Dzus Climate Resiliency Assessment Report
Dzus Fastener Company, Inc. (152033)
West Islip, New York

Willetts Creek and Lake Capri

Prepared for

New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway
Albany, New York 12233-7017

Prepared by

EA Engineering, P.C. and Its Affiliate
EA Science and Technology
269 West Jefferson Street
Syracuse, New York 13202
(315) 431-4610

July 2020
Version: FINAL
EA Project No. 1602501

This page left intentionally blank

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
COC	Contaminant of concern
DOC	Dissolved organic carbon
EA	EA Engineering, P.C. and Its Affiliate EA Science and Technology
EPA	U. S. Environmental Protection Agency
FS	Feasibility Study
ft	Feet (foot)
in.	Inch(es)
MHHW	Mean higher high water
NAVD88	North American Vertical Datum of 1988
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NYSDEC	New York State Department of Environmental Conservation
OU	Operable unit
RAO	Remedial action objectives
RCP	Representative concentration pathway
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SCO	Soil Cleanup Objective
SGV	Sediment Guidance Value
SLR	Sea level rise
SOC	Soil organic carbon
SVE	Soil vapor extraction
TCE	Trichloroethene

This page left intentionally blank

ES. EXECUTIVE SUMMARY

EA Engineering, P.C. and its affiliate EA Science and Technology, under Contract to the New York State Department of Environmental Conservation (NYSDEC) completed a Climate Resiliency Assessment for the Dzus Fastener Company, Inc. site (NYSDEC Site Number No. 152033) located in West Islip, Suffolk County, New York. The Climate Resiliency Assessment includes an assessment of projected climate change impacts, associated vulnerabilities, and both implemented and potential adaptation measures that could be undertaken now or in the future. Due to the ever-growing understanding of climate change, the information provided within the report should be revisited as climate change projections are refined over time.

Dzus Fasteners, including Willetts Creek and Lake Capri, had remedial work performed in 1999. However, periodic monitoring during site management found that the creek and lake sediments had increased levels of cadmium since the work was completed in 1999.

One possible explanation for the increased levels of cadmium in sediments was that given the historical accumulation of cadmium in creek sediments, it appears the organic-rich or fine-grained sediments in the creek that were not removed during the 1999 cleanup may have been mobilized during storm events (such as Superstorm Sandy in 2012) and contaminants were likely redistributed as floodwaters receded. It is believed that the conditions which may have led to the recontamination will no longer exist after the proposed remedial work is completed. To ensure this potential recontamination scenario was fully evaluated, this climate resiliency plan was developed.

To address metals contamination downstream of the former Dzus Fastener facility, NYSDEC performed a remedial action to address cadmium and chromium impacted media. This action involved the removal of approximately 42,200 cubic yards of sediment and soil from Willetts Creek (Operable Unit [OU] 3) and Lake Capri (OU4). Groundwater is under a long-term monitoring program to monitor residual cadmium levels in groundwater. On the slope behind the Captree Plaza building located along Willetts Creek, a 2 to 1 (horizontal to vertical) slope was maintained as a slope stability protective measure due to the nearby building, resulting in some residual cadmium levels slightly above soil cleanup objectives being left in place. A demarcation layer and clean backfill material was placed above residual levels to ensure these materials do not migrate. Similarly, to protect the timber bulkhead along Montauk Highway, no sediment removal was performed in Lake Capri within 30 ft of the bulkhead. In addition, a demarcation layer and clean backfill was placed to ensure these materials do not migrate. The Site Management Plan will identify and monitor the presence of these materials.

Climate change impacts such as increases in temperatures, frequency and severity of precipitation events, and sea level rise are included in site remediation and long-term management to ensure the site remains stable in the future. By 2050, projected impacts in West Islip include increases in average temperature by 5 degrees Fahrenheit (°F) and in precipitation by 5 inches per year. The sea level at West Islip is projected to rise by 1.3 to 2.5 feet without storm surge considerations. If a storm equivalent in size to the 2012 Super Storm Sandy were to occur in 2050 the resulting storm surge could be 9.6 to 10.8 feet greater than present day sea level. This would create significant changes to the local area such as inundating lands in the project area. Sea level rise, increased precipitation, and heavy rainfall events may cause localized flood related damage to the Dzus site.

In general, remedies at contaminated sites may be vulnerable to the implications of climate change and extreme weather events. The Superfund program developed an approach that raises awareness of these vulnerabilities and applies climate change and weather science as a standard operating practice in cleanup projects. The approach involves periodic screening of Superfund remedy vulnerabilities, prioritizing the Superfund program's steps to adapt to a changing climate and identifying adaptation measures to assure climate resilience of Superfund sites.

The topic of climate change defines several key terms:

- Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.

- Resilience: A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

- Adaptation: Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.

- Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities or to cope with the consequences.

As part of the resiliency assessment, an adaptation plan has been created which will be integrated with the Site Management Plan. This adaptation plan incorporates strategies and measures already implemented or planned for the site and defines impact thresholds and monitoring for exceedance of these thresholds. If a set threshold is surpassed, appropriate action will be taken to ensure the remedy remains in place and is effective. A new set of thresholds and plan may be created to decrease risks associated with climate change impacts.

1. INTRODUCTION AND PROJECT OVERVIEW

This report provides an assessment of the projected climate change impacts on the remedies implemented to address cadmium and chromium contamination in sediment, soil, and groundwater. These impacts were reviewed to assess possible site vulnerabilities. The report provides a list of adaptation measures being implemented now or that could be implemented in the future as climate change projections are refined to address any identified vulnerabilities. This resiliency plan along with the site management program will employ a strategic monitoring approach to ensure the effectiveness of the implemented remedies. The remedial program also addresses the goal of the West Islip NY Rising Community Reconstruction Plan of March 2014 to reduce flooding in the Willetts Creek drainage basin through removal of sedimentation and redesign of one culvert (NY Rising Community Reconstruction (NYRCR) 2014).

This report includes current climate impact projections as of 2019. Due to the ever-growing understanding of climate change, this report can be viewed as a living document, with information to be updated as climate change projection data is refined.

This page left intentionally blank

2. PROJECT SITE CHARACTERIZATION

2.1 PHYSICAL SETTING

The Dzus Fastener Company, Inc. (NYSDEC Site No. 152033) is located in West Islip, Suffolk County, New York (**Figure 2-1**). Willets Creek is east of the former Dzus Fastener facility and flows south between housing developments and schools for 0.75 mile before reaching Lake Capri. Lake Capri flows into the tidal portion of Willetts Creek under Montauk Highway, which ultimately flows into Babylon Cove and Great South Bay of the Atlantic Ocean. The site was listed as a Class 2 Inactive Hazardous Waste Sites in the State Registry and represented a significant threat to public health or the environment. Complex sites such as this are often divided into distinct areas, called operable units (OUs), to facilitate investigation and cleanup. The site is broken into six OUs (OU1, OU2, OU3, OU4, OU5, and OU6), some of which are overlapping. These areas are shown in **Figure 2-2** and described below:

- OU1 – The former Dzus property source of contamination. NYSDEC completed a Record of Decision (ROD) for treatment of OU1 in 1995. The implemented remedy consisted of in situ stabilization/solidification of cadmium impacted soils through mixing of Portland cement. Additional remedial components included installation of a topsoil/asphalt cover system at the eastern portion of the facility, which protects the stabilized area from erosion, as well as a deed restriction to prevent disturbance of the stabilized area. The facility continued operations until 2015, with the facility closure leading to the designation of OU6.

- OU2 – Lake Capri and a portion of Willetts Creek and soil and water contamination. NYSDEC completed a ROD in 1997. The implemented remedy included removal of contaminated sediments from Lake Capri and areas of Willetts Creek, and a long-term monitoring program to monitor the groundwater, sediment, and surface water. In 2016, monitoring under the long-term program found levels of cadmium in sediment within Lake Capri and Willetts Creek that exceeded both the goals established in the OU2 ROD and NYSDEC Sediment Guidance Values (SGVs) (NYSDEC 2014). These exceedances and subsequent investigations led to the designation of OU3 (Willetts Creek) and OU4 (Lake Capri).

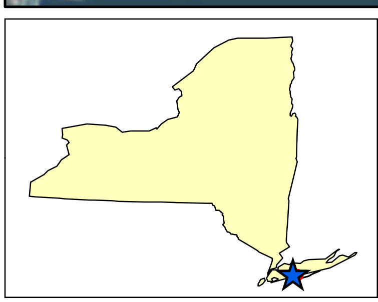
- OU3 – Willetts Creek and associated floodplain, from Union Boulevard to West Islip High School. NYSDEC completed a ROD in 2017. Clean-up of this area was completed in 2019-2020 and included contaminated sediment and soil removal and associated restoration.

- OU4 – Willetts Creek from West Islip High School to Lake Capri, Lake Capri, and the surrounding floodplains. NYSDEC completed a ROD in 2018. The implemented remedy for this area was completed in 2019-2020 and included contaminated sediment and soil removal and associated restoration.

- OU5 – Tidal area of Willetts Creek south of Montauk Highway. This area is currently being investigated to determine the extent of contamination.

- OU6 – The closed former Dzus facility buildings and property. The implemented remedy for this area was completed in 2018 and included decontamination of the building, removal of the remaining contaminated soils, operation and subsequent decommissioning of a soil vapor extraction (SVE) system, and a deed restriction. The building was demolished in November 2019 as part of a planned redevelopment of the property.

G:\Projects\State&Local\NYSDEC - D007624\D007624 - Work Assignments\14907.39 - Dzus Fastners OU3 RDI05 GIS\Projects\Climate Resiliency Assessment\Figure 1 SiteFeatures and Surrounding Area.mxd



0 400 800 1,600
Feet

1 inch = 1,175 feet

N

Legend

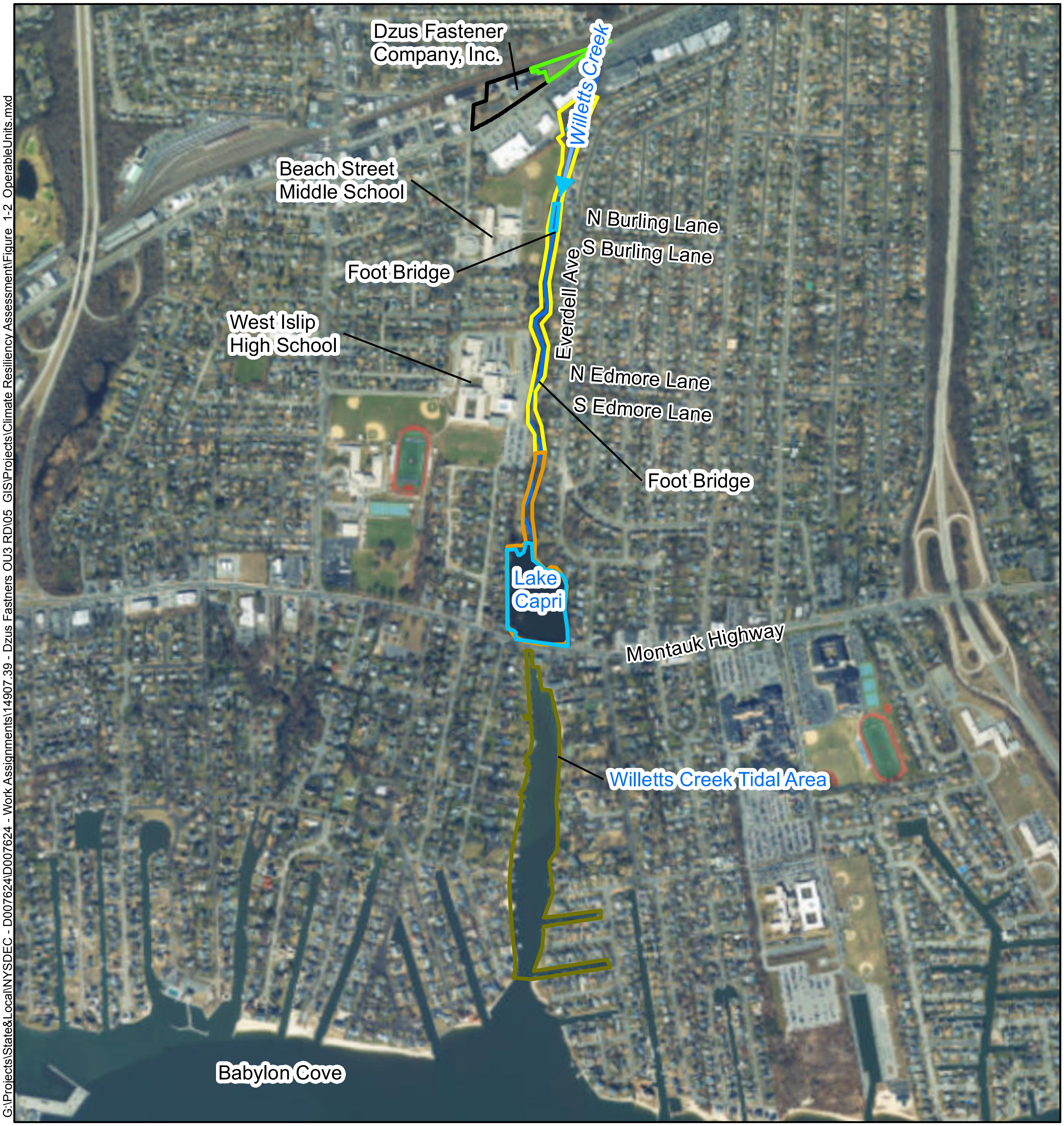
Willletts Creek

Figure 2-1
Site Features and Surrounding Area

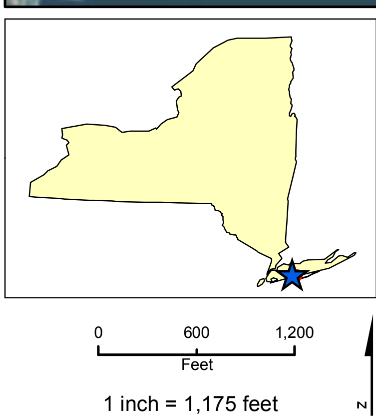
Dzus Climate Resiliency Assessment Report
Dzus Fastener Company, Inc.
West Islip, NY

