TOWN OF FALMOUTH, MAINE

Climate Adaptation Plan

OCTOBER 2023

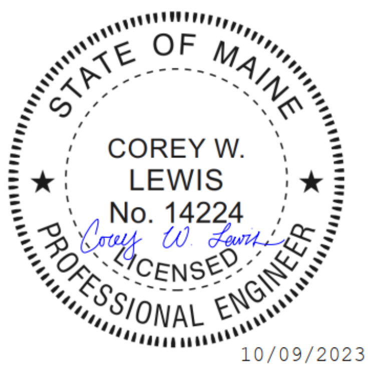
Municipal Wastewater Treatment Facility & Sanitary Sewer System

WRIGHT-PIERCE
Engineering a Better Environment

Municipal Wastewater Treatment Facility & Sanitary Sewer System Climate Adaptation Plan

Town of Falmouth, Maine

October 2023



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Section 1 Executive Summary

The Town owns and operates a sanitary sewer collection system that contains about 57 miles of piping and 33 wastewater pumping stations. Eighteen of the pump stations are equipped with on-site back-up power and the remainder are served by five portable generators. Most of the original collection system was installed in or around 1971. The Town owns and operates a wastewater treatment facility (WWTF) at 96 Clearwater Drive in Falmouth, Maine. The WWTF was constructed in 1971 and updated and expanded over the course of three upgrades in 1983, 1985, 2006, and 2008. The WWTF was designed to provide secondary treatment for a design year average flow of 1.56 MGD and a peak hourly flow of 4.88 MGD. The plant discharges secondary treated wastewater to the Presumpscot River and its tributaries, adjacent to the WWTF property.

The goals of the CAP study are to:

1. Review the possible effects of climate change to the Town's wastewater collection and treatment system.
2. Identify and assess possible climate change-related hazards specific to the Town's WWTF, pumping stations, and collection system and their impact on reliability.
3. Evaluate potential adaptation measures to the identified hazards.
4. Provide a cost-effective implementation plan to help protect the Town's critical assets and maintain wastewater collection system reliability.

Potential climate change impacts and the associated hazards applicable to the Town's assets and personnel are identified in Section 3 of the report. A risk assessment, including the likelihood of potential hazards affecting the Town's critical assets, was conducted and the findings were summarized in Section 5.2 (System-wide), Section 5.3 (WWTF), Section 5.4 (Pump Stations), and Section 5.4.13 (Collection System) of the report.

Hazard consequences identified that affect the entire system include poor travel conditions, hazardous working conditions, increased snow loading to enclosures, and increased wind loading to enclosures and panels. The WWTF outfall was identified as being at risk from soil erosion and marsh migration. Pump stations were identified as being at risk from flooding, utility power outages, accessibility issues, SSOs, increased I/I, downed trees causing equipment failure, and soil erosion. Some of the sewers that are located in flood-prone areas such as stream and river floodplains and along the coastline were identified as being at risk from widespread and localized flooding, accessibility issues, increased I/I, soil erosion, and SSOs. Widespread flooding refers to flooding over a large geographic area from a major storm or precipitation event. Localized flooding is general term that refers to flooding or ponding of water in a specific location that is not necessarily tied to flooding of a large waterbody or extensive flooding over a large geographic area.

Possible adaptation measures were identified and evaluated based on the findings of the risk assessments and are described in Section 6. Recommended adaptation measures can be grouped into one of two categories, operational or asset-specific measures. Operational adaptation measures are tasks or procedural changes that Town staff could undertake at minimal cost to prevent or mitigate potential hazard consequences. Asset-specific measures include non-routine or one-time tasks, in-depth studies or evaluations, design modifications, or capital expenditures to achieve the goal of preventing or mitigating the potential hazard consequence. The recommended adaptation measures are summarized in Table 7-1 in Section 7 and at the end of the Executive Summary (Table 1-1). Table 7-1 includes a recommended timeframe for implementation of the recommended adaptation measures and conceptual-level project cost estimates for the asset-specific adaptation measures that will require a capital expense. Section 7 also includes possible funding sources that may be available to the Town for the recommended adaptation measures.

Table 1-1 CAP Implementation Plan & Estimated Costs

Asset Description	Recommended Adaptation Measures (1- Highest Priority; 2 - High Priority; 3 - Moderate Priority; 4 - Lower Priority)		Expected Project Cost	Implementation Timeline
Operational Adaptation Measures	Evaluating older portions of the collections system for I/I source reduction and rehabilitation and working with code enforcement staff to eliminate illicit stormwater connections to the sanitary sewer system (sump pumps, floor drains, foundation drains, etc.)		Included in O&M budget	Ongoing
Mill Creek Interceptor Sewer	To Be Determined	Selection to be made after further geotechnical investigation.	$7,160,000 – 12,280,000	0-10 years
Mackworth Point Interceptor Sewer	Option 1	Install stabilizing berms and armor embankment with riprap	**To Be Determined**	0-10 years
WWTF Outfall	Option 1 (Phase 1)	Short-term: Support existing headwall and armor embankment	**$150,000**	0-5 years
	Option 3 (Phase 2)	Long-term: New HDD-installed outfall pipe with a diffuser structure in same location	**$680,000**	15-20 years
Mill Road Interceptor Sewer	Option I-1 (Phase 1)	Short-term: Remove overgrowth along the sewer easement	**$30,000**	0-5 years
	Option I-3 (Phase 2)	Long-term: Replace and relocate the cross-country portion of the interceptor	**$380,000**	20+ years
Mill Road PS (No. 22)	Option PS-1 (Phase 1)	Short-term: Continue to armor the riverbank with riprap	**$20,000**	0-5 years
	Option PS-3 (Phase 2)	Long-term: Retaining wall or permanent sheeting	**$100,000**	15-20 years
Lunt Road PS (No. 4)	Option 1 (Phase 1)	Short-term: Armor the streambank with riprap	**$20,000**	0-5 years
	Option 2 (Phase 2)	Long-term: Loam and overseed the riverbank	**$10,000**	15-20 years
Brown Street PS (No. 2)	Option 3	Construct a new submersible pump station further upland	**$1,080,000**	5-10 years
Town Landing Interceptor Sewer	Option 1	Install stabilizing berms and armor embankment with riprap	**$570,000**	5-10 years
Landing Woods Lane PS (No. 11)	Option 1 (Phase 1)	Short-term: Illicit sewer connection removal (inspections only)	**$10,000**	5-10 years
	Option 3 (Phase 2)	Long-term: Sanitary Sewer System Evaluation	**$110,000**	10-15 years
Clearwater Drive PS (No. 3)*	Option PS-3	Construct a new submersible pump station further upland	**$1,200,000**	10-15 years
Clearwater Drive Interceptor Sewer*	Option I-2	Install a new interceptor sewer via HDD	**$300,000**	10-15 years
Underwood Road PS (No. 7)*	Option 4	Construct a new submersible pump station further upland	**$1,700,000**	10-15 years
Handy Boat PS (No. 6)*	Option 4	Construct a new submersible pump station further upland	**$1,250,000**	15-20 years
Mill Creek PS (No. 5)*	Option PS-1 (Phase 1)	Armor the streambank with riprap	**$30,000**	15-20 years
	Option PS-2 (Phase 2)	Construct retaining wall barrier	**$290,000**	20+ years

* The Town of Falmouth does not have the funds available to commit to implementing the recommended long-term adaptation measures sooner than the timeframe listed in Table 7-1. Therefore, the Town is willing to monitor and employ temporary mitigation measures (sandbags, temporary pumping, etc.) on an as needed basis until funds are available for the Town to implement the recommended long-term adaptation measures within the recommended timeframe, unless resiliency grant funding becomes available before then.

Section 2 Introduction

2.1 Goals & Approach

The Town of Falmouth was awarded a grant by the Maine Department of Environmental Protection (Maine DEP) Clean Water State Revolving Fund (CWSRF) program to develop a Climate Adaptation Plan (CAP) for the Town's WWTF, pumping station, and sewer collection system assets.

The goals of the CAP are to review the possible effects of climate change, identify and assess possible climate change-related threats specific to the Town's municipal WWTF and collection system, evaluate potential adaptation measures, and provide a cost-effective implementation plan to help protect the Town's critical assets and maintain wastewater collection and treatment system reliability. The Town has retained Wright-Pierce to assist with the development of the CAP.

The approach to developing the Town's CAP included:

1. A review of historic information on environmental hazards based on past observations by Town personnel, GIS information, record drawings, the Town of Falmouth's Comprehensive Plan and Energy Inventory and Climate Action Plan, and readily available Federal Emergency Management Agency (FEMA) 100-year Base Flood Elevation (BFE) floodplain mapping, including the addition of 2 to 3 feet of elevation above the FEMA 100—year BFE based on NEIWPCC's TR-16: Guides for the Design of Wastewater Treatment Works guidance on flood protection.
2. Supplemental field reconnaissance by Wright-Pierce personnel.
3. An evaluation of the effects of floodplain inundation on critical assets and system reliability as well as the ability to access critical infrastructure during periods of floodplain inundation.
4. An evaluation of the impacts on critical assets from changes to temperature, precipitation patterns, storm intensity, duration, and frequency.
5. An evaluation of the impacts on critical assets from changes in sea level rise, including projected sea level rise values that are consistent with the recommendations summarized in the Maine Climate Council's Scientific Assessment of Climate Change and Its Effects in Maine, and Maine legislation LD1572; A Resolve To Analyze the Impact of Sea Level Rise.
6. An evaluation of Maine Geological Survey mapping of potential sea level rise coastal flooding scenarios (1.2, 1.6, and 3.9 feet), projected coastal marsh migration as a result of sea level rise, and Sea, Lake and Overland Surge Hurricane (SLOSH) modeling of flooding and storm surge from Category 1, 2, 3 and 4 hurricanes impacting the Falmouth region.
7. An evaluation of weaknesses in community or utility support systems that may be impacted by climate change and the consequences on the Town's system reliability.
8. An evaluation of the impact that wind-related hazards (e.g., falling trees/utility poles/wires) may have on critical infrastructure.

2.2 Participating Personnel

The key participating personnel in the development of the CAP were the Town WWTF Superintendent and Assistant Superintendent, Sustainability Coordinator, key Wastewater Department staff and operators, local emergency management agency personnel and Wright-Pierce. The CAP has been funded by Maine DEP and is subject to Maine DEP review and approval. It is recommended that the results of the CAP report be shared with the Town's municipal planning board for future planning and emergency/natural disaster coordination purposes.

WWTF Superintendent: Dan Marks**,** dmarks@falmouthme.org
Town of Falmouth Sustainability Coordinator: Theresa Galvin, tgalvin@falmouthme.org
Local Emergency Management: Fire Chief, Howard Rice, Jr., hrice@falmouthme.org
County EMA: Cumberland County EMA Director, Matthew Mahar, mahar@cumberlandcounty.org

Section 3 Existing Conditions

3.1 Wastewater Treatment Facility

The Town of Falmouth's WWTF is located at 96 Clearwater Drive in Falmouth, Maine. The facility was originally constructed in 1971 and has undergone significant upgrades in 1983, 1985, and 2008. Recent upgrades included new screening, aeration tanks with anoxic zone and recycle, conversion of old units to increased clarifier volume, new chlorine contact tank, sludge pumping, sludge storage, septic storage and handling, and plant water systems. These upgrades provided nutrient reduction and an increased hydraulic capacity during peak weather flows.

The facility is designed and permitted to provide treatment for a design year average of 1.56 MGD, and peak hourly flow of 4.88 MGD. As indicated by Town staff, slightly more than half of the homes in Falmouth and Cumberland use onsite sewage disposal systems. The remaining homes in Falmouth, and the Town of Cumberland discharge wastewater to the collection system and are served by the facility. The treatment facility receives sanitary waste waters generated by residential and commercial entities and has no categorical industrial users contributing flow or pollutant loads to the collection and or wastewater treatment facility.

The WWTF provides the following treatment unit processes to help treat incoming wastewater from the sewers:

- Preliminary mechanical screening to remove large incoming debris and floatables
- Aerated grit and sand removal
- Biological treatment of organic wastes via activated sludge process with enhanced nutrient removal
- Secondary clarification of biologically treated process water
- Chlorine disinfection of treated effluent
- Solids handling, digestion, dewatering and disposal

The WWTF also has a dedicated 300 kW outdoor standby power generator located to the north of the Electrical Building at the WWTF site. A site map of the WWTF is shown in Figure 3-1.

The treated effluent is conveyed to the river through a 20-inch diameter 234-foot-long pipe without a diffuser. The pipe is above high tide and discharges to the intertidal zone. At low tide, effluent flows through a branch of Skitterygusset Creek through a salt marsh and combines with the main stem of Skitterygusset Creek, before reaching the main channel of the Presumpscot River estuary. At high tide conditions, estuary waters rise to just below the base of the outfall structure.

Existing record drawings from previous WWTF upgrades and field data collected during a site visit conducted by Wright-Pierce staff on May 20th, 2022, were used to identify and assess the applicability of potential climate hazards to the WWTF. The WWTF is not located within the current FEMA 100-year floodplain, as shown in Figure B-1 in Appendix B. Climate-hazard related observations from the May 20, 2022 site visit are discussed as part of the evaluation of climate change impacts in Section 5. The risk assessment included specific areas of the WWTF that are in close proximity to the FEMA 100-year floodplain, in addition to, general hazards that might be applicable to the entire WWTF.

Figure 3-1 Town of Falmouth Wastewater Treatment Facility

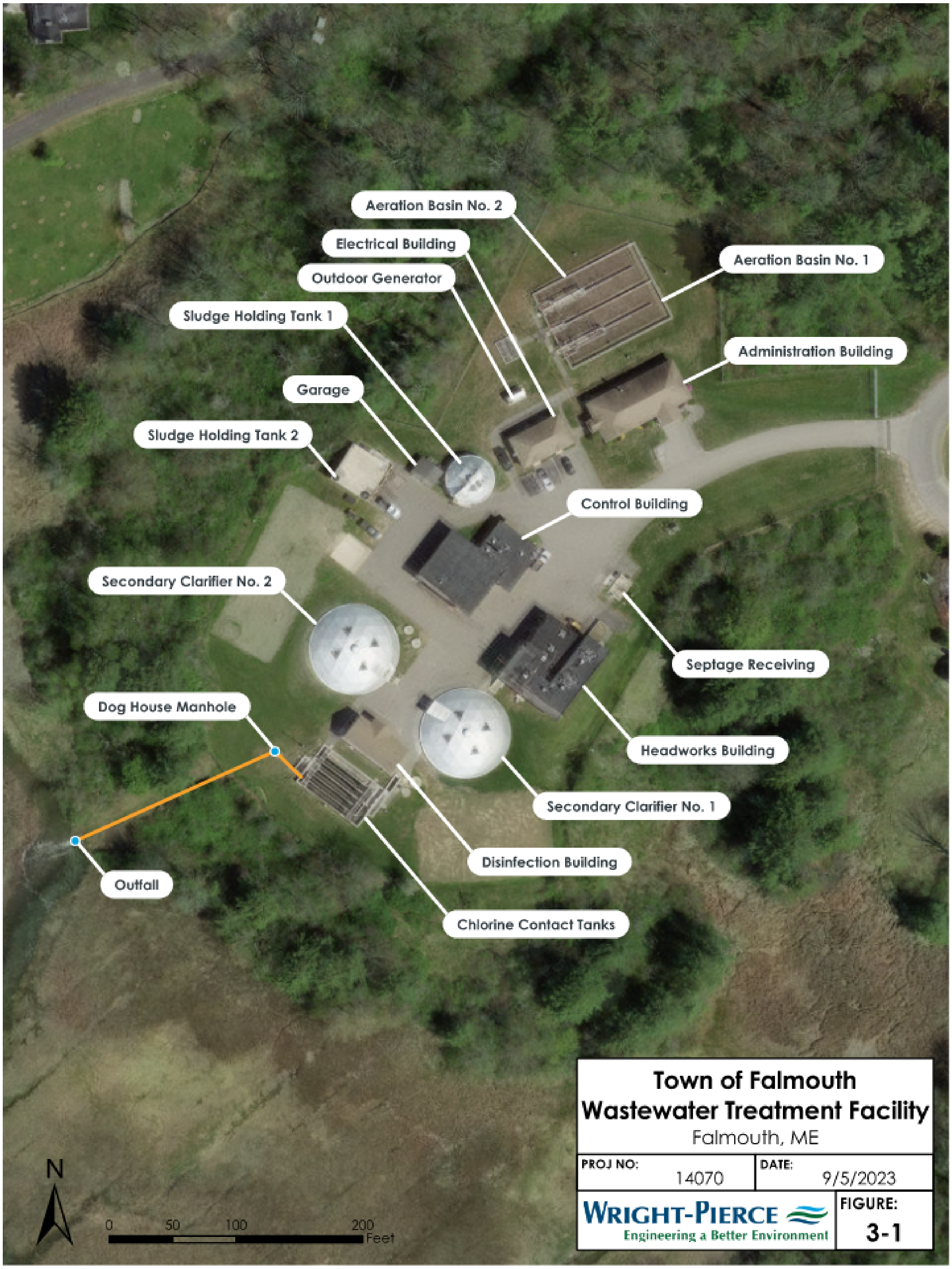


Figure 3-2 Wastewater Treatment Facility Photos


Administrative Building


Aeration Basins


WWTF Generator


Electrical Building


Sludge Holding Tank 1


Blower Building


Secondary Clarifiers


Sludge Holding Tank 2


Chlorine Contact Tanks


Headworks Building

Control Building


Septage Receiving

Portable Generator

Disinfection Building

Outfall Pipe Headwall

3.2 Pump Stations

The sanitary sewer collection system consists of approximately 50 miles of piping with 33 pump stations. Eighteen of the pump stations are equipped with on-site back-up power and the remainder are served by five portable stand-by power generators. All stations are equipped with visual and audio alarms connected to central SCADA computers incorporating alarm notification systems. The sanitary collection system is completely separated from the storm water collection system and as a result, there are no combined sewer overflow (CSO) points in the collection system. Appendix A includes a GIS map of the Town of Falmouth's municipal wastewater collection system including the locations and service areas of the 33 pump stations.

The Town owns 26 submersible type stations where the pumps are located within the station's below-grade wetwell where the incoming wastewater is collected. The Town owns 5 Smith & Loveless "tin can" wetwell/drywell type pump stations where the pumps in a below grade dry-well structure adjacent to the wetwell, drawing the wastewater from the wetwell via suction piping. The Town owns one above-grade suction lift type station (No. 4 Lunt Road) where the pumps sit above the wetwell in an enclosure and draw from the wetwell using extended suction piping and vacuum-assisted priming centrifugal pumps. The Town also owns one dry-pit submersible pump station (No. 5 Mill Creek) where submersible pumps with an internal cooling jacket are mounted on a pedestal in a drywell and are fitted with suction piping that extends into an adjacent wetwell chamber. All the stations are equipped with radio-based remote pump failure alarming.

Four of the pump station sites are located within the preliminary 2018 FEMA 100-year floodplain (No. 2 Brown Street, No. 3 Clearwater Drive, No. 6 Handy Boat and No. 7 Underwood). The pump stations that were identified within the FEMA 100-year floodplain can be seen in Figure B of the entire Falmouth wastewater system in Appendix B.

Figure 3-3 Wastewater Pump Stations Photos

Clearwater Drive

Brown Street

Waite's Landing

Landing Woods Lane

Handy Boat

Underwood

Mill Creek

Thornhurst Drive

Mill Road

The Town's 33 wastewater pump stations were screened by both Town wastewater department and Wright-Pierce staff to determine which pump stations are most likely to be critically impacted by potential climate change hazards and should be the focus of this study. System-wide climate hazards (refer to Section 5.2) were not considered as part of the preliminary pump station screening because all of the Town's pump stations are at risk of these hazards. The preliminary screening relied upon existing wastewater collection system record drawings and studies, Town wastewater system GIS data, and supplemental field observations from a site inspection conducted by Wright-Pierce and Town wastewater department staff on May 20th, 2022.

Table 3-1 that follows provides a summary of the preliminary pump station screening results. The screening concluded that 13 of the 33 pump stations could potentially be impacted by climate-related hazards and 20 of the pump stations are unlikely to be critically impacted by climate-related hazards. Pump stations that are unlikely to be critically impacted by climate-related hazards are considered to be at minimal risk and were not evaluated in further detail as part of this study. The remainder of this study focuses on the 13 pump stations that were determined to potentially be critically impacted by climate-related hazards.

Table 3-2 includes summary data for the 13 pump stations that were selected for further evaluation as part of this study.

