EVALUATING THE VULNERABILITY OF INFRASTRUCTURE TO COASTAL STORMS – A CASE STUDY

Marine Transfer Station Coastal Storm Surge Vulnerability Assessment

Prepared for: New York City Department of Sanitation

Prepared by: HDR Engineering

HDR Project Team

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- Derick Tonning, PE - Civil


BRONX
MANHATTAN
East 91st Street
North Shore
West 59th Street
QUEENS
Hamilton Avenue
BROOKLYN
STATEN ISLAND
Southwest Brooklyn

‘Vulnerability’, as applied in this evaluation, refers to being prone to destabilization, as it relates to structural features, or inoperability, as it relates to life safety or process-critical infrastructure and equipment.

Project Phasing

- Phase 1 – Design Criteria and Vulnerability Assessment
- Phase 2 – Facility Alternatives Analysis
- Phase 3 – Design and Development of Bid Packages

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- *Phase 1 – Design Criteria and Vulnerability Assessment*
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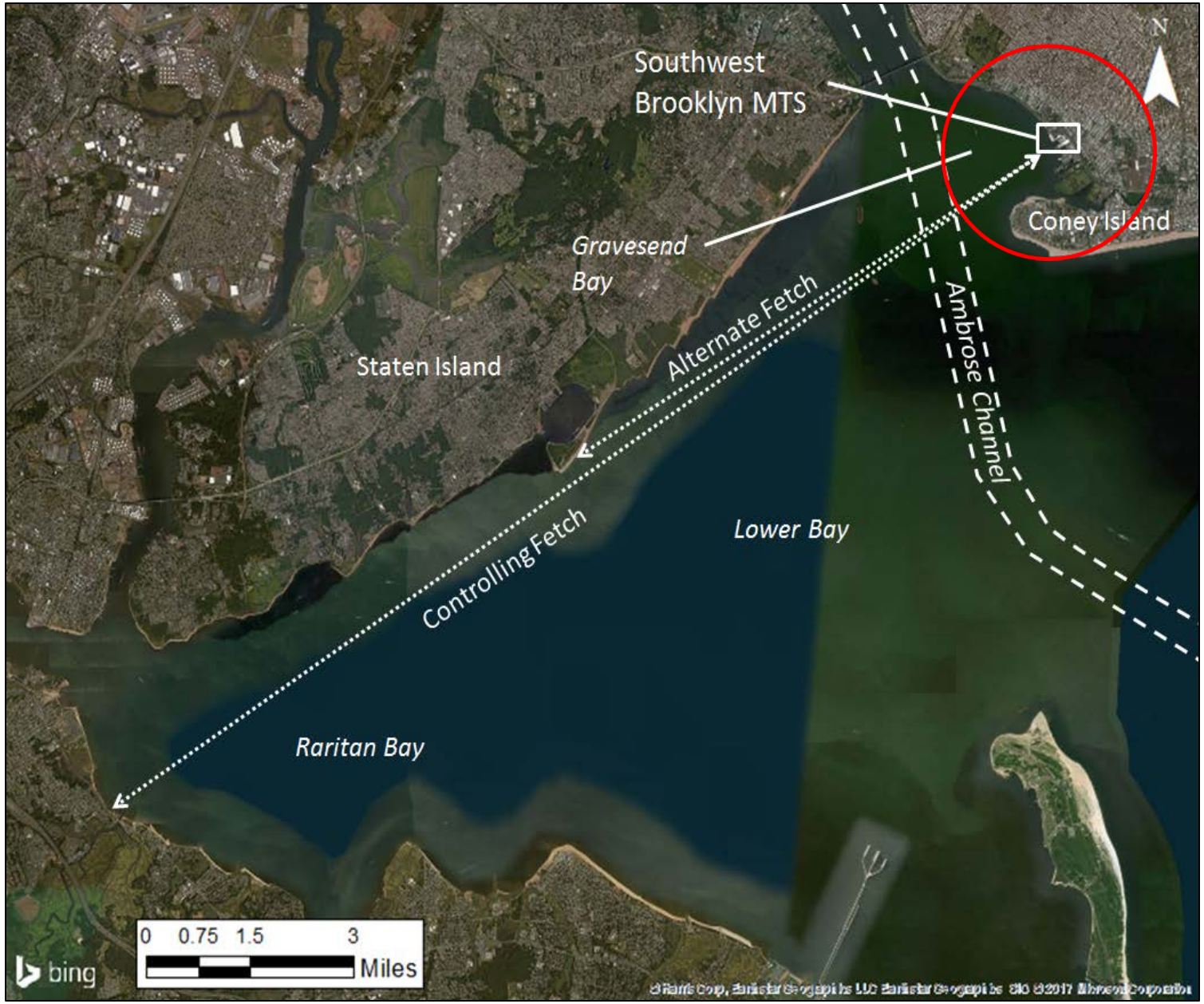
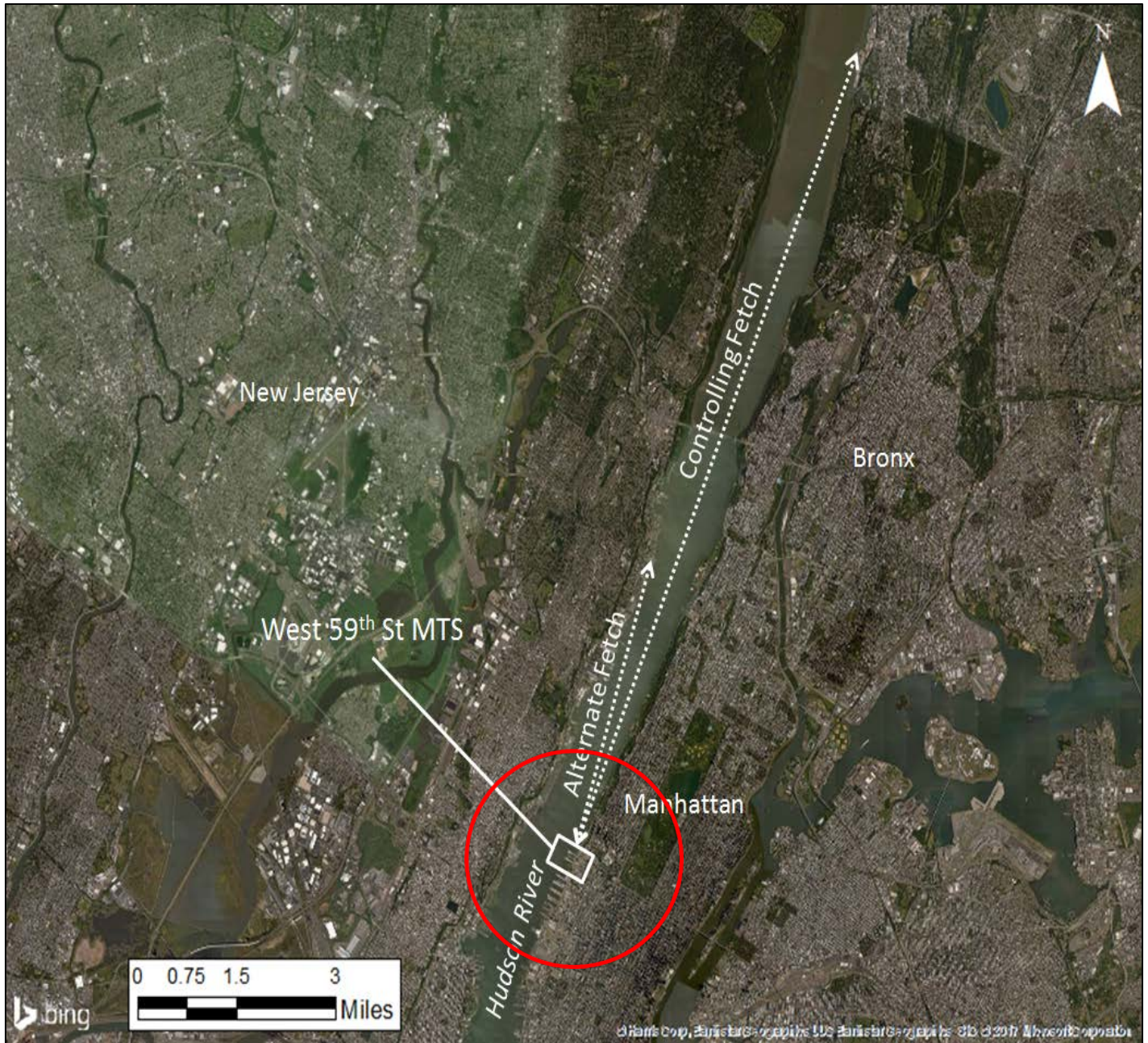
Marine Transfer Station Setting

Wave Approach at Southwest Brooklyn



Wave Approach at Hamilton Avenue

Wave Approach at 59th Street



Wave Approach at East 91st Street

Wave Approach at North Shore

Basis of Vulnerability Assessment

- Loads associated with 100-year Coastal Storm
- Focused on Six Loading Conditions:

    1. Inflow of High Water Through Building Openings
    2. Hydrostatic Force on Walls
    3. Backflow Through Stormwater or Sanitary Sewers
    4. Wave Impacts
    5. Debris Impacts
    6. Vessel Impacts

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- Loading Conditions Studied or Addressed Previously and Not Studied Previously

HDR Summary Recommendations

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1. ***High Water Inflow*** **Add and Upgrade Dry Flood Proofing for Revised DFE**

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1. *High Water Inflow* Add and Upgrade Dry Flood Proofing for Revised DFE

2. ***Backflow*** **Add and Upgrade Backflow Protection for Revised DFE**

HDR Summary Recommendations

1. *High Water Inflow* — Add and Upgrade Dry Flood Proofing for Revised DFE
2. *Backflow* — Add and Upgrade Backflow Protection Evaluation for Revised DFE
3. ***Debris and Vessel Impact*** — **Advance In-Water Pile Clusters to Design**

