CANNON AVENUE PUMPING STATION, STATEN ISLAND, NY

CHAPTER 3:
PUMPING STATIONS

Introduction

The New York City Department of Environmental Protection (DEP) own and operates 96 pumping stations. These facilities are critical in transporting wastewater and stormwater from low-lying areas of the city and maintaining drainage and sanitation. As such, New York City's intricate system of pumping stations is fundamental to protecting the environment and public heath, and DEP is committed to ensuring its continued performance and reliability.

One of DEP's priorities in the coming years will be hardening its wastewater infrastructure to increase resiliency against flood damage. Many of the City's pumping stations are located within close proximity to the waterfront and are at-risk from flooding and power outages, as was evident during Hurricane Sandy. Flooding and power outages at pumping stations can have negative impacts for residents and businesses, including sewage overflows and backups and impacts on bathing beaches. It should be noted that while backups may result from pumping station failure, loss of power to an electric sump pump at a home or business can also cause or prolong backups.

Given that the risk of flooding is likely to increase over time with sea level rise, DEP performed the 2013 Climate Risk Assessment and Adaptation Study to identify pumping station risks and protective measures that will reduce flood damage and the time needed to restore normal operating conditions following a flood event.

The critical flood elevation examined in this study is based on the Federal Emergency Management Agency (FEMA) Advisory Base Flood Elevation (ABFE) for the 100-year flood due to storm surge plus an additional 30 inches to account for potential sea level rise. At the time the analysis was completed, the March 2013 ABFE was the best available data. This data only represents flooding due to storm surge, therefore some stations which have been historically been inundated due to localized or riverine flooding may not have been captured in this study.

The study revealed that 58 of 96 pumping stations are at risk of flood damage during the critical flood event, totaling $218 million in at-risk infrastructure. The recommended protective measures, totaling $128 million in improvements, are also costly but will significantly reduce

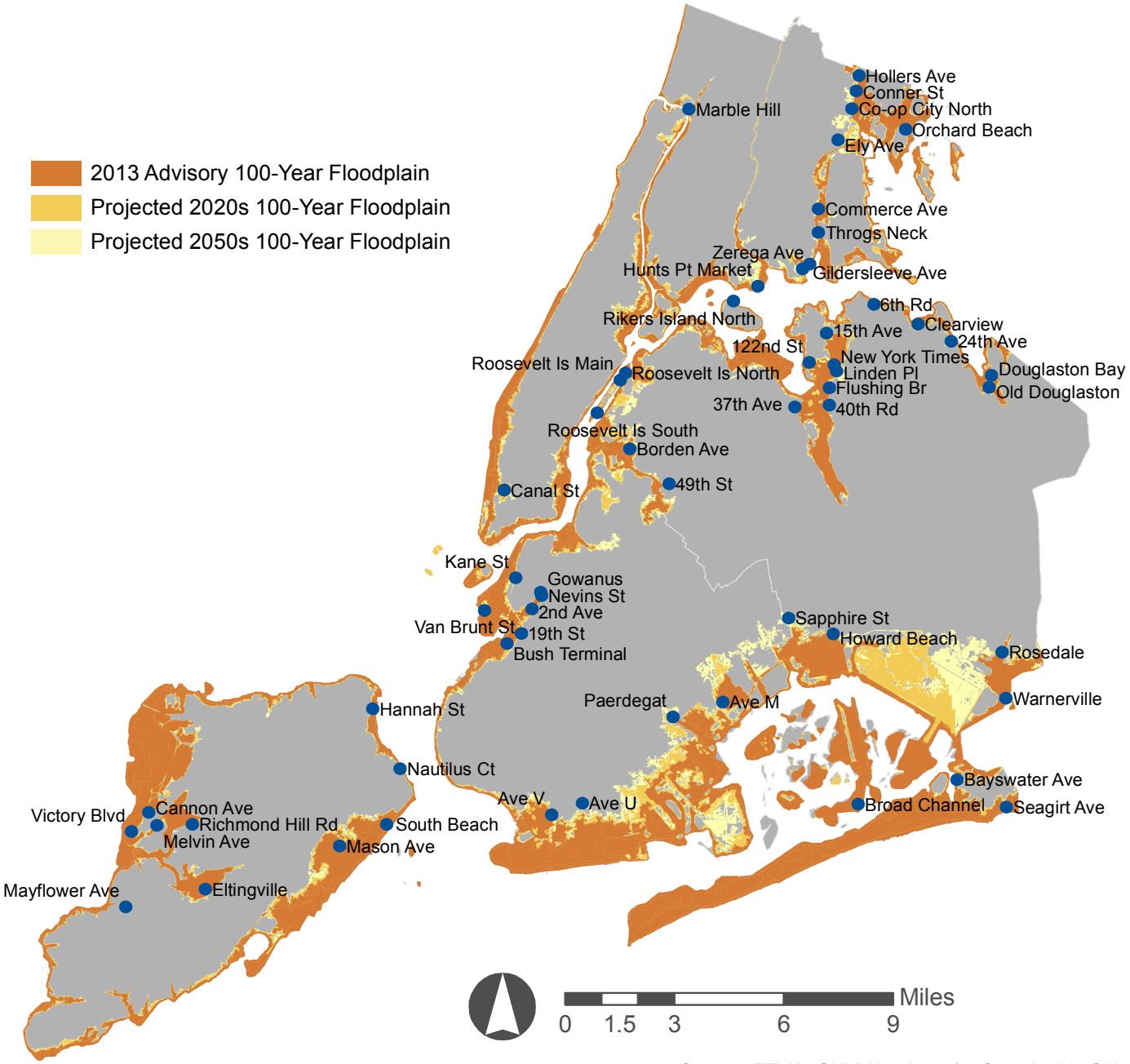
risk to the equipment, environment, and public health, and will maximize the likelihood of continued service through and immediately following a flood event.

DEP plans to implement the protective measures systematically through capital projects in the coming years, with added consideration given to those pumping stations that meet some or all of the following criteria:

- Bathing beaches affected by loss of function at pumping station
- Historic flooding issues, beyond flooding caused by Hurricane Sandy
- Historic power outage problems (i.e., loss of power without flooding, lack of backup power)
- Locations that serve critical facilities (e.g., hospitals, fire stations, schools)

This chapter provides additional information regarding individual pumping stations, their risks, and which measures DEP may implement in the future to protect them.

Pumping Stations At-Risk of Storm Surge Inundation



Source: FEMA; CUNY Institute for Sustainable Cities

Pumping Station Estimated Cost			
Pumping Stations	Cost of Protective Measures ($M)[1]	Damage Cost for Critical Flood without Protection ($M)[1,2]	Cumulative Risk Avoided Over 50 Years ($M)[1,3]
122nd Street	$0.28	$1.85	$0.62
15th Avenue	$2.66	$3.51	$1.00
19th Street	$0.30	$3.66	$1.43
24th Avenue	$1.48	$5.03	$15.75
2nd Avenue	$1.91	$1.32	$6.78
37th Avenue	$0.06	$3.51	$3.85
40th Road	$0.51	$1.77	$8.32
49th Street	$2.87	$2.12	$10.91
6th Road	$2.87	$1.37	$6.77
Avenue M	$1.07	$3.84	$19.75
Avenue U	$2.60	$3.70	$19.04
Bayswater Avenue	$0.17	$1.14	$5.29
Borden Avenue	$1.94	$3.24	$15.22
Broad Channel	$2.40	$2.34	$12.03
Bush Terminal	$0.59	$3.47	$17.84
Canal Street	$2.42	$2.71	$13.33
Cannon Avenue	$1.43	$4.39	$20.46
Clearview	$4.71	$7.82	$16.80
Commerce Avenue	$0.63	$1.04	$5.34
Conner Street	$5.46	$6.57	$32.13
Co-op City North	$0.35	$3.70	$3.26
Douglaston Bay	$7.39	$1.80	$9.26
Eltingville	$0.59	$9.51	$5.44
Ely Avenue	$0.47	$2.02	$3.58
Flushing Bridge	$1.26	$1.74	$8.51
Gildersleeve Avenue	$0.89	$1.14	$3.97
Hannah Street	$1.37	$12.80	$63.24
Hollers Avenue	$2.48	$2.82	$14.53
Howard Beach	$8.16	$17.44	$20.65
Hunts Point Market	$0.73	$1.86	$5.65
Kane Street	$4.80	$6.23	$11.93
Linden Place	$1.15	$4.03	$4.41
Marble Hill	$0.62	$3.38	$15.67
Mason Avenue	$0.55	$3.37	$15.60
Mayflower Avenue	$0.04	$6.50	$28.43
Melvin Avenue	$2.54	$1.78	$9.14
Nautilus Court	$2.42	$3.28	$16.85
Nevins Street	$1.09	$1.31	$6.75
New York Times	$5.56	$1.99	$10.23

Pumping Station Estimated Cost			
Pumping Stations	**Cost of Protective Measures ($M)[1]**	**Damage Cost for Critical Flood without Protection ($M)[1,2]**	**Cumulative Risk Avoided Over 50 Years ($M)[1,3]**
Old Douglaston	$0.74	$4.07	$20.95
Orchard Beach	$0.66	$1.15	$3.05
Paerdegat	$16.96	$15.41	$19.21
Richmond Hill Road	$0.01	$5.49	$1.20
Rikers Island North	$2.87	$3.14	$6.35
Roosevelt Island Main	$0.27	$3.02	$0.70
Roosevelt Island North	$2.54	$1.66	$8.56
Roosevelt Island South	$0.66	$1.66	$0.51
Rosedale	$9.94	$5.22	$26.84
Sapphire Street	$0.80	$3.70	$19.04
Seagirt Avenue	$2.30	$4.23	$21.75
South Beach	$0.29	$2.36	$10.93
Throgs Neck	$5.92	$10.67	$53.00
Van Brunt Street	$2.74	$0.93	$4.79
Victory Boulevard	$0.88	$1.85	$9.52
Warnerville	$0.88	$1.14	$5.87
Zerega Avenue	$0.66	$1.28	$6.60
Total	**$128 M**	**$218 M**	**$709 M**

Notes: Avenue V and Gowanus Pumping Stations are considered at-risk, but are already undergoing extensive protective upgrades and are not considered in this cost estimate.
1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade Pumping Station Running on Bypass

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$1,910,000**

2nd Avenue Pumping Station

STATION CHARACTERISTICS

The 2nd Avenue combined pumping station is located near the intersection of 2nd Avenue and 5th Street in Brooklyn. It is a below grade station that was running on a bypass pump at the time of the site visit.

The Pumping Station Summary table lists the general characteristics of the 2nd Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. Failure of the station would affect an area of approximately 376 acres. There are 20 critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

At the time of the station visit in March 2013, the station was running on a bypass pump due to damage caused by flooding during Hurricane Sandy. Streets nearby the station flood during smaller storm events, but the station itself does not have a history of flooding.

RISK ASSESSMENT

The risk of the 2nd Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). The critical flood elevation would completely inundate the below grade station; the surrounding flood would be more than 6 feet above local grade. This would flood and damage the electrical controls. The submersible pumps should withstand flooding. A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

ADAPTATION STRATEGIES

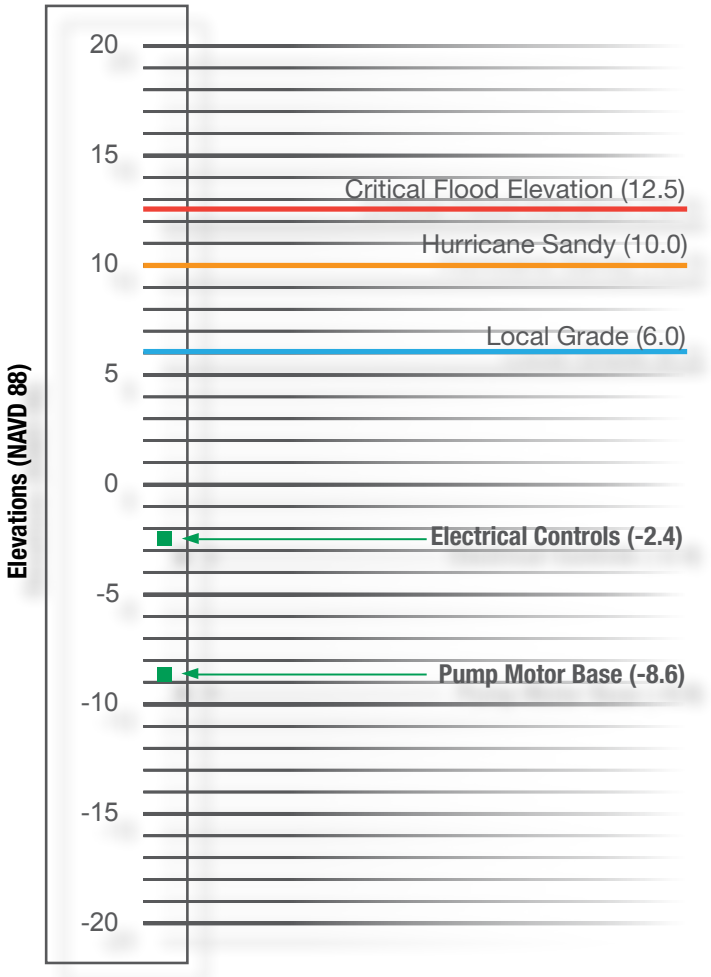
The 2nd Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the critical flood depth of more than 6 feet, the recommended strategy at 2nd Avenue is to elevate controls in a new building. Residual risk is related to the potential for larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	1.0
	Affected Area (Acres)	376
Risk	Population in Affected Area	34,003
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	20
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$1,910,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,318,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$6,783,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station with entrances in sidewalk

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$2,866,000**

6th Road Pumping Station

STATION CHARACTERISTICS

The 6th Road sanitary pumping station is located near the intersection of 6th Road and 151st Street in Queens. It is entirely below grade and is accessible through hatches in the sidewalk along 6th Road.

The Pumping Station Summary table lists the general characteristics of the 6th Road pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a mixed residential and industrial area. Failure of the station would affect an area of approximately 8 acres. There are no critical facilities in the area that could be affected if the station fails.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The 6th Road pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

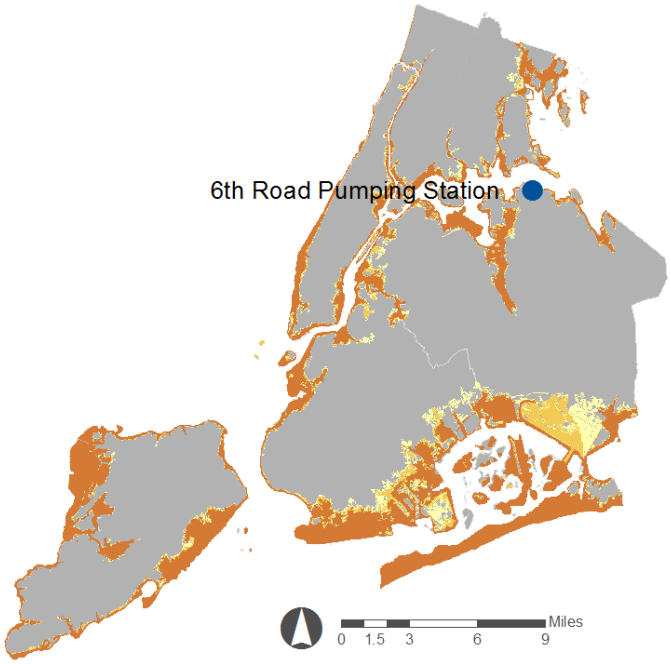
The risk of the 6th Road pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings. Submersible pumps were confirmed but the condition of the pumps and the resiliency of supporting equipment is not known.

The critical flood elevation would completely inundate the below grade station, and the surrounding flood would be nearly 5 feet above local grade. Water would flood and damage the pump controls. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The 6th Road pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. The significant flood depth of about five feet and the station's location in an industrial area led to the selection of the most resilient option; the recommended strategy at 6th Road is to elevate the pumping station's controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

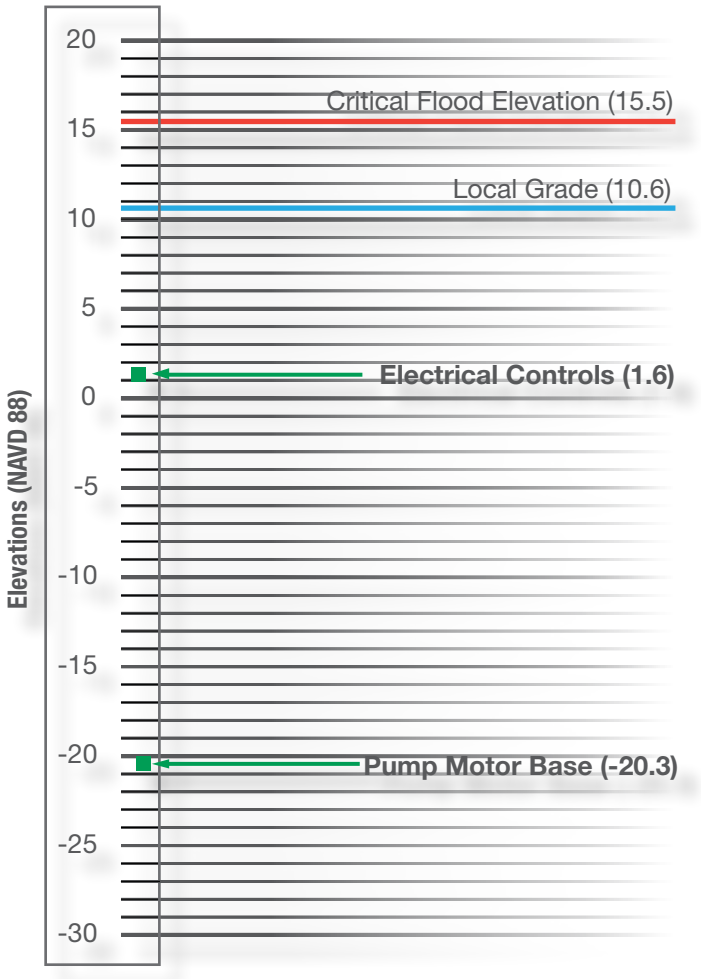
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	0.7
	Affected Area (Acres)	8
Risk	Population in Affected Area	163
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,866,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,370,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$6,773,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Hatch entryways in sidewalk adjacent to small, vacant lot

Recommended Adaptation Strategy: **Elevate Electrical in New Building & Submersible Pump Motors**

Adaptation Cost: **$2,664,000**

15th Avenue Pumping Station

STATION CHARACTERISTICS

The 15th Avenue sanitary pumping station is located near the southeast corner of 15th Avenue and 131st Street in Queens. The station is completely below grade with grates and hatch entryways located in the sidewalk along 15th Avenue. There is a small grassy area between the pumping station and a concrete wall.

The Pumping Station Summary table lists the general characteristics of the 15th Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a mixed-use residential, industrial, and commercial area and services an area of approximately 46 acres and a population of more than 700. There is one critical facility in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The 15th Avenue Pumping Station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

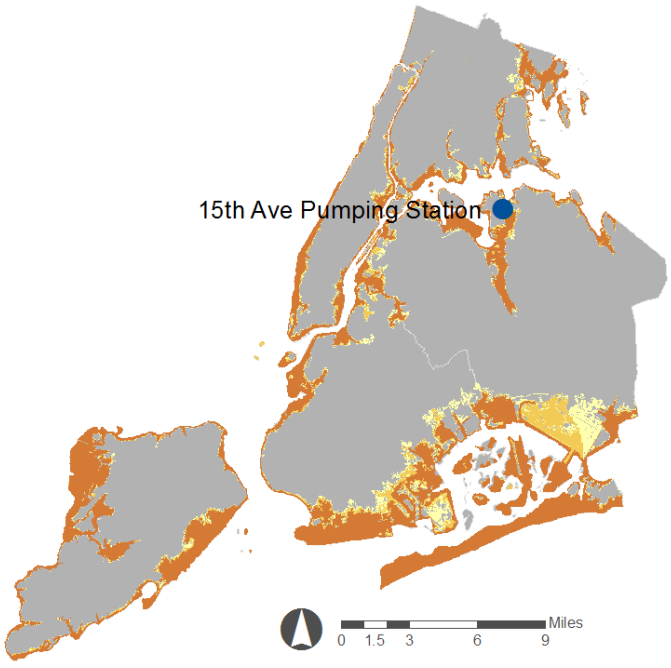
The risk of the 15th Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would flood the local grade to a depth of about 4 inches. Because the station is entirely below grade, and access hatches and grating are very near to grade level, even this minor flood could significantly affect the station. Electrical controls and non-submersible pumps could be damaged if flood waters enter the pumping station.

ADAPTATION STRATEGIES

The 15th Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. The station entrances are currently located in a sidewalk, there is a plot of vacant land bordering the sidewalk, and a concrete wall approximately 15 feet high runs along the back of the lot. With space available and no apparent limitations on structure height, the recommended strategy at 15th Avenue is to elevate the electrical controls in a new building and install submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

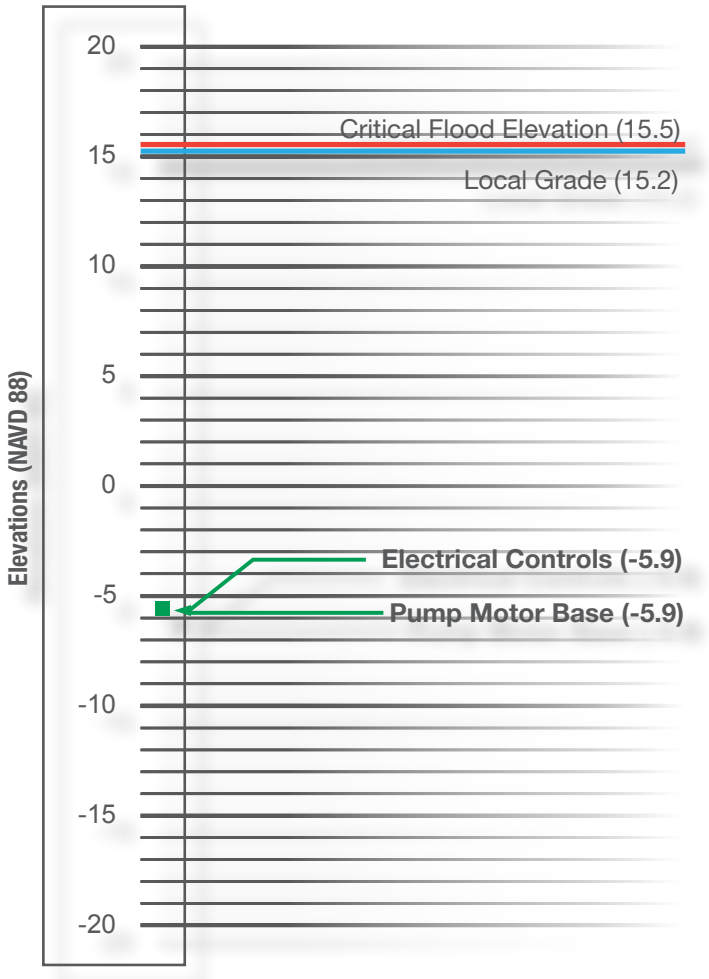
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	2.9
	Affected Area (Acres)	46
Risk	Population in Affected Area	793
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building & Submersible Pump Motors
	Cost of Protective Measures[1]	$2,664,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,510,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$995,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Seal Building

Adaptation Cost:
$300,000

Brick structure with elevated entrances

19th Street Pumping Station

STATION CHARACTERISTICS

The 19th Street sanitary pumping station is located near the northwest corner of 19th Street and 3rd Avenue in Brooklyn. The pumping station has a brick structure that houses the motor control center; pumps are located three floors below grade in the dry well. The doorway to the structure and hatches to the wet well are elevated on a concrete slab 1–2 feet above grade.

The Pumping Station Summary table lists the general characteristics of the 19th Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The 19th Street pumping station is located in an industrial area. Failure of the station would affect an area of approximately 25 acres. There are no critical facilities in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The 19th Street Pumping Station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

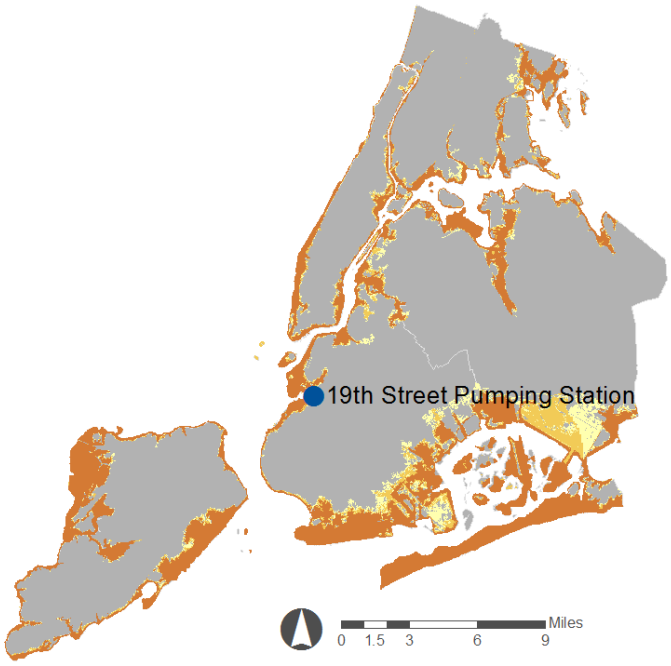
The risk of the 19th Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would flood the local grade to a depth of about 6 inches above local grade. This would not reach the electrical controls, which are located nearly 3 feet above grade. If water enters the building, it could damage the non-submersible pumps located well below grade.

ADAPTATION STRATEGIES

The 19th Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing structure with entrances above the critical flood elevation, the recommended strategy at 19th Street is to seal the building. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

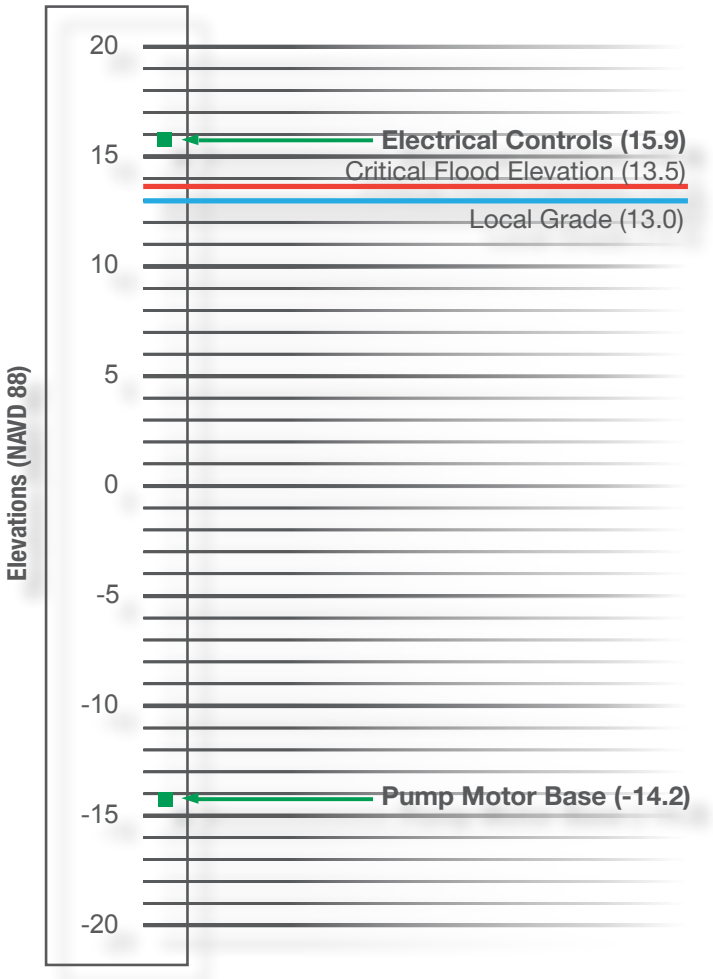
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	5.0
	Affected Area (Acres)	25
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$300,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,660,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$1,432,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Elevated Electrical on a Platform/Pad & Elevate Motor and Controls

Adaptation Cost:
$1,482,000

Motor control center above grade in stainless-steel enclosure; hatch entryways to wells

24th Avenue Pumping Station

STATION CHARACTERISTICS

The 24th Avenue sanitary pumping station is located near the intersection of 24th Avenue and 217th Street in Queens, near the dead end of 24th Avenue; 217th Street is labeled Waters Edge Drive on street signs. The motor control center (MCC) sits above grade in a fenced-in stainless-steel enclosure. There are hatch entryways to the wells in the roadway of Waters Edge Drive as well as in the adjacent sidewalk.

The Pumping Station Summary table lists the general characteristics of the 24th Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area and failure would affect an area of approximately 75 acres. There is one critical facility within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The 24th Avenue pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

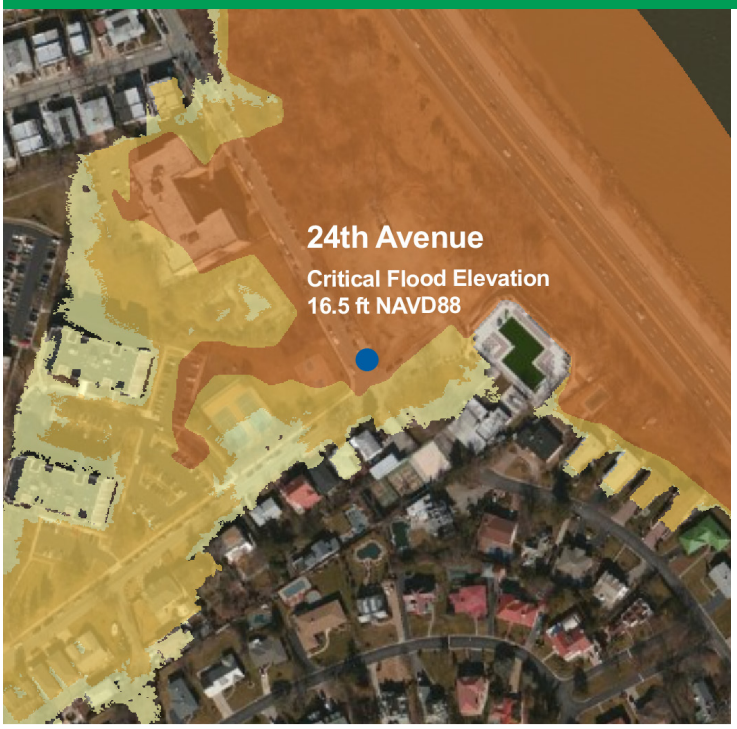
The risk of the 24th Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station revealed the MCC and other components, which were shown below grade in all drawings, had been moved to a slab at grade level.

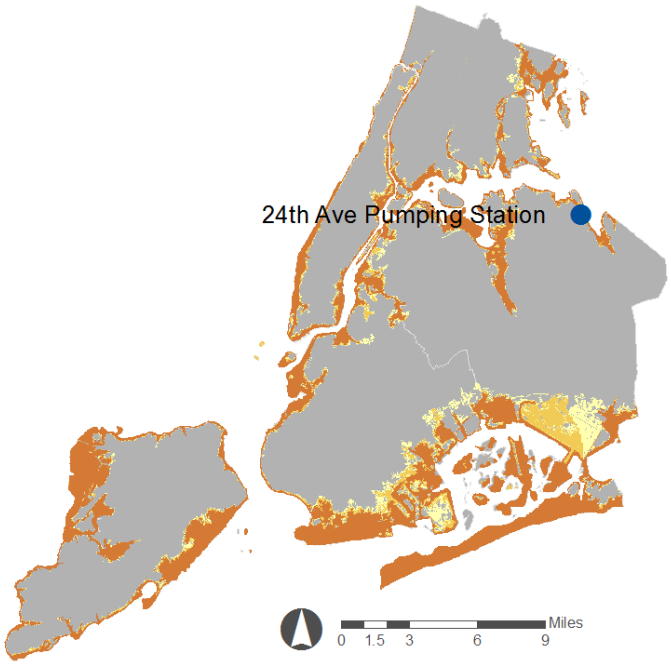
The critical flood elevation would flood the local grade to a depth of nearly 4 feet. This would completely inundate the wells, damaging the non-submersible pumps. It would also submerge and damage the MCC and other grade-level electrical components.

ADAPTATION STRATEGIES

The 24th Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. The pumping station's electrical components are visible in their current location above grade, and the station borders an empty lot. Because the appearance of elevated components should not be a concern, the recommended strategy at 24th Avenue is to elevate both the electrical controls and the pump motors on a platform. This would achieve resiliency without the expense of constructing a building or replacing pumps. Elevating pump motors and replacing existing motors with submersibles are both acceptable solutions, however elevating pump motors may be a more cost-effective adaptation for this pumping station. Residual risk is related to the potential for greater storms or climate change impacts.

FEMA Flood Zones

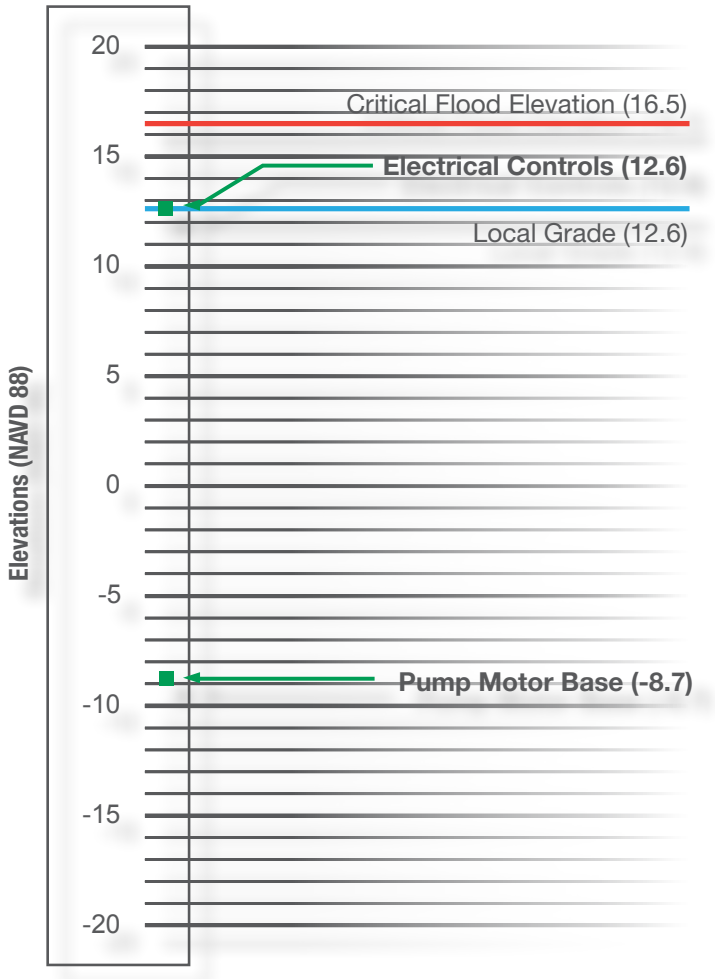




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	4.3
	Affected Area (Acres)	75
Risk	Population in Affected Area	1,500
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad & Elevate Motors and Controls
	Cost of Protective Measures[1]	$1,482,000
	Damage Cost for Critical Flood without Protection[1, 2]	$5,029,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$15,751,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station located on park land

Recommended Adaptation Strategy: **Sandbagging**

Adaptation Cost: **$59,000**

37th Avenue Pumping Station

STATION CHARACTERISTICS

The 37th Avenue combined sanitary and storm pumping station is located on park land near the intersection of 37th Avenue and 114th Street in Queens. The station is entirely below grade with access hatches at grade level.

The Pumping Station Summary table lists the general characteristics of the 37th Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. Failure of the station would affect an area of approximately 78 acres. There is one critical facility within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The 37th Avenue pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

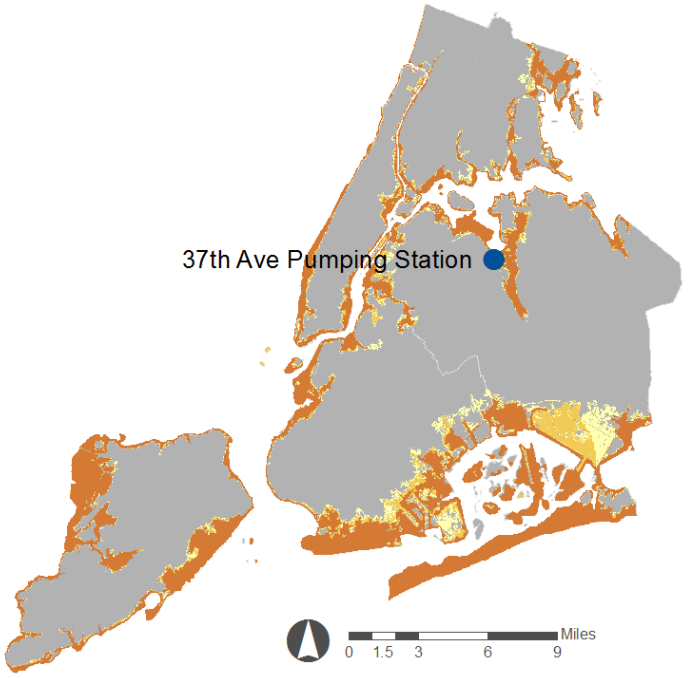
The risk of the 37th Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would result in a flood depth of 1.6 feet above grade, and it would inundate the below grade station. This would damage electrical controls but would not affect the submersible pumps.

ADAPTATION STRATEGIES

The 37th Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the shallow flood depth and the station's location, in park land out of the way of vehicles and pedestrians, the recommended strategy is to place sandbags around potential water-entry points prior to flooding events. Residual risk is related to sandbags being stacked improperly or being disturbed by residents.

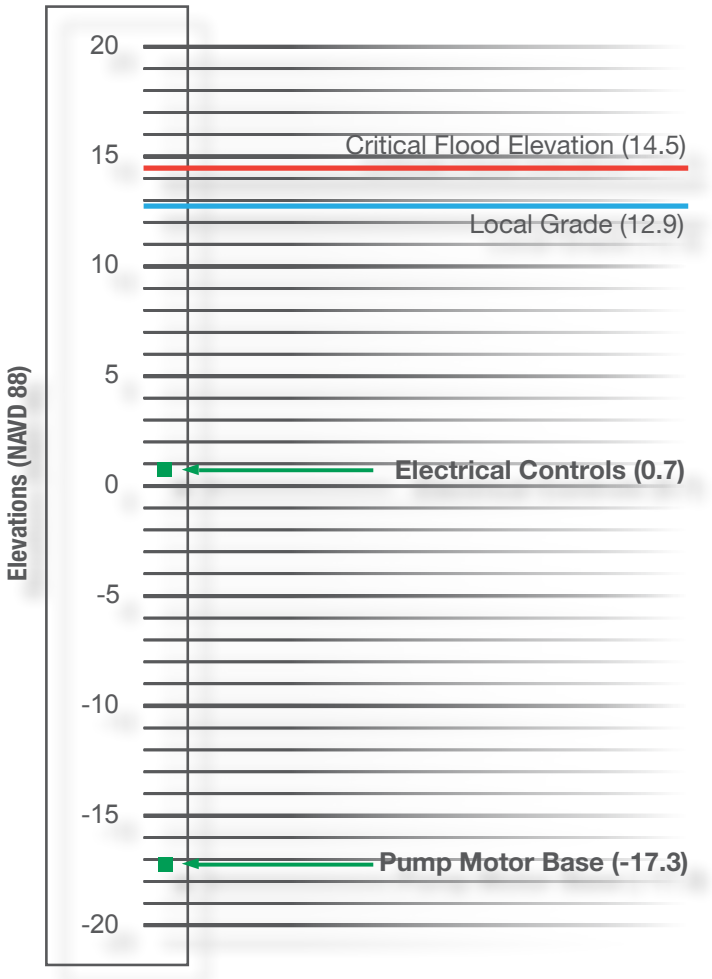
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	5.0
	Affected Area (Acres)	78
Risk	Population in Affected Area	6,183
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Sandbagging
	Cost of Protective Measures[1]	$59,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,510,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$3,850,000
	Resiliency Level	Moderate-Low

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure between roadway and shopping center

Recommended Adaptation Strategy:
Seal Building

Adaptation Cost:
$509,000

40th Road Pumping Station

STATION CHARACTERISTICS

The 40th Road sanitary pumping station is near the corner of 40th Road and College Point Boulevard, between 40th Road and a shopping plaza, in Queens. Controls are located in a small metal structure next to the sidewalk. The dry and wet wells are accessible through hatches in the sidewalk. The Pumping Station Summary table lists the general characteristics of the 40th Road pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial area. Failure of the station would affect an area of approximately 66 acres. There are four critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

This pumping station flooded during Hurricane Sandy. The control room flooded to a depth of approximately 3 inches, and the surrounding area was flooded to a depth of 2 to 3 feet. The station suffered damage to lighting and ventilation equipment, but the submersible pumps remained operating throughout the storm and were not damaged. There is no history of flooding aside from Hurricane Sandy.

RISK ASSESSMENT

The risk of the 40th Road pumping station was first assessed based on a review of the pumping station's plan drawings, comparing the elevation of critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room and wells.

The critical flood elevation would completely inundate the station, and the surrounding flood would be more than 6 feet above local grade. This would flood and damage the pump controls, a compressor, and the lighting panel. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

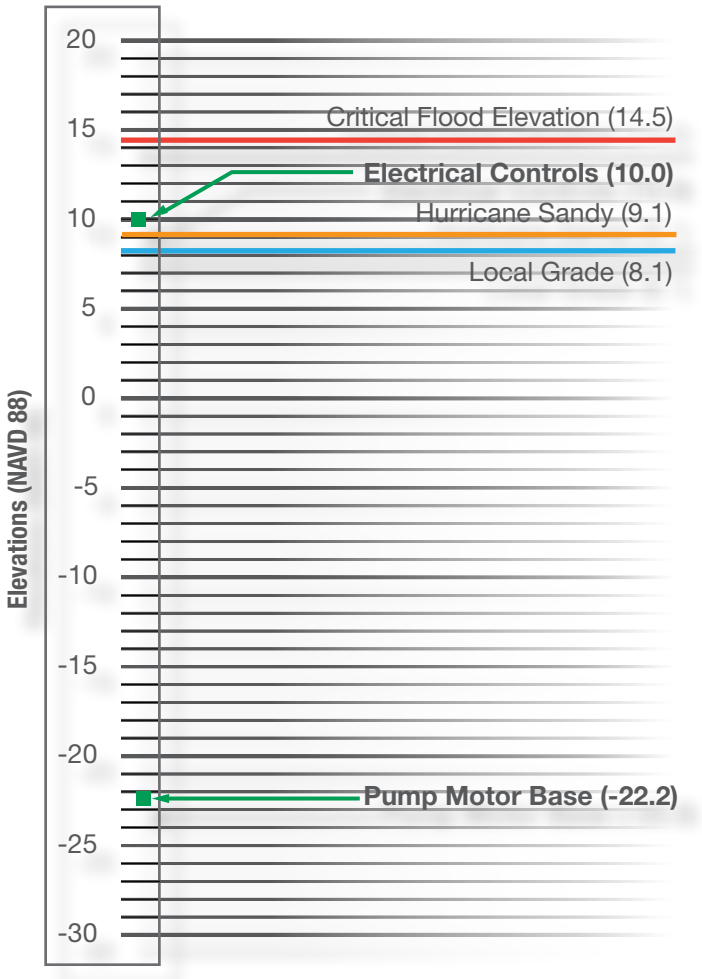
The 40th Road pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Pumps are submersible and do not require any modifications, but electrical controls, located in the existing above grade structure, are vulnerable to flood water. Property size and location limits the potential for a new, larger structure. Viable strategies include moving controls to the walls or roof of the existing structure as well as sealing the building; these strategies were reviewed to identify the most cost-effective, resilient option. The recommended strategy at 40th Road is to seal the existing building and add sluice gates to restrict inflows. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	2.0
	Affected Area (Acres)	66
Risk	Population in Affected Area	13,895
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	4
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$509,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,766,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$8,316,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$2,866,000**

Pumping station under construction due to Hurricane Sandy damage

49th Street Pumping Station

STATION CHARACTERISTICS

The 49th Street sanitary pumping station is near the southeast corner of 57th Avenue and 49th Street in Queens. It is entirely below grade and is accessible through hatches in the sidewalk along 49th Street. At the time of the visit the station was under construction and it was running on a bypass pump.