Table 3-1 Preliminary Pump Station Screening Summary

PS No.	Pump Station Description	Approximate site ground elevation (ft)	FEMA 100-year Base Flood elevation (ft)	TR-16 flood protection elevation for critical components (ft)	Is site below TR-16 flood protection elevation?	Does Sea Level Rise appear to be a concern?	Does Category 1 or 2 hurricane storm surge appear to be a concern?	Is the site remotely located from WWTF?	Station criticality to WW system function	Critically Impacted?
1	Old Mill	18	22	25	Yes	Possibly	Possibly	Yes	High	Yes
2	Brown Street	10	10	13	Yes	Yes	Yes	No	High	Yes
3	Clearwater Drive	11	10	13	Yes	Possibly	Yes	No	High	Yes
4	Lunt Road	20	10	13	No	Possibly	Possibly	No	Low	Yes
5	Mill Creek	12	9	12	No	Possibly	No	No	High	Yes
6	Handy Boat	17	15	18	Yes	Yes	Yes	Yes	Moderate	Yes
7	Underwood	12	19	22	Yes	Yes	Yes	Yes	Low	Yes
8	Hedgerow Drive	108	19	22	No	No	No	Yes	Low	No
9	Thornhurst Drive	32	22	25	No	No	No	Yes	Low	Yes
10	Waite's Landing	22	10	13	No	No	No	Yes	Low	Yes
11	Landing Woods Lane	38	10	13	No	No	No	Yes	Low	Yes
12	Middle Road	20	12	15	No	Possibly	No	No	High	Yes
13	Baysite	54	19	22	No	No	No	Yes	Low	No
14	Woodland Drive	128	27	30	No	No	No	Yes	Low	No
15	Pinehurst Lane	124	27	30	No	No	No	Yes	Low	No
16	Clubhouse	136	27	30	No	No	No	Yes	Low	No
17	High School	108	27	30	No	No	No	Yes	Low	No
18	Johnson Road	60	9	12	No	No	No	No	Moderate	No

PS No.	Pump Station Description	Approximate site ground elevation (ft)	FEMA 100-year Base Flood elevation (ft)	TR-16 flood protection elevation for critical components (ft)	Is site below TR-16 flood protection elevation?	Does Sea Level Rise appear to be a concern?	Does Category 1 or 2 hurricane storm surge appear to be a concern?	Is the site remotely located from WWTF?	Station criticality to WW system function	Critically Impacted?
19	Northbrook Drive	29	9	12	No	No	No	No	Low	No
20	Leighton Road	37	30	33	No	No	No	Yes	Moderate	Yes
21	Falmouth Road	36	27	30	No	No	No	Yes	High	No
22	Mill Road	58	42	42	No	No	No	Yes	Low	Yes
23	Tidewater	40	10	13	No	No	No	No	Low	No
24	Leachfield	153	27	30	No	No	No	Yes	Low	No
25	Birkdale Road	41	27	30	No	No	No	Yes	Low	No
26	Baltusrol Circle	159	27	30	No	No	No	Yes	Low	No
27	Inverness Road	140	27	30	No	No	No	Yes	Low	No
28	Hazeltine Drive	106	27	30	No	No	No	Yes	Low	No
29	Lindenwood Lane	128	27	30	No	No	No	Yes	Low	No
30	Cherrywood Lane	128	27	30	No	No	No	Yes	Low	No
31	Old Oak Way	139	27	30	No	No	No	Yes	Low	No
32	Ridgewood Drive #1	140	27	30	No	No	No	Yes	Low	No
33	Ridgewood Drive #2	150	27	30	No	No	No	Yes	Low	No

Table 3-2 Critically-Impacted Pump Stations Inventory

PS No.	Pump Station Description	Year Constructed	Design Capacity (gpm)	Station Design	FM Dia. (inches)	Pumps				Standby Power			
						No. of Units	Year Installed/ Upgraded	Pump Motor Size (HP)	Capacity (gpm)	Standby Power Source	Year Installed	Fuel Type	Capacity (kW)
1	Old Mill	1971	110	Wetwell/Drywell	6	2	P-1: 2023 P-2: 2023	P-1: 7.5 P-2: 7.5	P-1: 137 P-2: 86	Portable Genset Receptacle	--	--	--
2	Brown Street	1971	560	Wetwell/Drywell	6	2	P-1: 1971 P-2: 2017	P-1: 15 P-2: 15	P-1: 352 P-2: 298	Outdoor Genset	2023	Diesel	60
3	Clearwater Drive	1971	580	Wetwell/Drywell	8	2	P-1: 2006 P-2: 2017	P-1: 15 P-2: 15	P-1: 573 P-2: 579	Indoor Genset	2023	Diesel	80
4	Lunt Road	2003	600	Suction-Lift	8	2	P-1: 2006 P-2: 2006	P-1: 30 P-2: 30	P-1: 592 P-2: 597	Outdoor Genset	2006	Diesel	80
5	Mill Creek	2016	2,850	Wetwell/Drywell	14	4	P-1: 2016 P-2: 2016 P-3: 2016 P-4: 2016	P-1: 60 P-2: 25 P-3: 25 P-4: 60	P-1: 1,800 P-2: 1,050 P-3: 1,050 P-4: 1,800	Indoor Genset	2016	Diesel	250
6	Handy Boat	1971	500	Wetwell/Drywell	6	2	P-1: 2017 P-2: 2017	P-1: 20 P-2: 20	P-1: 438 P-2: 485	Outdoor Genset	1999	Diesel	75
7	Underwood Road	1971	115	Wetwell/Drywell	6	2	P-1: 1971 P-2: 1971	P-1: 7.5 P-2: 7.5	P-1: 133 P-2: 102	Portable Genset Receptacle	--	--	--
9	Thornhurst Drive	1978	Unk.	Submersible	4	2	P-1: 2023 P-2: 2023	P-1: 5.0 P-2: 5.0	P-1: 124 P-2: 119	Portable Genset Receptacle	--	--	--
10	Waite's Landing	1978	Unk.	Submersible	4	2	P-1: 1978 P-2: 2018	P-1: 5.0 P-2: 5.0	P-1: 106 P-2: 106	Portable Genset Receptacle	--	--	--
11	Landing Woods Lane	1978	Unk.	Submersible	4	2	P-1: 2002 P-2: 2018	P-1: 2.8 P-2: 1.5	P-1: 110 P-2: 123	Portable Genset Receptacle	--	--	--
12	Middle Road	1981	Unk.	Submersible	6	2	P-1: 2005 P-2: 2005	P-1: 10 P-2: 10	P-1: 78 P-2: 94	Outdoor Genset	2022	Diesel	60
20	Leighton Road	1999	270	Submersible	6	2	P-1: 2001 P-2: 1998	P-1: 6.2 P-2: 6.2	P-1: 196 P-2: 208	Outdoor Genset	2000	Propane	20
22	Mill Road	2002	200	Submersible	6	2	P-1: 2002 P-2: 2002	P-1: 7.5 P-2: 7.5	P-1: 204 P-2: 196	Outdoor Genset	2004	Diesel	30

Notes:
1. All stations are equipped with radio-based remote communication systems.
2. Listed pump capacities are based on the most recently available drawdown test data.

3.3 Collection System

The current sewer system is comprised of approximately 57 miles of piping that is mostly concentrated in the Falmouth Foreside, Route 1/I295 Corridor, and Woodlands areas. The sewers and pumping stations collect and convey wastewater to the Town's WWTF located at 96 Clearwater Drive. Figure A in Appendix A shows the full extent of the current Falmouth sewer collection system service area.

About 59% of the sewer collection system pipes are constructed of PVC, 35% are constructed of asbestos-cement, and 1% are vitrified clay pipes. The remaining 5% are pressurized force mains constructed of a mix of ductile iron, HDPE and PVC pipe serving the wastewater pumping stations. Sewer main pipe sizes range between 4 and 24 inches in diameter.

The Town of Falmouth's sanitary sewer system experiences its highest peak flows during the spring and moderate peaks during periods of wet weather. A significant portion of the excess rainfall-induced inflow and infiltration originates from private inflow sources (sump pumps, foundation drains, etc.) and groundwater infiltration through deteriorated pipes and manholes.

Several areas of the collection system are located within the current FEMA 100-year floodplain or are in low-lying areas, increasing the likelihood of excess infiltration in these areas. The Town has an ongoing pipe relining and replacement program to improve sewer longevity and reduce I/I into the system. The Town has replaced or relined most of the older sections of clay pipe so that older clay pipe comprises only a small percentage of the system. The Town also has an active project for manhole rehabilitation to repair or reline leaking manholes.

The Town also has an active collection system operations and maintenance program in place that includes cleaning and CCTV inspection of the sewer lines on a regular basis. Frequent cleaning and inspection of the sewer lines helps maintain pipe capacity and identifies pipe defects to be targeted for repair and/or replacement.

Section 4 Description of Climate Change Impacts

4.1 Potential Climate Change Impacts

Climate change is a term that refers to a change in the average weather conditions or the time variation of weather patterns within a defined geographic region. Climate changes can have negative impacts on service utilities and should be considered as part of a utility's long-term planning process. Climate change can have amplified effects in certain geographic regions, depending on the region's topography, proximity to waterbodies and typical meteorological conditions. The first step in considering the potential impacts of climate change on a utility is to determine which impacts are most applicable to the utility's geographic region. Potential climate change impacts and the associated hazards applicable to the Town's assets and personnel are discussed in detail in the following sections. Hazards applicable to the Town's municipal wastewater collection and treatment system have also been summarized in Table 4-1 at the end of Section 4.

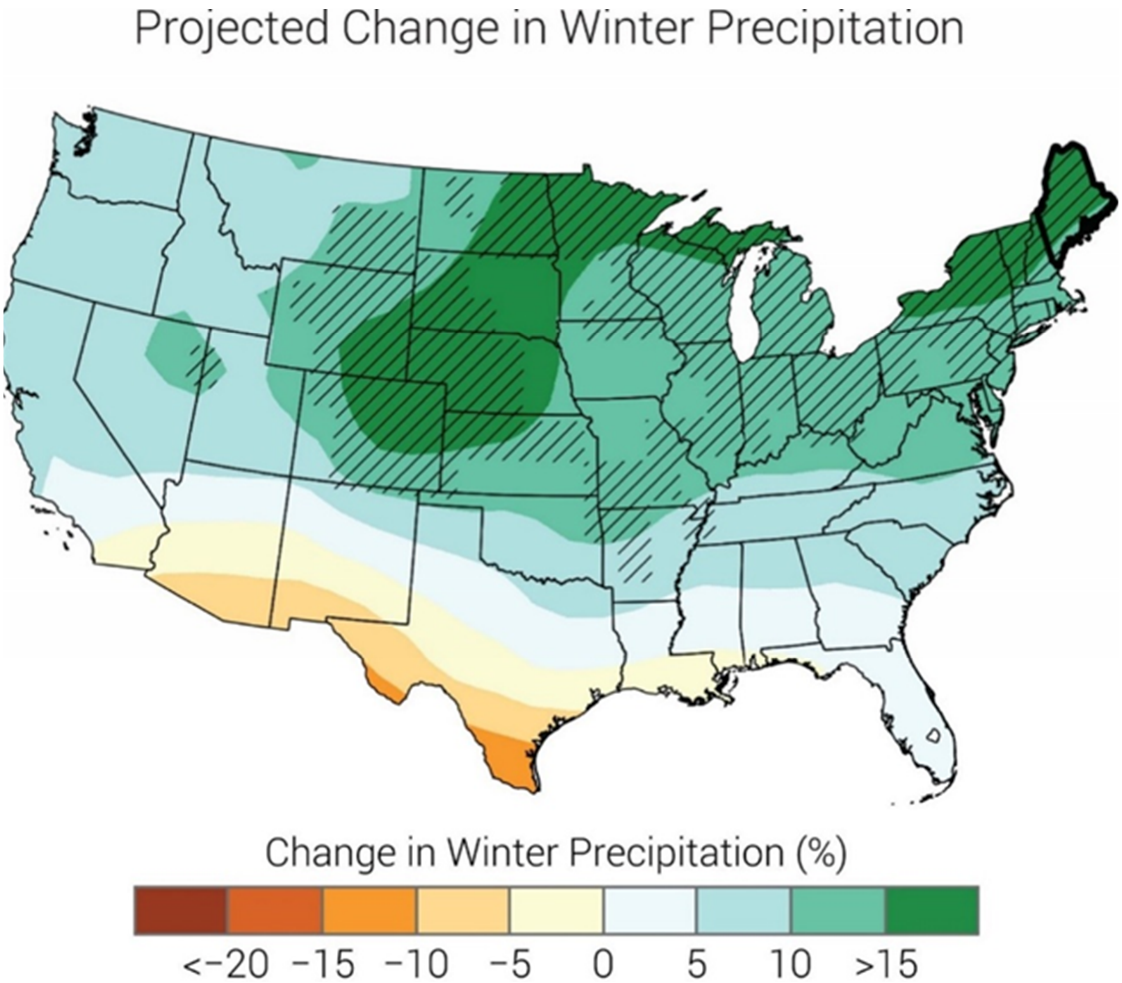
Utility climate adaptation planning should also consider how climate change may affect future service capacity needs and a utility's ability to meet them. According to projections prepared by the State of Maine Office of Policy and Management, the Town of Falmouth is projected to see a population increase of 12.4% over the 20-year planning horizon from 2018-2038 (Maine State Economist Department of Administrative and Financial Services, 2018). The WWTF should have adequate capacity for the projected wastewater flows from the Town expected over the 20-year planning period, commensurate with the expected population increase. The WWTF is permitted to discharge a monthly average limit of 1.56 MGD of secondary treated wastewater from the facility.

The Town of Falmouth experiences excess I/I into the sewer system during severe wet weather events that can limit sewer pipe and pump station capacities. Without specific I/I rates from flow metering, it would be difficult to conclude that additional I/I from changing precipitation patterns will have a significant impact on collection system capacity. However, in general, it can be assumed that more intense and/or prolonged storm events will increase rainfall-induced inflow and infiltration volume into the sewers over time as the system ages. This would result in reductions of the effective capacity of the sewers and pump stations during these periods.

4.1.1 Precipitation and Extreme Weather Trends

The Maine Climate Council (MCC) Scientific and Technical Subcommittee (STS) published a report in August 2020 that summarizes the effects of expected climate change in Maine. Statewide, total annual precipitation (rainfall and snowfall) has increased by about 6.1 inches since 1895 (MCC STS, 2020). The most pronounced increase has occurred over the last 20 years, with Maine experiencing more frequent and intense extreme precipitation events. A number of climate models project that Maine will continue to get wetter, with a significant increase in precipitation occurring as rainfall during the summer and early fall (Collow et al. 2016; Frie et al. 2015; Hoerling et al. 2016; Howarth et al. 2019; Huang et al, 2017, as cited in MCC STS, 2020). Figure 4-1 shows the projected changes in total annual winter precipitation across the country over the next 50 to 70 years. The Town of Falmouth area is expected to see a 10-15% increase in winter precipitation during this period (Runkle et al. 2017).

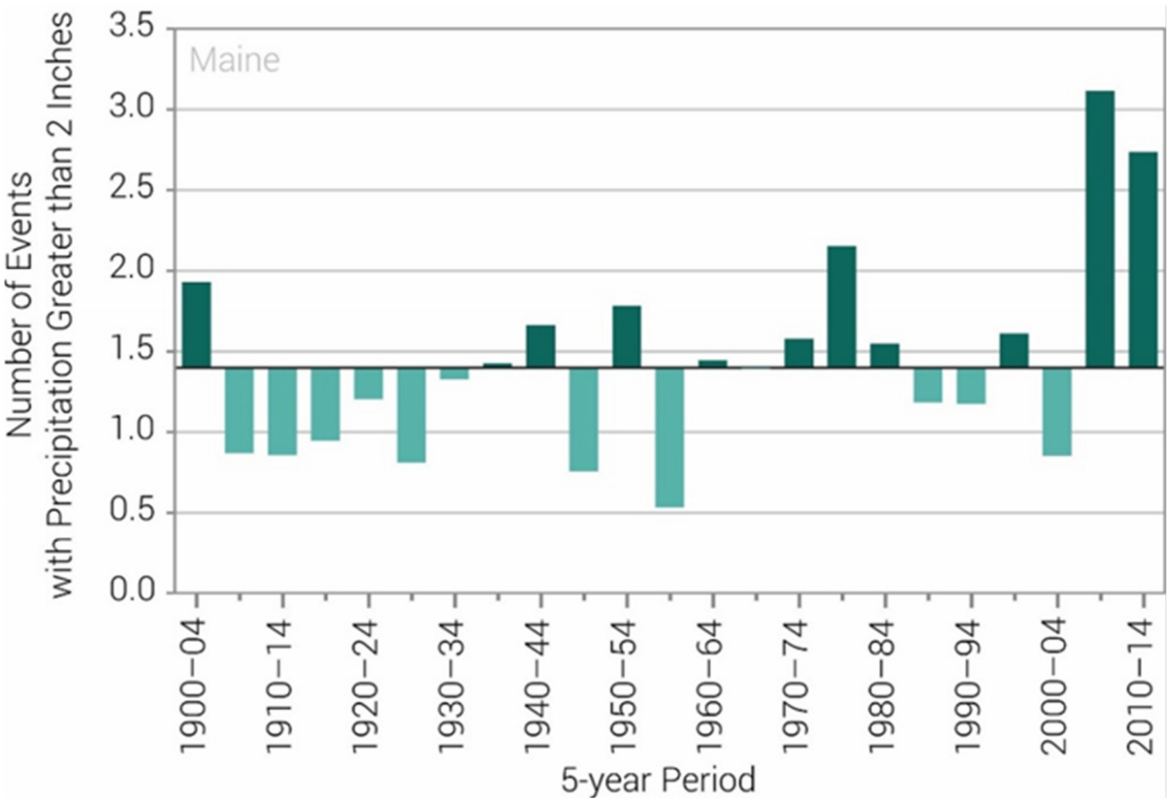
Figure 4-1 Projected Winter Precipitation Changes



Source: Runkle et al., 2017

The Fourth National Climate Assessment, published in 2017, showed that heavy precipitation events in the Northeast have increased at a higher rate than any other region in the United States (Easterling et al. 2017, Kunkel et al. 2013, USGCRP, 2017, as cited in MCC STS, 2020). Large infrequent rain events (within the annual 99th percentile precipitation) have also increased by 55% in the Northeast during the last 50 years (Easterling et al. 2017, as cited in MCC STS, 2020). At nine out of the eleven long term weather stations in Maine, the highest number of days with 2" or more of precipitation occurred within the most recent decade. Figure 4-2 is a graphical depiction of extreme precipitation events in Maine since 1900. Each bar represents the five-year average number of storm events with precipitation totals of 2" or greater in relation to the long-term average, represented by the horizontal line across the chart.

Figure 4-2 Observed Number of Extreme Precipitation Events



Source: Runkle et al., 2017

4.1.2 Storm Recurrence Intervals and Flooding

The recurrence interval of a certain sized precipitation or storm event is defined as the amount of time that elapses between events of that same size. For example, if a year passes between two storm events with 1 inch of precipitation, the recurrence interval of a 1-inch storm is said to be one year.

The National Weather Service tracks historical precipitation events reported from permanent weather stations across the country. This historical precipitation record is publicly available and can be used for long-term resiliency planning purposes to help predict the expected future recurrence of certain storms, using their average recurrence interval. Of particular interest are large storms that can cause hazardous travel conditions, flooding and property damage. These severe storms tend to occur infrequently, so their recurrence interval is relatively large; sometimes referred to as a "100-year" or "500-year" storm. This means when looking at the historical record, the time that has elapsed between these storms has been, on average, over 100 or 500 years, respectively.

The Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) uses historical precipitation data from the National Weather Service, topographic survey, and land cover information and sophisticated hydrologic modeling software programs to model and attempt to predict the expected extent of flooding in a region as a result of major storm events such as the 100-year and 500-year storm events. The predicted extent of flooding from these major storms is then used to develop aerial maps that graphically depict the possible extent of flooding as a result of these storms. These maps are referred to as Flood Insurance Rate

Maps (FIRMs). These maps are used to help inform national flood insurance policy and regulations, are publicly available through FEMA's website (https://www.fema.gov/flood-maps/national-flood-hazard-layer) and are an excellent resiliency planning resource for communities and utilities.

Several technical terms associated with FEMA FIRMs are defined are defined as follows:

Effective FIRM: Official map of a community on which FEMA has delineated the Special Flood Hazard Areas (SFHAs), the Base Flood Elevations (BFEs) and the risk premium zones applicable to the community.

Preliminary FIRM: Unofficial map of a community on which FEMA has delineated new or revised information the Special Flood Hazard Areas (SFHAs), the Base Flood Elevations (BFEs) and the risk premium zones applicable to the community. Preliminary FIRMs provide the public with an early look at their home or community's projected risk to flood hazards and are typically associated with FEMA's public process of developing new or revised FIRMs.

Base Flood Elevation (BFE): The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The "Base Flood" is also sometimes referred to as the "100-year flood" because it has a statistical probability of occurring once every 100 years, based on the historical record.

Zone A: Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.

Zone AE: The base floodplain where base flood elevations are provided.

Zone AO: River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.

Zone AR: Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A zones if the structure is built or restored in compliance with Zone AR floodplain management regulations.

Zone V: Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.

Zone B or X (Shaded): Area of moderate flood hazard, usually the area between the limits of the 100- year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.

Zone C or X (Unshaded): Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100- year flood.

Zone D: Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

The New England Interstate Water Pollution Control Commission (NEIWPCC) publishes recommended guidelines and design standards for wastewater infrastructure in its Technical Report #16 (TR-16), *Guides for the Design of Wastewater Treatment Works*. TR-16 includes design standards for wastewater infrastructure in or adjacent to the published FEMA 100-year and 500-year floodplains. TR-16 recommends that new pump stations and treatment plant facilities be designed to protect equipment against structural or functional damage by locating critical equipment at least 3 feet above the published FEMA 100-year flood elevation and non-critical equipment at least 2 feet above the 100-year flood elevation. Critical equipment is defined by TR-16 as:

> *"conveyance and treatment system components identified for protection including, but not limited to, all electrical, mechanical, and control systems associated with pump stations and treatment facilities that are responsible for conveyance of wastewater to and through the treatment facility to maintain primary treatment and disinfection during the flood event. Other equipment that, if damaged by flood conditions, will prevent the facility from returning to pre-event operation after cessation of flood conditions is also critical equipment" (TR-16, 2016).*

TR-16 also recommends that critical and non-critical equipment in treatment facilities and pump stations constructed prior to the publishing of NEIWPCC's updated guidelines on flood protection be protected in a similar manner against the 100-year flood elevation, where practical. In situations where this is technically or not financially feasible, it is recommended that both critical and non-critical equipment be protected from flooding to the greatest extend practical.