HDR Summary Recommendations

1. *High Water Inflow* — Add and Upgrade Dry Flood Proofing for Revised DFE
2. *Backflow* — Add and Upgrade Backflow Protection for Revised DFE
3. *Debris and Vessel Impact* — Advance In-Water Pile Clusters to Design
4. ***Wave Impacts*** — **Refine Wave and Structural Vulnerability Evaluation**

HDR Summary Recommendations

1. ***High Water Inflow*** **Add and Upgrade Dry Flood Proofing for Revised DFE**

2. ***Backflow*** **Add and Upgrade Backflow Protection for Revised DFE**

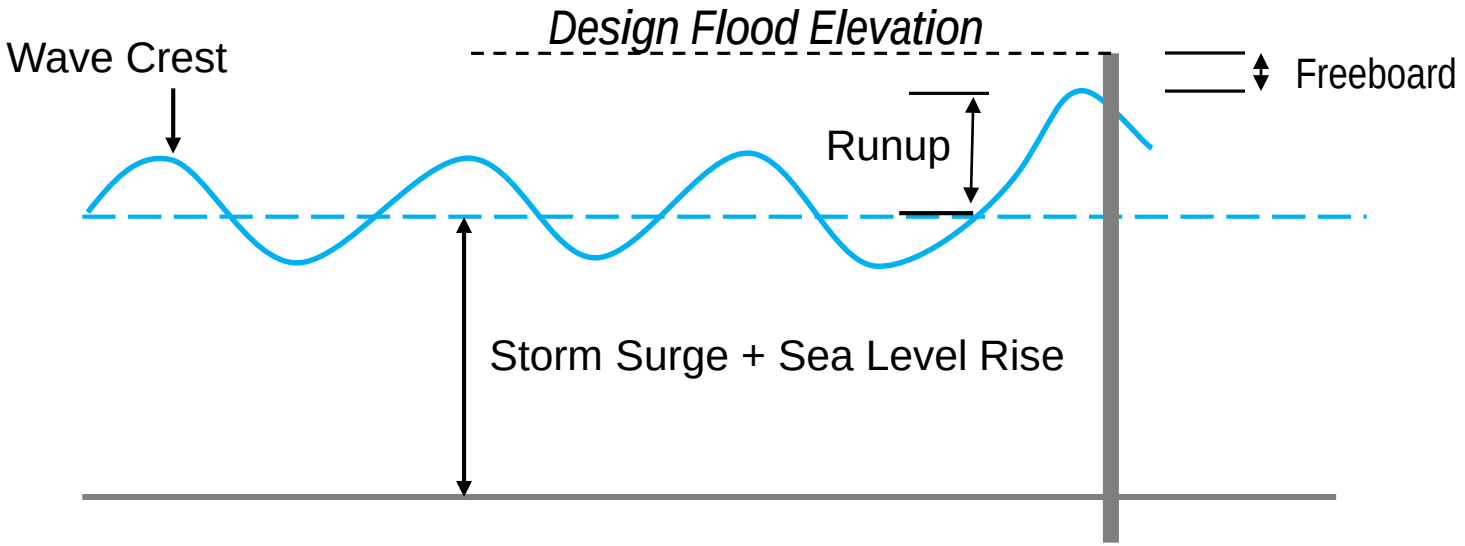
3. ***Debris and Vessel Impact*** **Advance In-Water Pile Clusters to Design**

4. ***Wave Impacts*** **Refine Wave and Structural Vulnerability Evaluation**

REVIEW / Design Flood Elevation (DFE)

- Storm surge elevation (still-water elevation, “SWE”)
- Waves (wave crest, and runup)
- Freeboard
- Sea level rise (SLR)

Design Flood Elevation = Still Water Elevation + Waves + Sea Level Rise +Freeboard



REVIEW / References Reviewed for Design Flood Elevation

Source	SWE	Waves	SLR	Freeboard	DFE
FEMA FIS and FIRM	✓	✓			
USACE NACCS	✓				
Super Storm Sandy High Water Marks	✓	✓			
NPCC			✓		
USACE SLR Calculator			✓		
FEMA 44 CFR 65.10				✓	✓
ASCE 24				✓	✓
NYC Building Code				✓	✓
PANYNJ Resiliency Guidelines			✓	✓	✓

NACCS – North Atlantic Coast Comprehensive Study
NPCC – New York Panel on Climate Change

REVIEW / Key Findings

Water Elevation (feet)		
Location	**Super Storm Sandy High Water Marks**	**FEMA BFE (from prelim FIRM)**
Southwest Brooklyn	11.5	12
Hamilton Avenue	11.1	12
West 59th Street	10.3	12 to 15
East 91st Street	10.4	15
North Shore	10.5	17
* *All elevations are referenced to North American Vertical Datum 1988 (NAVD88).*		

Sea Level Rise			
	2000-2050		
Reference	**Low**	**Med**	**High**
PANYNJ	-	1.3	-
NPCC	0.6	0.9 – 2.0	2.6
USACE	0.4	0.6	1.5

Recommended DFE for 100 yr Condition, ft (NAVD) Southwest Brooklyn				
		Freeboard		
50 yr SLR (NPCC Values)		FEMA (44 CFR 65.10)	ASCE 24-14 (Flood Design Class 3)	NYC BC (ASCE 24-05) (Str Occupancy Cat 3)
		1 ft	2 ft	1 ft
Middle	1.5 ft	DFE = +14.5 ft	DFE = +15.5 ft	DFE = +14.5 ft
High	2.6 ft	DFE = +15.6 ft	DFE = +16.6 ft	DFE = +15.6 ft

Prior DFE = 13 ft

Recommended DFE for 100 yr Condition, ft (NAVD) Hamilton Avenue				
		Freeboard		
50 yr SLR (NPCC Values)		FEMA (44 CFR 65.10)	ASCE 24-14 (Flood Design Class 3)	NYC BC (ASCE 24-05) (Str Occupancy Cat 3)
		1 ft	1 ft*	1 ft
Middle	1.5 ft	DFE = +14.5 ft	DFE = +14.5 ft	DFE = +14.5 ft
High	2.6 ft	DFE = +15.6 ft	DFE = +15.6 ft	DFE = +15.6 ft

Prior DFE = 13 ft

*ASCE 24-14, Table 2-1, specifies 1 ft freeboard in non Coastal A Zones for Flood Design Class 3.

Recommended DFE for 100 yr Condition, ft (NAVD) West 59th Street				
		Freeboard		
50 yr SLR (NPCC Values)		FEMA (44 CFR		(ASCE 24-05) ancy Cat 3)
		1 ft		ft
Middle	1.5 ft	DFE = +17.5 ft	DFE = +18.5 ft	DFE = +17.5 ft
High	2.6 ft	DFE = +18.6 ft	DFE = +19.6 ft	DFE = +18.6 ft

Prior DFE = 13 ft

Prior DFE = 13 ft

Prior DFE = 11 ft

Recommended DFE for 100 yr Condition, ft (NAVD) 91st Street				
		Freeboard		
50 yr SLR (NPCC Values)		FEMA (44 CFR 65.10)	ASCE 24-14 (Flood Design Class 3)	NYC BC (ASCE 24-05) (Str Occupancy Cat 3)
		1 ft	2 ft	1 ft
Middle	1.5 ft	DFE = +17.5 ft	DFE = +18.5 ft	DFE = +17.5 ft
High	2.6 ft	DFE = +18.6 ft	DFE = +19.6 ft	DFE = +18.6 ft

Prior DFE = 16 ft

Recommended DFE for 100 yr Condition, ft (NAVD) North Shore				
		Freeboard		
50 yr SLR (NPCC Values)		FEMA (44 CFR 65.10)	ASCE 24-14 (Flood Design Class 3)	NYC BC (ASCE 24-05) (Str Occupancy Cat 3)
		1 ft	2 ft	3 ft*
Middle	1.5 ft	DFE = +19.5 ft	DFE = +20.5 ft	DFE = +21.5 ft
High	2.6 ft	DFE = +20.6 ft	DFE = +21.6 ft	DFE = +22.6 ft

Prior DFE = 18 ft

*NYC BC specifies 3 ft freeboard for Structural Occupancy Category 3 in FEMA V Zones

NYC Mayor's Office of Resiliency
Climate Resiliency Design Guidelines (April 2017)

Recommendations for Defining Design Flood Elevations

Critical* facilities				
End of useful life	Base Flood Elevation (BFE)[71]	+ Freeboard[72]	+ Sea Level Rise Adjustment[73]	= Design Flood Elevation (DFE)
Through 2039	FEMA 1% (PFIRMs)	24"	6"	= FEMA 1% + 30"
2040-2069	FEMA 1% (PFIRMs)	24"	16"	= FEMA 1% + 40"
2070-2099	FEMA 1% (PFIRMs)	24"	28"	= FEMA 1% + 52"
2100+	FEMA 1% (PFIRMs)	24"	36"	= FEMA 1% + 60"