The Pumping Station Summary table lists the general characteristics of the 49th Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an industrial area. Failure of the station would affect an area of approximately 91 acres. There are no known critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

This station experienced significant flooding during Hurricane Sandy and was undergoing a complete rehabilitation at the time of the visit. DEP staff indicated there was a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

The risk of the 49th Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings. Discussion with an engineer from D&B present on site for the station's repairs provided further details on the station's flooding history and vulnerability.

The critical flood elevation would flood the local grade to a depth of nearly 7 feet and would completely inundate the below grade station. This would flood and damage the pump controls. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

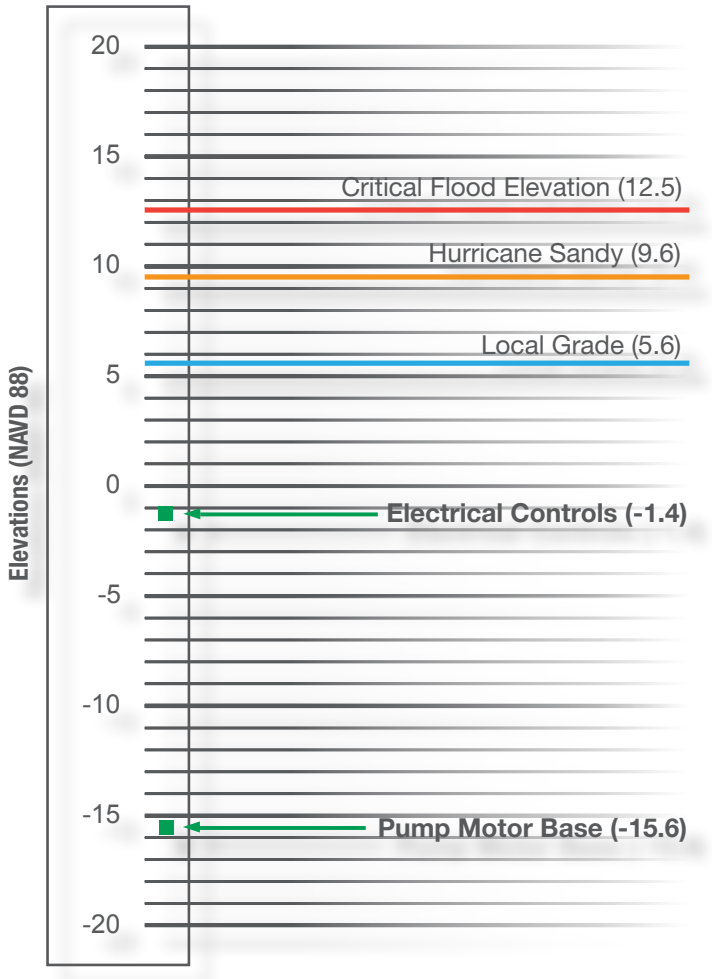
The 49th Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Viable options included elevating electrical controls on a platform, on the adjacent wall, or in a new building. The station's flooding history and the significant depth of the critical flood contributed to the selection of the most resilient option; the recommended strategy at 49th Street is to elevate the pumping station's controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	7.9
	Affected Area (Acres)	91
Risk	Population in Affected Area	360
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,866,000
	Damage Cost for Critical Flood without Protection[1, 2]	$2,120,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$10,911,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Flood-Proof Controls

Adaptation Cost:
$276,000

Below grade pumping station with entrances in sidewalk

122nd Street Pumping Station

STATION CHARACTERISTICS

The 122nd Street sanitary pumping station is near the intersection of 122nd Street and 28th Avenue in Queens. The hatch entryways to the below grade station are located in the sidewalk between the roadway and a concrete plant. A chain-link fence runs along the back of the sidewalk.

The Pumping Station Summary table lists the general characteristics of the 122nd Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an industrial area and failure would affect an area of approximately 13 acres. There are no known critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The 122nd Street pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

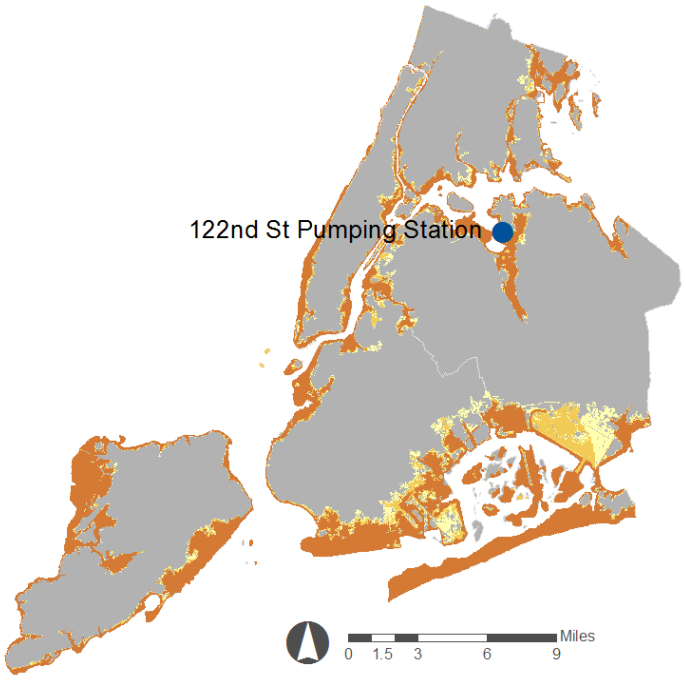
The risk of the 122nd Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would flood the surrounding area to a depth of just over 7 inches above grade. This would affect the station's electrical components; near-grade-level access hatches could serve as entryways for water to reach the below grade controls. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The 122nd Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because the below grade pumping station's entrances are located within a sidewalk, any strategy that requires an above grade structure, such as elevating controls or constructing a barrier, is not feasible. The recommended strategy at 122nd Street is to flood-proof electrical controls. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the seals could fail. Therefore, residual risk is related to the potential for water pressure to exceed the rating of the flood-proofing enclosures.

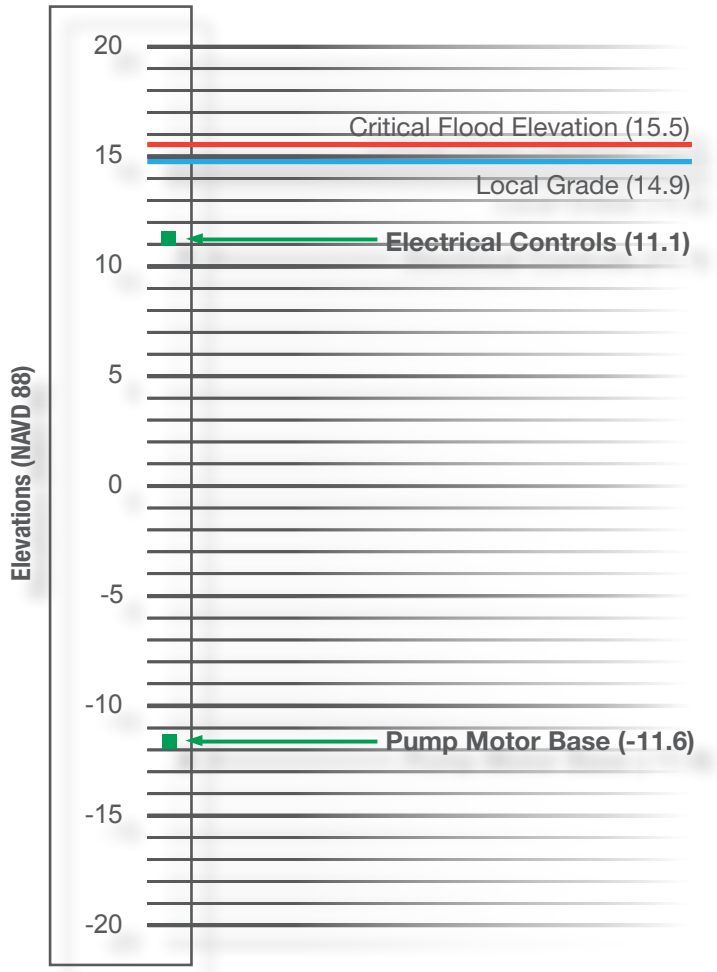
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	1.5
	Affected Area (Acres)	13
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Flood-Proof Controls
	Cost of Protective Measures[1]	$276,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,849,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$616,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad & Submersible Pump Motors**

Adaptation Cost: **$1,066,000**

Below grade pumping station in residential neighborhood

Avenue M Pumping Station

STATION CHARACTERISTICS

The Avenue M sanitary pumping station is near the intersection of Avenue M and East 99th Street in Brooklyn. It is an entirely below grade station with hatch entryways located in the sidewalk.

The Pumping Station Summary table lists the general characteristics of the Avenue M pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 375 acres with a population of nearly 19,000. There are six critical facilities within that area that could be affected if the station fails.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Avenue M pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

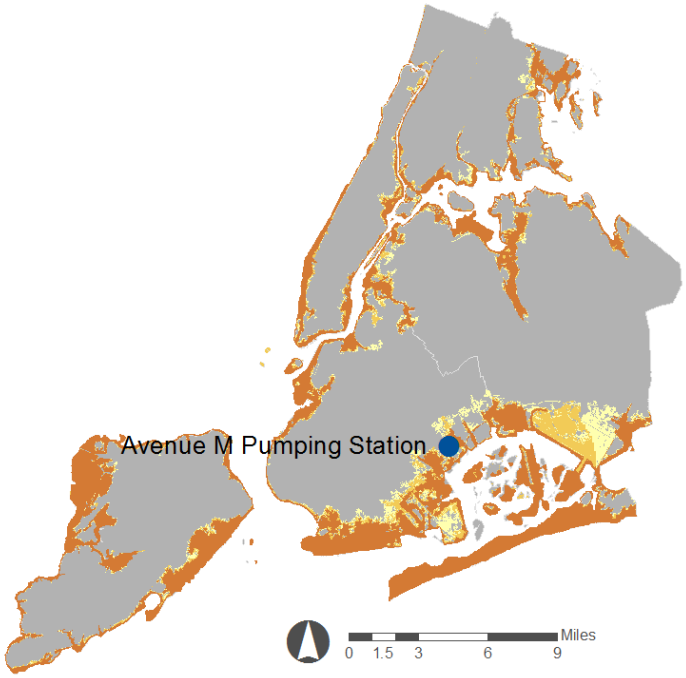
The risk of the Avenue M pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would completely inundate the station, and the surrounding flood would be nearly 4 feet above grade. Water would flood and damage the pump controls and the non-submersible pumps. The Avenue M pumping station is connected to another station; however it discharges to this station, rather than receiving flow from it. Therefore, loss of function at Avenue M does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Avenue M pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the critical flood depth of nearly 4 feet, the controls must be elevated to withstand the flood. Because the station is located beneath a sidewalk in a residential neighborhood, the recommended strategy at Avenue M is to elevate the pumping station's controls on a platform and install submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

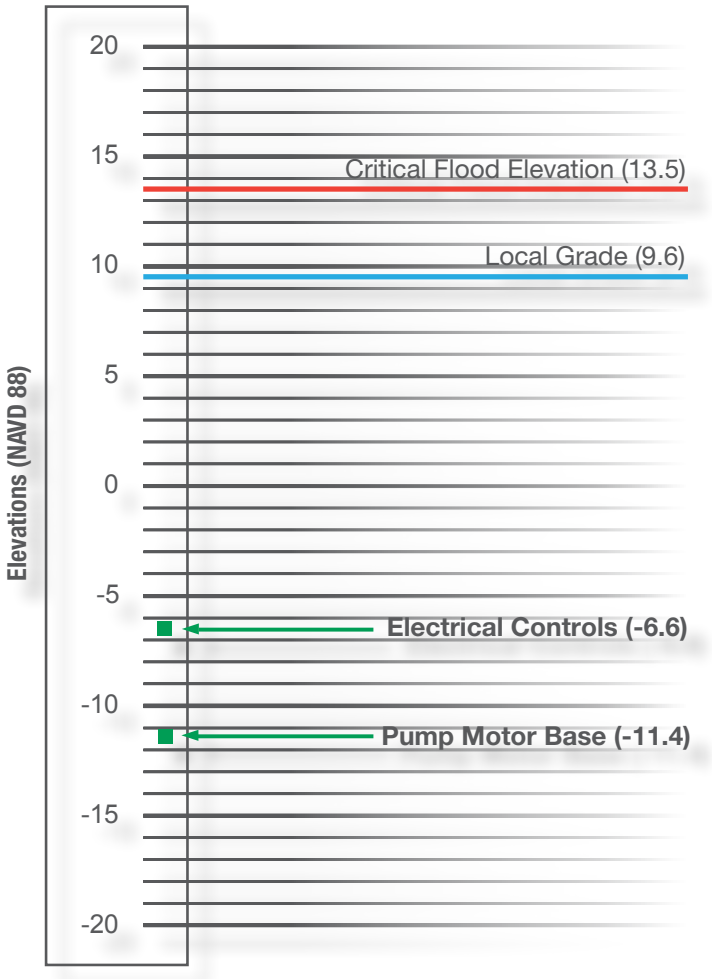
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	7.1
	Affected Area (Acres)	375
Risk	Population in Affected Area	18,753
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	6
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad & Submersible Pump Motors
	Cost of Protective Measures[1]	$1,066,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,837,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$19,745,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Elevate Equipment in Building & Submersible Pump Motors**

Adaptation Cost: **$2,600,000**

Pumping station in sidewalk between roadways in residential neighborhood

Avenue U Pumping Station

STATION CHARACTERISTICS

The Avenue U sanitary pumping station is located near the intersection of Ocean Parkway and Avenue U in Brooklyn. The station is below grade in a sidewalk that runs between Ocean Parkway and its parallel service road. A vent in a decorative housing sits above grade.

The Pumping Station Summary table lists the general characteristics of the Avenue U pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area and services an area of approximately 719 acres with a population of over 50,000. There are 37 critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Avenue U pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

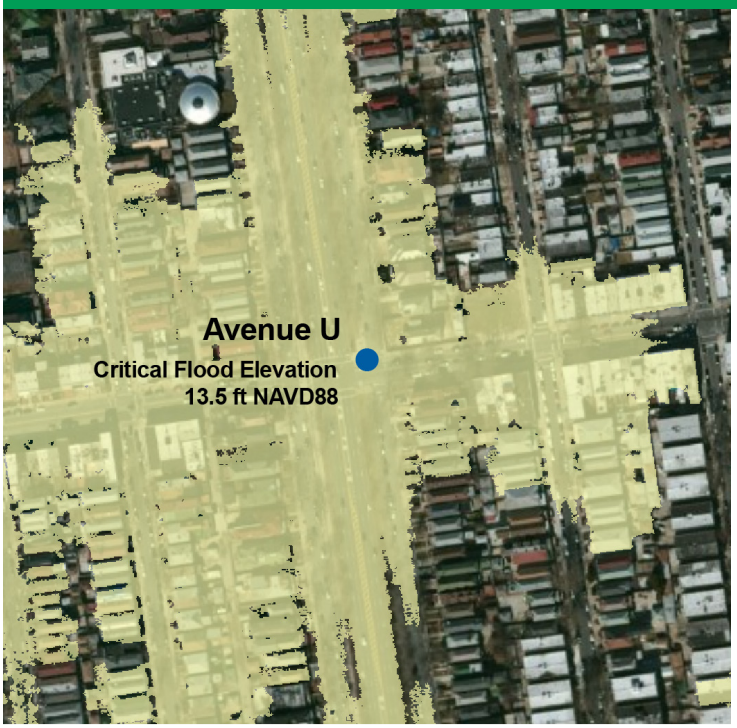
The risk of the Avenue U pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would completely inundate the station, and the surrounding flood would be more than 3 feet above grade. This would flood and damage the pump controls and the non-submersible pumps.

ADAPTATION STRATEGIES

The Avenue U pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because the station is located in a sidewalk and is below grade, to withstand the flood, electrical components must be elevated, and to do this, the station must be moved to another location. The options for above grade components will likely be limited by aesthetic requirements of the surrounding residential neighborhood. Therefore, the recommended strategy at Avenue U is to elevate the pumping station's controls in a new building and install submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

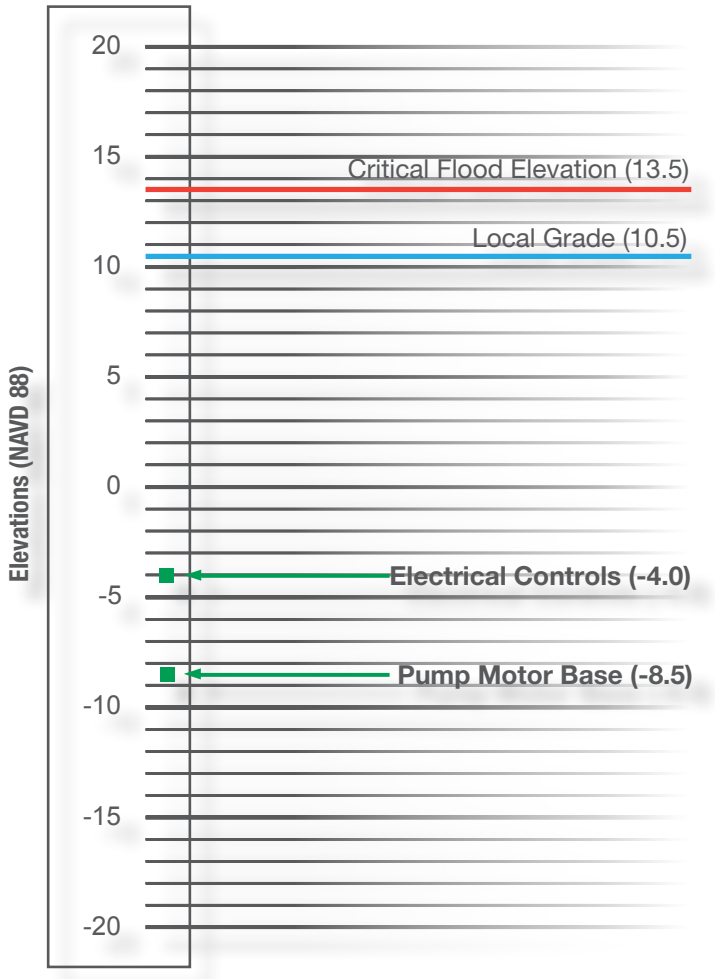
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	11.5
	Affected Area (Acres)	719
Risk	Population in Affected Area	50,793
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	37
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in Building & Submersible Pump Motors
	Cost of Protective Measures[1]	$2,600,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,700,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$19,040,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Electrical components mounted on pier

Recommended Adaptation Strategy: **Flood-Proof Controls**

Adaptation Cost: **$171,000**

Bayswater Avenue Pumping Station

STATION CHARACTERISTICS

The Bayswater Avenue sanitary pumping station is near the intersection of Bayswater Avenue and Norton Drive in Queens. It is adjacent to an inlet off of Jamaica Bay, and its controls are mounted above grade on a pier that juts into the water.

The Pumping Station Summary table lists the general characteristics of the Bayswater Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 167 acres. There is one critical facility in the area that could be affected if the station fails.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

Flood waters from Hurricane Sandy were about 2 inches above grade in the area surrounding the Bayswater Avenue pumping station and the facility experienced minor impacts. DEP indicated there was a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

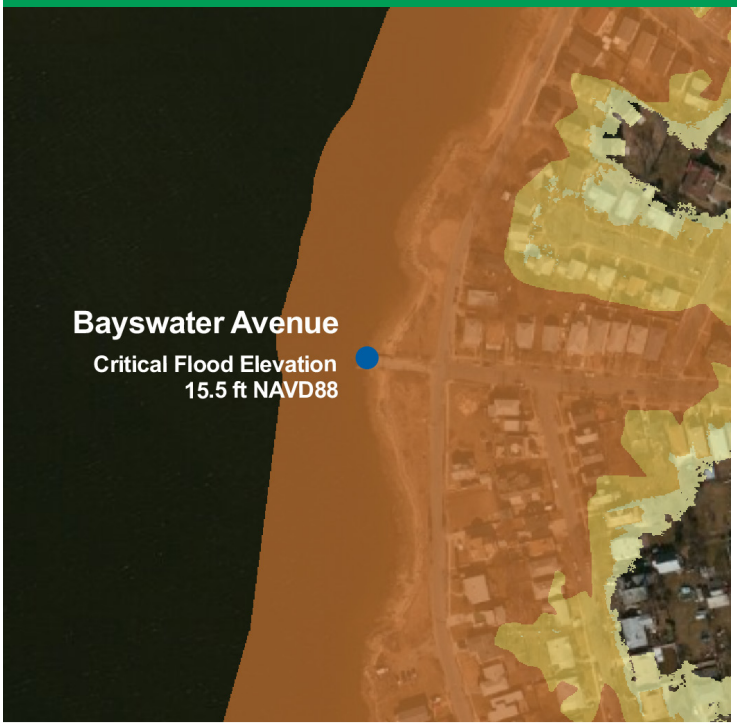
The risk of the Bayswater Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

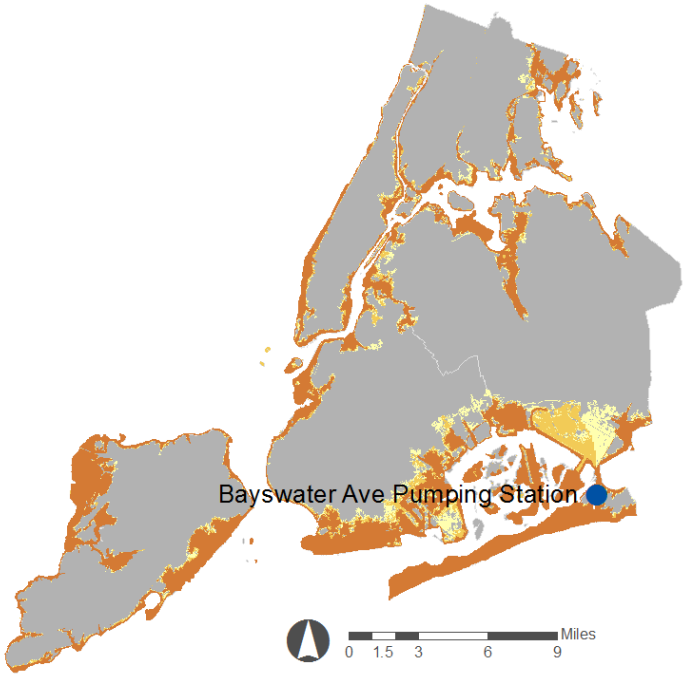
The critical flood elevation would be nearly 9 feet above grade. The electrical controls, mounted about 6 feet above grade, would be flooded and would sustain damage. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Bayswater Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because controls are currently exposed but would be submerged by the critical flood, the recommended strategy at Bayswater Avenue is to waterproof controls. Further review and design may indicate that this option is not sufficiently resilient in which case electrical controls will be elevated on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

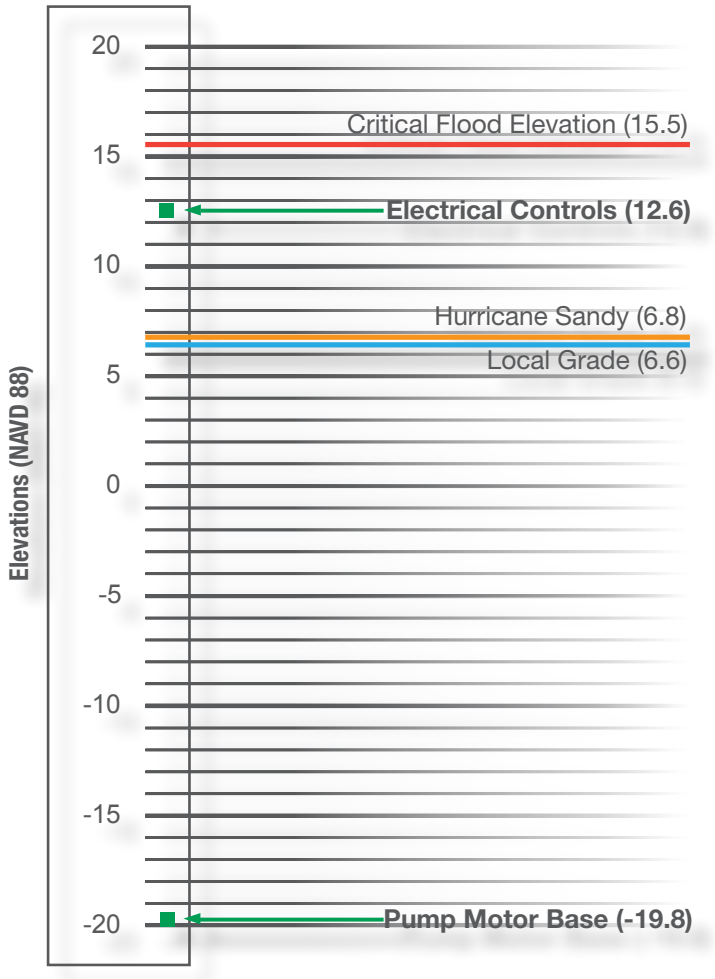




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	2.2
	Affected Area (Acres)	168
Risk	Population in Affected Area	2,383
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Flood-Proof Controls
	Cost of Protective Measures[1]	$171,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,143,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$5,292,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure directly beneath elevated Long Island Expressway

Recommended Adaptation Strategy: **Seal Building & Submersible Pump Motors**

Adaptation Cost: **$1,943,000**

Borden Avenue Pumping Station

STATION CHARACTERISTICS

The Borden Avenue combined pumping station is located near the northeast corner of Borden Avenue and Review Street in Queens. Its one-story structure sits directly underneath an elevated section of the Long Island Expressway.

The Pumping Station Summary table lists the general characteristics of the Borden Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial area. It services an area of approximately 63 acres and a population of nearly 600. There is one critical facility within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Borden Avenue pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

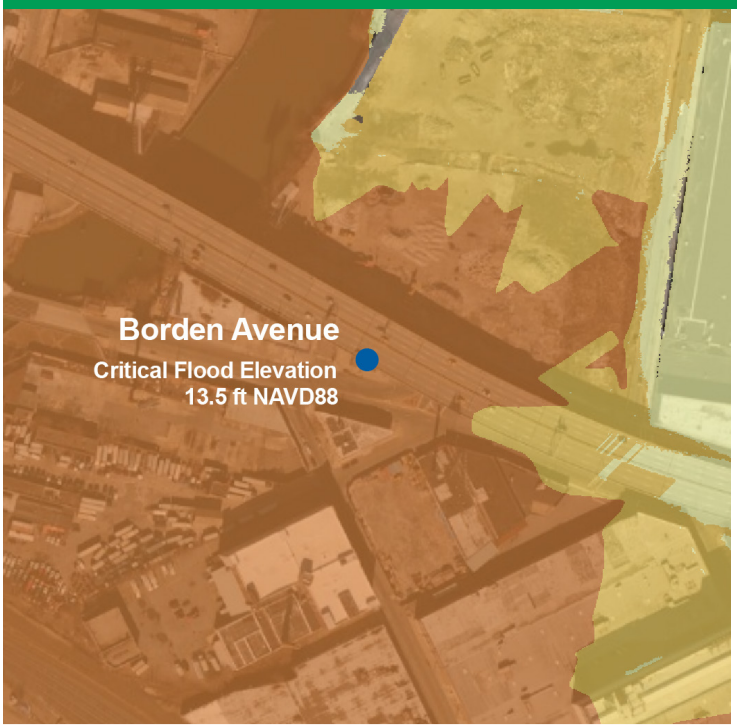
The risk of the Borden Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be 4 feet above grade. It would also flood and damage the control panels, which are located on the main floor of the structure less than 2 feet above grade. The non-submersible pumps located below grade would also be damaged.

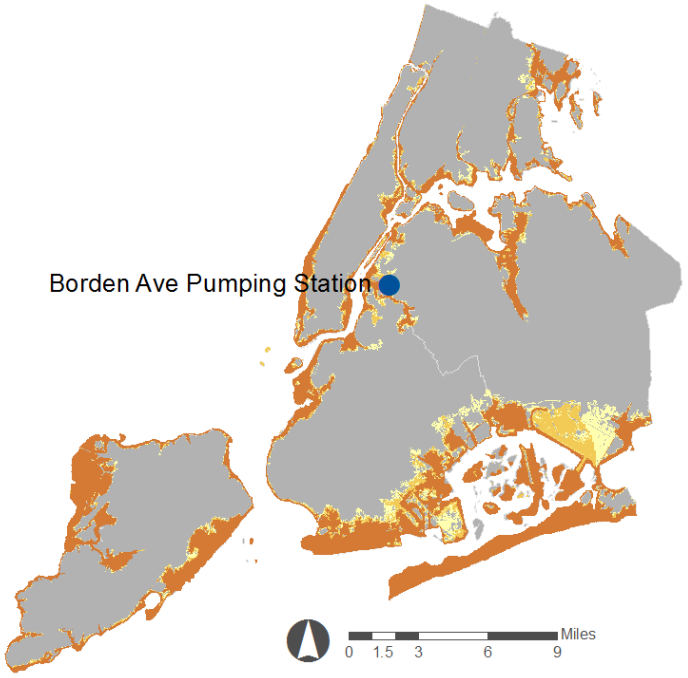
ADAPTATION STRATEGIES

The Borden Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing building but non-submersible pumps are below grade, the recommended strategy at Borden Avenue is to seal the building and install submersible pumps.

FEMA Flood Zones

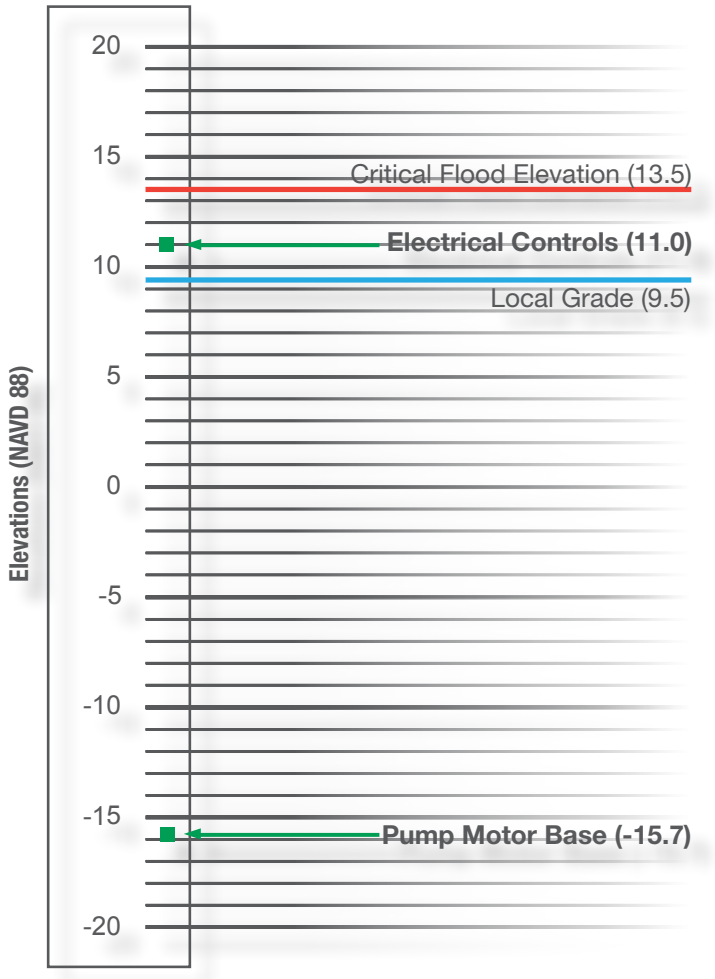


2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain



Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Non-submersible
	Operating Capacity (MGD)	3.9
	Affected Area (Acres)	63
Risk	Population in Affected Area	590
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building & Submersible Pump Motors
	Cost of Protective Measures[1]	$1,943,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,241,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$15,218,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Pumping station adjacent to flooded lot

Recommended Adaptation Strategy: **Elevated Electrical in New Building**

Adaptation Cost: **$2,400,000**

Broad Channel Pumping Station

STATION CHARACTERISTICS

The Broad Channel sanitary pumping station is near the intersection of West 22nd Street and Shad Creek Road in Queens. It is adjacent to both Cross Bay Boulevard and a parking lot for the Broad Channel American Park, and is less than 500 feet from the open water of Jamaica Bay. The pumping station is predominantly below grade, with control panels mounted above grade.

The Pumping Station Summary table lists the general characteristics of the Broad Channel pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an open area and services an area of approximately 145 acres. There is one critical facility within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The area surrounding the pumping station is flat and at risk of experiencing overland flooding. Hurricane Sandy caused flooding more than 3.5 feet above grade.

RISK ASSESSMENT

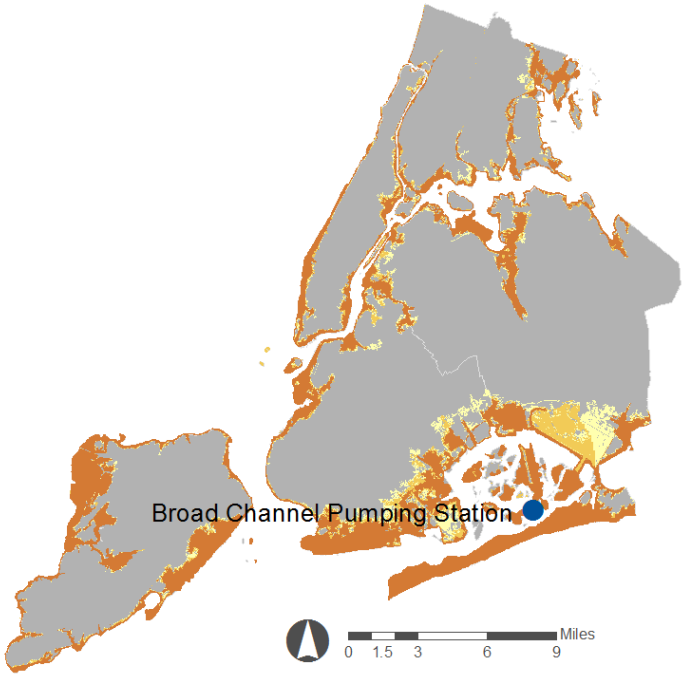
The risk of the Broad Channel pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a visit to the pumping station.

The critical flood elevation would be nearly 9 feet above grade, inundating all components both above and below grade. This would damage the pump controls, but the submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Broad Channel pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because space is available and flood depth is extreme at 9 feet, the most resilient option was selected; the recommended strategy at Broad Channel is to elevate the pumping station's controls in a new building.

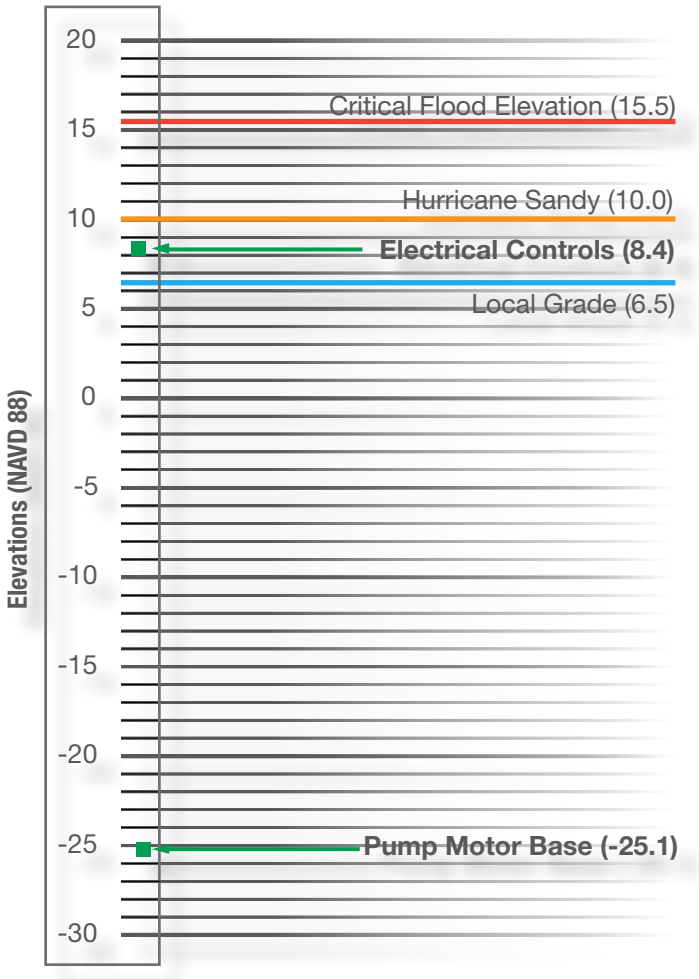
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

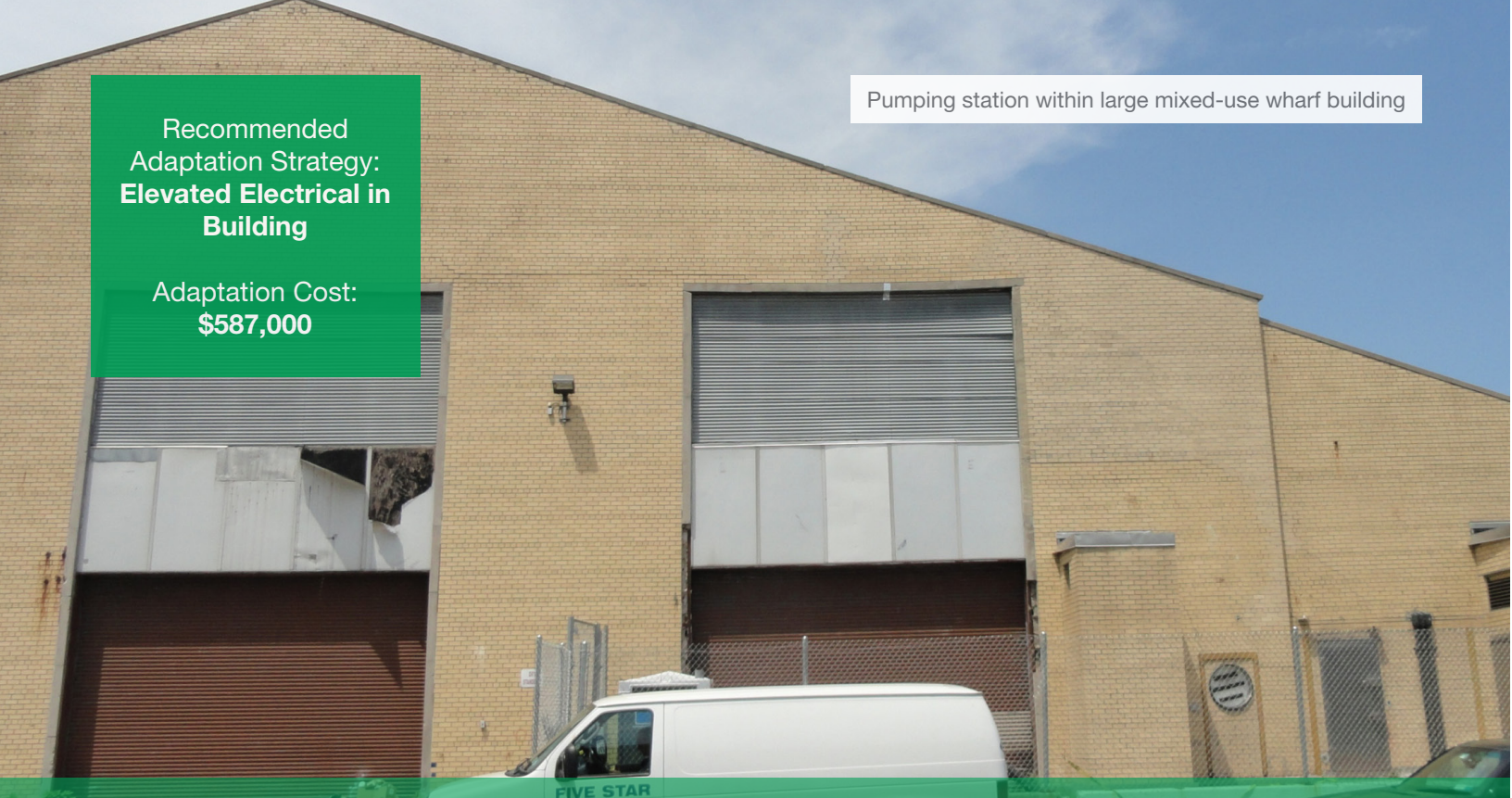
Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	4.1
	Affected Area (Acres)	145
Risk	Population in Affected Area	1,730
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,400,000
	Damage Cost for Critical Flood without Protection[1, 2]	$2,337,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$12,028,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Pumping station within large mixed-use wharf building

Recommended Adaptation Strategy: **Elevated Electrical in Building**

Adaptation Cost: **$587,000**

Bush Terminal Pumping Station

STATION CHARACTERISTICS

The Bush Terminal combined sanitary and stormwater pumping station is located on 2nd Avenue, north of 29th Street, in Brooklyn. The pumping station is located in a wharf building that juts into Gowanus Bay. The age of the plans (dated 1985) and the cost involved with rehabilitating a 7.2-million-gallon-per day facility prompted a thorough inspection.

The Pumping Station Summary table lists the general characteristics of the Bush Terminal pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an industrial area. Failure of the station would affect an area of approximately 57 acres. There is one known critical facility within the area.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

This station was inundated during Hurricane Sandy; flood depth was 2 feet above grade. Electrical equipment was damaged, and repairs were in progress at the time of the inspection. While the motors were not damaged during the storm, they were not in operation at the time of the inspection due to electrical problems. A portable diesel pump was running the station. DEP indicated there is also a history of flooding at this location due to smaller storms.