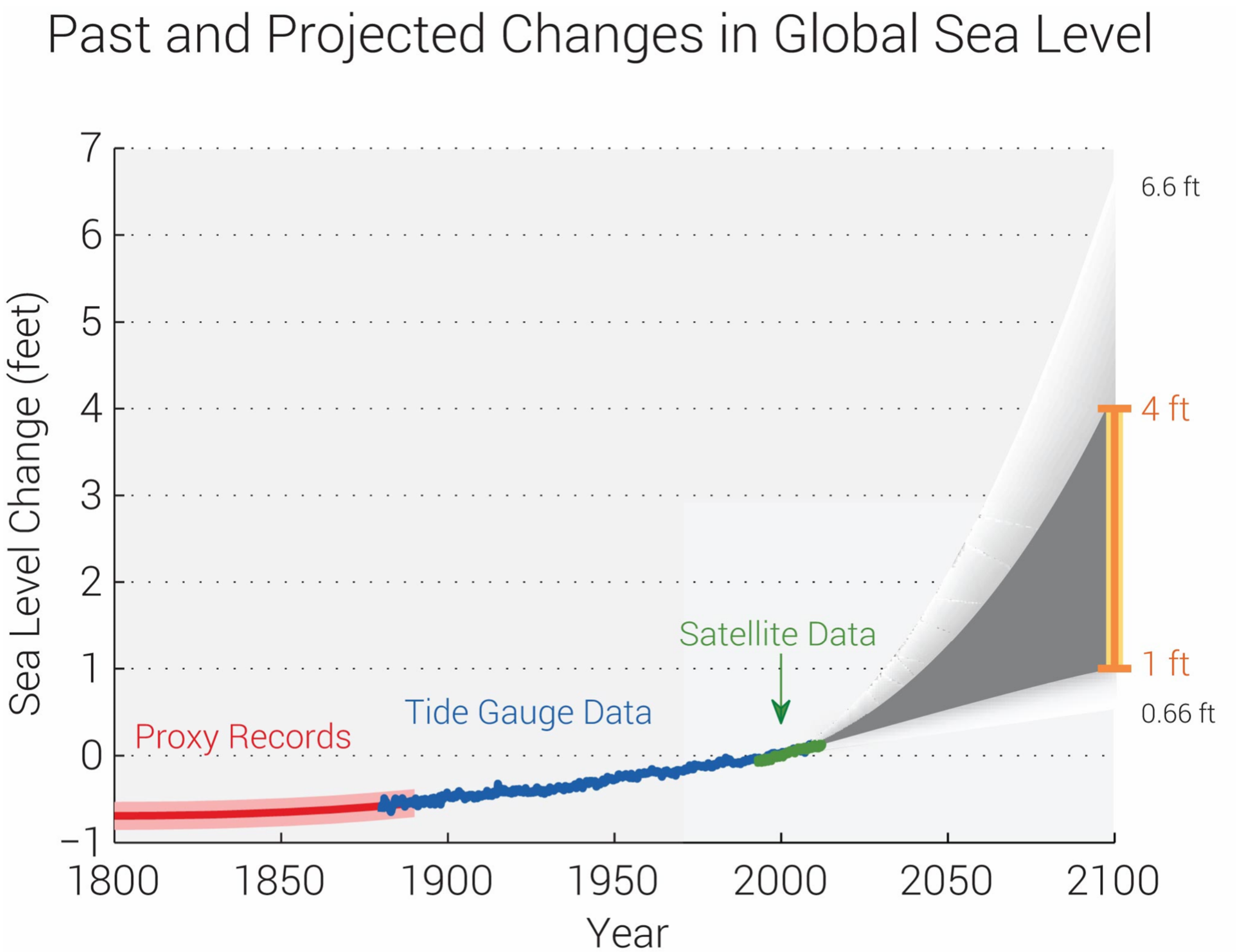
GIS-based maps of the Town's municipal wastewater treatment facility and collection system segments, overlaid with the 100-year and 500-year floodplains, are included in Appendix B to help visualize the potential extent of flooding from these storm events in relation to the municipal wastewater system's assets.

4.1.3 Sea Level Rise

Sea levels along Maine's coast have been rising at about 0.6-0.7 feet per century over the last century (MCC STS, 2020). Over the past few decades that rate has accelerated to be about 1 foot per century; a rate nearly three times faster than the millennial rate. NOAA climatology models have been used to simulate a range of climate change scenarios including the expected magnitude of sea level rise (Figure 4-3). The orange line at right in Figure 4-3 shows the most likely range of 1 to 4 feet by 2100 based on an assessment of scientific studies, which falls within a larger possible range of 0.66 feet to 6.6 feet.

The MCC Scientific and Technical Subcommittee produced a range of higher probability / lower risk scenarios and lower probability / higher risk scenarios to plan for the risk of sea level rise on infrastructure. Using this approach, the STS recommended that the State *commit* to manage for 1.5 feet of relative sea level rise by 2050 and 3.9 feet of sea level rise by the year 2100 (compared to 2000 sea level) and to *prepare* to manage for 3.0 feet of relative sea level rise by 2050, and 8.8 feet by 2100. The subcommittee's recommendations have since been adopted into Maine's Four-Year Plan for Climate Action: Maine Won't Wait, which was published December 2020. In addition, Legislative Document *LD1572: A Resolve To Analyze the Impact of Sea Level Rise*, requires that state agencies, including the DEP, review the laws and rules they are charged with administering and submit recommendations to incorporate consideration of 1.5 feet of relative sea level rise by 2050 and 3.9 feet by 2100 into administration of those laws and rules. This could result in more stringent requirements for protecting infrastructure from the projected sea level rise.

Figure 4-3 NOAA Sea Level Rise Scenarios



Source: Mellilo et al. 2014 and Parris et al. 2012.

Maine Geological Survey has also modeled and developed a dataset of potential future highest astronomical tide conditions due to several sea level rise scenarios (1.2, 1.6, 3.9, 6.1, 8.8 and 10.9 feet). This dataset approximates the potential inland extent of inundation from these sea level rise scenarios along the Maine coastline on top of the Highest Astronomical Tide. That Highest Astronomical Tide layer displays the maximum predicted astronomical high tide for the current National Tidal Datum Epoch (1983-2001). The sea level rise scenarios were developed by using available long-term sea level rise data from Portland, Bar Harbor, and Eastport tide gauges and the US Army Corps of Engineers Sea-Level Change Curve Calculator and sea level rise scenarios established by NOAA et al. (2017) prepared for the U.S. National Climate Assessment. Scenarios include low, intermediate low, intermediate,

intermediate high, high, and extreme sea level rise at the 50% confidence interval. The data were developed with a static (“bathtub”) inundation model that uses LiDAR topographic data as a base digital elevation model, and first adjusts Highest Astronomical Tide tidal predictions to take into account variability in elevation datums along the Maine coastline, and then adds the sea level rise scenarios to that initial starting elevation.

GIS-based maps of the Town’s municipal wastewater treatment facility and collection system segments, overlaid with the Maine Geological Survey’s sea level rise scenarios data, are included in Appendix C to help visualize the potential impact that future highest astronomical tide conditions could have on the Town’s wastewater system assets as a result of sea level rise.

4.1.4 Hurricane Storm Surge

When storms on Maine’s coastline create an abnormal rise of water above or over a predicted astronomical tide, it is called a storm surge. Because of the large tidal range of Maine’s coastline, when a storm surge occurs at a lower tide, the effect of the storm surge might not exceed the natural tidal range. However, the combination of a high tide (the highest predicted tide expected to occur, defined as the Highest Astronomical Tide (HAT)) and a storm surge will create conditions that exceed the natural resiliency of the coastline. These scenarios are called storm tides and can produce conditions that meet or exceed published flood stages, triggering flood warnings that are issued by the National Weather Service to alert coastal or low-lying areas of the possibility of flooding. The Maine Geological Survey has also modeled potential storm surge flooding from category 1-4 hurricanes at mean high tide using the Sea, Lake, and Overland Surges from Hurricanes, or SLOSH, model. Areas of inundation in the modeled datasets are expected to be below the overall storm tide, which is a combination of predicted astronomical tide and storm surge.

GIS-based maps of the Town’s municipal wastewater treatment facility and collection system segments, overlaid with the hurricane storm surge scenarios, are included in Appendix D to help visualize the potential storm surge flooding that could be expected at these wastewater facilities during these hurricane scenarios.

4.1.5 Tidal Marsh Migration (from Sea Level Rise)

Tidal marsh migration refers to non-tidal lands within existing tidal estuaries that could be inundated and facilitate the development of new areas of tidal marsh if sea level rises above current highest annual tide (HAT). The Maine Geological Survey has modeled the potential extent of tidal marsh migration along the Maine coastline, including in the Falmouth area. The Maine Geological Survey data were developed using a static ("bathtub") inundation model that uses LiDAR topographic data as a base digital elevation model, and then adjusts HAT tidal predictions to take into account variability in the water surface elevations along the Maine coastline and adds scenarios of 1, 2, 3.3, and 6 feet of sea level rise to that initial starting elevation.

GIS-based maps of the Town’s municipal wastewater treatment facility and collection system segments, overlaid with the Maine Geological Survey tidal marsh migration datasets, are included in Appendix E to help visualize the potential changes to tidal marshlands near the Town’s wastewater assets and potential restrictions on future land use as a result of shifting tidal marsh boundaries along the Falmouth coast and intertidal areas.

4.1.6 Summary of Potential Climate Change Impacts

Climate change could manifest in the form of shorter or longer recurrence intervals of severe storms in the Falmouth region, making them occur either more frequently or less frequently than expected, and could contribute to increases or decreases in storm intensity, in terms of the time rate of precipitation (i.e., inches falling per hour).

Published climate change data and research appears to indicate that annual average precipitation in the Falmouth area is likely to increase as a result of a projected trend toward wetter summer, fall and winter seasons. It is possible that the predicted additional precipitation could come in the form of more frequent severe storms, as historical data on heavy precipitation events (greater than 2”) would appear to indicate. From a resiliency planning perspective, it is important to consider the potential financial and social impacts that more frequent severe flooding could have on the Town of Falmouth and the additional strain it could put on the municipal collection system’s long-term reliability.

Climate change is also expected to take the form of continued sea level rise along the Falmouth coastline. NOAA climate models predict that a range of 1 to 4 feet of sea level rise is the most likely sea level rise scenario applicable to Falmouth over the coming decades. At a minimum, it is recommended that the Town of Falmouth align its flood protection goals with the flood protection benchmarks of the Maine Four-Year Plan for Climate Action to best position the Town for potential future state and federal grant funding for wastewater infrastructure capital improvements and resiliency improvement projects.

4.2 Potential Hazards

The climate change phenomena described above have the potential to create hazardous conditions in the Falmouth area that could negatively impact the Town’s wastewater infrastructure and assets. Key hazards that were screened for further analysis as part of this study are described in the following paragraphs along with a brief discussion of their applicability to the Falmouth municipal wastewater system assets. Table 4-1 at the end of this section provides a summary of the screened climate change impacts, potential hazards, and associated hazard consequences that were further analyzed in Section 5.

4.2.1 Potential Flood Hazards

Hazard: Riverine Flooding

Description: Flooding of the land adjacent to the banks of rivers and streams because of precipitation, snow melt or a combination of both. Flooding can cause catastrophic damage to equipment and structures, render critical assets temporarily inaccessible and impact emergency response time.

Applicability: A significant portion of the collection system assets and pump stations lie within or nearby the 100-year floodplains of the Presumpscot River and its tributaries or Casco Bay. The FEMA 100-year floodplain elevations ranges from 9.0 to 48.0 feet throughout the areas in Falmouth that were analyzed as part of this report.

Hazard: Flash Flooding

Description: Flooding that begins within 6 hours of heavy rainfall or other causes (e.g., dam or levee breach). Flooding can cause catastrophic damage to equipment and structures, render critical assets temporarily inaccessible and impact emergency response time. Flash flooding can be a greater risk for urban areas because of the increased percentage of impervious ground cover and for low-lying areas without stormwater infrastructure.

Applicability: There are several pump stations located in low lying areas that could be susceptible to flash flooding if nearby culverts and other stormwater infrastructure were to be overwhelmed during flash flood conditions.

4.2.2 Potential Storm Characteristics Hazards

Hazard: Increased Storm Intensity

Description: Storm intensity is a measure of precipitation magnitude over time. As storm intensity increases, greater magnitudes of rainfall occur over a specific period. This can lead to secondary hazards (e.g., flooding, storm surge, poor travel conditions, power and communication systems outages, SSOs, accessibility issues, slope destabilization).

Applicability: Secondary hazards from increased storm intensity, such as utility power outages, flooding, and accessibility issues, could impact several the Town’s critical pump station assets that are more susceptible to power outages, or are in relatively remote locations and don’t have a dedicated standby power source. Slope destabilization, as a result of increased storm intensity, could destabilize or erode the soils surrounding sanitary sewer pipelines and manhole structures along the Town’s coastlines and riverbanks.

Hazard: Increased Storm Duration	
Description:	Storm duration is the amount of time elapsed between the start and end of precipitation. An increase in average storm duration could lead to secondary hazards (e.g., flooding, poor travel conditions, power outages, SSOs, accessibility issues).
Applicability:	Secondary hazards from increased storm duration, such as prolonged utility power outages and flooding, and accessibility issues, could impact several the Town's critical pump station assets that are in areas more susceptible to utility power outages, or are in relatively remote locations with limited accessibility and don't have a dedicated standby power source.

Hazard: Increased Storm Frequency	
Description:	Storm frequency is a measure of the time between each storm event. As storms become more frequent, secondary hazard conditions (e.g., flooding, poor travel conditions, power and communication systems outages, SSOs, accessibility issues) occur more frequently or may be exacerbated. Increased storm frequency also allows less time for recovery between storms, both natural (drying out – leaving saturated ground for the next storm) and storm recovery efforts (larger washouts because initial washout was not fixed, etc.).
Applicability:	Secondary hazards from increased storm frequency, such as more frequent utility power outages and flooding could impact several the Town's critical pump station assets that are in areas more susceptible to utility power outages, or are in relatively remote locations with limited accessibility and don't have a dedicated standby power source. More frequent flooding could also accelerate soil erosion and slope destabilization in areas where sanitary sewer pipelines and manhole structures are located along the Town's coastlines and riverbanks.

Hazard: Excessive Wind Speed	
Description:	Excessive wind speeds can result in direct damage to buildings, enclosures or equipment exposed to the outdoors, can lead to secondary hazards from downed trees, utility poles and power lines (e.g., dangerous working conditions, structural damage, power and communication systems outages, accessibility issues) and can potentially cause operational issues.
Applicability:	Critical assets that require electricity or are directly exposed to the outdoors, located near trees, utility poles or power lines may be impacted by secondary hazards brought on by excessive wind speed such as downed trees or powerlines. Downed trees and power lines can also temporarily restrict accessibility to remotely located assets.

4.2.3 Potential Coastal Hazards

Hazard: Sea Level Rise	
Description:	Gradual increase in the mean sea level can exacerbate the above mentioned riverine and flash flooding hazards by increasing the frequency of flood scenarios. Sea Level Rise also has

the potential to increase inflow and infiltration to the system, raise the water table and move the salt-water interface landward (increasing pipe corrosion and leading to septic system failure), and produce secondary hazards including accessibility issues and more frequent SSOs.

Applicability: The Town's wastewater system assets that are within coastal zones are most at risk of the direct impacts of Sea Level Rise, such as more frequent flooding, soil destabilization, and increased I/I. Restricted access to the Town's wastewater assets in the coastal zones, brought on by flooding or highest astronomical tides that have been exacerbated by Sea Level Rise, could also make operating and maintaining remotely located assets in these zones more difficult in the future.

Hazard: Storm Surge

Description: Storms on the coastline can create an abnormal rise of water that can surpass the predicted astronomical tides or published flood stages and create conditions that severely impact coastal areas. When such storms occur at the same time as natural high tide stages, the effect can be exacerbated. Storm surge can cause flooding that can come on quickly and lead to the same secondary hazards that are attributed to the flooding hazards listed above.

Applicability: Several of the Town of Falmouth's pump stations are located within coastal zones. Storm surge and flooding from large coastal storms and hurricanes would be expected to primarily impact the portion of the sewer collection system and pump stations that are adjacent to Casco Bay and the Presumpscot River and its tributaries. Modeled storm surge scenarios from category 1-4 hurricanes were used to analyze the potential extent of storm surge flooding in Section 5.

Table 4-1 Climate Change Impacts & Potential Hazards Overview

Climate Change Impact	Potential Hazards	Hazard Consequences
Increased Flood Risk	Riverine Flooding Flash Flooding	• Widespread flooding (e.g. 100-year flood) • Localized flooding or ponding (low-lying and flood-prone areas) • Accessibility issues from temporary flooding • Soil erosion • SSOs from additional I/I exceeding system capacity
Storm Characteristics	Increased Storm Intensity Increased Storm Duration Increased Storm Frequency	• Localized flooding or ponding • Soil erosion • Poor travel conditions • Utility power outages • Hazardous working conditions • SSOs from additional I/I exceeding system capacity • Increased snow loading to enclosures • Accessibility issues from excess snowfall
	Excessive Wind Speeds	• Utility power outages • Increased wind loading to enclosures and panels • Downed trees causing equipment damage
Changing Coastlines	Sea Level Rise	• Exacerbated localized flooding • Accessibility issues from temporary flooding and long-term changes in the sea level • SSOs from additional I/I exceeding system capacity • Reduction in the expected useful lifetime for corrosion-susceptible piping • Marsh migration
	Storm Surge	• Exacerbated localized flooding • Soil erosion • SSOs from additional I/I exceeding system capacity • Accessibility issues from temporary flooding

Section 5 Evaluation of Climate Change Impacts

5.1 Risk Assessment Summary

One of the CAP goals is to assess how climate change hazards could impact the Town's ability to reliably serve its customers, meet regulatory obligations and provide a safe working environment for its staff. To assess the potential impacts, Wright-Pierce performed a risk assessment of the potential hazard consequences discussed in Section 4. Table 5-1 that follows provides a summary as to the applicability of the hazard consequences to the WWTF, sewer collection system, and 13 critically-impacted pump stations.

The risks from the hazard consequences applicable to the Town's entire wastewater system, WWTF, sewer system and critically impacted pump stations and are discussed in greater detail in Section 5.2, 5.3, 5.4 and 5.5, respectively, that follow.

Table 5-1 Hazard Consequence Risk Assessment Summary

Hazard Consequence ● – Applicable					INTERCEPTORS			PUMP STATIONS												
	WWTF, Outfall	Gravity Sewers	Force Mains	Manholes	Town Landing	Mackworth	Mill Creek	Mill Road	Leighton Road	Brown Street	Clearwater Drive	Mill Creek	Landing Woods	Thornhurst Road	Underwood	Waits Landing	Lunt Road	Middle Road	Old Mill Road	Handy Boat
Localized/flash flooding	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●			●
100-year storm flooding		●	●	●	●	●	●			●	●				●					●
Sea level rise	●	●	●	●	●	●				●	●	●			●		●			●
Hurricane storm surge	●	●	●	●	●	●	●			●	●	●			●		●	●		●
Poor travel conditions	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Hazardous working conditions	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Accessibility issues (temporary flooding, downed trees or snowfall)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Increased wind or snow loading to enclosures	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Utility power outages	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Downed trees causing equipment damage	●							●		●	●		●		●	●				
Increased I/I significantly limiting system capacity or causing SSOs		●	●	●	●	●	●	●	●	●		●	●							●
Soil erosion		●	●	●	●	●	●	●		●	●	●			●		●			●
Marsh migration	●									●	●	●					●			

5.2 System Wide Risk Assessment

Hazard: Increased Storm Intensity, Duration, and Frequency	
Description:	Poor travel conditions, hazardous working conditions, and accessibility issues from more frequent and intense storms and blizzards, increased wind and snow loading to enclosures.
Applicability:	Hazardous travel conditions could increase as a result from more frequent storms and blizzards. Town staff are not expected to travel during extremely hazardous travel conditions but working outdoors during heavy rain or snowfall conditions increases the risks of slips, trips, and falls. Frostbite and hypothermia is also a risk during freezing conditions. More frequent flooding and snowfall could impact accessibility to the Town's wastewater assets. Increased wind and snow loading increases the risk of property damage to exposed above-grade enclosures and structures.