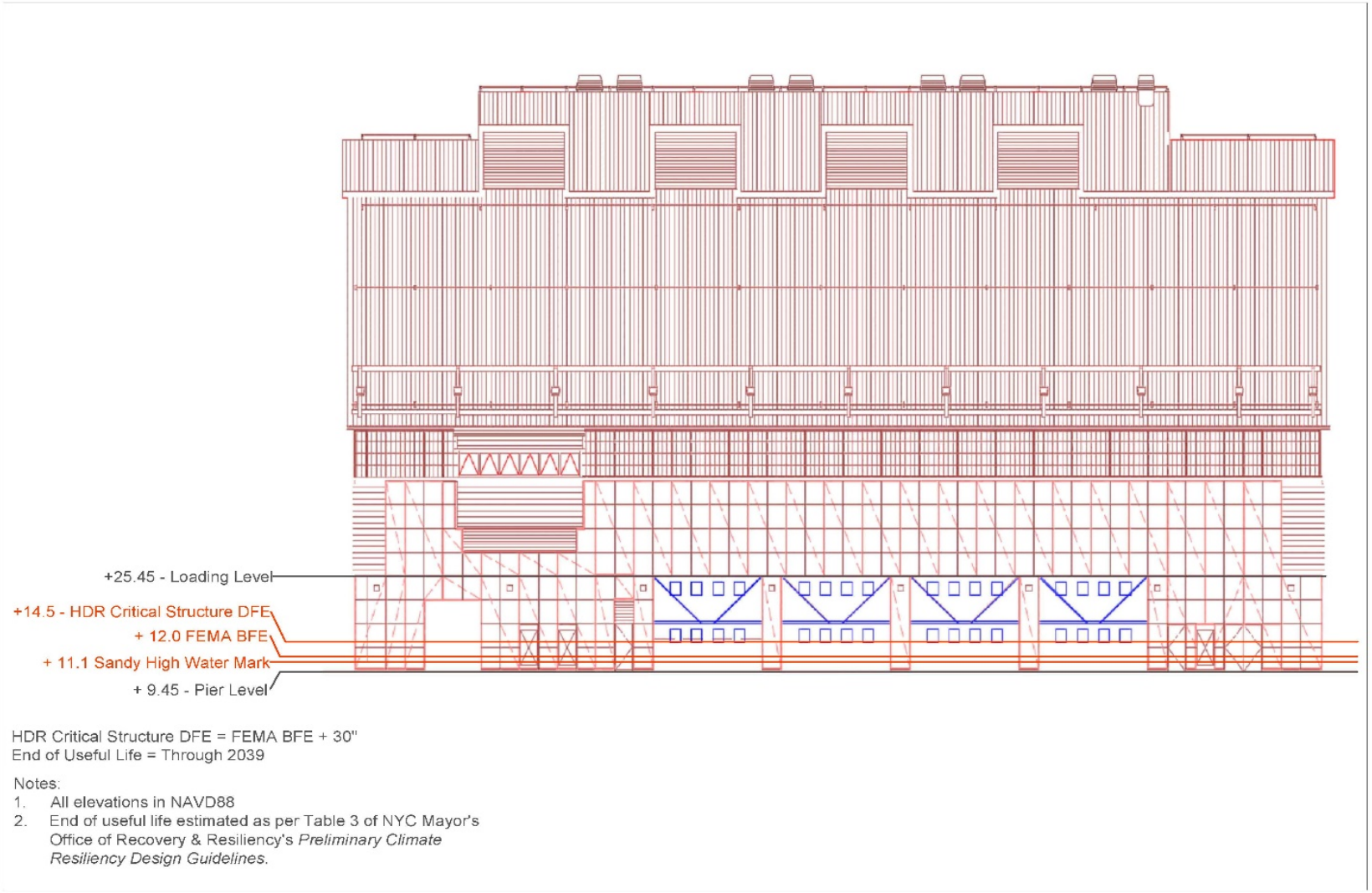
Comparison of Design Flood Elevations

Marine Transfer Station	Current DFE (ft NAVD 88)	Previous DFE (ft NAVD 88)	Comment
Southwest Brooklyn	15.5	13.0	Increase due to addition of sea level rise and freeboard consistent with that FEMA recommends for a Coastal A flood hazard zone.
Hamilton Avenue	14.5	13.0	Increase due to addition of sea level rise.
West 59th Street	18.5	(11.0)	Increase due to updated FEMA base flood elevation, addition of sea level rise and addition of freeboard consistent with that FEMA recommends for a Coastal A flood hazard zone.
East 91st Street	18.5	16.0	Increase due to sea level rise and addition of freeboard consistent with that FEMA recommends for a Coastal A flood hazard zone.
North Shore	21.5	18.0	Increase due to addition of sea level rise and addition of consistent with freeboard recommended by NYC BC for Structural Occupancy Call III in a V flood hazard zone.

Information Reviewed to Evaluate Inflow and Backflow Vulnerabilities

MTS Name	Conformed Drawings	Construction Specifications	Facility Assessment Report	Flood Protection Conceptual Design Report	Seawall Feasibility Study
West 59th Street	✓	✓	✓		
East 91st Street	✓	✓		✓	
Hamilton Avenue	✓	✓		✓	✓
North Shore	✓	✓		✓	
Southwest Brooklyn	✓	✓		✓	

