LOWER MANHATTAN COASTAL RESILIENCY

APRIL 2018

HR&A AECOM BIG BJARKE INGELS GROUP one

NYCEDC New York City Economic Development Corporation

NYC Mayor's Office of Recovery & Resiliency

LOWER MANHATTAN COASTAL RESILIENCE STUDY

STUDY OBJECTIVES

- Identify extent of climate hazards and exposure in Lower Manhattan
- Assess options for adapting to climate threats over the long-term (i.e., to 2100)

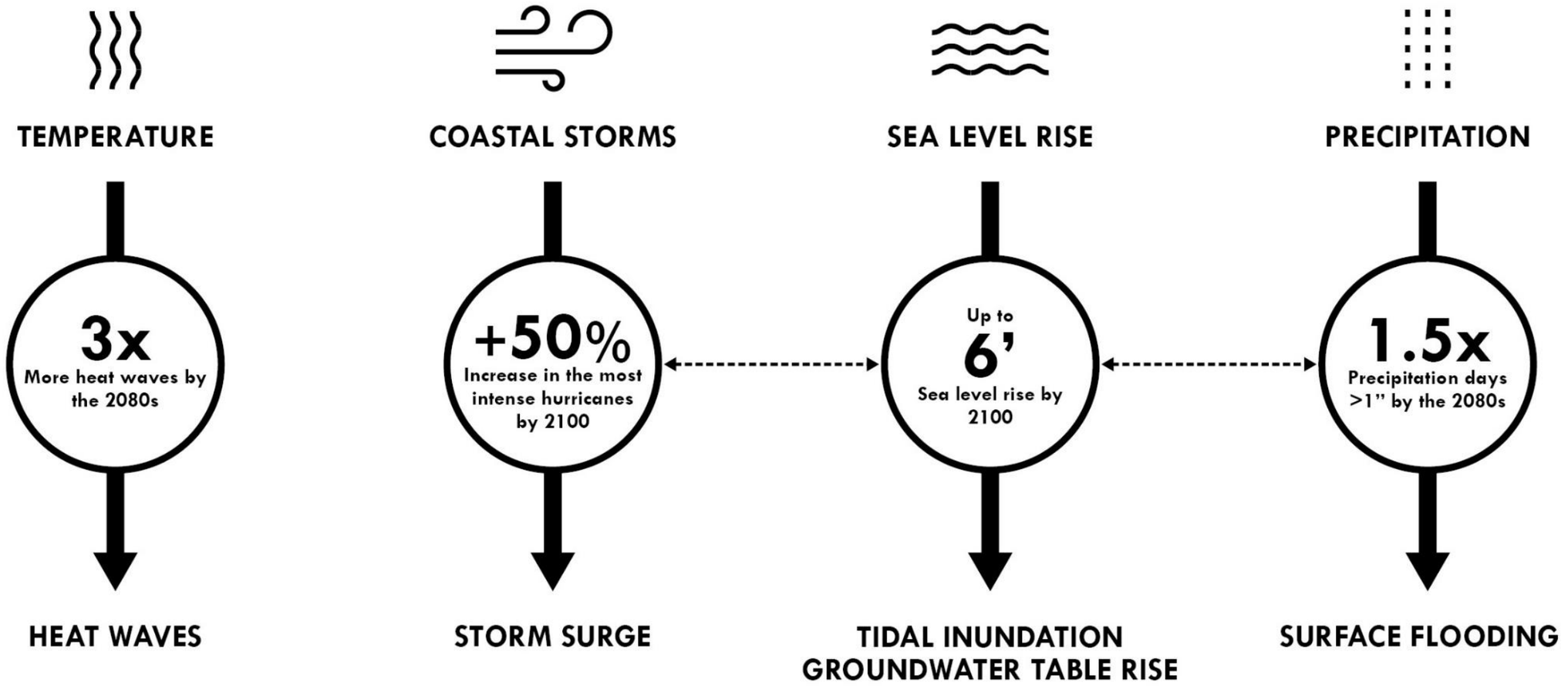
PRELIMINARY FINDINGS

- Lower Manhattan faces increasingly frequent climate events of ever greater intensity, impacting critical infrastructure systems and the economy of not only the district but also New York City and the wider region.

- Lower Manhattan's evolving economy and population growth are stressing existing systems – transportation, stormwater infrastructure and the public realm.

- Certain previously contemplated concepts have reduced viability because of range of climate threats

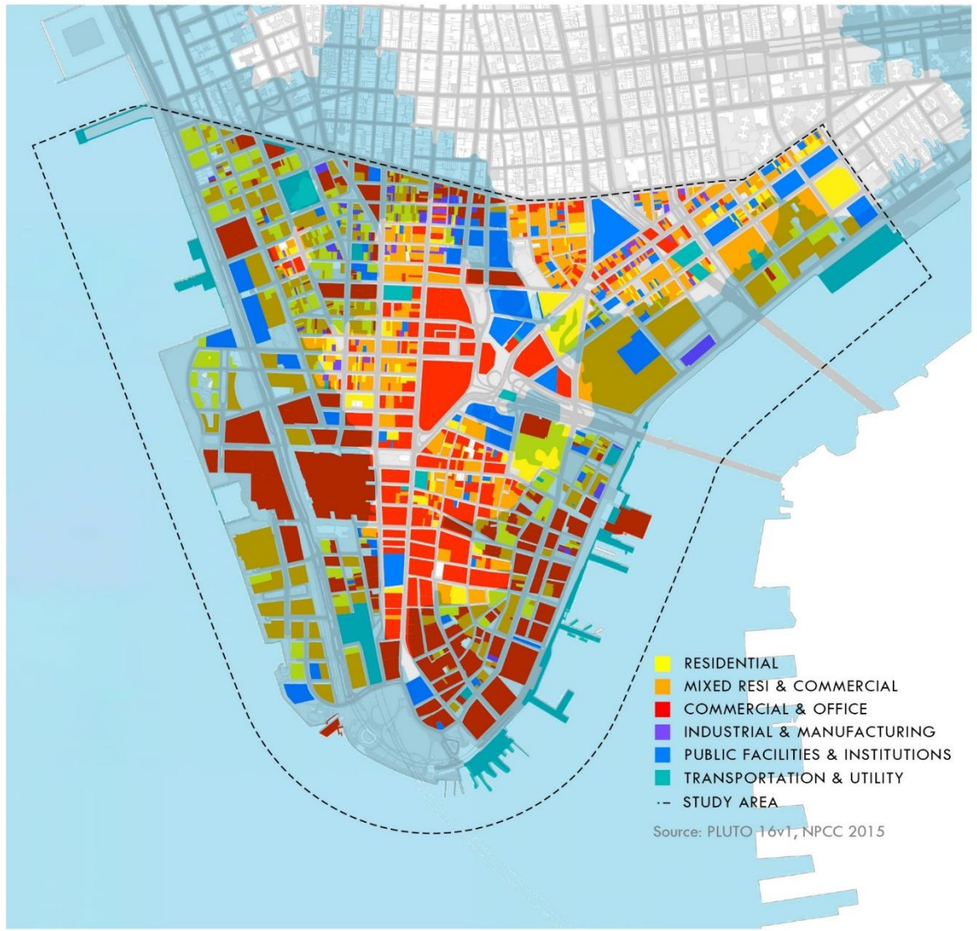
CLIMATE HAZARDS ARE INCREASING IN SEVERITY AND FREQUENCY



Source: NPCC

xLOWER MANHATTAN NEEDS A COMPREHENSIVE CLIMATE PLAN TO ADAPT

Climate change threatens the economic engine, most critical transit hub, and historic heart of NYC.