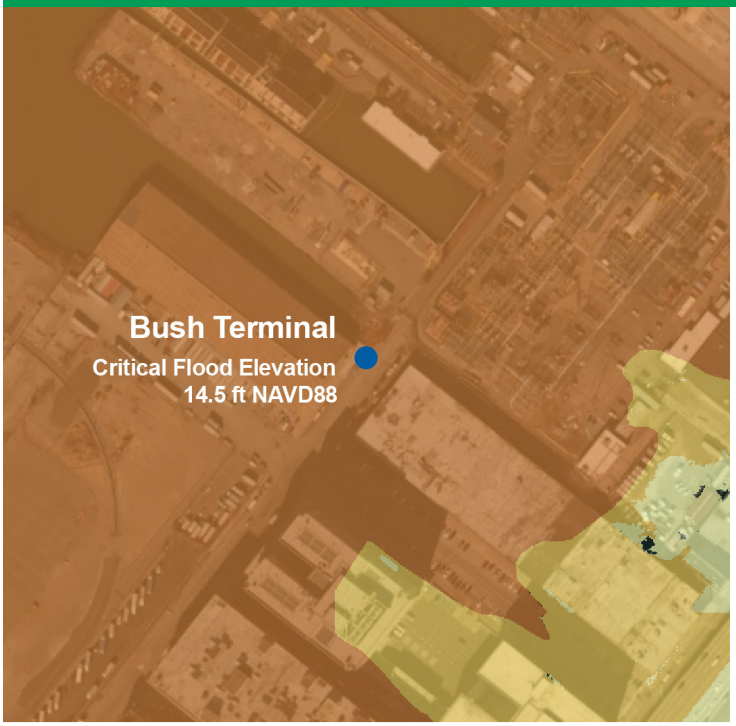
RISK ASSESSMENT

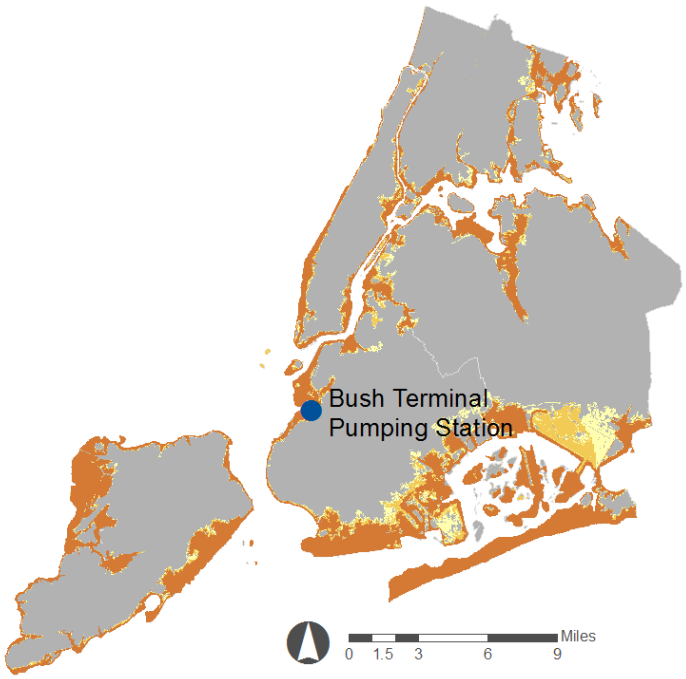
The risk of the Bush Terminal pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room and the dry well. The critical flood elevation would cause a flood more than 8 feet above grade. This would flood and damage all of the pump controls. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Bush Terminal pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Controls must be elevated to withstand the critical flood. The existing building is large and may be able to accommodate the controls to the second floor or roof. Therefore, the recommended strategy at Bush Terminal is to elevate the electrical controls to one of these locations in the existing building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

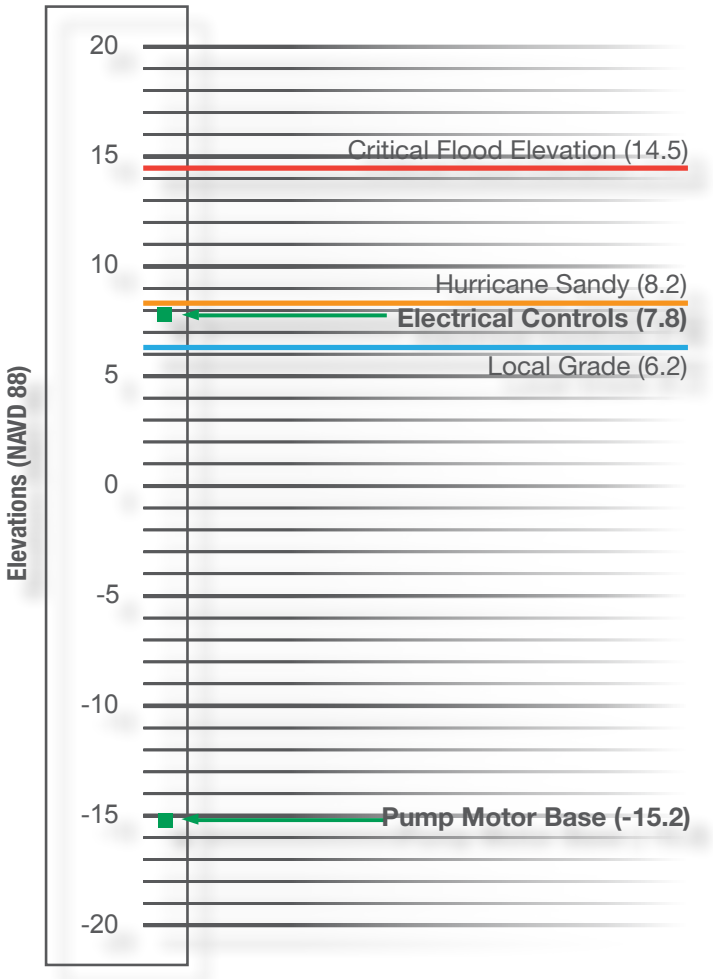




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	7.2
	Affected Area (Acres)	57
Risk	Population in Affected Area	118
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on Building Roof
	Cost of Protective Measures[1]	$587,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,467,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$17,839,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad & Submersible Pump Motors**

Adaptation Cost: **$2,419,000**

Pumping station beneath sidewalk, adjacent to small park

Canal Street Pumping Station

STATION CHARACTERISTICS

The Canal Street sanitary pumping station is located on the northeast side of Canal Street between Varick Street and 6th Avenue in Manhattan. It is an entirely below grade station with access hatches in the sidewalk.

The Pumping Station Summary table lists the general characteristics of the Canal Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a dense, mixed-use area adjacent to a small park. Failure of the station would affect an area of approximately 37 acres and a population of nearly 3,200. There are two critical facilities within the area.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Canal Street pumping station experienced minor impacts due to Hurricane Sandy but there is no history of flooding at this location.

RISK ASSESSMENT

The risk of the Canal Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be approximately 4 feet above local grade, completely inundating the entire station. The electrical controls and non-submersible pumps are all located below grade and would be flooded and damaged.

ADAPTATION STRATEGIES

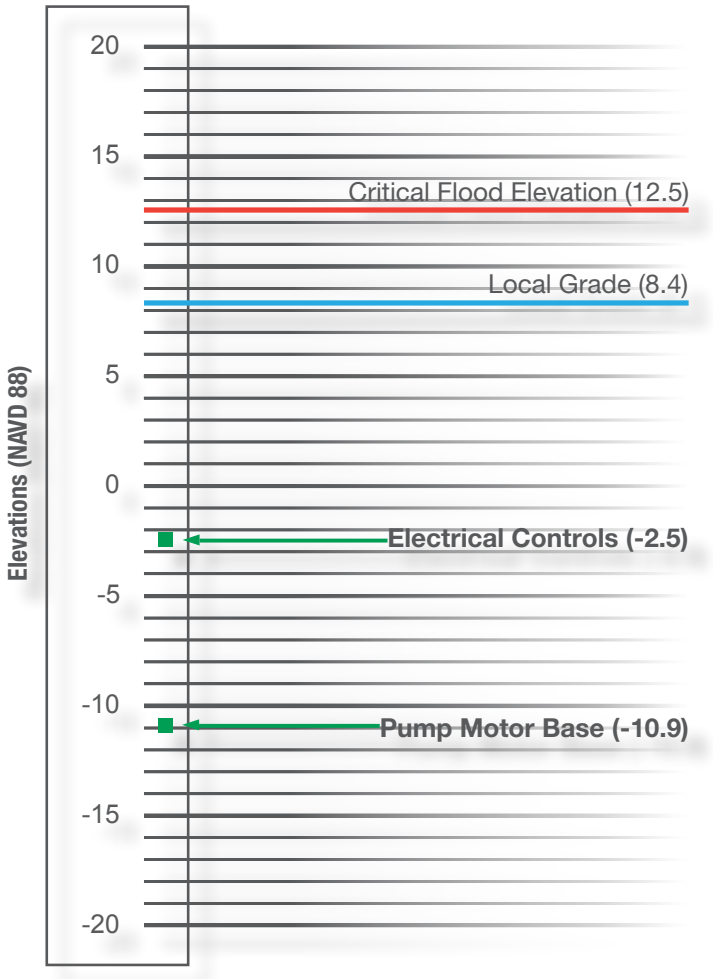
The Canal Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the depth of the critical flood, controls must be elevated and pumps must be submersible to withstand the flood. The pumping station's entrances are located in a sidewalk, but there is a small park directly behind the sidewalk; the recommended strategy at Canal Street is to elevate electrical controls on a platform and install submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

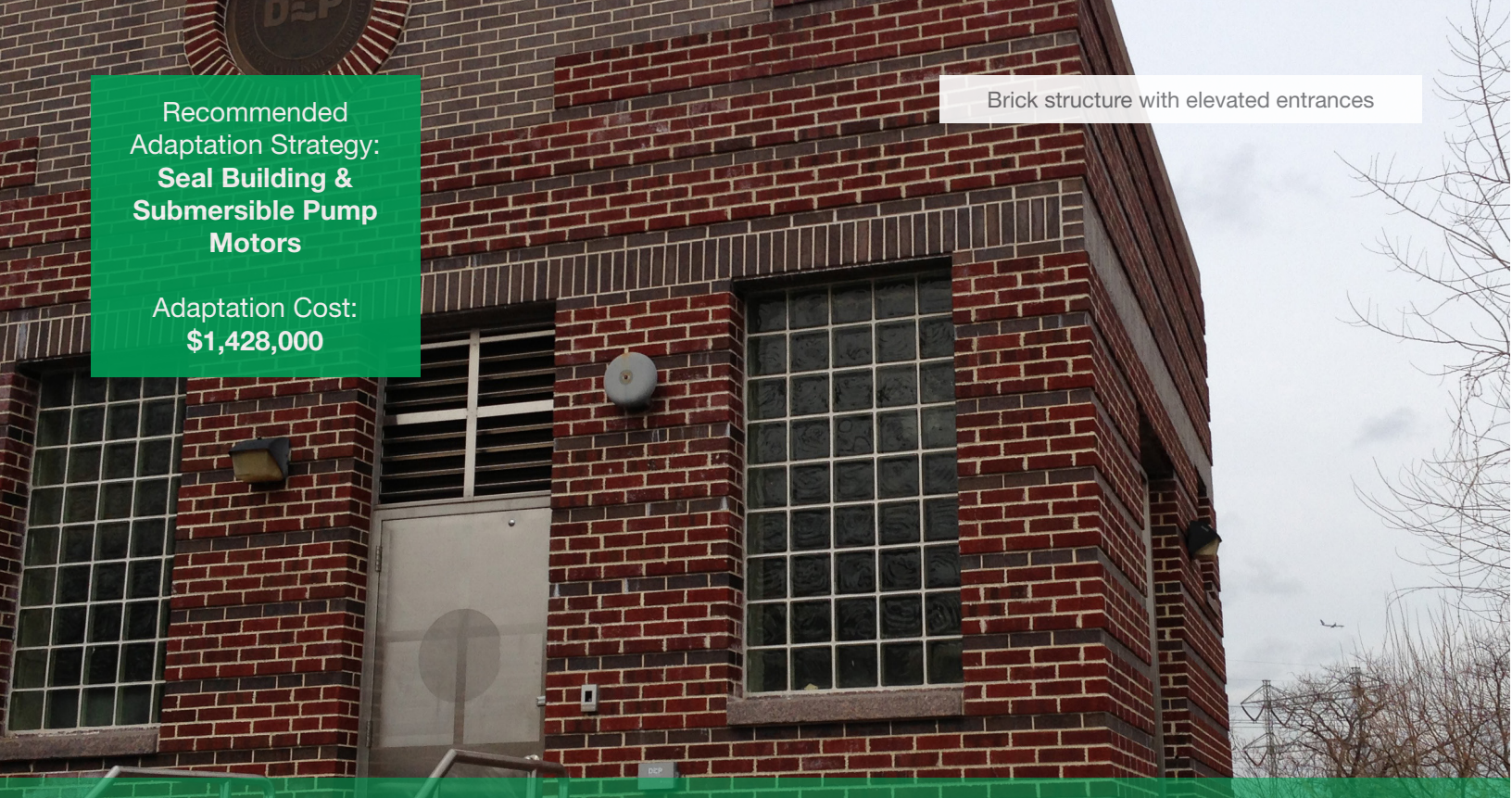
Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	2.2
	Affected Area (Acres)	37
Risk	Population in Affected Area	3,193
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	2
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/ Pad & Submersible Pump Motors
	Cost of Protective Measures[1]	$2,419,000
	Damage Cost for Critical Flood without Protection[1, 2]	$2,710,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$13,332,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Brick structure with elevated entrances

Recommended Adaptation Strategy: **Seal Building & Submersible Pump Motors**

Adaptation Cost: **$1,428,000**

Cannon Avenue Pumping Station

STATION CHARACTERISTICS

The Cannon Avenue sanitary pumping station is located on Cannon Avenue near Glen Street, close to the western shore of Staten Island. A brick building houses the motor control center, and wet and dry wells are located below grade.

The Pumping Station Summary table lists the general characteristics of the Cannon Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 76 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, flood depth in the area surrounding the Cannon Avenue pumping station was 2.5 feet above grade. Flood waters from the storm surge did not enter the station, but loss of power caused the wet well to flood into the dry well during the event. At the time of the inspection, pumps and some electrical components were under repair, and an emergency pump-around was in place. DEP indicated there is also a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

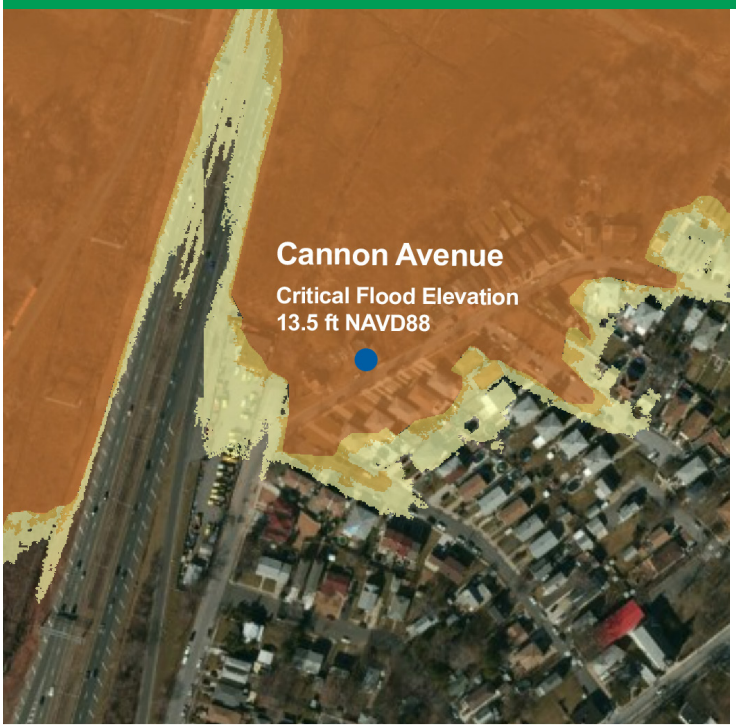
The risk of the Cannon Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room.

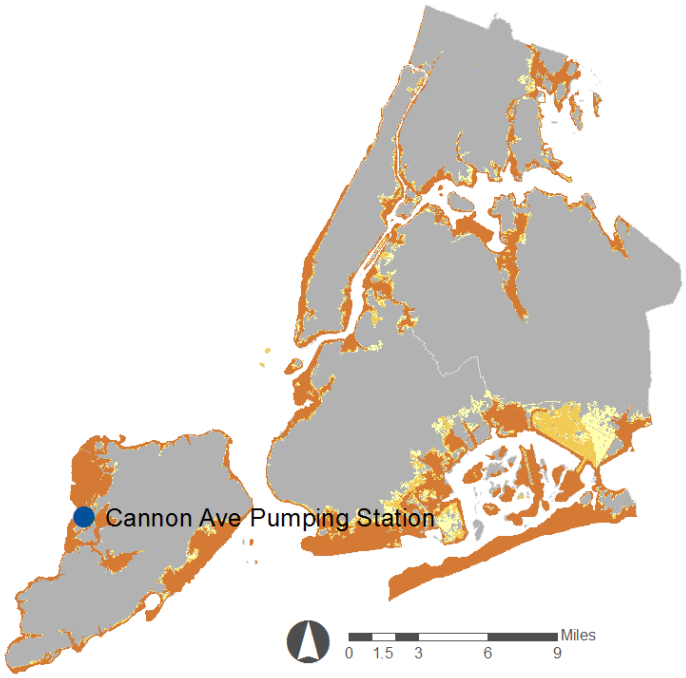
The critical flood elevation would be nearly 7 feet above local grade. Water would likely enter the building, flooding and damaging the electrical controls and the non-submersible pumps, all of which are below the critical flood elevation. The Cannon Avenue pumping station is connected to other stations; however it discharges to these stations, rather than receiving flow from them. Therefore, loss of function at Cannon Avenue does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Cannon Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing structure, but non-submersible pumps are well below grade, the recommended strategy at Cannon Avenue is to seal the building and install submersible pumps. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

FEMA Flood Zones

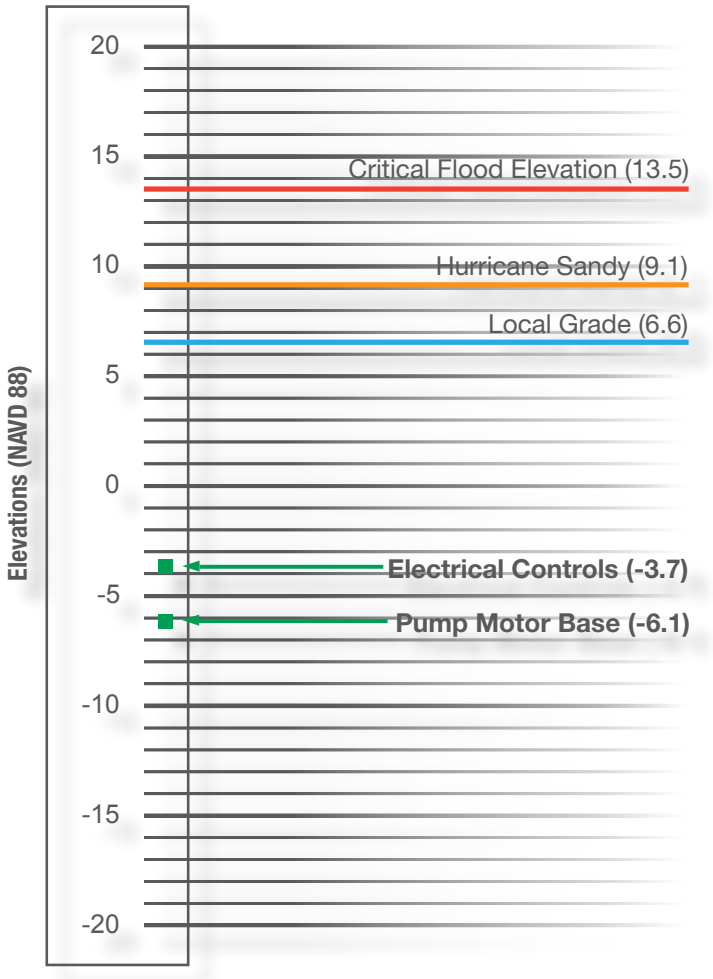




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	1.1
	Affected Area (Acres)	76
Risk	Population in Affected Area	1,388
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building & Submersible Pump Motors
	Cost of Protective Measures[1]	$1,428,000
	Damage Cost for Critical Flood without Protection[1, 2]	$4,388,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$20,460,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Elevate Electrical in New Building

Adaptation Cost:
$4,710,000

Motor control center above grade in stainless-steel enclosure; hatch entryways to wells

Clearview Pumping Station

STATION CHARACTERISTICS

The Clearview pumping station is located in Queens along the Clearview Expressway service road, in a triangle of land that runs between the service road, the expressway, and an exit ramp from the expressway. The motor control center and other electrical components sit on a grade level concrete slab in stainless steel enclosures, and the wells are accessible through hatches.

The Pumping Station Summary table lists the general characteristics of the Clearview pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located between major roadways. Failure of the station would affect an area of approximately 523 acres and a population of more than 22,450. There are two critical facilities within that area that could be affected if the station failed, and a nearby bathing beach would also be affected.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

Clearview has experienced infrequent flooding in the past, but the station was not affected by Hurricane Sandy. Sandbags were onsite at the time of the visit in March 2013, indicating a possible recent flooding event

RISK ASSESSMENT

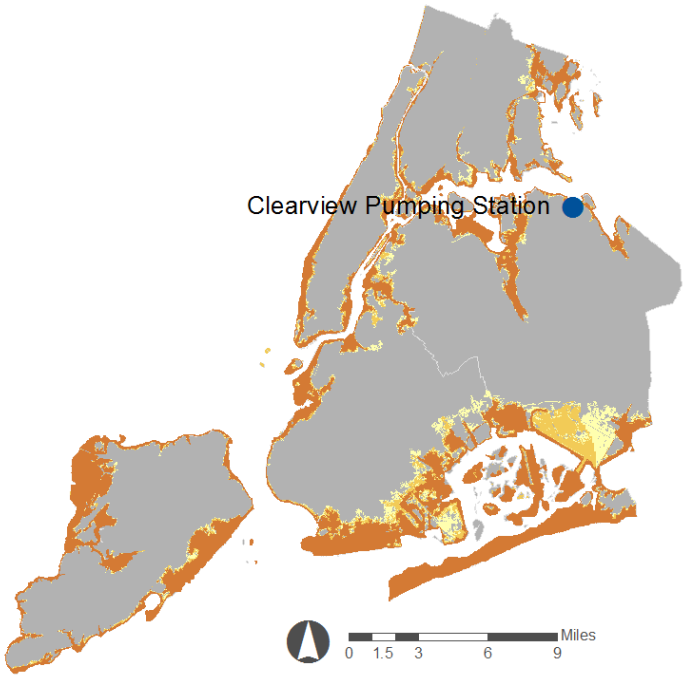
The risk of the Clearview pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the March 2013 FEMA Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior revealed that the Motor Control Center (MCC) and other electrical controls, which were shown below grade in the drawings, had been moved to a slab above grade. DEP data also indicate that the pumps had been replaced with submersibles.

The critical flood elevation would be more than 3 feet above grade. This would flood and damage the grade-level motor control center and pump.

ADAPTATION STRATEGIES

The Clearview pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the critical flood depth and the lack of an existing structure, the recommended strategy at Clearview is to elevate the pumping station's controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

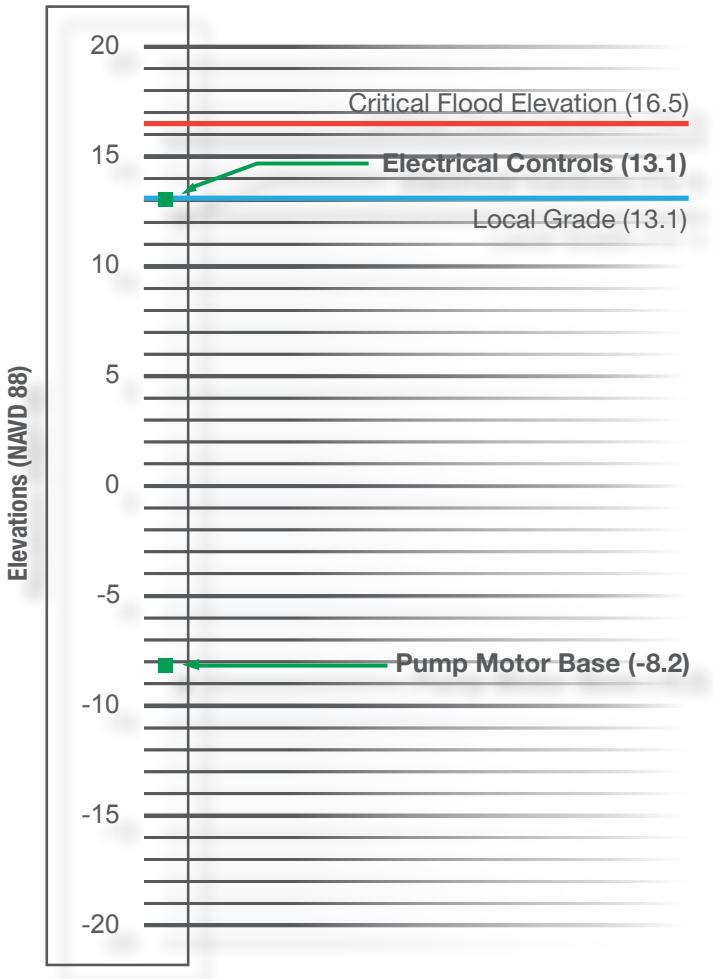
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	13.0
	Affected Area (Acres)	523
Risk	Population in Affected Area	22,450
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	2
	Historic Flooding	Y
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$4,710,000
	Damage Cost for Critical Flood without Protection[1, 2]	$7,818,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$16,802,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Motor control center above grade in stainless-steel enclosure; hatch entryways to wells

Recommended Adaptation Strategy:
Elevate Electrical on Platform/Pad

Adaptation Cost:
$634,000

Commerce Avenue Pumping Station

STATION CHARACTERISTICS

The Commerce Avenue pumping station is located in a triangle of land between Commerce Avenue, Seabury Avenue, and Ellis Avenue in the Bronx. It is primarily below grade and accessible through hatches in the concrete, but the motor control center is mounted above grade on a small concrete slab. Power appears to lead from overhead lines to a transformer.

The Pumping Station Summary table lists the general characteristics of the Commerce Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an industrial area. Failure of the station would affect an area of approximately 7 acres. There are no critical facilities within the area.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, flood depth in the surrounding area was about 1 foot above the street level but the pumping station operation was not affection. DEP staff indicated that historic flooding has been an issue at this pumping station.

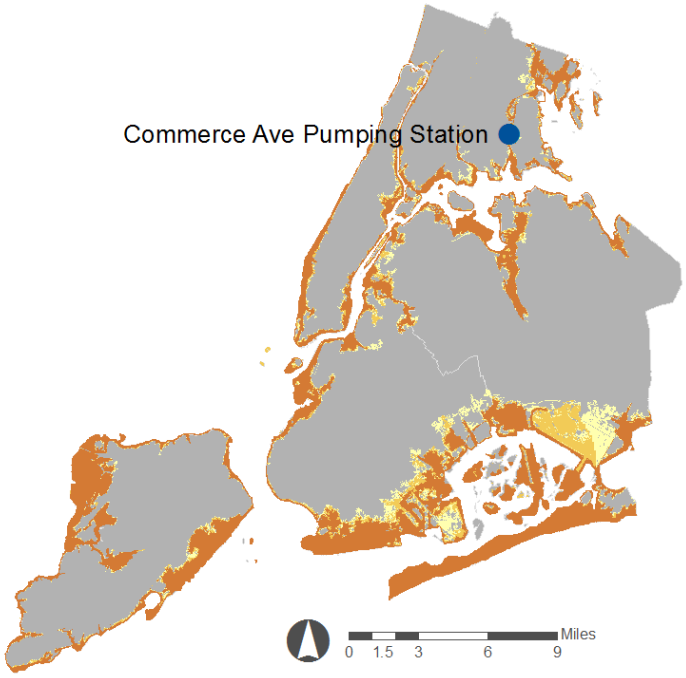
RISK ASSESSMENT

The risk of the Commerce Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior revealed that the electrical controls, which are shown below grade in the drawings, have been moved to a slab above grade. The critical flood elevation would be 5 feet above grade. Water would flood and damage the motor control center. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Commerce Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Controls should be elevated to withstand the critical flood, and there is ample space to do so on the current lot. Because the station is located in an industrial area, a building is not necessary for aesthetic reasons. Components are currently exposed above grade, and there have been no known incidents of vandalism, so a building should not be necessary for security reasons, either. Therefore, the recommended strategy at Commerce Avenue is to elevate electrical controls onto a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

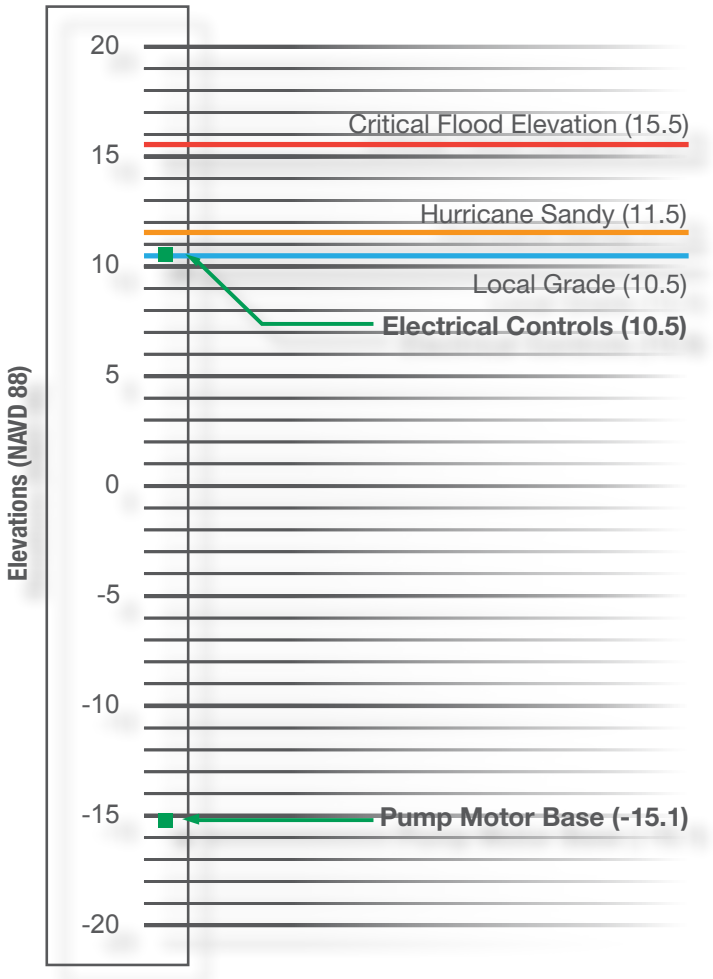
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	1.4
	Affected Area (Acres)	7
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on Platform/Pad
	Cost of Protective Measures[1]	$634,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,037,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$5,337,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Concrete structure on paved lot adjacent to Hutchinson River

Recommended Adaptation Strategy: **Construction Barrier**

Adaptation Cost: **$5,456,000**

Conner Street Pumping Station

STATION CHARACTERISTICS

The Conner Street combined sanitary and stormwater pumping station is near the end of Conner Street in the Bronx; the property is bounded by Conner Street to the west and the Hutchinson River to the east. Controls are located on the main floor of the station's concrete structure. Overhead power lines connect to buried power lines near the western edge of the lot, and the buried lines run under the station's parking lot to two transformers on the main floor.

The Pumping Station Summary table lists the general characteristics of the Conner Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an industrial area. Failure of the station would affect an area of approximately 1,336 acres and a population of nearly 46,000. There are 36 critical facilities in the service area that could be affected if the station fails. Additionally, failure of this pumping station could affect a nearby bathing beach.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

This station has experienced multiple flooding events during which water approached the station from the adjacent Hutchinson River. During Hurricane Sandy, the lot surrounding the station flooded to a depth of around 1 foot. Fuses on the poles supporting the overhead power lines blew out, cutting power before it reached the transformers. At the time of the visit, ventilation in the wet well was not working due to flooding damage.

RISK ASSESSMENT

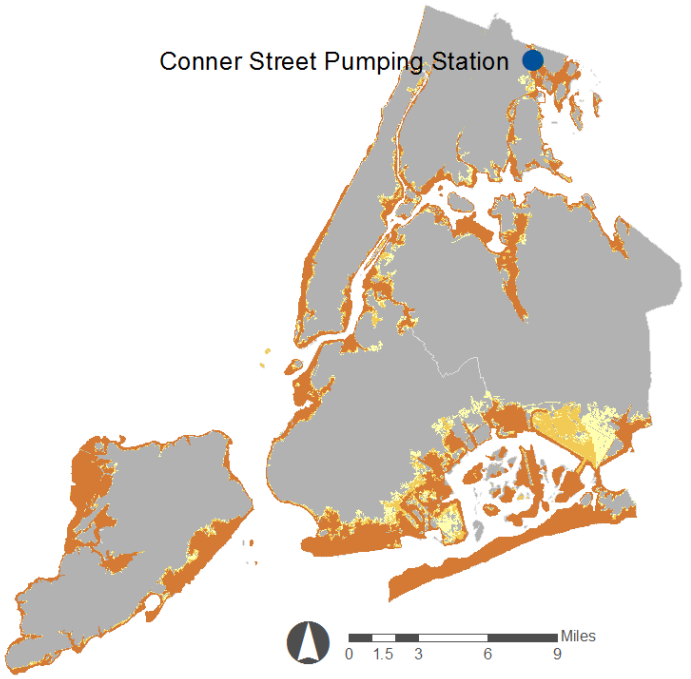
The risk of the Conner Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room and wells.

The critical flood elevation would be about 6 feet above local grade. Water would likely enter the building, flooding and damaging the electrical controls as well as the non-submersible pumps, all of which are located below the critical flood elevation. The Conner Street pumping station has the ability to receive flow from another pumping station. Therefore, loss of function at Conner Street increases the vulnerability of an additional pumping station, tributary area, and population.

ADAPTATION STRATEGIES

The Conner Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is an existing structure, but there are extensive controls which could not easily be moved, the recommended strategy at Conner Street is to construct a barrier. The installation of a backup generator is also recommended, and when pumps need to be replaced as part of regular maintenance, submersible pumps should be installed. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

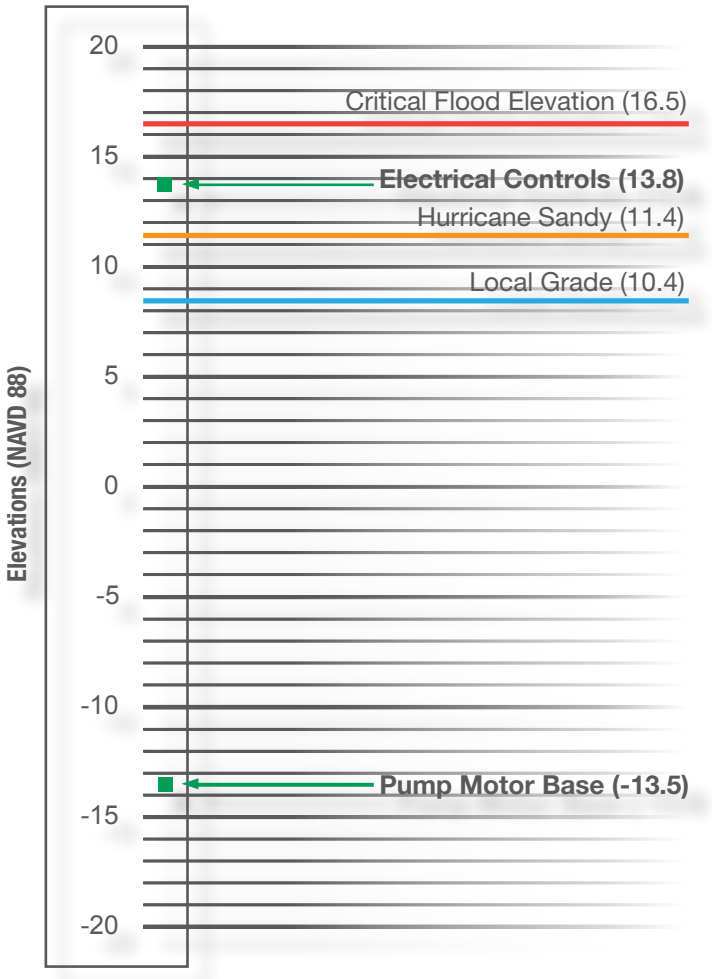
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Non-submersible
	Operating Capacity (MGD)	11.5
	Affected Area (Acres)	1,336
Risk	Population in Affected Area	45,885
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	36
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	Y
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Construct Barrier
	Cost of Protective Measures[1]	$5,456,000
	Damage Cost for Critical Flood without Protection[1, 2]	$6,573,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$32,135,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Seal Building**

Adaptation Cost: **$350,000**

All entrances to pumping station elevated at least 1.5 feet

Co-op City North Pumping Station

STATION CHARACTERISTICS

The Co-op City North sanitary pumping station is located at the corner of Co-op City Blvd. and Bellamy Loop. The Hutchinson River runs behind the station. The pumping station has a cinder block structure as well as concrete-housed vents atop a concrete slab.

The Pumping Station Summary table lists the general characteristics of the Co-op City North pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a densely-populated residential area. Failure of the station would affect an area of approximately 210 acres and a population of over 27,000. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Co-op City North pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

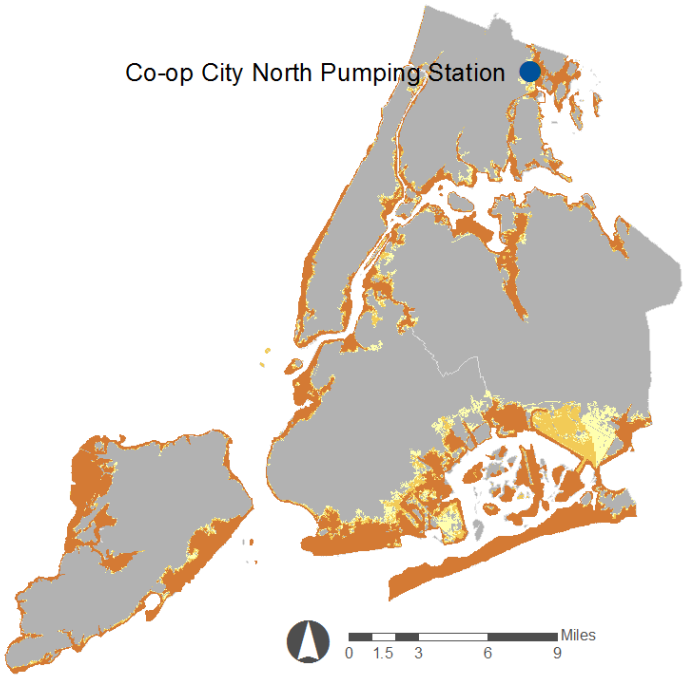
The risk of the Co-op City North pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be 2 feet above local grade. Electrical controls are below grade within the structure, and the doorway threshold into the structure is about 1 foot above grade, which is 1 foot below the critical flood elevation. Flood waters could enter the structure and damage the electrical controls. The submersible pumps should withstand flooding. The Co-op City North pumping station has the ability to receive flow from another pumping station. Therefore, loss of function at Co-op City North increases the vulnerability of an additional pumping station, tributary area, and population.

ADAPTATION STRATEGIES

The Co-op City North pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a significant existing structure, the recommended strategy at Co-op City North is to seal the building. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

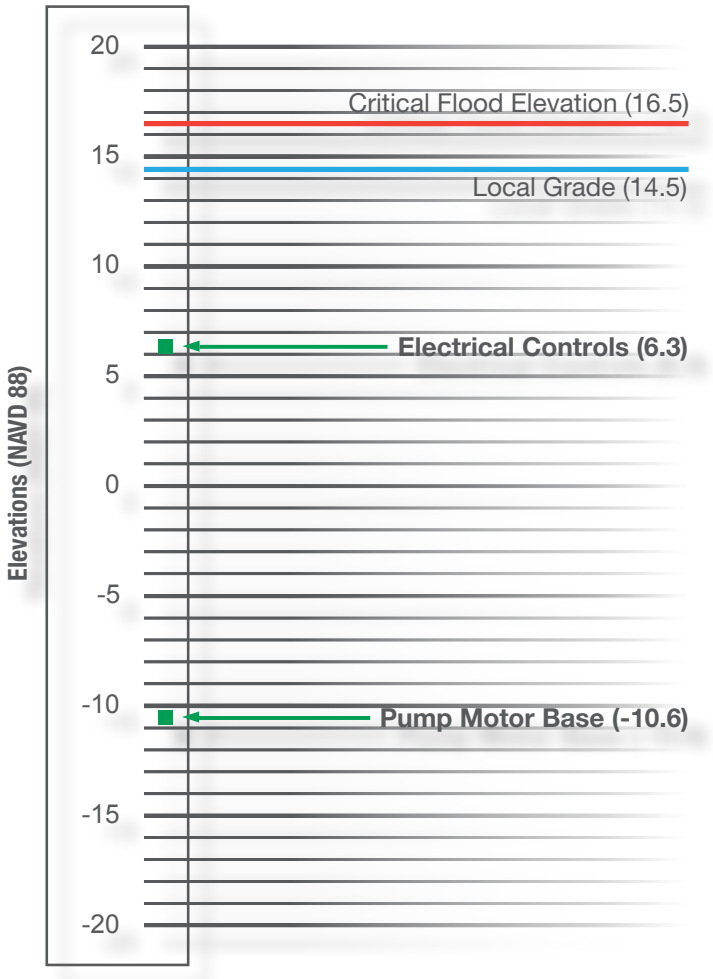
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	16.1
	Affected Area (Acres)	210
Risk	Population in Affected Area	27,285
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	Y
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$350,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,700,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$3,262,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station between residential neighborhood and wetlands

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$7,389,000**

Douglaston Bay Pumping Station

STATION CHARACTERISTICS

The Douglaston Bay sanitary pumping station is located near the corner of 41st Avenue and 233rd Street in Queens. It is situated in a paved area between the roadway and wetlands that run along the southeastern shore of Little Neck Bay. The Douglaston Bay pumping station is entirely below grade and is accessible through hatches in the pavement.

The Pumping Station Summary table lists the general characteristics of the Douglaston Bay pumping station, the potential effect of its failure, and the recommended adaptation strategy. The Douglaston Bay pumping station is located in a residential area. Failure of the station would affect an area of approximately 27 acres and a population of more than 600. There is one critical facility in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Douglaston Bay pumping station was flooded during Hurricane Sandy, though there is no history of flooding outside of this event.

RISK ASSESSMENT

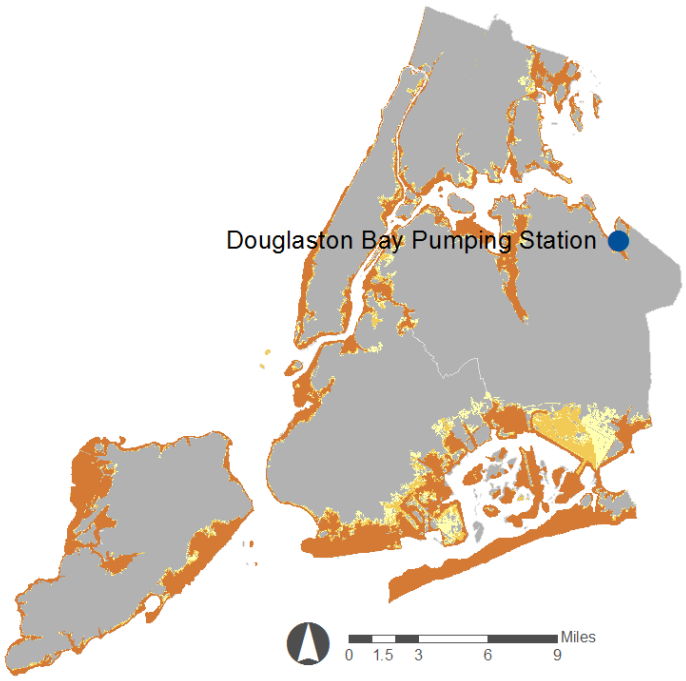
The risk of the Doug Bay pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

Collection Systems staff provided further details on the station's flooding history and vulnerability. The critical flood elevation would be more than 8 feet above local grade, completely inundating the entire station. The electrical controls, which are below grade, would be flooded and damaged. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Doug Bay pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the 8-foot depth of the critical flood and the lack of an existing structure, the recommended strategy at Doug Bay is to elevate electrical controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

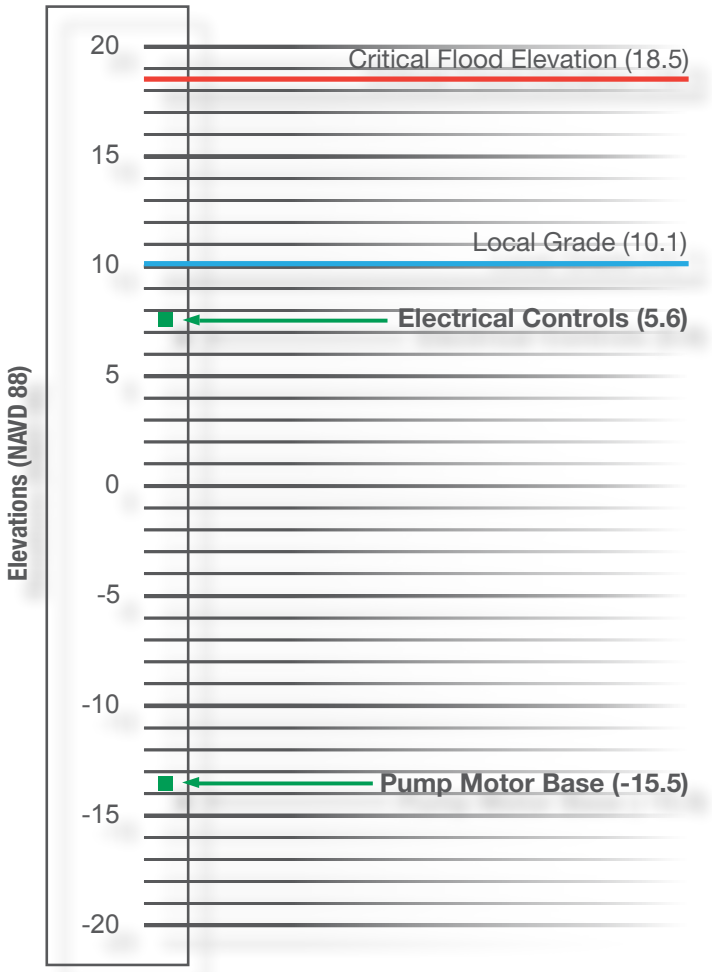
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	1.0
	Affected Area (Acres)	27
Risk	Population in Affected Area	613
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$7,389,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,799,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$9,256,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Seal Building

Adaptation Cost:
$588,000

Large structure within Fresh Kills Landfill

Eltingville Pumping Station

STATION CHARACTERISTICS

The Eltingville sanitary pumping station is located within the Fresh Kills landfill on Staten Island, along a service road that runs into the landfill. The entrance to the service road is on Arthur Kill Road across from Brookfield Avenue. The station is in a large stucco structure completely surrounded by a driveway. Two entrances to the wet well are located in back of the structure.