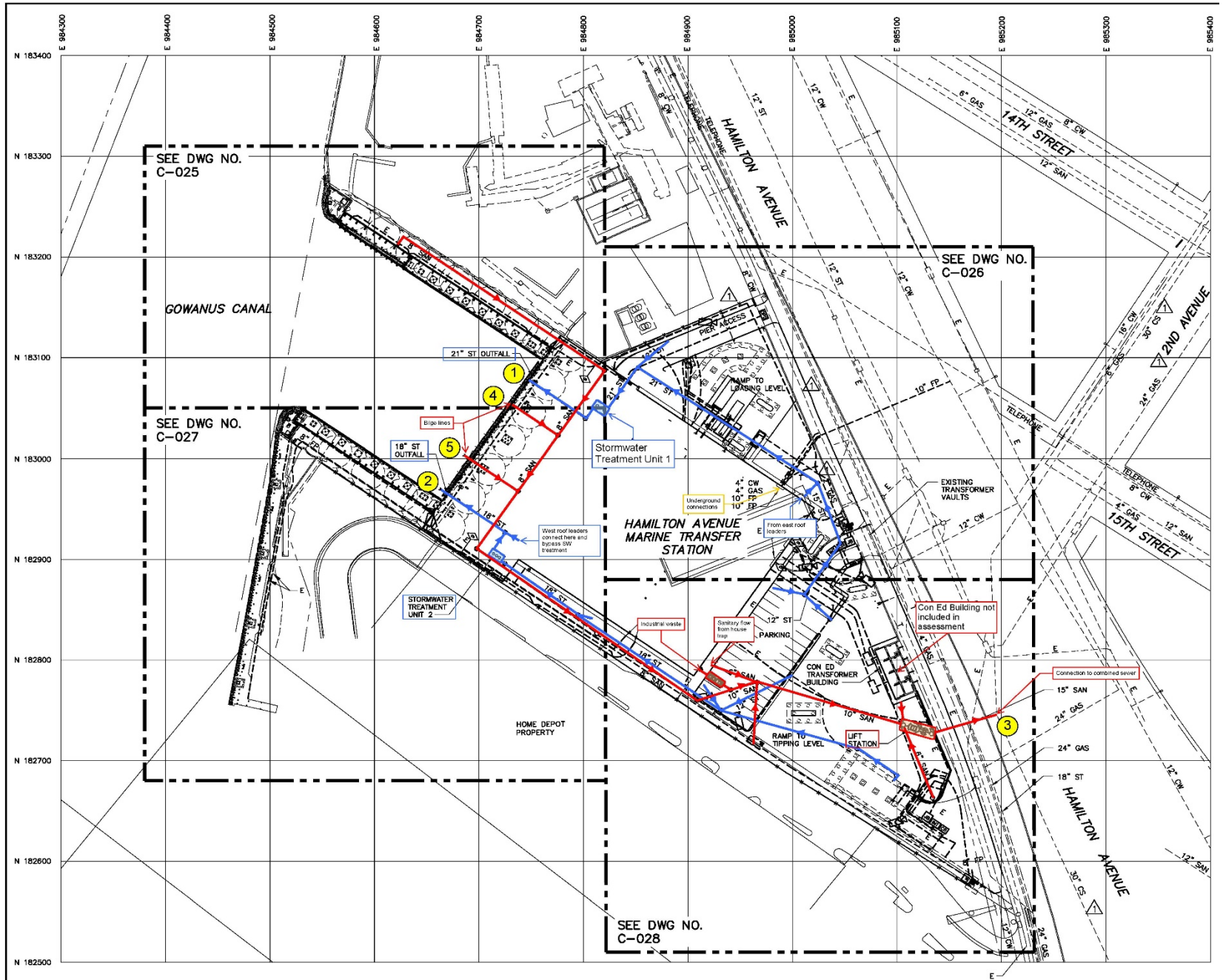
Hamilton Avenue Profile



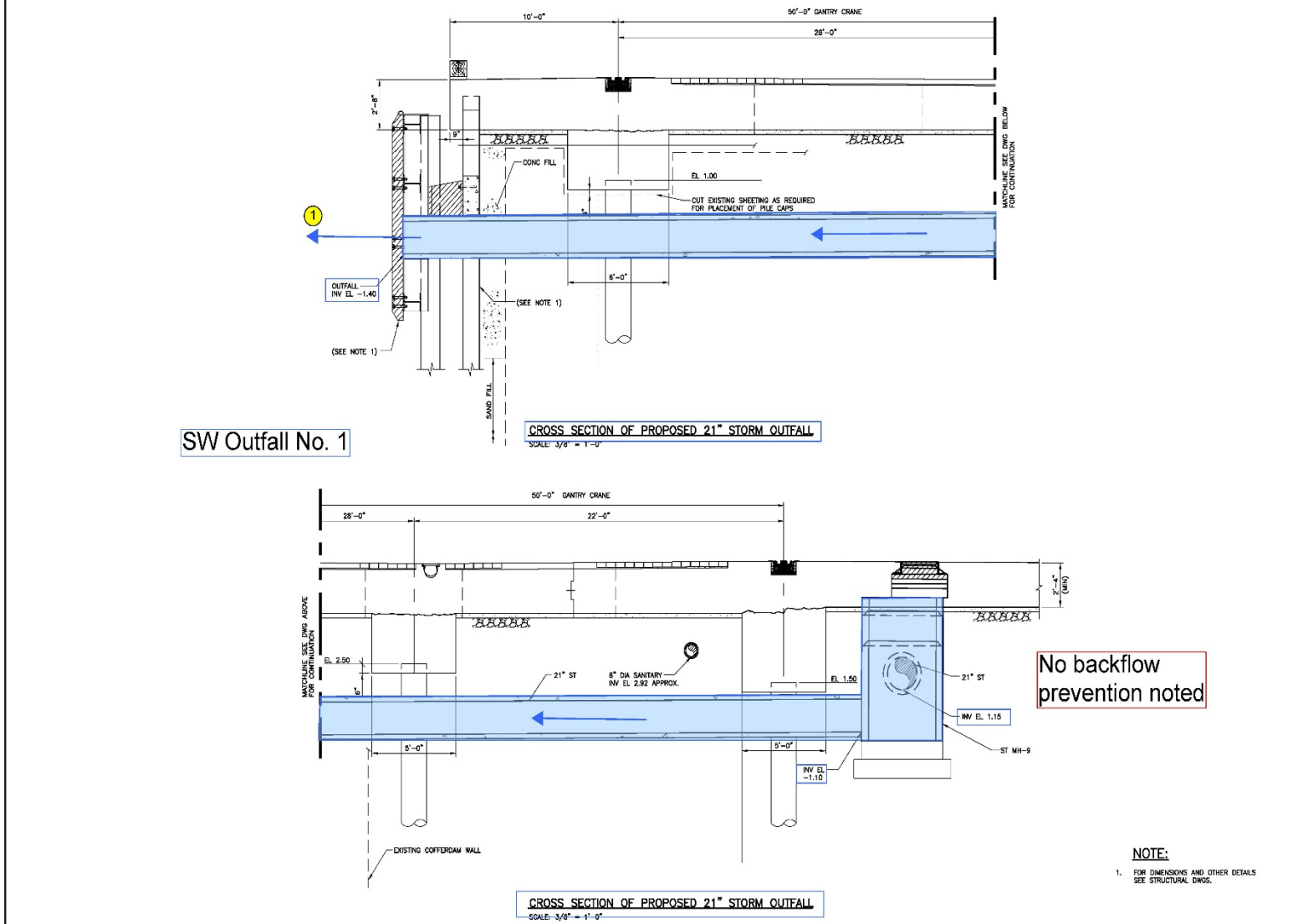
HDR Critical Structure DFE = FEMA BFE + 30"
End of Useful Life = Through 2039

Notes:
1. All elevations in NAVD88
2. End of useful life estimated as per Table 3 of NYC Mayor's Office of Recovery & Resiliency's *Preliminary Climate Resiliency Design Guidelines*.