Map Date: 5/29/2019
Projection: NAD83 State Plane New York Long Island

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation



G:\Projects\State&Local\NYSDEC - D007624\D007624 - Work Assignments\14907.39 - Dzus Fastners OU3 RDI05_GIS\Projects\Climate Resiliency Assessment\Figure_1-2_OperableUnits.mxd



Legend

Willletts Creek

Approximate Operable Unit Boundary

- Operable Unit 1
- Operable Unit 2
- Operable Unit 3
- Operable Unit 4
- Operable Unit 5
- Operable Unit 6

Figure 2-2
Operable Units

Dzus Climate Resiliency Assessment Report
Dzus Fastener Company, Inc.
West Islip, NY

Map Date: 7/29/2019
Projection: NAD83 State Plane New York Long Island

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

2.1.1 Site Geology

The site is in the Atlantic Coastal Plain Physiographic Province and is underlain by the Upper Glacial Aquifer. Groundwater beneath the site is 0 to 14 ft below ground surface and flows to the south-southwest.

The sediment in Willetts Creek and Lake Capri is medium to coarse sand and gravel overlain by a shallow layer of fine silt and organic debris. The Willetts Creek tidal area sediments are generally very fine silt with little amounts of clay underlain by fine to medium grain, moderately sorted sand with little amounts of gravel and trace pebbles. The sand is typically observed at a depth of 0.1 to 3 ft below the sediment surface.

2.1.2 Site Hydrology/Hydrogeology

Willetts Creek is a slow-moving creek, located east of the Dzus facility which flows approximately 4,500 ft to the south toward Lake Capri. It is generally 16 to 23 ft wide and less than 8 inches (in.) in depth. The creek is fed by both surface water runoff and groundwater infiltration. Upstream of Lake Capri the creek is freshwater, while downstream of Lake Capri the creek is tidally influenced.

Lake Capri is a privately owned, 8-acre man-made lake formed by impoundment of the Willetts Creek estuary upon construction of the embankment for Montauk Highway (Route 27A). The northwest corner of the lake is a small ¼-acre lagoon, fed in part by a short intermittent stream. Lake Capri is surrounded by low-lying residential properties, except for the fenced south end that fronts Montauk Highway. The freshwater lake is relatively shallow, with a depth of 3 ft over broad areas. Willetts Creek is divided into an upper and a lower reach. The upper portion is the freshwater reach located upstream of Lake Capri; the lower portion is the tidal channelized reach downstream of Lake Capri. Lake Capri is fed primarily by Upper Willetts Creek, stormwater runoff from local streets, and groundwater.

A structure at the south end of the lake controls overflow under Montauk Highway to Lower Willetts Creek. From Lake Capri, the creek flows another 3,000 ft to Babylon Cove. This tidal portion of Willetts Creek has an average daily tidal range of approximately 1 ft. Given the approximately 3 to 4 ft average head drop between Lake Capri and the tidal Lower Willetts Creek, it is likely that the lake also discharges to groundwater.

Historical groundwater studies calculate groundwater flow in the Upper Glacial Aquifer to average 2.4 to 24 ft per year.

2.2 HISTORY OF OPERATIONS

Dzus Fastener Company, Inc. produced fasteners and springs beginning in 1932. Wastes from metal operations consisted of oils, heavy metals, volatile organic compounds, and salts. Leaching pools onsite were used to dispose of hazardous wastes. NYSDEC completed hazardous waste investigations of the facility in 1984 and 1990. An Interim Remedial Measure (IRM) was completed by Dzus Fastener Company, Inc. in 1991, which included the closure of one leaching pool on the eastern portion of the facility and the removal of approximately 1,960 cubic yards of contaminated soil. A small pipe was discovered during activities in this leach field and is believed to have been used to discharge waste directly into upper Willetts Creek. These operations led to soil and groundwater contamination at the Dzus facility and downstream soil, groundwater, sediment, and surface water contamination of Willetts Creek and Lake Capri.

The facility changed its name from Dzus Fastener Company, Inc. to DFCI Solutions, Inc. in 2001, but operations did not change. In 2015, DFCI Solutions, Inc. ceased operations and moved all equipment out of the facility.

2.3 CONTAMINANTS OF CONCERN

Historical site data and the findings of numerous investigations have identified cadmium and chromium (III) as the primary contaminants of concern (COCs). Cadmium and chromium (III) were detected above guidance values, while detections of volatile organic compounds were not observed above screening levels (NYSDEC 1998). Both contaminants of concern were found in groundwater, soil, and sediment. Historically, cadmium exceeded guidance values in Willetts Creek surface water, but not in Lake Capri.

2.4 REMEDIAL ACTION

Under the State Superfund Program, the NYSDEC initiated a Remedial Investigation (RI)/Feasibility Study (FS) in 1992 to determine the nature and extent of contamination attributable to the Dzus Fasteners Company, Inc. site and develop an appropriate remedy. During RI activities, soil was found to be contaminated with cadmium, chromium (III), and cyanide and groundwater was found to be contaminated with cadmium, chromium (III), cyanide, and volatile organic compounds (primarily trichloroethene [TCE], tetrachloroethene, and 1,1,1-trichloroethane).

Resource Conservation and Recovery Act (RCRA) closure activities were conducted at the facility and a Closure Certification Report was completed in 2018. The activities performed as part of the RCRA closure included the decontamination and washing of the building floors, removal of contaminated soils, installation and operation of a SVE system, and remediation and closure of remaining contaminated leaching pools. The property is planned for commercial redevelopment.

RODs for OU3 and OU4 were issued by NYSDEC in August 2017 and 2018, respectively. The implemented remedy included removal of contaminated sediment and soil from Willetts Creek, Lake Capri, and surrounding floodplain. Post-remedy, sediment meets Class A SGVs, presenting little or no potential for risk to aquatic life (NYSDEC 2016). Similarly, post-remedy soil meets "unrestricted use" Soil Cleanup Objectives (SCOs) indicating that soil can be used without imposed restriction, such as environmental easements or other land use controls (6 New York Codes, Rules and Regulations Part 375). The specific remedial action objectives (RAOs) for OU3 and OU4 are provided in **Tables 2-1 and 2-2**.

Table 2-1 Soil-Specific RAOs

Soil	Specific RAOs
RAOs for Public Health Protection	• Prevent ingestion/direct contact with contaminated soil. • Prevent inhalation exposure to contaminants through particulates in airborne dust.
RAOs for Environmental Protection	• Prevent migration of contaminants that would result in sediment contamination. • Prevent impacts to biota from ingestion/direct contact with soil causing toxicity or impacts from bioaccumulation through the terrestrial food chain.

Table 2-2. Sediment-Specific RAOs

Sediment	Specific RAOs
RAOs for Public Health Protection	• Prevent direct contact with contaminated sediments.
RAOs for Environmental Protection	• Prevent impacts to biota from ingestion/direct contact with sediments causing toxicity or impacts from bioaccumulation through the marine or aquatic food chain. • Restore sediments to pre-release/background conditions to the extent feasible.

Under the remedial action completed in 2020, approximately 42,200 cubic yards of soil and sediment was removed from Willetts Creek, Lake Capri, and the associated floodplain. The average depths of removal were 30 inches in Willets Creek and 12 inches in Lake Capri. All areas disturbed during construction were restored by adding clean soil, plantings, and replacement of infrastructure, where necessary.

Willets Creek was restored to increase the amount of flow the creek channel could handle to reduce the extent of significant flooding and erosion during storm events.

This page left intentionally blank

3. POST REMEDIAL ACTION SITE

Sediment and groundwater sampling results historically indicated elevated levels of cadmium in groundwater. Since the remedy has been implemented and the plume has attenuated over the last 20 years, groundwater is not likely to result in further migration of residual contamination to soils or sediments. Residual materials remain in areas as listed below.

3.1 RESIDUAL CONTAMINATION

Table 3-1 Residual Contaminants

Operating Unit	Location/Remedy	Contaminants
OU1 / OU-6	Residual materials are addressed by a deed restriction and long-term monitoring program.	Cadmium, chromium (III), TCE
OU2	Included in OU3 and OU4; see below.	
OU3	Residual materials in slope behind the Captree Plaza, west of the creek, covered with a demarcation layer and clean backfill, are addressed by a long-term monitoring program.	Cadmium,
OU4	Residual materials within 30 ft of bulkhead along Montauk Highway, covered with a demarcation layer and clean backfill, are addressed by long-term monitoring program.	Cadmium,
OU5	RI/FS process is ongoing at the time of this report to determine the nature and extent of potential impacts and complete an alternatives analysis.	Cadmium, chromium (III)
Groundwater	Low-level groundwater levels are being monitored as part of the long-term monitoring program.	Cadmium, chromium (III)

3.1.1 OU1 and OU6 Areas

OU1/OU6 included decontamination of the building, removal of an oil water separator, leach field and associated infrastructure, operation and subsequent decommissioning of a SVE system, stabilization/solidification of contaminated soils, covering with a parking lot cover system, removal of all other contaminated soils, and implementation of a deed restriction and long-term site monitoring program. Long-term monitoring of this area will be conducted under the Site Management Plan to ensure the implemented remedy remains protective.

3.1.2 OU3 and OU4 Areas

As a slope stability protective measure due to the nearby structure a 2 to 1 (horizontal to vertical) slope was maintained during soil removal behind the Captree Plaza. As a result, residual materials were left in place (**Figure 3-1**). This residual material was covered with orange demarcation fabric, followed by clean soil to ensure these materials do not migrate.

To protect the retaining wall along Montauk Highway, no sediment removal was performed in Lake Capri within 30 ft of the structure. Clean stone was placed over residual materials to ensure these materials do not migrate (**Figure 3-2**). Long-term monitoring in both locations is underway through the Site Management Plan to ensure the implemented remedy remains protective.

3.1.3 OU5 Area

The RI/FS process is ongoing in the OU5 area of Willets Creek south of Lake Capri at the time of this report.

3.2 GROUNDWATER PLUME

The levels of cadmium and chromium in groundwater have attenuated to the point that the migration of these metals to soils or sediments is not anticipated to result in exceedances of SCOs or SGVs (**Figure 3-3**). Long-term monitoring will continue to evaluate the effectiveness of the remedy. Other than cadmium, there have historically been a few other detections of iron, manganese, and sodium, but these are typically found in Long Island groundwater and are representative of background conditions and not site related.

3.3 POSSIBLE EXPOSURE PATHWAYS

3.3.1 Human Health Risk Assessment

Post remedial action risks to human health are low. Human exposure to COCs through inhalation, touch, or ingestion is not expected as the majority of impacted material has been removed from the site. According to the Long Island Region Fish Advisories published by the New York State Department of Health, women under 50 and children under 15 should not eat any fish from Lake Capri. Men over 50 and women over 15 are advised to not eat more than one meal per month of American eel or carp, and not more than four meals per month of all other fish. These guidelines are based on chlordane and cadmium, with only cadmium associated with the former Dzus facility. Chlordane is a pesticide that was banned in the late 1980's and was often used for termite-treatment.

Two Declarations of Covenants and Restrictions have been filed with the Suffolk County Clerk's office for the site. These documents require maintenance of the parking lot cover system, NYSDEC notification and approval for soil disturbance, and control of potential vapor intrusion before occupancy of any new buildings. Additionally, groundwater is monitored under a long-term monitoring program to ensure that it does not impact public health or the environment. Surrounding neighborhoods are serviced by a municipal potable water supply.

3.3.2 Ecological Risk Assessment

Post remedial action risks to fish and wildlife are low. Zones of impacted soils which exceed unrestricted SCOs, as defined by 6 NYCRR Part 375-6.8, were excavated and transported from the zone of impact for disposal. The project removed sediment above Class A Sediment Standards in Willetts Creek and Lake Capri and the creek was restored with clean backfill materials (**Figure 3-4**).