The Pumping Station Summary table lists the general characteristics of the Eltingville pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a landfill surrounded by residential neighborhoods. Failure of the station would affect an area of approximately 417 acres. There are 3 critical facilities within that area that could be affected if the station failed, and there is a nearby bathing beach that could be affected.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Eltingville pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

The risk of the Eltingville pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be just under 1 foot above local grade. Because electrical controls and non-submersible pumps are located below grade and below the flood elevation, they could be damaged if water enters the structure.

ADAPTATION STRATEGIES

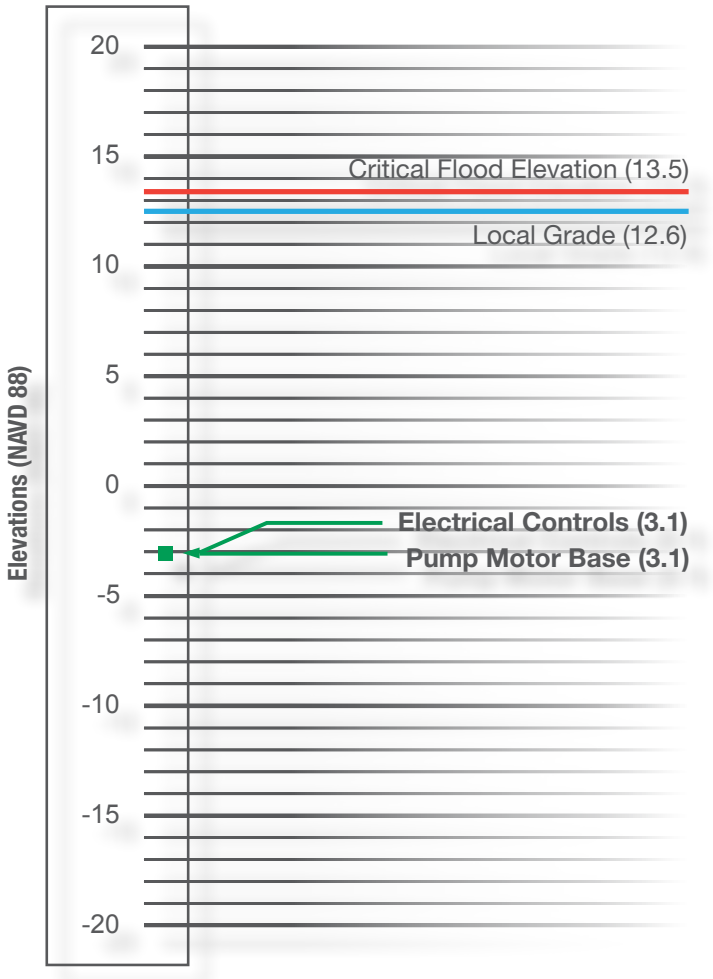
The Eltingville pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a significant existing structure, the recommended strategy at Eltingville is to seal the building so that flood waters cannot enter; this is a less expensive option than those that involve moving electrical controls or motors. While this strategy will provide resilient protection, there is the potential for leaks, inflows to the wells, or unidentified flow paths. DEP will consider replacing the non-submersible pumps with submersibles as normal replacement is needed as part of regular maintenance. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	17.3
	Affected Area (Acres)	417
Risk	Population in Affected Area	9,363
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	3
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$588,000
	Damage Cost for Critical Flood without Protection[1, 2]	$9,508,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$5,438,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Brick structure in residential commercial area

Recommended Adaptation Strategy: **Seal Building**

Adaptation Cost: **$470,000**

Ely Avenue Pumping Station

STATION CHARACTERISTICS

The Ely Avenue sanitary pumping station is located at the corner of Ely Avenue and Waring Avenue in the Bronx, adjacent to a Home Depot parking lot. The station has a brick structure with entrances and the main floor situated approximately 2 feet above grade.

The Pumping Station Summary table lists the general characteristics of the Ely Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The Ely Avenue pumping station is located in a mixed residential and commercial area. Failure of the station would affect an area of approximately 300 acres and a population of nearly 1,500. There are five critical facilities in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Ely Avenue pumping station was affected by Hurricane Sandy but there is no history of flooding at this location.

RISK ASSESSMENT

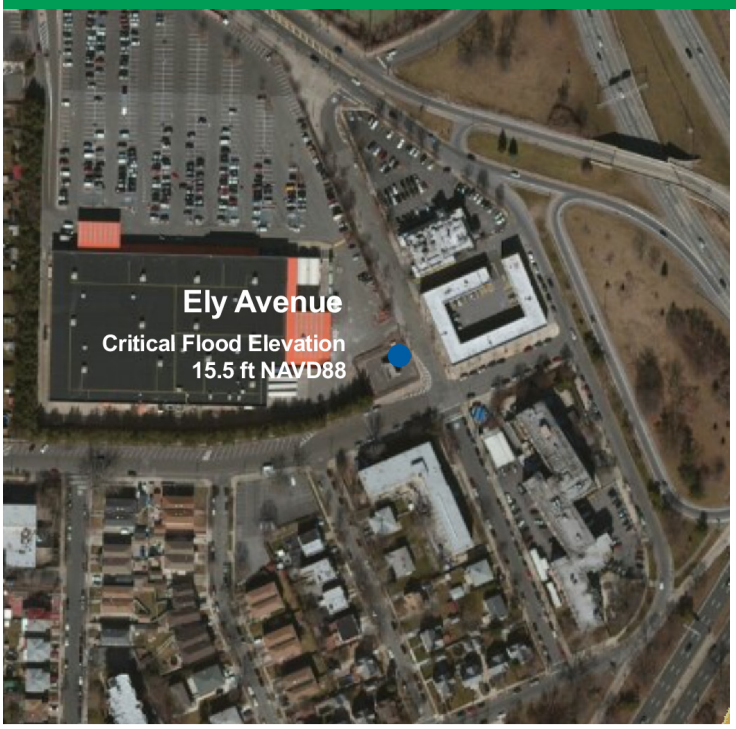
The risk of the Ely Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

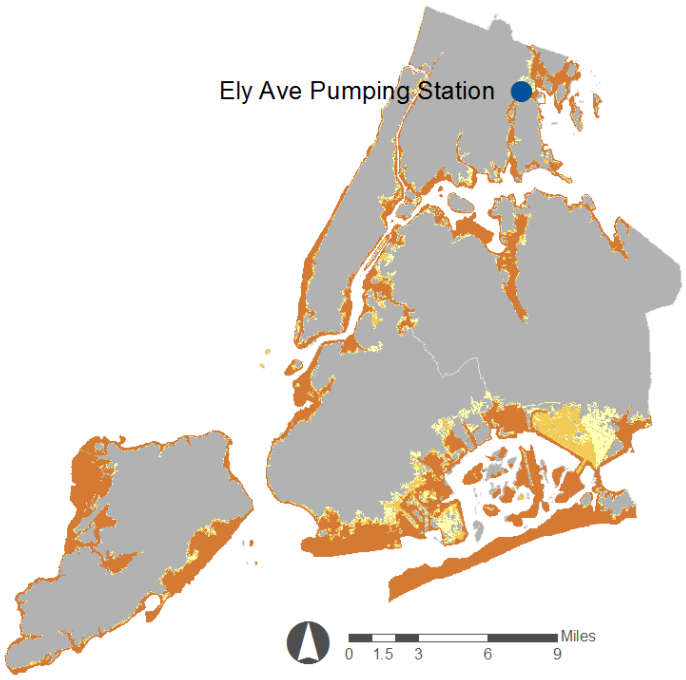
The critical flood elevation would be 2 feet above local grade, which is equal to the elevation of the main floor of the structure where electrical controls are housed. This could cause damage to the electrical controls; submersible pumps should be unaffected.

ADAPTATION STRATEGIES

The Ely Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing structure with entrances above the critical flood elevation, the recommended strategy at Ely Avenue is to seal the building. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

FEMA Flood Zones

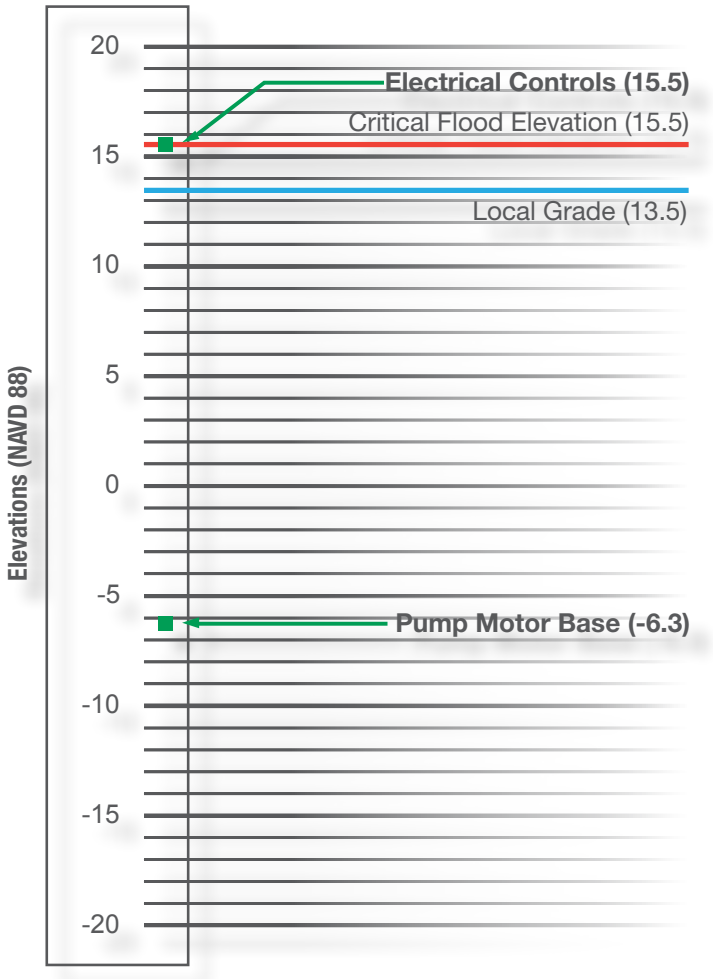




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	1.6
	Affected Area (Acres)	300
Risk	Population in Affected Area	1,460
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	5
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$470,000
	Damage Cost for Critical Flood without Protection[1, 2]	$2,015,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$3,584,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure beneath Flushing Bridge in driveway of concrete company

Recommended Adaptation Strategy:
Construct Barrier

Adaptation Cost:
$1,256,000

Flushing Bridge Pumping Station

STATION CHARACTERISTICS

The Flushing Bridge sanitary pumping station is located within the parking lot and driveway of Best Concrete Mix Corp. at 3510 College Point Boulevard in Queens. The station's small brick structure is located directly underneath the roadway of the Flushing Bridge. Hatch entryways to the wells are located in the concrete directly behind the structure.

The Pumping Station Summary table lists the general characteristics of the Flushing Bridge pumping station, the potential effect of its failure, and the recommended adaptation strategy. The Flushing Bridge pumping station is located in an industrial and commercial area. Failure of the station would affect an area of approximately 25 acres. There are no critical facilities in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Flushing Bridge pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

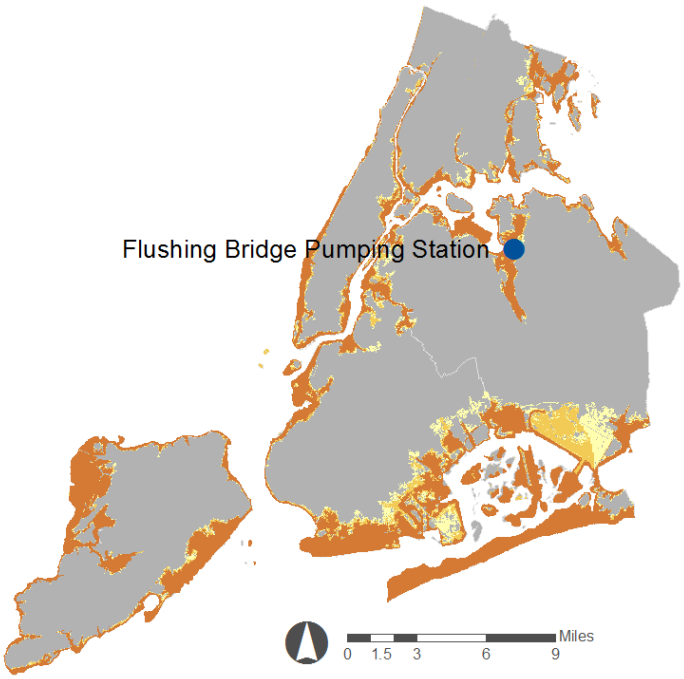
The risk of the Flushing Bridge pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be more than 7 feet above local grade. Water would likely enter the building, flooding and damaging the electrical controls. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Flushing Bridge pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is an existing structure, but there are numerous potential flood entryways, the recommended strategy at Flushing Bridge is to seal the main door and construct a barrier around the vents on the rear pad of the station. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the seal could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

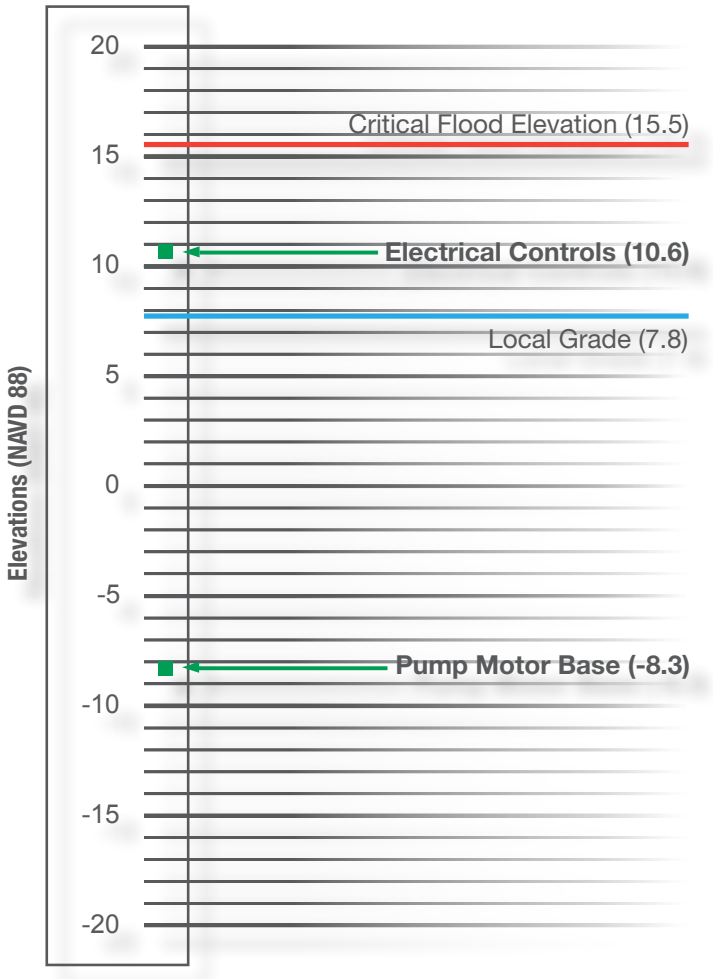
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	1.2
	Affected Area (Acres)	25
Risk	Population in Affected Area	3
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Construct Barrier
	Cost of Protective Measures[1]	$1,256,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,742,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$8,514,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Elevate Electrical on a Platform/Pad

Adaptation Cost:
$895,000

Pumping station in residential neighborhood between dead-end street and open water

Gildersleeve Avenue Pumping Station

STATION CHARACTERISTICS

The Gildersleeve Avenue sanitary pumping station is located at the dead end of Gildersleeve Avenue near the intersection with Betts Avenue in the Bronx. It is less than 20 feet from an inlet that connects to Long Island Sound. The motor control center (MCC) and electric meters sit on the sidewalk in stainless-steel enclosures. There are hatch entryways to the wells in the sidewalk.

The Pumping Station Summary table lists the general characteristics of the Gildersleeve Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 15 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Gildersleeve Avenue pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

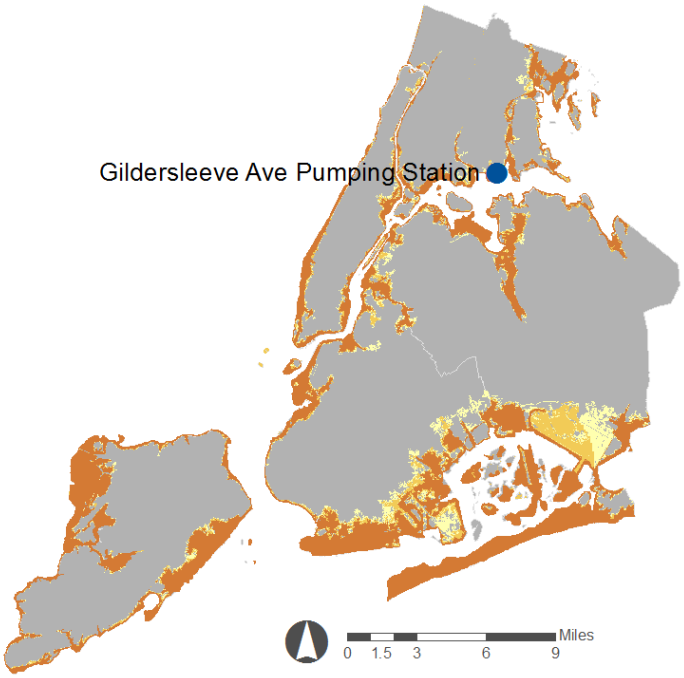
The risk of the Gildersleeve Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior revealed that the MCC and other electrical controls, which are not clearly shown in drawings, are located above grade on the sidewalk.

The critical flood elevation would be 3 feet above local grade. Electrical controls sit only a few inches above grade on the sidewalk, and they would be damaged. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

The Gildersleeve Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the flood depth and the fact that exposed above grade components are acceptable in this location, the recommended strategy at Gildersleeve Avenue is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

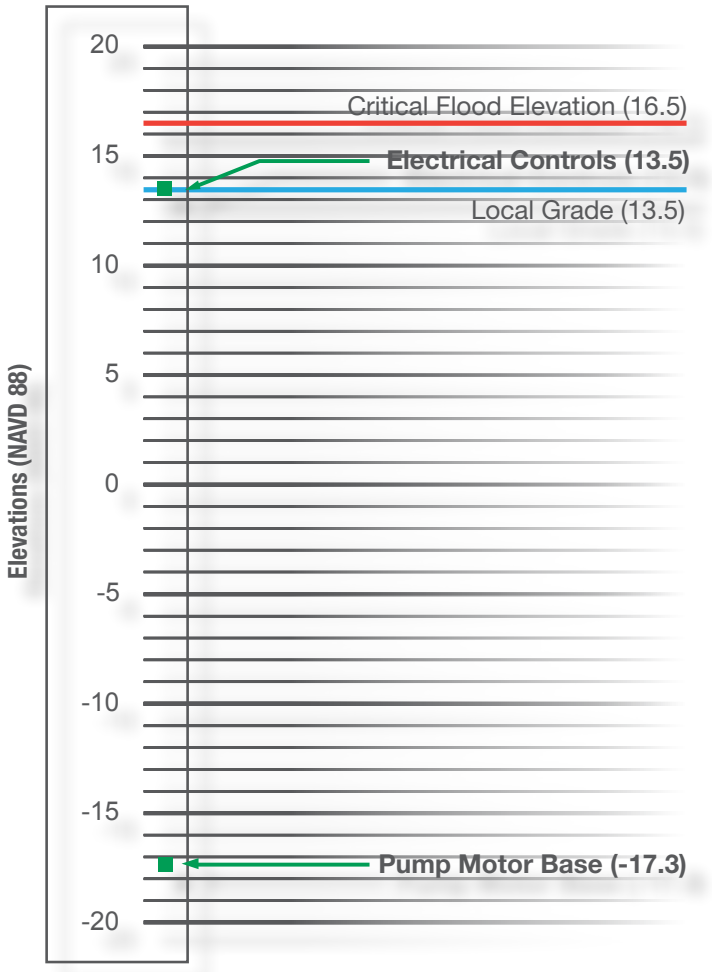
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	<1MGD
	Affected Area (Acres)	15
Risk	Population in Affected Area	363
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$895,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,142,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$3,971,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Large structure; pumping station in design to be rebuilt

Recommended Adaptation Strategy:
Elevate Electrical in New Building & Submersible Pump Motors

Adaptation Cost:
$1,372,000

Hannah Street Pumping Station

STATION CHARACTERISTICS

The Hannah Street combined pumping station is located near the intersection of Hannah Street and Murray Hulbert Avenue in Staten Island. The site is approximately 300 feet from the open water of the Narrows. The station consists of large above- and below grade structures. The motor control center and non-submersible pumps are housed below grade within the structure.

The Pumping Station Summary table lists the general characteristics of the Hannah Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 2,166 acres and a population of more than 50,000. There are 44 critical facilities in the area that could be affected if the station fails. Additionally, failure of this pumping station could affect a nearby bathing beach.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, the Hannah Street pumping station lost power but did not experience any flooding. Nearby areas experienced flooding that was 4 feet above grade. The Hannah Street station does have a history of flooding outside of Hurricane Sandy.

RISK ASSESSMENT

The risk of the Hannah Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room and dry well.

The critical flood elevation would be approximately 4.5 feet above local grade. This would likely enter the building, flooding and damaging the electrical controls as well as the non-submersible pumps, all of which are located below the critical flood elevation. The Hannah Street pumping station receives flow from another pumping station. Therefore, loss of function at Hannah Street increases the vulnerability of an additional pumping station, tributary area, and population.

ADAPTATION STRATEGIES

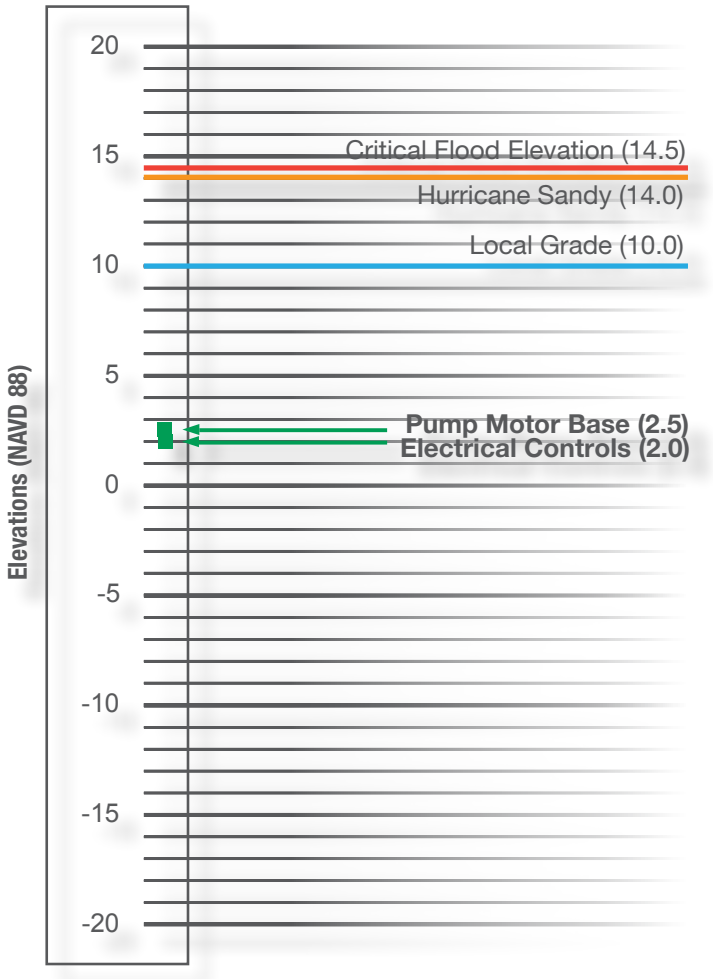
The Hannah Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. The Hannah Street pumping station is currently in design to be rebuilt. To add resiliency, the new plans should include elevating electrical controls and installing submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Non-submersible
	Operating Capacity (MGD)	37.5
	Affected Area (Acres)	2,166
Risk	Population in Affected Area	50,193
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	44
	Historic Flooding	Y
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building & Submersible Pump Motors
	Cost of Protective Measures[1]	$1,372,000
	Damage Cost for Critical Flood without Protection[1, 2]	$12,796,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$63,238,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station with above grade entrance adjacent to Eastchester Creek

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$2,484,000**

Hollers Avenue Pumping Station

STATION CHARACTERISTICS

The Hollers Avenue sanitary pumping station is located at the corner of Hollers Avenue and Eastchester Place in the Bronx; it is situated between the roadway and Eastchester Creek. The below grade control room is accessible by a stairwell that has an enclosed doorway entrance above grade, and wells are accessible through hatches. There is an adjacent substation that can be used as backup when the primary station must be taken offline.

The Pumping Station Summary table lists the general characteristics of the Hollers Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 642 acres and a population of more than 800. There are no critical facilities in that area.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Hollers Avenue pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

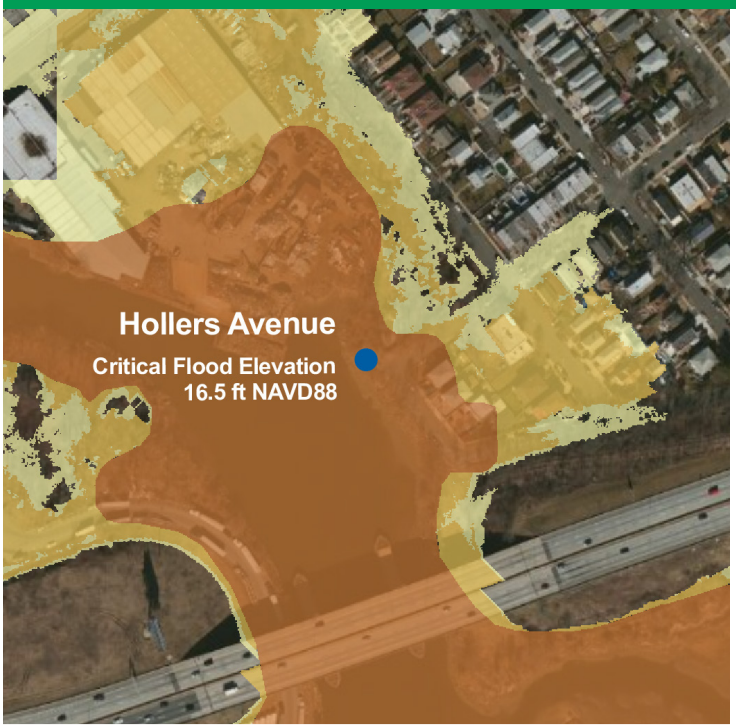
The risk of the Hollers Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

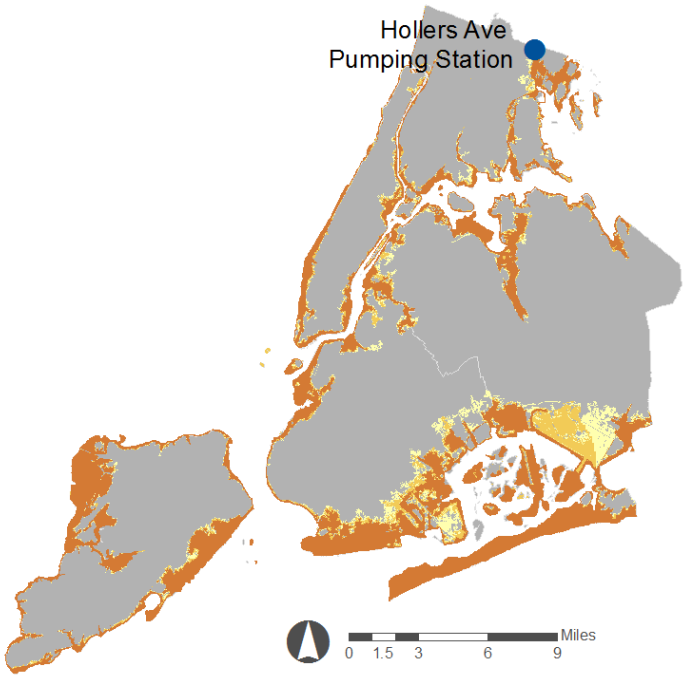
The predicted critical flood elevation would be 7 feet above local grade. This would damage the below grade electrical controls. The submersible pumps should be unaffected.

ADAPTATION STRATEGIES

The Hollers Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the significant depth of the critical flood, the lack of an existing structure, and the available space, the recommended strategy at Hollers Avenue is to elevate electrical controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

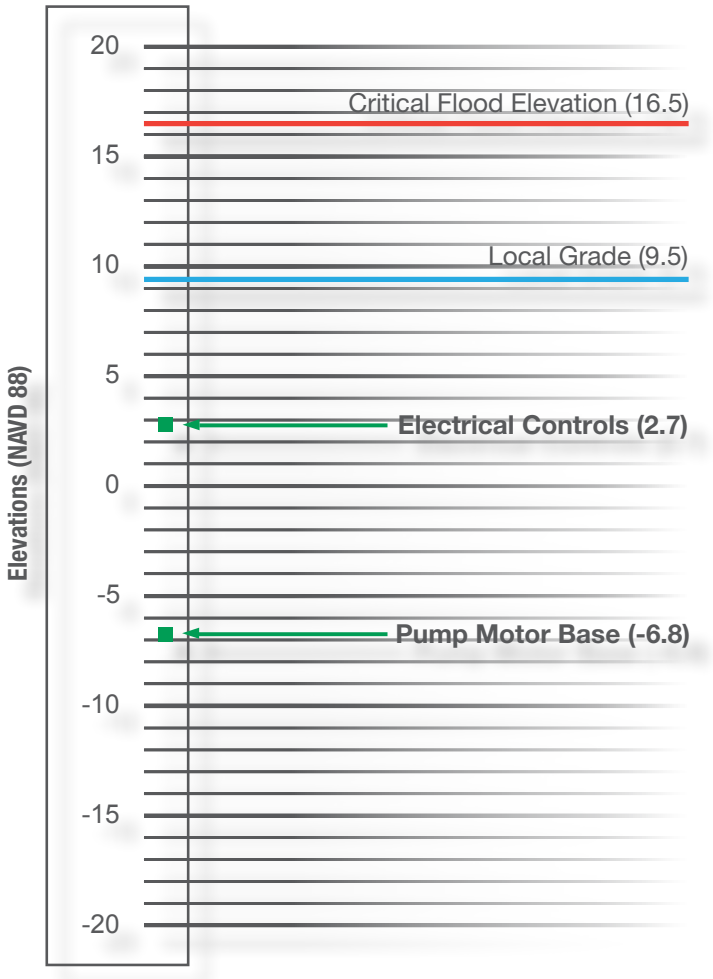




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	1.4
	Affected Area (Acres)	642
Risk	Population in Affected Area	808
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,484,000
	Damage Cost for Critical Flood without Protection[1, 2]	$2,824,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$14,531,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Construct Barrier

Adaptation Cost:
$8,165,000

Howard Beach Pumping Station

STATION CHARACTERISTICS

The Howard Beach combined pumping station is located near the corner of 155th Avenue and 100th Street in Queens. The station is below grade, but the entrances to it are elevated about 2 feet above grade on a concrete slab.

The Pumping Station Summary table lists the general characteristics of the Howard Beach pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 3,188 acres and a population of more than 85,000. There are 25 critical facilities, including four hospitals, in the area that could be affected if the station fails.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, the surrounding area did not experience flooding but the station experienced minor impacts due to the storm. There is not history of flooding at this station.

RISK ASSESSMENT

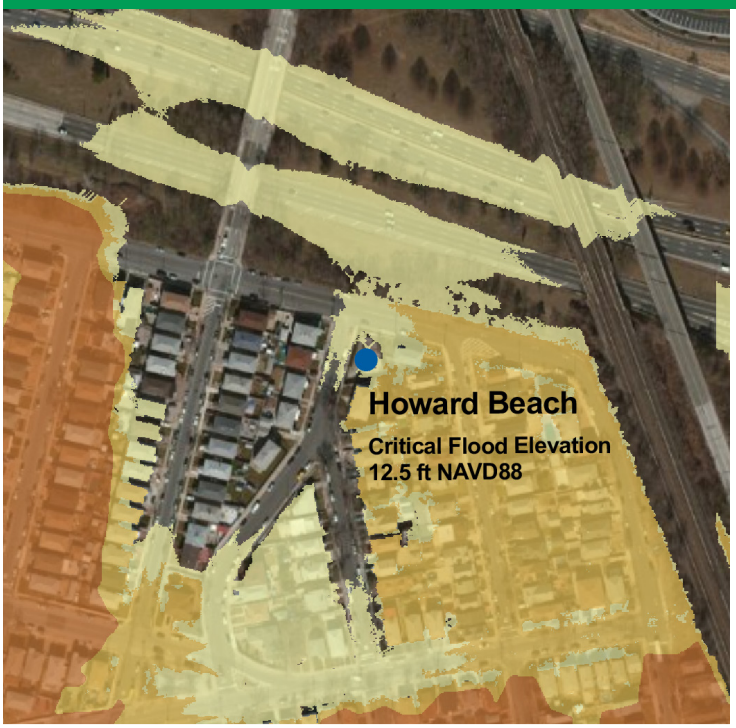
The risk of the Howard Beach pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

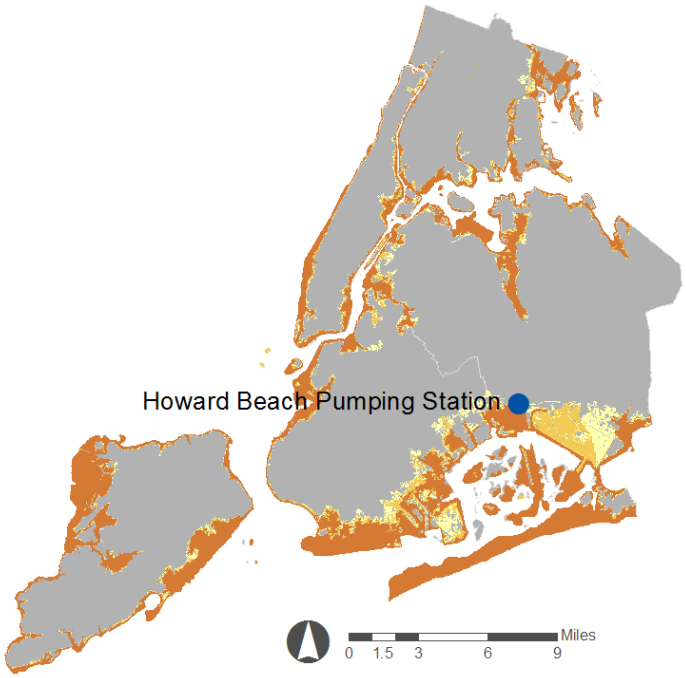
The critical flood elevation would be about 7 inches above local grade. While entrances are elevated above the flood height, the structure is not flood-proof, and the below grade electrical controls and non-submersible pumps could be flooded and damaged.

ADAPTATION STRATEGIES

The Howard Beach pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because of the shallow depth of the critical flood and the location of most entrances above the flood elevation, the recommended strategy at Howard Beach is to add watertight doors in the existing wall at pedestrian and vehicle entry points. Sandbagging is also a potential option but water tight access doors provide a permanent and more resilient solution. The installation of emergency generators is also recommended. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

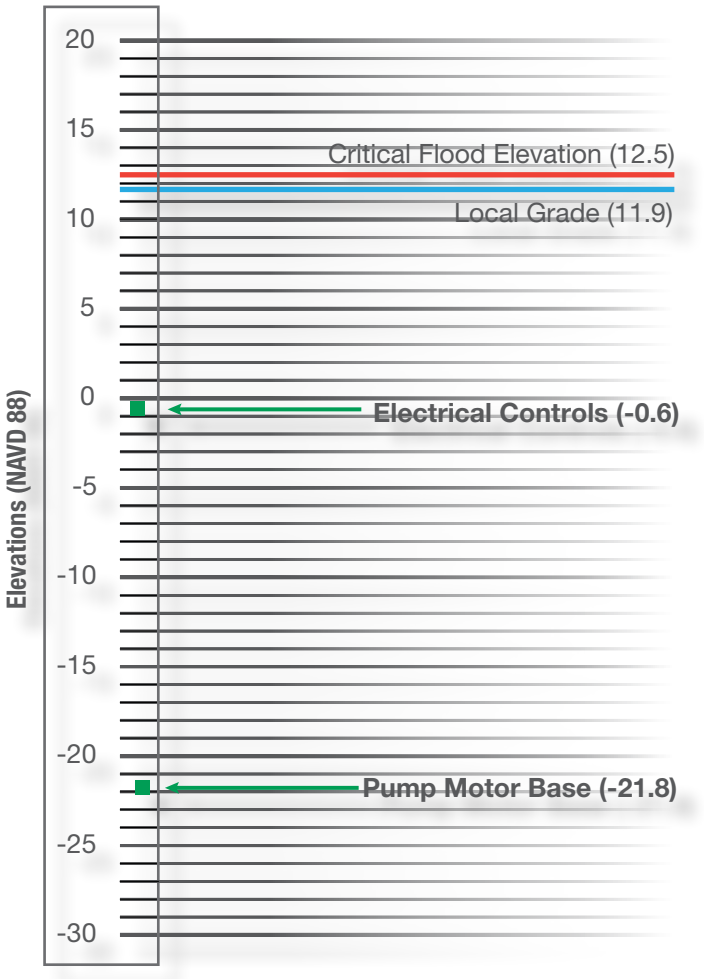




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Non-submersible
	Operating Capacity (MGD)	57.6
	Affected Area (Acres)	3,188
Risk	Population in Affected Area	85,540
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	25
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Construct Barrier
	Cost of Protective Measures[1]	$8,165,000
	Damage Cost for Critical Flood without Protection[1, 2]	$17,438,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$20,649,000
	Resiliency Level	Moderate-Low

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Electrical controls in small structure; hatches and vents at grade level

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad & Sandbagging**

Adaptation Cost: **$730,000**

Hunts Point Market Pumping Station

STATION CHARACTERISTICS

The Hunts Point Market sanitary pumping station is located on Farragut Street near its corner with Food Center Drive in the Bronx. The motor control center is located above grade in a small brick enclosure, and the rest of the station is below grade.

The Pumping Station Summary table lists the general characteristics of the Hunts Point Market pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial area. It services an area of approximately 126 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Hunts Point Market pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

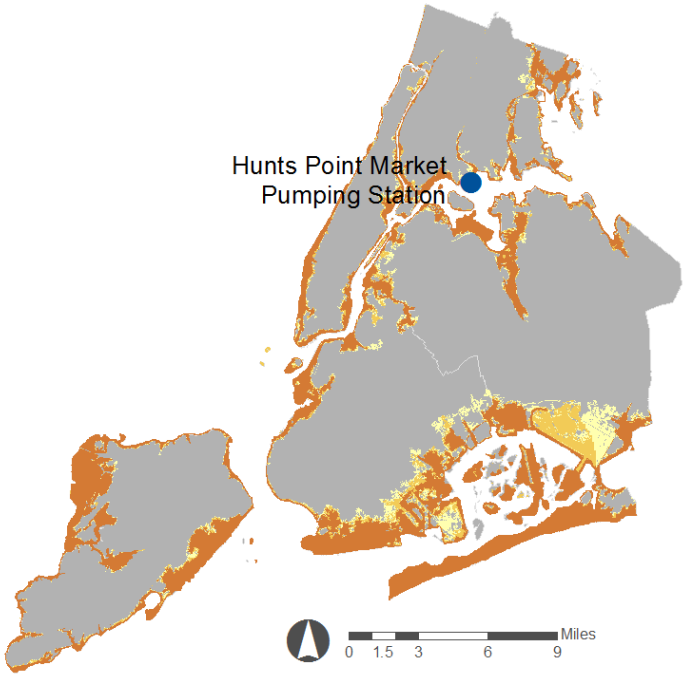
The risk of the Hunts Point Market pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be 2 feet above local grade. The bottom of the motor control center is only 1 foot above grade, so flood waters could enter the surrounding structure and damage the controls. The submersible pumps should be unaffected.

ADAPTATION STRATEGIES

The Hunts Point Market pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the vulnerability of electrical controls in their current location and the presence of vents and hatches near grade level, the recommended strategy at Hunts Point Market is to elevate electrical controls on a platform and place sandbags around the remaining potential water entry points prior to a flooding event.