5.3 Wastewater Treatment Facility Risk Assessment

5.3.1 WWTF Site

Reference: Appendix B-1 FEMA Flood Map; C-1 Sea Level Rise Map; D-1 SLOSH Map; E-1 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, Frequency, and Excess Wind Speeds	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the WWTF. The impact of a utility power outage on the WWTF and its operations is mitigated by the dedicated standby power generator located on the WWTF site. The generator is capable of run essential process equipment and ancillary systems during a utility power outage that allow the WWTF to maintain adequate treatment.
Risk:	Loss of power: Low

Hazard: Increased Storm Intensity, Duration, Frequency, Storm Surge, and Sea Level Rise	
Description:	Flooding and marsh migration exacerbated by sea level rise and storm surge
Applicability:	Based on a review of the available sea level rise projections developed by MGS, as shown in Figure C-2 in Appendix C, it appears that the future HAT elevation as a result of 1.2, 2.6 and 3.9 feet of SLR is not likely to cause significant flooding at the WWTF site. However, the increase in the HAT may impact the WWTF outfall pipe in terms of soil destabilization under the outfall pipe's concrete headwall, increased saltwater corrosion of the concrete headwall structure over time, temporary inundation of the headwall during HAT conditions, and limited surcharging in the outfall pipe. Based on a review of the WWTF's hydraulic profile and the projected SLR scenarios, it does not appear that the increased HAT elevation as a result of 1.2, 2.6 and 3.9 feet of SLR will cause surcharging in the outfall pipe into the WWTF's chlorine

	contract tank. Therefore, the impact of this limited surcharging of the outfall pipe would be negligible to WWTF operations.
Risk:	Flooding/Marsh Migration: Low; minor impact to access to outfall pipe
Hazard: Increased Storm Intensity, Duration, Frequency, Storm Surge, and Sea Level Rise	
Description:	Soil erosion, slope destabilization
Applicability:	Soil erosion at the WWTF site as a result of tidal action appears to be already taking place at the WWTF outfall pipe's concrete headwall. WP and Town staff noted undermining of the concrete headwall structure during a May 2022 site visit to the WWTF. Soil destabilization under the headwall will continue to progress with runoff from more frequent large storms, increased storm surge and sea level rise raising the HAT in this area. Projected marsh migration as a result of sea level rise, as shown in Figure E-2 in Appendix E, will likely result in further soil erosion and destabilization under the headwall structure as well.
Risk:	Soil erosion/slope destabilization: Moderate; potential for undermining outfall pipe
Hazard: Increased Storm Intensity, Duration, Frequency, Sea Level Rise and Storm Surge	
Description:	Accessibility issues from flooding as a result of more frequent large storms and sea level rise.
Applicability:	Overlays of the FEMA 100-year floodplain, 1.2, 2.6 and 3.9 feet of SLR, and SLOSH model category 1, 2, 3 and 4 hurricanes at the WWTF site were reviewed to evaluate if accessibility at the WWTF site will be impacted by these scenarios. It appears that WWTF site access will not be significantly restricted during any of these scenarios.
Risk:	Site accessibility: none expected
Hazard: Excessive Wind Speeds	
Description:	Increased wind loading to enclosures and panels, and downed trees causing equipment damage.
Applicability:	Increase wind loading from large storms and hurricanes are likely to cause some minor damage to the WWTF site and potential loss of utility power as result of downed trees and power lines. The risk of power loss at the WWTF is mitigated by the WWTF's dedicated standby power generator. It also appears that most critical systems and equipment are set back from large trees on the property such that the risk of damage as a result of a blowdown is low. A portion of the WWTF was recently upgraded in 2006, structures were designed and built in accordance with IBC 2003, including the appropriate wind loading for the WWTF location. According to the 2006 Wright-Pierce WWTF Upgrade record drawings, a 100-mph reference wind velocity was used in the design of the new structures that were included in the 2006 WWTF upgrades. The remainder of the WWTF facilities that were installed prior to the 2006 upgrades were also assumed to be built in accordance with the current building code

	requirements in effect at the time of their construction. Reference information on the wind loading used in their design was not readily available. The historical wind loadings used to design the WWTF facilities and structures were not evaluated to determine if they are adequate to meet the currently adopted local building code requirements for wind loading at the WWTF's location as part of this study.
Risk:	Wind Loading: none expected Downed Trees: none expected

5.4 Pump Station Risk Assessment

5.4.1 Old Mill Road Pump Station (No. 1)

Reference: Appendix B-2 FEMA Flood Map; C-2 Sea Level Rise Map; D-2 SLOSH Map; E-2 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, exacerbated by sea level rise and storm surge
Applicability:	According to the available LiDAR data, the average ground elevation around the Old Mill Road Pump Station is about 18.0 feet. The 2018 preliminary FEMA floodplain data for this area indicates that the 100-year BFE is 22.0 (Figure B-14 in Appendix B). The Old Mill Road Pump Station is a wetwell/drywell type design with the pumps housed in a below-grade steel drywell adjacent to the wetwell structure. The access hatch to the drywell is approximately 16 inches above grade. The electrical controls are mounted on a wooden backerboard panel and are approximately 16 inches above grade as well. This indicates that the pump station's drywell access hatch and the pump controls are expected to be inundated during a 100-year storm event. However, historically, Town staff have not observed flooding near the pump station site. Therefore, the risk of localize flooding during a 100-year storm event impacting pump station operations is considered moderate. The coastline adjacent to the pump station is relatively steeply sloped, so it appears that 1,2, 1.6 or 3.9 feet of SLR alone will not result in flooding of the pump station site during HAT conditions (Figure C-14 in Appendix C). NOAA SLOSH model data indicates that storm surge from a category 3 or 4 hurricane would be expected to cause flooding to approximately elevation 26.0 to 30.0 feet, which would be expected to inundate the site and the pump station facilities (Figure D-14 in Appendix D). Since category 3 and 4 hurricanes are considered extremely rare in Maine, the risk of them occurring is considered low. A category 1 hurricane is not expected to cause flooding at the pump station site, and category 2 hurricane may cause partial flooding at the pump station site to about elevation 18.0 feet, but would not be expected to have a significant impact on operations. Therefore, the risk of future storm surge impacting future operations at the pump station site is considered low.
Risk:	Flooding: moderate

5.4.2 Brown Street Pump Station (No. 2)

Reference: Appendix B-3 FEMA Flood Map; C-3 Sea Level Rise Map; D-3 SLOSH Map; E-3 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage

Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Brown Street Pump Station area. The impact of a utility power outage on the Brown Pump Station and its operations is mitigated by the dedicated outdoor standby power generator located at the pump station located on a concrete pad at the pump station site. The generator is capable of running essential pump station equipment during a utility power outage that allows the pump station to maintain adequate pumping capacity. Therefore, the risk of more frequent power outages affecting pump station operations is considered low.
Risk:	Loss of power: low

Hazard: Increased Storm Intensity, Duration, Frequency, SLR, and Storm Surge	
Description:	Flooding, exacerbated by sea level rise and storm surge; marsh migration, soil erosion
Applicability:	Available LiDAR topographic information indicates that the approximate ground elevation around the pump station wetwell, drywell and generator is about 10.0 feet and the 2018 preliminary FEMA 100-year floodplain elevation for this area is 12.0 feet (Figure B-4 in Appendix B). Based on MGS SLR projections, the HAT elevation, as a result of 3.9 feet of SLR, could be as much as 10.0 feet in this area (Figure C-4 in Appendix C). NOAA SLOSH modeling indicates that storm surge from a category 1 hurricane could result in flooding to elevation 12.0 feet, and to 16.0 feet for a category 2 hurricane (Figure D-4 in Appendix D). Two feet of flooding above the average grade elevation at the pump station site is expected to result in flooding to within 2 inches of the drywell access hatch elevation, inundation of the generator and partial flooding of the pump station control panel. Three or more feet of flooding above the average ground elevation is expected to inundate nearly all of the pump station equipment and structures. There is also a large drainage swale that runs through the pump station property. During large storm events, the drainage swale will likely concentrate runoff from the surrounding area to the pump station site, which could exacerbate the risk of pump station flooding. Based on the assessment of the FEMA floodplain, SLR, and storm surge data, the Brown Street Pump Station appears to be at relatively high risk of flooding. Figure E-5 in Appendix E shows the expected marsh migration at the Brown Street Pump Station as a result of 1, 2, 3 and 6 feet of sea level rise. Under the scenarios of 3 and 6 feet of SLR, it is expected that most of the area surrounding the wetwell, drywell and generator will be marshland. Therefore, the risk of marsh migration onto the pump station property is considered relatively high. Based on available FEMA floodplain information and SLR and storm surge projections, it appears that the pump station site is at high risk of flooding and increased tidal action as a result of SLR. Therefore, the pump station site is at relatively high risk of soil erosion stemming from flooding and future tidal action.

	The large drainage swale that runs through the pump station property could exacerbate the risk of soil erosion by concentrating runoff from the surrounding area to the pump station site during large storm events.
Risk:	Flooding: high Soil erosion/slope destabilization: high

5.4.3 Clearwater Drive Pump Station (No. 3)

Reference: Appendix B-4 FEMA Flood Map; C-4 Sea Level Rise Map; D-4 SLOSH Map; E-4 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Clearwater Pump Station area. The impact of a utility power outage on the Clearwater Pump Station and its operations is mitigated by the dedicated standby power generator located at the pump station in a simple wood-framed generator building. The generator is capable of running essential pump station equipment during a utility power outage that allows the pump station to maintain adequate pumping capacity. Therefore, the risk of more frequent power outages affecting pump station operations is considered low.
Risk:	Loss of power: low

Hazard: Increased Storm Intensity, Duration, Frequency, SLR, and Storm Surge	
Description:	Flooding, exacerbated by sea level rise and storm surge, marsh migration, soil erosion
Applicability:	Available LiDAR topographic information indicates that the approximate ground elevation around the pump station wetwell and generator building is about 8.0 feet. The 2018 preliminary FEMA 100-year floodplain elevation for this area is 10.0 feet. Based on MGS SLR projections, the HAT elevation, as a result of 3.9 feet of SLR, could be as much as 12.0 feet in this area. NOAA SLOSH modeling indicates that storm surge as a result of a category 1 hurricane could result in flooding to elevation 12.0 feet, and to 18.0 feet for a category 2 hurricane. Three feet of flooding above the average grade elevation at the pump station site is expected to result in inundation of the pump station drywell access hatch, wetwell, standby power generator and electrical conduits to and from the main power service panel, pump station control panel and ATS. Four or more feet of flooding above the average ground elevation is expected to inundate the pump control panel and ATS as well. Based on the assessment of

	the FEMA floodplain, SLR, and storm surge data, the Clearwater Pump Station appears to be at high risk of flooding. Figure E-6 in Appendix E shows the expected marsh migration at the Clearwater Pump Station as a result of 1, 2, 3 and 6 feet of sea level rise. Under each SLR scenario, there is some marsh migration onto the pump station property. With three or more feet of SLR, it is expected that most of the area surrounding the wetwell, drywell and generator building will be marshland. Therefore, the risk of marsh migration onto the pump station property is considered high. Based on available FEMA floodplain information and SLR and storm surge projections, it appears that the pump station site is at high risk of flooding and increased tidal action as a result of SLR. Therefore, the pump station site is at relatively high risk of soil erosion stemming from flooding and future tidal action.
Risk:	Flooding: high Marsh migration: high Soil erosion: high

5.4.4 Lunt Road Pump Station (No. 4)

Reference: Appendix B-5 FEMA Flood Map; C-5 Sea Level Rise Map; D-5 SLOSH Map; E-5 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, exacerbated by sea level rise and storm surge; marsh migration, soil erosion, slope destabilization
Applicability:	The LiDAR contour information at the Lunt Road Pump Station indicates that the average grade elevation around the pump enclosure is about 20.0 feet and the FEMA 2018 preliminary 100-year BFE for Skitterygusset Creek in this location is 10.0 feet (Figure B-12 in Appendix B). This indicates that flooding of the pump station site would not be expected during a 100-year flood event. MGS SLR modeling data indicates that 3.9 feet of SLR is expected to raise the HAT water surface elevation to about 10.0 feet. Therefore, 3.9 feet (or less) of SLR would not be expected to cause flooding at the pump station site (Figure C-12 in Appendix C). Based on the MGS SLR marsh migration modelling, marsh migration, as a result of 6.0 feet of SLR (or less), is not expected to cause salt marsh intrusion beyond elevation 12.0 feet along the banks of Skitterygusst Creek adjacent to the pump station site. NOAA SLOSH model data indicates that storm surge from a category 3 or 4 hurricane may cause flooding to approximately elevation 22.0 to 26.0 feet, respectively, which would be expected to inundate the site and the pump station facilities (Figure D-12 in Appendix D). Since category 3 and 4 hurricanes are considered extremely rare in Maine, the risk of them occurring at this location is considered low. A category 1 hurricane is not expected to cause flooding at the pump station site, and category 2 hurricane may cause partial flooding at the pump station site around the fiberglass pump enclosure and the electrical controls to about elevation 20.0

	feet, without consideration of future SLR. It should be noted that the available NOAA SLOSH model dataset uses an oceanic water surface elevation baseline of mean high tide. Future SLR may effectively raise the average mean high tide elevation, and thereby exacerbate storm surge from a category 1 or 2 hurricane in this area. Therefore, the risk of future storm surge impacting future operations at the pump station site is considered moderate when future SLR is considered. The southern portion of the Lunt Road Pump Station site is steeply sloped where it borders the intertidal mudflat along the western bank of Skitterygusset Creek. Increased tidal action in this area, as a result of SLR, could contribute to accelerated slope destabilization near the pump station facilities. Lunt Road has a crown elevation of about 38.0 feet at the pump station driveway entrance, which is about 18 feet above the ground elevation at the fiberglass pump enclosure on the pump station site. The top layer of the pump station driveway is impervious bituminous pavement and slopes in the direction of the pump enclosure. Increased runoff toward the steep bank of Skitterygusset Creek along the southern portion of the pump station site, as a result of more frequent and intense storms, could contribute to future slope destabilization to the south of the pump enclosure. At present, soil erosion at the Lunt Road Pump Station site was not noted by the wastewater department staff as an item of notable concern during routine checks of the pump station site. Therefore, the risk of soil erosion and slope destabilization affecting future pump station operations is considered moderate and should be taken into consideration at the time of future upgrades to the station.
Risk:	Flooding: low Storm surge: moderate Soil erosion/slope destabilization: moderate

5.4.5 Mill Creek Pump Station (No. 5)

Reference: Appendix B-6 FEMA Flood Map; C-6 Sea Level Rise Map; D-6 SLOSH Map; E-6 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Mill Creek Pump Station area. The impact of a utility power outage on the Mill Creek Pump Station and its operations is mitigated by the availability of a dedicated standby power generator located within the pump station building. Therefore, the risk of more frequent power outages affecting pump station operations is considered low.
Risk:	Loss of power: low

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, surcharging of Mill Creek, marsh migration, soil erosion
Applicability:	The Mill Creek Pump Station is adjacent to the location where Foreside Road crosses Mill Creek. The bridge abutments, at times, have historically created a hydraulic restriction in Mill Creek during flood stage conditions, which has led to a backwater effect in Mill Creek upstream of the bridge. The impact of Mill Creek surcharging onto the pump station property during flood stage conditions is considered low because the pump station building's finished floor elevation is 6 feet above the 2018 preliminary FEMA floodplain elevation (10.0 feet) in this area (Figure B-7 in Appendix B). The NOAA SLOSH model data indicates that a category 3 or 4 hurricane could cause storm surge reaching elevations between 20.0 to 24.0 feet in the area surrounding the pump station site (Figure D-7 in Appendix D). Although this would have the potential to partially inundate the pump station building, the risk of a category 3 or 4 hurricane occurring in Maine is considered extremely low. MGS SLR data in Figure C-7 in Appendix C indicates that under the 3.9 feet of SLR scenario, the HAT elevation could rise to about 12.0 feet. This is the same elevation as the average ground elevation around the northwest corner of the pump station building's foundation. However, the risk of flooding as a result of 3.9 feet of SLR is considered low because the finished floor elevation of the pump station building is at elevation 16.0 feet. The expected marsh migration scenarios, as a result of 1, 2, 3 and 6 feet of SLR, as shown in Figure E-7 in Appendix E indicate that the backwater effect from the hydraulic restriction at the bridge adjacent to the pump station property will contribute to marsh migration onto the pump station property northwest of the pump station building. With more than 3 feet of SLR, it appears that the influent sewers and manhole to the northwest of the pump station building will be within marshland. Six feet of SLR could result in marshland encroaching around the pump station building to the north and west, making access to these portions of the station more difficult. WP and Town staff noted soil erosion and streambank destabilization occurring along the banks of Mill Creek along the edge of the pump station property bordering Mill Creek. It is likely that tidal action and the hydraulic restriction in Mill Creek during flood stage conditions, caused by the bridge abutments adjacent to the pump station property, is contributing to accelerated soil erosion along Mill Creek's banks in this location. The pump station building and its foundation are currently offset from the banks of Mill Creek by about 50 feet. MGS SLR data in Figure C-7 in Appendix C indicates that under the 3.9 feet of SLR scenario, the HAT elevation could rise to about 12.0 feet, which would bring the water surface elevation during HAT close to the average grade elevation at the pump station building foundation's northwest corner. Under this SLR scenario, soil erosion and streambank destabilization could continue to occur near the pump station building's foundation. Therefore, the risk of soil erosion impacting future operations at the pump station site is considered moderate. The expected marsh migration scenarios, as a result of 1, 2, 3 and 6 feet of SLR (Figure E-7 in Appendix E), indicate that the backwater effect from the hydraulic restriction at the bridge adjacent to the pump station property will contribute to marsh migration and subsequent soil

	destabilization onto the pump station property northwest of the pump station building. More than 3 feet of SLR may result in the area surrounding the influent sewers and manhole to the northwest of the pump station building eventually becoming marshland. This could also lead to undermining of these structures by tidal action driving the future marsh migration. Six feet of SLR could also result in marshland encroaching around the pump station building to the north and west of the building foundation and eventually cause destabilization of the soils around the pump station building. The data presented above indicates storm surge, SLR and marsh migration could all contribute to ongoing soil erosion and streambank destabilization. Therefore, the of the risk of these hazards impacting future pump station operations is considered moderate.
Risk:	Flooding: low Marsh migration: moderate Soil erosion: moderate

5.4.6 Handy Boat Pump Station (No. 6)

Reference: Appendix B-7 FEMA Flood Map; C-7 Sea Level Rise Map; D-7 SLOSH Map; E-7 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, exacerbated by sea level rise and storm surge, Soil erosion, slope destabilization
Applicability:	According to the available LiDAR data, the average ground elevation around the Handy Boat Pump Station is between 15.0 and 16.0 feet at the pump station drywell, wetwell and electrical controls, and about 20.0 feet around the standby power generator on the east side of the pump station site. The 2018 preliminary FEMA floodplain data for this area indicates that the 100-year BFE is 15.0 in this area (Figure B-14 in Appendix B). The Handy Boat is a wetwell/drywell type design with the pumps housed in a below-grade steel drywell adjacent to the wetwell structure. The access hatch to the drywell is approximately 16 inches above grade. The electrical controls are mounted on a wooden backerboard panel and are approximately 24 inches above grade. This indicates that the pump station's drywell access hatch and the pump controls are not expected to be inundated during a 100-year storm event. The coastline adjacent to the pump station is relatively steeply sloped, so it appears that 1,2, 1.6 or 3.9 feet of SLR alone will not result in flooding of the pump station site during HAT conditions (Figure C-14 in Appendix C). NOAA SLOSH model data indicates that storm surge from a category 3 or 4 hurricane may cause flooding to approximately elevation 20.0 to 26.0 feet, respectively, which would be expected to inundate the site and the pump station facilities (Figure D-15 in Appendix D). Since category 3 and 4 hurricanes are considered extremely rare in Maine, the risk of them occurring at this location is considered low. A category 1 hurricane is not expected to cause flooding at the pump station site, and category 2 hurricane may cause partial flooding at the pump station site around the pump station drywell and electrical controls on the eastern side of the pump station site to about elevation 16.0 feet, without consideration of future SLR. It should be noted that the

	available NOAA SLOSH model dataset uses an oceanic water surface elevation baseline of mean high tide. Future SLR may effectively raise the average mean high tide elevation, and thereby exacerbate storm surge from a category 1 or 2 hurricane in this area. Therefore, the risk of future storm surge impacting future operations at the pump station site is considered moderate when future SLR is considered. WP and Town staff noted some signs of soil erosion and slope destabilization through a drainage swale to the south of the pump station site during a site visit to the pump station in May 2022. The interceptor sewer that flows to the Handy Boat pump station crosses this drainage swale. The Town staff noted that repairs to mitigate the soil erosion from stormwater runoff were previously made, but had been partially eroded again. Given the observed historical soil erosion and slope destabilization near the pump station site, it is likely that more intense and frequent storms will accelerate soil erosion in this area. Although soil erosion is occurring now and is expected to accelerate in the future, the risk of soil erosion and slope destabilization affecting future pump station operations is considered moderate because of the distance between the destabilized slope and the critical pump station equipment.
Risk:	Flooding: low Future storm surge: moderate Soil erosion/slope destabilization: moderate

5.4.7 Underwood Road Pump Station (No. 7)

Reference: Appendix B-8 FEMA Flood Map; C-8 Sea Level Rise Map; D-8 SLOSH Map; E-8 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Underwood Pump Station area. There are also several large trees near the pump station that could be a blowdown risk onto the power lines feeding power to the pump station's controls. The station collects sewer flows from the immediate neighborhood and pumps them to the Town Landing Interceptor sewer on Amerescoggin Road. The impact of a utility power outage on the Underwood Pump Station and its operations is somewhat mitigated by the availability of a standby power receptable to connect a portable standby power generator to the pump station during a utility power failure. The Town's wastewater department staff have a portable generator available to power the station in the event of a utility power outage. Therefore, the risk of power outages affecting pump station operations is considered low.
Risk:	Loss of power: low

Hazard: Increased Storm Intensity, Duration, Frequency, Storm Surge and Sea Level Rise

Description:	Flooding, exacerbated by sea level rise and storm surge, soil erosion
Applicability:	The 2018 preliminary FEMA 100-year BFE at the Underwood Pump Station site is 19.0 feet. According to available LiDAR data, the average ground elevation around the pump station wetwell, drywell, and electrical controls is between 12.0 and 13.0 feet (Figure B-10 in Appendix B). This indicates that the pump station electrical controls, drywell and wetwell could be inundated during a 100-year storm event. NOAA SLOSH modeling data indicates that storm surge from a category 1 or 2 hurricane could cause the flood water surface elevation to rise to about 12.0 to 16.0 feet, respectively (Figure D-10 in Appendix D). Therefore, the risk of the pump station flooding as a result of a 100-year storm or hurricane is considered high. The Underwood Pump Station property borders the shoreline of Casco Bay, which is subject to regular tidal action that could contribute to soil erosion and slope destabilization along the western portion of the pump station site. WP staff noted a small stone retaining wall near the station that appears to have been constructed to armor the shoreline to some extent. However, it is unclear if the retaining wall will significantly mitigate soil erosion along the shoreline. Soil erosion and bank destabilization will be further exacerbated during large storms and by SLR. Under the 3.9 feet of SLR scenario, the water surface elevation during HAT may rise to around elevation 10.0. The subterranean Underwood Spring and an above-ground drainage swale also runs through the southern portion of the pump station site. These topographic features are likely to concentrate runoff and groundwater along the pump station property, which could further destabilize the soils at the site. Therefore, the risk of soil erosion and slope destabilization at the Underwood Pump Station affecting future pump station operations is high.
Risk:	Flooding: high Soil erosion/slope destabilization: high

5.4.8 Thornhurst Road Pump Station (No. 9)

Reference: Appendix B-9 FEMA Flood Map; C-9 Sea Level Rise Map; D-9 SLOSH Map; E-9 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage, accessibility issues from excess snowfall
Applicability:	The Thornhurst Road Pump Station receives flow from the immediate neighborhood by gravity flow and receives pump flows from the Landing Woods Lane and Waite's Landing pump station service areas and pumps these flows to gravity sewer along Foreside Road. Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Thornhurst Road Pump

	Station area. There are also several large trees near the pump station that could be a blowdown risk. The Town's wastewater department staff have a portable generator available to power the station in the event of a utility power outage. Therefore, the risk of more frequent power outages affecting pump station operations is considered moderate. The pump station is on a privately maintained road, so accessibility to the pump station during large snowstorms could be a concern. However, wastewater staff did not note any historical occasions where snowfall negatively impacted their ability to maintain the pump station. Therefore, the risk of increased winter storm intensity negatively impacting pump station operations is considered low.
Risk:	Loss of power: moderate Accessibility: low