G:\Projects\State&Local\NYSDEC - D007624\D007624 - Work Assignments\14907.39 - Dzus Fastners OU3 RD\05_GIS\Projects\PDI_Residential\CapTree_residual.mxd

0 50 100
Feet
1 inch = 62.644 feet
N

Legend

Residual Confirmation Sampling Location

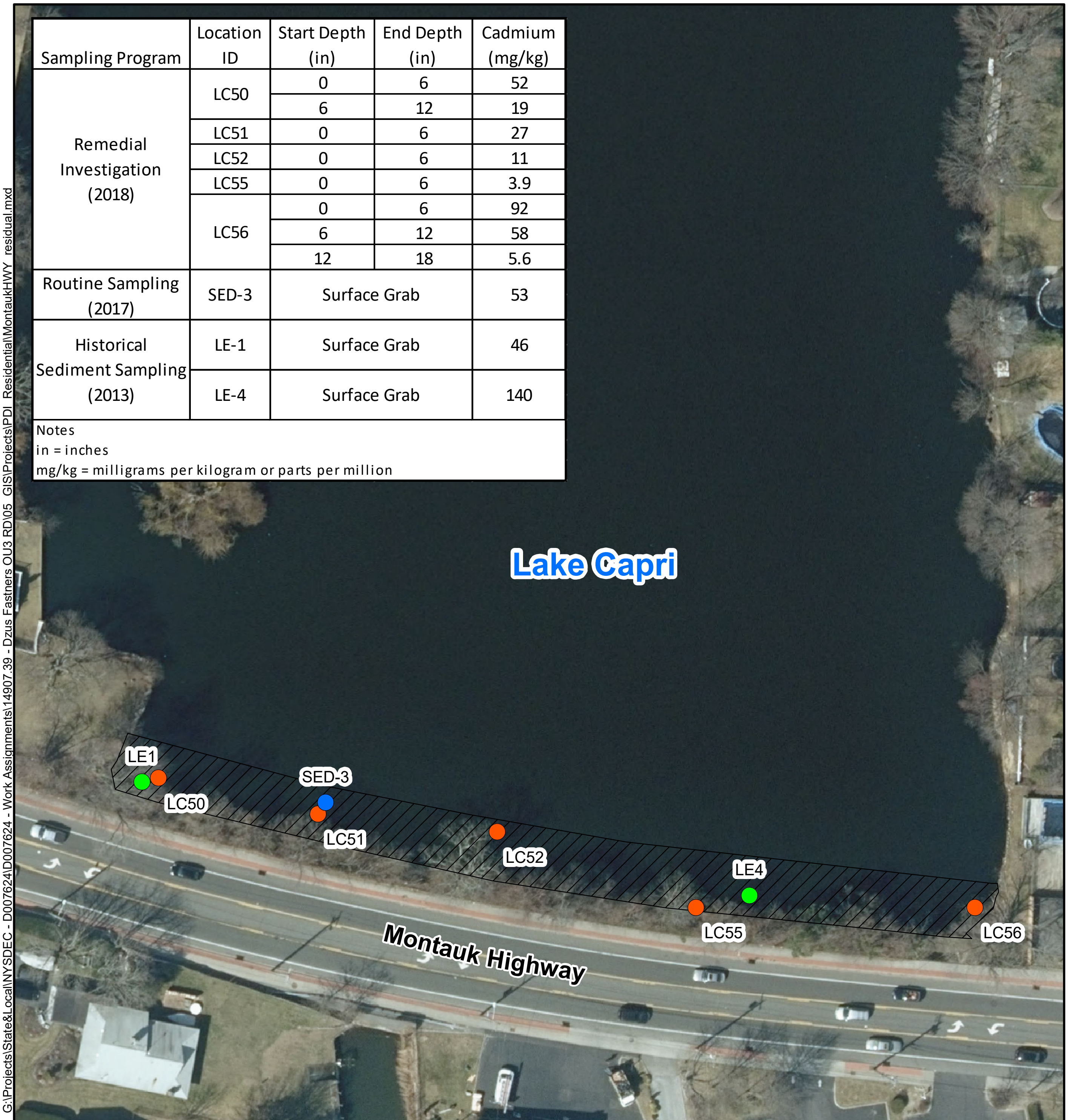
Figure 3-1
Residual Cadmium in Willetts Creek Floodplain
Dzus Fastener Company, Inc.
Climate Resiliency Assessment Report
West Islip, NY

Map Date: 12/20/2019
Projection: NAD83 UTM Zone 18N

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Sampling Program	Location ID	Start Depth (in)	End Depth (in)	Cadmium (mg/kg)
Remedial Investigation (2018)	LC50	0	6	52
		6	12	19
	LC51	0	6	27
	LC52	0	6	11
	LC55	0	6	3.9
	LC56	0	6	92
		6	12	58
		12	18	5.6
Routine Sampling (2017)	SED-3	Surface Grab		53
Historical Sediment Sampling (2013)	LE-1	Surface Grab		46
	LE-4	Surface Grab		140

Notes
in = inches
mg/kg = milligrams per kilogram or parts per million



0 50 100
Feet
1 inch = 72.754 feet

N

Legend

- Rip Rap/Armor Placement Area
- 2018 Sampling Location
- 2017 Sampling Location
- 2013 Sampling Location

Figure 3-2
Residual Cadmium in Lake Capri
Dzus Fastener Company, Inc.
Climate Resiliency Assessment Report
West Islip, NY

Map Date: 12/20/2019
Projection: NAD83 UTM Zone 18N

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

G:\Projects\State&Local\NYSDEC - D007624 - Work Assignments\14907.39 - Dzus Fastners OU3 RD\05 GIS\Projects\PDI Residential\MontaukHWY residual.mxd

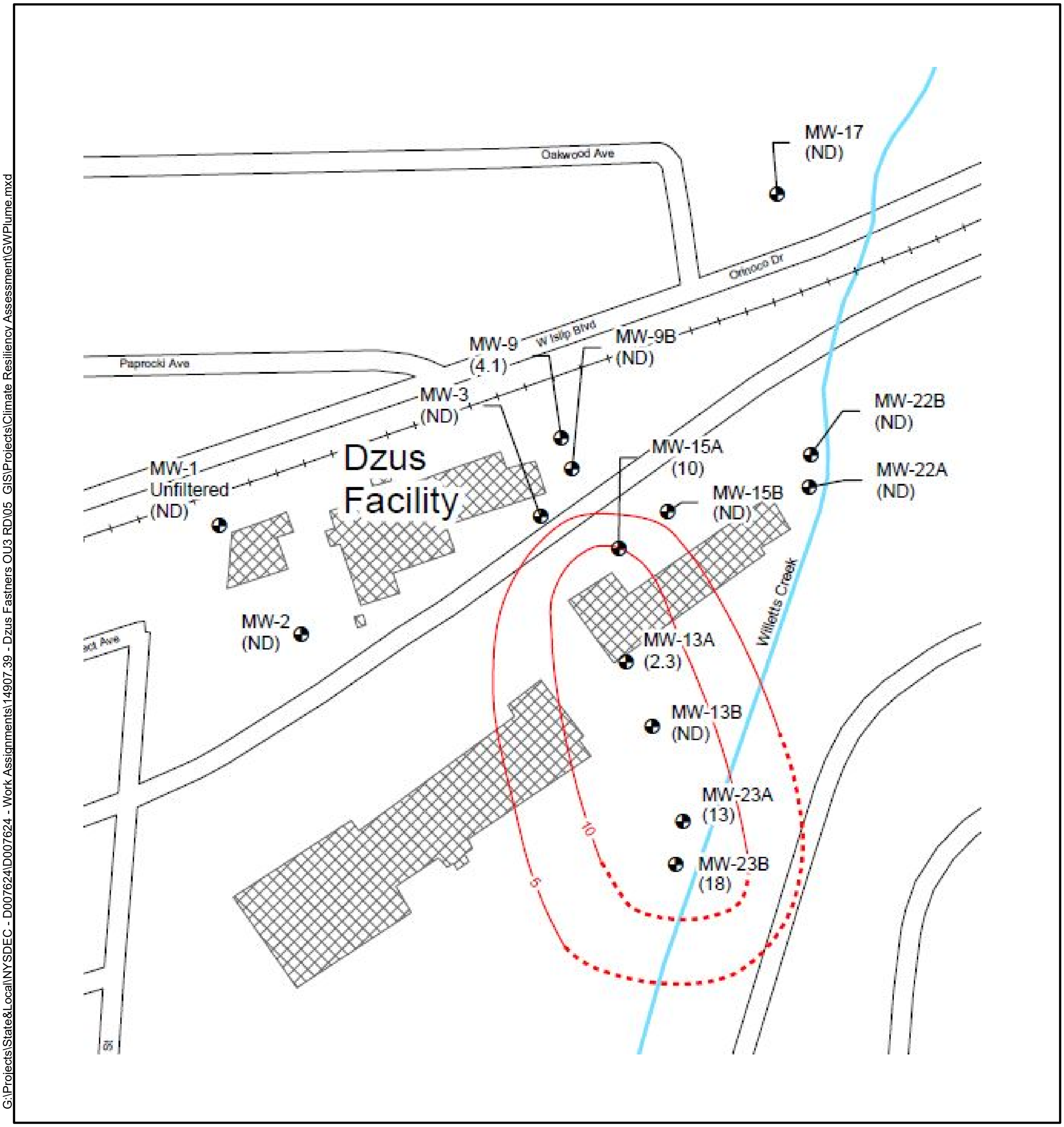
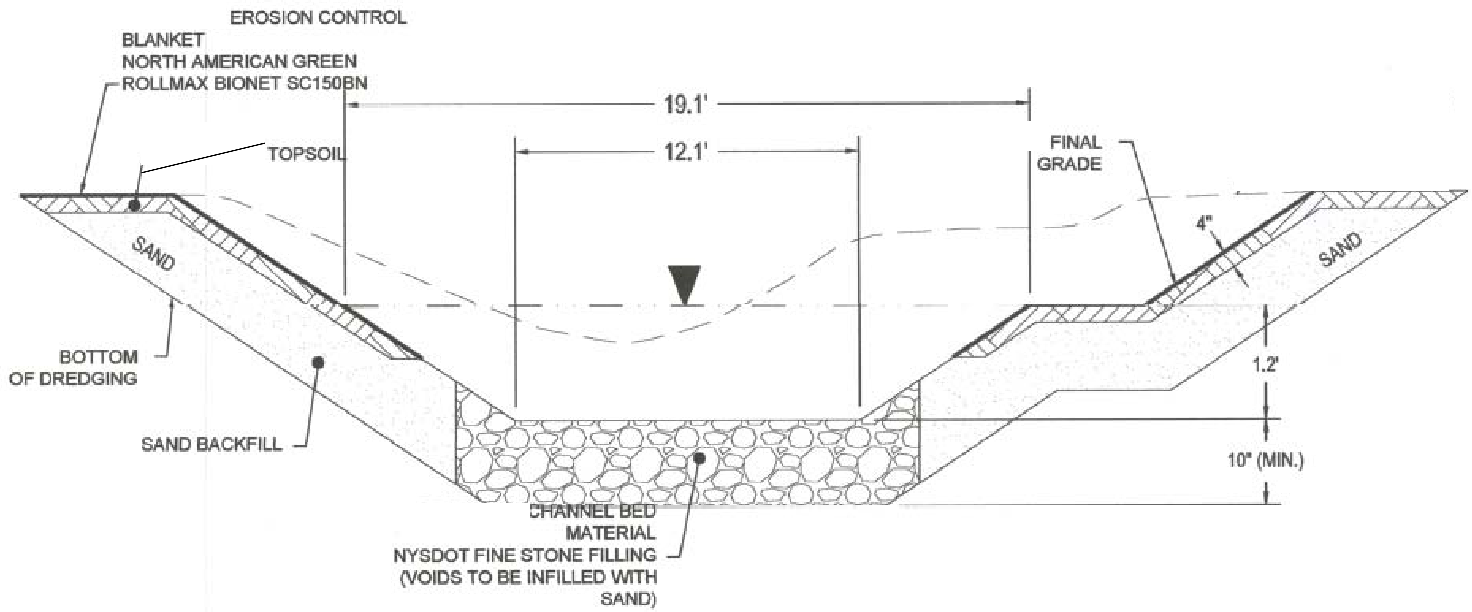


Figure 3-3
Residual Cadmium in Groundwater
Dzus Fastener Company, Inc.
Climate Resiliency Assessment Report
West Islip, NY

Note: Figure from AECOM. 2019. Groundwater Sampling Report (November 2018 Sampling Event) Dzus Fasteners Site, Site #1-52-033. Final. May

Map Date: 12/20/2019
Projection: NAD83 UTM Zone 18N



SAND BACKFILL GRADATION

Sieve	Percent Passing by Weight
1/2 inch	100
1/4 inch	90 to 100
No. 200	5

TOPSOIL GRADATION

Sieve	Percent Passing by Weight
2 Inch	100
1 Inch	85 – 100
¼ Inch	65 – 100
No. 40	45 – 65
No. 200	5 – 10

CHANNEL BED MATERIAL GRADATION

Stone Size	Percent of Total by
Smaller than 8 inch	90 - 100
Larger than 3 inch	50 - 100
Smaller than No. 10 Sieve	0 - 10

TOPSOIL NOTES:

1. THE PH OF THE MATERIAL SHALL BE BETWEEN 5.5 AND 7.6.
2. THE ORGANIC CONTENT SHALL BE NOT LESS THAN 3% OR MORE THAN 8%, (DRY WEIGHT BASIS).