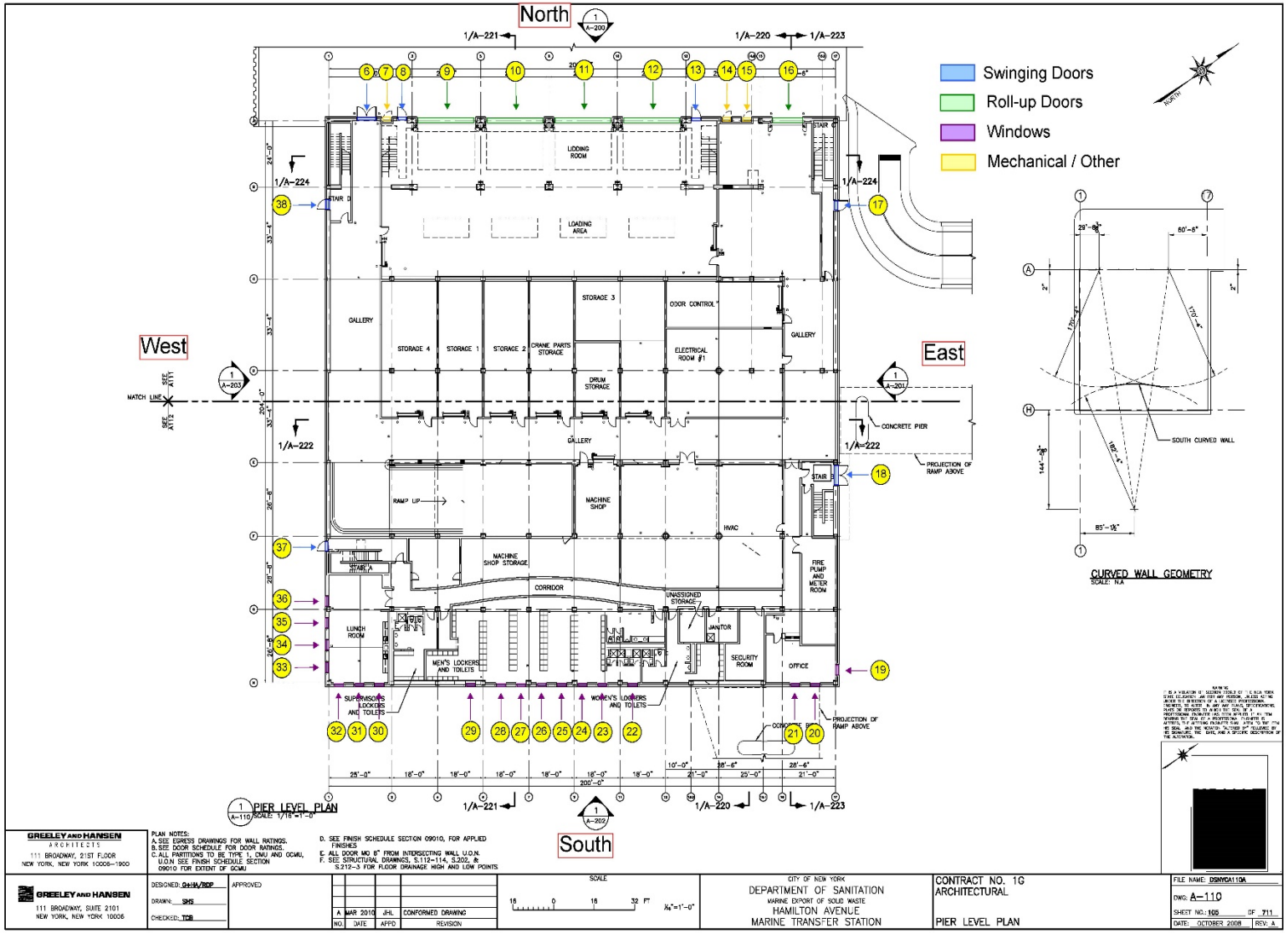
Inflow Through Openings and Backflow



Backflow Vulnerability Through Stormwater Outfall



Exterior Inflow Vulnerabilities at Pier Level



Vulnerability Inventory

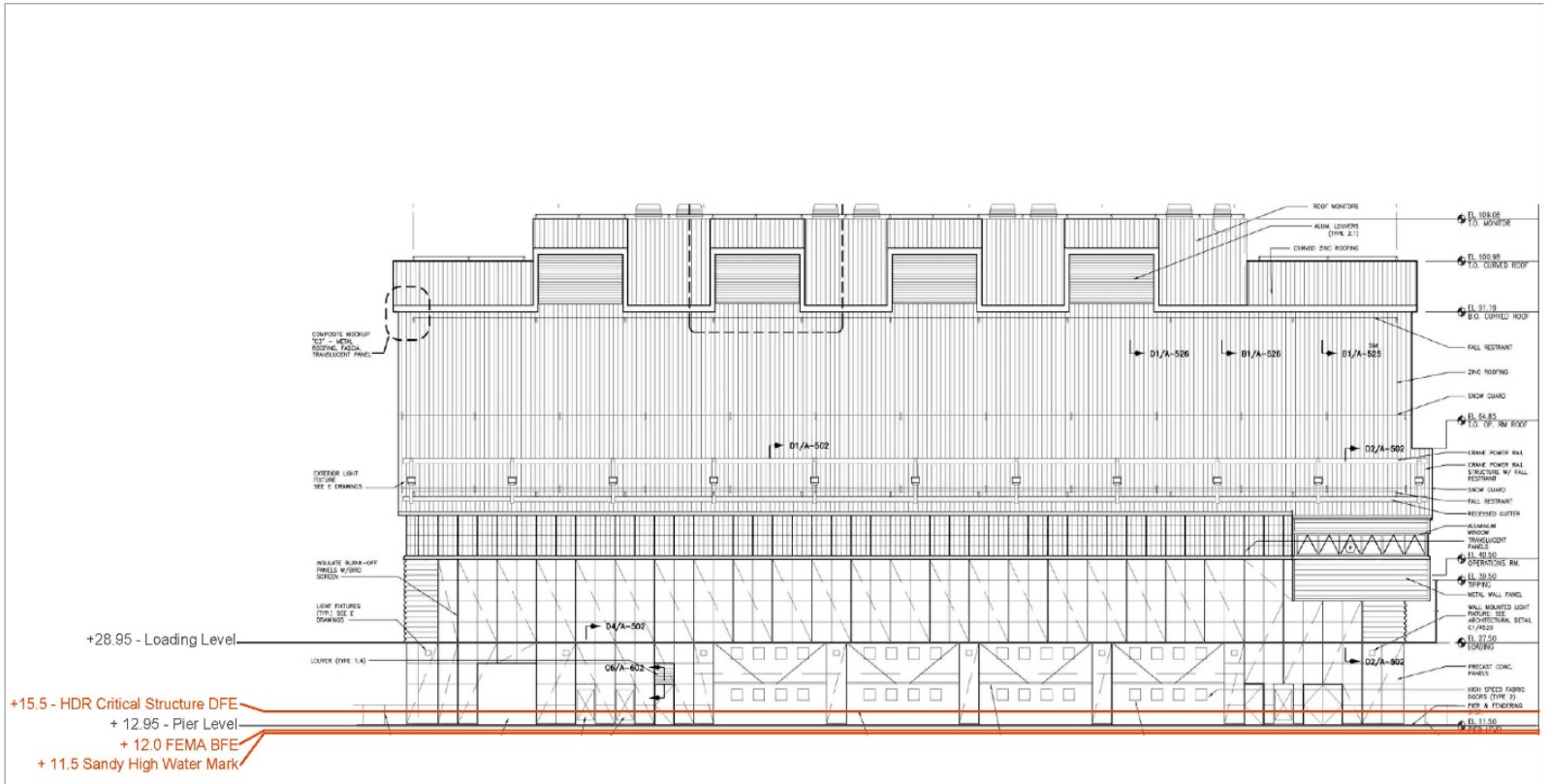
Hamilton MTS Vulnerability Summary

Vulnerability ID	Backflow/Inflow	Description	Location	Sheet Number(s)
1	Backflow	SW Outfall	West Pier	C-024, C-025, C-033
2	Backflow	SW Outfall	West Pier	C-025, C-027, C-034
3	Backflow	Combined Sewer Connection	Hamilton Avenue	C-025, C-028
4	Backflow	Bilge Line	West Pier	C-025, C-027
5	Backflow	Bilge Line	West Pier	C-025, C-027
6	Inflow	Double Swinging Door	North Exterior Wall	A-110, A-200
7	Inflow	Crane Disconnect Box	North Exterior Wall	A-110, A-200
8	Inflow	Single Swinging Door	North Exterior Wall	A-110, A-200
9	Inflow	Large Roll-up Door	North Exterior Wall	A-110, A-200
10	Inflow	Large Roll-up Door	North Exterior Wall	A-110, A-200
11	Inflow	Large Roll-up Door	North Exterior Wall	A-110, A-200
12	Inflow	Large Roll-up Door	North Exterior Wall	A-110, A-200
13	Inflow	Large Roll-up Door	North Exterior Wall	A-110, A-200
14	Inflow	Crane Disconnect Box	North Exterior Wall	A-110, A-200
15	Inflow	Crane Disconnect Box	North Exterior Wall	A-110, A-200
16	Inflow	Large Roll-up Door	North Exterior Wall	A-110, A-200
17	Inflow	Single Swinging Door	East Exterior Wall	A-110, A-201
18	Inflow	Double Swinging Door	East Exterior Wall	A-110, A-201
19	Inflow	Alum. Window	East Exterior Wall	A-110, A-201
20	Inflow	Alum. Window	South Exterior Wall	A-110, A-202
21	Inflow	Alum. Window	South Exterior Wall	A-110, A-202
22	Inflow	Alum. Window	South Exterior Wall	A-110, A-202
23	Inflow	Alum. Window	South Exterior Wall	A-110, A-202
24	Inflow	Alum. Window	South Exterior Wall	A-110, A-202

Inflow and Backflow Vulnerabilities – Hamilton Avenue

Design Flood Elevation: +14.50			
Pier Level : +9.45			
Critical Area	**Vulnerability Type**	**Number of Vulnerabilities**	**Comments**
Combined Sewer Connection	Backflow	1	Discharges to sewer manhole
Stormwater Outfall	Backflow	2	Discharges to Gowanus Canal
Bilge Lines	Backflow	2	Connects to interior drainage
Exterior Walls	Inflow	52	Door, window, crane box, utilities
Electrical Room	Inflow	2	Door
Fire Pump and Meter Room	Inflow	8	Door, utilities
HVAC Room	Inflow	9	Door, utilities

Southwest Brooklyn Profile



HDR Critical Structure DFE = FEMA BFE + 42"
End of Useful Life = 2040-2069

Notes:
1. All elevations in NAVD88
2. End of useful life estimated as per Table 3 of NYC Mayor's Office of Recovery & Resiliency's *Preliminary Climate Resiliency Design Guidelines*.

Inflow and Backflow Vulnerabilities – Southwest Brooklyn

Design Flood Elevation: +14.50			
Pier Level : +9.45			
Critical Area	**Vulnerability Type**	**Number of Vulnerabilities**	**Comments**
Combined Sewer Connection	Backflow	1	Discharges to sewer manhole
Stormwater Outfall	Backflow	2	Discharges to Gowanus Canal
Bilge Lines	Backflow	2	Connects to interior drainage
Exterior Walls	Inflow	52	Door, window, crane box, utilities
Electrical Room	Inflow	2	Door
Fire Pump and Meter Room	Inflow	8	Door, utilities
HVAC Room	Inflow	9	Door, utilities

59th Street Profile

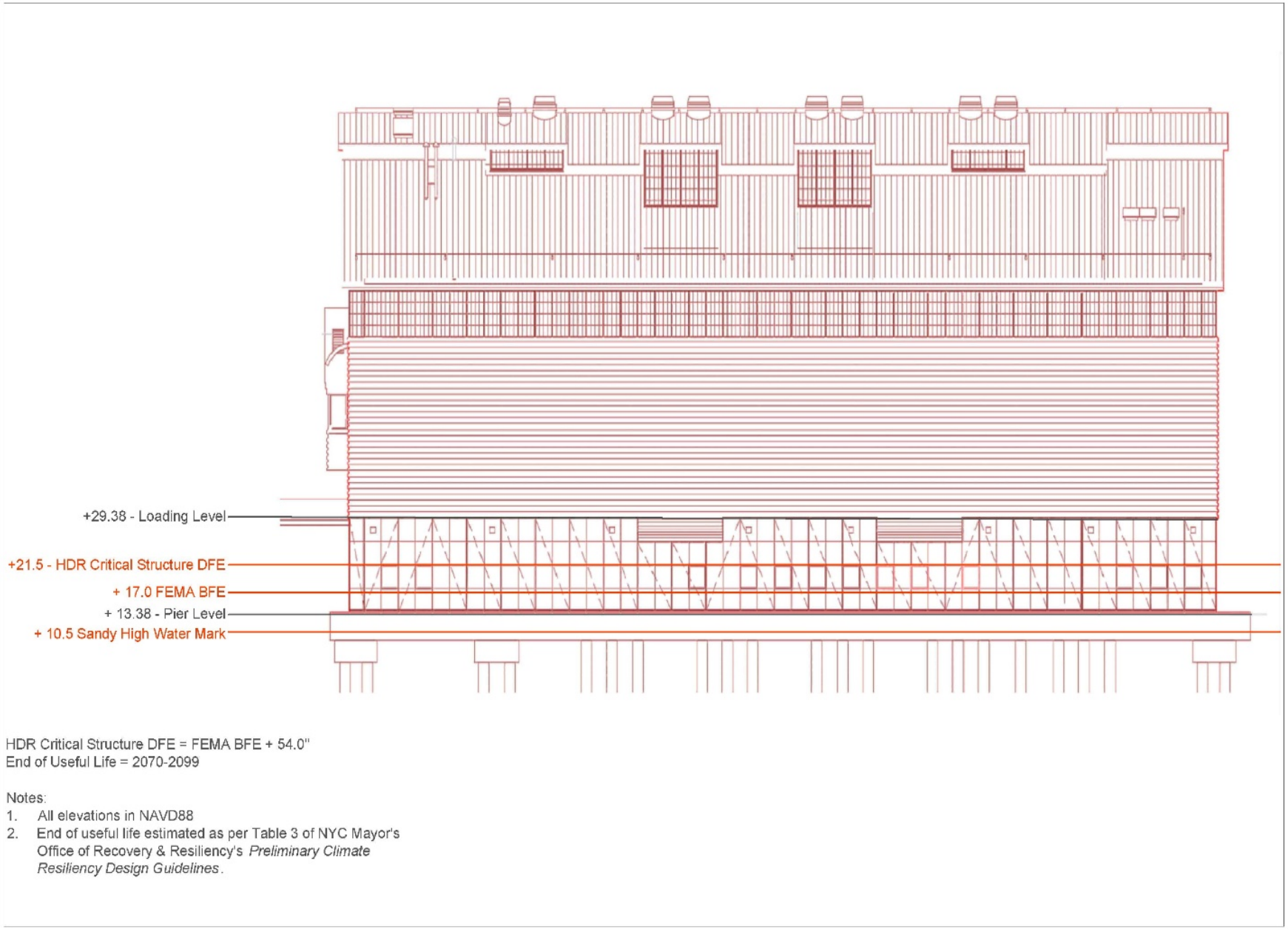
HDR Critical Structure DFE = FEMA BFE + 42.0"
End of Useful Life = 2040-2069

Notes:
1. All elevations in NAVD88
2. End of useful life estimated as per Table 3 of NYC Mayor's Office of Recovery & Resiliency's *Preliminary Climate Resiliency Design Guidelines* .

Inflow and Backflow Vulnerabilities – 59th Street

Design Flood Elevation: +18.50			
Pier Level : +5.90			
Critical Area	**Vulnerability Type**	**Number of Vulnerabilities**	**Comments**
Sanitary Sewer Connection	Backflow	1	Discharges to sewer manhole
Electric Room #2(1)	Inflow	9	Ducts, doors, fans, utilities
Fire Protection Room(1)	Inflow	2	Door, louver
Emergency Generator Room(1)	Inflow	10	Door, louver, exhaust, utilities
Mechanical Room(1)	Inflow	10	Door, louver, utilities
Operations Building	Inflow	26	Door, window, fixture, utilities
Note: (1) Has flood protection barriers.			