Map. Land use exposure to 2100 100 year surge

50% of **BUILDINGS** will be at risk from a 100-year storm surge of 9-16' by 2100

$4.7B of **ECONOMIC IMPACTS** in assessed value of 100-year storm by 2050

100 **CULTURAL ASSETS**, museums, and historic sites will be exposed to flooding in 2100

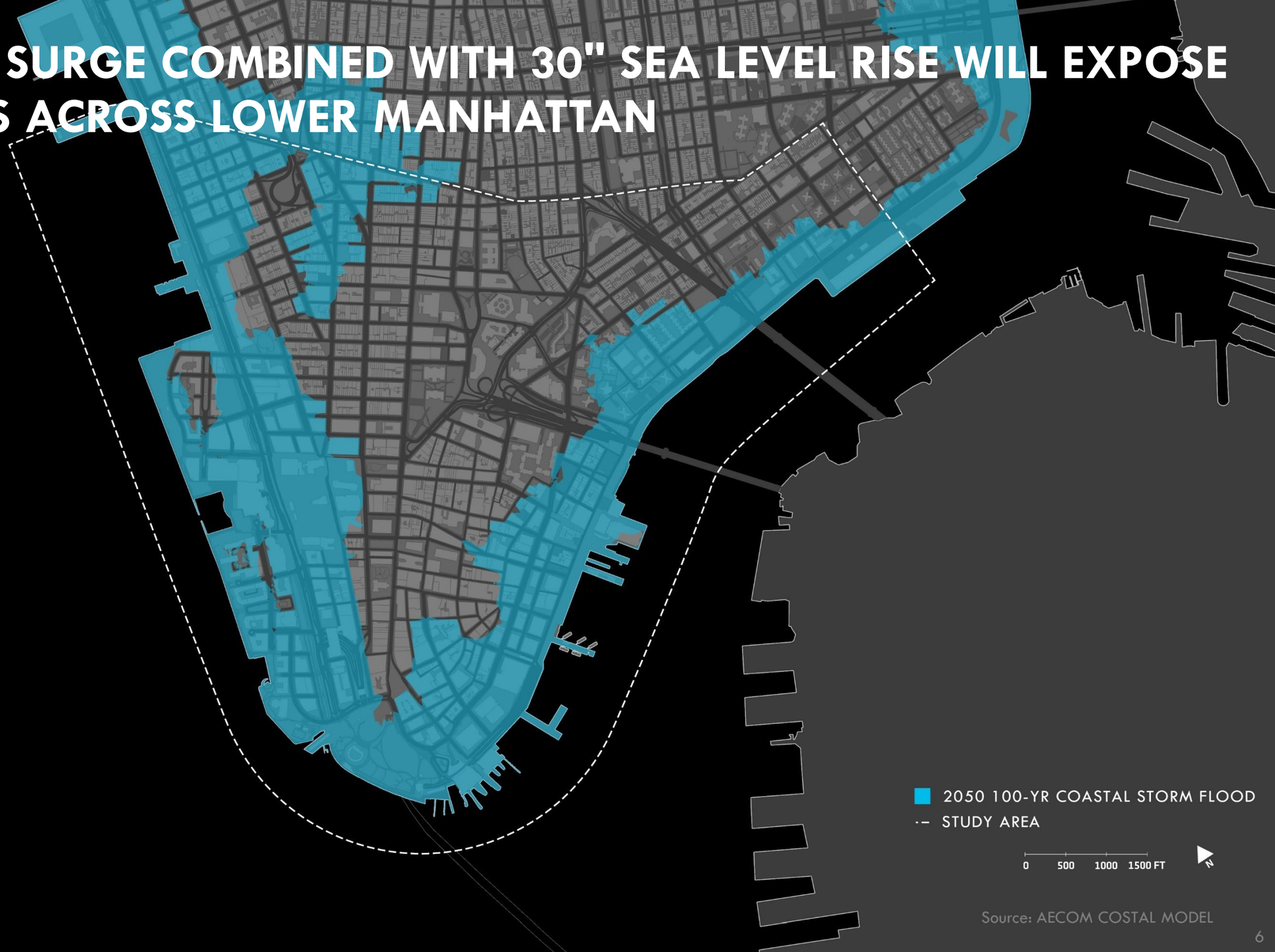
11% of **BUILDINGS** will be subject to monthly tidal inundation from sea level rise by 2100

17 MILES Of **UNDERGROUND INFRASTRUCTURE** and 7% of **BUILDINGS** will be exposed to rising groundwater by 2100, causing destabilization, corrosion, and settlement