EA Engineering, P.C. and Its Affiliate
EA Science and Technology

FIGURE 3-4
Willett's Creek Typical Backfill Detail
Dzus Fastener Company, Inc.
Climate Resiliency Assessment Report
West Islip, NY

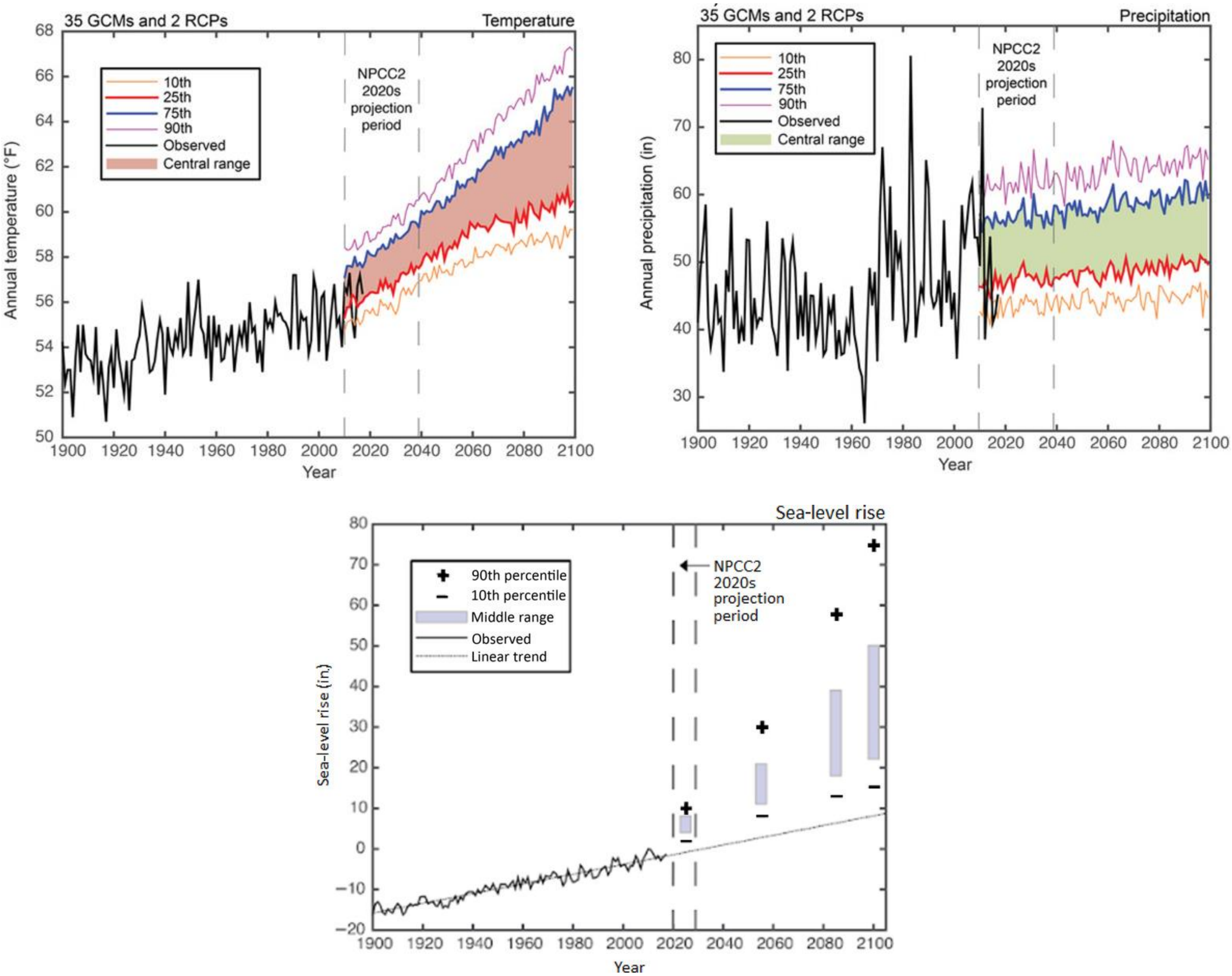
NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

4. CLIMATE CHANGE PROJECTIONS

A review of the information regarding the projected climate impacts was performed, focusing on impacts projected to the year 2050. Impacts investigated included sea level rise scenarios and associated possible saltwater intrusion to groundwater; precipitation intensity and quantity along with associated impacts to surface water, stormwater, and groundwater; temperature; and wind.

Climate change impacts have already been observed in the state of New York, including increases in temperature, precipitation, and sea-level (**Figure 4-1**). The current rate of sea level rise in New York is almost twice the observed global rate, due in part to a high rate of land subsidence (National Oceanic and Atmospheric Administration [NOAA] 2017). Future modeling predicts current climate change trends will continue. The climate change projections used in the Dzus analysis are derived from a New York State climate change report prepared in 2011, with updates in 2014, as well as the 2019 New York City Panel on Climate Change Report (Rosenzweig et al. 2011; Horton et al. 2014; Rosenzweig and Solecki 2019). These reports include historical, current, and future projections of climate change scenarios for several distinct regions within New York. The Dzus project site falls in the report's Region 4, which encompasses New York City and Long Island. These data were compared to site-specific conditions to evaluate impacts and vulnerabilities at the site. To capture some of the uncertainty associated with climate change predictions, a range of five projections are provided. The medium prediction is likely to occur, while the high prediction represents a possible worst-case scenario. Based on the models, there is a 50 percent probability that actual future conditions will meet or exceed the medium projection. The high prediction has a 1 percent probability that actual future conditions will meet or exceed the projection.

Projections are based on both global climate models and representative concentration pathways (RCPs). A global climate model is a mathematical representation of the Earth's climate, which uses atmospheric greenhouse gases and aerosols, as well as land use changes, to simulate physical exchanges between the ocean, atmosphere, land, and ice (Rosenzweig and Solecki 2019). RCPs are varying trends of greenhouse gases, aerosols, and land use changes included as inputs to global climate models. The New York City Panel on Climate Change report used two RCPs: (1) "RCP 4.5," defined as a medium-emissions scenario; and (2) "RCP 8.5," defined as a high-emissions scenario.



Source: Rosenzweig and Solecki 2019.

Figure 4-1 Observed and Projected Annual Temperature, Precipitation, and Sea Level Rise for New York City

4.1 PRECIPITATION

Since 1900, average precipitation in New York State has increased each year. From 1958 to 2010, the amount of precipitation in the northeastern United States falling in heavy events (over 1 in. of precipitation in a day) increased by more than 70 percent. During this time frame, winter precipitation increased, while summer precipitation decreased. Modeling of future conditions predicts both precipitation quantities and variability will continue to increase. In the middle range projection, Region 4 precipitation may increase by as much as 11 percent, approximately 5 in. per year, by 2050 (**Table 4-1**). Heavy rainfall events may increase by as much as 16 percent, or 2 days per year, by 2050 (**Table 4-2**).

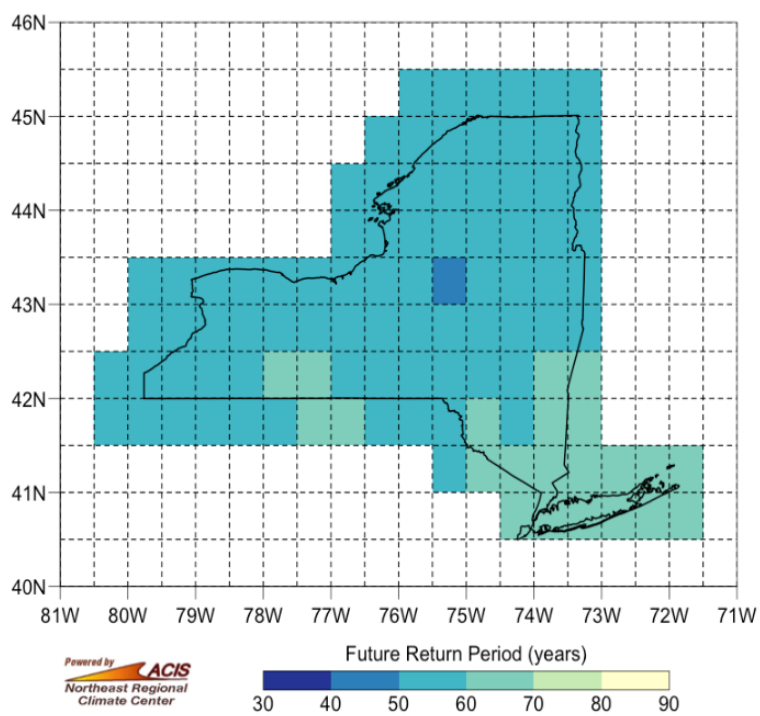
Table 4-1 Mean Annual Precipitation Changes in Region 4

Baseline (1971–2000) 49.7 in.	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	- 1 percent	+ 1 to + 8 percent	+ 10 percent
2050s	+ 1 percent	+ 4 to + 11 percent	+ 13 percent
Source: Horton et al. 2014.			

Table 4-2 Extreme Precipitation Event Projections in Region 4

Baseline Days over 1 in. Rainfall (13 days)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	13	14 to 15	16
2050s	13	14 to 16	17
Source: Horton et al. 2014.			

The current 100-year rainfall event is projected to equal a 60- to 70-year event in Long Island by 2040-2069, according to both the high and low projections (**Figure 4-2,** Northeast Regional Climate Center 2015).



Source: Northeast Regional Climate Center 2015.

Figure 4-2 Mean Future Return Periods: 1-Day 100-Year Rainfall Amounts, High Emission Scenario, 1970–1999 Versus 2040–2069

4.1.1 Surface water

Precipitation and heavy rainfall event increases are likely to decrease water quality and increase flooding within Willetts Creek and Lake Capri. Heavy rainfall events may be cause for greater concern, as intense short events limit infiltration of water and increase flooding. During intense precipitation events the modest topographical relief in the project area generally mitigates runoff velocities.

Post-remedial action conditions in Willetts Creek were evaluated to ensure stability of the channel velocities and shear stress values. Water surface elevations are relatively similar or decreased from pre- to post-remedial action conditions. Areas with greater risk for scour and erosion were protected with rock sized to withstand the current 100-year storm event. These areas include the upstream extent of Willets Creek and areas directly upstream and downstream of footbridge crossings. Stormwater flow in Willets Creek and Lake Capri has a southward flow to the ocean, with a maximum velocity of approximately 7.25 miles per hour during the present day 10-year storm. Velocity increases will be mitigated by the modest channel slope of approximately 0.25%. As discussed in Section 4.2 below, selection and placement of stone materials considered the northward coastal storm surge as well.

Vertical or horizontal degradation of the stream channel would require the replacement of fill materials placed during remediation.

4.1.2 Groundwater

The Upper Glacial Aquifer underlying the site is an unconfined aquifer that is not a potable water source. Decreases in precipitation during summer months may reduce annual recharge, but impacts are expected to be minimal to the Upper Glacial Aquifer as the majority of recharge typically occurs during the late winter and early spring (Rosenzweig et al. 2011).

4.2 SEA LEVEL RISE

The greatest potential climate impact at the Dzus site is an increase in sea level. Factors that affect sea level include thermal expansion, melting of glaciers, melting of land ice, vertical land movement, and changes in ocean circulations. An increase in sea level impacts is primarily driven by: (1) sea level rise from climate change, and (2) storm surge from significant storm events. Both factors are described in the following sections. Areas where the existing topography is overlapped by the predicted future sea level elevation are expected to be impacted. Predicted sea level elevations are calculated with current sea level at mean higher high water (MHHW) in terms of the North American Vertical Datum of 1988 (NAVD88) and combinations of water level increases from sea level rise and storm surge. These combinations are termed sea level scenarios (**Table 4-3**). The sea level scenarios are presented for the year 2050, representing potential boundaries for water level impacts.

Reference Sea Level (MHHW)

To calculate the sea level scenarios presented in this report, a reference sea level was needed as sea levels change within a day (e.g., tides). This reference sea level is MHHW in NAVD88. The water in the project coastal area has two high tides and two low tides that continue in a cycle. The MHHW is the average of the highest tides within each tidal day (two high tides and two low tides) calculated over a specified 19-year period (National Tidal Datum Epoch). Therefore, sea level scenarios include the highest sea level within a tidal day.