5.4.9 Waite's Landing Pump Station (No. 10)

Reference: Appendix B-10 FEMA Flood Map; C-10 Sea Level Rise Map; D-10 SLOSH Map; E-10 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Waite's Landing Pump Station area. The pump station is in a relatively remote location that is subject to frequent power outage from downed trees during large storms. There are also several large trees near the pump station that could be a blowdown risk. The pump station receives flow from the immediate neighborhood by gravity flow and pumped flow from the Landing Woods Lane Pump Station service area and pumps these flows to the Thornhurst Road Pump Station. The impact of a utility power outage on the Waite's Landing Pump Station and its operations is somewhat mitigated by the availability of a standby power receptable to connect a portable standby power generator to the pump station during a utility power failure. The Town's wastewater department staff have a portable generator available to power the station in the event of a utility power outage. Therefore, the risk of power outages affecting pump station operations is considered low.
Risk:	Loss of power: low
Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Accessibility issues from excess snowfall, downed trees
Applicability:	Similar to Landing Woods Lane Pump Station, Waite's Landing Pump Station is on a public road that is maintained by the Town, but is in a relatively remote location in Falmouth that is not a top priority for snowplowing operations during a major snowstorm. If this area received significant snowfall during a major snowstorm, this could delay wastewater department staff

	accessing the pump station. There are also many large trees that line Landing Woods Road that could be a blowdown risk onto the road and temporarily restrict access to the pump station. However, historically, accessing the pump station during inclement weather conditions has not been an issue for wastewater department staff. Therefore, the risk of more intense and frequent storms and blizzards restricting access to the pump station such that pump station operations will be significantly impacted is considered moderate.
Risk:	Accessibility: moderate

5.4.10 Landing Woods Lane Pump Station (No. 11)

Reference: Appendix B-11 FEMA Flood Map; C-11 Sea Level Rise Map; D-11 SLOSH Map; E-11 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Landing Woods Lane Pump Station area. The Landing Woods Lane pump station is in a relatively remote location that is subject to frequent power outage from downed trees during large storms. There are also several large trees near the pump station that could be a blowdown risk. The pump station receives flow from the immediate neighborhood by gravity flow and pumps these flows to the Waite's Landing Pump Station. The impact of a utility power outage on the Landing Woods Lane Pump Station and its operations is somewhat mitigated by the availability of a standby power receptable to connect a portable standby power generator to the pump station during a utility power failure. The Town's wastewater department staff have a portable generator available to power the station in the event of a utility power outage. Therefore, the risk of more frequent power outages affecting pump station operations is considered low.
Risk:	Loss of power: low

Hazard: Increased Storm Intensity, Duration, and Frequency	
Description:	Increased rainfall-induced inflow and infiltration
Applicability:	Increased inflow and infiltration from more frequent and intense storms is expected to impact the pump station because there are several residential foundation drains tied into the pump station's service area. Increased inflow from foundation drains and other infiltration sources in the sewer system served by the pump station will, in effect, reduce the pump station wetwell's baseline storage capacity. This could translate to the wastewater department staff having less time to transport and deploy a portable standby power generator to the station to run the pumps during a utility

	power outage before there is a sewer backup into basements or the wetwell overflows. Therefore, the risk of increased inflow and infiltration impacting pump station operations is considered moderate.
Risk:	Inflow/infiltration: moderate
Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Accessibility issues from excess snowfall, downed trees
Applicability:	Landing Woods Lane is a public road that is maintained by the Town, but is in a relatively remote location in Falmouth that is not a top priority for snowplowing operations during a major snowstorm. If this area received significant snowfall during a major snowstorm, this could delay wastewater department staff accessing the pump station. There are also many large trees that line Landing Woods Road that could be a blowdown risk onto the road and temporarily restrict access to the pump station. However, historically, accessing the pump station during inclement weather conditions has not been an issue for wastewater department staff. Therefore, the risk of more intense and frequent storms and blizzards restricting access to the pump station such that pump station operations will be significantly impacted is considered moderate.
Risk:	Accessibility: moderate

5.4.11 Middle Road Pump Station (No. 12)

Reference: Appendix B-12 FEMA Flood Map; C-12 Sea Level Rise Map; D-12 SLOSH Map; E-12 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, exacerbated by sea level rise and storm surge
Applicability:	The LiDAR contour information at the Middle Road Pump Station indicates that the average grade elevation around the pump station wetwell and electrical control panel is about 19.0 feet and the FEMA 2018 preliminary 100-year BFE for the Presumpscot River in this location is 9.0 feet (Figure B-13 in Appendix B). This indicates that flooding of the pump station site would not be expected during a 100-year flood event. MGS SLR modelling indicates that 3.9 feet of SLR is expected to raise the HAT water surface elevation to about 12.0 feet, indicating that 3.9 feet (or less) of SLR alone would not be expected to cause flooding at the pump station site (Figure C-13 in Appendix C). NOAA SLOSH model data indicates that storm surge from a category 3 or 4 hurricane may cause flooding to approximately elevation 20.0 to 24.0 feet, respectively, which would be expected to partially inundate the site and the pump station facilities (Figure D-13 in Appendix D). Category 3 and 4 hurricanes are considered extremely rare in Maine. Therefore, the risk of them occurring at this location is considered low. The currently available NOAA SLOSH

	modeling data indicates that category 1 and 2 hurricanes would not be expected to cause flooding at the pump station site.
Risk:	Flooding/storm surge: low Storm surge: low

5.4.12 Leighton Road Pump Station (No. 20)

Reference: Appendix B-13 FEMA Flood Map; C-13 Sea Level Rise Map; D-13 SLOSH Map; E-13 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Leighton Road Pump Station area. The station is equipped with a dedicated standby power generator at the pump station site. The pump station collects sewer flows from the surrounding neighborhood and pumps collected sewer flows to a common force main with the Mill Road Pump Station that eventually runs to the Falmouth Road Pump Station. The impact of a utility power outage on the Leighton Road Pump Station and its operations is mitigated by the availability of a dedicated standby power generator with an automatic power transfer switch. Therefore, the risk of more frequent power outages affecting pump station operations is considered low.
Risk:	Loss of power: low
Hazard: Increased Storm Intensity, Duration, and Frequency	
Description:	Flooding, soil erosion, slope destabilization
Applicability:	According to the preliminary 2018 FEMA flood maps (Figure B-4 in Appendix B), the pump station building and wetwell are within the 500-year floodplain of the Piscataqua River at this location (approximately elevation 36.0 feet). Since the pump station electrical controls and generator are elevated 1+ feet above this elevation, the risk of a 500-year flood affecting pump station operations is considered low. The pump station site is located at the foot of a nearby hill that could concentrate stormwater runoff on Leighton Road in the direction of the pump station site. The site appears to have some storm drainage infrastructure in place along the road shoulder bordering the pump station site to the north to direct runoff from the road away from the site to the nearby Piscataqua River. The southeast corner of the pump station site is steeply sloped in the direction of the nearby Piscataqua River and lies within the FEMA 100-year floodplain. The pump station control building wetwell and generator are outside of this steeply sloped portion of the pump station

	site and are not within the 100-year floodplain. A 100-year storm event could destabilize the steeply sloping soils in this portion of the pump station property. However, because the critical pump station equipment is not located in this area, the risk of soil erosion and slope destabilization affecting pump station operations is considered low.
Risk:	Flooding: low Soil erosion/slope destabilization: low

5.4.13 Mill Road Pump Station (No. 22)

Reference: Appendix B-14 FEMA Flood Map; C-14 Sea Level Rise Map; D-14 SLOSH Map; E-14 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Excess Wind Speeds	
Description:	Utility Power Outage
Applicability:	Falmouth has historically experienced power outages during large storms and windy conditions that have temporarily interrupted local utility power to the Mill Road Pump Station area. The station is equipped with a dedicated standby power generator at the pump station site. The pump station collects sewer flows from a low-pressure sewer system in northwestern Falmouth via the Mill Road Interceptor that runs along the Piscataqua River. The Mill Road Pump Station pumps collected sewer flows to a common force main with the Leighton Road Pump Station that eventually runs to the Falmouth Road Pump Station. The impact of a utility power outage on the Mill Road Pump Station and its operations is mitigated by the availability of a dedicated standby power generator with an automatic power transfer switch. Therefore, the risk of more frequent power outages affecting pump station operations is considered low.
Risk:	Loss of power: low

Hazard: Increased Storm Intensity, Duration, and Frequency	
Description:	Flooding, increased rainfall-induced inflow and infiltration, soil erosion, riverbank destabilization
Applicability:	The 2018 preliminary FEMA 100-year floodplain elevation is 42.0 feet at the pump station site (Figure B-3 in Appendix B) and the average ground elevation at the pump station site is about 58.0 feet. The station is located near the shoulder of Mill Road, which is elevated at its crown several feet above the ground elevation at the pump station site. Stormwater runoff from Mill Road could shed off Mill Road onto the Mill Road Pump Station access driveway, which slopes toward the pump station equipment. WP staff noted some signs of runoff occurring down the riverbank within which the pump station wetwell is installed between the Mill Road Bridge and the pump station wetwell during a site visit to the pump station in May 2022. However, wastewater department staff did not note any historical flooding concerns at that pump

	station as a result of stormwater runoff from Mill Road. Therefore, the risk of flood waters and stormwater runoff affecting pump station operations is considered low. WP staff noted some signs of soil erosion and riverbank destabilization near the pump station wetwell during a site visit to the pump station in May 2022. It was also noted the riverbank adjacent to the pump station wetwell had been previously armored with riprap, presumably to mitigate soil erosion and help stabilize the riverbank. Given the observed historical riverbank erosion, it is likely that more intense and frequent storms will accelerate riverbank erosion in this area. Therefore, the risk of soil erosion and riverbank destabilization affecting future pump station operations is considered moderate.
Risk:	Flooding: low Soil erosion/slope destabilization: moderate

5.5 Collection System Risk Assessment

5.5.1 Force Mains, Gravity Sewers, Manholes (General)

Reference: Appendix B, Figure B FEMA Flood Map; Appendix C, Figure C Sea Level Rise Map; Appendix D, Figure D SLOSH Map; Appendix E, Figure E Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, accessibility issues, increased I/I, saltwater intrusion, sanitary sewer overflows, soil erosion
Applicability:	There are several portions of the sewer collection system that are located within the FEMA 100-year floodplain or in low-lying areas prone to flooding. Figure B-1 in Appendix B identifies the extent of the collection system located within the preliminary FEMA 2018 100-year floodplain. The risk of flood damage to underground sewers and force mains is considered low. However, some of the secondary impacts of flooding include increased inflow from sump pumps, cellar drains, foundation drains and roof drains and groundwater infiltration into older sections of pipe and manholes via cracks and offset pipe joints is considered high. Saltwater intrusion, as a result of increased infiltration in tidally influenced areas, could be a concern with respect to accelerated deterioration of concrete pipes and manhole structures. Flood waters could also float manhole covers in flood-prone areas that are not secured to the manhole cover frame. Flooding could also temporarily hinder access to some cross-country sewer mains and interceptor sewers that are near the coastline or along stream and riverbanks and are in the floodplain. More frequent flooding can also lead to soil erosion and slope destabilization, which could eventually lead to exposure of pipes and sewer manholes. The MGS SLR data shown in Figure C-1 in Appendix C indicates that the HAT elevation, as a result of 1 to 4 feet of sea level rise, could also contribute to increased inflow and infiltration into the sewers along the coastline and along tidal rivers and streams. SLR could also contribute to temporarily restricted access during HAT conditions to some of the sewer mains and interceptor sewers along the coastline and along tidal rivers and streams. Tidal action is also likely to contribute to accelerated soil erosion and slope destabilization in these same areas. Marsh migration, as a result of 1, 2, 3 and 6 feet of SLR, is also expected to restrict access to some sewer mains and interceptor sewers in relatively flat tidal areas and contribute to increased infiltration into these sewers as they age. The NOAA SLOSH modelling data shown in Figure D-1 in Appendix D similarly confirms that several cross-country sewer main and interceptor sewer routes that are near the coastline and along river and streambanks are expected be flooded as a result of storm surge. Flooding from storm surge could temporarily restrict access to the sewers in these areas, contribute to increased inflow and infiltration into the sewers, and cause accelerated soil erosion and slope destabilization around these sewers. Based on an assessment of the available information, the risk of increased sewer inflow and infiltration, saltwater intrusion, SSOs and sewer undermining from soil erosion are considered high for sewers that are in areas that are expected to flood more frequently as a result of

	larger and more frequent storms, SLR and/or storm surge. The assessment of several critically-impacted interceptor sewers are discussed in further detail in the following sections.
Risk:	Flooding (damage): low Inflow/Infiltration, saltwater intrusion, SSOs, limited access in flooded areas: high

5.5.2 Town Landing Interceptor Sewer

Reference: Appendix B-15 FEMA Flood Map; C-15 Sea Level Rise Map; D-15 SLOSH Map; E-15 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, accessibility issues, increased I/I, soil erosion
Applicability:	A small portion of the Town Landing Interceptor sewer passes within the preliminary 2018 FEMA 100-year floodplain (Figure B-1 in Appendix B). Therefore, the risk of a significant increase in inflow and infiltration into the interceptor in this area from a 100-year storm event is considered relatively low. However, the interceptor is located within relatively steeply sloped embankments along the coastline in several areas, and flooding of the lower portions of these embankments from a large storm in 2015 contributed to significant soil erosion and slope destabilization in this area. The Town then retained Wright-Pierce to study these slope failures. The study noted that, *"…the profile of soils along the shoreline generally consists of outwash sands overlying glaciomarine clays with sand seams. The glaciomarine clays extend out into the natural reed marsh fronting most of the shoreline and then to the mudflats. Both predominant soil types are highly erodible particularly when disturbed from wave action or when denuded of vegetation. It has been observed in many areas that groundwater seeps exiting the face of the shoreline also contribute to erosion of these soils and the gradual blocking failure that can be observed in a number of areas along the shoreline…The predominant failure scenario along the shoreline appears to be related to block failures triggered by wave erosion and groundwater seepage. The cohesive characteristics of the glaciomarine clays permit these soils to stand at relatively steep slopes for a period of time before blocks break off and deposit at the toe of the slope. The deposited soil at the base of the slope creates a stabilizing berm which is subsequently eroded by wave action, thereby restarting the cycle. Groundwater seepage at the base of the slope is expected to exacerbate the situation."* More frequent and intense storms could accelerate this natural erosion process and lead to exposure of the interceptor pipes and sewer manholes as these embankment continue to erode over time. Therefore, the risk of soil erosion impacting the Town Landing Interceptor sewer because of increased storm intensity, duration and frequency is considered very high. The MGS SLR data shown in Figure C-1 in Appendix C also indicates that the extent of tidal action on the steep banks along the coastline, as a result of 1 to 4 feet of sea level rise, is likely

	to increase further up the embankments and contribute to accelerated soil erosion and slope destabilization in these same areas. Therefore, the risk of soil erosion from SLR impacting the Town Landing Interceptor sewer considered very high. The NOAA SLOSH modelling data in Figure D-1 in Appendix D indicates that a relatively small portion of the Town Landing Interceptor sewer area is expected be flooded as a result of storm surge, which could temporarily restrict access to the sewers in these areas, contribute to increased inflow and infiltration into the sewers at these locations, However, the risk of flooding during a Category 1 or 2 hurricane appears to be relatively low. Category 3 and 4 hurricanes are considered extremely rare for Maine. Therefore, overall, the risk of flooding and its secondary impacts including increased I/I and restricted access to the sewers, as a result of Category 1 to 4 hurricanes and their associated storm surge is considered low. However, it appears that storm surge from these same types of storms is likely to further inundate the lower portions of steep embankments along the coastline where portions of the Town Landing Interceptor are located. This could lead to accelerated soil erosion and slope destabilization around these sewers. Therefore, the risk of soil erosion impacting the Town Landing Interceptor in the future as a result of storm surge is considered very high.
Risk:	Flooding (damage): low Soil erosion/ slope destabilization: high Inflow/Infiltration, saltwater intrusion, SSOs, limited access in flooded areas: high

5.5.3 Mackworth Point Interceptor Sewer

Reference: Appendix B-16 FEMA Flood Map; C-16 Sea Level Rise Map; D-16 SLOSH Map; E-16 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, accessibility issues, increased I/I, soil erosion, saltwater intrusion
Applicability:	The Mackworth Point Interceptor is roughly 4,700 linear feet of sewer that runs along the east side of Mackworth Point from the Route 1 Bridge to the Brown Street Pump Station. Most of the interceptor lies within the preliminary 2018 FEMA 100-year floodplain (Figure B-16 in Appendix B). Therefore, the risk of a significant increase in inflow and infiltration and saltwater intrusion into the interceptor in this area from a 100-year storm event is considered relatively high. The interceptor is also located within relatively steeply sloped embankments along the coastline in several areas, and more frequent flooding of the lower portions of these embankments from large storms can accelerate soil erosion and slope destabilization. This is evidenced by the exposure of previously buried portions of several manholes along the interceptor run observed by WP and Town staff during a site visit in May 2022. Therefore, the risk of soil erosion from increased storm intensity and flooding impacting the Mackworth Point Interceptor sewer is considered very high. The MGS SLR data shown in Figure C-16 in Appendix C also indicates that the extent of tidal action on the steep banks along the coastline, as a result of 1 to 4 feet of sea level rise, is likely to increase further up the embankments and contribute to accelerated soil erosion and slope

	destabilization. Therefore, the risk of SLR-induced soil erosion further impacting the Mackworth Point Interceptor is considered very high. The NOAA SLOSH modelling data in Figure D-16 in Appendix D indicates that most of the Mackworth Point Interceptor sewer is expected be flooded as a result of storm surge from a Category 1 or larger hurricane, which could temporarily restrict access to the sewers in these areas, contribute to increased inflow/infiltration into the sewers, and lead to accelerated soil erosion and slope destabilization around these sewers. Therefore, the risk of these storm surge hazard consequences negatively impacting the interceptor and the wastewater department's ability to maintain and monitor the interceptor during these conditions is considered very high.
Risk:	Flooding (damage): high Soil erosion/ slope destabilization: high Inflow/Infiltration, saltwater intrusion, SSOs, limited access in flooded areas: high

5.5.4 Clearwater Interceptor Sewer

Reference: Appendix B-17 FEMA Flood Map; C-17 Sea Level Rise Map; D-17 SLOSH Map; E-17 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, accessibility issues, increased I/I to the collection system, soil erosion, saltwater intrusion
Applicability:	The Clearwater Interceptor sewer is suspended on elevated pipe supports over a portion of one the inter-tidal inlets of the Presumpscot River between Hartford Street and the Clearwater Pump Station. The interceptor is within the preliminary 2018 FEMA 100-year floodplain (Figure B-17 in Appendix B). The risk of a significant increase in inflow and infiltration into the interceptor from a 100-year storm event is considered relatively low because the pipe is suspended above-ground. However, it was noted during a sight visit to the interceptor in May 2022 by the Town and Wright-Pierce staff that there is some deterioration to the elevated pipe supports present, likely as a result of previous flooding, tidal action, or both. Deterioration of these pipe supports could eventually lead to their failure and collapse of the interceptor pipe into the inter-tidal marshland below. Therefore, the risk of increased flooding and soil erosion impacting the Town Landing Interceptor sewer because of increased storm intensity, duration and frequency is considered high. The MGS SLR data shown in Figure C-17 in Appendix C also indicates that the extent of tidal action around the interceptor supports will increase and likely contribute to accelerated soil erosion and slope destabilization in these same areas. Therefore, the risk of soil erosion impacting the Clearwater Interceptor sewer because of SLR is considered high. The NOAA SLOSH modelling data in Figure D-17 in Appendix D indicates that most of the Clearwater Interceptor is expected be flooded as a result of storm surge from a Category 1 hurricane or larger. This could temporarily restrict access to the sewer, and contribute to further undermining of the suspended pipe supports and soil erosion. Flooding to this level could also increase the risk of large floating debris hitting and damaging the suspended sewer.

	Therefore, the risk of storm surge from a Category 1 or larger hurricane negatively impacting the Clearwater Interceptor is considered high.
Risk:	Flooding (damage): high Soil erosion/ slope destabilization: high Inflow/Infiltration, saltwater intrusion, SSOs: low

5.5.5 Mill Creek Interceptor Sewer

Reference: Appendix B-18 FEMA Flood Map; C-18 Sea Level Rise Map; D-18 SLOSH Map; E-18 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, accessibility issues, increased I/I to the collection system, soil erosion, saltwater intrusion
Applicability:	A significant portion of the Mill Creek Interceptor sewer passes within the preliminary 2018 FEMA 100-year floodplain of Mill Creek (Figure B-1 in Appendix B). Therefore, the risk of a significant increase in inflow and infiltration into the interceptor in this area from a 100-year storm event is considered relatively high. Portions of the interceptor are also located within relatively steeply sloped embankments along the banks of Mill Creek. Recently, it has been noted by Town staff that flooding and tidal action has accelerated soil erosion and slope destabilization around several of the interceptor manholes, exposing previously buried portions of these structures. This could eventually lead to exposure of the interceptor pipes and undermining of sewer manholes over time. Therefore, the risk of soil erosion impacting the Mill Creek Interceptor sewer because of increased flooding and tidal action is considered very high. The Town retained Wright-Pierce to study the interceptor and provide short term rehabilitation and long-term replacement options. Access to the Mill Creek interceptor is also remote and difficult because of overgrowth along the sewer route and the lack of an access road or path. Flooding and downed trees from large storms could temporarily restrict access to portions of the interceptor along Mill Creek. Therefore, the risk of more frequent and intense storms causing accessibility issues that impact interceptor maintenance is considered high.
Risk:	Flooding (damage): high Soil erosion/ slope destabilization: high Inflow/Infiltration, saltwater intrusion, SSOs, limited access in flooded areas: high

5.5.6 Mill Road Interceptor Sewer

Reference: Appendix B-19 FEMA Flood Map; C-19 Sea Level Rise Map; D-19 SLOSH Map; E-19 Marsh Migration Map

Hazard: Increased Storm Intensity, Duration, and Frequency, Sea Level Rise, Storm Surge	
Description:	Flooding, accessibility issues, increased I/I to the collection system, soil erosion
Applicability:	The Mill Road Interceptor sewer is a roughly 700 linear foot stretch of cross-country sewer that was constructed in the early 2000's between Mill Road and the portion of Falmouth Road between Route 100 and Winn Road. The interceptor lies within the preliminary 2018 FEMA 100-year and 500-year floodplains (Figure B-19 in Appendix B). The sewer easement along the cross-country portion is overgrown with brush and large trees in several areas, making it difficult to access this portion of the sewer. Root systems of brush and trees over sewers can also eventually penetrate the sewers at separated or offset pipe joints, contributing to groundwater infiltration. However, this portion of the Mill Road Interceptor is likely still in good condition considering is age and is constructed of PVC pipe, so the risk of infiltration from increased flooding is considered low. A 100- or 500-year storm event along this portion of the sewer could cause manhole covers that are not bolted down to float off their frames, which could become a source of increased inflow and SSOs. These extreme flood events would also be expected to temporarily restrict access to this portion of the sewer, making it difficult for wastewater staff to check if manhole covers have floated. A 100- or 500-year storm event would also be expected to contribute to soil erosion along the floodplain. Soil erosion can eventually lead to manholes and the sewer pipes becoming exposed, increasing their risk of damage and premature failure. Ironically, the brush and tree root systems over the sewers that may eventually contribute to groundwater infiltration into pipe joints as the sewers deteriorate over time are likely also mitigating the effects of soil erosion during extreme flood events by helping anchor the soils along the riverbanks. Therefore, the risk of soil erosion impacting future operations is considered moderate. As storm intensity and frequency increases as a result of climate change, the risk of what is currently considered a 100-year or 500-year storm event occurring increases. This, in turn, elevates the risk of increased inflow, accessibility issues and soil erosion for this portion of the Mill Road Interceptor sewer. Therefore, the risk of these flood hazard consequences occurring is considered moderate.
Risk:	Flooding (damage): moderate Soil erosion/ slope destabilization: moderate Inflow/Infiltration, saltwater intrusion, SSOs: low Limited accessibility: high

Section 6 Adaptation Measures

6.1 Evaluation and Prioritization of Adaptation Measures

Possible adaptation measures to the climatic hazard consequences discussed in Section 5 were identified and evaluated for possible implementation as part of the Climate Adaptation Plan. Identified adaptation measures have been grouped into two major categories: operational measures and asset-specific measures. For some of the critically impacted assets, multiple asset-specific measures were identified, and the alternative measures were evaluated in terms of their technical feasibility and relative cost-effectiveness to implement. The following section discusses the recommended operational adaptation measures, the evaluation of the alternative asset-specific climate adaptation measures and the recommended adaptation measures for incorporation in the Town of Falmouth's Municipal Wastewater System Climate Adaptation Plan. The relative priority for implementation of the recommended adaptation measures is also discussed at the end of this section.