BY 2050, STORM SURGE COMBINED WITH 30" SEA LEVEL RISE WILL EXPOSE MORE BUILDINGS ACROSS LOWER MANHATTAN

30%
of the buildings exposed to 100 year surge in 2050

$11B
in assessed value at risk from 100 year surge in 2050



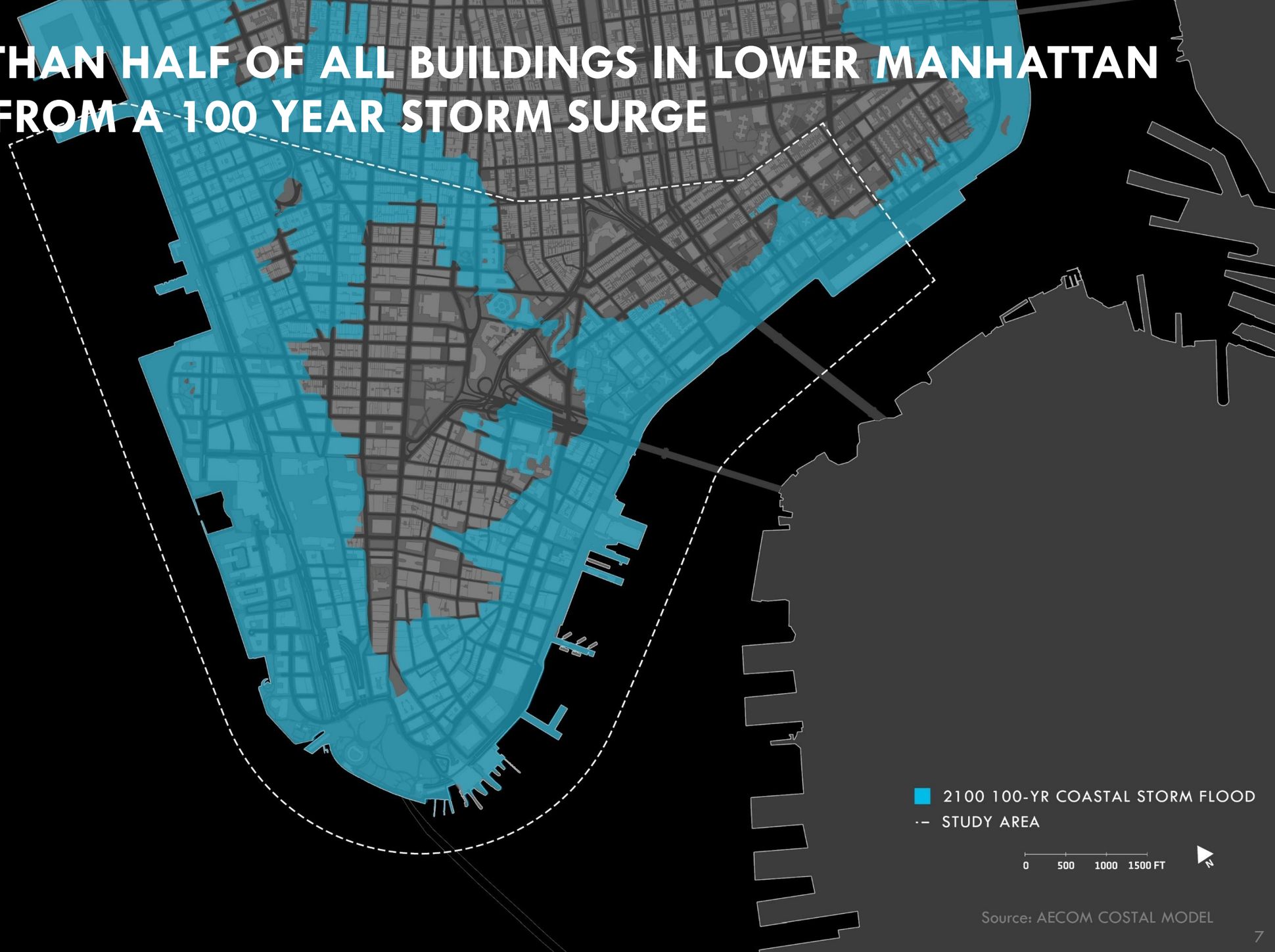
Source: AECOM COSTAL MODEL

BY 2100, MORE THAN HALF OF ALL BUILDINGS IN LOWER MANHATTAN WILL BE AT RISK FROM A 100 YEAR STORM SURGE

9-16 feet
surge height

$13B
assessed value at risk
from 2100 100 year surge

50%
of buildings exposed
to 100 year surge in 2100



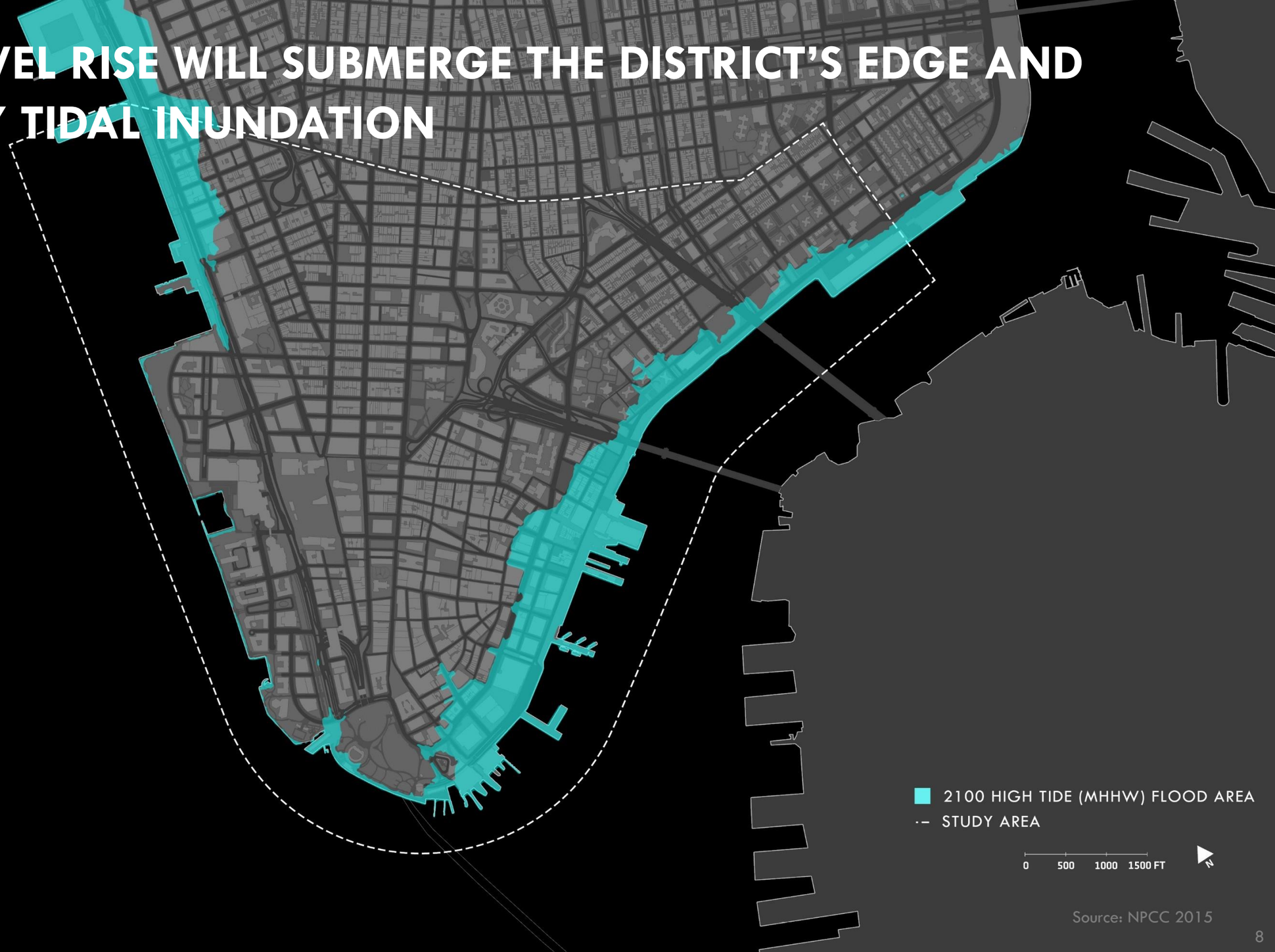
Source: AECOM COSTAL MODEL

BY 2100, SEA LEVEL RISE WILL SUBMERGE THE DISTRICT'S EDGE AND CAUSE MONTHLY TIDAL INUNDATION

11%
of buildings at risk
from monthly tidal inundation

29%
of impacted buildings in FiDi

$4B
assessed value at risk
from monthly tidal inundation



Source: NPCC 2015

GROUNDWATER TABLE RISE WILL DESTABILIZE BUILDINGS AND EXPOSE UNDERGROUND INFRASTRUCTURE TO CORROSION AND SETTLEMENT

167

high-risk buildings vulnerable to destabilization due to groundwater table rise

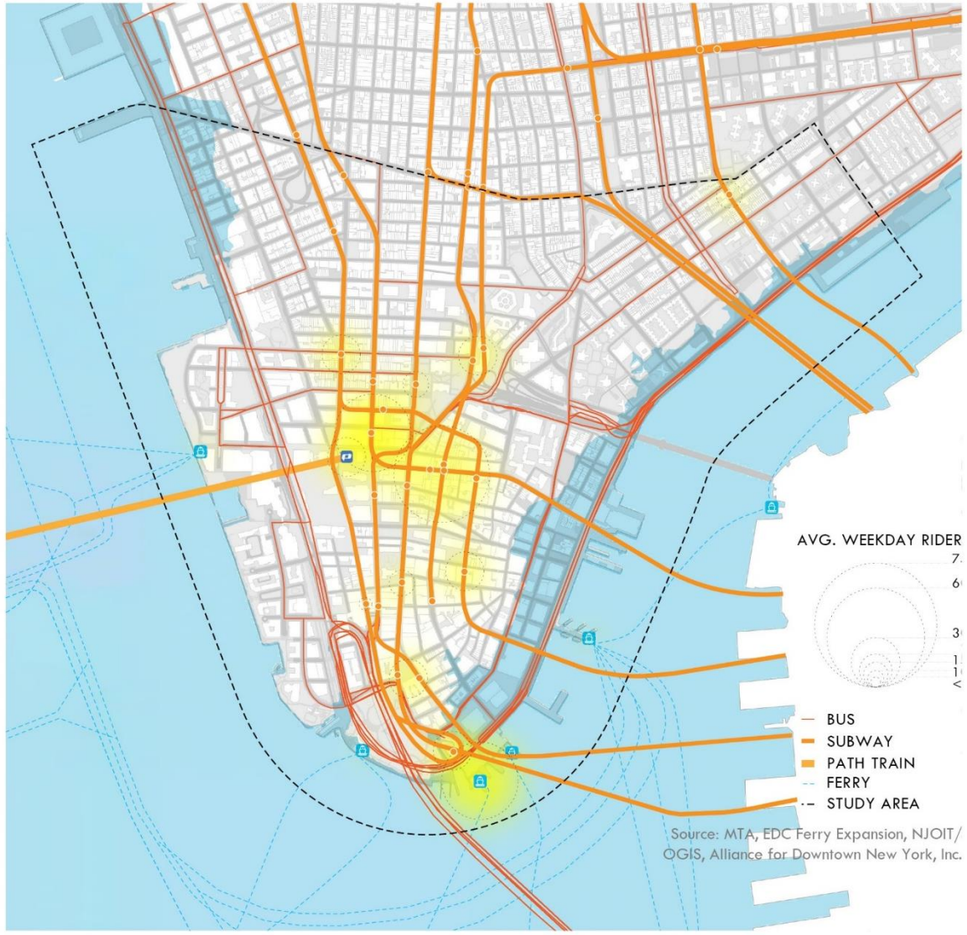
39%

of the district's streets will have impacted underground utilities

Source: AECOM
(Assuming utility depths at -4' below grade.)

THREATS TO LOWER MANHATTAN ARE THREATS TO THE CITY AND REGION

The protection of Lower Manhattan is vital to the future of NYC.



Map. Weekday ridership and 2100 SLR

70% or 19 out of 27 subway lines pass through Lower Manhattan

127M annual riders are served by the Lower Manhattan transit network

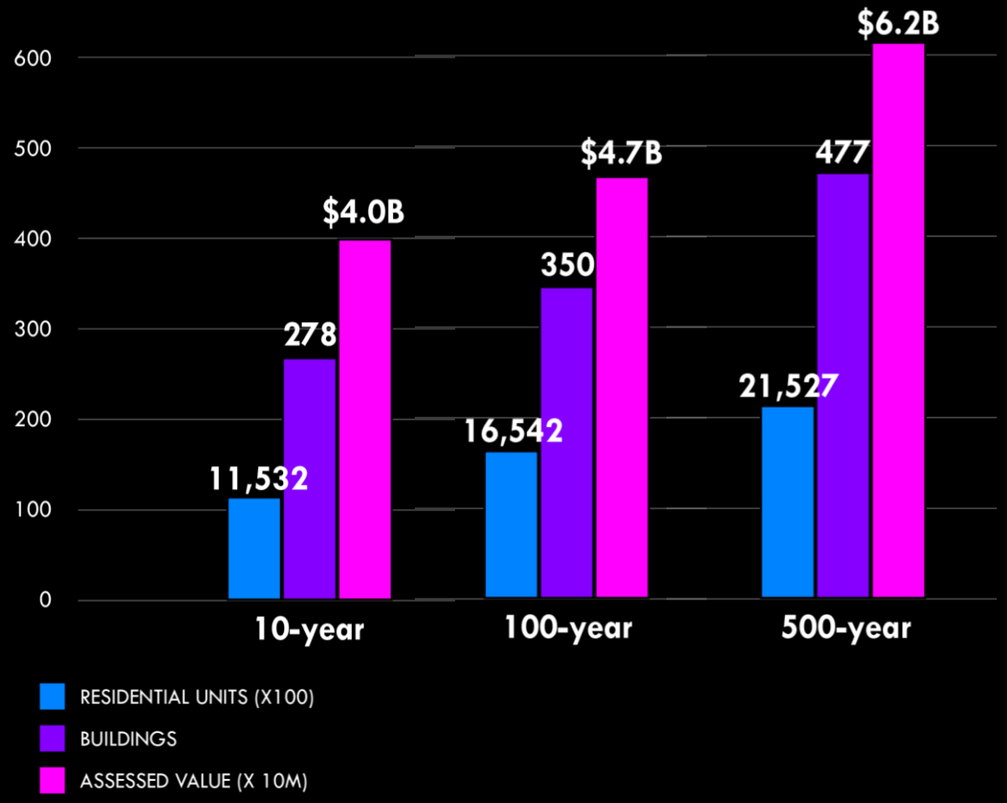
9.2% of NYC's total GDP comes from Lower Manhattan, home to the financial capital of the world