Relative Sea Level Rise from Climate Change

In the context of this report, relative sea level rise refers to projected water level increases estimated from climate change for Long Island, New York. Since 1900, average coastal sea levels in New York have risen more than a foot, at a rate of 1.2 in. per decade (**Figure 4-1**). The rate of rise in New York is almost twice the global rate over the same period. This is due to several local factors including subsidence of the land mass in relation to the earth's crust. Modeling predicts the medium projection of sea level rise in Region 4 (New York City and Long Island) from baseline conditions to the year 2050 to be 1.3 ft. The predominant factor driving the rate and extent of sea level rise is greenhouse gas emissions. To capture some of the uncertainty associated with sea level rise predictions, a range of water level increases is presented in the current report. The medium sea level rise prediction for the range presented in this report is likely to occur, while the high sea level rise prediction represents a possible worst-case scenario. Based on the probabilistic models, there is a 50 percent probability that sea level rise will meet or exceed the medium projection. The high sea level rise prediction has a 1 percent probability that sea level will meet or exceed the projection. The increases in sea level from climate change are predicted to result in a "new normal" and, therefore, are anticipated to result in relatively permanent flooding, except for tides. According to the high projection, sea level rise could be 2.5 ft above the current elevation by the year 2050.

Flooding from Storm Events

The water level increases from flooding in **Table 4-3** are the 2019 major flood stages. The major flood stages are determined by NOAA and the National Weather Service. Major flooding is defined as extensive inundation of structures and roads resulting in significant evacuations of people. These major flooding events occur infrequently. In this report, the major flood stage provides an estimate of water inundation from a storm event, although the flood stages are anticipated to change with sea level rise from climate change in the future.

An important consideration for design of resiliency measures besides the expected water elevation of the storm surge is the velocity which the surge will likely move inland. In the case of storm surge, it will move onshore at the forward velocity of the storm. In the case of a hurricane this can be highly variable but is often from 10 to 15 miles per hour.

For comparison purposes the reference impact of Hurricane Sandy in 2012 is also provided to compare the predicted water level increase from sea level rise scenarios outlined in **Table 4-3** relative to a historic event that caused significant flooding in the area. In 2012, Hurricane Sandy inundated portions of the project area with a storm surge of 6.1 ft and peak storm tide between 6.5 and 7.7 ft (Schubert et al. 2015; National Weather Service Lindenhurst Gauging Station). This storm was estimated to have a recurrence interval of approximately 500 years for the peak storm surge. Considering the projections for sea level rise, future storms equal in magnitude to Hurricane Sandy will result in greater flooding (Shrestha et al. 2014).

It is also important to note in the context of climate change impacts that severe storms similar to Hurricane Sandy are likely to occur more often as warmer oceans may contribute to a more northerly track of severe storms. Warmer ocean water will also lead to increased water vapor in the atmosphere, increased energy which can translate into more powerful hurricanes, and an extended hurricane season.

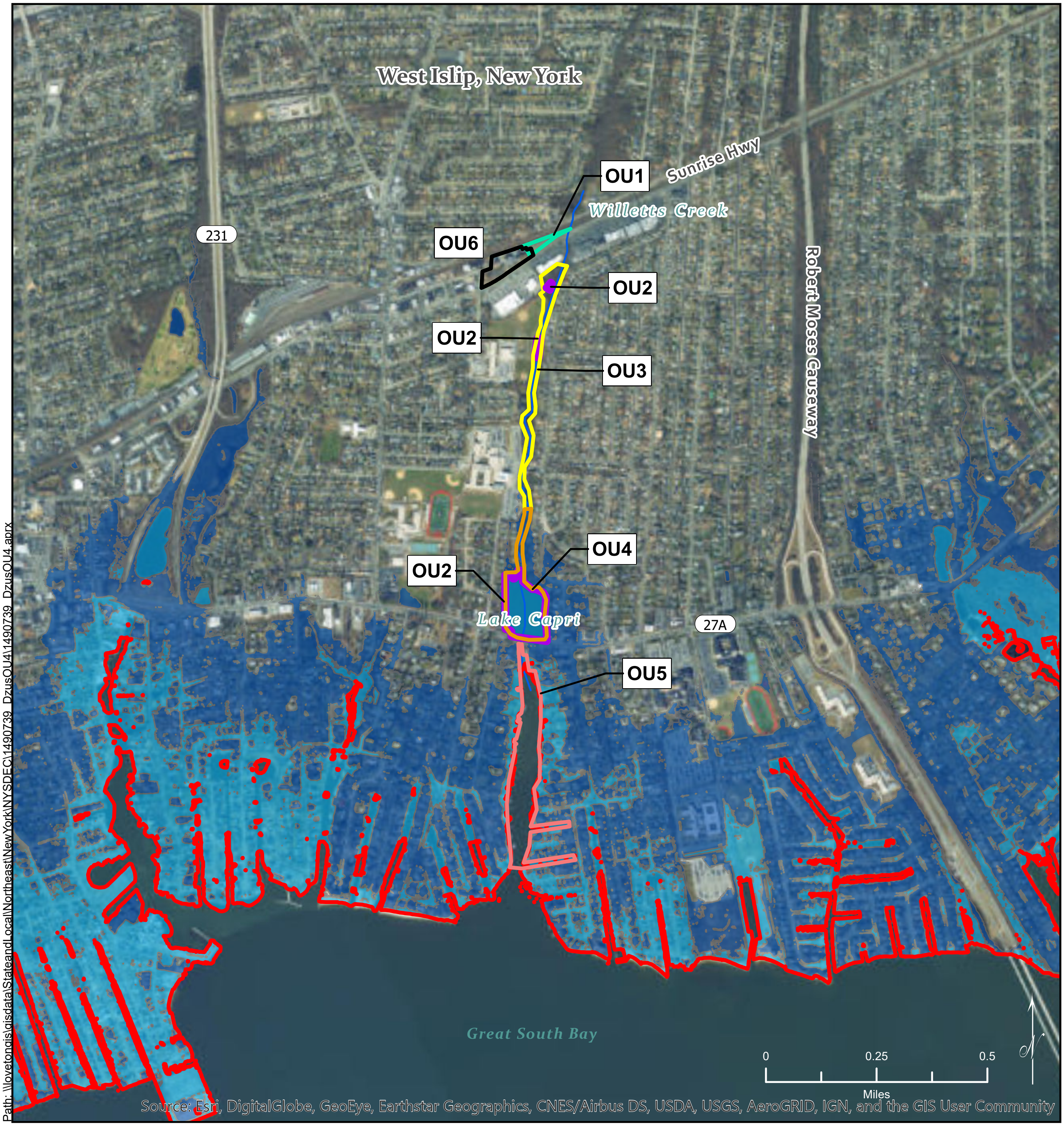
Table 4-3 Sea Level Rise Scenarios

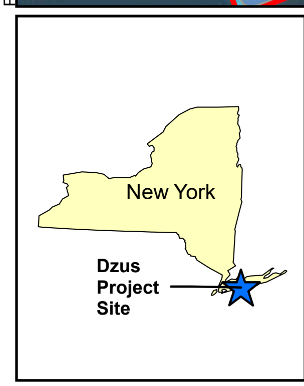
Year	Relative SLR Scenario Range	Water Level Increase from SLR (ft)	Predicted MHHW Elevation with SLR (ft)	Major Storm Stage with SLR (ft)	Sandy Storm Stage with SLR (ft)
Present Day		0	0.6	4.1	7.7
2050	Mid	1.3	1.9	6.0	9.6
	High	2.5	3.1	7.2	10.8

Note: SLR = Sea Level Rise.
Source: USGS Tide Station/Gauge = 01309225/Great South Bay at Lindenhurst NY, NAVD88 Datum.

Figures 4-3 to **4-5** provide a visual representation of the Sea Level Rise Scenarios presented in **Table 4-3**. **Figure 4-3** provides a presentation of the current conditions with current MHHW, water level impacts from a NOAA event categorized as a major storm stage, and the effects of a storm equal to the magnitude of Sandy. This figure depicts the actual extent of water level impact from the 2012 Hurricane Sandy. As can be seen, these events impact OU5 and have the potential to impact Lake Capri and uplands to the adjacent east of OU2/OU4.

The next two figures present the medium (50 percent chance of occurrence) and worst case (1 percent chance of occurrence) scenarios for the year 2050 (**Figures 4-4 and 4-5**). In reference to **Table 4-3**, this equates to 1.3 ft and 2.5 ft in addition to the current water level, respectively. In the 2050 mid-range scenario, the inland penetration of storm surge impacts is similar to present day impacts. The 2050 worst-case scenario shows storm surge inundation moving further inland along the banks of Willetts Creek up to West Islip High School. In both 2050 scenarios a storm of the magnitude of Sandy would cause significant flooding to the lands adjacent to OU5, the tidal portion of Willetts Creek.





Legend

Willetts Creek
OU1
OU2
OU3
OU4
OU5
OU6

SLR Scenario

Major Storm Stage
Sandy Storm Stage

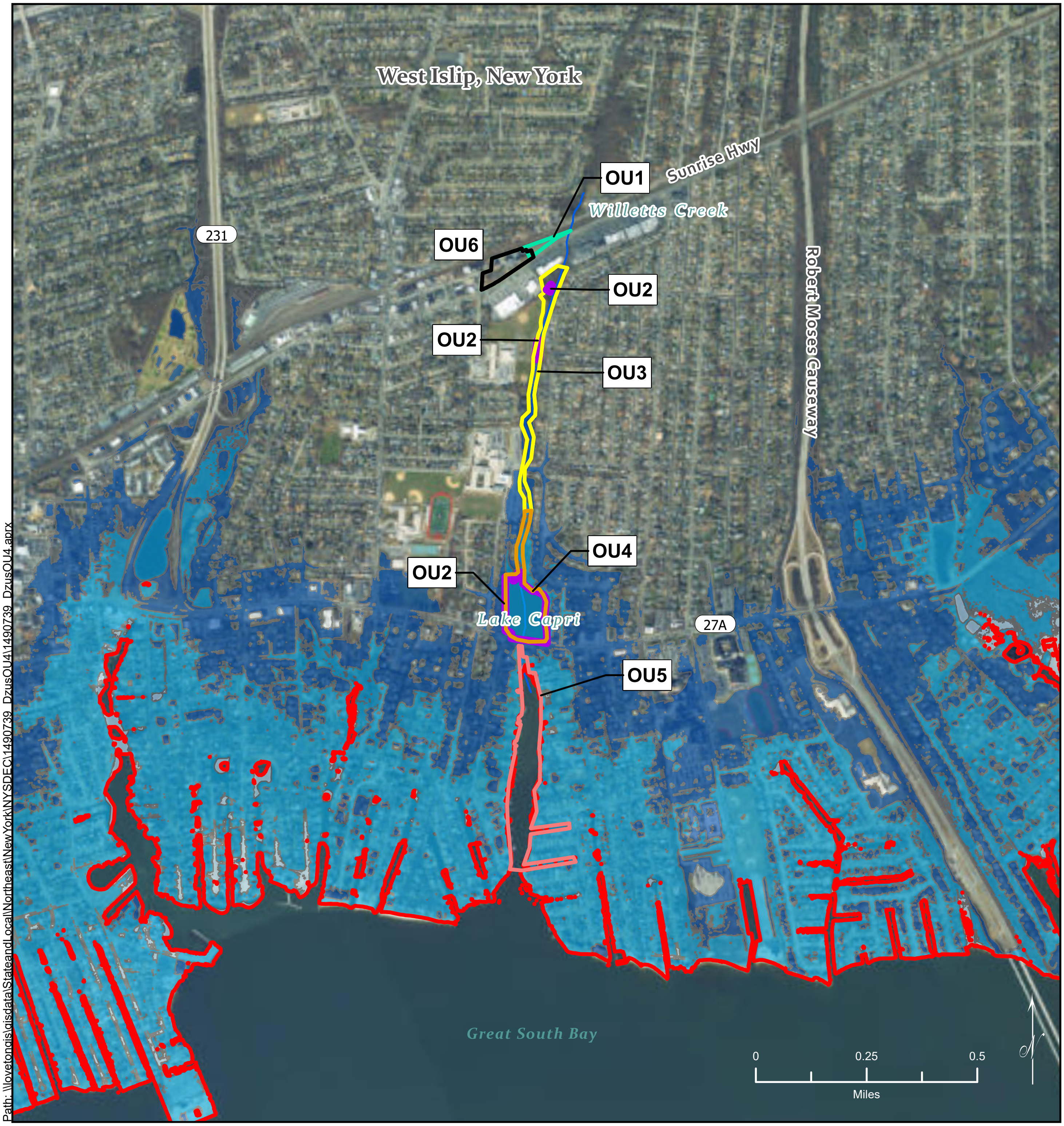
Current MHHW Line

Notes:
OU - Operable Unit
MHHW - Mean Higher High Water
SLR - Sea Level Rise
Data Source: NYS GIS 2018, Imagery: ESRI 2018