North Shore Profile



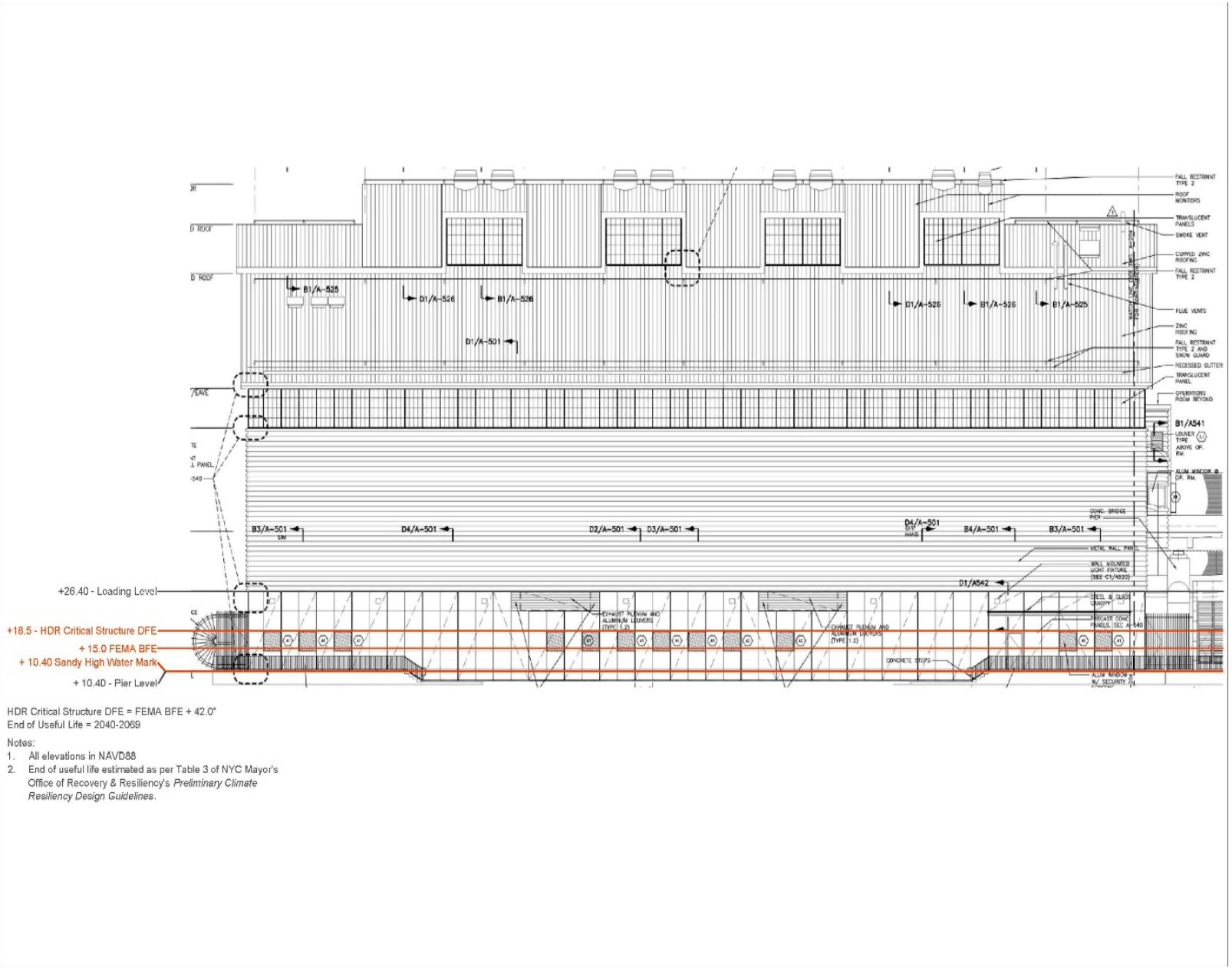
HDR Critical Structure DFE = FEMA BFE + 54.0"
End of Useful Life = 2070-2099

Notes:
1. All elevations in NAVD88
2. End of useful life estimated as per Table 3 of NYC Mayor's Office of Recovery & Resiliency's *Preliminary Climate Resiliency Design Guidelines*.

Inflow and Backflow Vulnerabilities – North Shore

Design Flood Elevation: +21.50			
Pier Level : +13.38			
Critical Area	**Vulnerability Type**	**Number of Vulnerabilities**	**Comments**
Sanitary Sewer Connection	Backflow	1	Discharges to sewer manhole
Stormwater Outfall	Backflow	3	Discharges to Flushing Bay
Roof Drain	Backflow	4	Discharges to Flushing Bay
Exterior Walls	Inflow	45	Door, window, louver, utilities
Ejector Room	Inflow	4	Door, utilities
Electrical Room #1	Inflow	1	Door
Fire Pump and Meter Room	Inflow	10	Door, utilities
HVAC Room	Inflow	7	Door, utilities
Separator Room	Inflow	4	Door, utilities

East 91st Profile



HDR Critical Structure DFE = FEMA BFE + 42.0"
End of Useful Life = 2040-2069

Notes:
1. All elevations in NAVD88
2. End of useful life estimated as per Table 3 of NYC Mayor's Office of Recovery & Resiliency's *Preliminary Climate Resiliency Design Guidelines*.

Inflow and Backflow Vulnerabilities – East 91st Street

Design Flood Elevation: +18.50			
Pier Level : +10.40			
Critical Area	**Vulnerability Type**	**Number of Vulnerabilities**	**Comments**
Combined Sewer Connection	Backflow	1	Discharges to sewer manhole
Stormwater Outfalls	Backflow	5	Treatment units and connections
Exterior Walls	Inflow	39	Door, window, crane box, utilities
Ejector Pump Room	Inflow	3	Door, utilities
Electrical Room	Inflow	2	Door
Fire Pump and Meter Room	Inflow	11	Door, utilities
HVAC Room	Inflow	9	Door, utilities
Separator Room	Inflow	6	Door, utilities

What About Loading Factors Other Than Elevated Water Surface Elevations?

Vessel Impact (Breakaway during Superstorm Sandy)

Vessel Impact (Breakaway during Superstorm Sandy)

Impact due to Waves (Breezy Point during Sandy)

Wave Loading During Coastal Storm

- Estimate wave heights during storm

- USACE wave model

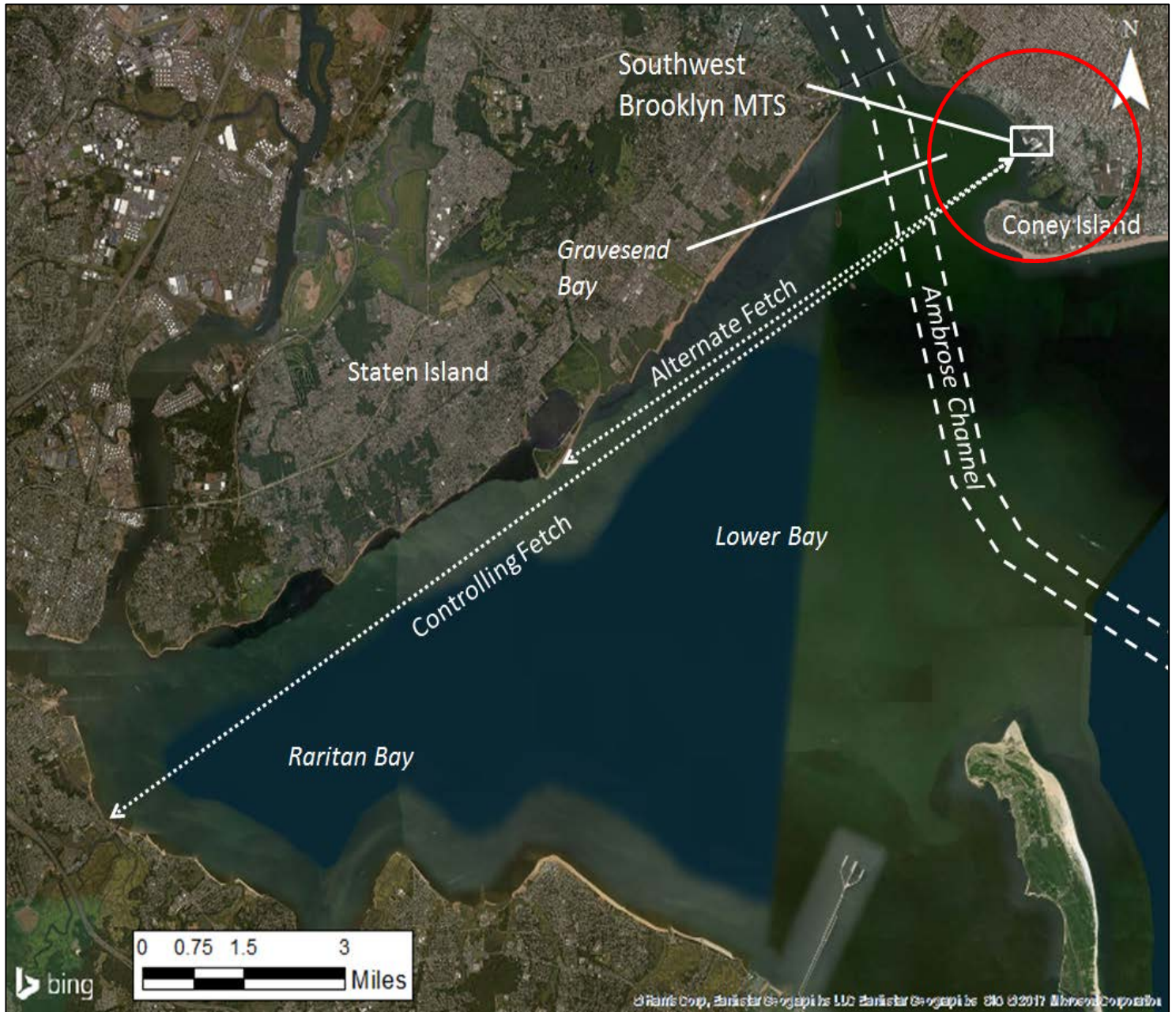
- Model Input
  - Storm surge elevation (FEMA Preliminary FIRM)
  - Water Depth (NOAA)
  - Wind Speed (FEMA)
  - Fetch or ‘Angle of Wave Approach’ / Engineering Judgment

Wave Loading References

- The ACES model was used to develop wave heights.