14.8M yearly visitors come to attractions in Lower Manhattan, the iconic symbol of NYC

11,000 residential units have been converted since 2001, demonstrating the success story of the neighborhood's resurgence since 9/11

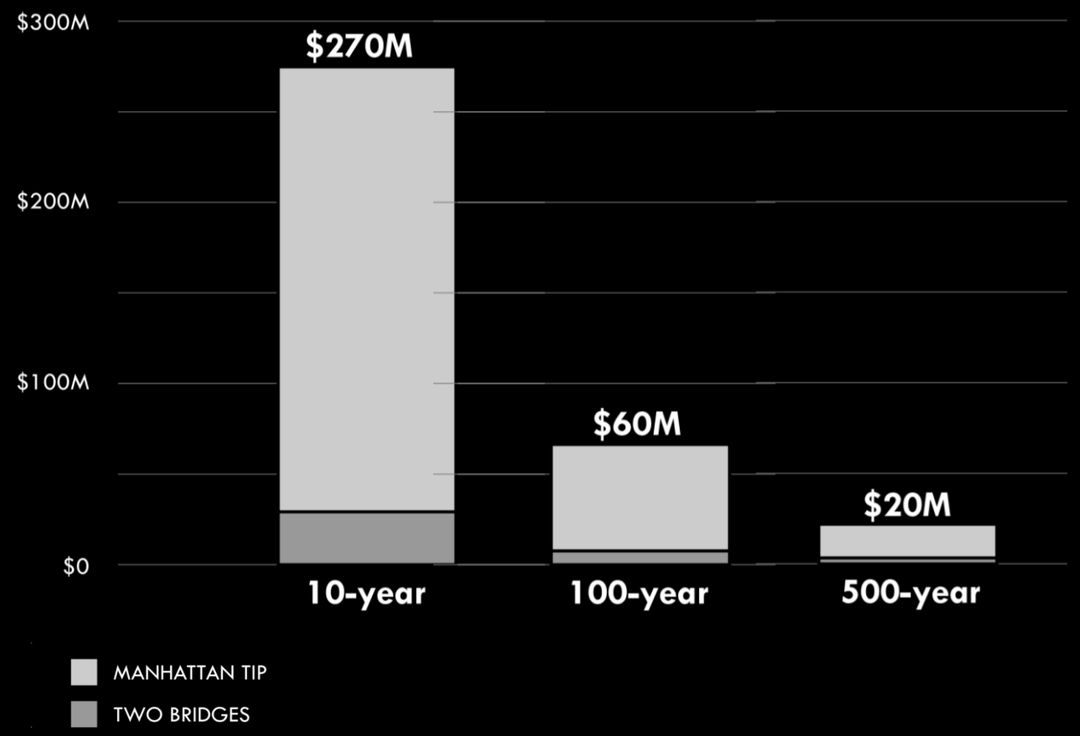
THERE IS EXPOSURE FROM A VARIETY OF CLIMATE HAZARDS

ASSETS EXPOSED BY 2050 STORM EVENT



Source: AECOM Coastal Model (10-year, 100-year), NPCC 2015 (500-year),

PROBABILITY ADJUSTED ECONOMIC IMPACT BY 2050 STORM EVENT



Source: City of New York, NDRC Phase 2 Application, Benefit Cost Analysis

VISION

The city's continued economic engine, 400 years and counting.

A growing, inclusive, and increasingly mixed-use neighborhood.

A global leader in climate adaptation.

OBJECTIVES

CLIMATE RESILIENCY

↓

ECONOMIC & SOCIAL RESILIENCY

MOBILITY

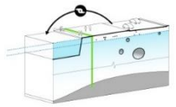
PUBLIC REALM

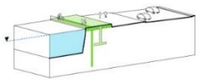
BUILT ENVIRONMENT

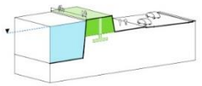
ANALYSIS OF CLIMATE ADAPTATION STRATEGIES

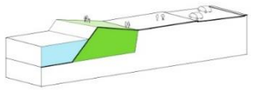
A RANGE OF ADAPTATION MEASURES WERE STUDIED

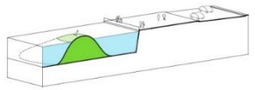
EDGE

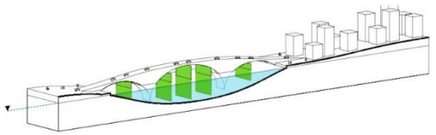

SEEPAGE BARRIER


RAISED TO SLR


RAISED TO SURGE - INBOARD

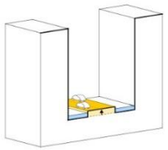

RAISED TO SURGE - OUTBOARD

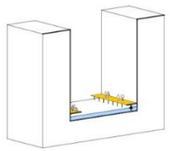

WAVE BREAK ISLANDS

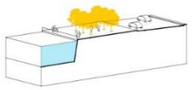

STORM SURGE GATE

PUBLIC REALM

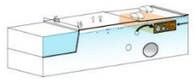

GREEN STREETS


ELEVATED STREETS

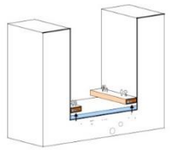

ELEVATED PEDESTRIAN REALM

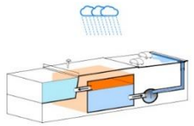

INCREASE TREE CANOPY

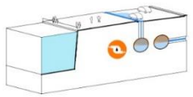
SUBSURFACE


UTILITY BOX


EMERGENCY PUMPING

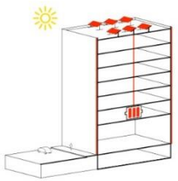

RAISED UTILITIES

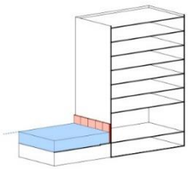

STORMWATER TANK

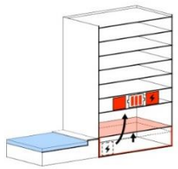

PARALLEL SYSTEM

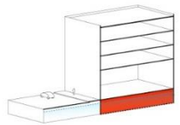
BUILDINGS

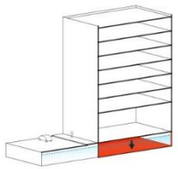

STORMWATER RETENTION

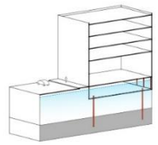

LOCAL ENERGY ASSURANCE


DEPLOYABLES


ELEVATE/RAISE


WET FLOODPROOFING

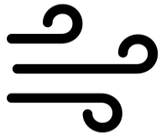

DRY FLOODPROOFING


STABILIZATION/TIE-DOWN

DESIGN PRINCIPLES ORGANIZED OUR ADAPTATION SCENARIOS

← BUILDING — PUBLIC REALM — SUB-SURFACE — EDGE →

1

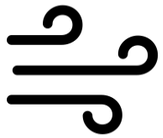


COASTAL STORM SURGE

TIDAL INUNDATION

GROUNDWATER TABLE RISE (GWT)