6.1.1 Operational Adaptation Measures

Operational climate adaptation measures are tasks or procedural changes that Town staff could undertake system-wide at minimal cost to prevent or mitigate potential climate-related hazard consequences. The Town has already implemented many of these recommendations.

Ongoing adaptation measures that should be continued:

- Monitoring pump station flow trends during wet-weather events and snow-melt conditions to track increased I/I in the system and help identify portions of the sewer collection system in need of further inspection and possible rehabilitation.
- Performing inspections of exposed equipment and structures after heavy or intense storms, high wind conditions, and HAT conditions (in tidally influenced areas) for signs of property damage, equipment malfunctions, downed trees or branches, flooding, ponding, SSOs, or significant soil erosion.
- Regularly exercising standby and portable generators in accordance with the manufacturer's instructions, checking and maintaining generator fuel reserve levels on a routine basis and after every utility power failure, and scheduling routine generator service calls.
- Discussing utility power restoration priorities with local utility power supply company.
- Routinely removing excess snow and ice to facilitate safe access to critical pump station and WWTF assets. Snowblowers and plow trucks should be routinely serviced before the start of each winter season.
- Keeping cross-country sewer easements clear of trees and brush that could impede access to the sewers.
- Exercising extreme caution and limiting travel time during poor travel conditions.
- Monitoring large trees adjacent to the pump stations, WWTF facilities, and overhead utility power lines that provide power to the pump stations and WWTF. Trimming or possible removal of trees that pose a potential risk of power failure at the pump stations or WWTF in the event of a blowdown should be discussed with the local utility power supply company.

Recommended additional operational adaptation measures:

- Evaluating older portions of the collections system for I/I source reduction and rehabilitation.
- Working with code enforcement staff to eliminate illicit stormwater connections to the sanitary sewer system (sump pumps, floor drains, foundation drains, etc.)

These recommended operational adaptation measures are considered best management practices, and because of their low cost and ease of implementation, should be a top priority for implementation.

6.1.2 Asset-Specific Adaptation Measures

Asset-specific climate adaptation measures include non-routine or temporary measures, in-depth studies or evaluations, permanent design modifications, or other significant capital improvements to achieve the goal of preventing or mitigating potential climatic hazard consequences for a specific asset or an asset class (e.g., pump stations).

The following sections describe the identified climate adaptation measures for each of the critically impacted assets discussed in Section 5 and compare adaptation measure options (where applicable). Planning-level cost estimates are listed for the recommended adaptation measure options. These estimates have been developed primarily for evaluating alternative solutions and are generally reliable for determining the relative costs of various options. Many factors arise during design (e.g. owner selected features and amenities, code issues, etc.) that cannot be definitively identified and estimated at this time. The cost information presented herein is in current dollars and is based on ENR Index 13176 (February 2023).

6.1.2.1 WWTF Outfall

Sea level rise and storm surge from large storms is expected to exacerbate soil erosion and undermining around the concrete WWTF outfall pipe headwall structure that is already taking place. Identified adaptation measures are as follows:

- Option 1: Support existing headwall structure and armor embankment in its current location.
- Option 2: Replace headwall structure and outfall pipe in-kind and armor embankment.
- Option 3: Install new outfall pipe into Skitterygusset Creek with a diffuser structure via horizontal directional drilling.

Options 1 and 2 will likely only delay damage from soil erosion and marsh migration in this area for the short-term before similar measures would need to be completed again to stabilize the embankment at this location. Option 2 would be replacing the existing infrastructure in-kind and it is expected to see the same problem in the future, not provide a long-term solution and is therefore not recommended. Option 3 is a better long-term adaptation measure to ongoing soil erosion in this location. Option 3 has the added benefit of converting the current WWTF outfall pipe discharge point from a bank discharge to a diffused discharge in the middle of the streambed in the current outfall location along Skitterygusset Creek. This change could increase the dilution factor used to calculate the Town's wastewater discharge pollutant limits. The end of the outfall pipe and its headwall structure is within the 75-foot setback from the ordinary high-water mark of Skittergusset Creek. All three options will be subject to Natural Resources Protection Act (NRPA) environmental permitting requirements. Option 3 is expected to require additional permitting from MaineDEP in order to modify the Town's wastewater discharge license and pollution limits due to the change in the location and design of the WWTF outfall pipe to include diffusers.

Project Costs:

- Option 1: $150,000

- Option 2: $200,000
- Option 3: $680,000

Recommended Project(s):

- Option 1: $150,000 (Phase 1)
- Option 3: $680,000 (Phase 2)

In the short-term, it is recommended that the Town implement Option 1 to stabilize the existing headwall structure and slow soil erosion at this location. However, as SLR continues to destabilize the soils in this area, the Town should consider implementing Option 3 as a more permanent solution for the long-term.

6.1.2.2 Brown Street Pump Station (No. 2)

Sea level rise and storm surge from large storms is expected to lead to flooding, accelerated soil erosion and marsh migration at the Brown Street Pump Station site. Identified adaptation measures are as follows:

- Option 1: Convert the existing station into a submersible pump station and raise the critical electrical equipment out of the floodplain.
- Option 2: Construct a seawall or berm barrier around the pump station site.
- Option 3: Construct a new submersible pump station further upland and extend the Mackworth Point Interceptor to the new pump station wetwell.

Option 1 would require renovations to the existing wetwell to accommodate new submersible pumps that would be less impacted if the wetwell were to flood. However, it's not clear if submersible pumps of adequate size to pump the expected flows to the pump station could fit within the existing wetwell dimensions, and it is possible a new wetwell would be required. Option 1 would also require elevating the pump station's generator and electrical controls nearly 6 feet above their current elevation to avoid the expected flooding at this location from a Category 2 hurricane. Option 1 would not be expected to have a significant impact on mitigating future soil erosion at this location, as the pump station equipment and structures would generally remain in the same location. Option 1 would also require extensive bypassing of incoming flows to the station during construction in order to install new submersible pumps and possibly a new wetwell.

Option 2 would not require any major renovations to the existing equipment and structures and would cause little to no disruption to pump station operations during construction. However, Option 2 would require extensive engineering and preliminary environmental permitting to determine the expected impact of constructing a seawall or berm around the pump station site. The drainage swale running through the pump station site would likely need to be modified or rerouted to avoid conflict with the new seawall or berm, adding to the environmental permitting complexity and construction difficulty. A seawall around the site would need to have a relatively deep pile foundation to prevent significant groundwater migration under the wall during flooding that could undermine the seawall. Based on the above described challenges, Option 2 does not appear to be feasible at this location.

Option 3 would provide the best long-term mitigation from flooding because it relocates the pump station facilities outside of the floodplain. Option 3 would also reduce the risk of flooding and soil erosion by moving the pump station facilities further away from the drainage swale and salt marsh along the southwestern portion of the pump station site. Option 3 would have limited impact on pump station operations because most of the new pump station facilities could be constructed while the existing pump station remains online. Option 3 would require the extension of the Mackworth Point Interceptor sewer to the new pump station wetwell. Option 3 would also require the purchase of additional land or sewer easements to construct the new pump station further upland.

Project Option Costs:

- Option 1: $1,130,000
- Option 2: $500,000
- Option 3: $1,080,000

Recommended Project Costs:

- Option 3: $1,080,000 (does not include land acquisition/easements).

The recommended adaptation measure for the Brown Street Pump Station is Option 3.

Figure 6-2 shows a possible location for a new submersible pump station site near the existing site upland of the expected flooding from a Category 2 hurricane (light blue line in Figure).

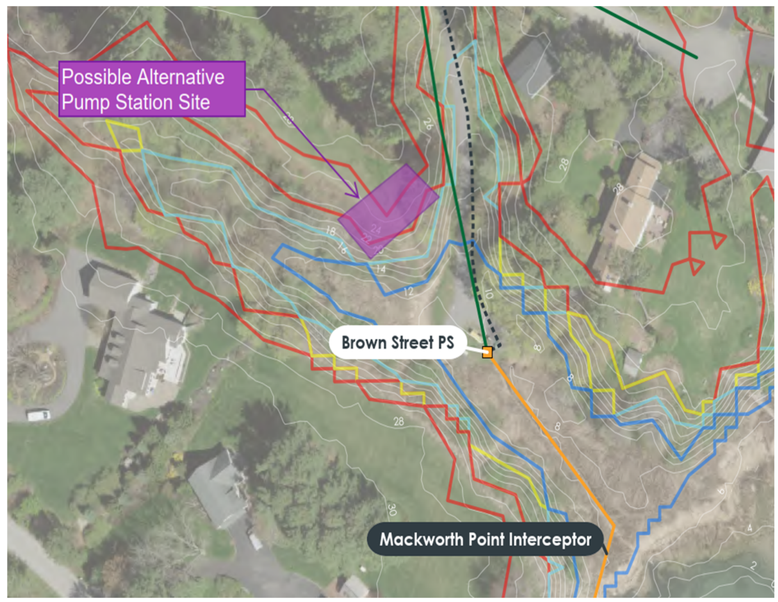


Figure 6-1 Brown Street PS Option 3 Site

6.1.2.3 Clearwater Drive Pump Station (No. 3) and Clearwater Interceptor

Sea level rise and storm surge from large storms is expected to lead to flooding and accelerated soil erosion and marsh migration at the Clearwater Drive Pump Station and Clearwater Interceptor sewer site. Identified pump station adaptation measures are as follows:

- Option PS-1: Convert the existing pump station into a submersible-type design and install new critical electrical equipment above the expected flood elevations.
- Option PS-2: Construct a seawall or earthen berm around the pump station site to protect against flooding and marsh migration onto the site.
- Option PS-3: Construct a new submersible pump station further upland beyond the extent of expected flooding and marsh migration.

Option PS-1 would require extensive renovations and disruption of normal pump station operations to convert the station to a submersible station and elevate or relocate the existing electrical controls and generator beyond the extent of expected future flooding. There is a significant grade increase in the wooded area east of the pump station, that could be cleared for the locating the generator and electrical gear, Though it is unclear the limits of the

Towns easement/property at this site. The Town may have to also purchase additional land or sewer easements. Option PS-1 will help mitigate possible property damage from flooding, but will have limited impact on mitigating accelerated soil erosion and marsh migration from SLR around the existing pump station structures.

Under Option PS-2, the Town would likely have to construct an earthen berm surrounding the pump station site that is 8 to 10 feet above the average grade elevation at the site in order to protect the critical pump station equipment and structures from expected Category 2 hurricane storm surge in this area. Marsh migration will likely saturate and destabilize the soils in this area over time, so a berm designed with a deep foundation to slow groundwater migration would be the preferable. Option PS-2 is expected to require extensive environmental permitting, but may warrant further investigation for feasibility at this site.

Option PS-3 is expected to be the most effective adaptation measure to mitigate the impacts of flooding, soil erosion and marsh migration at the current pump station site. Option PS-3 would require the purchase of additional land or sewer easements upland from the current pump station site. The area further upland to the northeast of the current pump station site may be a feasible site for a new pump station (Figure 6-1).

Based on a review of the Town's sewer GIS data, Option PS-3 is expected to also require rerouting the incoming gravity sewers from Route 1 and Providence Avenue to a new deeper wetwell structure and of a portion of the pump station's discharge force main to the new pump station site. A submersible-type pump station design is recommended to limit the depth needed for the new wetwell, to facilitate pump removal from above-ground and avoid regular confined space entries.

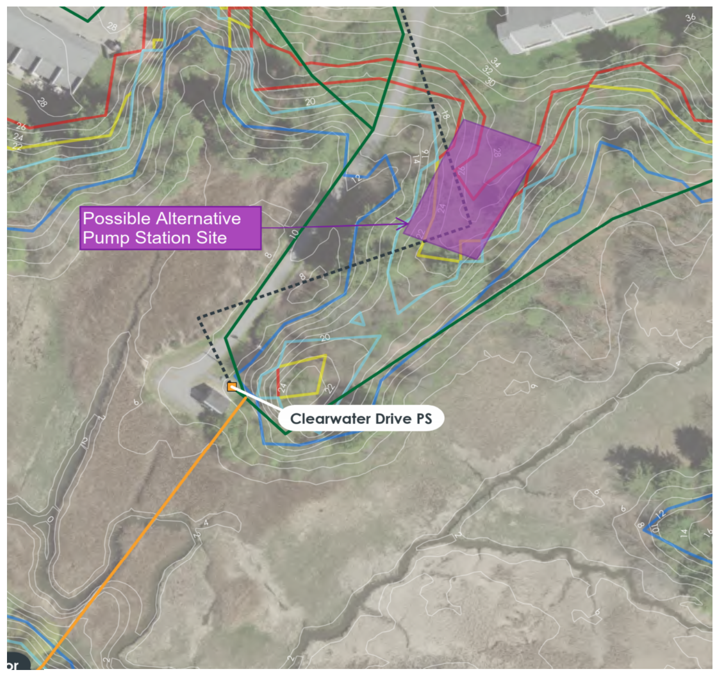


Figure 6-2 Clearwater Drive PS Option 3 Site

Project Option Costs:

- Option PS-1: $1,220,000
- Option PS-2: $690,000
- Option PS-3: $1,200,000

Recommended Project Costs (does not include land acquisition/easements):

- Option PS-3: $1,200,000

Identified Clearwater Interceptor adaptation measures are as follows:

- Option I-1: Replace the existing insulated suspended interceptor in-kind with pipe materials that are less susceptible to saltwater corrosion in the same location and renovate the existing suspended pipe supports to increase their longevity.
- Option I-2: Install a new 500 linear foot interceptor sewer with corrosion resistant piping under the salt marsh between Providence Avenue and the pump station site via horizontal directional drilling.

Project Option Costs:

- Option I-1: $340,000
- Option I-2: $300,000

Replacing the existing suspended sewer and pipe supports, and support foundations in-kind as part of Option I-1 would be more expensive, time-consuming and more disruptive to nearby abutters than Option I-2. Option I-1 would also cause more disturbance to sensitive environmental resources and may also require comparatively more environmental permitting to HDD construction under the salt marsh because of the greater disturbance caused by construction compared to HDD construction. For these reasons, it is recommended that the Town consider implementing Option I-2.

Recommended Project Costs:

- Option I-2: $300,000

6.1.2.4 Lunt Road Pump Station (No. 4)

Sea level rise is expected to increase tidal action along the southern portion of the pump station property that includes a relatively steep embankment along the tidal mud flats that form the western bank of Skitterygusset Creek. Increased tidal action in this area may also increase the risk of soil erosion and slope destabilization along this embankment, which could eventually undermine the pump station facilities. Stormwater runoff from Lunt Road flowing from north to south through the pump station site during flash flood conditions may also contribute to embankment erosion. The identified adaptation measures are as follows:

- Option 1: Armor the lower half of the embankment at the pump station site with riprap to slow the progression of soil erosion.
- Option 2: Plant additional saltwater tolerant vegetation along the embankment to help anchor the riverbank soils.
- Option 3: Install a retaining wall or permanent sheeting along the upper portion of the bank to help retain the soils under the pump station facilities.

Option 1 would be more effective at slowing soil erosion along the streambank than Option 2. Option 1 would require work within the Maine DEP 75-foot setback from the high-water mark of Skitterygusset Creek, so Maine DEP approval would be required.

Option 2 would require less environmental permitting than Options 1 and 3. However, Option 2 alone would not be expected to be as effective at slowing soil erosion along the streambank as Options 1 and 3. Option 2 would also require more frequent maintenance after its initial implementation to help the cover vegetation establish itself over at least one planting season.

Option 3 would be the most effective alternative to slowing the progression of soil erosion along the streambank near the pump station facilities. However, Option 3 would also be the most complex option to construct. Option 3 would be expected to require the most environmental permitting to study the potential impacts of constructing a retaining wall along the streambank. Considering the overall level of effort to construct compared with the moderate hazard risk, Option 3 is not recommended at this time.

Expected Project Costs:

- Option 1: $20,000
- Option 2: $10,000
- Option 3: $180,000

It is recommended that the Town implement Option 1 in the short-term to help reduce the risk of soil erosion along the streambank near the pump station facilities. The Town may want to consider also implementing Option 2 as a supplementary adaptation measure to help enhance stabilization of the soils on the upper half of the slope.

Recommended Project Costs:

- Option 1: $20,000
- Option 2: $10,000

6.1.2.5 Mill Creek Pump Station (No. 5) and Interceptor Sewer

Flooding, storm surge, SLR and marsh migration could contribute to ongoing soil erosion and streambank destabilization along the tidally influenced Mill Creek adjacent to the pump station site. Therefore, the of the risk of these hazards impacting future pump station operations is considered moderate. Identified pump station adaptation measures are as follows:

- Option PS-1: Monitor soil erosion along Mill Creek and armor the streambank with riprap, as needed, to help slow soil erosion and marsh migration onto the pump station site.
- Option PS-2: Construct a retaining wall along the northeastern portion of the pump station property near the Mill Creek streambank to help slow soil erosion and marsh migration onto the site.

Option 1 would give the Town flexibility to adjust the scope of the adaptation measures as needed over time. Option 1 would also be relatively simple to construct. Option 1 would require work within the Maine DEP 75-foot setback from the high-water mark of Mill Creek, so Maine DEP approval would be required. Option 1 would likely only delay natural soil erosion and marsh migration in this area resulting from continued tidal action and seasonal flooding.

Option 2 would be a more permanent adaptation measure to halt the advancement of soil erosion and marsh migration onto the pump station site. Option 2 could also have the added benefit of allowing the Town to protect against possible future storm surge flooding at the pump station as SLR continues to influence the extent of storm surge flooding from major storms such as a Category 1 or 2 hurricane over time. Additional hydrologic modeling of possible future flooding scenarios should be completed to help determine the appropriate wall height. Option 2 would be significantly more complex to construct than Option 1. Option 2 would require more extensive environmental permitting than Option 1, adding to the project implementation schedule.

Project Option Costs:

- Option PS-1: $30,000
- Option PS-2: $290,000

In the short-term, it is recommended that the Town monitor soil erosion and marsh migration in Mill Creek and implement Option 1 as needed based on regular monitoring of the Mill Creek streambank. If, after implementing Option 1, it appears that armoring the streambank with riprap alone will not be sufficient to curb excess soil erosion and marsh migration onto the pump station site, or excess flooding onto the pump station site becomes a concern in the future, the Town should reconsider implementing Option 2 at that time.

Recommended Project Costs:

- Option PS-1 (Phase 1): $30,000
- Option PS-2 (Phase 2): $290,000

As part of a separate study, titled *Mill Creek Interceptor Long Term Replacement Options*, dated February 2022, the Town retained Wright-Pierce to evaluate possible alternatives to investigate short- and long-term solutions to mitigate the flooding and soil erosion hazards that are currently contributing to the undermining of several portions of the cross-country Mill Creek Interceptor. The study identified and screened several options that would allow the Town to eventually abandon a significant portion of the cross-country interceptor sewer along the banks of Mill Creek, with four options recommended for further consideration. The study recommended that the Town obtain additional supplemental subsurface soil information to help better understand the geotechnical conditions and the potential cost to implement each of the remaining four alternatives before selecting an alternative for implementation. Some of the adaptation measures considered in the study are listed below. The alpha-numeric designation for each Alternative from the study has been included in parathesis for clarity:

- Option I-1 (Alternative 3A): Install new Upper Mill Creek Pump Station to redirect most of the Mill Creek flows along Johnson Road to the interceptor on Foreside Road.
- Option I-2 (Alternative 3B): Install new Upper Mill Creek Pump Station to redirect most of the Mill Creek flows along Johnson Road to the interceptor on Foreside Road and install a deep interceptor sewer on Route 1 to allow the Town to eliminate the Johnson Road Pump Station.
- Option I-3 (Alternative 3C): Install new smaller capacity Upper Mill Creek Pump Station to redirect most of the Mill Creek flows to Johnson Road Pump Station and upsize Johnson Road Pump Station and force main capacity.
- Option I-4 (Alternative 5): Install new Upper Mill Creek Pump Station and force main along Route 1, Depot Road and Hattrick Drive and connect to into the existing Mill Creek Pump Station force main on Clearwater Drive.