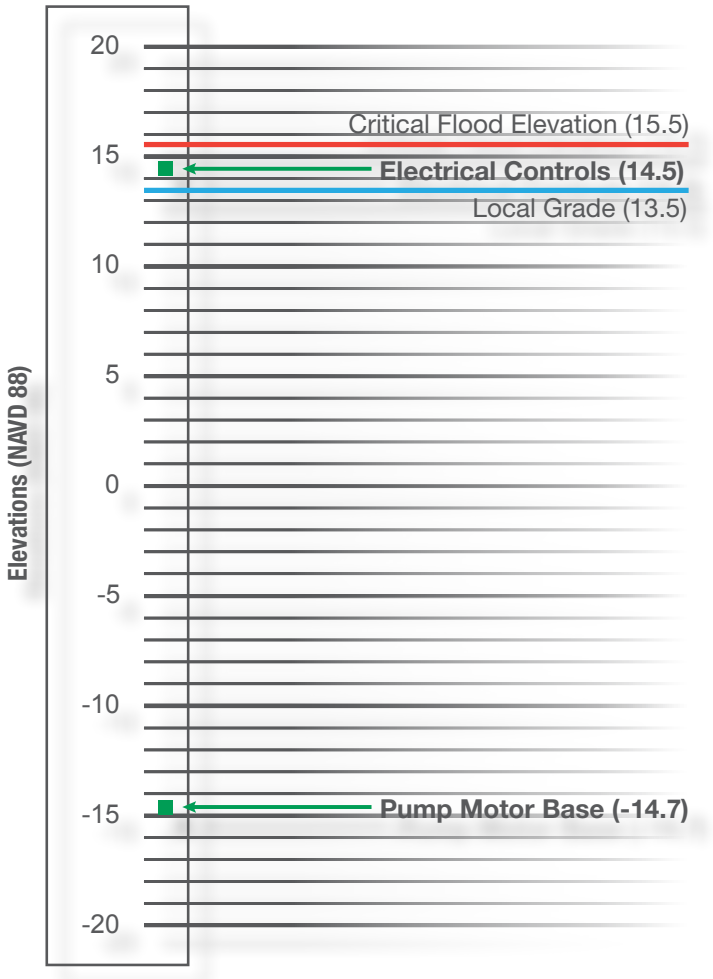
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

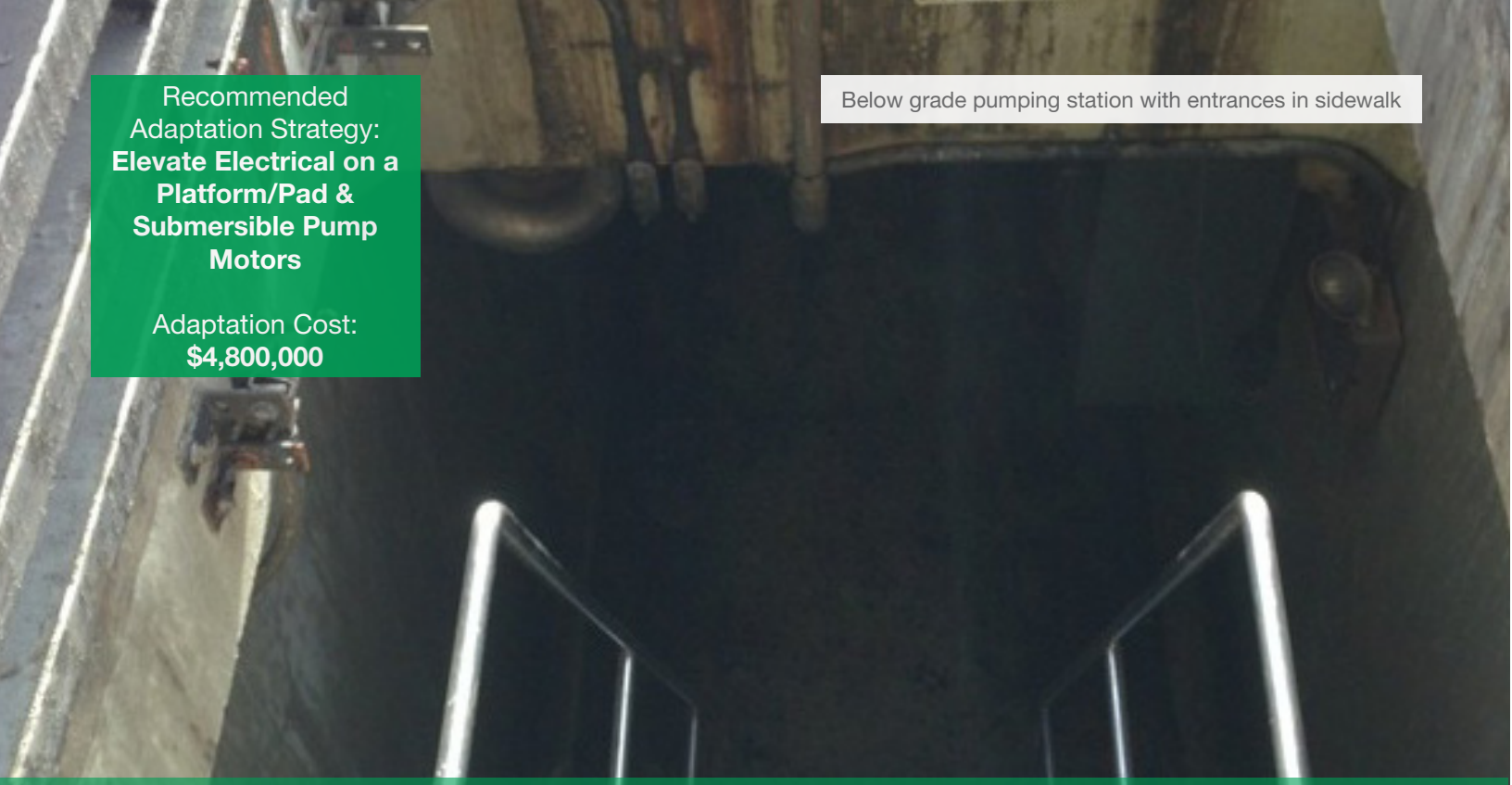
Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	5.8
	Affected Area (Acres)	126
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad & Sandbagging
	Cost of Protective Measures[1]	$730,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,859,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$5,654,000
	Resiliency Level	Moderate-Low

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Below grade pumping station with entrances in sidewalk

Recommended Adaptation Strategy:
Elevate Electrical on a Platform/Pad & Submersible Pump Motors

Adaptation Cost:
$4,800,000

Kane Street Pumping Station

STATION CHARACTERISTICS

The Kane Street stormwater pumping station is located on the northwest corner of the intersection of Kane Street and Hicks Street in Brooklyn. The station is located completely below grade, under a sidewalk between residential buildings and the southbound lanes of Hicks Street.

The Pumping Station Summary table lists the general characteristics of the Kane Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a high-density residential area. Failure of the station would affect an area of approximately 51 acres with a population of approximately 5,700. There are three critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Kane Street pumping station has not experienced flooding in the past, including during Hurricane Sandy. Its location adjacent to the Brooklyn–Queens Expressway means that flooding of the pumping station would coincide with flooding of the roadway.

RISK ASSESSMENT

The risk of the Kane Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The predicted critical flood elevation would be more than 2 feet above local grade. This would damage the electrical controls and the non-submersible pumps, all of which are located below grade.

ADAPTATION STRATEGIES

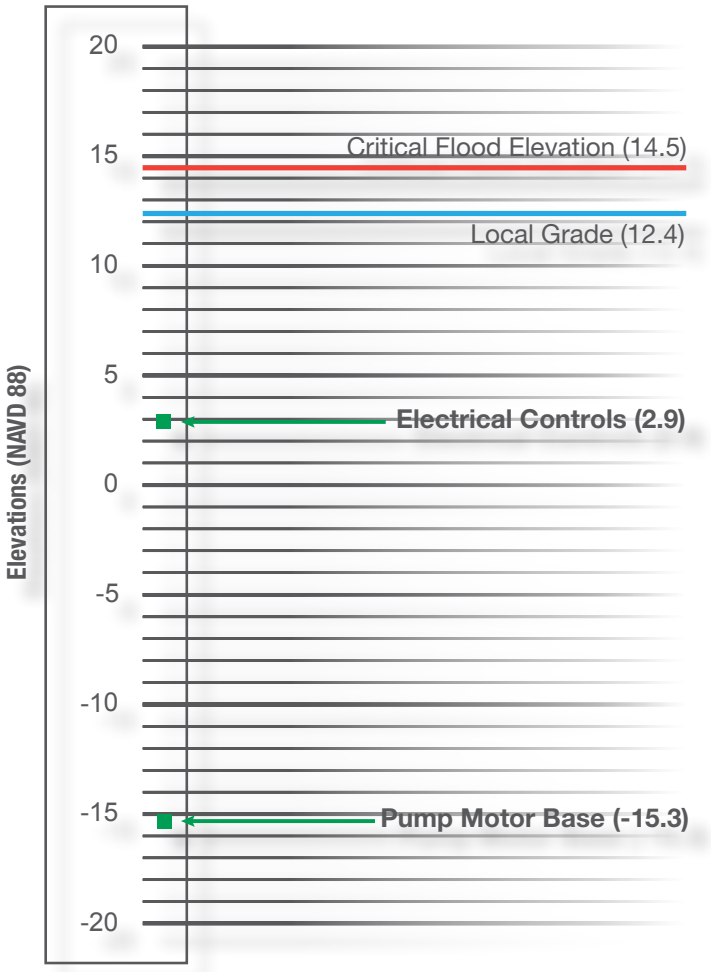
The Kane Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to space limitations, the lack of an existing structure, and the current vulnerability of the pumping station, the recommended strategy at Kane Street is to elevate electrical controls on an aboveground platform and install submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Stormwater
	Pump Type	Non-submersible
	Operating Capacity (MGD)	7.2
	Affected Area (Acres)	51
Risk	Population in Affected Area	5,725
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	3
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on Platform/Pad & Submersible Pump Motors
	Cost of Protective Measures[1]	$4,800,000
	Damage Cost for Critical Flood without Protection[1, 2]	$6,230,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$11,926,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad**

Adaptation Cost: **$1,153,000**

Hatch entryways in sidewalk in front of school

Linden Place Pumping Station

STATION CHARACTERISTICS

The Linden Place combined pumping station is located near the northeast corner of Linden Place and 31st Road in Queens. The pumping station is below grade with grating and hatch entryways in the sidewalk in front of a school.

The Pumping Station Summary table lists the general characteristics of the Linden Place pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a mixed residential and commercial area. Failure of the station would affect an area of approximately 274 acres and a population of more than 13,500. There are six critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Linden Place pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

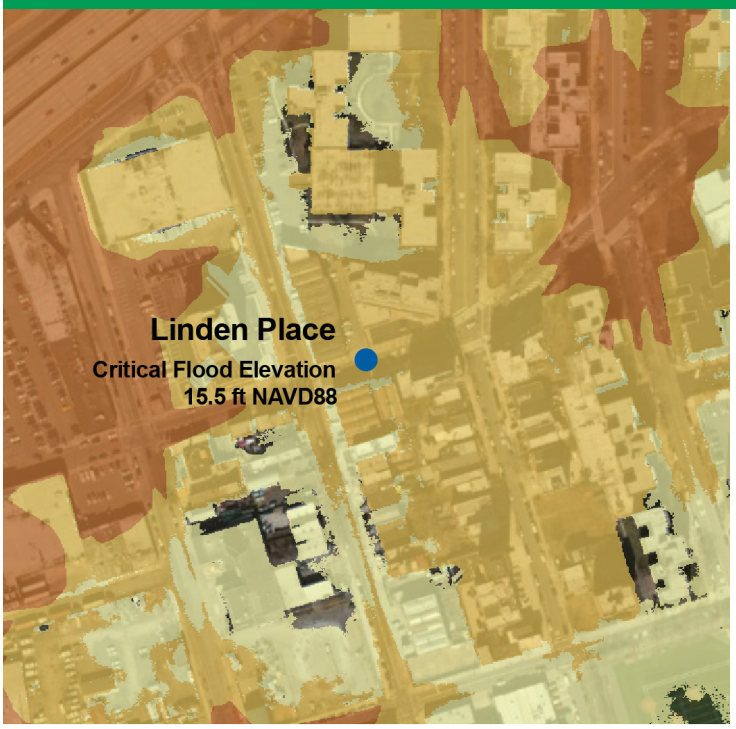
The risk of the Linden Place pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be more than 2 feet above local grade, completely inundating this below grade station. Water would damage the electrical controls, but the submersible pumps should be unaffected.

ADAPTATION STRATEGIES

The Linden Place pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the need to move electrical controls out of the reach of flood waters and limited available space, the recommended strategy at Linden Place is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

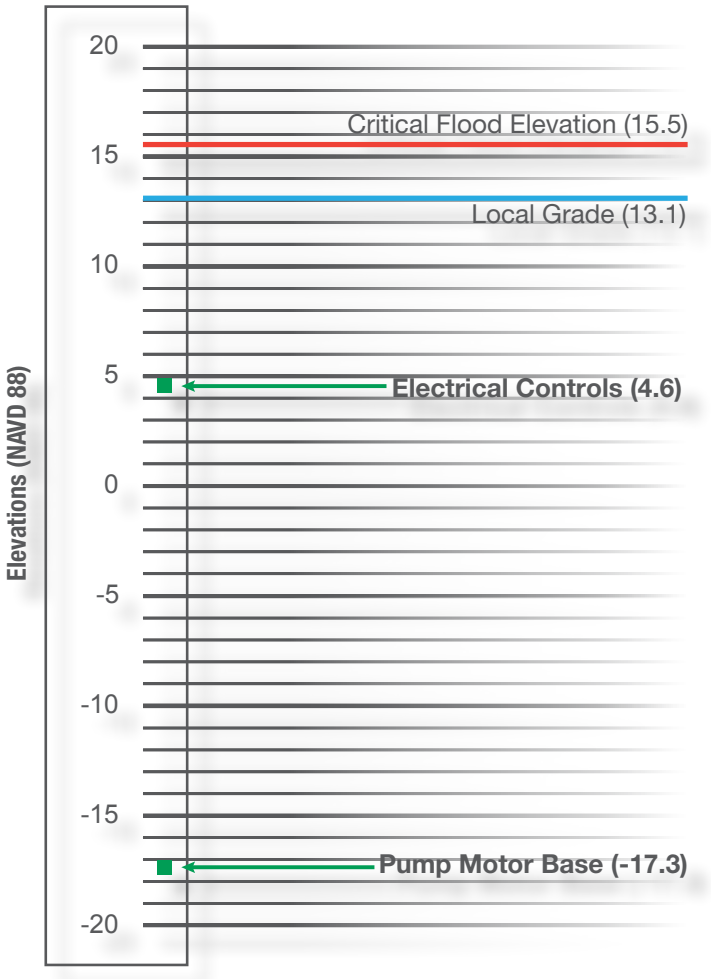
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	5.0
	Affected Area (Acres)	274
Risk	Population in Affected Area	13,665
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	6
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$1,153,000
	Damage Cost for Critical Flood without Protection[1, 2]	$4,025,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$4,405,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure located along shopping plaza access road near Harlem River

Recommended Adaptation Strategy:
Seal Building

Adaptation Cost:
$624,000

Marble Hill Pumping Station

STATION CHARACTERISTICS

The Marble Hill combined pumping station is located near 58 West 225th Street in the Bronx. It is situated along a shopping plaza entrance road on the south side of 225th Street between Planet Fitness and Target. The Harlem River is about 100 feet away from the station. The station has a brick structure surrounded by a paved lot.

The Pumping Station Summary table lists the general characteristics of the Marble Hill pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial and residential area. Failure of the station would affect an area of approximately 841 acres and a population of nearly 47,000. There are 23 critical facilities within that area that could be affected if the station failed. Additionally, failure of this pumping station could affect a nearby bathing beach.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy nearby areas flooded to a depth of about 6 inches and the station experienced minor impacts. There is no history of flooding at this location beyond flooding caused by Hurricane Sandy.

RISK ASSESSMENT

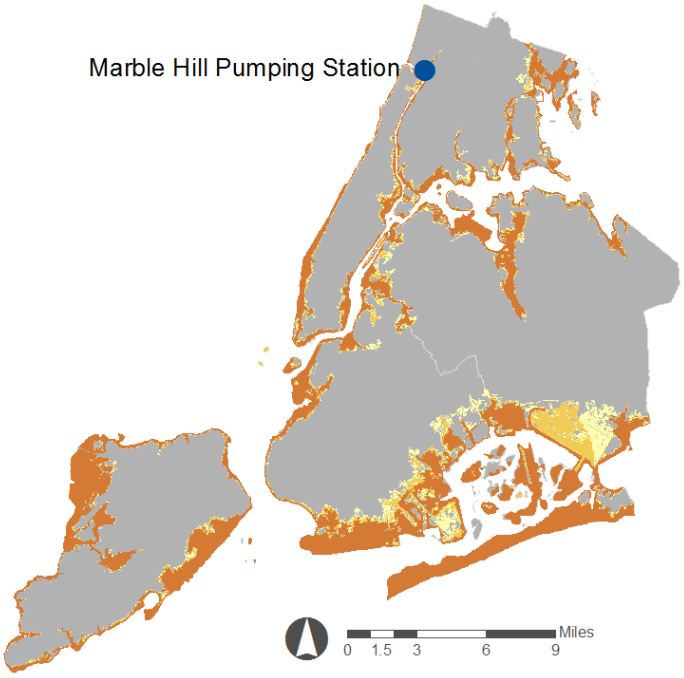
The risk of the Marble Hill pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the March 2013 FEMA Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be nearly 6 feet above local grade. Water would likely enter the building, flooding and damaging the electrical controls, which are located below the flood elevation. The submersible pumps should withstand flooding. The Marble Hill pumping station receives flow from three pumping stations. Therefore, loss of function at Marble Hill increases the vulnerability of additional pumping stations, tributary areas, and populations.

ADAPTATION STRATEGIES

The Marble Hill pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a significant existing structure, the recommended strategy at Marble Hill is to seal the building so that flood waters cannot enter. This is a less expensive option than those that involve moving electrical controls or motors. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

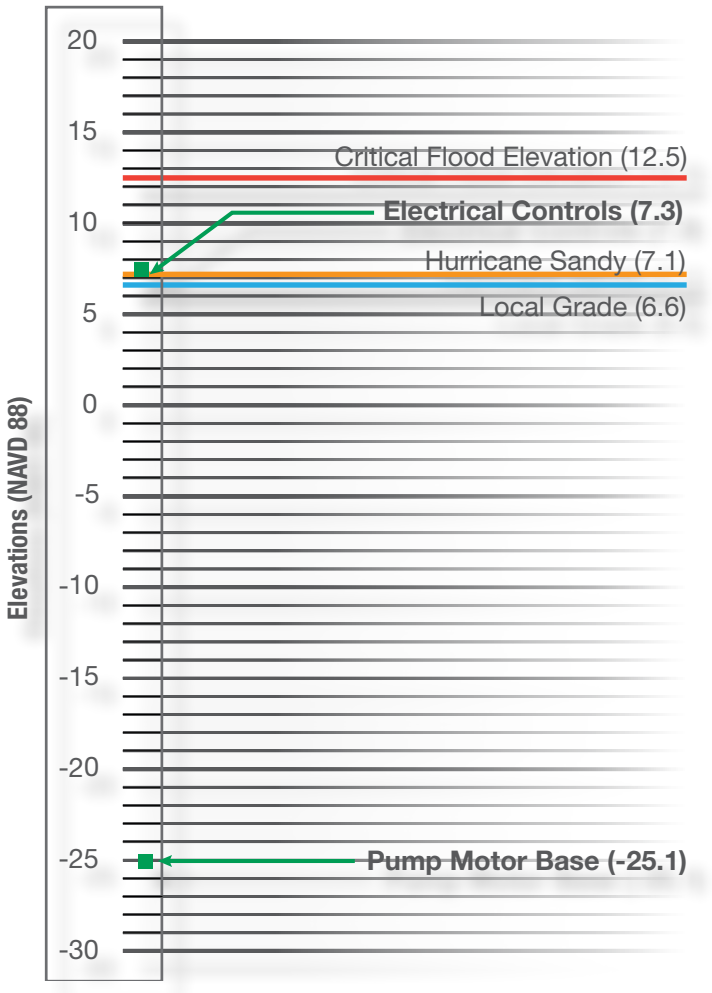
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	15.0
	Affected Area (Acres)	841
Risk	Population in Affected Area	46,958
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	23
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$624,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,383,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$15,670,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Brick structure in residential neighborhood adjacent to wetland

Recommended Adaptation Strategy: **Seal Building**

Adaptation Cost: **$549,000**

Mason Avenue Pumping Station

STATION CHARACTERISTICS

The Mason Avenue sanitary pumping station is on the east side of Mason Avenue, south of Slater Boulevard, on Staten Island. It is in a residential neighborhood adjacent to tidal wetlands. The station has a brick structure whose main floor is about 4 feet above grade; a fence surrounds the lot.

The Pumping Station Summary table lists the general characteristics of the Mason Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is in a residential area. Failure of the station would affect an area of approximately 362 acres and a population of more than 8,200. There are no critical facilities within the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, the surrounding area flooded to a depth of more than 5 feet above grade. A resident across the street described Sandy's flood waters as coming in through the wetlands and into the neighborhood "like a wave." DEP Collections System staff on site at the time of the visit indicated that the station flooded and suffered significant damage during the storm. Electrical components on the main floor were damaged, and the station went offline due to power loss, damage to electrical equipment, and loss of telemetry. The damaged electrical equipment has since been replaced. DEP indicated there is also a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

The risk of the Mason Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

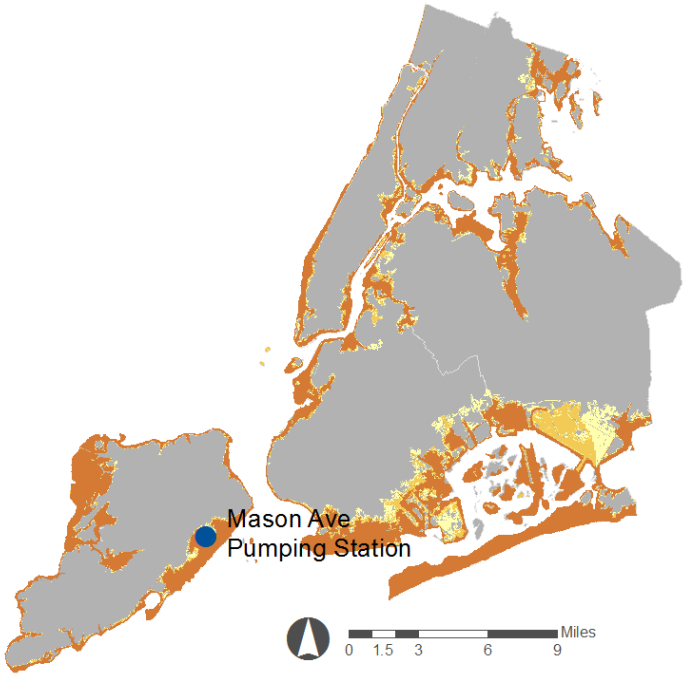
The critical flood elevation would be more than 7 feet above local grade. Water would enter the building, flooding and damaging the electrical controls and the non-submersible pumps, all of which are located below the critical flood elevation.

ADAPTATION STRATEGIES

The Mason Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a significant existing structure, the recommended strategy at Mason Avenue is to seal the building so that flood waters cannot enter; this is a less expensive option than those that involve moving existing electrical controls and pump motors. While this strategy will provide resilient protection, there is the potential for leaks, inflows to the wells, or unidentified flow paths. DEP will consider replacing the non-submersible pumps with submersibles as normal replacement is needed as part of regular maintenance.

Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures. Failure of seals could result in damage to controls and the pump motors.

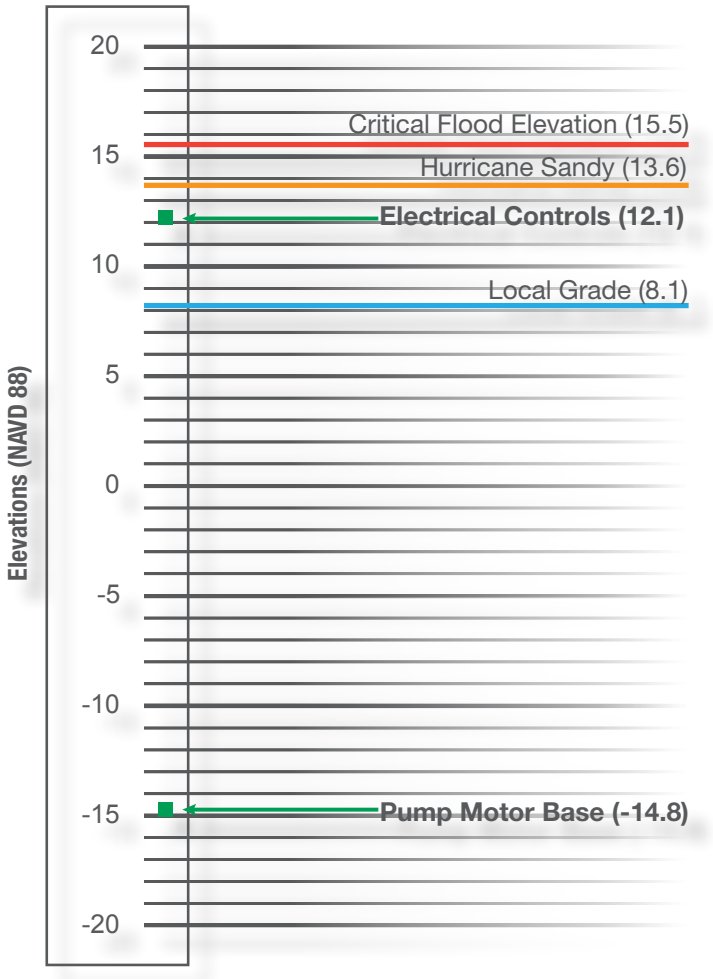
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	2.7
	Affected Area (Acres)	362
Risk	Population in Affected Area	8,293
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$549,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,369,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$15,601,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Brick structure with elevated entrances

Recommended Adaptation Strategy: **Sandbagging**

Adaptation Cost: **$40,000**

Mayflower Avenue Pumping Station

STATION CHARACTERISTICS

The Mayflower Avenue sanitary pumping station is located near the intersection of Arthur Kill Road and Huguenot Avenue in Staten Island. The pumping station includes a large superstructure located on a gated lot. The station is equipped with a permanent backup diesel generator on the main floor of the superstructure. Electrical controls are also located on the main floor, and non-submersible pumps are located below grade. The main floor and doorway thresholds are 3 feet above local grade.

The Pumping Station Summary table lists the general characteristics of the Mayflower Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 1,099 acres with a population of nearly 18,000. There are four critical facilities in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Mayflower Avenue pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

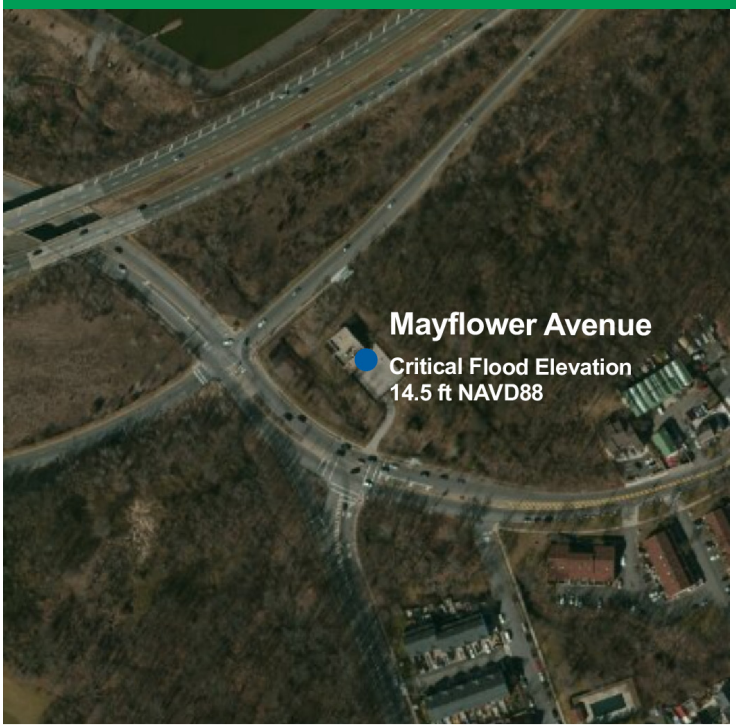
The risk of the Mayflower Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room and dry well.

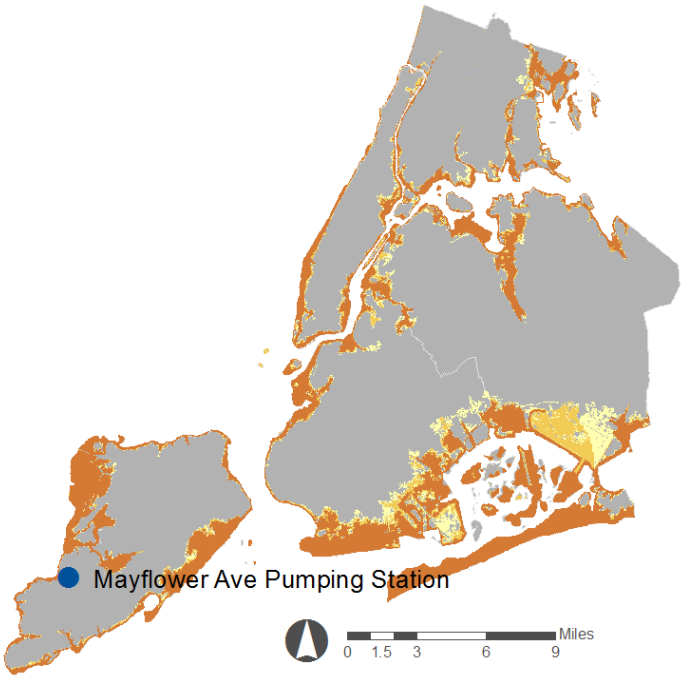
The critical flood elevation would inundate the area surrounding the facility with over 3 feet of water. If flood waters were able to find a pathway into the pumping station, electrical controls and motors could be damaged.

ADAPTATION STRATEGIES

The Mayflower Avenue pumping station requires minor adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing structure and most entryways are elevated, the recommended strategy at Mayflower Avenue is to sandbag potential flood entry points. Residual risk is related to a greater depth of flooding from larger storms, more extreme climate change, failure of the sandbag barrier, or leakage through alternative flow pathways.

FEMA Flood Zones

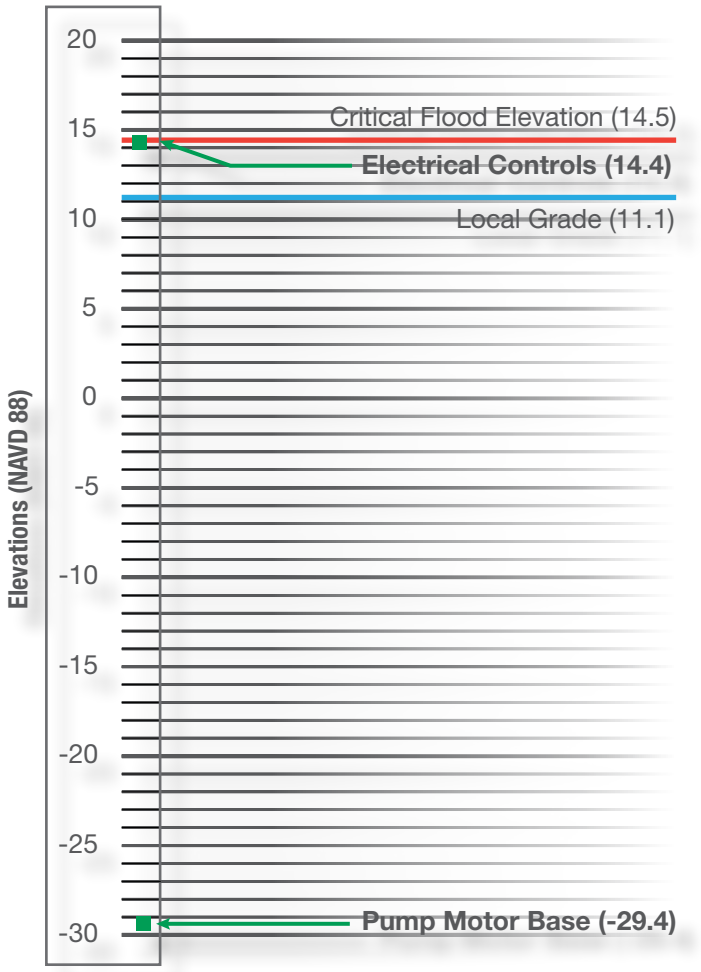




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	13.0
	Affected Area (Acres)	1,099
Risk	Population in Affected Area	17,940
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	4
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Sandbagging
	Cost of Protective Measures[1]	$40,000
	Damage Cost for Critical Flood without Protection[1, 2]	$6,500,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$28,431,000
	Resiliency Level	Moderate-Low

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Access hatch in roadway at dead-end of Melvin Avenue

Recommended Adaptation Strategy: **Elevated Electrical in New Building & Submersible Pump Motors**

Adaptation Cost: **$2,539,000**

Melvin Avenue Pumping Station

STATION CHARACTERISTICS

The Melvin Avenue sanitary pumping station is located underneath the roadway at the dead end of Melvin Avenue where the road abuts Schmul Park. There is one hatch in the road to access the wet well; the meter and what appear to be controls are mounted in a box on a telephone pole. Power is supplied by overhead lines.

The Pumping Station Summary table lists the general characteristics of the Melvin Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 9 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy nearby areas flooded to a depth of more than 3 feet above grade. The Melvin Avenue pumping station also has a history of flooding due to smaller events.

RISK ASSESSMENT

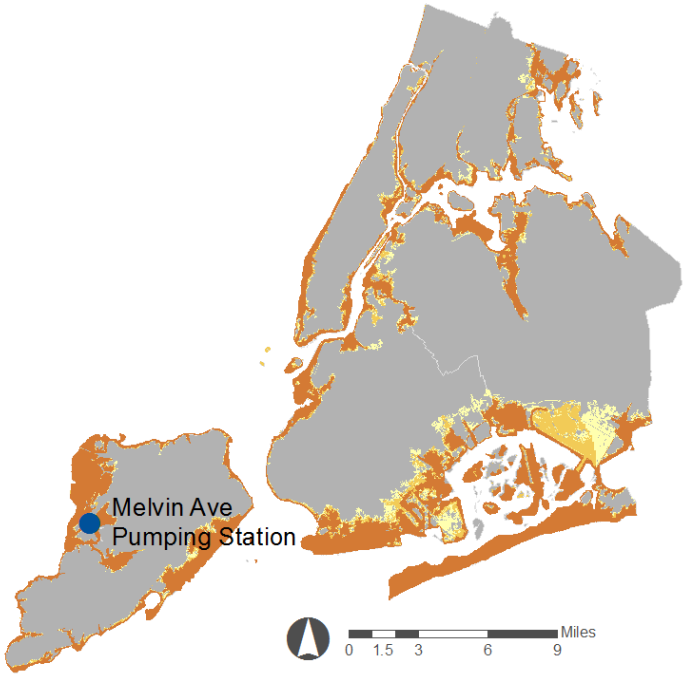
The risk of the Melvin Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the data available in the plan drawings.

The critical flood elevation would be 8 feet above local grade. This would reach beyond the above grade controls, damaging them, and it would completely inundate the below grade portion of the station, also damaging the non-submersible pumps.

ADAPTATION STRATEGIES

The Melvin Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the station's current vulnerability, the extreme depth of the critical flood, and available space nearby, the recommended strategy at Melvin Avenue is to elevate electrical controls in a new building and install submersible pumps. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

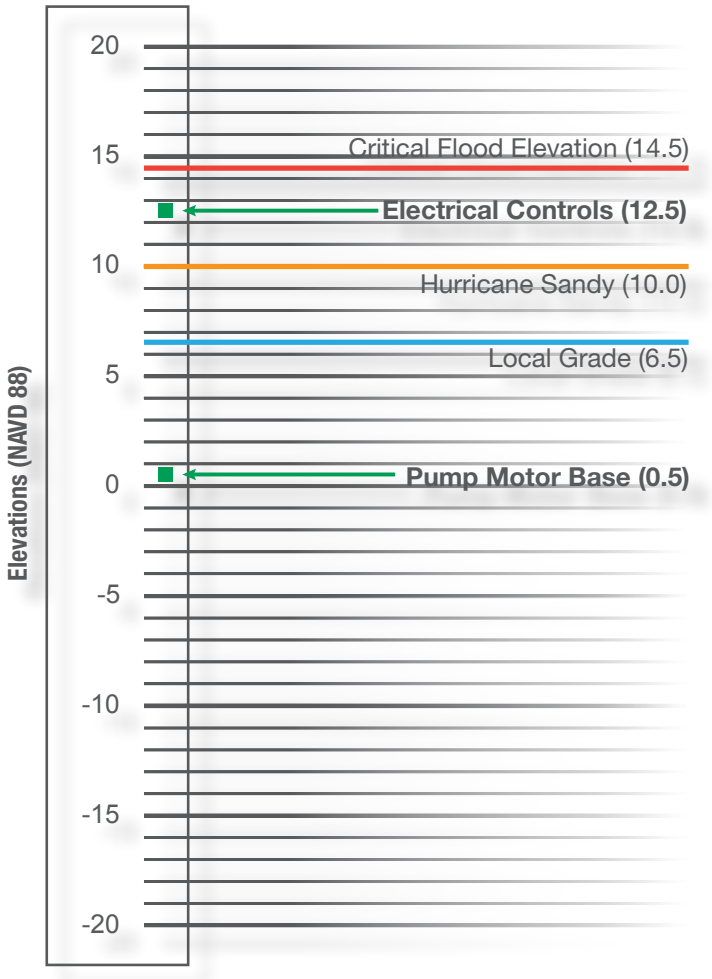
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	0.3
	Affected Area (Acres)	9
Risk	Population in Affected Area	90
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building & Submersible Pump Motors
	Cost of Protective Measures[1]	$2,539,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,775,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$9,135,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Generator plug and new pump controls panel loacated above grade

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$2,420,000**

Nautilus Court Pumping Station

STATION CHARACTERISTICS

The Nautilus Court combined pumping station is at the eastern end of Cliff Street near Nautilus Court on Staten Island. The pumping station is almost entirely below grade and located approximately 100 feet from the banks of The Narrows, leaving it vulnerable to flooding. The site consists of a flat asphalt surface with two access points to the pumping station: a hatch to access the electrical control vault and an open grate over the wet well, which houses three submersible pumps.

The Pumping Station Summary table lists the general characteristics of the Nautilus Court pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 374 acres with a population of approximately 8,000. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

Nautilus Court pumping station was completely inundated by the storm surge during Hurricane Sandy, which damaged the electrical controls. DEP indicated there is also a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

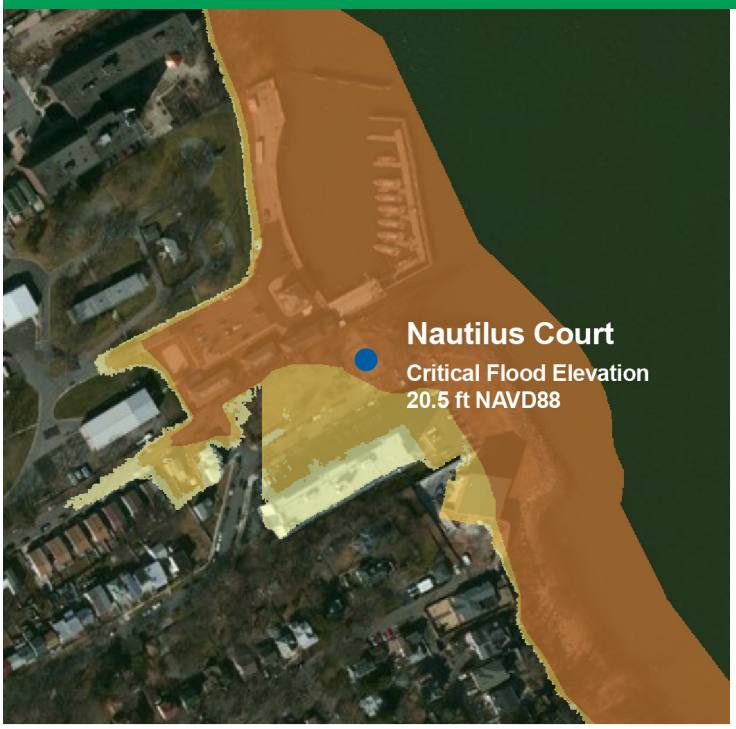
The risk of the Nautilus Court pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the property to view the station's components.

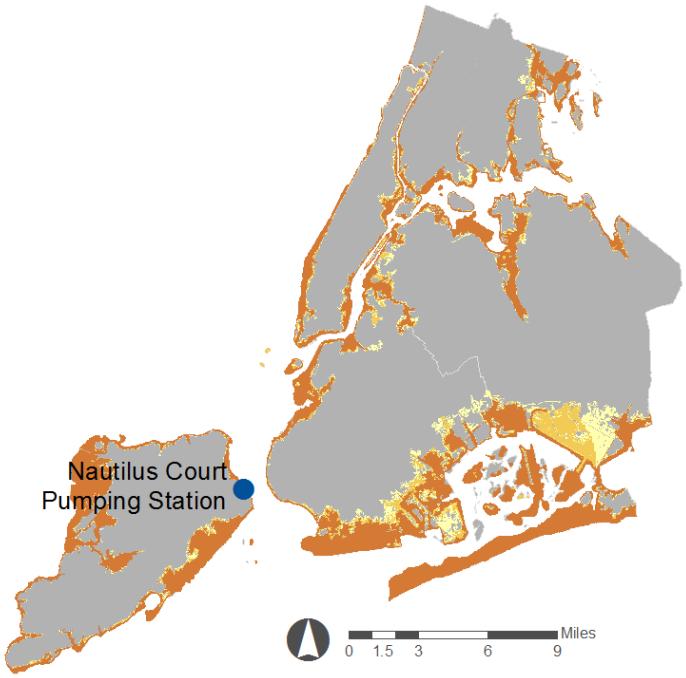
The critical flood elevation would inundate the area surrounding the facility with over 12 feet of water. This would damage electrical controls but would not affect the submersible pumps. The Nautilus Court pumping station is connected to another station; however it discharges to it rather than receiving flow. Therefore, loss of function at Nautilus Court does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Nautilus Court pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the lack of an existing structure and the extreme depth of the critical flood, the recommended strategy at Nautilus Court is to elevate electrical controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

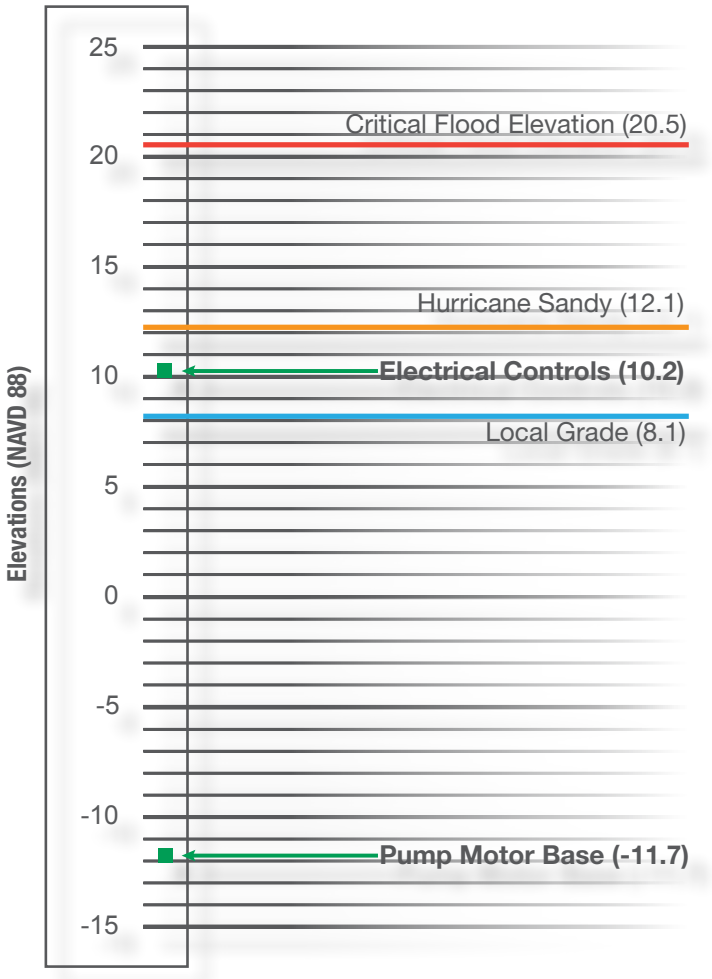




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	0.9
	Affected Area (Acres)	374
Risk	Population in Affected Area	8,053
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,420,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,275,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$16,851,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Pumping station running on bypass due to damage from Hurricane Sandy

Recommended Adaptation Strategy: **Elevate Electrical on Wall**

Adaptation Cost: **$1,091,000**

Nevins Street Pumping Station

STATION CHARACTERISTICS

The Nevins Street combined pumping station is located on Nevins Street, east of Degraw Street in Brooklyn. It is completely below grade, under the sidewalk on Nevins Street and adjacent to the handball courts at the Thomas Greene playground. Access to the station is provided through hatches in the sidewalk. A 4½ foot high wall runs behind the pumping station, separating the sidewalk from the handball courts.