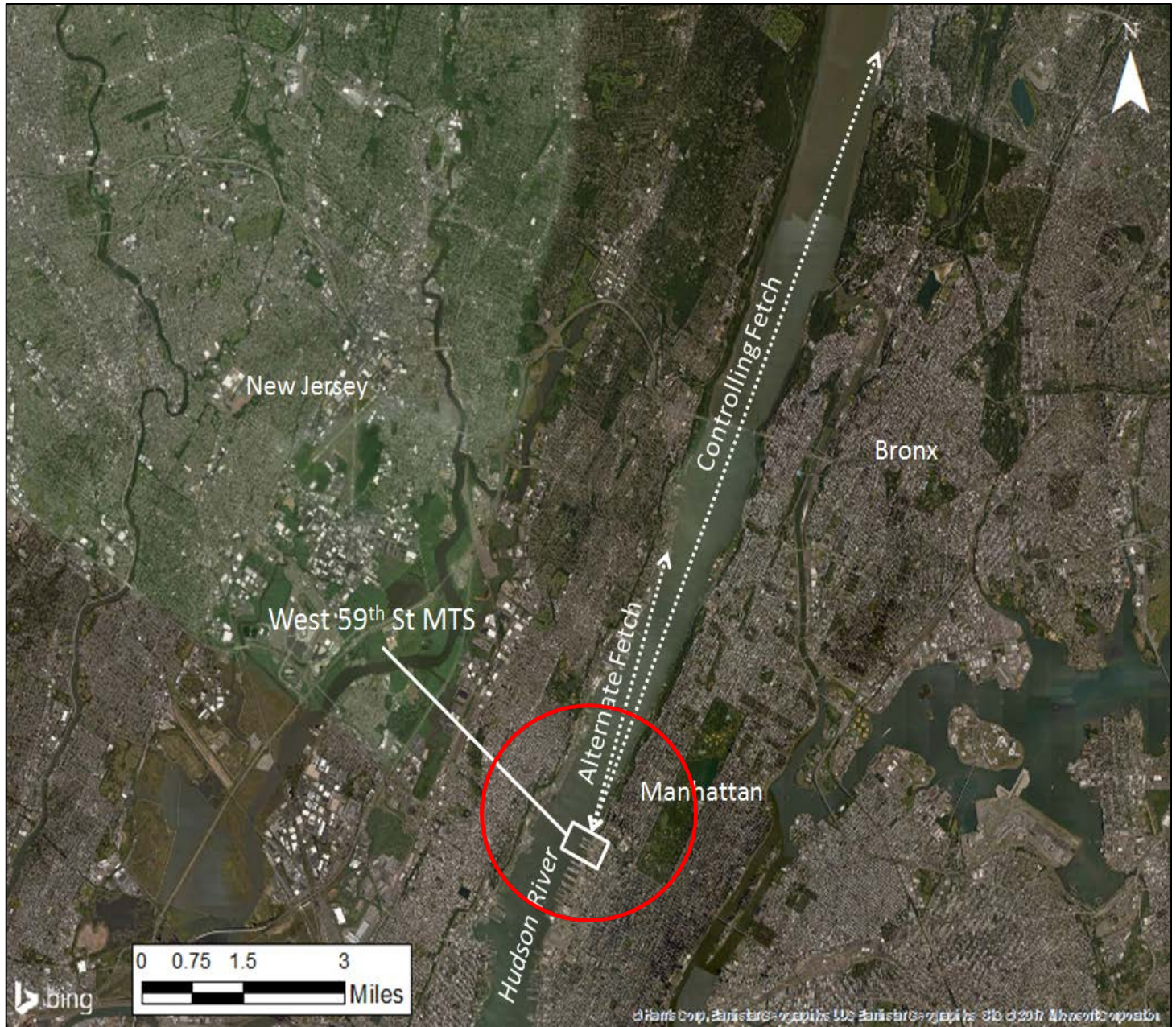
- Wave loads were calculated for piles, deck elements, and vertical walls using USACE methodologies and guidance in “Piers, jetties, and related structures exposed to waves: Guideline for hydraulic loadings” (HR Wallingford 2004)

Wave Approach at Southwest Brooklyn



Wave Approach at Hamilton Avenue

Wave Approach at 59th Street



Wave Approach at East 91st Street

Wave Approach at North Shore

Wave Heights at Five MTSs During 100-yr Coastal Storm

Facility	Wave Height (ft)	Wave Period (sec)
Southwest Brooklyn	10.6	6.2
Hamilton	1.1	1.2
North Shore	5.4	3.6
West 59th Street	11.9	5.9
East 91st Street	4.3	3.1

Wave Loads

Parameter	MTS Site				
	Southwest Brooklyn	Hamilton Avenue	North Shore	West 59th Street	East 91st Street
Pile Loading					
Total Horizontal Force Per Pile (kip)	-	-	3.9	3.1	1.2
Decking Loading					
Horizontal Force Per LF (kip/ft)	-	-	0.2	0.7	0.3
Vertical Pressure (kip/ft^2)	-	-	0.4	0.9	0.4
Building Loading					
Horizontal Force Per LF (kip/ft)	10.1	0.4	3.0	16.1	2.1
Bulkhead Loading					
Horizontal Force Per LF (kip/ft)	16.3	1.0	-	-	-

Vessel Impact

- Two methods of computing vessel loads were compared: American Association of State Highways and Transportation Officials (AASHTO) and that recommended by the USACE Hurricane Storm Damage Risk Reduction Design Guidelines (HSDRRDGs)

- The loads for both methods were found to be similar.

- The USACE HSDRRDGs define loads for different coastal settings, based on typical vessel type and the degree of facility exposure.

Zone 1A – Barge Impact Design Load Cases – Protected Waterways

- Usual – no vessel load
- Unusual – 200 kip load applied to top of wall
- Extreme – Case 1 – 400 kip load applied to top of wall (including SWL and Wind)
- Extreme – Case 2 – 200 kip load applied to top of wall (including SWL and Wave)

Zone 1B – Barge Impact Design Load Cases – Waterways Directly Exposed to Tidal Surge

- Usual – no vessel load
- Unusual – 225 kip load applied to top of wall
- Extreme – Case 1 – 450 kip load applied to top of wall (including SWL and Wind)
- Extreme – Case 2 – 225 kip load applied to top of wall (including SWL and Wave)

Zone 2 – Boat Impact Design Load Case

- Usual – no boat impact load
- Unusual – 50 kip load applied to top of wall
- Extreme – Not Applicable

Vessel Loads

- North Shore MTS
  - Protected location
  - Assume Zone 2 – no barge impact but recreational boat impact (50 kips) – storm surge will still affect the facility
- East 91st Street
  - East River – potential for impact depending on wind direction during storm – somewhat protected
  - Further inland than other MTS locations
  - Assume Zone 1A – Extreme – Case 2 (200 kips)
- West 59th Street
  - Hudson River – potential for impact – vulnerable to large vessels and MTS is constructed on an existing pier
  - Although somewhat inland – it is exposed to impact
  - Assume Zone 1B – Case 1 – (450 kips)

- Hamilton Avenue
  - Hudson River/Gowanus Canal – Somewhat protected in but exposed to storm surge
  - MTS orientation and location would be difficult to see a direct vessel strike
  - Assume Zone 2 – no barge impact but recreational boat impact (50 kips)
- Southwest Brooklyn
  - Hudson River/Lower Bay – Highly vulnerable to vessel impact and storm surge
  - MTS orientation and location could see a direct hit
  - Assume Zone 1B – Case 1 (450 kips)

Debris Loading

- Definition of ‘Debris’ – Floating material that wind and waves can propel into a structure (vegetative material – logs, limbs; signage, dumpsters, portable generators, other equipment/loose structures, etc)
- HDR compared guidance provided by ASCE 7 and the Hurricane and Storm Damage Risk Reduction System Design Guidelines (HSDRRSDGs)
- HSDRRSDs Guidelines were selected because they more conservative (i.e. larger values)

Vulnerability to Hydrostatic Forces, Waves, Debris, and Vessels – *Hamilton Ave*

- **Red**: High likelihood of structural instability
- **Orange**: Moderate likelihood of structural instability
- **Green**: Low likelihood of structural instability

Element	Still Water Level (SWL)	SWL + Wave	SWL + Wind + Boat or Debris Impact
Bulkhead			
Concrete Panels			
Concrete Walls			
Concrete Columns			

Vulnerability to Hydrostatic Forces, Waves, Debris, and Vessels – *Southwest Brooklyn*

- **Red**: High likelihood of structural instability
- **Orange**: Moderate likelihood of structural instability
- **Green**: Low likelihood of structural instability

Element	Still Water Level (SWL)	SWL + Wave	SWL + Wind + Boat or Debris Impact
Bulkhead			
Concrete Panels			
Concrete Walls			
Concrete Columns			

Vulnerability to Hydrostatic Forces, Waves, Debris, and Vessels – *E. 91st Street*

- **Red**: High likelihood of structural instability
- **Orange**: Moderate likelihood of structural instability
- **Green**: Low likelihood of structural instability

Element	Still Water Level (SWL)	SWL + Wave	SWL + Wind + Boat or Debris Impact
Pile Cap			
Pile			
Concrete Panels			
Concrete Walls			
Concrete Columns			

Vulnerability to Hydrostatic Forces, Waves, Debris, and Vessels – *North Shore*

- **Red**: High likelihood of structural instability
- **Orange**: Moderate likelihood of structural instability
- **Green**: Low likelihood of structural instability

Element	Still Water Level (SWL)	SWL + Wave	SWL + Wind + Boat or Debris Impact
Pile Cap			
Pile			
Concrete Panels			
Concrete Walls			
Concrete Columns			