2



COASTAL STORM SURGE

TIDAL INUNDATION

GROUNDWATER TABLE RISE

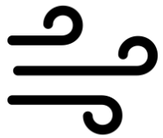
SURFACE FLOODING FROM RAIN

3A

3A.1 Passive /
3A.2 Deployable

3B

Land Reclamation



COASTAL STORM SURGE

TIDAL INUNDATION

GROUNDWATER TABLE RISE

INTERNAL DRAFT FOR DISCUSSION

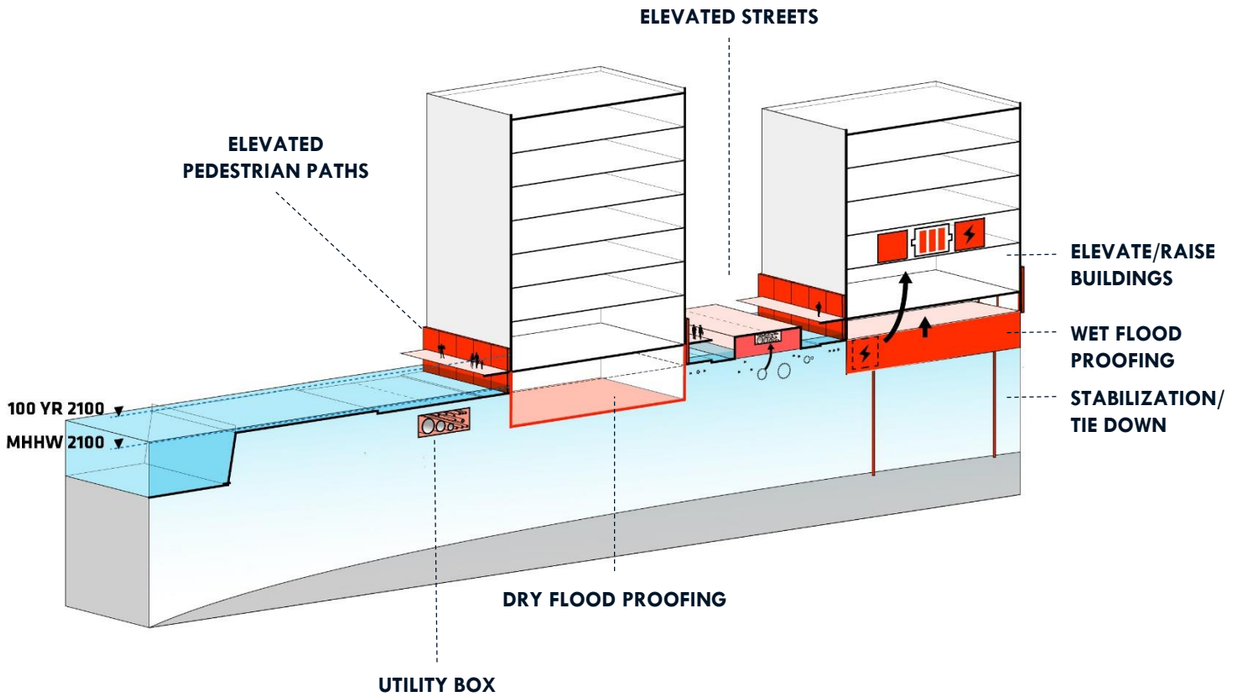
SCENARIO 1 | LET ALL WATER IN

BUILDING

- Elevation of building ground floors in tidal inundation zone
- Structural stabilization in GWT zone for older buildings
- Wet floodproofing to 2100 storm surge (older buildings)
- Dry floodproofing to 2100 storm surge (newer buildings)

PUBLIC REALM

- Elevation of impacted streets, sidewalks and esplanades within tidal inundation zone
- Utility box and relocation in GWT zone



SCENARIO 1
COMBINED MEASURES

SCENARIO 2 | LET LOWER FREQ. WATER IN; KEEP HIGHER FREQ. OUT

BUILDING

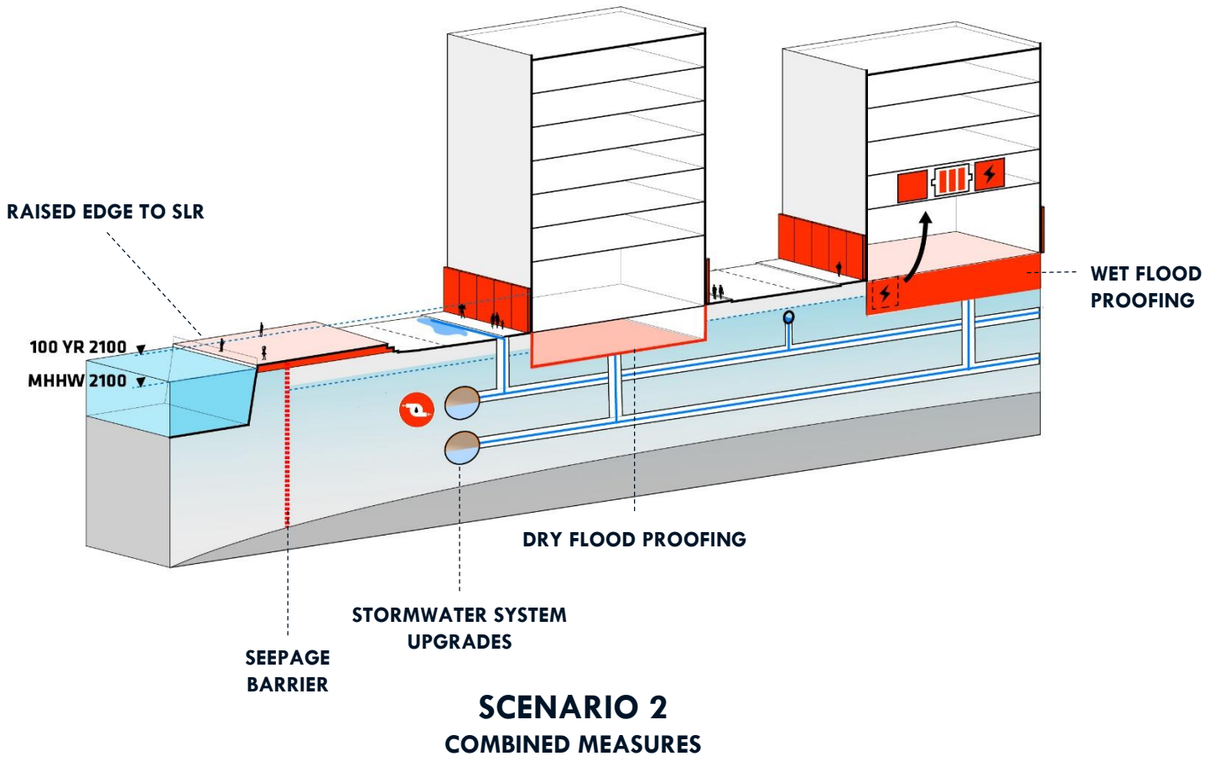
- Wet floodproofing to 2100 storm surge (older buildings)
- Dry floodproofing to 2100 storm surge (newer buildings)

SUBSURFACE

- Existing stormwater system separation
- Added stormwater pumping and filtration capacity to accommodate 2100 10-year rain event

EDGE

- Seepage barrier
- Raised edge to 2100 sea level rise



SCENARIO 2
COMBINED MEASURES

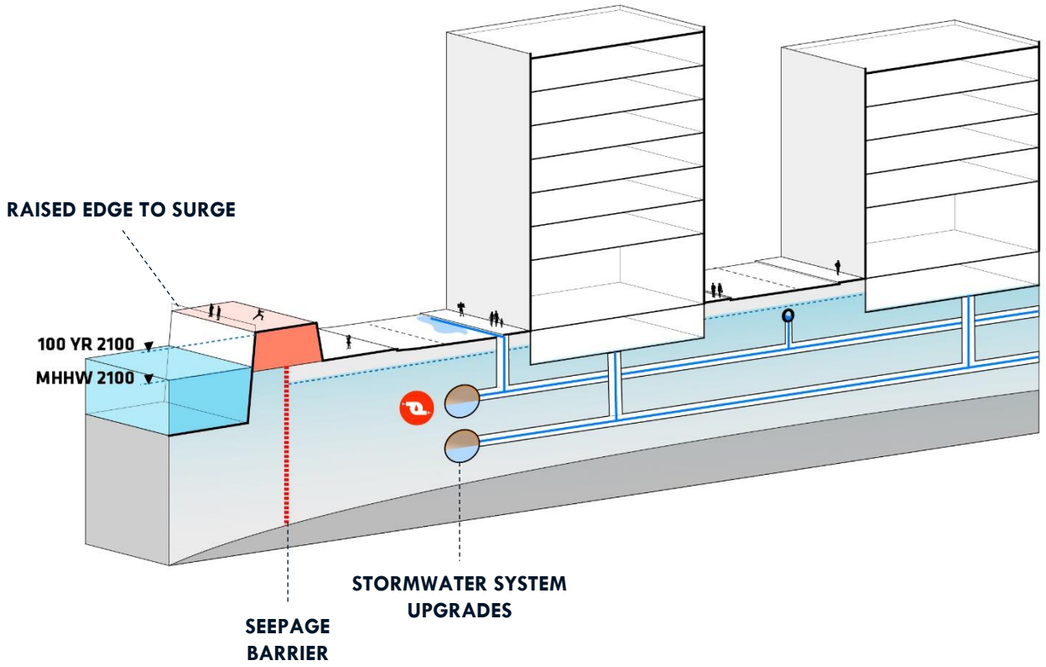
SCENARIO 3A.1 | LET NO WATER IN W/ INBOARD, PASSIVE PROTECTION

SUBSURFACE

- Existing stormwater system separation
- Added stormwater pumping and filtration capacity to accommodate 2100 10-year rain event

EDGE

- Seepage barrier
- Raised edge to 2100 100-year storm surge
- FDR relocation to an at-grade arterial road to facilitate raised edge