The Pumping Station Summary table lists the general characteristics of the Nevins Street station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a primarily area. Failure of the station would affect an area of approximately 34 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

Nevins Street pumping station was completely inundated by the storm surge during Hurricane Sandy, which flooded the electrical controls. DEP employees estimated that this station was under 8–10 feet of water during the storm. DEP indicated there is also a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

The risk of the Nevins Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the property to view the station's components.

The critical flood elevation would inundate the area surrounding the facility with over 5 feet of water. This would damage electrical controls but would not affect the submersible pumps. The Nevins Street pumping station is connected to another station; however it discharges to it rather than receiving flow. Therefore loss of function at Nevins Street does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

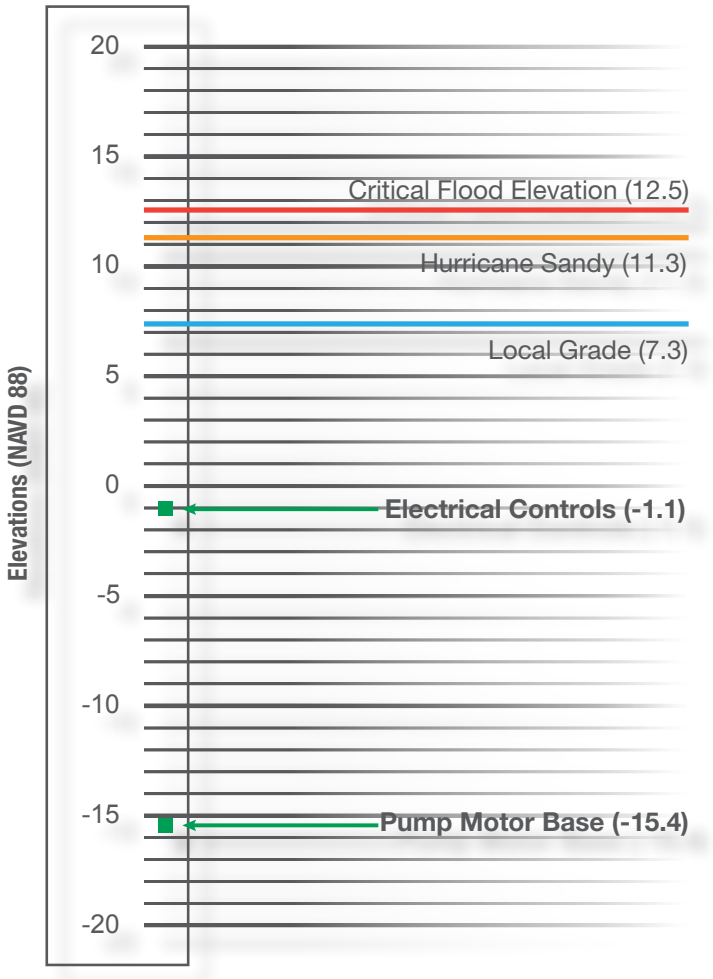
The Nevins Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to limited available space and the extreme depth of the critical flood, the recommended strategy at Nevins Street is to elevate electrical controls onto the nearby wall. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	2.2
	Affected Area (Acres)	34
Risk	Population in Affected Area	645
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical on Wall
	Cost of Protective Measures[1]	$1,091,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,311,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$6,747,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station in industrial-commercial area

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad**

Adaptation Cost: **$5,562,000**

New York Times Pumping Station

STATION CHARACTERISTICS

The New York Times sanitary pumping station is located near the corner the Whitestone Expressway service road and Linden Place in Queens, adjacent to the property surrounding the New York Times building. It is an entirely below grade station with access hatches in concrete slabs.

The Pumping Station Summary table lists the general characteristics of the New York Times pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in an industrial and commercial area. Failure of the station would affect an area of approximately 59 acres. There are no critical facilities within that area.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The New York Times pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

The risk of the New York Times pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

The critical flood elevation would be 6 feet above local grade, completely inundating the entire station. The electrical controls, which are below grade, would be flooded and damaged. The submersible pumps should withstand flooding.

ADAPTATION STRATEGIES

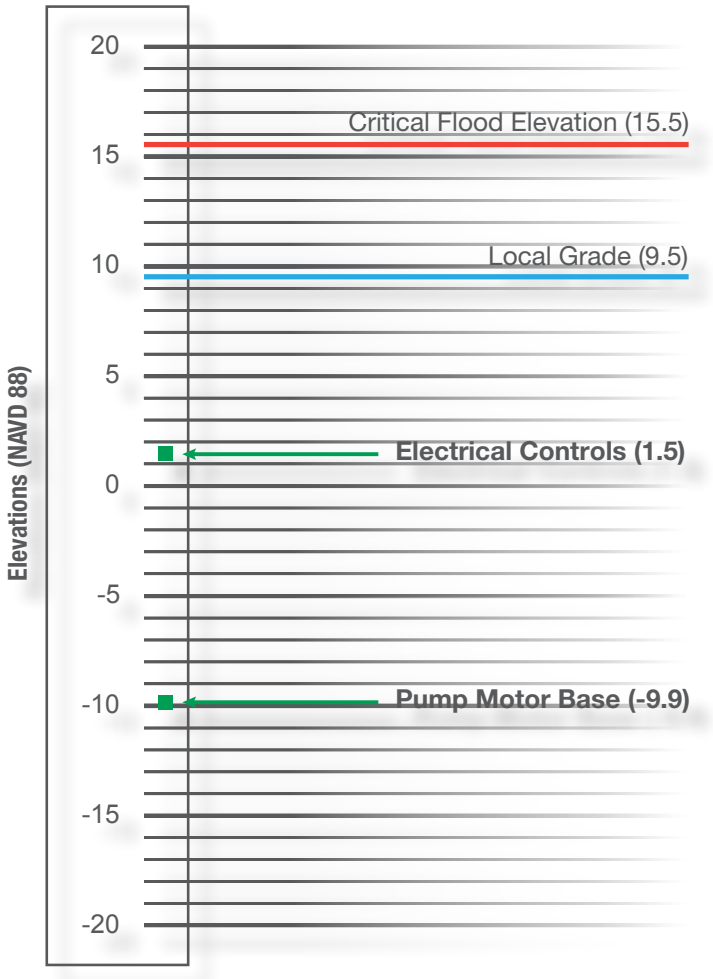
The New York Times pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because of the significant depth of the critical flood, the recommended strategy at New York Times is to elevate electrical controls on a platform. The installation of backup generators is also recommended. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	0.6
	Affected Area (Acres)	59
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$5,562,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,988,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$10,230,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Primary below grade pumping station adjacent to tidal wetlands

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad**

Adaptation Cost: **$738,000**

Old Douglaston Pumping Station

STATION CHARACTERISTICS

The Old Douglaston sanitary pumping station is located on park land, along the south side of Northern Blvd. and west of the intersection with 234th Street in Queens. The pumping station site is adjacent to wetlands. The station, rebuilt in 2010, is almost completely below grade.

The Pumping Station Summary table lists the general characteristics of the Old Douglaston pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial area surrounded by residentially zoned land. Failure of the station would affect an area of approximately 2,566 acres. There are 21 critical facilities within the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Old Douglaston pumping station was not inundated by the storm surge during Hurricane Sandy and does not have a history of flooding.

RISK ASSESSMENT

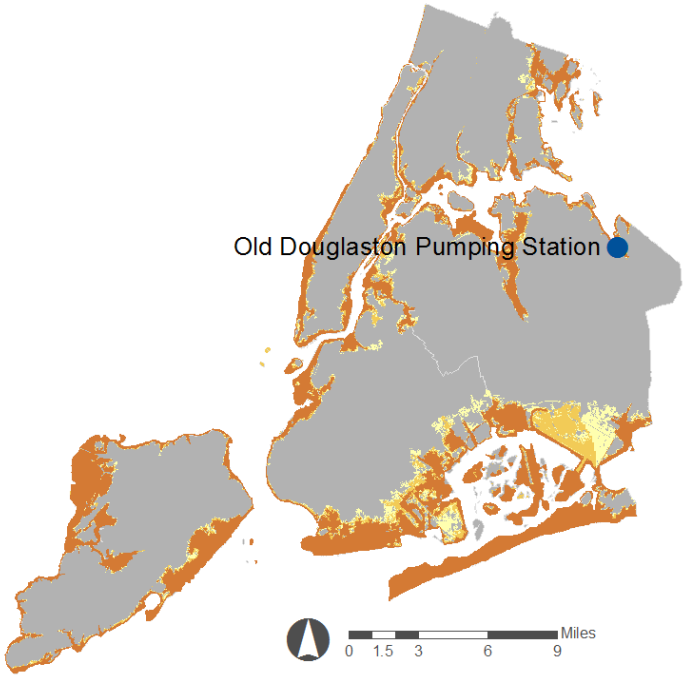
The risk of the Old Douglaston pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room, valve room, and dry well.

The critical flood elevation would inundate the area surrounding the facility with nearly 5 feet of water. This would damage electrical controls but would not affect the submersible pumps.

ADAPTATION STRATEGIES

The Old Douglaston pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. To achieve resiliency while respecting park structure limitations, the recommended strategy at Old Douglaston is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

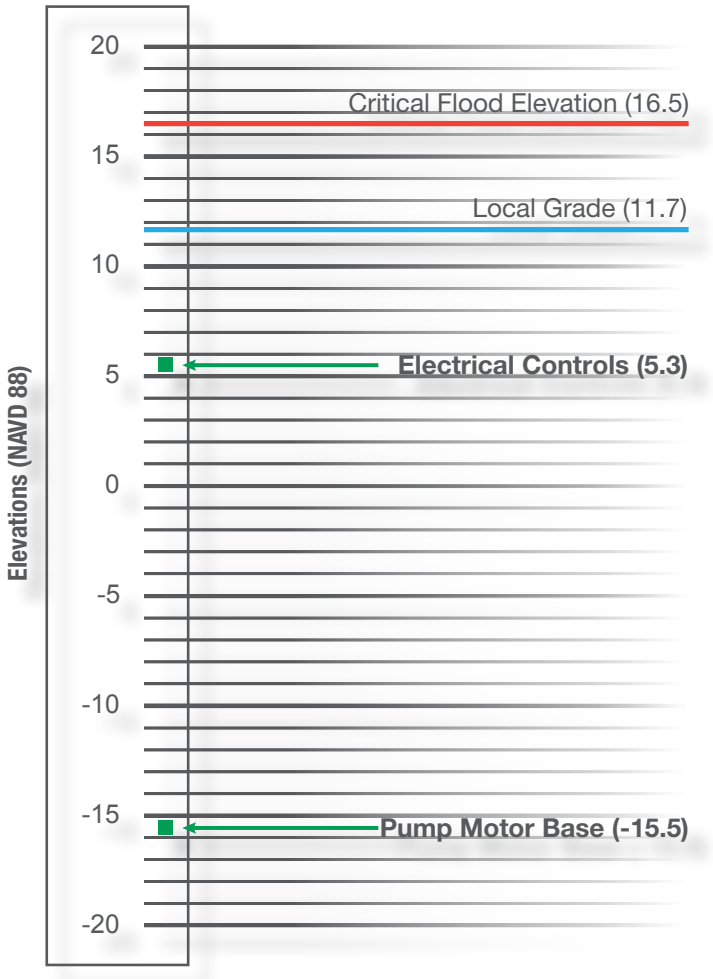
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	8.5
	Affected Area (Acres)	2,566
Risk	Population in Affected Area	58,400
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	21
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$738,000
	Damage Cost for Critical Flood without Protection[1, 2]	$4,071,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$20,951,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

New pumping station still under construction with transformer and panels above grade

Recommended Adaptation Strategy: **Elevate Electrical on a Platform/Pad**

Adaptation Cost: **$662,000**

Orchard Beach Pumping Station

STATION CHARACTERISTICS

The station is located in Pelham Bay Park near Orchard Beach in the Bronx. The Orchard Beach pumping station is a new station that was still under construction during the development of this report. The station consists of a wet well below grade and electrical components, including control panels and a high-voltage transformer, mounted above grade on a concrete and gravel structure.

The Pumping Station Summary table lists the general characteristics of the Orchard Beach pumping station, the potential effect of its failure, and the recommended adaptation strategy. Failure of the station would affect an area of approximately 81 acres. There are no critical facilities in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Orchard Beach pumping station experienced minor impacts from Hurricane Sandy but there is no other history of flooding at this location.

RISK ASSESSMENT

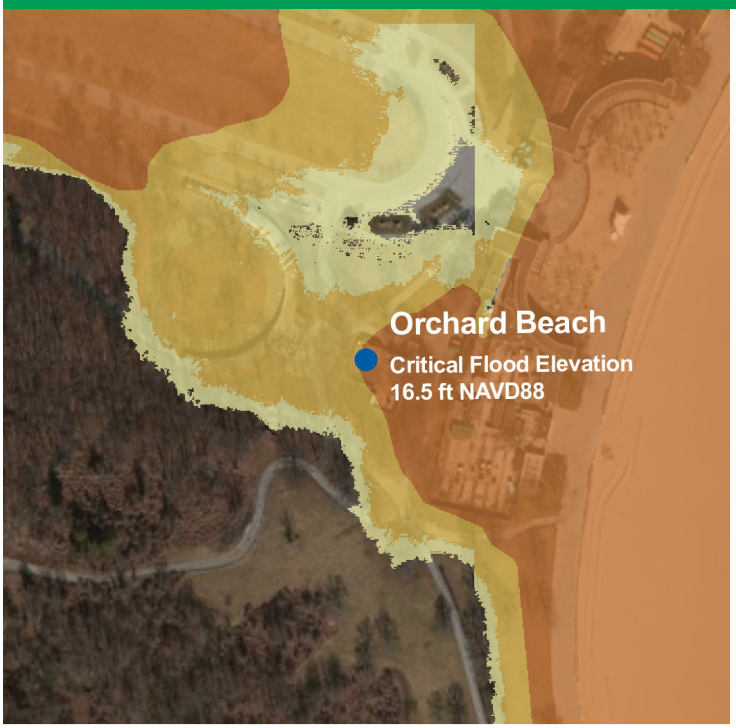
The risk of the Orchard Beach pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

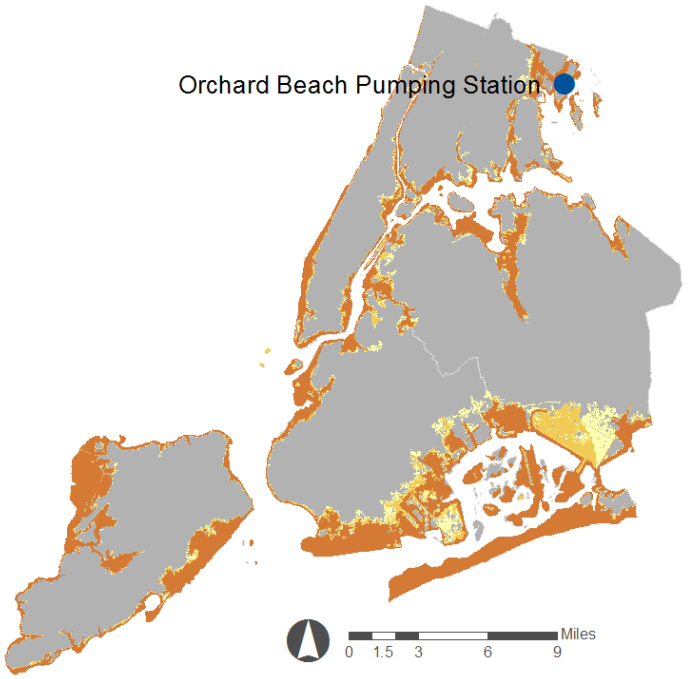
The critical flood elevation would inundate the area surrounding the facility with over 3 feet of water. This flood elevation would be just below electrical controls, but it would inundate the transformer. The submersible pumps would not be affected by a flood. There is a high wall between the beach and the pumping station that could reduce or slow inundation.

ADAPTATION STRATEGIES

The Orchard Beach pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because controls are currently exposed, the addition of a surrounding building does not appear to be necessary, but electrical equipment must be moved above the flood elevation. Therefore, the recommended strategy at Orchard Beach is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

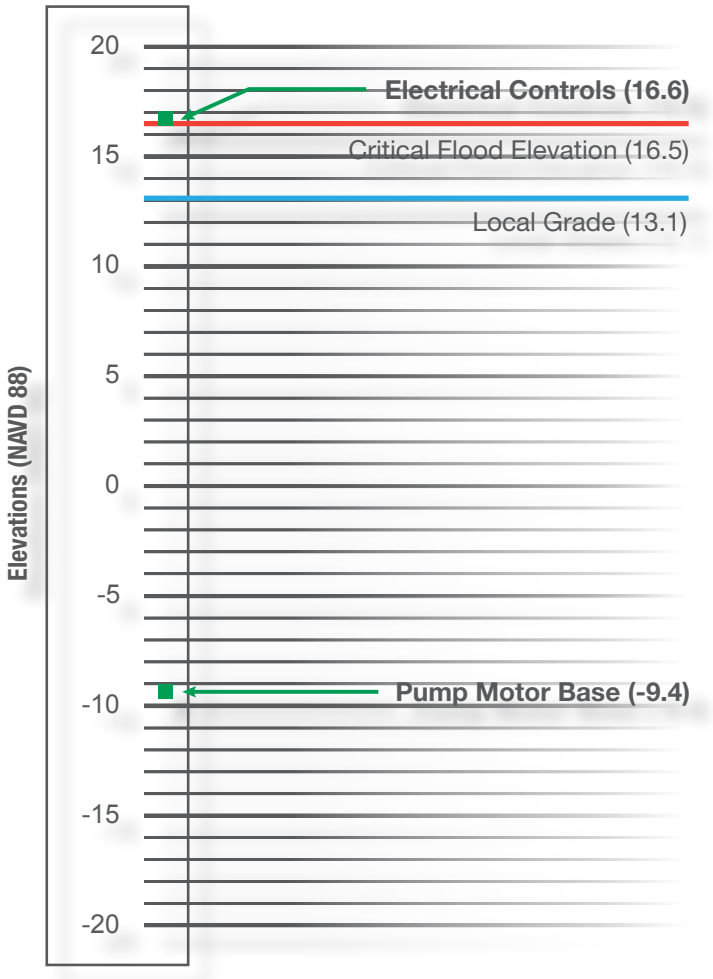




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

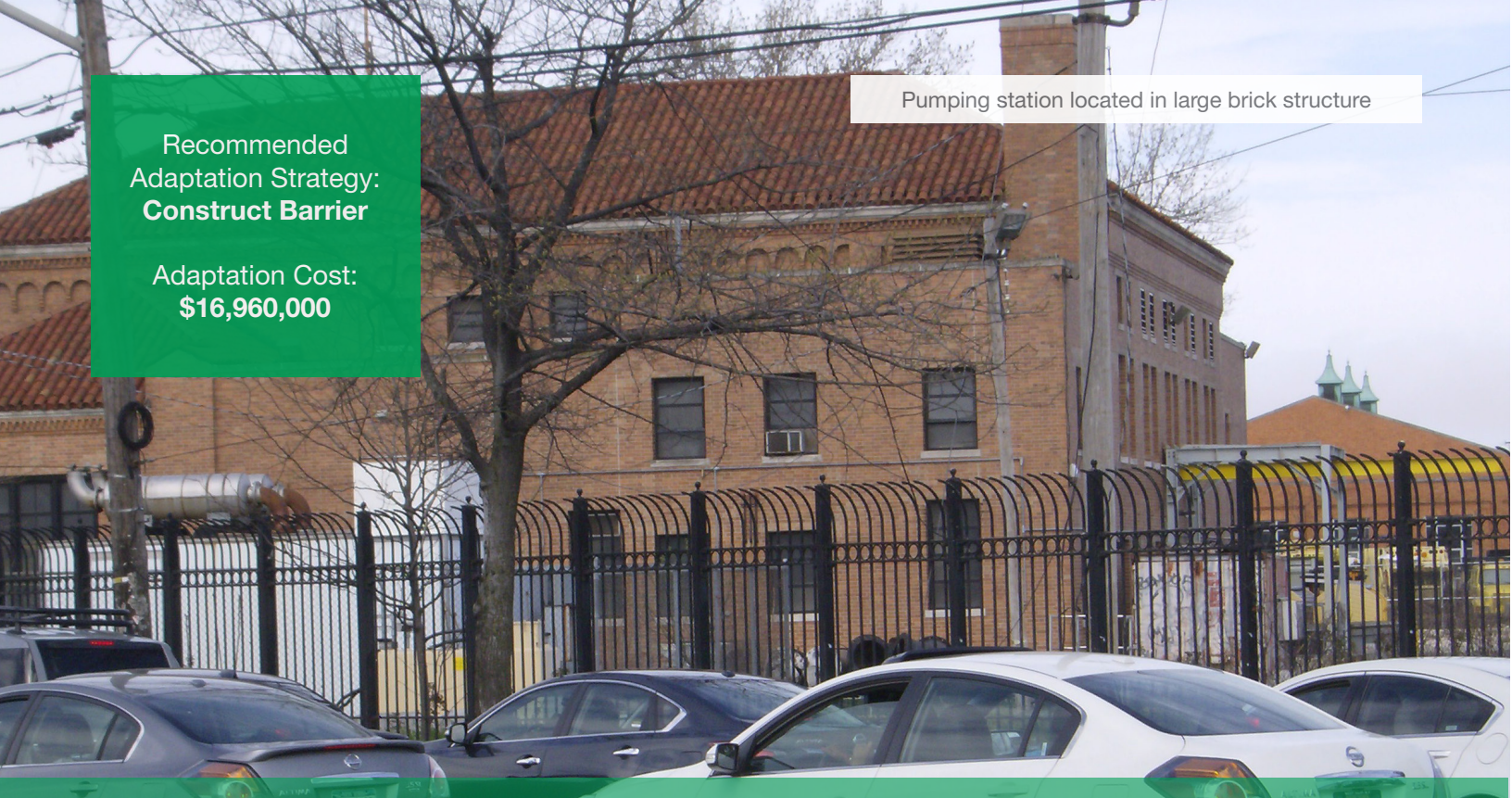
Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	0.9
	Affected Area (Acres)	81
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$662,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,147,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$3,053,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Pumping station located in large brick structure

Recommended Adaptation Strategy: **Construct Barrier**

Adaptation Cost: **$16,960,000**

Paerdegat Pumping Station

STATION CHARACTERISTICS

The Paerdegat combined pumping station is located at 6016 Flatlands Avenue in Brooklyn. The pumping station has a large brick structure that sits between the roadway and the Paerdegat Basin.

The Pumping Station Summary table lists the general characteristics of the Paerdegat pumping station, the potential effect of its failure, and the recommended adaptation strategy. Failure of the station would affect an area of approximately 2,200 acres and a population of nearly 130,000. There are 83 critical facilities within that area and a nearby bathing beach would also be affected.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Paerdegat pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

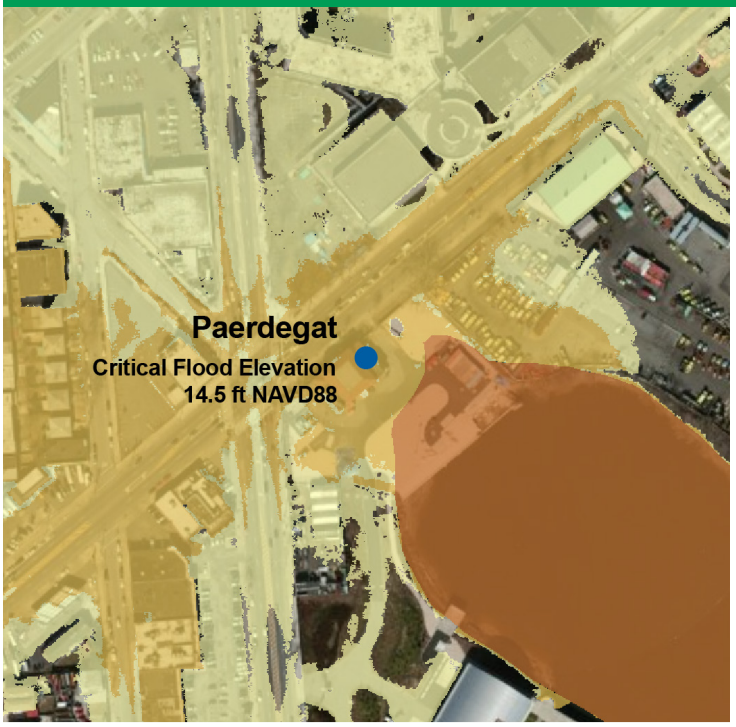
The risk of the Paerdegat pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

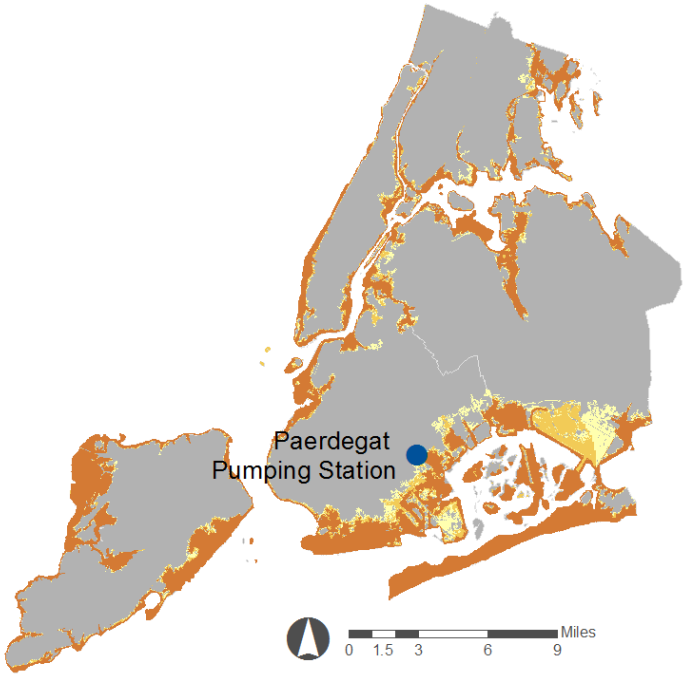
The critical flood elevation would be approximately 2.5 feet above local grade. Electrical controls are located on the main floor of the structure, above grade but a few inches below the flood elevation. Non-submersible pumps are located below grade. The Paerdegat pumping station receives flow from another station. Therefore, loss of function at Paerdegat increases the vulnerability of an additional pumping station, tributary area, and population.

ADAPTATION STRATEGIES

The Paerdegat pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because the extensive controls would be difficult to relocate, the recommended strategy at Paerdegat is to construct a barrier around the station. The installation of backup generators is also recommended. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change, or alternative pathways for floodwaters.

FEMA Flood Zones

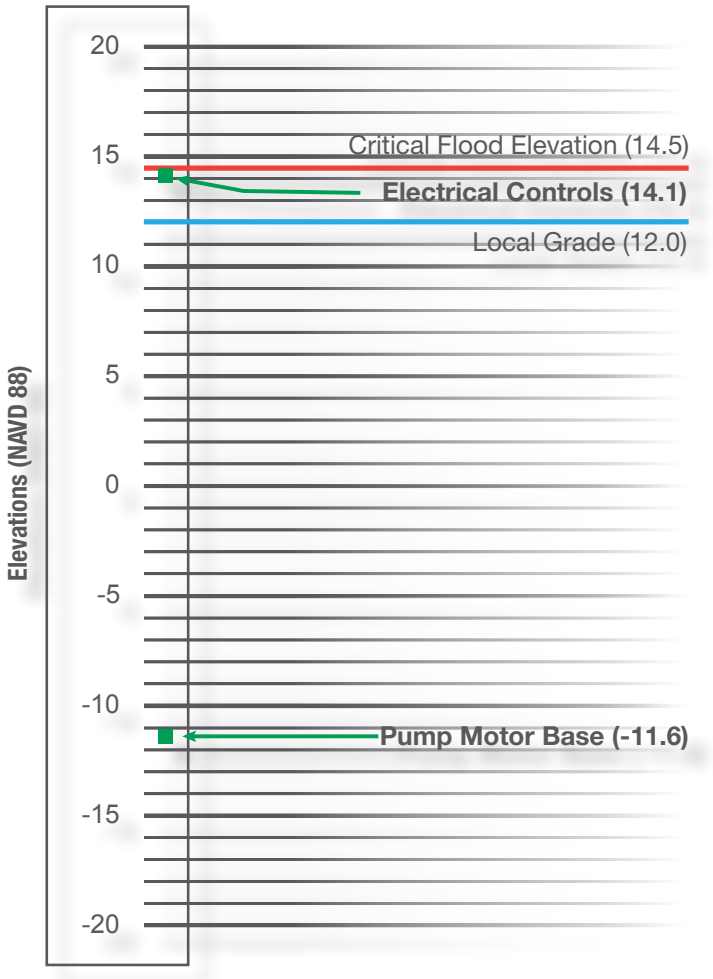




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Non-submersible
	Operating Capacity (MGD)	57.0
	Affected Area (Acres)	2,226
Risk	Population in Affected Area	128,903
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	83
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Construct Barrier
	Cost of Protective Measures[1]	$16,960,000
	Damage Cost for Critical Flood without Protection[1, 2]	$15,409,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$19,205,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure atop small mound; property between commercial area and wetlands

Recommended Adaptation Strategy: **Sandbagging**

Adaptation Cost: **$11,000**

Richmond Hill Road Pumping Station

STATION CHARACTERISTICS

The Richmond Hill Road sanitary pumping station is located at the dead end of Richmond Hill Road near the intersection with Richmond Avenue on Staten Island. The property borders the tidal wetlands of the William T. Davis Wildlife Refuge. The pumping station's substantial structure is located atop a small mound of land. Transformers and a generator fuel tank sit outside the station within its fenced-in lot.

The Pumping Station Summary table lists the general characteristics of the Richmond Hill Road pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial area adjacent to open wetlands. Failure of the station would affect an area of approximately 894 acres and a population of more than 23,000. There are six critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Richmond Hill Road pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

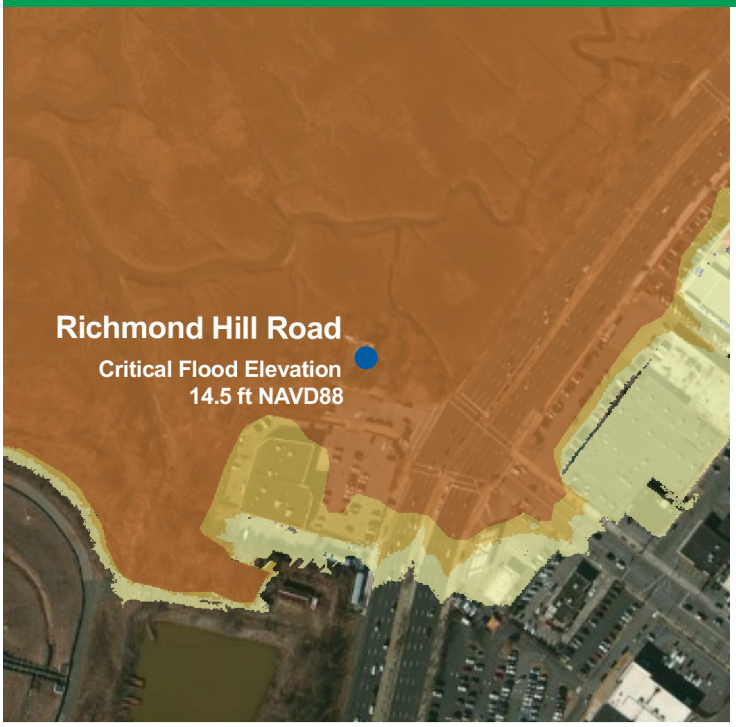
The risk of the Richmond Hill Road pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

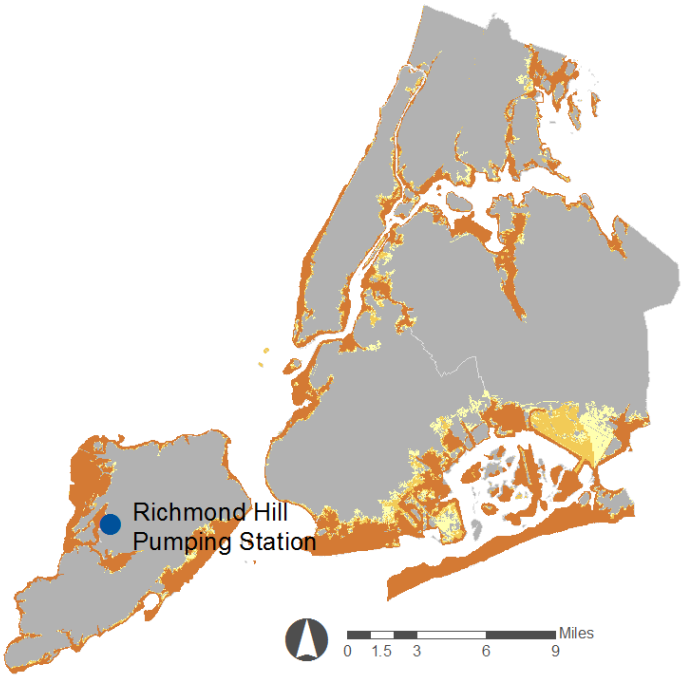
The critical flood elevation would be about an inch above local grade. Because the electrical controls and non-submersible pumps are located below grade, infiltration along piping and through well walls could potentially enter the building and damage those components.

ADAPTATION STRATEGIES

The Richmond Hill Road pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the shallow depth of the critical flood and the substantial existing structure, the recommended strategy at Richmond Hill Road is to place sandbags around potential water entry points prior to flooding events. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change, or from sandbags being stacked improperly or disturbed by residents. Because the property is fenced in, sandbags are unlikely to be disturbed.

FEMA Flood Zones

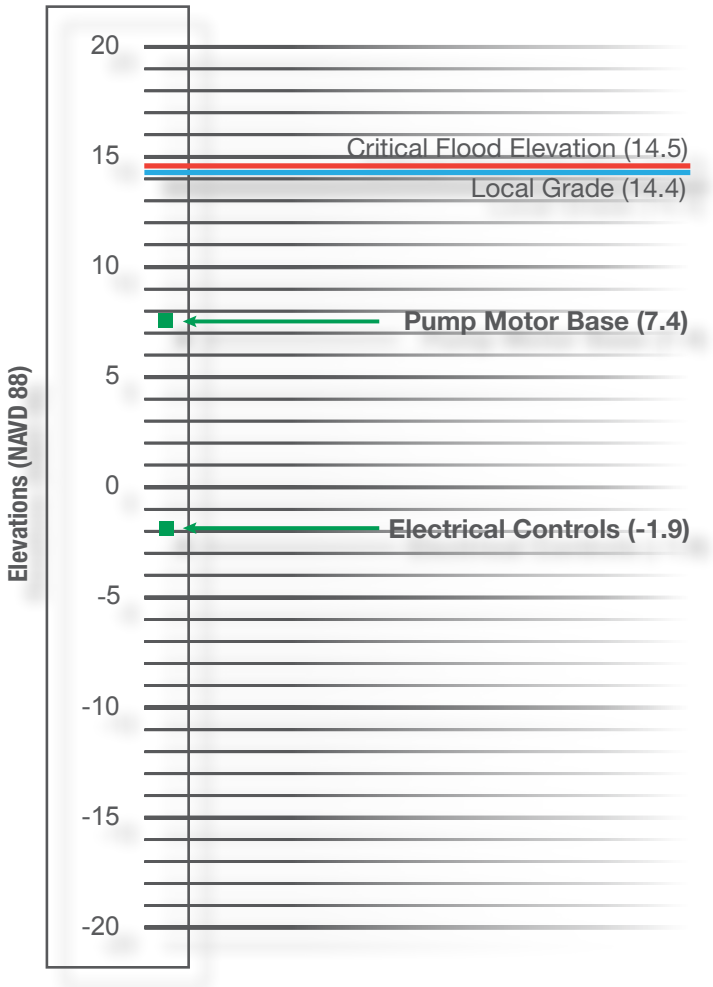




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

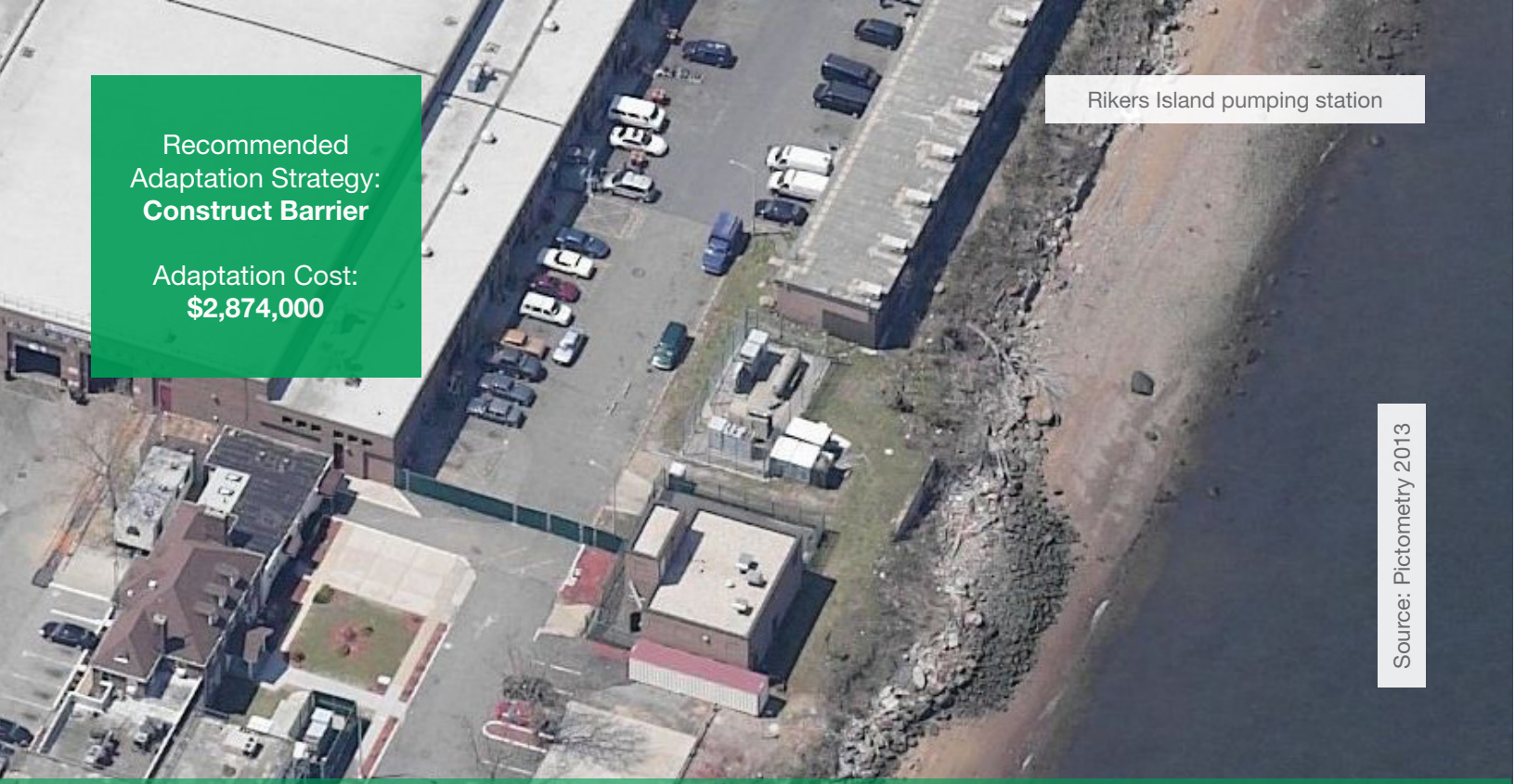
Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	6.1
	Affected Area (Acres)	894
Risk	Population in Affected Area	23,188
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	6
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Sandbagging
	Cost of Protective Measures[1]	$11,000
	Damage Cost for Critical Flood without Protection[1, 2]	$5,490,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$1,201,000
	Resiliency Level	Moderate-Low

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Rikers Island pumping station

Source: Pictometry 2013

Recommended Adaptation Strategy: **Construct Barrier**

Adaptation Cost: **$2,874,000**

Rikers Island North Pumping Station

STATION CHARACTERISTICS

The Rikers Island North pumping station is located on Rikers Island. It is just north of the warden's building and is nearly adjacent to the East River. The station has a structure above grade that houses electrical controls; the wells are beneath the structure. Due to its location, this site was not visited, and no pictures are currently available.

The Pumping Station Summary table lists the general characteristics of the Rikers Island North pumping station, the potential effect of its failure, and the recommended adaptation strategy. Failure of the station would affect an area of approximately 124 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Rikers Island pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

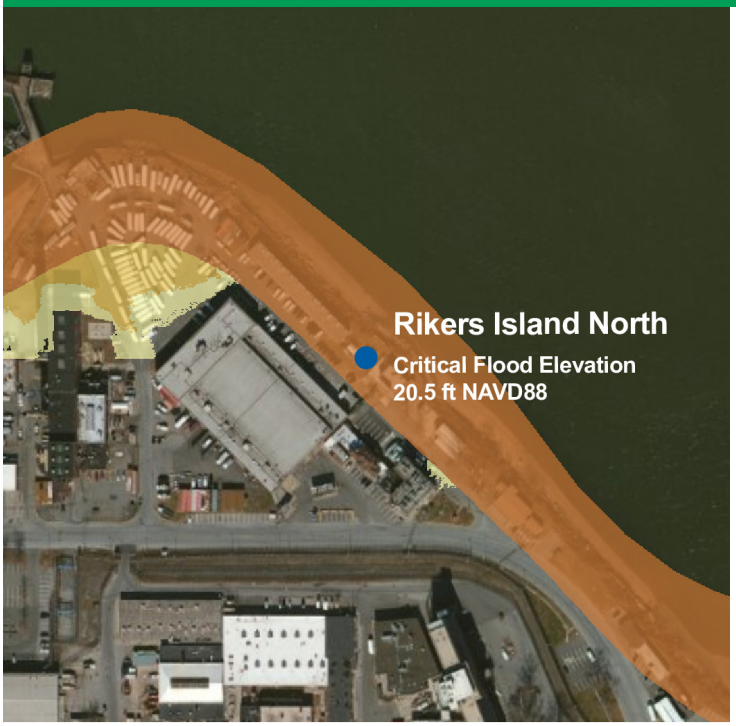
The risk of the Rikers Island North pumping station was assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation).

