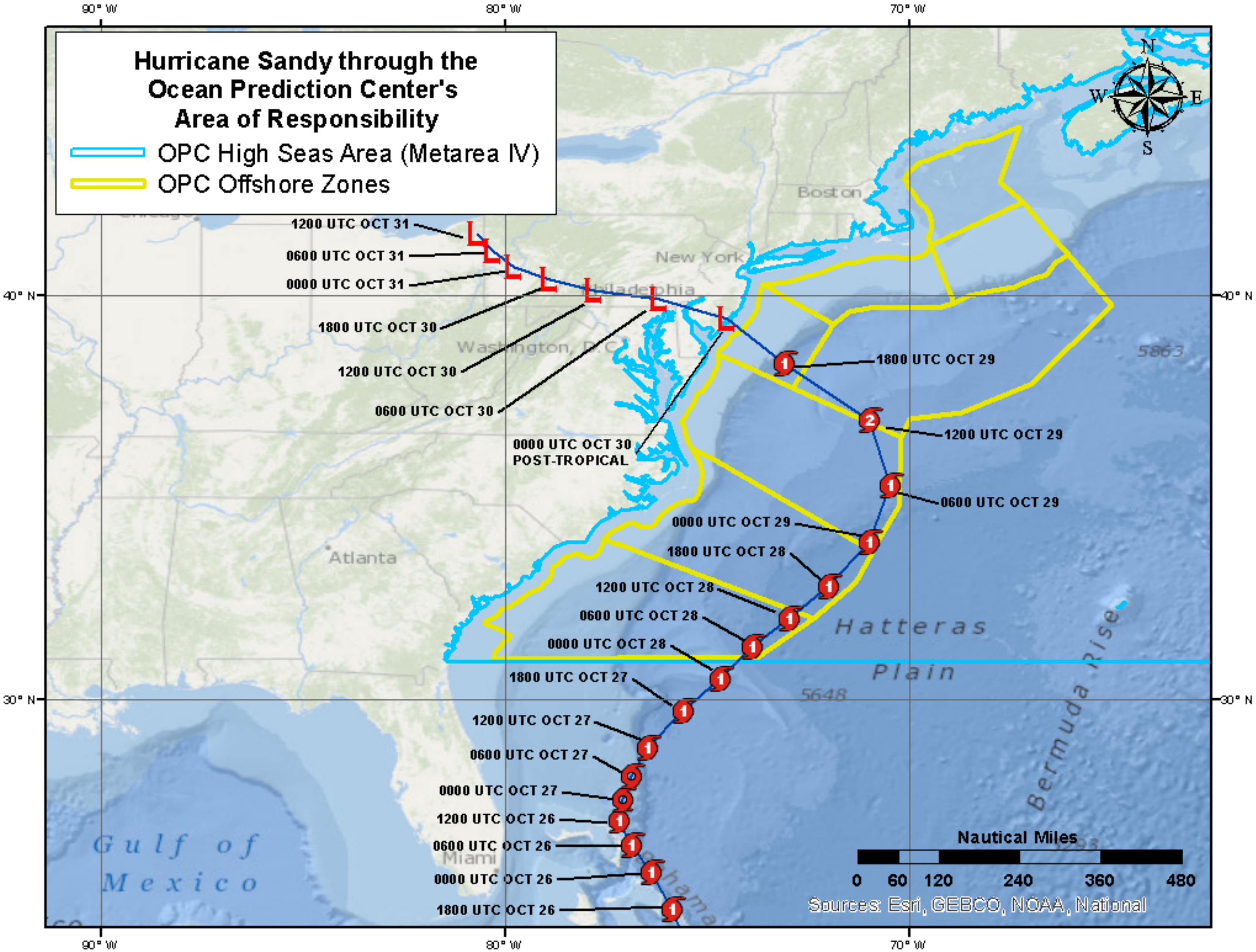


Hurricane Robbin – Table Top Exercise 9/29/15



Hurricane Joaquin – October 1, 2015

Expect the Unexpected



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Discussion