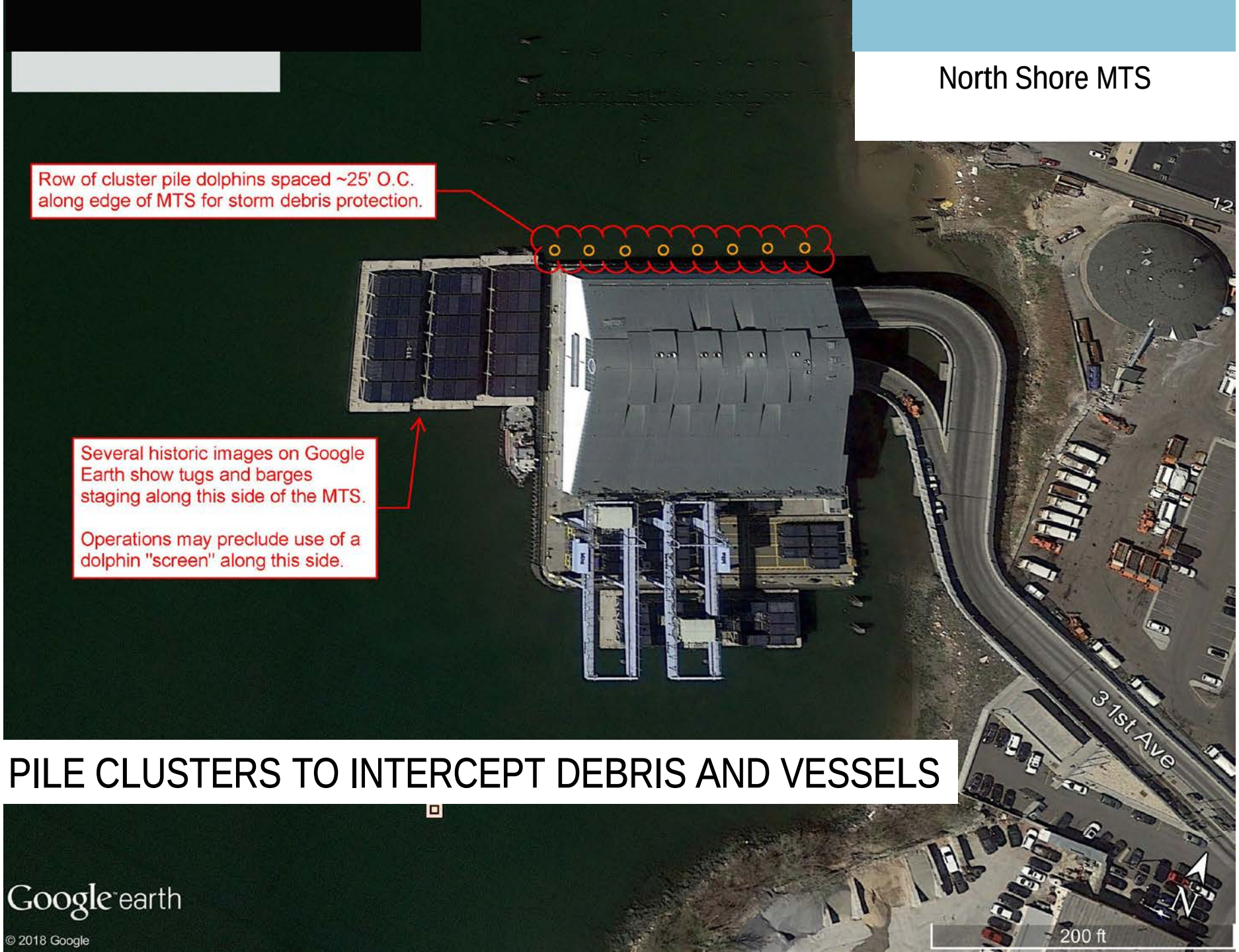
Vulnerability to Hydrostatic Forces, Waves, Debris, and Vessels – *W. 59th Street*

- **Red**: High likelihood of structural instability
- **Orange**: Moderate likelihood of structural instability
- **Green**: Low likelihood of structural instability

Element	Still Water Level (SWL)	SWL + Wave	SWL + Wind + Boat or Debris Impact
Pile Cap			
Pile			
Kalwall Panels			
CMU Walls			
Steel Columns			

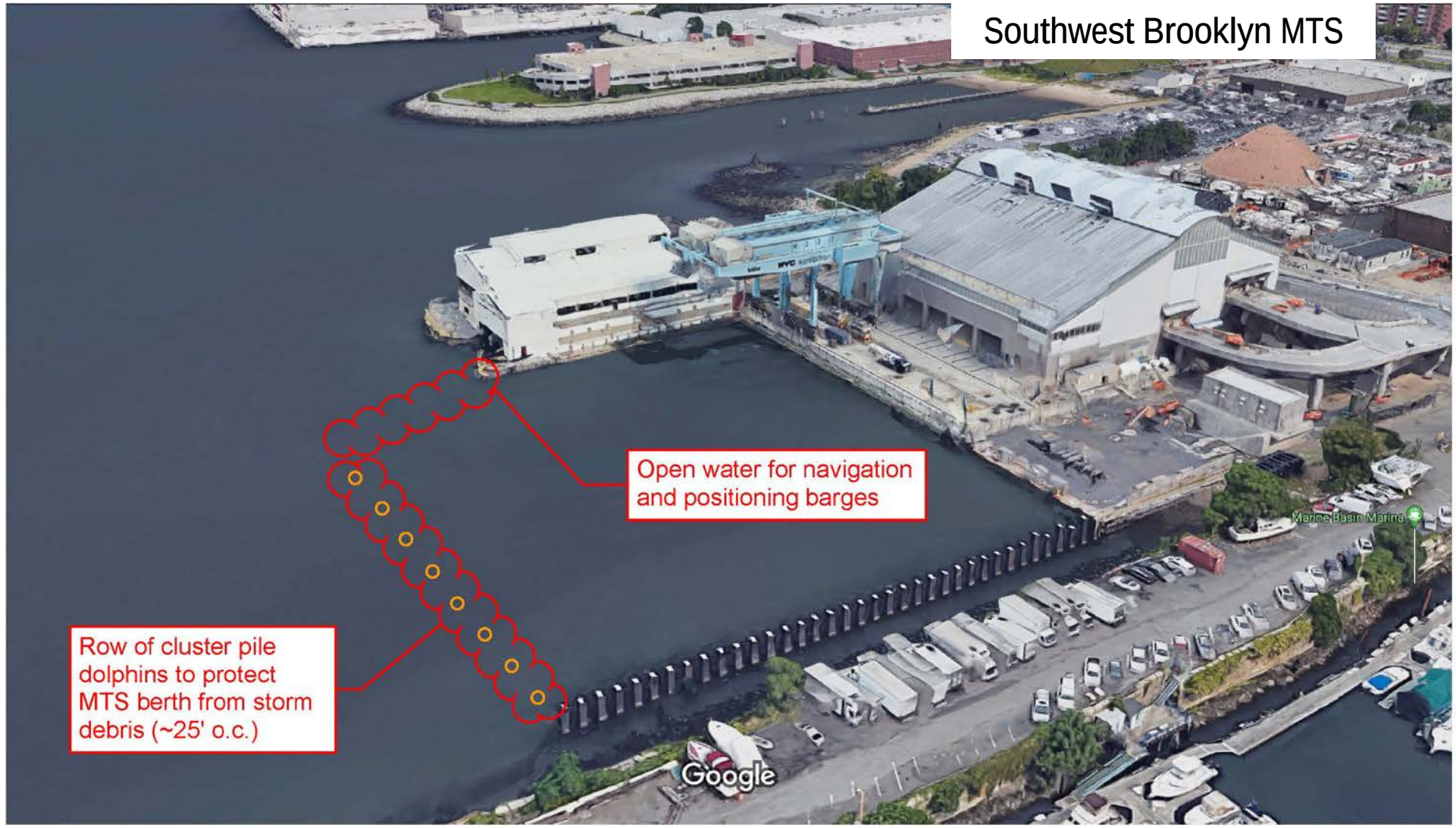
Moving Forward

North Shore MTS



PILE CLUSTERS TO INTERCEPT DEBRIS AND VESSELS

Southwest Brooklyn MTS



PILE CLUSTERS TO INTERCEPT DEBRIS AND VESSELS

QUESTIONS?

Flood Protection Conceptual Design Report, SW Brooklyn and E.91st Street MTSs, Greeley and Hansen, May 2013

System	Equipment	Location	Criticality
Electrical	Switchgear	Electrical Room #1	Life Safety
	MCCs		Life Safety
	Transformers		Life Safety
	Panelboards		Life Safety
Emergency Power	Emergency Generator	Outside	Life Safety
	Automatic Transfer Switches	Electrical Room #1	Life Safety
Fire Protection	Fire Pump	Fire Pump and Meter Room	Life Safety
	Jockey Pump		Life Safety
	Fire Control Panel		Life Safety
	Deluge Foam Tank		Life Safety
	Dry Sprinkler Air Compressor		Life Safety
Alarm System	Building Wide Alarm System	BWAS Room	Life Safety
Security System	Security System Equipment	Security Room	Life Safety
HVAC	Air Conditioner Units	HVAC Room	Non-critical
	Heating & Ventilation Unit		Life Safety
Oil Water Separator	Oil Water Separator Tank	Separator Room	Process
	Sewage Ejector/Sump Pumps		Life Safety
Odor Control System	Odor Control Equip Package	Odor Control Room	Process
Service Water System	Service Water Equip Package		Process
Domestic Water Systems	Booster Pump		Non-critical
	Water Heaters		Non-critical
Maintenance Oil Systems	Oil Tanks & Pump		Non-critical
Dust Suppression System	Dust Suppression Equip Package		Process
Lidding Operations	Container Transport System (Shuttle Car)	Lower Lidding Area	Process
Marine Equipment	Capstans	Outside Pier Area	Non-critical
	Constant Tension Winches		Non-critical
Gantry Crane	Drive Motors		Process
	Disconnect Switches		Process