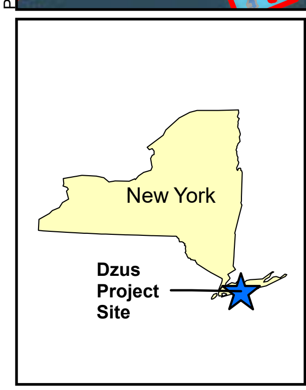
Figure 4-3
Current Conditions for MHHW, Major Storm Stage and Sandy Storm Stage

Operable Unit 3- Willetts Creek Area
Operable Unit 4- Lake Capri
West Islip, New York

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation



Path: \\lovetongis\gisdata\StateandLocal\Northeast\NewYork\NYSDEC\1490739_DzusOU4\1490739_DzusOU4.aprx



Legend

- Willetts Creek
- OU1
- OU2
- OU3
- OU4
- OU5
- OU6

SLR Scenario

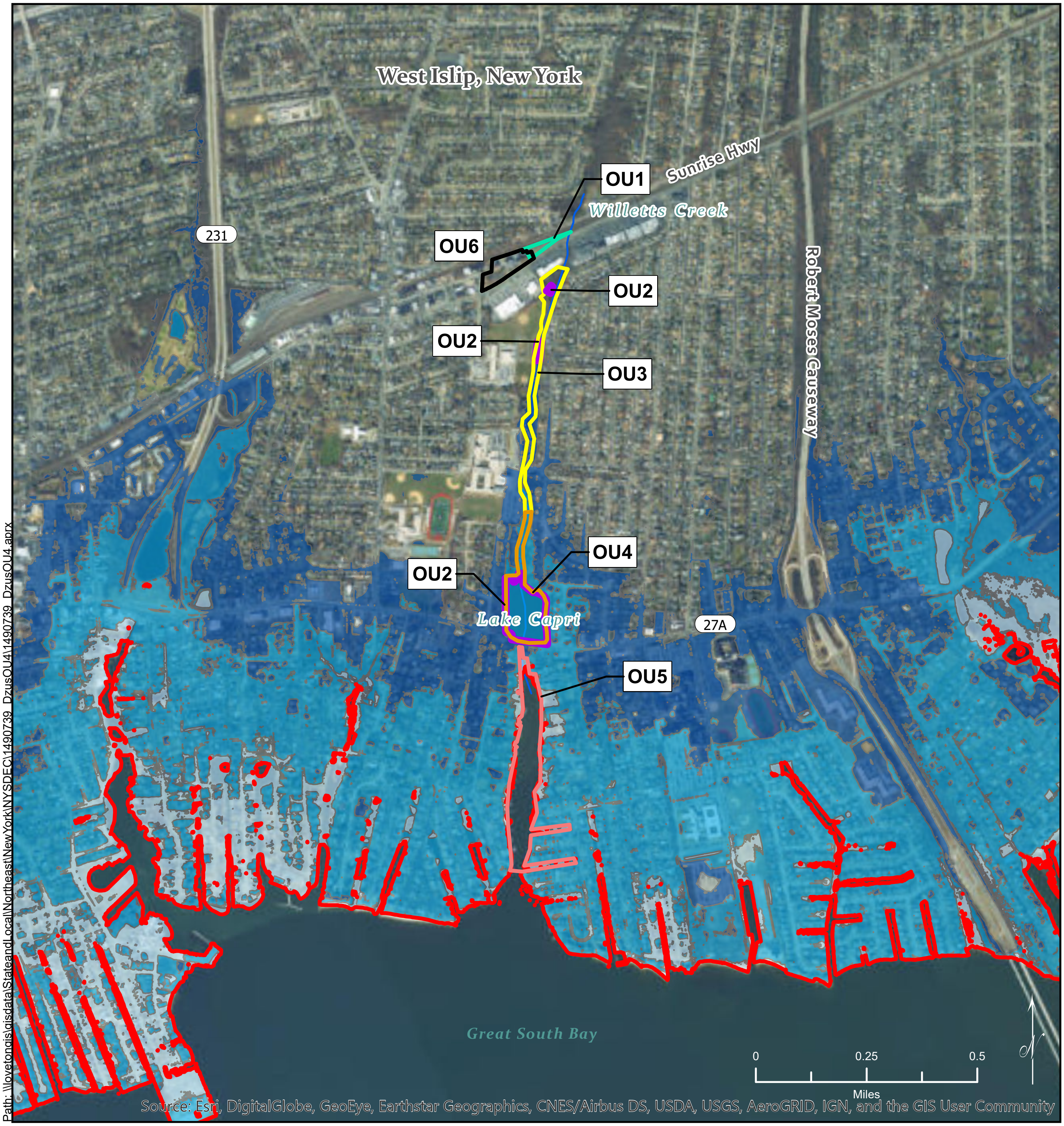
- Sandy Storm Stage
- Major Storm Stage
- MHHW
- Current MHHW Line

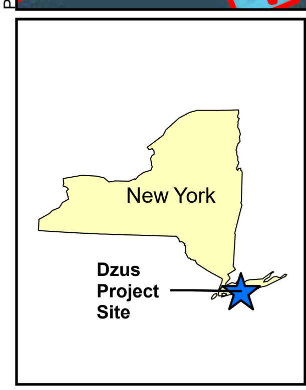
Notes:
OU - Operable Unit
MHHW - Mean Higher High Water
SLR - Sea Level Rise
Data Source: NYS GIS 2018, Imagery: ESRI 2018

Figure 4-4
2050 Mid Relative SLR for MHHW, Major Storm Stage and Sandy Storm Stage

Operable Unit 3- Willetts Creek Area
Operable Unit 4- Lake Capri
West Islip, New York

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation | EA





Legend

- Willetts Creek
- OU1
- OU2
- OU3
- OU4
- OU5
- OU6

SLR Scenario

- Sandy Storm Stage
- Major Storm Stage
- MHHW
- Current MHHW Line

Notes:
OU - Operable Unit
MHHW - Mean Higher High Water
SLR - Sea Level Rise
Data Source: NYS GIS 2018, Imagery: ESRI 2018

Figure 4-5
2050 High Relative SLR for MHHW, Major Storm Stage and Sandy Storm Stage

Operable Unit 3- Willetts Creek Area
Operable Unit 4- Lake Capri
West Islip, New York

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

4.2.1 Surface water

The culvert invert elevation at Lake Capri's outlet is 0.8 ft above mean sea level and the adjustable control structure is located at 3.3 ft above mean seal level. Montauk Highway is at an elevation ranging from 7 to 8 ft above mean sea level (NAVD88 Datum). These elevations are important to determining sea level impacts at the site. It is not anticipated that MHHW will exceed 3.3 ft above mean sea level by 2050.

4.2.2 Groundwater

The dynamic of the Upper Glacial Aquifer may be permanently affected by sea level rise. Saltwater intrusion has been documented in the eastern portion of Suffolk County since 1974 (Nemaska's and Koszalka 1982). The Upper Glacial Aquifer is noted to be in direct contact with the ocean. Saline water will enter the aquifer if the freshwater head is lower than the saline-water head. Encroachment of saline water may also occur by movement of saline water in other aquifers or vertical coning due to groundwater withdrawals. Hydraulic conductivity of the Upper Glacial Aquifer is 350 ft per day and transmissivity ranges from 5,350 to 22,725 square ft per day.

4.3 TEMPERATURE

Since 1970, the average state temperature has risen 2.4 degrees Fahrenheit (°F) overall annually and 4.4 °F for the winter months. Temperature has increased in all regions of New York, equating to about a 0.25 °F increase each decade. Modeling shows that temperatures are anticipated to continue to increase, with Region 4 (New York City and Long Island) middle range projection average temperatures expected to be approximately 4 to 5 °F warmer by the 2050s (**Table 4-4**). Summers are expected to intensify with extreme heat and heat waves, while winters are expected to become milder.

Table 4-4 Temperature Mean Annual Changes in Region 4

Baseline (1971–2000) 54.6 °F	Low Estimate (10^{th} Percentile)	Middle Range (25^{th} to 75^{th} Percentile)	High Estimate (90^{th} Percentile)
2020s	+ 1.5 °F	+ 2.0 to 2.9 °F	+ 3.2 °F
2050s	+ 3.1 °F	+ 4.1 to 5.7 °F	+ 6.6 °F
Source: Horton et al. 2014.			

4.4 WIND

Quantitative information for projected wind impacts is not currently available. It is not known how the number of tropical cyclones will change in the North Atlantic Basin, but it is likely that intense hurricanes and associated extreme winds will increase (Horton et al. 2014).

5. CLIMATE CHANGE SENSITIVITY ASSESSMENT

Based upon the review of the existing site information and the projected impacts from climate change at the project site, the project team has assembled a list of site climate-related sensitivities and vulnerabilities. This assessment includes a review of site components including but not limited to surface water, groundwater, and any planned remedial structures. This information has been used to identify the sensitivity of these site components to identified climate impacts over time. This information is presented in text, table, and map format for ease of review.

Review of Possible Climate-Related Impacts to Remedial Efforts at Hazardous Sites

Before reviewing the possible impacts at the project site, it is beneficial to provide a brief survey of the possible effects of climate change on remedial efforts at sites containing hazardous materials in general. At sites with legacy contamination and ongoing remedial efforts, climate change and extreme weather events can potentially impact the effectiveness of site remediation design and can also impact contaminant toxicity, exposure, organism sensitivity, fate and transport, and long-term operations, management, and stewardship of remediation sites.

Higher temperature and lower pH can potentially increase the availability of contaminants in the environment. For example, the speciation and availability of metals changes with environmental pH, and the fate and transport of persistent organic contaminants changes with temperature and precipitation. Increasing temperatures can also change the water cycle, influencing the local water budget. Warmer temperatures can result in altered precipitation, increased evaporation rates of surface water, increased rates of water uptake by vegetation, and reduced rates of water recharge to soils and groundwater reservoirs (Famiglietti 2014).

Increased temperatures and changes to the water cycle may also result in more frequent and severe weather events, such as the occurrence of the 100-year storm event, as well as contribute to more frequent nuisance flooding due to the prevalence of supersaturated soils. Both events are exacerbated by sea level rise resulting in shoreline encroachment and increased nuisance flooding during high tide if the site is situated near enough to the tidal range.

Additional vulnerabilities of water resources include, but are not limited to, changes to water supplies; subsidence; increased amounts of water contamination, erosion, and related risks to water and wastewater infrastructure and operations; degradation of watersheds; alteration of aquatic ecosystems and loss of habitat, creating multiple impacts in coastal areas. These hydrological changes are happening at the same time as groundwater extraction is increasing as heat also increases demand for various water needs, including drinking, irrigation, and industrial uses (Famiglietti 2014).

A recent study showed a potential impact of such climatic shifts on residual contaminants in soil and groundwater (Libera et al., 2018). The study found that the hydrological shifts influence contaminant concentrations in a complex manner, since increased infiltration, for example, could cause conflicting effects of both diluting and mobilizing contaminants. The study showed that, in general, higher infiltration events could mobilize vadose-zone residual contaminants, raising contaminant concentrations in groundwater for a prolonged period.

Similarly, the sensitivity of organisms and ecosystems can be affected by environmental change. Higher temperatures increase the metabolic rate of certain organisms, which can increase the rate at which they absorb or process contaminants (Noyes et al., 2009). Behavioral changes in response to environmental change may also alter exposure and sensitivity as organisms react to new stresses.

For context, a list of possible climate change sensitivity and vulnerabilities associated with remedial activities at sites in general terms is presented in **Table 5-1** derived from Maco et al., 2018.

Table 5-1 Possible Climate Change Impacts for Remediation

Climate Impact	Secondary Effect	Relevant remediation effect
Altered precipitation pattern	Wetter: Flooding, storms, more runoff	• Mobilization of contaminants (e.g., from vadose zone to groundwater) → Higher contaminant concentration/export, overpowering significant degradation rate in groundwater zone could remove natural protective barriers or cause infill subsidence in low-lying areas
		• Dilution → Lower contaminant concentration/export
		• Damage to cover systems
	Drier: Drought	• Oxidation of soils
		• Increased volatility
		• Less dilution → Higher contaminant concentration/export
		• Reduced mobilization → Higher contaminant persistence (higher contaminant concentration/export)
		• Insufficient water for remediation; Overuse of groundwater
		• Possible enhanced natural attenuation, expedited contaminant removal
	Altered salinity	• Altered degradation rates (physical, microbial)
Sea level rise	Erosion	• Damage to site integrity
	Site inundation	• Increased mobilization of contaminants, possible dilution, or compromised site with mixing or loss of contaminated materials, increased bioavailability of contaminants
	Mobilization of sediment	• Clean sediments transported on top of contaminated sediments
	Surface water elevations increase	• Changing footprint of floodplains, river boundaries, and coastal shoreline encroachment → Impact on regulations (e.g., dredging, cleanup levels, negotiation of water levels, monitoring)
Extreme weather	Scour (wind/wave action; surface water flow velocity)	• Damage to site integrity, cover systems
	Flooding	• Possible dilution (lower contaminant concentration/export), or compromised site with mixing or loss of contaminated materials, damage to cover systems
	Extreme heat	• Increased volatility → Mobilization of contaminants from site through soil and air
		• Changes in use of site by wildlife

Table 5-1 Possible Climate Change Impacts for Remediation

Climate Impact	Secondary Effect	Relevant remediation effect
		• Melting permafrost → Mobilization of contaminants from site through water, soil, and air
	Freezing conditions	• Damage to cover systems and in situ stabilization systems
Extreme weather: Fire	Increased use of fire retardants	• Spread of contaminants
	Damage to site infrastructure	• Loss of function of remediation systems
Decreasing pH of surface water, soil and sediment		• Increased availability, mobilization, toxicity
		• Increased sensitivity of species due to pH stress
		• Altered transformation rates
Increasing temperature	Altered transformation or degradation	• Increased or decreased toxicity
	Decreased dissolved oxygen/anoxic conditions	• Altered transformation, decreased species resilience
	Increased species heat stress and associated conditions	• Increased sensitivity to contaminants
Human impact and responses	Vulnerable communities commonly comprised of low socioeconomic and minority populations	• Cardiopulmonary illness; Food, water, and vector-borne diseases • Loss of homes, drinking water, and livelihoods; Mental health consequences and stress
Source: Maco et al. 2018.		