A full consideration of the merits and drawbacks of each alternative are discussed in greater detail in the Wright-Pierce study. The summary conclusions drawn from the study are that some of the alternatives should be investigated for subsurface conditions present, to refine overall estimated costs. It is recommended that the Town first complete the supplemental subsurface investigative work discussed in the Wright-Pierce study to better understand the geotechnical considerations and financial implications of each alternative before selecting a single alternative for further development and implementation.

Expected Project Costs:

- Option I-1 (Alternative 3A): $7,420,000
- Option I-2 (Alternative 3B): $12,280,000
- Option I-3 (Alternative 3C): $10,110,000
- Option I-4 (Alternative 5): $7,160,000

Notes: Project costs are from Wright-Pierce study, in the absence of supplemental geotechnical information. Project costs provided also include some interrelated upgrades to the Johnson Road Pump Station.

It is also recommended that the southern portion of the cross country Mill Creek interceptor sewer that is less at risk of imminent failure from climate-related hazards and that will remain in operation after the completion of the selected project from the options described above be monitored for signs of undermining and reevaluated for possible climate adaptation measures at a later date.

6.1.2.6 Handy Boat Pump Station (No. 6)

The Handy Boat Pump Station may be at risk of inundation during a Category 1 or 2 hurricane if future sea level rise effectively raises the mean high tide elevation of Casco Bay in the pump station area. The identified adaptation measures are as follows:

- Option 1: Purchase portable flood-proof barrier system to deploy around the pump station during a major flood event.
- Option 2: Construct a permanent flood-proof barrier around the existing drywell and electrical controls.
- Option 3: Convert the pump station into a submersible type station and elevate the electrical controls out of the expected floodplain.
- Option 4: Construct a new pump station further upland and redirect the incoming sewer to the new pump station.

Option 1 would involve purchasing a removable flood-proof barrier system like those described in the Section 6.1.2.8. A removable flood barrier systems would provide the Town with the flexibility to deploy the system as needed, and could be used to protect other assets in other locations as well. This Option is also expected to have the lowest initial capital cost to implement. This Option would require more time and effort from wastewater department staff to implement than the other three options once they are constructed. The removable systems are also somewhat limited in the height to which they can provide flood protection due to physical limitations on these systems to allow them to be easily transported and assembled.

Option 2 would involve the construction of a permanent or semi-permanent flood wall system around the pump station facilities. Flood barrier design options could include deployable barrier walls supported by a permanent framework at the pump station site, a permanent sheet-pile type seawall barrier with the option for architectural finishes on the exterior, or a permanent concrete wall and footing structure with the option for architectural finishes on the exterior. Fully permanent wall systems such as the sheet pile or concrete wall systems would also need to include an integral flood gate to allow routine access to the pump station. A semi-permanent flood barrier system would allow for regular access to the pump station facilities when the removable wall sections were not deployed and would restrict access to the pump station facilities during flood conditions when the removable wall sections are in place. Option 2 would have more flexibility in terms of flood barrier height than Option 1, and could be designed for a range of possible flood scenarios if a customizable wall height design (such as stop logs) is used. If the Town selects Option 2 for implementation, it is recommended that the Town perform additional research and engage flood barrier manufacturers on the benefits and drawbacks of each system before implementing a specific technology. Option 2 may be less aesthetically desirable to abutting residents and businesses than the 3 other Options because it would require installing either a permanent wall or wall framework that could not be removed between flood events.

Option 3 would require renovations to the existing pump station wetwell to accommodate new submersible pumps that would be less impacted if the wetwell were to flood. It's not clear if submersible pumps of adequate size to pump the expected flows to the pump station could fit within the existing wetwell dimensions, so Option 3 may not be technically feasible without further evaluation of appropriately sized submersible pumps. Option 3 would also require elevating and/or relocating the pump station's electrical controls, which would add to the complexity of construction and project cost. Relocating the electrical controls further away from the rest of the pump station facilities would also make operations and maintenance of the pump station less convenient for wastewater department staff. Option 3 would also require extensive bypassing of incoming flows to the station during construction in order to install new submersible pumps, adding to the construction cost.

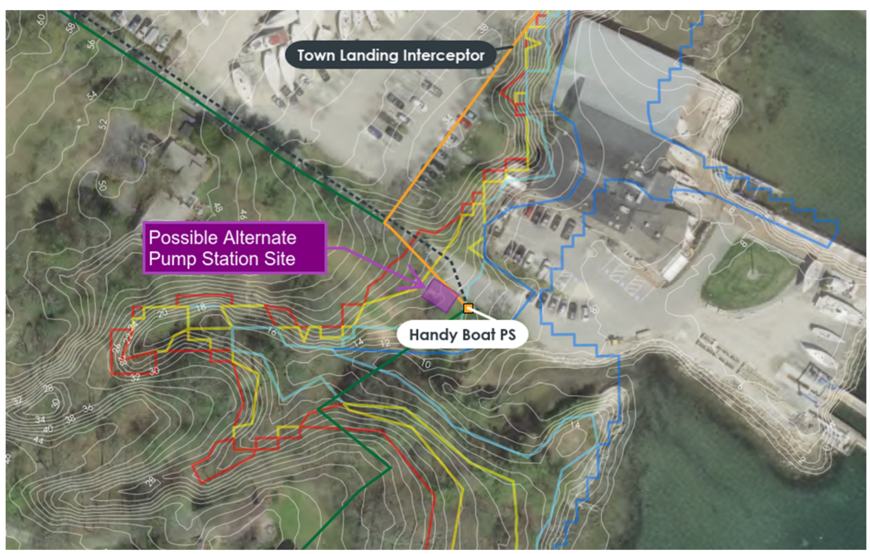


Figure 6-3 Handy Boat PS Option 4 Alternative Site

Option 4 to install a new submersible pump station further upland from the current pump station location would provide the best long-term mitigation from flooding because it relocates the pump station facilities outside of the expected Category 1 and 2 hurricane storm surge floodplains. Option 4 would have limited impact on pump station operations because most of the new pump station facilities could be constructed while the existing pump station remains online. However, Option 4 would require installing a deeper wetwell and extended and deeper gravity sewers, and extension of the pump station force main to the new pump station site, adding to the project cost. Therefore, it is expected that Option 4 would be the most expensive alternative to construct.

Expected Project Costs:

- Option 1: $100,000
- Option 2: $90,000
- Option 3: $730,000
- Option 4: $1,250,000

Like the Underwood Pump Station, Handy Boat Pump Station has not undergone any major upgrades since its initial construction in the early 1970's. It is expected that the pump station equipment is reaching the end of its useful life and may be in need of renewal in the near future. Therefore, it is recommended that the Town consider installing a new submersible pump station further upland when the Town decides to renew the pump station facilities. This will increase the pump station's longevity and avoid having to potentially invest in additional adaptation measures at the station to protect against flooding in the near future as SLR continues to exacerbate storm surge at this location. Figure 6-5 shows a possible alternate location for the pump station.

Recommended Project Costs:

Option 4: $1,250,000

6.1.2.7 Underwood Road Pump Station (No. 7)

The Underwood Road Pump Station may be at risk of inundation during a 100-year flood event or from Category 1 or 2 hurricane storm surge. Increased flooding is expected to also increase the risk of soil erosion and slope destabilization in the pump station area along Underwood Beach. The identified adaptation measures are as follows:

- Option 1: Purchase portable flood-proof barrier system to deploy around the pump station facilities during a major flood event.
- Option 2: Construct a permanent or semi-permanent flood-proof barrier system or seawall around the existing drywell and electrical controls.
- Option 3: Convert the pump station into a submersible pump station and elevate or relocate the electrical controls out of the expected floodplain.
- Option 4: Construct a new pump station further upland and redirect the incoming sewer to the new pump station.

Option 1 would involve purchasing a removable flood-proof barrier system such as the AquaFenceTM manufactured by AquaFence USA, Inc., IneroTM removable flood barrier system manufactured by Flood Control International or Floodline fillable flood barrier manufactured by Hesco Group, to name a few. A removable flood barrier systems would provide the Town with the flexibility to deploy the system as needed, and could be used to protect other assets in other locations as well. This option would require more time and effort from wastewater department staff to implement than the other three options once they are constructed. The removable systems are also somewhat limited in the height to which they can provide flood protection due to physical limitations on these systems to allow them to be easily transported and assembled. Option 1 would also not be expected to have a significant impact on mitigating future soil erosion at this location.

Option 2 would involve the construction of a permanent or semi-permanent flood wall system around the pump station facilities. Flood barrier design options could include deployable barrier walls supported by a permanent framework at the pump station site, a permanent sheet-pile type seawall barrier with the option for architectural finishes on the exterior, to a permanent concrete wall and footing structure with the option for architectural finishes on the exterior. Fully permanent wall systems such as the sheet pile or concrete wall systems would also need to include an integral flood gate to allow routine access to the pump station. A semi-permanent flood barrier system would allow for regular access to the pump station facilities when the removable wall sections were not deployed and would restrict access to the pump station facilities during flood conditions when the removable wall sections are in place. Option 2 would have more flexibility in terms of flood barrier height than Option 1, and could be designed for a range of possible flood scenarios if a customizable wall height design (such as stop logs) is used. If the Town selects Option 2 for implementation, it is recommended that the Town perform additional research and engage flood barrier manufacturers on the benefits and drawbacks of each system before implementing a specific technology. Option 2 may be less aesthetically desirable to abutting residents and users of Underwood Beach than the 3 other options, because it would require installing either a permanent wall or wall framework that could not be removed between flood events. If a permanent sheet pile type wall design is selected, Option 2 could also serve as a retaining wall to help slow the progression of future soil erosion at this location.

Option 3 would require renovations to the existing wetwell to accommodate new submersible pumps that would be less impacted if the wetwell were to flood. However, it’s unlikely that submersible pumps of adequate size to pump the expected flows to the pump station can fit within the existing wetwell, as such it would most likely require construction of a new wetwell. Option 3 would also require elevating and/or relocating the pump station’s electrical controls to nearly 7 vertical feet above their current elevation to avoid the expected flooding at this location from a 100-year storm event. Elevating the controls would likely require construction of an elevated structure or platform to support and allow access to the controls, which would not be aesthetically desirable to the abutting residents and users of Underwood Beach. Relocating the electrical controls further away from the rest of the pump station facilities would make operations and maintenance of the pump station less convenient for wastewater department staff. Option 3 would not be expected to have a significant impact on mitigating future soil erosion at this location, as the pump station equipment and structures would generally remain in the same location. Based on these concerns, Option 3 is not recommended for this location.

Option 4 would provide the best long-term mitigation from flooding because it relocates the pump station facilities outside of the floodplain. Option 4 would also reduce the risk of soil erosion by moving the pump station facilities further away from Underwood Spring, the drainage swale along the south side of the pump station property and Underwood Beach. Option 4 would have limited impact on pump station operations because most of the new pump station facilities could be constructed while the existing pump station remains online. Option 4 would require some rerouting of the local sewers or conversion to low pressure sewer for some nearby residences to convey flows to the new wetwell at a higher elevation than the current wetwell. It would also require the installation of a new cross-country pump station force main underneath Underwood Spring and the drainage swale between Casco Road and Amerescoggin Road. Directional drilling of the force main would the least disruptive approach to nearby residents and would require the least amount of environmental permitting. Rerouting the sewers under Option 4 would have an additional benefit of allowing the Town to abandon the gravity sewer that runs under a seawall constructed by the private landowner of the property abutting the northern portion of the pump station site. The sewer under this seawall is a concern for potential undermining from storm surge, based on recently observed soil erosion and sea wall damage during a large storm in December 2022 that coincided with astronomical high tides.

Rerouting the gravity sewers and/or converting them to low-pressure systems would add to the cost to implement Option 4.

Expected Project Costs:

- Option 1: $100,000
- Option 2: $80,000
- Option 3: $730,000
- Option 4: $1,160,000

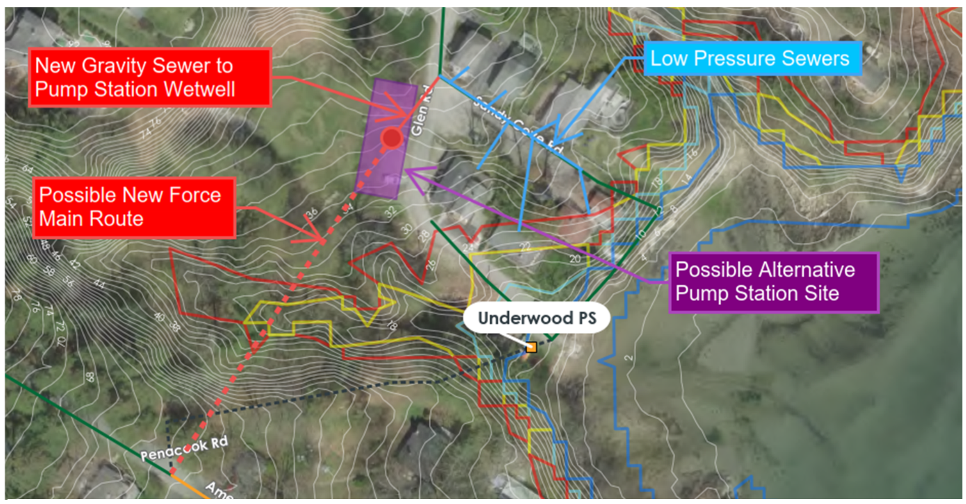


Figure 6-4 Underwood Road PS Option 4 Site

The Underwood Pump Station has not undergone any major upgrades since its initial construction in the early 1970's. Therefore, it is expected that the pump station equipment is reaching the end of its useful life and may be in need of renewal in the near future. Therefore, it is recommended that the Town invest in installing a new submersible pump station further upland to maximize its longevity and avoid having to potentially invest in additional adaptation measures in the near future as SLR continues to exacerbate storm surge and flooding at this location. Figure 6-4 shows a possible alternate location for the pump station and new cross-country force main. It also shows the possible layout of the rerouted gravity sewer and new low-pressure sewer system to convey flows to the new pump station site.

Recommended Project Costs:

Option 4: $1,160,000

6.1.2.8 Waite's Landing Pump Station (No. 10)

Recommended operational adaptation measures described in Section 6.1.1 that are targeted to Waite's Landing Pump Station may help mitigate the risk of possible accessibility issues from increased snowfall or downed trees onto Waite's Landing Road.

6.1.2.9 Landing Woods Lane (No. 11) Pump Station

Increased inflow and infiltration and accessibility issues from downed trees as a result of more frequent and intense storms could increase the risk of future SSOs at Landing Woods Lane Pump Station. Recommended operational adaptation measures described in Section 6.1.1 may help mitigate the risk of accessibility issues at the Landing Woods Lane Pump Station, but are not expected to significantly reduce the risk of increased inflow to the gravity sewers served by the Landing Woods Lane Pump Station without additional targeted measures. The identified adaptation measures to decrease inflow/infiltration at the Landing Woods Lane Pump Station are as follows:

- Option 1: Work with code enforcement department to complete inspections of sewer connections in the pump station service area to identify and remove illicit private sources inflow including sump pumps, foundation drains, etc. that are currently connected to the sanitary sewer.
- Option 2: Install new larger submersible pumps to increase the station's pumping capacity.
- Option 3: Conduct a sanitary sewer evaluation study (SSES) of the pump station service area to identify possible sources of inflow and infiltration to the gravity sewers.
- Option 4: Construct new gravity interceptor sewer to convey flows from Landing Woods Lane Pump Station service area to the Waite's Landing Pump Station.

Option 1 is recommended as a best management practice for reducing the risk of increased rainfall-induced inflow into the sanitary sewer system and would have minimal to no capital costs. Option 1 would be more disruptive to local residents compared with Option 2, but could possibly remove significant sources of inflow to the gravity sewers, which would have a more permanent mitigating effect on future inflow.

Option 2 would help mitigate the short-term risk of SSOs from increased rainfall-induced inflow and infiltration and would be less disruptive to the residents served by the pump station than Options 1, 3 and 4. Option 2 would also be less disruptive to pump station operations than Option 4, but would require some pump station downtime to replace the existing pumps (and possibly the pump station electrical service size, depending on the pump selected). Option 2 would also have the benefit of no significant additional capital investment beyond the wastewater department's budgeted reserves to eventually renew the station's pumps as they reach the end of their expected useful life. However, Option 2 may not be technically feasible without also upsizing the capacity of the Waite's Landing Pump Station, to which it pumps incoming sewer flows, without increasing the risk of an SSO at the Waite's Landing Pump Station. Limitations to additional flow through the Landing Woods Lane Pump Station's discharge force main should also be evaluated as part of Option 2, as this may limit the amount of additional flow that could be gained from upsizing the pumps. Option 2 would also not eliminate sources of inflow and infiltration to the gravity sewers served by the pump station, which could worsen as the gravity sewers in this area deteriorate over time.

Option 3 would involve field investigation of sewer manholes, cleaning, CCTV inspection and smoke testing of the gravity sewers in the pump station service area to provide a more comprehensive evaluation of the sewers, including possible sources of rainfall-induced inflow and infiltration during wet weather conditions. However, Option 3 would only be a first step in inflow/infiltration reduction and would need to be followed on by additional tasks to remove identified sources of inflow and infiltration. Therefore, Option 3 is expected to also require additional future capital expenditures to implement the recommendations of the SSES.

Option 4 would reduce the risk of future SSOs at the Landing Woods Lane Pump Station attributable to increased inflow by allowing the Town to demolish the pump station and instead convey the sewer flows to the Waite's Landing Pump Station by new gravity sewer. However, Option 4 alone would not eliminate sources of inflow/infiltration and may, in effect, worsen inflow/infiltration issues at the Waite's Landing Pump Station by eliminating flow equalization currently afforded by the Landing Woods Lane Pump Station wetwell during wet weather events. Option 4 may also not be technically feasible depending on the topographic and subsurface conditions. Option 4 would also be the most disruptive to local residents than Options 1, 2 and 3 because it would require obtaining cross-country sewer easements and the installation of about 1,200 linear feet of new gravity interceptor sewer from the Landing Woods Pump Station to the Waite's Landing Pump Station. Figure 6-3 shows a possible route for a new gravity interceptor sewer from the Landing Woods Lane Pump Station to the gravity sewer on Waite's Landing Road, that flows to the Waite's Landing Pump Station.

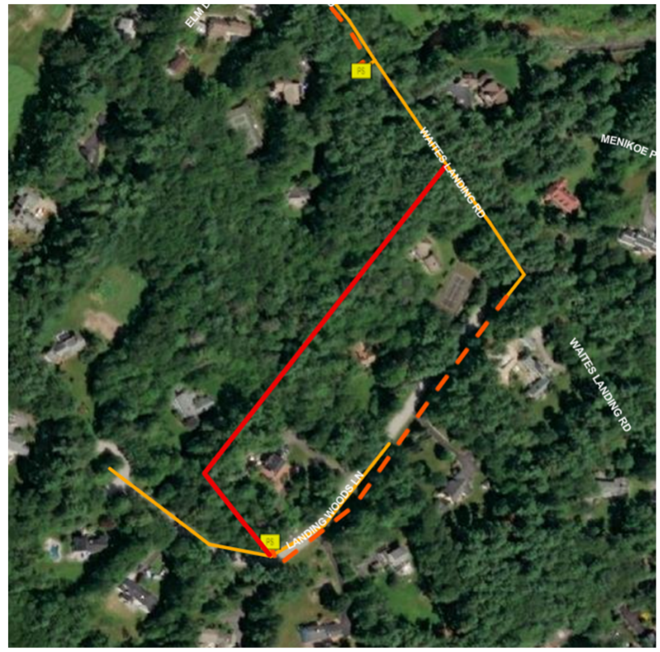


Figure 6-5 Landing Woods Lane PS Option 4 Interceptor Route

Expected Project Costs:

- Option 1: $10,000
- Option 2: $150,000
- Option 3: $110,000
- Option 4: $790,000

It is recommended that the Town implement Option 1 in the short-term as an initial phase to help remove private inflow sources to the sanitary sewers in the pump station service area. If I/I is seen to increase over time, and the Town is unsuccessful in identifying and removing significant private inflow sources from the sanitary sewers during the initial phase of inflow investigations, the Town should evaluate the feasibility of implementing Option 3 as a secondary phase to identify other projects to remove extraneous I/I flows to the pump station.

Recommended Project Costs:

- Option 1 (Phase 1): $10,000
- Option 3 (Phase 2): $110,000

6.1.2.10 Middle Road Pump Station (No. 12)

Storm surge from a Category 1 or 2 hurricane, exacerbated by SLR may have the potential to partially inundate the pump station site in the future, although it is difficult to predict to what extent without additional hurricane storm surge modeling that considers future elevated mean high tide conditions as a result of SLR. For now, it is recommended that the Town monitor any upward trends in the mean high tide elevation in this area and the extent of river flooding near the pump station during or after major storm events that coincide with high tide conditions.

6.1.2.11 Leighton Road Pump Station (No. 20)

Hazards idenfied are low risk. No additional asset-specific adaptation measures are recommended at this time.

6.1.2.12 Mill Road Pump Station (No. 22) and Interceptor Sewer

Soil erosion and slope destabilization from increased flooding at the Mill Road Pump Station site could increase the risk of undermining of the pump station structures. The Mill Road Pump Station's force main that is suspended on the Mill Road Bridge is also potentially susceptible to damage as the bridge condition continues to deteriorate over time. The portion of the Mill Road Interceptor sewer that runs cross-country along the Presumpscot River is relatively inaccessible due to excess growth along the sewer easement. This portion of the interceptor could also be susceptible to increased inflow through manhole covers during a 100-year flood event and increased groundwater infiltration through cracks and offset sewer pipe joints. Roots from overgrowth above the interceptor sewer could worsen the risk of increased infiltration and SSOs from root balls causing sewer backups. The identified pump station adaptation measures are as follows:

- Option PS-1: Continue to armor the riverbank with riprap to slow the progression of soil erosion at the pump station site.
- Option PS-2: Loam and overseed the riverbank at the pump station site to establish more permanent soil cover to help anchor the riverbank soils.
- Option PS-3: Install a retaining wall or permanent sheeting along the upper portion of the bank to help retain the soils under the pump station facilities.
- Option PS-4: Relocate the pump station facilities further upland from the riverbank.