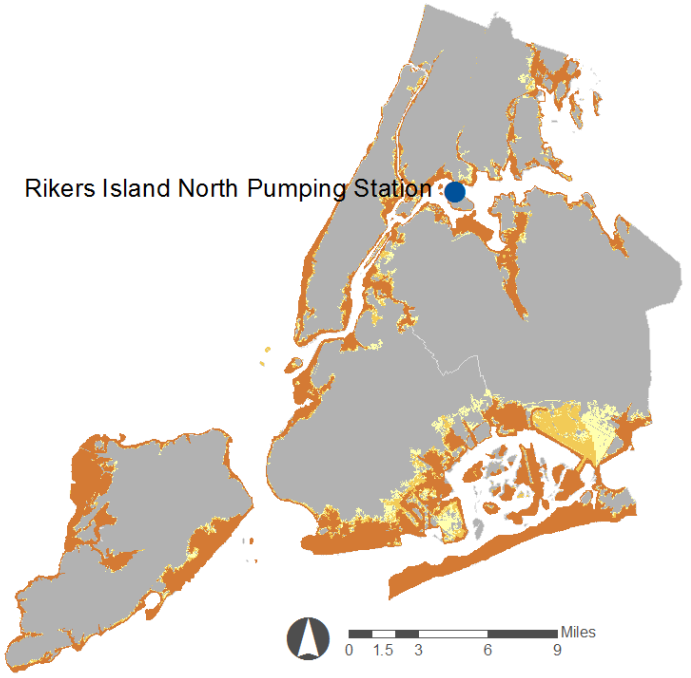
The critical flood elevation would be more than 3 feet above local grade. If water entered the building, the control room could be flooded to a depth of about 3 feet as well. This would damage the electrical controls. The submersible pumps should withstand flooding. The Rikers Island North pumping station is connected to another station; however it discharges to it rather than receiving flow. Therefore loss of function at Rikers Island North does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Rikers Island North pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. The recommended strategy at Rikers Island North is to construct a barrier to keep flood waters from reaching the station. The condition of the submersible pumps is not known. Onsite generators may also be required. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

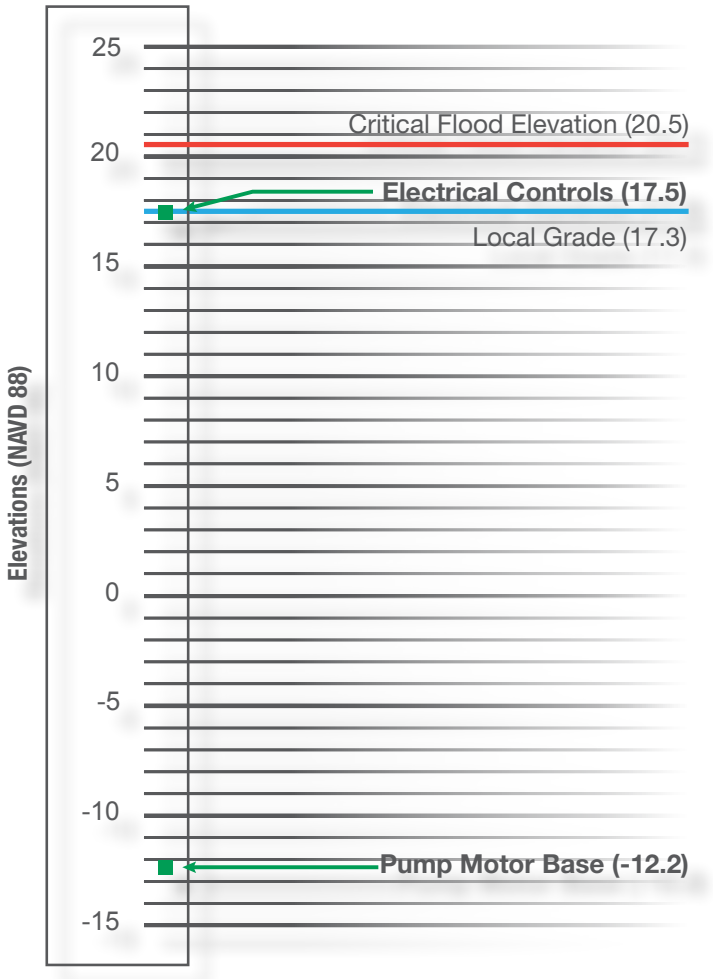




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	4.6
	Affected Area (Acres)	124
Risk	Population in Affected Area	0
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	Y
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Construct Barrier
	Cost of Protective Measures[1]	$2,874,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,140,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$6,354,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy:
Seal Building

Adaptation Cost:
$266,000

Structure with grade level entrances

Roosevelt Island Main Pumping Station

STATION CHARACTERISTICS

The Roosevelt Island Main sanitary pumping station is located within the Department of Sanitation facility off of Main Street on Roosevelt Island. The large superstructure has an electrical control room at grade where the main controls are housed. Submersible pumps and additional electrical controls are located below grade.

The Pumping Station Summary table lists the general characteristics of the Roosevelt Island Main pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located a commercial area surrounded by residential land use. Failure of the station would affect an area of approximately 20 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

There is no history of flooding at this station and the effects of Hurricane Sandy were limited to power outages.

RISK ASSESSMENT

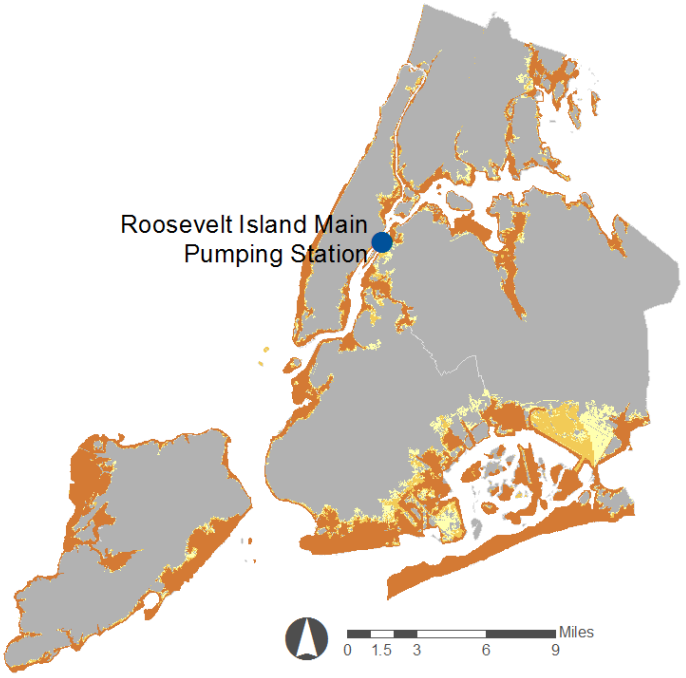
The risk of the Roosevelt Island Main pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room.

The critical flood elevation would inundate the area surrounding the facility with about 1.6 feet of water. This flood elevation could damage the electrical controls housed in the above grade structure as well as any electrical components below grade. The submersible pumps would not be affected by a flood. The Roosevelt Island Main pumping station receives flow from two additional stations. Therefore loss of function at Roosevelt Island Main increases the vulnerability of additional pumping stations, tributary areas, and populations.

ADAPTATION STRATEGIES

The Roosevelt Island Main pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing structure, the recommended strategy at Roosevelt Island Main is to seal the building. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to the potential for water pressure to exceed the rating of the sealing measures.

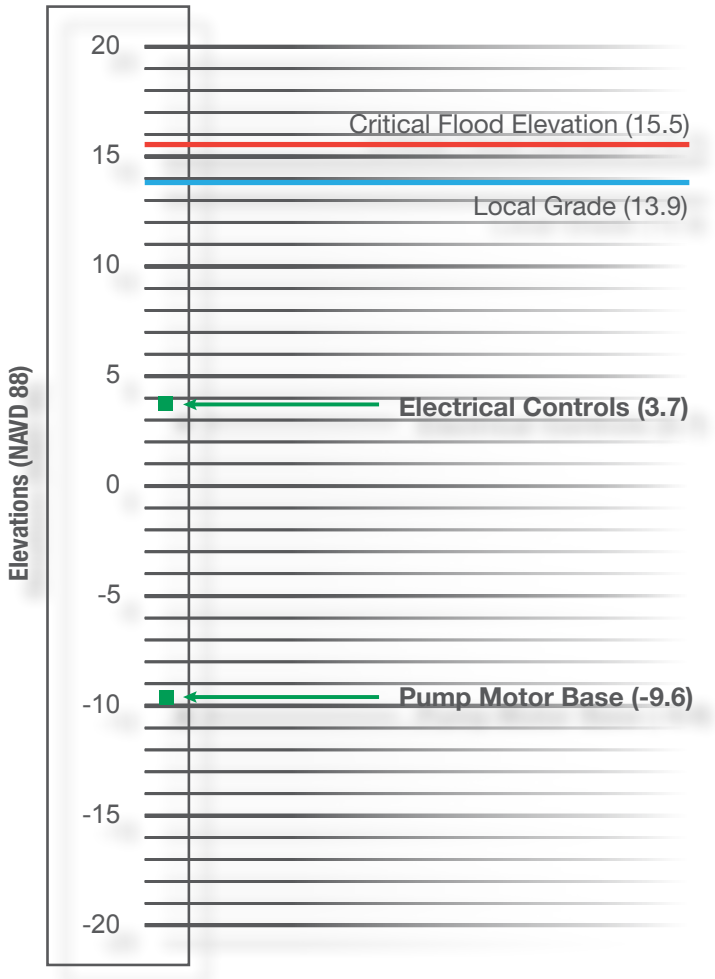
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	10.8
	Affected Area (Acres)	20
Risk	Population in Affected Area	5,239
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$266,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,015,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$698,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Small Structure for controls and hatch entryways to wells; East River in background

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$2,539,000**

Roosevelt Island North Pumping Station

STATION CHARACTERISTICS

The Roosevelt Island North sanitary pumping station is located at the southeast corner of the Coler Hospital property along East Road on Roosevelt Island. An above grade concrete structure houses the motor control center; the wells are accessible through grade-level hatches.

The Pumping Station Summary table lists the general characteristics of the Roosevelt Island North pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 26 acres and a population of over 22,000. There are seven critical facilities within the area.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Roosevelt Island North pumping station experienced minor impacts during Hurricane Sandy but there is no other history of flooding at this location.

RISK ASSESSMENT

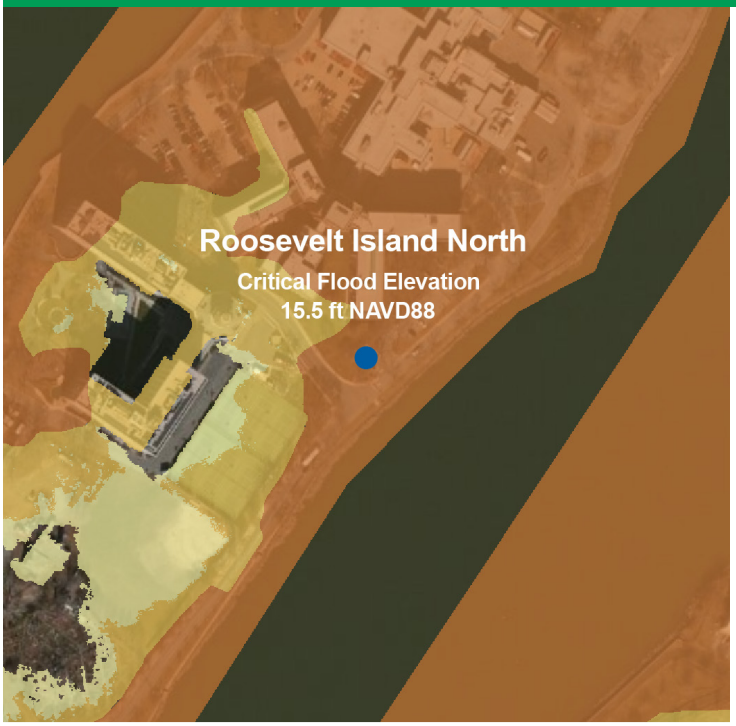
The risk of the Roosevelt Island North pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior confirmed that it appears consistent with the plan drawings.

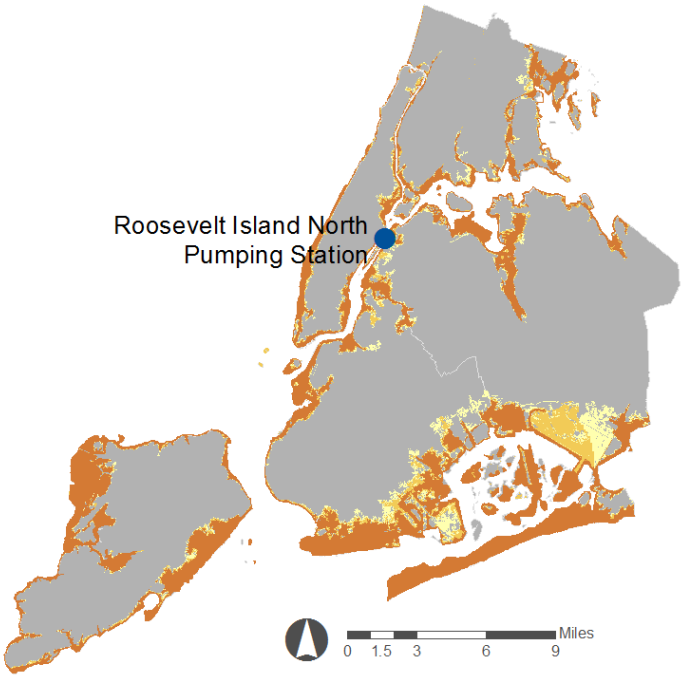
The critical flood elevation would be more than 6 feet above local grade, completely inundating the wells and the above grade control panels. This would damage the electrical controls, but the submersible pumps should be unaffected. The Roosevelt Island North pumping station is connected to another station; however it discharges to it rather than receiving flow. Therefore loss of function at Roosevelt Island North does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Roosevelt Island North pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the significant depth of the critical flood and the small size of the existing structure, the recommended strategy at Roosevelt Island North is to elevate electrical controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

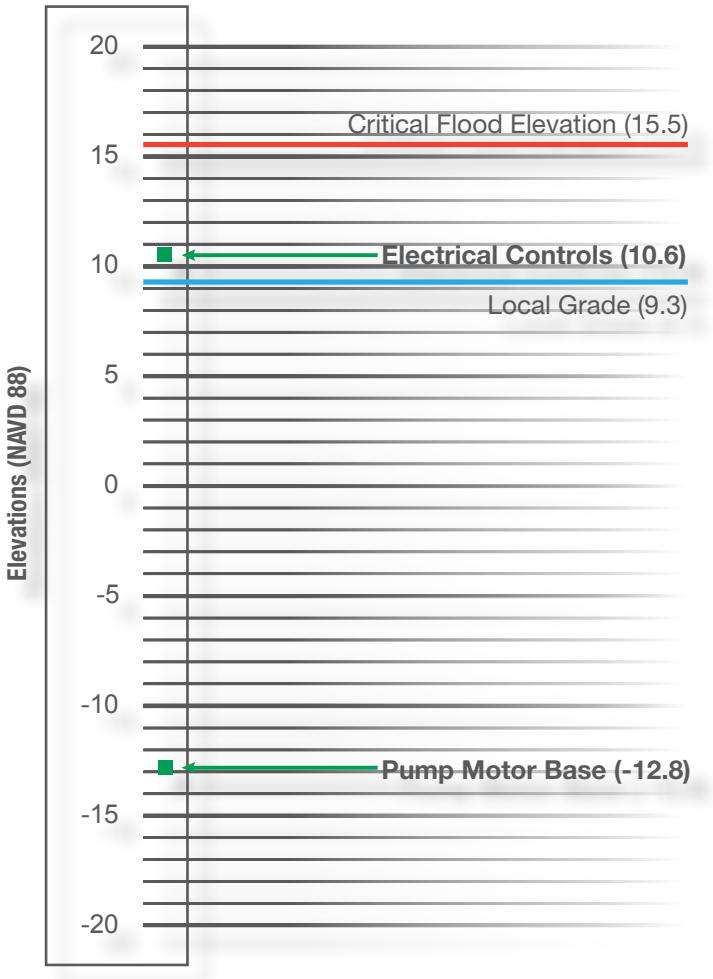




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	2.3
	Affected Area (Acres)	26
Risk	Population in Affected Area	22,045
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,539,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,663,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$8,560,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Small structure for controls and hatch entryways to wells; East River on left side of photo

Recommended Adaptation Strategy: **Seal Building**

Adaptation Cost: **$658,000**

Roosevelt Island South Pumping Station

STATION CHARACTERISTICS

The Roosevelt Island South sanitary pumping station is located at the corner of East Road and Road 3 behind the Goldwater Hospital on Roosevelt Island. The site is less than 100 feet from the open water of the East River. The electrical controls are housed above grade in a small brick superstructure, and there are hatch entryways to the wells.

The Pumping Station Summary table lists the general characteristics of the Roosevelt Island South pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 85 acres. There are seven critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, the door to the electrical control room was sandbagged, which prevented the shallow floodwaters from reaching critical electrical equipment. Though the station lost power, no damage occurred. There is no history of flooding due to smaller events.

RISK ASSESSMENT

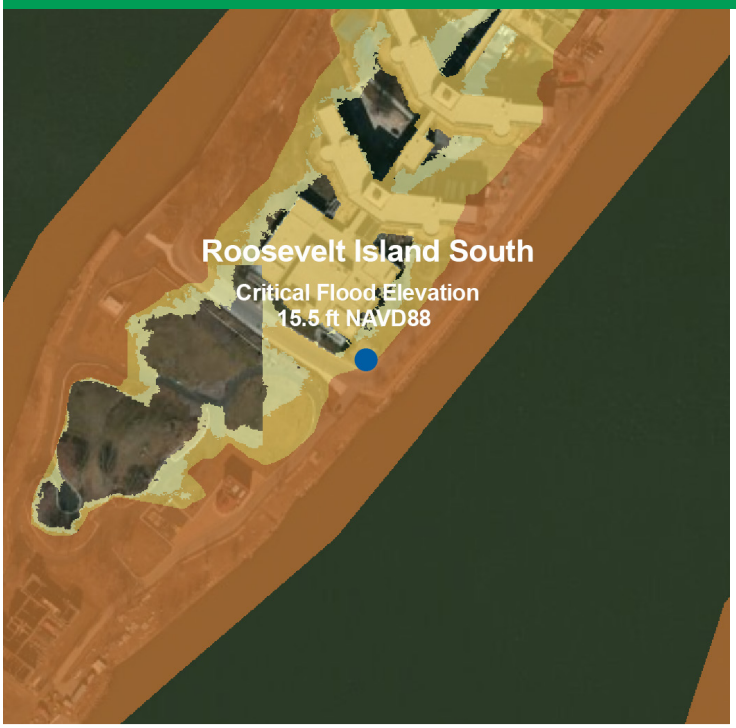
The risk of the Roosevelt Island South pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room.

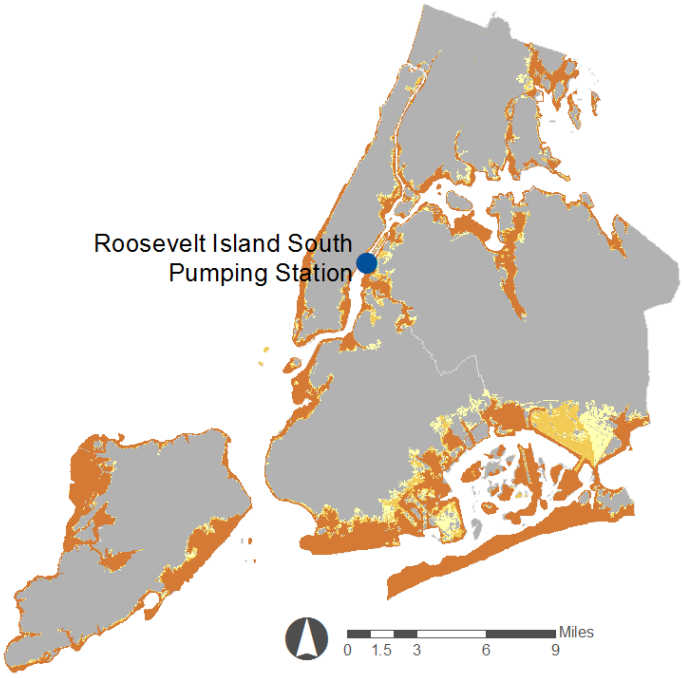
The critical flood elevation would inundate the area surrounding the facility with about 2.4 feet of water. This would damage the electrical controls house in the above grade structure as well as any electrical components below grade. The submersible pumps would not be affected by a flood. The Roosevelt Island South pumping station is connected to another station; however it discharges to it rather than receiving flow. Therefore loss of function at Roosevelt Island South does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Roosevelt Island South pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the shallow depth of the critical flood and the presence of an existing building to house controls, the recommended strategy at Roosevelt Island South is to seal the building. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to the potential for water pressure to exceed the rating of the sealing measures.

FEMA Flood Zones

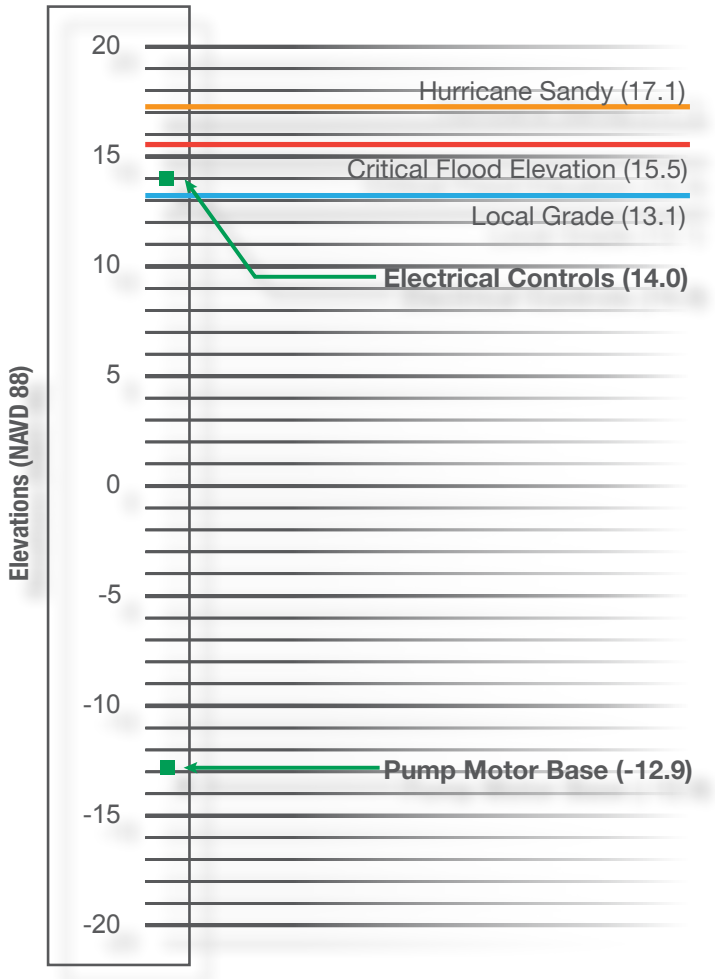




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	2.5
	Affected Area (Acres)	85
Risk	Population in Affected Area	22,631
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	7
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Seal Building
	Cost of Protective Measures[1]	$658,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,663,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$513,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station under construction due to Hurricane Sandy

Recommended Adaptation Strategy: **Elevate Electrical in New Building & Elevate Pump Motors**

Adaptation Cost: **$9,943,000**

Rosedale Pumping Station

STATION CHARACTERISTICS

The Rosedale sanitary pumping station is located near the intersection of 147th Avenue and 235th Street in Queens, on a flat parcel of land adjacent to Brookville Park. The edge of Conselyeas Pond, in the park, and the creek into which it drains, are just over 100 feet from the pumping station. Rosedale pumping station is completely below grade, with the exception of some ventilation equipment housed in an onsite brick structure. Damage from Hurricane Sandy prompted reconstruction, including replacing pump controls, sump pumps, ventilation and heating equipment, and compressors.

The Pumping Station Summary table lists the general characteristics of the Rosedale pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 990 acres. There are four critical facilities in the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

Rosedale pumping station was completely inundated by the storm surge during Hurricane Sandy, which damaged the electrical controls and non-submersible pump motors. DEP staff indicated there is also a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

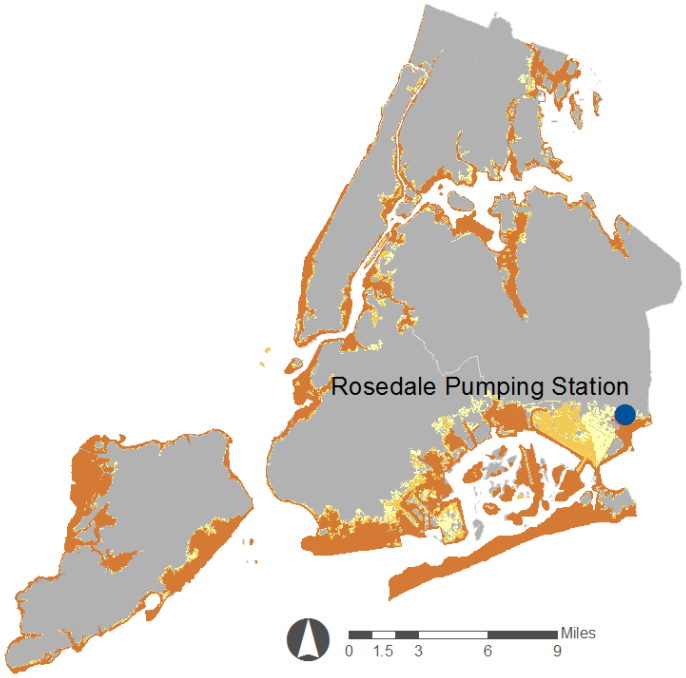
The risk of the Rosedale pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room.

The critical flood elevation would inundate the area surrounding the facility with over 4 feet of water. This would damage electrical controls and the non-submersible pump motors. The Rosedale pumping station receives flow from another pumping station. Therefore loss of function at Rosedale increases the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Rosedale pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the depth of the critical flood, the lack of an existing structure, and concerns about vandalism in the area, the recommended strategy at Rosedale is to elevate electrical controls and pump motors in a new building. Elevating pump motors and replacing existing motors with submersibles are both acceptable solutions, however elevating pump motors may be a more cost-effective adaptation for this pumping station. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

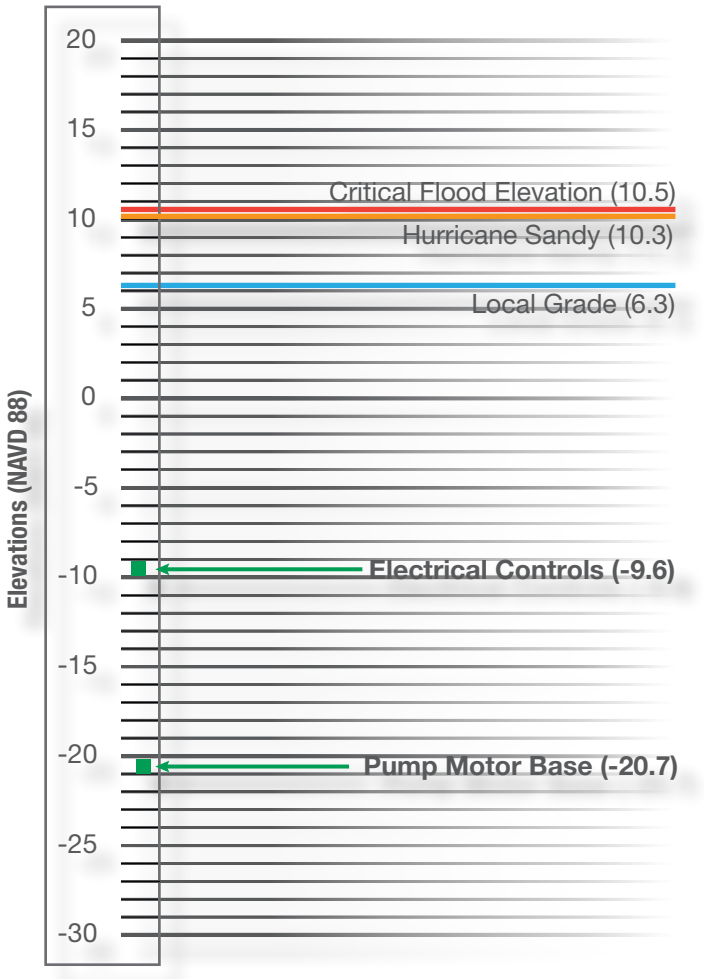
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	5.8
	Affected Area (Acres)	990
Risk	Population in Affected Area	17,683
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	4
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building & Elevate Pump Motors
	Cost of Protective Measures[1]	$9,943,000
	Damage Cost for Critical Flood without Protection[1, 2]	$5,216,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$26,842,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Recommended Adaptation Strategy: **Elevate Electrical on Platform/Pad**

Adaptation Cost: **$800,000**

Electrical control panel above grade; hatch entryways to wells

Sapphire Street Pumping Station

STATION CHARACTERISTICS

The Sapphire Street stormwater pumping station is located on Sapphire Street between Linden Boulevard and Dumont Avenue in Brooklyn, along the side of a minor street and adjacent to an empty lot. Sapphire Street is a small and simply designed station with two submersible pumps in a wet well surrounded by a fence. Electrical controls are elevated on a pole.

The Pumping Station Summary table lists the general characteristics of the Sapphire Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential/industrial area. Failure of the station would affect an area of approximately 1 acre. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

Though this station was not damaged during Hurricane Sandy, DEP staff indicated that overland flooding from stormwater runoff, predominantly from the vacant lot to the west, has been an issue at this station in the past. Evidence of this was found in the electrical control panel. The controls themselves have not been damaged, but flood waters have reached the bottom of the control panel housing and deposited debris there. The station's operation has not been affected by flooding and is therefore not considered to have a problem with historic flooding, but access to the station may be affected by localized flooding issues.

RISK ASSESSMENT

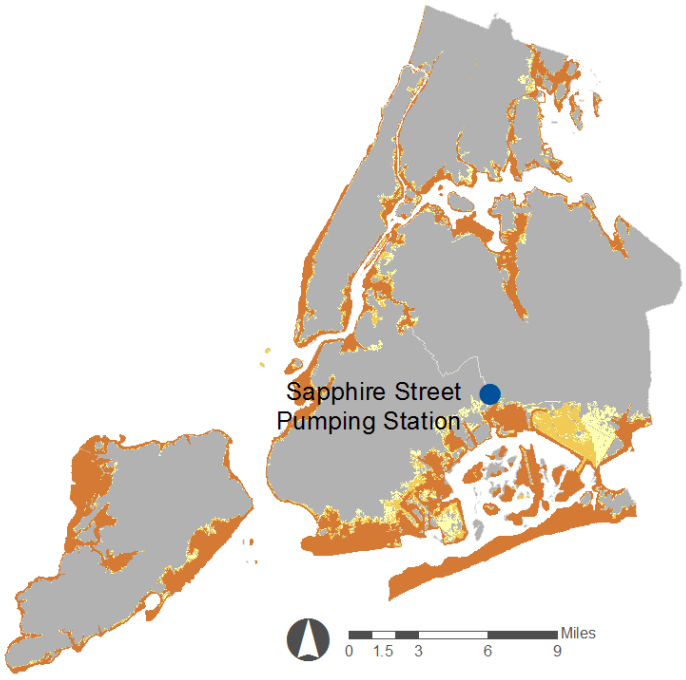
The risk of the Sapphire Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the property to view the station's components.

The critical flood elevation would inundate the area surrounding the facility with over 8 feet of water. This would damage electrical controls. Submersible pump motors would not be affected.

ADAPTATION STRATEGIES

The Sapphire Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because components are currently exposed above grade but need to be moved out of reach of potential flood waters, the recommended strategy at Sapphire Street is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

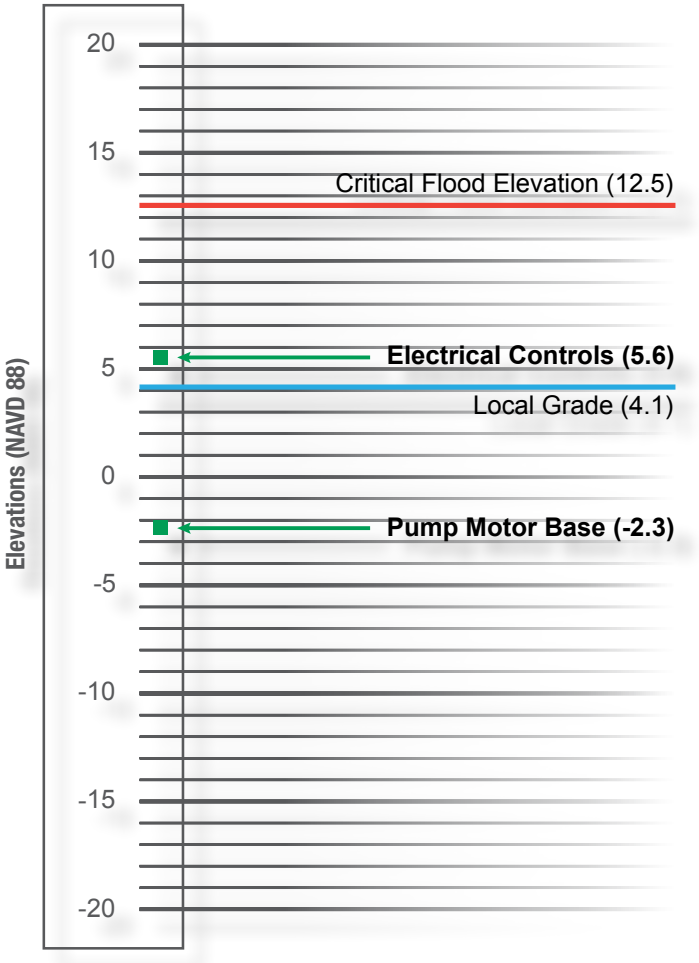
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Stormwater
	Pump Type	Submersible
	Operating Capacity (MGD)	<1MGD
	Affected Area (Acres)	1
Risk	Population in Affected Area	5
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on Platform/Pad
	Cost of Protective Measures[1]	$800,000
	Damage Cost for Critical Flood without Protection[1, 2]	$3,700,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$19,040,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Below grade pumping station under repair due to Hurricane Sandy damage

Recommended Adaptation Strategy: **Elevate Electrical in New Building & Submersible Pump Motors**

Adaptation Cost: **$2,304,000**

Seagirt Avenue Pumping Station

STATION CHARACTERISTICS

The Seagirt Avenue sanitary pumping station is located on the southwest corner of the intersection of Seagirt Avenue and Beach 9th Street, about 500 feet from the open water of Reynolds Channel. All critical electrical components and non-submersible motors are located on the below grade main floor of the onsite concrete superstructure. The pumping station may be accessed through a stairwell that runs from the top of the concrete structure into the station, as well as through hatches and vents on top of the structure.

The Pumping Station Summary table lists the general characteristics of the Seagirt Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 244 acres. There are seven critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Seagirt Avenue pumping station was not inundated by the storm surge during Hurricane Sandy, but loss of power caused the wet well to flood the station, damaging motors and the electrical controls in the process. There is no history of flooding due to smaller storms at this location.

RISK ASSESSMENT

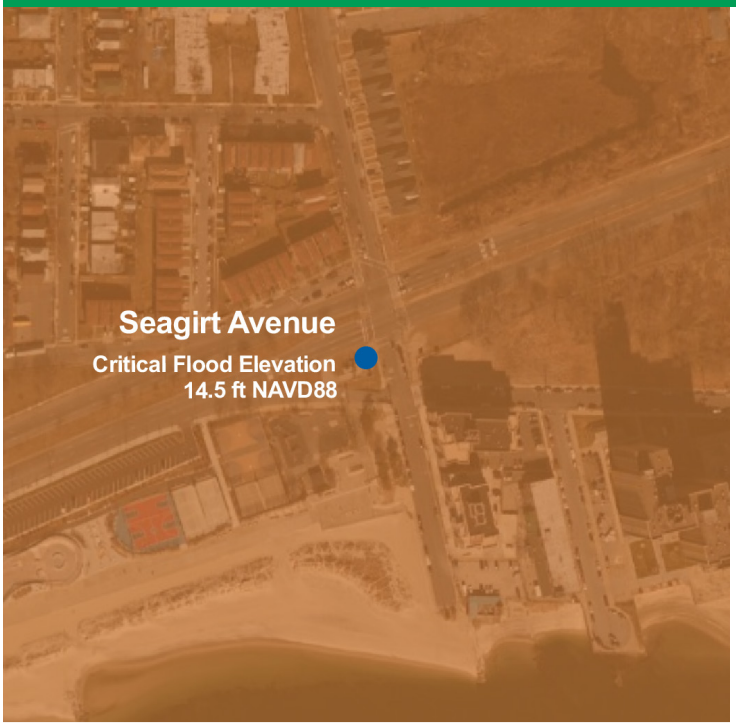
The risk of the Seagirt Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room.

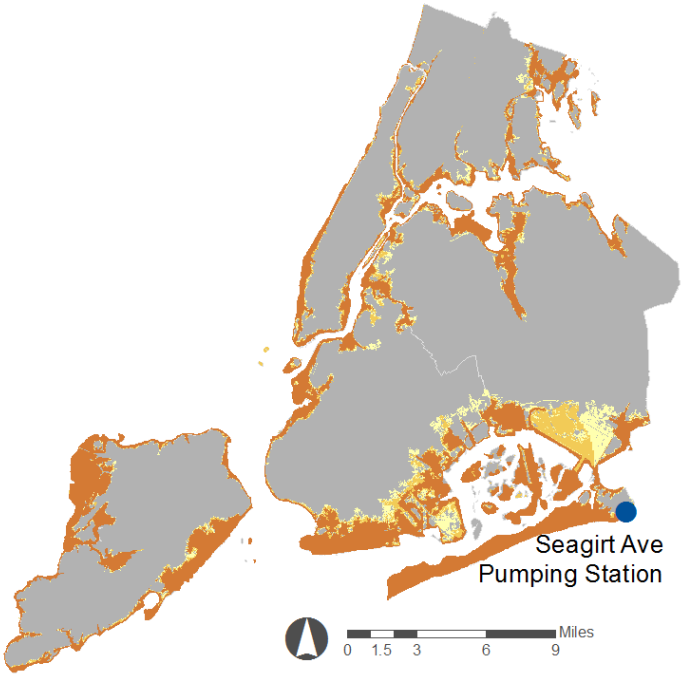
The critical flood elevation would inundate the area surrounding the facility with over 6 feet of water. This would damage electrical controls and pump motors.

ADAPTATION STRATEGIES

The Seagirt Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the significant depth of the critical flood, the recommended strategy at Seagirt Avenue is to elevate electrical controls in a new building. When pumps need to be replaced as part of regular maintenance, submersible pumps should be installed. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

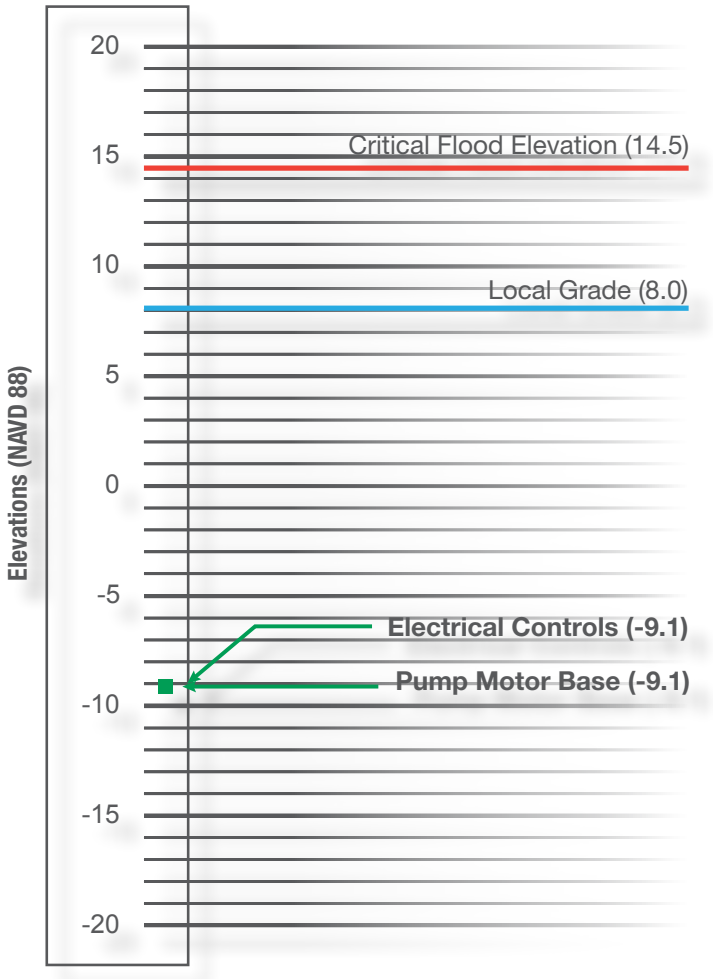




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

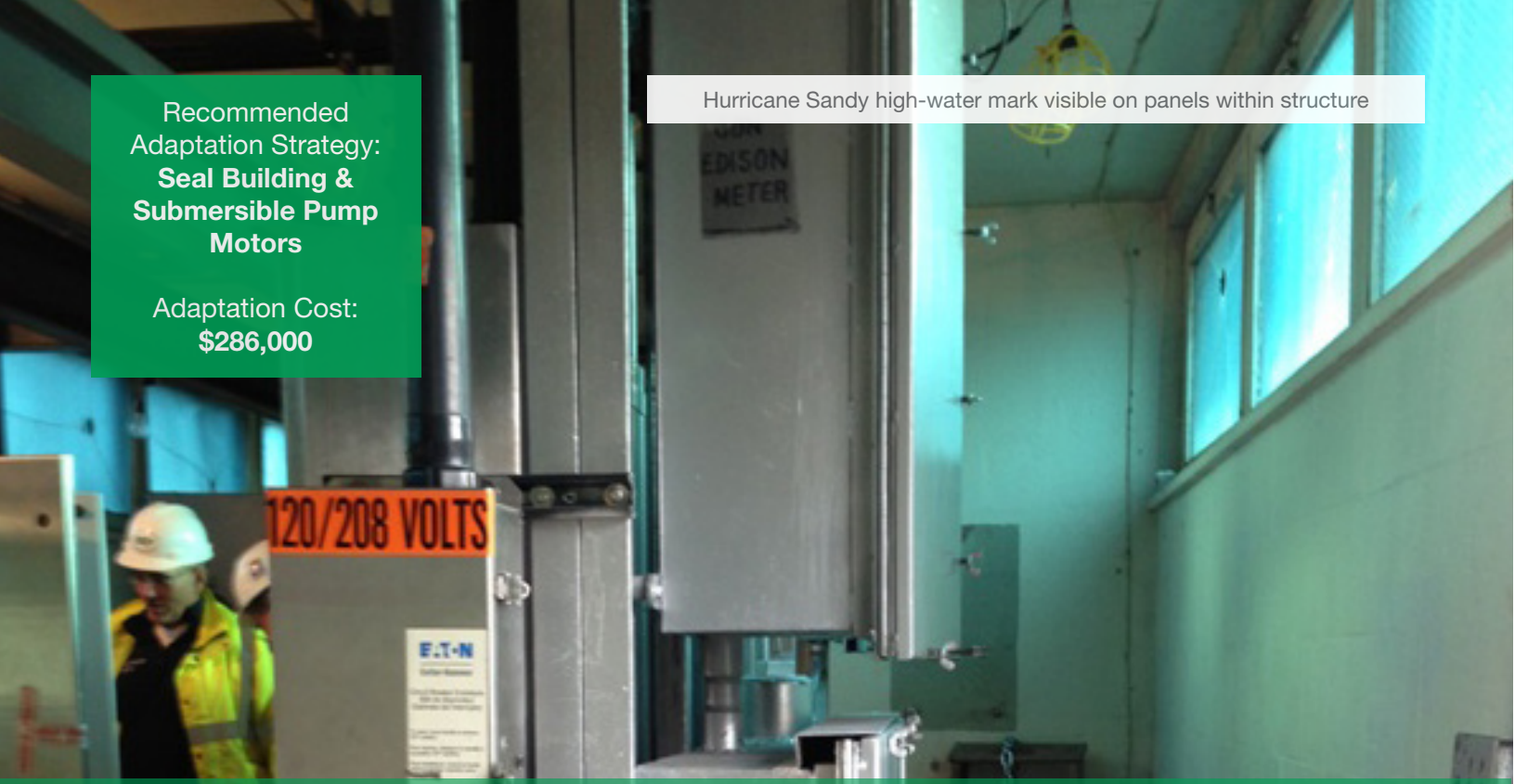
Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	6.5
	Affected Area (Acres)	244
Risk	Population in Affected Area	7,725
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	7
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building & Install Submersible Pump Motors
	Cost of Protective Measures[1]	$2,304,000
	Damage Cost for Critical Flood without Protection[1, 2]	$4,226,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$21,749,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Hurricane Sandy high-water mark visible on panels within structure

Recommended Adaptation Strategy: **Seal Building & Submersible Pump Motors**

Adaptation Cost: **$286,000**

South Beach Pumping Station

STATION CHARACTERISTICS

The South Beach sanitary pumping station is located at 300 Father Capodanno Blvd. in Staten Island about 650 feet from the open water of the Lower Bay. The pumping station consists of an aboveground structure, where critical electrical components are located; non-submersible pump motors are located below grade.