SCENARIO 3A.1
COMBINED MEASURES

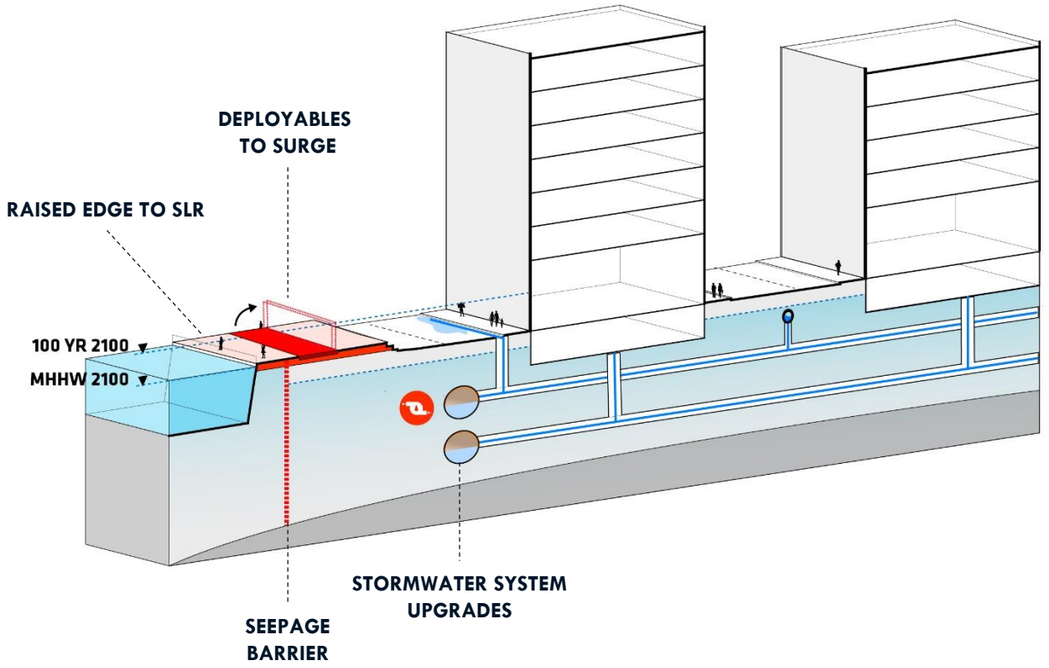
SCENARIO 3A.2 | LET NO WATER IN W/ INBOARD, DEPLOYABLE PROTECTION

SUBSURFACE

- Existing stormwater system separation
- Added stormwater pumping and filtration capacity to accommodate 2100 10-year rain event

EDGE

- Seepage barrier
- Raised edge to 2100 sea level rise
- District-wide deployables to 2100, 100-year storm surge



SCENARIO 3A.2
COMBINED MEASURES

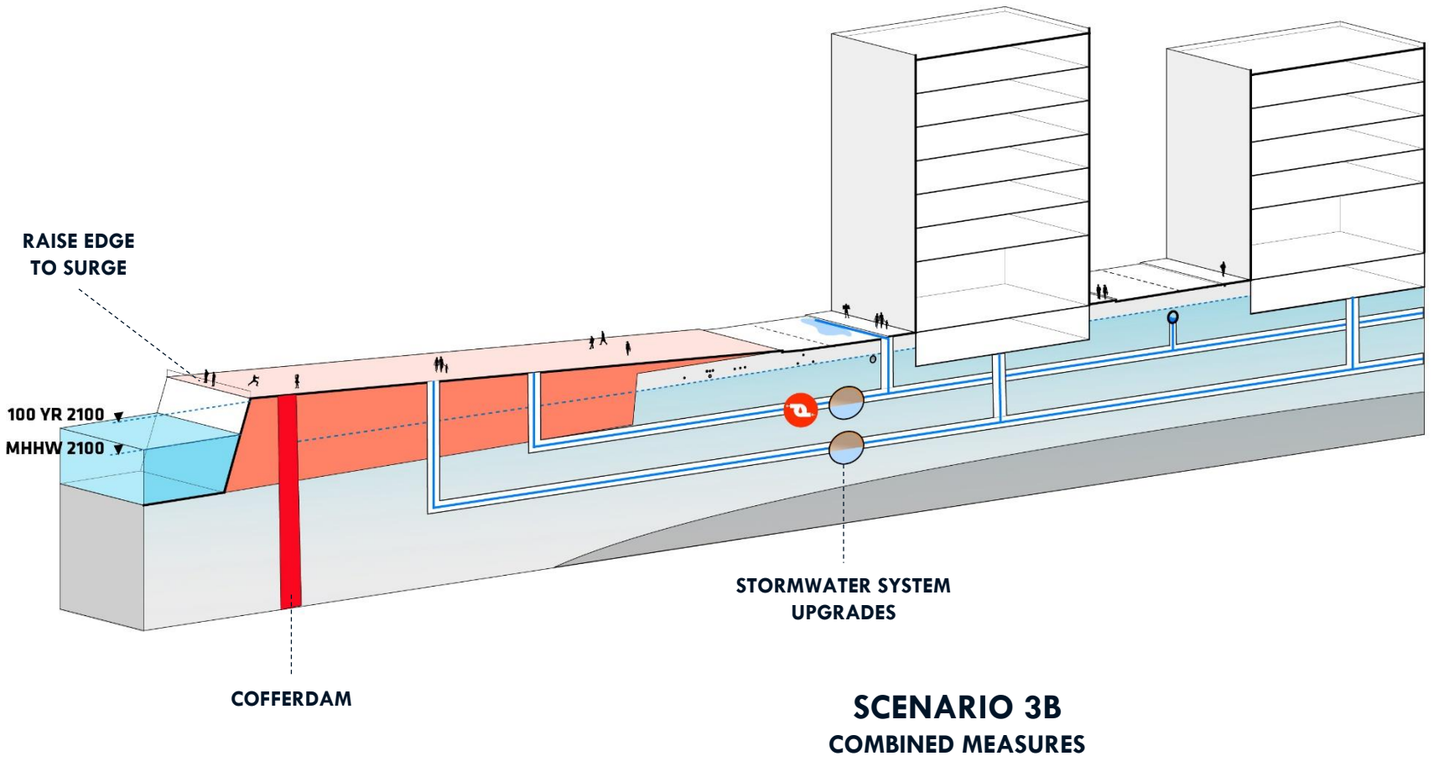
SCENARIO 3B | LET NO WATER IN W/ RECLAIMED LAND PROTECTION

SUBSURFACE

- Existing stormwater system separation
- New stormwater and sanitary systems in reclaimed land
- Additional stormwater pumping and filtration capacity

EDGE

- Land reclamation and cofferdam seepage barrier



EVALUATION CRITERIA

BENEFITS

Climate Benefit achieved through avoided losses and disruption caused by hazard impacts

Co-Benefits produced through improved mobility, enhanced and expanded public realm, and building modernization

FEASIBILITY

Technical constructability and ability to phase without large-scale disruption

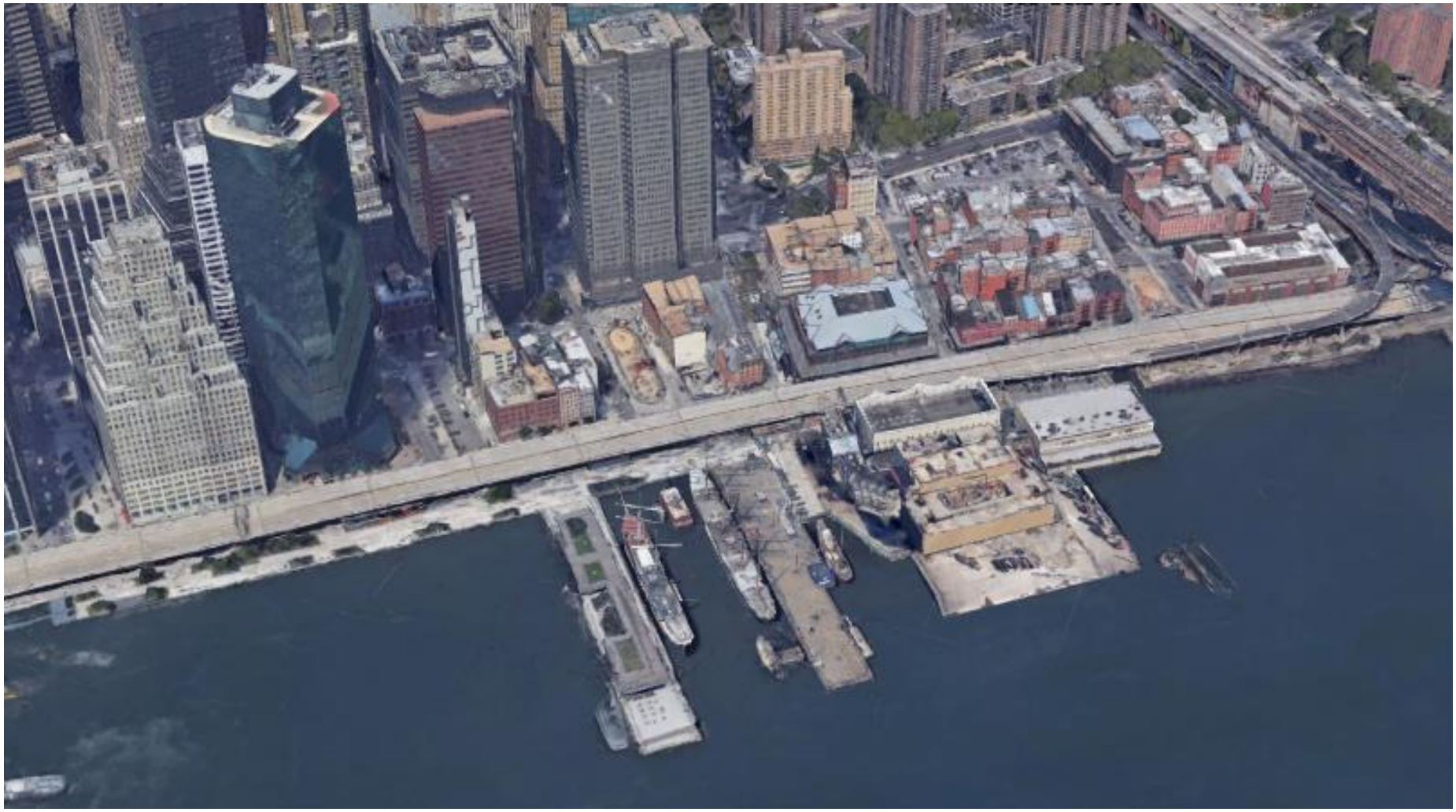
Permitting ease and ability, as well as environmental considerations