Option 1 would be expected to slow the progression of slope erosion in the short-term and would be relatively inexpensive to implement, when compared to Options 3 and 4. However, considering the steepness of the riverbank in this location, the historic occurrence of soil erosion at the site, and the continued risk of runoff from Mill Road contributing the slope erosion, it's likely that soil erosion will continue to occur in this location over time, if only at a reduced rate. Option 1 would require work within the 75-ft setback from the high-water mark of the Piscataqua River, so Maine DEP approvals would be required to implement this option, adding to the overall cost of the project.

Option 2 would require less environmental permitting than Option 1 and 3. However, Option 2 alone would not be expected to be as effective at slowing soil erosion along the streambank as Options 1, 3 and 4. Option 2 would also require more frequent maintenance after its initial implementation to help the cover vegetation establish itself over time, therefore Option 2 is not recommended.

Option 3 would include driving sheeting along the riverbank to the north of the pump station wetwell and backfilling behind the sheet pile wall to level out the ground around the station. Additional regrading around the pump station wetwell and control panel to direct runoff away from the portion of the riverbank adjacent to the pump station site should also be considered to further reduce the long-term risk of riverbank erosion at this location. Option 3 would be more effective at slowing the progression of soil erosion along the riverbank near the pump station facilities than Options 1 and 2. However, Option 3 would also be complex to construct and more expensive than Options 1 and 2. Option 3 would require work within the 75-ft setback from the high-water mark of the Piscataqua River, so Maine DEP approvals would be required to implement this Option, adding to the overall cost of the project.

Option 4 would provide the best long-term mitigation of soil erosion by moving the pump station facilities further away from the steeply sloped riverbank. Option 4 would have limited impact on pump station operations because most of the new pump station facilities could be constructed while the existing pump station remains online. Option 4 could be constructed to locate the facilities out of the 75-ft setback of the Piscataqua River high-water mark, and thus avoiding additional approvals from Maine DEP. Option 4 would require the extension of the Mill Road Interceptor sewer to the new pump station wetwell, adding to the cost to construct the new pump station. Option 4 may also require the purchase of additional land or sewer easements to construct the new pump station further upland. Based on the need for complete replacement and sewer extension, this option is not recommended.

Project Option Costs:

- Option PS-1: $20,000
- Option PS-2: $10,000
- Option PS-3: $100,000
- Option PS-4: $450,000

It is recommended that in the short-term, the Town routinely monitor the condition of the slope after major storm events to check for signs of further slope erosion, and if noted, consider replacing any riprap that has failed (Option PS-1) as needed. However, given that the natural geological erosion processes that are impacting the steeply sloped riverbank in this area are expected to continue for the foreseeable future, the Town should consider Option PS-3 to install a permanent sheet pile retaining wall along the top of the riverbank slope as a more long-term solution to stabilize the pump station site. The Town should couple the sheet pile wall with grading modifications on the pump station site to help direct runoff away from the pump station facilities and the installation of a safety fence along the inside of the retaining wall to improve operator safety around the pump station controls.

Recommended Project Costs:

- Option PS-1: $20,000 (Phase 1)
- Option PS-3: $100,000 (Phase 2)

The identified interceptor adaptation measures are as follows:

- Option I-1: Remove overgrowth along the sewer easement.
- Option I-2: Reline the cross-country portion of the existing interceptor sewer.
- Option I-3: Replace and relocate the cross-country portion of the interceptor sewer further out of the floodplain with a new and larger capacity fused HDPE interceptor to minimize pipe joints.

Option 1 to remove the overgrowth along the interceptor sewer route would improve interceptor access and remove tree roots as a possible conduit for future groundwater infiltration into the sewers. However, cutting trees along the interceptor route that help anchor the soils along the riverbank could exacerbate soil erosion during large storms such as a 100-year storm event that would cause extensive flooding along the riverbanks where the cross-country sewer is located. Therefore, it is recommended that if large trees along the interceptor route need to be cut, the Town should consider overplanting the easement area with maintainable plantings with less extensive roots systems to help stabilize the topsoil.

Option 2 to reline the interceptor sewer would be a more effective adaptation measure than Option 1 by helping mitigate the risk of infiltration from both flooding during a 100-year storm event and tree roots penetrating the sewer joints by creating a relatively impenetrable barrier within the interior of the sewer pipeline. Relining the sewer would have the added benefit of increasing the lifespan of the sewer by 50+ years. However, relining the sewer alone will not improve current accessibility issues, and the sewer would still be expected to at least be partially inaccessible during flooding from a 100-year storm event, therefore this option is not recommended.

Option 3 to replace the existing cross-country interceptor section with a fused HDPE interceptor further upland from the existing interceptor would be the most effective at mitigating the risk of future infiltration. Option 3 would also have the added benefit of allowing the Town to upsize the interceptor to accommodate future growth and buildout in the West Falmouth area. However, Option 3 would be the most complex option to implement and would require work within the 75-foot setback from the high-water mark of the Piscataqua River, which would require Maine DEP approvals. Option 3 would also require tree-cutting along the new interceptor sewer route like the work described in Option 1.

Project Option Costs:

- Option I-1: $30,000
- Option I-2: $280,000
- Option I-3: $380,000

In the short-term, it is recommended that the Town implement Option I-1 as a best management practice to improve access to the Mill Road Interceptor sewer and reduce the risk of tree roots contributing to future infiltration as the sewers deteriorate over time. The Town should then continue to monitor excess infiltration as it completes routine CCTV inspections of the interceptor. If it appears that infiltration into the sewer joints is getting worse and buildout continues over the medium- and long-term in the area to be served by the Mill Road Pump Station, the Town should then consider implementing Option I-3.

Recommended Project Costs:

- Option I-1: $30,000 (Phase 1)
- Option I-3: $380,000 (Phase 2)

6.1.2.13 Town Landing Interceptor Sewer

Continued erosion of the steep embankments within which the Town Landing Interceptor sewer is located will increase the risk of the interceptor sewer being exposed and undermined. Storm surge, coupled with SLR, is expected to accelerate this trend over time. The identified adaptation measures are as follows:

- Option 1: create stabilizing berms at the base of the embankment slope that replicate those of the natural block failure mechanism, but are comprised of rip-rap that is resistant to erosion and keyed into the existing substrate to resist creep toward the ocean.
- Option 2: Install a permanent sheet pile retaining wall with a groundwater drainage system to retain the soils around the interceptor sewer and protect them wave action.
- Option 3: Reroute the sewers in the interceptor service area to flow to the interceptor sewer on Foreside Road.

The Town is considering moving forward with a more detailed evaluation of this interceptor (along with the Mackworth Point interceptor) to further develop recommendations improvements to resiliency.

For Option 1, the height of the stabilizing berms should be at least at the elevation of the preliminary 2018 FEMA 100-year flood elevation, with consideration for future sea level rise. Above the riprap stabilizing berms, the embankment slope could be flattened using a granular fill material faced with a vegetated mat with salt resistant plantings to help anchor and stabilize the soils. Non-woven geotextile fabrics should be installed against the existing substrate prior to installing the stabilizing berm riprap and slope repair materials to avoid them sinking into the substrate as the underlying substrate becomes saturated. Option 1 would involve work within 75 feet of the high-water mark and work below the high-water mark, which will require separate approvals from Maine DEP and the U.S. Army Corps of Engineers (ACOE), respectively. These regulatory approvals require extensive preliminary studies of the potential environmental impacts of implementing adaptation measure Option 1, which will increase the time required to implement this adaptation measure.

Option 2 would require driving permanent sheeting relatively deep into the substrate below the coastal bluffs in order to avoid groundwater migrating under the sheeting and destabilizing the soils under the retaining wall over time. Option 2 should also include some level of lower embankment armoring, similar to Option 1 to slow wave action from eroding the slope in front of the sheeting wall. The sheeting wall in Option 2 would provide an additional level of protection, but would be more disruptive to the abutting property owners, and more complex to construct than Option 1, but less so than Option 3. Similar to Option 1, Option 2 would require extensive environmental permitting to study the potential environmental impacts, which will increase the time required to implement these adaptation measures.

Option 3 to reroute the sewers that are served by the Town Landing Interceptor sewer is expected to require relaying of several gravity sewer mains on side streets to slope away from the coastline, construction of low-pressure sewers in some areas where gravity flow away from the coastline would be technically infeasible, and the construction of at least 3 to 4 additional small pump stations to collect and convey the wastewater to the interceptor sewer on Foreside Road. Option 3 would provide the greatest level of long-term protection from soil erosion and flooding because the Town Landing Interceptor could eventually be entirely abandoned. However, based upon the risks, this option would be cost-prohibitive compared to it benefits and to the other alternatives, would take much more time and effort to implement, and would be more disruptive to residents and businesses in the area than Options 1 and 2. Therefore, this option has been ruled out from further consideration.

Expected Project Costs:

- Option 1: $570,000
- Option 2: $690,000
- Option 3: $2,190,000

It is recommended that the Town implement Option 1 to help mitigate soil erosion along the embankments in the areas that areas that appear to be most at risk of embankment erosion and failure as a short-term measure. Future consideration should also be given for also constructing a permanent sheet pile wall, as described in Option 2, at the top of the slope to further reduce the risk of groundwater seepage contributing to soil erosion and storm surge flooding in this area, as available funding allows. Potential project financing and grant options that may be available to help offset the costs of this project are discussed in Section 7.

Recommended Project Costs:

- Option 1: $570,000

6.1.2.14 Mackworth Point Interceptor Sewer

Continued erosion of the steep embankments within which the Mackworth Point Interceptor sewer is located by tidal action, flooding and storm surge will increase the risk of the interceptor sewer being exposed, undermined and eventually failing. Storm surge, coupled with SLR, is expected to accelerate this trend over time. The identified adaptation measures would be similar to those for the Town Landing Interceptor sewer, and are as follows:

- Option 1: create stabilizing berms at the base of the embankment slope that replicate those of the natural block failure mechanism, but are comprised of rip-rap that is resistant to erosion and keyed into the existing substrate to resist creep toward the ocean.
- Option 2: Install a permanent sheet pile retaining wall with a groundwater drainage system to retain the soils around the interceptor sewer and protect them wave action.

The Town is considering moving forward with a more detailed evaluation of this interceptor (along with the Town Landing interceptor) to further develop recommendations improvements to resiliency.

For Option 1, the height of the stabilizing berms should be at least at the elevation of the preliminary 2018 FEMA 100-year flood elevation, with consideration for future sea level rise. Above the riprap stabilizing berms, the embankment slope could be flattened using a granular fill material faced with a vegetated mat with salt resistant plantings to help anchor and stabilize the soils. Non-woven geotextile fabrics should be installed against the existing substrate prior to installing the stabilizing berm riprap and slope repair materials to avoid them sinking into the substrate as the underlying substrate becomes saturated. Option 1 would involve work within 75 feet of the high-water mark and work below the high-water mark, which will require separate approvals from Maine DEP and the U.S. Army Corps of Engineers (ACOE), respectively. These regulatory approvals require extensive preliminary studies of the potential environmental impacts of implementing Option 1, which will increase the cost and time required to implement this adaptation measure.

Option 2 would require driving permanent sheeting relatively deep into the substrate below the coastal bluffs in order to avoid groundwater migrating under the sheeting and destabilizing the soils under the retaining wall over time. Option 2 should also include some level of lower embankment armoring, similar to Option 1 to slow wave action from eroding the slope in front of the sheeting wall. The sheeting wall in Option 2 would provide an additional level of protection and would allow the Town to backfill soil around the interceptor manholes that have already been partially exposed. Option 2 would be more disruptive to the abutting property owners, and more complex to construct than Option 1. Option 2 would also require extensive study of its environmental impacts in order to secure Maine DEP and ACOE approval, which will increase the time and cost required to implement these adaptation measures.

Expected Project Costs: To Be Determined.

The Town of Falmouth recently retained Wright-Pierce to prepare a more detailed study of the potential adaptation measure options for the Mackworth Point interceptor sewer and their potential costs. The Town is encouraged to review the results of the final study and incorporate the expected costs of the most preferrable option into the Town's overall wastewater system Climate Adaptation Plan.

Section 7 Recommended Adaptation Plan

7.1 Implementation Plan

A prioritized climate adaptation plan for implementing the recommended adaptation measures was prepared and is summarized in Table 7-1 below. The plan summary lists the recommended adaptation measures, including their color-coded priority level, recommended timelines for implementation and the planning-level implementation costs listed in Section 6.

Table 7-1 CAP Implementation Plan & Estimated Costs

Asset Description	Recommended Adaptation Measures (1- Highest Priority; 2 - High Priority; 3 - Moderate Priority; 4 - Lower Priority)		Expected Project Cost	Implementation Timeline
Operational Adaptation Measures	Evaluating older portions of the collections system for I/I source reduction and rehabilitation and working with code enforcement staff to eliminate illicit stormwater connections to the sanitary sewer system (sump pumps, floor drains, foundation drains, etc.)		Included in O&M budget	Ongoing
Mill Creek Interceptor Sewer	To Be Determined	Selection to be made after further geotechnical investigation.	$7,160,000 – 12,280,000	0-10 years
Mackworth Point Interceptor Sewer	Option 1	Install stabilizing berms and armor embankment with riprap	**To Be Determined**	0-10 years
WWTF Outfall	Option 1 (Phase 1)	Short-term: Support existing headwall and armor embankment	**$150,000**	0-5 years
	Option 3 (Phase 2)	Long-term: New HDD-installed outfall pipe with a diffuser structure in same location	**$680,000**	15-20 years
Mill Road Interceptor Sewer	Option I-1 (Phase 1)	Short-term: Remove overgrowth along the sewer easement	**$30,000**	0-5 years
	Option I-3 (Phase 2)	Long-term: Replace and relocate the cross-country portion of the interceptor	**$380,000**	20+ years
Mill Road PS (No. 22)	Option PS-1 (Phase 1)	Short-term: Continue to armor the riverbank with riprap	**$20,000**	0-5 years
	Option PS-3 (Phase 2)	Long-term: Retaining wall or permanent sheeting	**$100,000**	15-20 years
Lunt Road PS (No. 4)	Option 1 (Phase 1)	Short-term: Armor the streambank with riprap	**$20,000**	0-5 years
	Option 2 (Phase 2)	Long-term: Loam and overseed the riverbank	**$10,000**	15-20 years
Brown Street PS (No. 2)	Option 3	Construct a new submersible pump station further upland	**$1,080,000**	5-10 years
Town Landing Interceptor Sewer	Option 1	Install stabilizing berms and armor embankment with riprap	**$570,000**	5-10 years
Landing Woods Lane PS (No. 11)	Option 1 (Phase 1)	Short-term: Illicit sewer connection removal (inspections only)	**$10,000**	5-10 years
	Option 3 (Phase 2)	Long-term: Sanitary Sewer System Evaluation	**$110,000**	10-15 years
Clearwater Drive PS (No. 3)*	Option PS-3	Construct a new submersible pump station further upland	**$1,200,000**	10-15 years
Clearwater Drive Interceptor Sewer*	Option I-2	Install a new interceptor sewer via HDD	**$300,000**	10-15 years
Underwood Road PS (No. 7)*	Option 4	Construct a new submersible pump station further upland	**$1,700,000**	10-15 years
Handy Boat PS (No. 6)*	Option 4	Construct a new submersible pump station further upland	**$1,250,000**	15-20 years
Mill Creek PS (No. 5)*	Option PS-1 (Phase 1)	Armor the streambank with riprap	**$30,000**	15-20 years
	Option PS-2 (Phase 2)	Construct retaining wall barrier	**$290,000**	20+ years

* The Town of Falmouth does not have the funds available to commit to implementing the recommended long-term adaptation measures sooner than the timeframe listed in Table 7-1. Therefore, the Town is willing to monitor and employ temporary mitigation measures (sandbags, temporary pumping, etc.) on an as needed basis until funds are available for the Town to implement the recommended long-term adaptation measures within the recommended timeframe, unless resiliency grant funding becomes available before then.

7.2 Potential Funding Sources

7.2.1 Internal Reserves

The Town has internal budget reserves for minor capital improvements and expenditures that could be used to fund limited climate adaptation measures. Reserve funds could be used for relatively low-cost operational or process modifications and/or minor capital improvement projects. This would be the preferred funding mechanism for the recommended CAP measures since using existing budget reserve funds does not require raising sewer user rates to cover the cost.

7.2.2 Local Revenue

For adaptation measures that cannot be covered by budget reserves alone, the Town could raise the revenues needed to cover costs by implementing a structured sewer user rate increase. Generated revenues could be used for low-cost operational or process modifications, and both minor and significant capital improvements. This would be a less desirable funding mechanism than using budgeted reserves because it would require increasing sewer user rates

7.2.3 DEP Clean Water State Revolving Fund

The Maine DEP Clean Water State Revolving Fund (CWSRF) program provides grants and low-interest loans to local communities and quasi-municipal entities for wastewater infrastructure improvement projects. Asset-specific adaptation measures with a significant capital cost are likely be eligible for CWSRF grant or loan funding. CWSRF loan principal and interest would need to be fully repaid over the term of the loan (typically 20 years or the expected life of the asset) unless the Town qualified for a grant or principal forgiveness. To be eligible for a CWSRF loan, the Town would need to complete a CWSRF loan application with the Maine Municipal Bond Bank and other CWSRF program requirements including an environmental impact review report and preliminary design report.

As a result of the COVID-19 pandemic, the federal government released funds as part of the American Rescue Plan Act (ARPA) which were partially distributed through state programs, including the CWSRF program. Maine received the first of two allocations from ARPA in 2021. It is expected that the remainder of these funds will be released in 2022, with a portion included as part of the 2022 CWSRF program.

In the coming years, a significant increase in available CWSRF funding will be seen as a result of the 2021 Bipartisan Infrastructure Deal, which will allow for the EPA to distribute funding to States to be administered through the existing CWSRF programs. This portion of CWSRF funding will be administered as 49% grant and principal forgiveness loans, with the remaining 51% as low-interest loans.

7.2.4 U.S. Department of Commerce's Economic Development Administration (EDA) Grant Program

The U.S. Economic Development Administration (EDA) also has a grant program for municipal infrastructure construction necessary to attract or increase commercial and/or industrial development. Grants of 50% of project cost, typically up to a maximum of $1,000,000, are available. One of the primary eligibility criteria is that the project must create or maintain employment opportunities in an economically disadvantaged area. Since it is unlikely that the recommended projects can be shown to create or maintain employment, securing EDA funds is unlikely.

7.2.5 Federal Emergency Management Agency (FEMA)

There are a number of grants through FEMA that are available for planning and construction projects to assist communities in implementation of hazard mitigation measures. FEMA Flood Mitigation Assistance (FMA) grants are available for planning and construction projects that reduce or eliminate the long-term risk of flood damage to structures insured under the National Flood Insurance Program (NFIP). FEMA Building Resilient Infrastructure and Communities (BRIC) grants are available to support communities as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. FEMA Hazard Mitigation Grant Program (HMGP) assists in implementing long-term hazard mitigation planning and projects following a presidential disaster declaration. The ongoing COVID-19 Pandemic has triggered this presidential declaration, allowing for funds to be released for this grant program. Both BRIC grants and HMGP can fund up to 75% of the project cost, requiring the Town of Falmouth to provide 25% of the cost in non-federal funding. The non-federal funding can come from state or local government, an individual, construction labor, and in-kind services.

To apply for the above FEMA grants, the Town would be required to submit a project application to the State Hazard Mitigation Officer to then be forwarded on to the Regional FEMA office for review and approval. The hazard mitigation project would also be required to conform with the State and local Hazard Mitigation Plans to be eligible for FMA grants. Depending on the grant and available funds each year, the Town could be competing for FMA grant funds within a national pool of applicants. FEMA funding would be preferable to CWSRF loan funding because grant funds would not need to be repaid.

7.2.6 Water Infrastructure Finance and Innovation Act (WIFIA) Program

The Water Infrastructure Finance and Innovation Act of 2014 (WIFIA) established the WIFIA program, a federal credit program administered by EPA for eligible water and wastewater infrastructure projects. Eligible borrowers include local, state, tribal, and federal government entities, partnerships and joint ventures, corporations and trusts and Clean Water and Drinking Water State Revolving Fund (SRF) programs. The WIFIA program can fund projects that are eligible for the Clean Water SRF including development phase activities such as planning, preliminary engineering, design, environmental review, revenue forecasting, and other pre-construction activities, construction, reconstruction, rehabilitation, and replacement work, acquisition of real property or an interest in real property, environmental mitigation, construction contingencies, and acquisition of equipment.

Although the design and construction costs of the recommended projects would be categorically eligible for federal WIFIA program funds, the WIFIA program can only fund up to 49% of project costs and requires a minimum project size of $5 million. In addition, typical SRF program requirements including an Environmental Review, Davis-Bacon wage rates and American Iron and Steel requirements would apply to WIFIA funding. Given these eligibility criteria and funding limitations, WIFIA program financing would not be a preferred funding source when compared to USDA Rural Development, CDBG and the Maine DEP CWSRF funding programs.

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Appendix A
Overview Falmouth Sewer Collection System

Appendix B
Overview Collection System in FEMA 100-year Floodplain

Appendix C
Overview Collection System in Sea Level Rise (SLR) Scenarios

Appendix D
Overview Collection System in Category 1- 4 Hurricane Storm Surge Scenario

Appendix E
Overview Collection System with Marsh Migration

Figure E: Collection System Marsh Migration
E-1: Falmouth WWTF
E-2: Old Mill PS
E-3: Brown Street PS
E-4: Clearwater Drive PS
E-5: Lunt Road PS
E-6: Mill Creek PS
E-7: Handy Boat PS
E-8: Underwood Road PS
E-9: Thornhurst Road PS
E-10: Waite's Landing PS
E-11: Landing Woods PS
E-12: Middle Road PS
E-13: Leighton Road PS
E-14: Mill Road PS
E-15: Town Landing Interceptor
E-16: Mackworth Point Interceptor
E-17: Clearwater Interceptor
E-18: Mill Creek Interceptor
E-19: Mill Road Interceptor

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