The Pumping Station Summary table lists the general characteristics of the South Beach pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 69 acres. There is one critical facility within the area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The South Beach pumping station was inundated by the storm surge during Hurricane Sandy, which damaged motors and the electrical controls. DEP staff indicated there is a history of flooding due to smaller storms at this location.

RISK ASSESSMENT

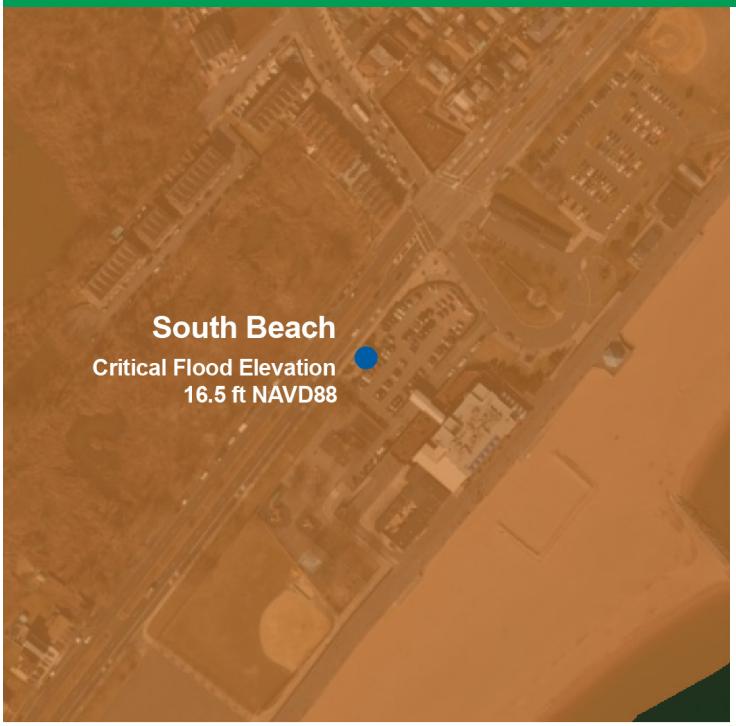
The risk of the South Beach pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room.

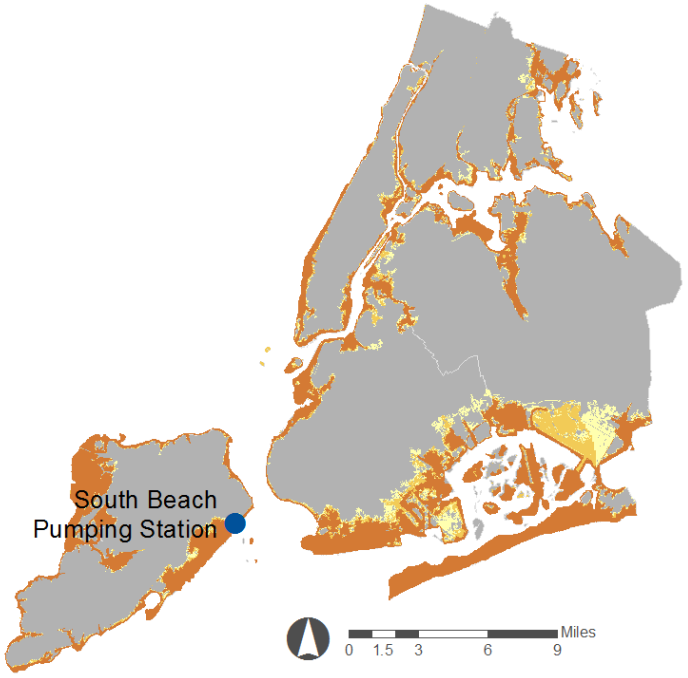
The critical flood elevation would inundate the area surrounding the facility with almost 9 feet of water. This would damage electrical controls and pump motors in the process.

ADAPTATION STRATEGIES

The South Beach pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because there is a substantial existing structure, the recommended strategy at South Beach is to seal the existing building. When pumps need to be replaced as part of regular maintenance, submersible pumps should be installed. Because water tight cases, doors, and building sealants are only rated up to a certain pressure, if flood depth is greater than expected the water pressure could exceed the rating and the building sealing could fail. Therefore, residual risk is related to a greater depth of flooding from larger storms or more extreme climate change and the potential for water pressure to exceed the rating of the sealing measures.

FEMA Flood Zones

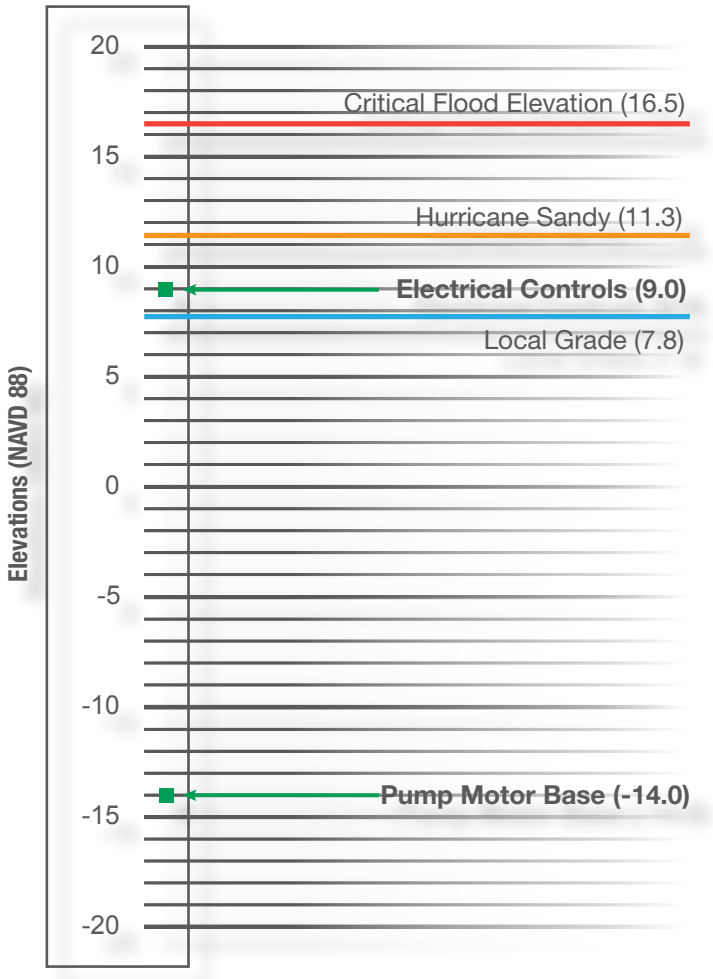




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Non-submersible
	Operating Capacity (MGD)	1.5
	Affected Area (Acres)	69
Risk	Population in Affected Area	2,165
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Seal Building & Install Submersible Pump Motors
	Cost of Protective Measures[1]	$286,000
	Damage Cost for Critical Flood without Protection[1, 2]	$2,359,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$10,925,000
	Resiliency Level	Moderate

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure surrounded by driveway and concrete perimeter wall

Recommended Adaptation Strategy: **Construct Barrier**

Adaptation Cost: **$5,920,000**

Throgs Neck Pumping Station

STATION CHARACTERISTICS

The Throgs Neck combined pumping station is located at the intersection of Lafayette Avenue and Zerega Avenue in the Bronx, behind the Department of Sanitation building. Controls and pumps are located on and below the below grade main floor of the structure onsite.

The Pumping Station Summary table lists the general characteristics of the Throgs Neck pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial/industrial area. Failure of the station would affect an area of approximately 2,639 acres and a population of over 67,000. There are 33 critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The station has experienced significant flooding, particularly during Hurricane Sandy. Flood water from Hurricane Sandy did not rise above the door threshold or windows, but the flood did submerge below grade Con Edison transformers, cutting power to the station and halting operation during the storm.

RISK ASSESSMENT

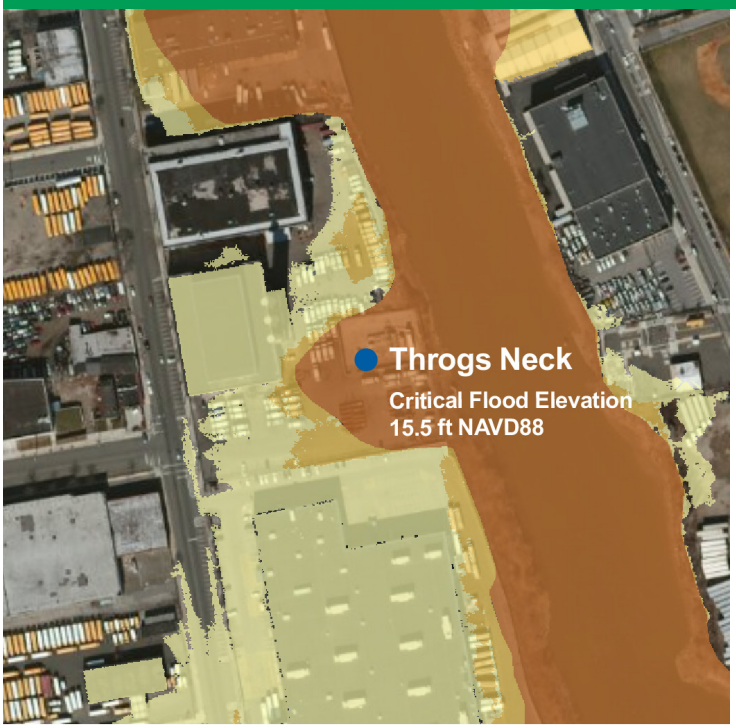
The risk of the Throgs Neck pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the control room and wells. Submersible pumps were confirmed but the condition of the pumps and the resiliency of supporting equipment is not known.

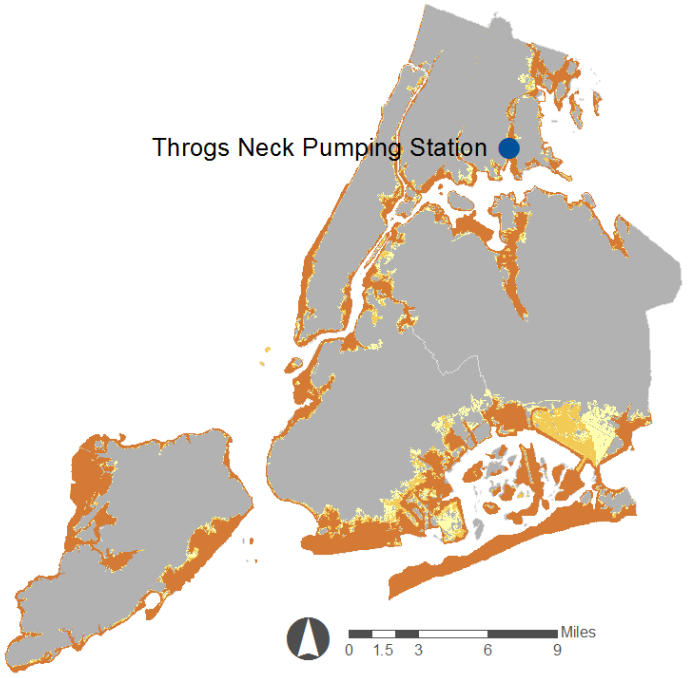
The critical flood elevation would completely inundate the station, and the surrounding flood would be 5 feet above local grade. This would damage electrical controls but would not affect the submersible pumps.

ADAPTATION STRATEGIES

The Throgs Neck pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because the extensive electrical controls would be difficult and expensive to move, the recommended strategy at Throgs Neck is to construct a barrier around the station. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

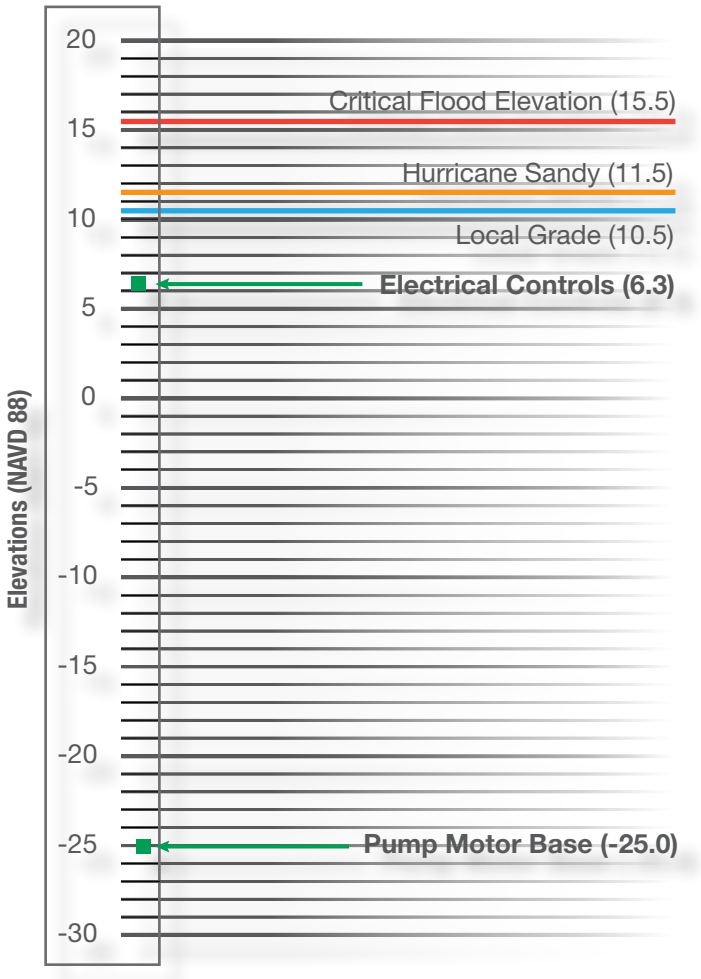




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

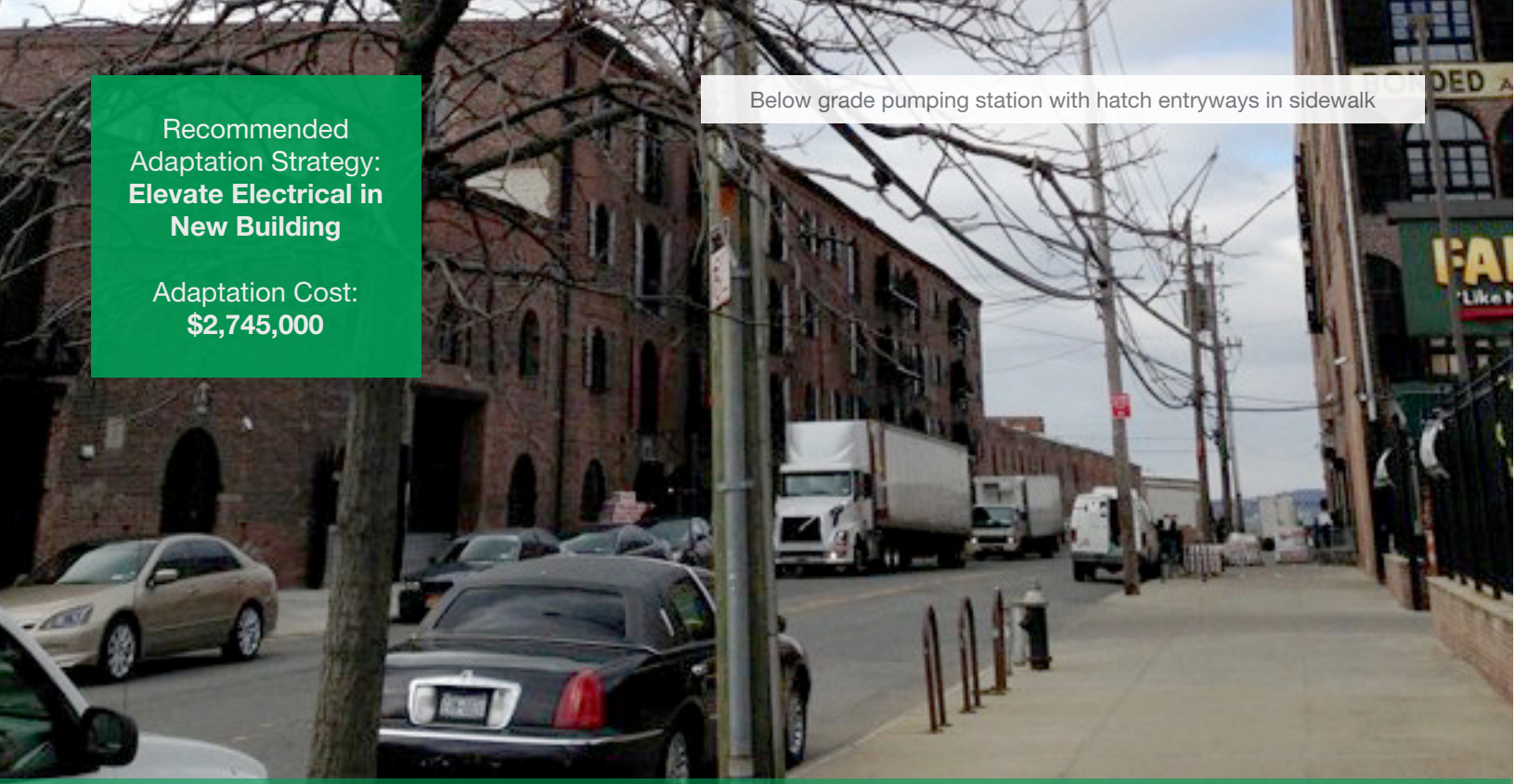
Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	36.7
	Affected Area (Acres)	2,639
Risk	Population in Affected Area	67,498
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	33
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Construct Barrier
	Cost of Protective Measures[1]	$5,920,000
	Damage Cost for Critical Flood without Protection[1, 2]	$10,672,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$53,001,000
	Resiliency Level	High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.



Below grade pumping station with hatch entryways in sidewalk

Recommended Adaptation Strategy: **Elevate Electrical in New Building**

Adaptation Cost: **$2,745,000**

Van Brunt Street Pumping Station

STATION CHARACTERISTICS

The Van Brunt combined pumping station is located in Brooklyn at the intersection of Van Brunt Street and Reed Street, less than 500 feet from the open water of the Upper Bay. The station is located entirely below grade, with the exception of telemetry equipment. Hatch entryways are located in the sidewalk.

The Pumping Station Summary table lists the general characteristics of the Van Brunt Street pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a commercial/industrial area. Failure of the station would affect an area of approximately 19 acres. There is one critical facility within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, the Van Brunt pumping station was completely inundated. All electrical equipment had to be replaced following the storm and new telemetry equipment was relocated above grade. DEP indicated there is a history of flooding at this location due to smaller storms.

RISK ASSESSMENT

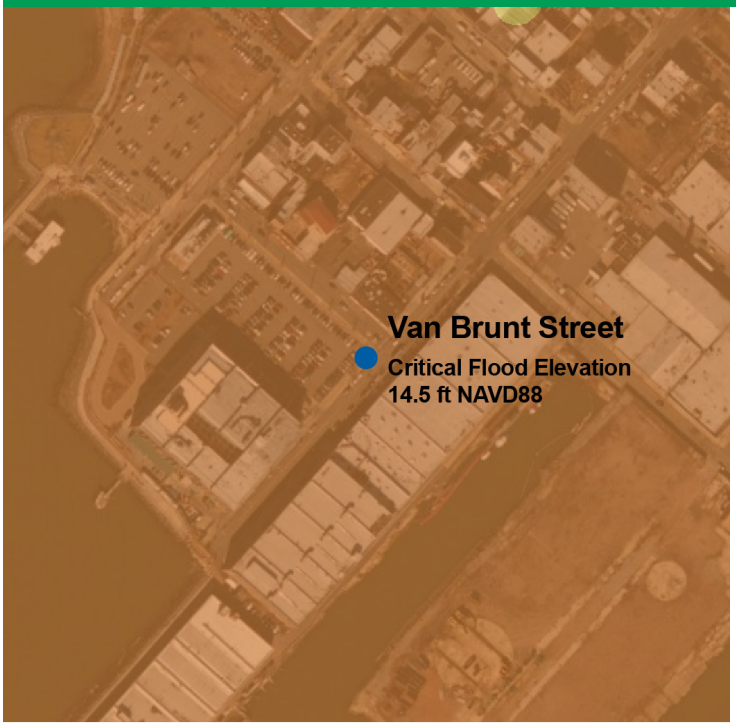
The risk of the Van Brunt Street pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included viewing the electrical components and dry well.

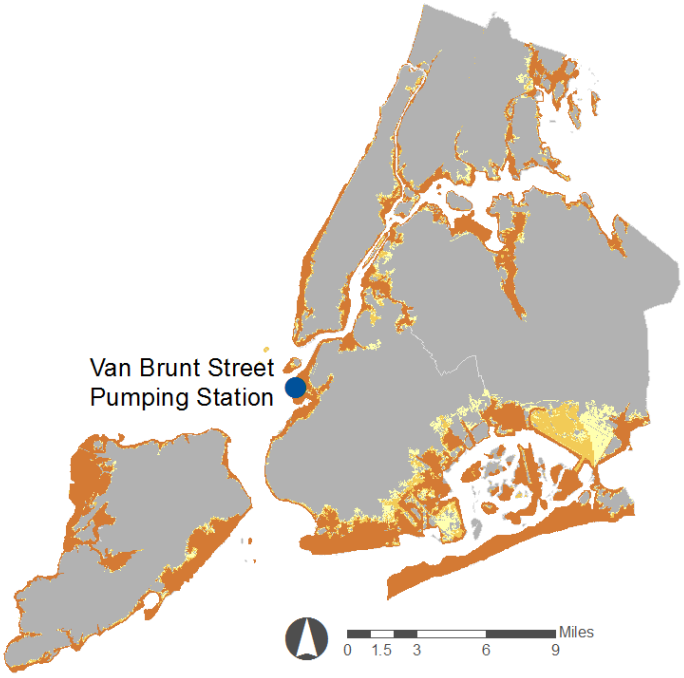
The critical flood elevation would completely inundate the station, and the surrounding flood would be nearly 9 feet above local grade. This would damage electrical controls but would not affect the submersible pumps.

ADAPTATION STRATEGIES

The Van Brunt Street pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Due to the extreme depth of the critical flood and the lack of an existing structure, the recommended strategy at Van Brunt Street is to elevate electrical controls in a new building. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

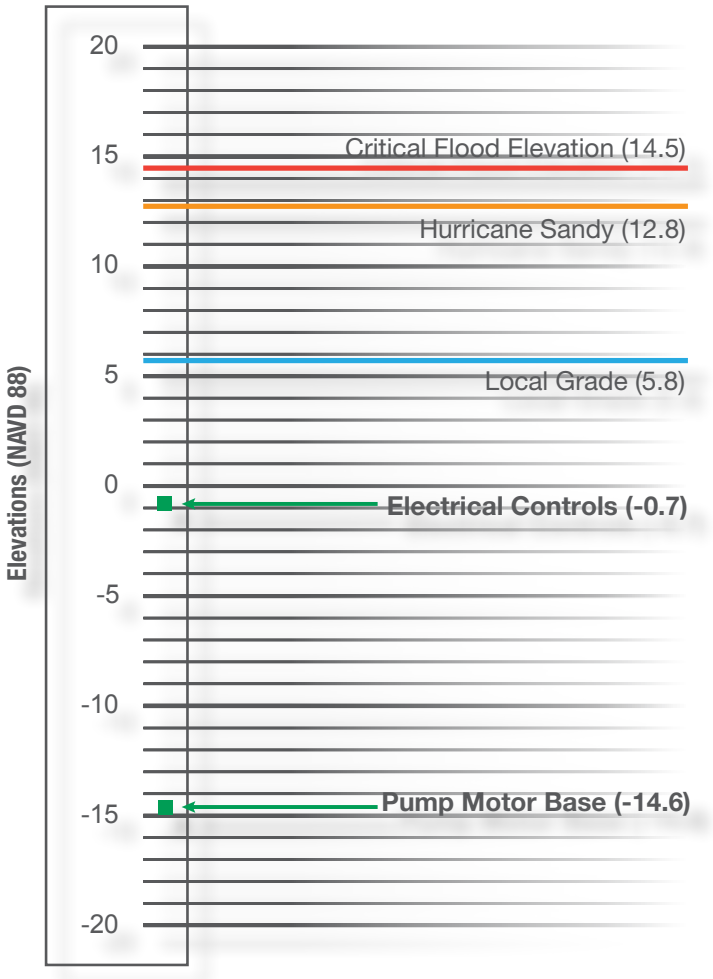




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Combined
	Pump Type	Submersible
	Operating Capacity (MGD)	1.4
	Affected Area (Acres)	19
Risk	Population in Affected Area	388
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	Y
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	Y
Adaptation	Recommended Protective Measure	Elevate Electrical in New Building
	Cost of Protective Measures[1]	$2,745,000
	Damage Cost for Critical Flood without Protection[1, 2]	$931,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$4,790,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Control panels and meters mounted above grade

Recommended Adaptation Strategy: **Elevate Electrical on Platform/Pad**

Adaptation Cost: **$876,000**

Victory Boulevard Pumping Station

STATION CHARACTERISTICS

The Victory Boulevard sanitary pumping station is located at the southwestern dead end of Victory Blvd. on Staten Island. It is adjacent to the property surrounding a Con Edison plant and is only a few hundred feet from the tidally influenced Arthur Kill. The station is primarily below grade underneath a concrete slab with control panels and meters mounted above the slab.

The Pumping Station Summary table lists the general characteristics of the Victory Boulevard pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a sparse industrial area. Failure of the station would affect an area of approximately 117 acres and a population of nearly 1,000. There is one critical facility within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Victory Boulevard pumping station was not affected by Hurricane Sandy and there is no history of flooding at this location.

RISK ASSESSMENT

The risk of the Victory Boulevard pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100-year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior revealed that electrical controls, which were shown below grade in the drawings, had been moved above grade. Otherwise, the station appeared consistent with the drawings.

The critical flood elevation would be nearly 4 feet above local grade. This may not reach the pump controls, which are mounted about 1 foot above the flood elevation but could reach other electrical equipment. Flood waters would enter the wells, but the submersible pumps should be unaffected. The Victory Boulevard pumping station is connected to another station, receiving flow from one pumping station and discharging to another. Loss of function at Victory Boulevard does not increase the vulnerability of the pumping station to which it discharges, but would increase the vulnerability of the pumping station from which it receives flow.

ADAPTATION STRATEGIES

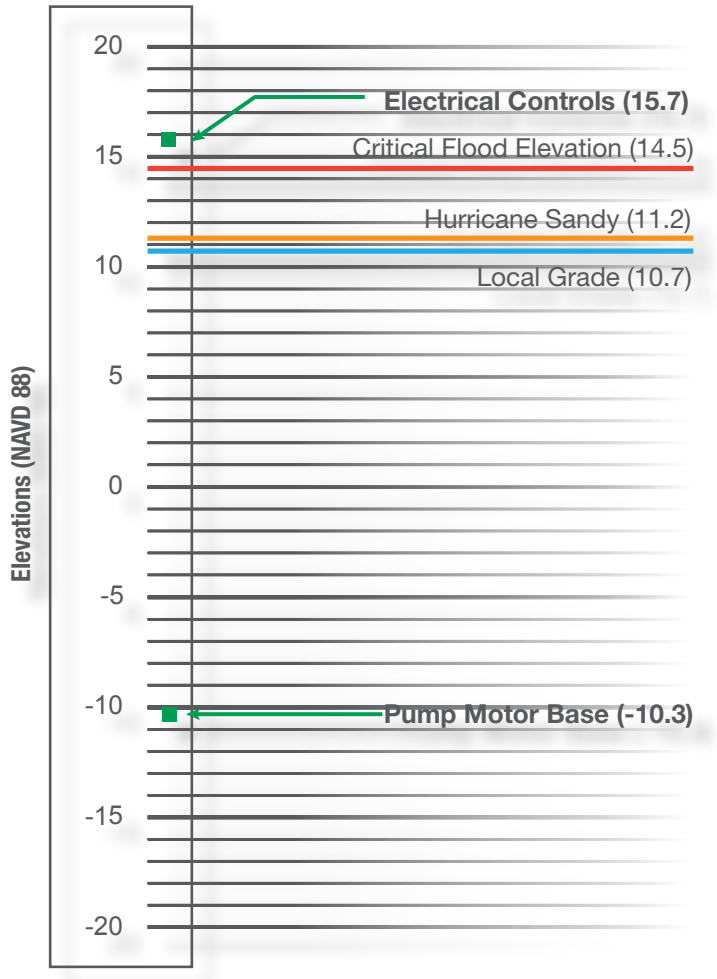
The Victory Boulevard pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because controls are located above the critical flood elevation, but only by a small margin, the recommended strategy at Victory Boulevard is to elevate controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	4.3
	Affected Area (Acres)	117
Risk	Population in Affected Area	970
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	1
	Historic Flooding	N
	Affected by Hurricane Sandy	N
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$876,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,849,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$9,517,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Structure houses the motor control center

Recommended Adaptation Strategy: **Elevate Electrical on Platform/Pad**

Adaptation Cost: **$880,000**

Warnerville Pumping Station

STATION CHARACTERISTICS

The Warnerville sanitary pumping station is located near the intersection of Brookville Boulevard and Rockaway Boulevard in Queens. All critical electrical components are located above grade either outdoors on a concrete pad or within the onsite superstructure. The Warnerville pumping station includes four submersible sewage pumps and grinders located below grade and accessible by hatches.

The Pumping Station Summary table lists the general characteristics of the Warnerville pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a manufacturing area. Failure of the station would affect an area of approximately 24 acres. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

During Hurricane Sandy, the station lost power. The power outage caused the wet well to flood the dry well; however, no equipment was damaged during the flooding. There is no additional history of flooding due to smaller storms at this location.

RISK ASSESSMENT

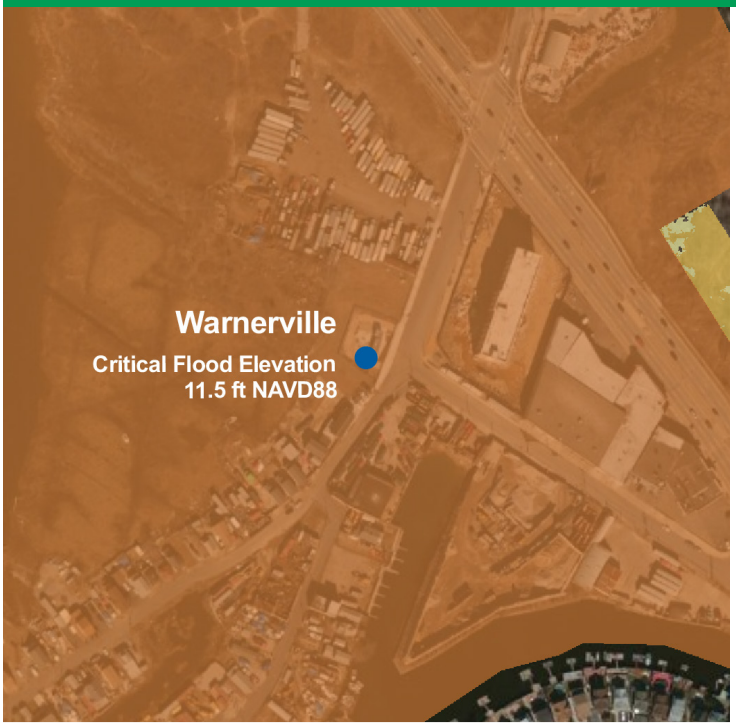
The risk of the Warnerville pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). These elevations and other notable characteristics were confirmed during a thorough station visit that included entering the structure and viewing the electrical components.

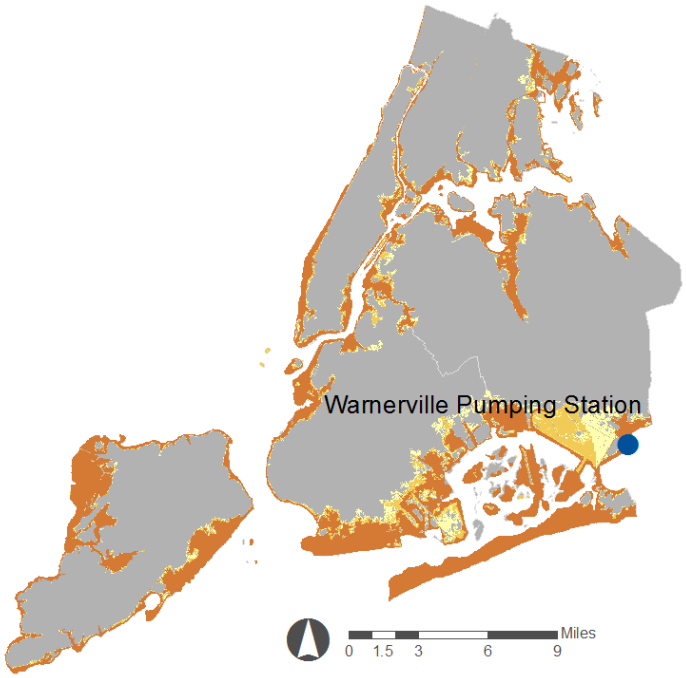
The critical flood elevation would inundate the area surrounding the facility with over 4 feet of water. This would damage electrical controls but would not affect the submersible pumps. The Warnerville pumping station is connected to another station; however it discharges to it rather than receiving flow. Therefore loss of function at Warnerville does not increase the vulnerability of an additional pumping station.

ADAPTATION STRATEGIES

The Warnerville pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because electrical controls are currently mounted outdoors but need to be moved out of the reach of flood waters, the recommended strategy at Warnerville is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

FEMA Flood Zones

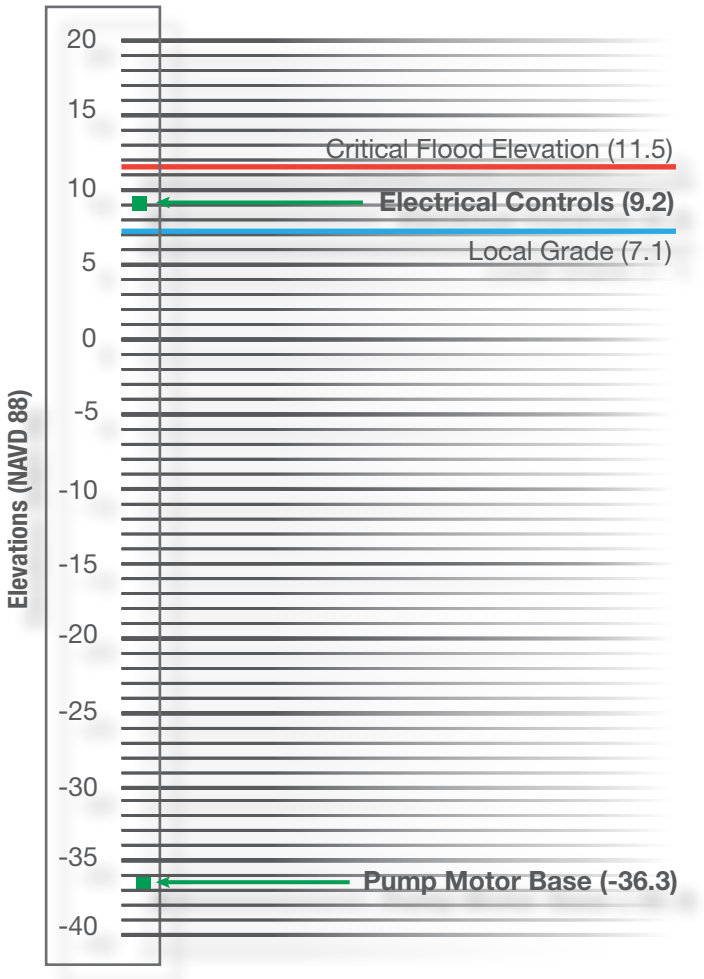




2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	<1MGD
	Affected Area (Acres)	24
Risk	Population in Affected Area	170
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	N
	Connected to Other Stations	Y
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$880,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,142,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$5,875,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.

Controls and vent mounted atop slabs on sidewalk

Recommended Adaptation Strategy: **Elevate Electrical on Platform/Pad**

Adaptation Cost: **$662,000**

Zerega Avenue Pumping Station

STATION CHARACTERISTICS

The Zerega Avenue sanitary pumping station is located at the southern dead end of Zerega Avenue near the corner of Castle Hill Avenue. It is across the street from a YMCA and is less than 500 feet from the East River. The pumping station is mostly below grade; the wells are accessible through hatches in the sidewalk, and electrical controls are located in a stainless-steel box on the sidewalk.

The Pumping Station Summary table lists the general characteristics of the Zerega Avenue pumping station, the potential effect of its failure, and the recommended adaptation strategy. The station is located in a residential area. Failure of the station would affect an area of approximately 7 acres and a population of approximately 200. There are no critical facilities within that area that could be affected if the station failed.

HURRICANE SANDY IMPACTS AND OTHER FLOODING HISTORY

The Zerega Avenue pumping station experienced minor impacts during Hurricane Sandy but there is no additional history of flooding at this location.

RISK ASSESSMENT

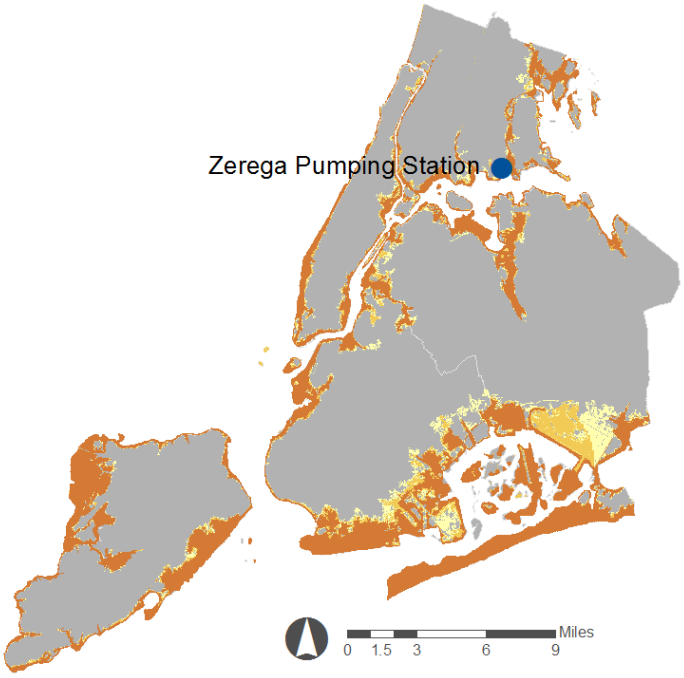
The risk of the Zerega Avenue pumping station was first assessed based on a review of the station's plan drawings, comparing the elevation of the critical components to that of the FEMA March 2013 Advisory Base Flood Elevation (ABFE) 100- year flood plus 30 inches of sea level rise (critical flood elevation). A visit to the pumping station to view its exterior revealed that electrical controls, which were shown below grade in the drawings, had been moved above grade. Otherwise, the station appeared consistent with the drawings.

The critical flood elevation would be almost 6 feet above local grade, completely inundating the wells and the above grade control panels. This would damage the electrical controls, but the submersible pumps should be unaffected.

ADAPTATION STRATEGIES

The Zerega Avenue pumping station requires adaptive measures to withstand the critical flood elevation. Potential strategies were evaluated against such factors as flood depth, equipment location, and space. Viable strategies were reviewed to identify the most cost-effective, resilient option. Because controls are currently exposed, space is limited, and controls need to be moved above the flood elevation, the recommended strategy at Zerega Avenue is to elevate electrical controls on a platform. Residual risk is related to a greater depth of flooding from larger storms or more extreme climate change.

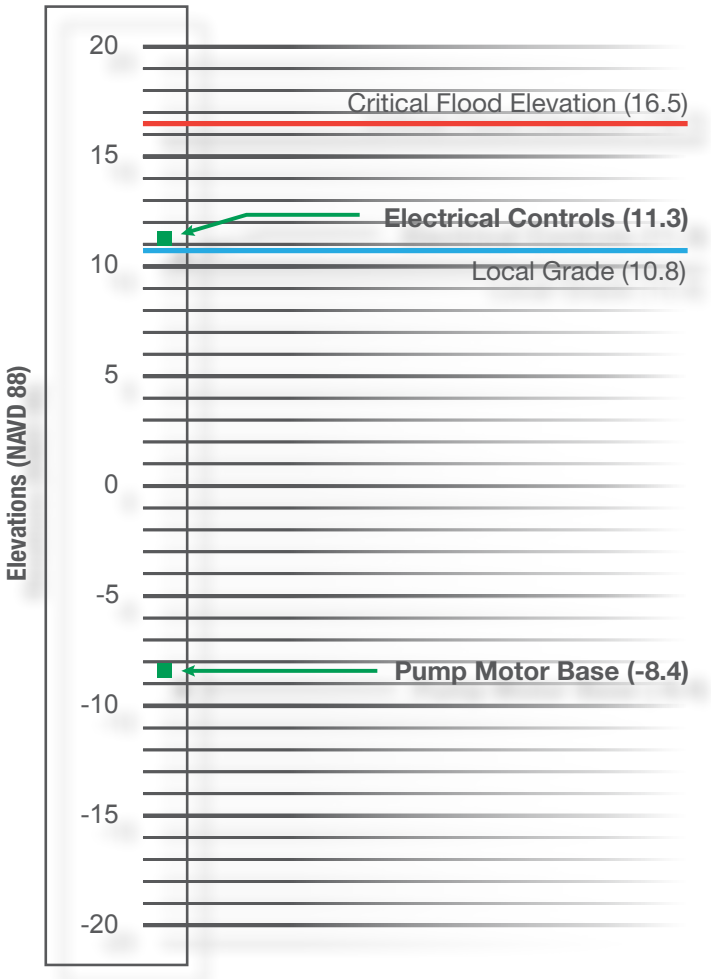
FEMA Flood Zones



2013 Advisory 100-Year Floodplain
Projected 2020s 100-Year Floodplain
Projected 2050s 100-Year Floodplain

Source: FEMA; CUNY Institute for Sustainable Cities

Critical Elevations



Pumping Station Summary

Background	Station Type	Sanitary
	Pump Type	Submersible
	Operating Capacity (MGD)	<1MGD
	Affected Area (Acres)	7
Risk	Population in Affected Area	195
	Number of Critical Facilities (e.g., Hospitals, Public Safety, Schools) in Affected Area	0
	Historic Flooding	N
	Affected by Hurricane Sandy	Y
	Historic Loss of Power	Y
	Connected to Other Stations	N
	Beach Affected	N
Adaptation	Recommended Protective Measure	Elevate Electrical on a Platform/Pad
	Cost of Protective Measures[1]	$662,000
	Damage Cost for Critical Flood without Protection[1, 2]	$1,283,000
	Cumulative Risk Avoided Over 50 Years[1, 3]	$6,603,000
	Resiliency Level	Very High

1) All cost estimates are presented in 2013 US Dollars.
2) One-time replacement cost of at-risk equipment if no protective measures are in place and critical flood scenario occurs (i.e., current 100-year flood plus 30 inches). This estimate does not consider the probability of storm occurrence.
3) Repair/replacement costs that would be avoided over 50 years if protective measures are in place for storm surges up to and including the 100-year flood plus 30 inches. This estimate incorporates the probability of storm occurrence.