5.1 REMEDIATION SYSTEM COMPONENTS

There will not be any long-term active remedial systems in place at the site.

5.2 REMEDIATION OPERATIONS

As noted previously there have been ongoing remedial efforts at the subject site since the 1990s. In the context of this document the focus is on long-term management of the implemented remedies and planned remedial operations related to OU5.

5.3 CONTAMINANTS OF CONCERN

Primary contaminants of concern that remain onsite (**Table 3-1**) include cadmium and trivalent chromium found in the in-situ stabilized/solidified soils in OU1, soil located behind the shopping plaza and in sediment along the Montauk Highway retaining wall beneath clean backfill materials. A potential climate change vulnerability includes scour of the clean backfill materials to expose covered material. Both the chemical form of contaminants and abiotic factors affect mobility and bioavailability. Climate change can increase exposure to contaminants due to changes in processes involving soil organic carbon, surface runoff, redox state, and microbial community (Biswas et al. 2018). Specifically, trivalent chromium solubility and toxicity varies with water quality characteristics such as hardness and alkalinity and cadmium vary with hardness and organic carbon. Both trivalent chromium and cadmium are more toxic in soft water than in hard water, as the presence of calcium and other ions reduces toxicity. Cadmium tends to become strongly adsorbed to clays, muds, humic and organic material, and is typically not bioavailable except to benthic feeders and bottom dwellers (U.S. Environmental Protection Agency [EPA] 2016). It may be re-suspended or return to the water column via turbulent flow of surface water associated with future storms. **Table 5-2** below provides a summary of the possible climate change impacts to residual contaminants of concern at the subject site.

Table 5-2 Summary of Possible Climate Change Impacts on Residual Contaminants of Concern

Climate Impact	Secondary Effect	Relevant Remediation Effect
Altered precipitation pattern	Flooding, storms, more runoff	Possible additional groundwater monitoring to assess impacts groundwater
		Lower contaminant concentration via dilution
		Increased inspection for erosion or other damage
Sea level rise	Altered salinity	Decreased toxicity of both trivalent chromium and cadmium
	Erosion	Damage to site integrity
	Site inundation	Need for increased monitoring to assess cover condition
	Elevations increase	Changing footprint of floodplains, creek boundaries, and coastal shoreline encroachment may impact regulations

The following section describes the possible climate sensitivities and/or vulnerabilities of these materials:

Precipitation

Increased flooding due to precipitation can lead to the mobilization of contaminants and increase concentrations in soils and surface waters. Increased infiltration can both dilute and mobilize contaminants. Higher infiltration events have been shown to raise contaminant concentrations in groundwater for a prolonged period (Maco et al. 2018). This is the case due to increased movement of the contaminant to groundwater from the vadose zone. Increased precipitation may result in increased use of chemicals (such as contained in fertilizers or pesticides), as chemicals may require repeated applications to provide the intended effect. The potential increased use of chemicals may increase chemical contamination in the project area, potentially interacting with exposed residual contaminants.

Sea Level Rise

Altered salinity due to sea level rise may change physical and microbial degradation rates (Maco et al. 2018). Trivalent chromium is less soluble in saltwater than freshwater. Although trivalent chromium may be ingested and bioconcentrated by filter and deposit-feeding bivalve mollusk and polychaetae species, general toxicity occurs at greater concentrations in saltwater. Cadmium is also less toxic with increasing salinity. Additionally, erosion from sea level rise may cause damage to the site integrity and may require additional monitoring and management activities.

Extreme Weather

As noted within the other sections, extreme weather at the site can impact any remaining contaminants of concern through a variety of ways. These include increased scour, wave action, and surface water flow velocity, which can all act to mobilize contaminated sediment. Flooding can also cause possible dilution of the contaminants in an area as they are mobilized and moved to other areas. (Maco et al. 2018).

This page left intentionally blank

6. ADAPTATION MEASURES

The evaluation includes implemented or planned adaptation measures for the project site. These were generated by cross-referencing site conditions related to expected climate impacts with identified vulnerabilities and sensitivities. The climate adaptation measures identified are characterized within a frame of reference for the overall strategic adaptation goal for the particular site component. In the context of climate resiliency, this could be either to provide resistance to the impact (or protection); to provide resilience (or accommodation); or to provide a response-based measure.

Climate Adaptation Plan Framework – General Overview

Climate change occurs within a temporal scale so that a robust adaptation plan is warranted. There are several factors that drive climate change today and are projected to have lasting impacts on sea levels, storm events, temperature, etc. that may be altered over time. Predictions of climate change impacts may become more precise with time; emissions of gases that contribute to climate change may be altered. These alterations would result in differences in predicted and actual climate change impacts. Therefore, an adaptation plan is needed that can be changed as conditions are altered. A robust plan is one that can be used without failure given a wide range of conditions. The components of a typical climate adaptation plan are outlined below.

The conceptual model (**Figure 6-1**) and the following sections outline a series of steps to develop a robust adaptation plan.

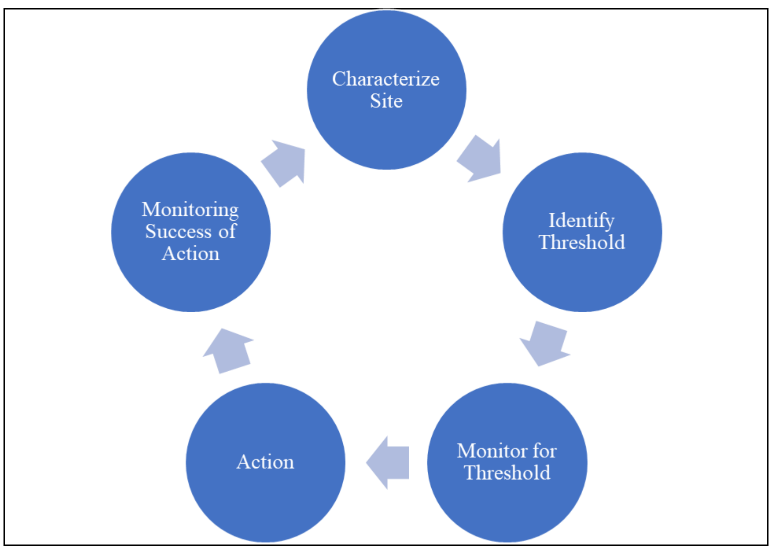


Figure 6-1 Conceptual Model for Adaptation Plan

Characterize Site

The first step of the adaptation plan is to characterize vulnerabilities and sensitivities at the site as has been completed in the previous sections. This data collection step answers the general questions:

1. Where are the issues (e.g., smaller scale – location)?

2. What are the issues (e.g., flooding, erosion, changes to groundwater transport)?

3. How severe are the issues?

These data can be used to inform further data collection and identification of thresholds.

Identify Threshold

A threshold is a parameter or parameters that are measured as indicators to implement or execute the next step of the management plan. Thresholds indicate that the issue at the site is no longer acceptable and the next step of the adaptation plan must be implemented. The thresholds will be specific to the vulnerabilities and sensitivities at a site and will need to be as concise as possible to quantify that the threshold has been achieved. Thresholds will have characteristics of frequency, magnitude, and duration.

Monitoring

Monitoring is used to evaluate if the specific threshold has been achieved. Monitoring data that need to be collected will be specific to the threshold. The sampling plan for data collection must have the specificity in spatial and temporal scale to capture frequency, magnitude, and duration.

Threshold and Subsequent Action

When a threshold is achieved, a specific action to limit risks and adverse outcomes should be executed.

Iterative Approach

The adaptation plan for each area will consist of a series of steps informed by events and monitoring that precede an action. Once a threshold is exceeded and a management action is implemented, monitoring should be continued to ensure that the action is and continues to be effective. As climate change impacts at the site change in the future, this action may no longer be effective. A new set of thresholds and a new monitoring plan should be initiated following implementation of an action.

To decrease risks associated with climate change at the Dzus site, multiple and combinations of adaptation strategies and measures may be implemented. An adaptation strategy is a broader term describing a general approach that may be used at the site. Adaptation measures are used to describe specific actions that can be implemented to decrease climate risks.

Three principle adaptation strategies that can be considered are (Maco et al. 2018):

- Resistance or 'Protection' strategies
- Resilience or 'Accommodate' strategies
- Response strategies – which may include managed retreat from a site.

Once a principal strategy is identified then one or a variety of measures can be deployed to accomplish the overall adaptation management strategy for the site. As climatic conditions change over time, the Adaptation Plan may be accomplished using different measures. Strategies and measures should be implemented based on known and projected impacts as well as the goals and objectives for the area. Additionally, the measures chosen may need to change over time as conditions change and as previous areas of uncertainty and unknown variables become more certain (ESA 2018).

6.1 REMEDIATION SYSTEM COMPONENTS

There will not be any long-term active remedial systems in place at the site.

6.2 REMEDIATION OPERATIONS

There are no remediation operations anticipated at this time; however, OU5 is currently being investigated.

6.3 CONTAMINANTS OF CONCERN

Remedial actions addressed cadmium in sediments and soils in operable units other than OU5 through removal of materials above soil or sediment cleanup objectives or institutional controls. Residual levels of cadmium are listed in **Table 3-1**. **Table 6-1** provides a list of implemented adaptation strategies and associated vulnerability addressed.

Table 6-1 Implemented Strategies

Adaptation Strategy	Sensitivities/Vulnerabilities Addressed
Clean Fill Resilience, Monitoring of Residual Levels of Cadmium, and Movement of Material	Erosion of fill materials
	Damage to clean fill
	Increased bioavailability of cadmium
	Mixing or loss of residual materials

Implemented adaptation measures are further discussed below:

Clean Fill Resilience— Clean material was placed on top of residual materials in certain areas since the residual materials were inaccessible due to structural concerns. The goal was to minimize mobilization of the residual materials.

Portions of the site have been restored with clean material. The climate resilience strategy for these areas was approached in a variety of ways depending on the overall objective for the location. Certain locations need to be able to withstand storm flow from precipitation flowing southward but also potential flow northward from coastal storm surge. The resilient fill strategy includes a monitoring program in place through the Interim Site Management Plan. If the fill system was damaged by a storm or freeze/thaw event(s) then the fill could be restored to the same configuration in place prior to the damage. If, based upon future climate projections or impact, a resistance-based strategy is needed, then the cover could be re-designed and installed to implement further protection. This could include armoring through the addition of stone or paving systems.

As described in the opening section of this chapter, within an adaptation plan the strategy for a particular location may change over time as climate impacts increase. Using the Montauk Highway location as an example it makes sense to employ a strategy of resilience at first. Through this strategy, a threshold is set, and monitoring employed to identify a point in the future when the strategy of resistance (installation of an armored and/or submersible fill system) will be implemented.

Monitoring of Concentrations and Movement of Material—This is an integral part of the 'resilience' or accommodate strategy and is implemented through the Interim Site Management Plan. Each location will be monitored periodically to ascertain if any damage or degradation has occurred and repair is needed. In addition, if a threshold point has been reached then this would also be a possible trigger to move to a different strategy for a location.

Monitoring may involve either, or both, a post storm event inspection of covered areas (looking for signs of erosion and demarcation fabric), and if warranted a post-storm survey of the fill areas. The post-storm survey would be compared to As-Built survey elevations to determine any impacts to fill thickness.

6.4 CLIMATE ADAPTATION PLAN

Based on available information and a review of most likely climate impacts as discussed within this report, a climate adaptation plan is presented below. This adaptation plan focuses on the following items and is included as **Table 6-2**.