FINANCIAL CONSTRAINTS

Net Cost to the city, net of revenues created or existing budgeted capital

Sectoral Burden to the public and private sectors

Interim Flood Protection Measures Program Overview



Interim Flood Protection Measures (IFPM)

Program Goal: Reduction of low-level, high recurrence coastal flood risks while the City continues to advance longer-term coastal protection needs

NYCEM, in coordination with ORR, launched the Interim Flood Protection Measures (IFPM) Program in 2016.

To date, the IFPM program includes 43 sites with flood protection measures ready to be deployed during a potential coastal flooding event.

Flooding Addressed by IFPM

- Interim flood protection measures ***are*** intended to:
  - Reduce storm surge flood risk

- Interim flood protection measures ***are not*** intended to:
  - Mitigate rainfall flooding
  - Address flood risk during severe events like Hurricane Sandy
  - Fully eliminate flood risk

Site Selection & Development

Criteria:

- Provide protection to a critical service, facility or vulnerable population
- Feasible based on existing stormwater drainage system
- Minimize access and visual (e.g. traffic, pedestrian) impacts

Design Development:

- Engineers provide conceptual, draft, and final engineered design drawings using high-recurrence flood models to identify potential alignments
- Multiple agencies provide input:
  - *NYC Department of Environmental Protection* – drainage impacts
  - *NYC Department of Transportation* – traffic and parking impacts
  - *Fire Department of New York*– emergency access and response
  - *NY Police Department* - emergency access and response
  - *Site owner*
- All applicable permits and approvals obtained
- Measures installed by City-contracted vendor
- Sites maintained by NYCEM until permanent mitigation is completed or program end in 2023, whichever comes first

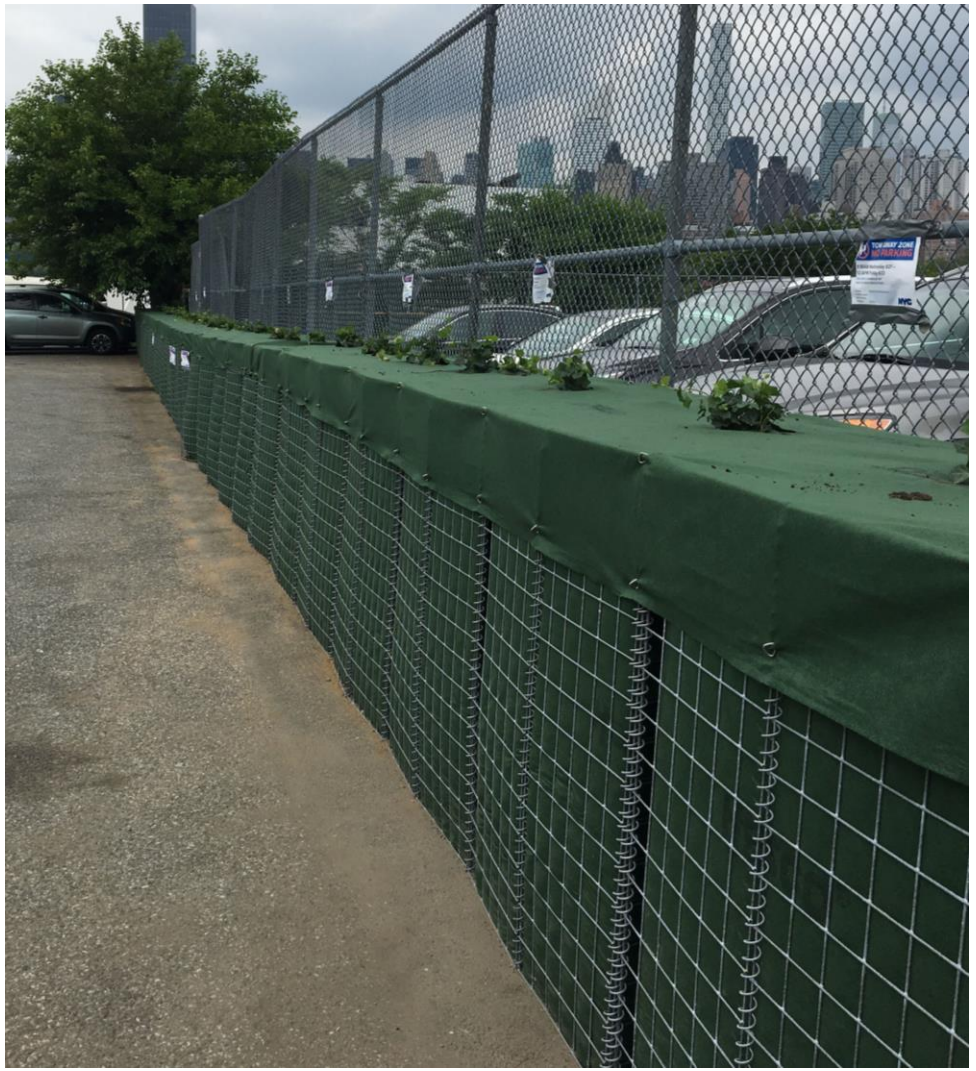
Pre-deployed vs. Just-in-Time

- Pre-deployed measures can be installed at any time prior to coastal storm season with no impacts to vehicular, pedestrian or commercial access.
  - IFPM Pre-deployed measures: **HESCO Barriers**

- Just-in-Time (JIT) measures are deployed 12-72 hours before the onset of storm force winds (winds in excess of 39 mph) and may impact pedestrian, vehicular or commercial access.
  - IFPM JIT measures: **Tiger Dams**