- Residual levels of cadmium covered by clean backfill along the banks of OU3 and OU4
- Residual levels of cadmium in groundwater

The climate adaptation plan, **Table 6-2**, provides the suggested details for the threshold levels and success measures for each.

Table 6-2 Draft Climate Adaptation Plan

Item	Project Location	COC	Existing Measure	Potential Climate Change Impact	Potential Effect	Adaptation Measure	Threshold Level	Monitoring for Threshold	Success Measure
1	OU5	Cadmium in soil and sediment	Remedial investigation/feasibility study currently being conducted at OU5.	Storm surge flow from Babylon Cove and Great South Bay northward.	Scour and erosion of sediment bed; deposition of sediment on adjacent floodplain.	To be determined in a future revision to this plan	Storm surge equal to or exceeding the mid-range projection for major storm surge in 2050, defined as 6.0 ft in NAVD88 Datum	Review United States Geological Service Tide Station 01309225 Great South Bay at Lindenhurst, New York, after major storm event to assess if storm surge surpasses threshold.	A visual assessment of areas inundated by major storm surge reveals minimal sediment deposition in the floodplain.
2	OU3 and OU4	Cadmium in sediment and soil	COC covered with demarcation fabric and clean material in specific areas following 2019-2020 remedial action	Storm surge flow northward along Willetts Creek	Scour and erosion of stream bed and banks	Size rip rap stone on the banks and creek bed to prevent erosion from design storm surge flowing north up Willetts Creek. Design based upon large coastal storm (such as Hurricane Sandy) type impact. As climate impacts increase, this design storm level will likely increase. Size of storm to inundate this area at the present time would be significant.	Storm surge equal to or exceeding the mid-range projection for major storm surge in 2050, defined as 6.0 feet in NAVD88 Datum.	Review USGS Tide Station 01309225 Great South Bay at Lindenhurst, NY after major storm event to assess if storm surge surpasses threshold.	An assessment of areas inundated by major storm surge reveals minimal erosion within project limits. Backfill elevations over residual materials verified by survey.
3	OU3 and OU4	Cadmium in sediment and soil	COC covered with demarcation fabric and clean material in specific areas following 2019-2020 remedial action	Storm runoff flow south along Willetts Creek	Scour and erosion of stream bed and banks	Implemented Adaptation Measure - Size rip rap stone on the banks and creek bed to prevent erosion from design storm. Current stone sized for present day 100-year storm level.	On an annual basis, three storm events equal to or exceeding the current 10-year recurrence interval event or one storm event equal to or exceeding the current 100-year recurrence interval event. The 10-year event is defined as 5.25 inches of precipitation in a 24-hour period. The 100-year event is defined as 9.00 inches of precipitation in a 24-hour period.	Review local precipitation gages after major storm event to assess if precipitation surpasses threshold.	An assessment of Willets Creek reveals minimal erosion within project limits. Backfill elevations over residual materials verified by survey.
4	OU1 to OU3	Cadmium and chromium in groundwater	In situ stabilization (ISS) and an asphalt/vegetation cover	Increased groundwater flow and weathering of asphalt cover and ISS mass due to higher runoff in the future	Mobilization of cadmium and chromium in groundwater with migration to surface water at Willetts Creek	Maintenance of asphalt and vegetative cover	Increasing concentrations of cadmium and chromium in groundwater.	Monitor for cadmium and chromium concentrations in groundwater at OU1 to evaluate temporal trends.	An assessment of cadmium and chromium in groundwater reveals continual declining/stable concentrations.

7. SUMMARY AND CONCLUSIONS

Impacts from climate change are anticipated to increase in the future and site management at the Dzus site may be altered by the changing climate. According to the middle range projection, precipitation on Long Island may increase by as much as 5 inches per year by 2050, with heavy rain events increasing by 16 percent over that time period. Higher precipitation totals and heavy rainfall events could lead to additional monitoring for erosion and contaminant concentrations in soils and surface waters related to the remedy.

Impacts from sea level rise provide for the most potentially significant climate impacts at the site. Flooding from sea level rise may cause damage to the site integrity and additional monitoring may need to be considered over time. Sea level rise projections for the site range from a mid-level projection of 1.3 feet in 2050 while the high projection, with a 1% probability of occurring, is 2.5 feet by 2050. Storm surge impacts in conjunction with sea level rise provide for a much greater potential impact. Considering a storm surge like Super Storm Sandy, in addition to the mid-level projection in 2050 would provide a 9.6-foot surge over present-day sea level.

As part of this resiliency assessment a draft climate adaptation plan, **Table 6-2**, has been completed and is to be incorporated into the Interim Site Management Plan with an associated periodic review process. This draft adaptation plan incorporates strategies and measures already implemented or planned for the site and defines impact thresholds and monitoring for exceedance of these thresholds. If a set threshold is surpassed, an action will be taken to protect the public and the environment. A new set of thresholds and plan would then be created to decrease risks associated with climate change impacts.

In conclusion, the plan demonstrates and concludes that any potential vulnerability of the remedy to climate change such as severe weather events can be managed and mitigated through proactive monitoring of the remedy and, if appropriate, corrective measures. Accordingly, the long-term monitoring program incorporates findings and recommendations of this climate resiliency evaluation as well as requiring periodic updates to the assessment.

This page left intentionally blank

8. REFERENCES

Akbari, H., D.M. Kurn, S.E. Bretz, J.W. Hanford. 1997. Peak power and cooling energy savings of shade trees. *Energy and Buildings* 25(2): 139-148 doi:10.1016/S0378-7788(96)01003-1.

Biswas, B., F. Qi, J.K. Biswas, A. Wijayawardena, M.A.I. Khan, and R. Naidu. 2018. The fate of chemical pollutants with soil properties and processes in the climate change paradigm – A review. *Soil Syst.* 2(51) doi:10.3390/soilsystems2030051.

NY Rising Community Reconstruction (NYRCR) West Islip Planning Committee. Jacobs and Cameron Engineering & Associates, LLP. March 2014. *West Islip NY Rising Community Reconstruction Plan.*

EA Engineering, P.C. and its affiliate EA Science and Technology (EA). 2017a. *Interim Remedial Measure, Construction Completion Report, Former Dzus Fastener Site (152033), Suffolk County, West Islip, New York*. February.

ESA. 2018. *City of Del Mar Sea-Level Rise Adaptation Plan, Del Mar, California*. Revised Draft. Prepared for City of Del Mar.

Famiglietti, J.S. 2014. The global groundwater crisis. *Nat. Clim. Change* 4(11), 945–948.

Horton, R., D.A. Bader, C. Rosenzweig, A. DeGaetano, and W. Solecki. 2014. *Climate Change in New York State; Updating the 2011 ClimAID Climate Risk Information.* New York State Energy Research and Development Authority, Albany, New York. September.

Jaffe, P.R., P.A. Kallin, S.L. Smith. 1998. Modelling trace metal dynamics in wetland sediments: The effect of the rhizosphere on the sediment redox profile. *Mineralogical Magazine* 62(A): 699-700.

Kimberly, D. and C.J. Salice. 2013. Interactive effects of contaminants and climate-related stressors: High temperature increases sensitivity to cadmium. *Environ. Toxicol. Chem.* 32(6):1337–13753. https://doi.org/10.1002/etc.2198.

Libera, A., F.P.J. de Barros, B. Faybishenko, C. Eddy-Dilek, K.M. Denham Lipnikov, D. Moulton, and H.M. Wainwright, H. M. 2018. *Climatic controls on residual contaminants under sustainable remediation. Environ. Sci. Technol.* Manuscript submitted for publication.

Lowman, M.D., T.D. Schowalter. 2012. Plant science in forest canopies – the first 30 years of advances and challenges (1980-2010). *New Phytologist* 194(1): 12-27 doi:10.1111/j.1469-8137.2012.04076.x.

Lytle, C.M., F.W. Lytle, N. Yang, J. Qian, D. Hansen, A. Zayed, N. Terry. 1998. Reduction of Cr(VI) to Cr(III) by wetland plants: Potential for in situ heavy metal detoxification. *Environmental Science and Technology* 32(20): 3087-3093 doi:10.1021/es980089x.

Maco, B., P. Bardos, F. Coulon, E. Erickson-Mulanax, L.J. Hansen, M. Harclerode, D. Hou, E. Mielbrecht, H.M T. Yasutaka, and W.D. Wick. 2018. Resilient remediation: Addressing extreme weather and climate change, creating community value. *Remediation* 29(1):7–18.

Mahajan, P., J. Kaushal. 2018. Role of phytoremediation in reducing cadmium toxicity in soil and water. *Journal of Toxicology* 2018 doi:10.1155/2018/4864365.

Mattuck, R., N.P. Nikolaidis. 1996. Chromium mobility in freshwater wetlands. *Journal of Contaminant Hydrology* 23(3): 213-232 doi:10.1016/0169-7722(95)00097-6.

National Oceanic and Atmospheric Administration (NOAA). 2017. *Global and Regional Sea Level Rise Scenarios for the United States.* NOAA Technical Report NOS CO-OPS 083.

Nemickas, B. and E.J. Koszalka. 1982. *Geohydrologic Appraisal of Water Resources of the South Fork, Long Island, New York*. Geological Survey Water-Supply Paper 2073.

New York State Department of Environmental Conservation (NYSDEC). 1998. *NYSDEC Division of Water Technical and Operational Guidance Series (1.1.1) Ambient Water Quality Standards (Class GA).* June.

New York State Department of Environmental Conservation (NYSDEC). 2016. *NYSDEC Division of Environmental Remediation. Hudson River Sediment and Off-site Areas State Superfund Project Record of Decision*. March.

———. 2014. *Screening and Assessment of Contaminated Sediment (June 24).*

Northeast Regional Climate Center. 2015. *Intensity duration frequency curves for New York State: Future projections for a changing climate*. http://ny-idf-projections.nrcc.cornell.edu/map_viewer.html

Noyes, P.D., M.K. McElwee, H.D. Miller, B.W. Clark, L.A. Van Tiem, K.C. Walcott, K.N. Erwin and E.D. Levin. 2009. The toxicology of climate change: Environmental contaminants in a warming world. *Environ. Int.* 35(6), 971– 986.

Ong, S.K., R. Surampalli, A. Bhandari, P. Champagne, R. Tyagi, I. Lo. 2008. Remediation Wetlands. In book: Natural Process and Systems for Hazardous Waste Treatment, Chapter: 7. *American Society of Civil Engineers* doi:10.1061/9780784409398.

Palmer, C.D. and R.W. Puls. 1994. Natural attenuation of hexavalent chromium in groundwater and soils. *EPA Ground Water Issue*. EPA 540/5-94/505. EPA Office of Solid Waste and Emergency Response. October.

Rai, D., L.E. Eary, and J.M Zachara. 1989. Environmental chemistry of chromium. *Sci. Total Environ.* 86(1–2):15–23. Doi: 10.1016/0048-9697(89)90189-7.

Rosenzweig, C. and W. Solecki. 2019. *Advancing Tools and Methods for Flexible Adaptation Pathways and Science Policy Integration.* New York City Panel on Climate Change. Annals of the New York Academy of Sciences 1439(1). doi: 10.1111/nyas.14008.

Rosenzweig, C., W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, P. Grabhorn (Eds.). 2011. *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation.* Technical Report. New York State Energy Research and Development Authority, Albany, New York.

Sandrint, T.R. and R.M. Maier. *Effect of pH on cadmium toxicity, speciation, and accumulation during naphthalene biodegradation*. *Environ. Toxicol. Chem.* 21(10):2075–2079. Doi: 10.1002/etc.5620211010.

Schubert, C.E., R.J. Busciolano, P.P. Hearn Jr, A.N. Rahav, R. Behrens, J.S. Finkelstein, J. Monti Jr, and A.E. Simonson. 2015. *Analysis of Storm-Tide Impacts from Hurricane Sandy in New York*. Scientific Investigations Report 2015-5036. U.S. Department of the Interior, U.S. Geological Survey. doi:10.3133/sir20155036.

Shrestha, P.L., S.C. James, P.J. Shaller, and M. Doroudian. 2014. Estimating the storm surge recurrence interval for Hurricane Sandy. *World Environ. Water Resour. Congr. 2014*. doi:10.1061/9780784413548.191.

———. 2016. *Aquatic life ambient water quality criteria: Cadmium – 2016*. EPA 820-R-16-002. Office of Water, Health and Ecological Criteria Division. March.

USGS. 2019. *USGS Current Conditions for New York - USGS 01309225 Great South Bay at Lindenhurst NY*. https://waterdata.usgs.gov/ny/nwis/uv?site_no=01309225.

University of North Carolina at Charlotte. 2006. Oysters can take heat and heavy metals, but not both. *ScienceDaily*. www.sciencedaily.com/releases/2006/12/061213174728.htm.

Xu, S., P.R. Jaffe. 2006. Effects of plants on the removal of hexavalent chromium in wetland sediments. *Journal of Environmental Quality Abstract – Wetlands and Aquatic Processes* 35(1): 334-341 doi:10.2134/jeq2005.0181.

This page left intentionally blank