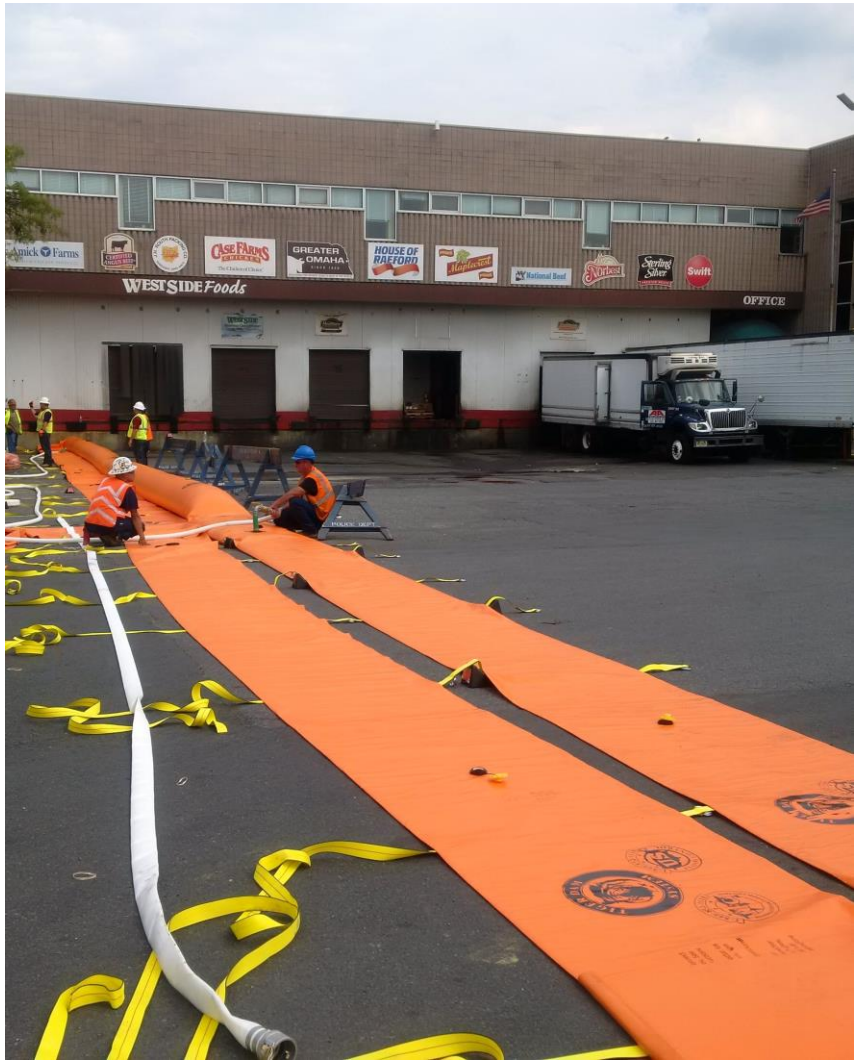
Pre-Deployed Hesco Barriers

Sand-filled geotextile and wire mesh containers remain in place up to 5 years



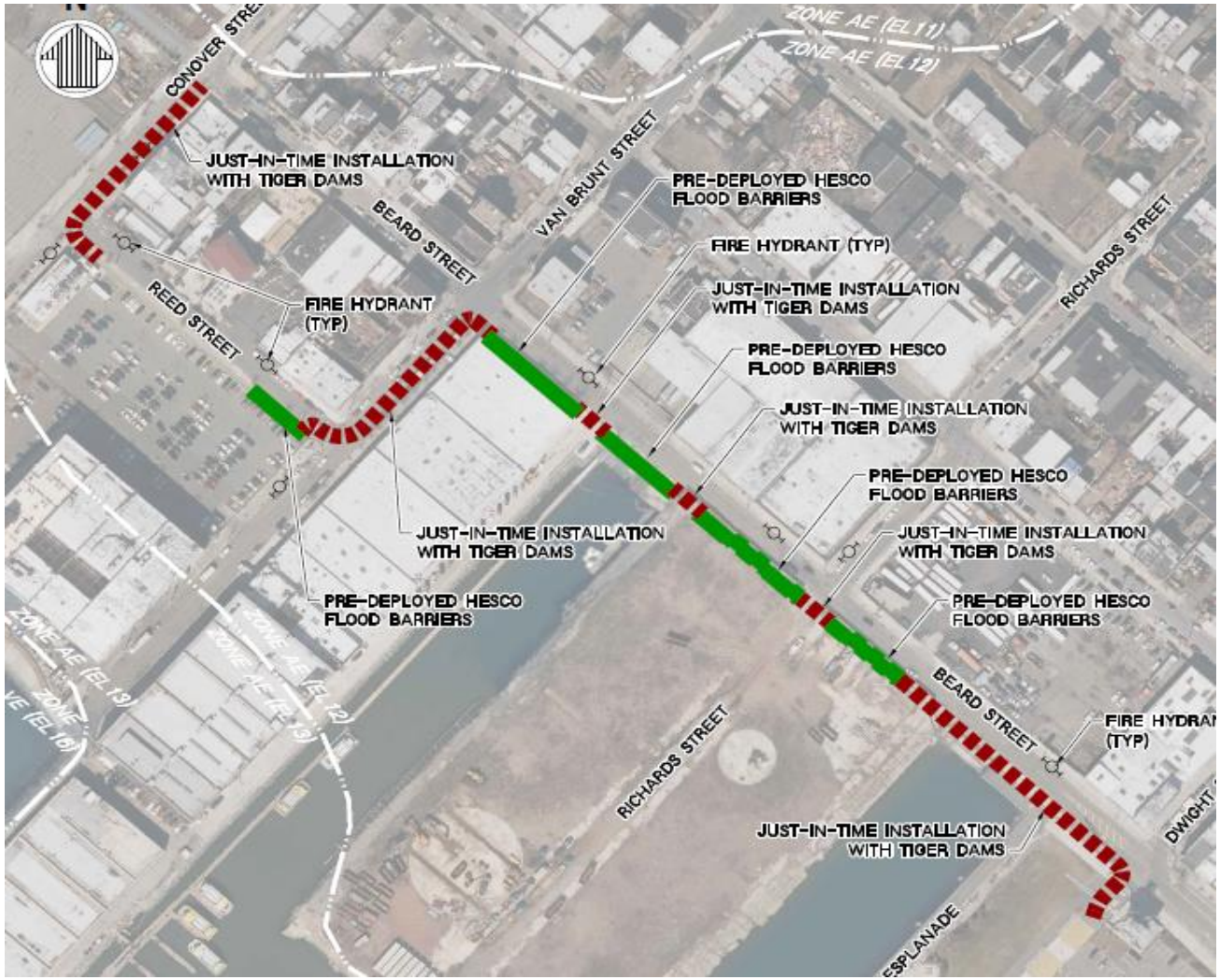
Just-In-time Tiger Dams

Water-filled tubes deployed in lead up to coastal storms



EXAMPLE: IFPM: Red Hook

Design Overview

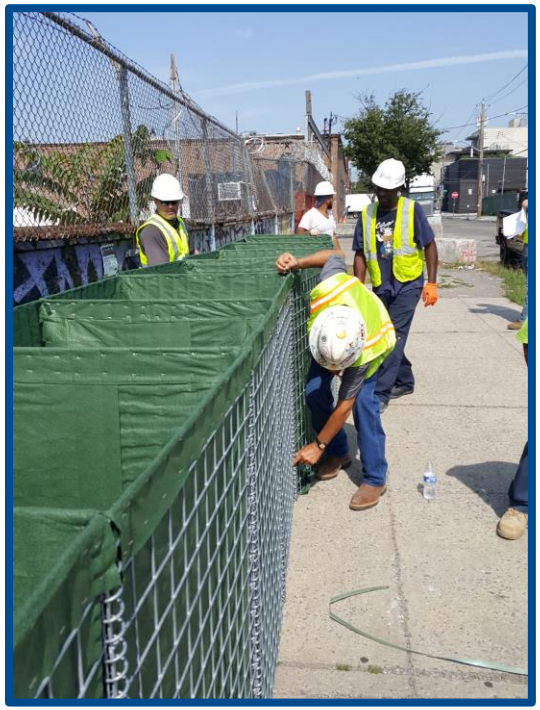


-----Denotes JIT Tiger Dam Placement

Denotes Pre-deployed HESCO barriers

EXAMPLE: IFPM: Red Hook

Installation



South Street Seaport Conceptual Design

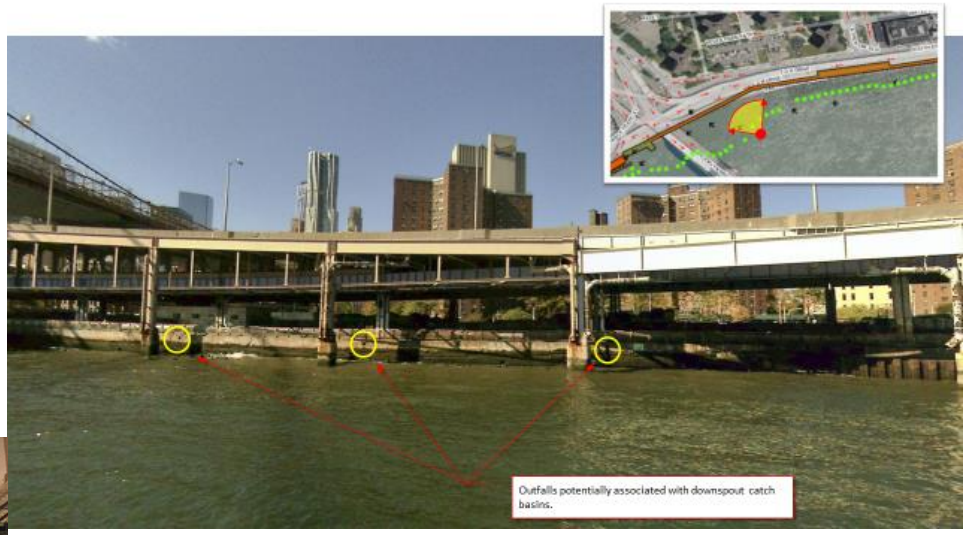
CONCEPTUAL DRAFT FOR DISCUSSION PURPOSES ONLY

South Street Seaport Conceptual Design

Feasibility analyses and challenges

Challenges:

- Unclaimed Outfalls
- Unknown Vault Extents
- Ongoing and Future Construction
- Daily Vehicle and Pedestrian Access
- DEP/DOT/SDOT Coordination
- Community Outreach



Analyses/Reviews Completed:

- Drainage system review
- Dye Tests
- DOT/DEP/EDC Review

Analyses Pending:

- Vault Assessment
- Unclaimed Outfalls

South Street Seaport Conceptual Design
Next Steps in determining Feasibility

- Vault Assessment
- Determine path for unknown outfalls
- Continued coordination with EDC regarding construction, access, etc
- Continued Coordination with DOT, DEP, SDOT

Interim Flood Protection Measures

Questions?