Five Towns Drainage Study

Final Report

Nassau County, New York
Department of Public Works

December 22, 2017

AECOM

Cameron Engineering & Associates, LLP

(This page intentionally left blank.)

PERTINENT DATA

For areas within the Five Towns subject to drainage and flooding problems, major components of the existing municipal storm drainage systems were evaluated and potential improvements were developed. Recommended improvements included: backflow prevention, pipe improvements, inline storage or detention, pump stations, and treatment devices. Below is a summary of the recommended projects.

Community	Project Description	Total Project Cost	Total Community Project Cost	Total E&D/CM Cost **	Jurisdiction	Notes
Cedarhurst, Village of	Install 50 cfs pump w/ pump station on property next to Peninsula blvd	$2,737,000	$2,737,000	$598,800	Village of Cedarhurst	Pump station location to be confirmed
Hewlett, Hamlett of	Remove 45 ft. of 36" pipe @ outfall. Install 45ft. of 42" pipe; Remove 60 ft. of 30" pipe @ outfall. Install 60ft. of 42" pipe. Install 4 backflow prevention devices. Install 2 CDS units.	$336,000	$336,000	$73,600	Town of Hempstead	Outfalls to Doxey Brook, Brook functions as bio swale, minimal treatment proposed
Hewlett Bay Park, Village of*	2x In-line backflow prevention device on 36" dia. & 60" Outfalls	$221,000	$3,226,000	$705,600	Village of Hewlett Bay Park	Not in CRZ, ID funding source.
	Pipe Improvements	$3,005,000				
Hewlett Harbor, Village of	Separate GOSR CDBG-DR Project	N/A	N/A	N/A	Village of Hewlett Harbor	Separate GOSR CDBG-DR Project
Hewlett Neck, Village of	3 x 15", 1 x 24" 1 x 18" in-line backflow prevention	$108,000	$1,021,000	$223,300	Village of Hewlett Neck	Access to private property for installation
	Pipe/drainage Improvements; Woodbine Ditch	$913,000				
Inwood, Hamet of	Inline backflow prevention device + Install storage chamber under parking lot at the Inwood Marina, install treatment device to main line	$802,000	$802,000	$175,500	Town of Hempstead	Confirmation of groundwater elevations for project performance; treatment devices
Lawrence, Village of	Pipe Improvements Along Meadow Lane, Marbridge Road, Causeway Road, North Road, and Barrett Road.	$8,276,000	$8,276,000	$1,810,400	Village of Lawrence	Includes Treatment Devices
Woodmere, Hamlet of	16x In-line backflow prevention device on outfalls + 8 treatment devices for largest drainage areas	$921,000	$921,000	$201,500	Town of Hempstead	Outfalls to Cedar Point Lake; due to urban area and lake outfalls, recommended treatment devices on larger networks, not on smaller networks
Woodsburgh, Village of*	Pipe Improvements; 2x backflow prevention + CDS	$1,875,000	$1,875,000	$410,200	Village of Woodsburgh	Not in CRZ, ID funding source.

**Communities not part of the original Community Reconstruction Plan (CRP)*
***Engineering & Design (E&D), Construction Management (CM), includes contingency.*

(This page intentionally left blank.)

TABLE OF CONTENTS

List of Tables

List of Figures

Appendices

Cover Photos: *Cedarhurst Avenue (Left) and Albermarle Road (Right), Cedarhurst, New York; flooding at high tide.*

(This page intentionally left blank.)

EXECUTIVE SUMMARY

Introduction

Nassau County's "Five Towns" region is comprised of nine jurisdictions on the south shore of western Long Island, at the head of the Far Rockaway Peninsula. Despite its name, the region is not comprised of five towns; rather, the full area lies within the Town of Hempstead, in southwestern Nassau County. The "Five Towns" designation dates back to the year 1931 when local fundraising organizations in Inwood, Lawrence, Cedarhurst, Woodmere, and Hewlett formed a joint entity dubbed the "Five Towns Community Chest". In the decades thereafter, the general public began referring to this geography of Nassau County as the "Five Towns". Today, the term encompasses the incorporated Villages of Cedarhurst, Lawrence, Hewlett Harbor, Hewlett Bay Park, Hewlett Neck and Woodsburgh; and the unincorporated Hamlets of Hewlett, Inwood, and Woodmere. The Five Towns region is largely surrounded by water including Jamaica Bay, Hewlett Bay, Reynolds Channel, and numerous tidal creeks and navigable canals. More than 49,000 people reside in the Five Towns. Land use is predominantly single-family residential. Other uses include commercial, retail, light industrial, and parkland/open space.

Flooding has historically occurred in the Five Towns during severe rainfall events, astronomical high tides, nor'easters, and tropical storms. The region's vulnerability to both tidal and stormwater flooding was highlighted during Superstorm Sandy in October of 2012 when significant tidal storm surge inundation combined with backwater flooding of municipal stormwater drainage systems caused catastrophic inland flooding even in areas that were beyond the extent of the storm surge.

The Five Towns' flood vulnerability directly affects the quality of life of its residents. Stormwater flooding occurs frequently and coastal storm surges have become more frequent, and are expected to continue and get more severe further impacting residents' property, travel, and well-being.

Purpose and Scope of the Drainage Study

Municipal drainage improvement projects originated as a concept in the Five Towns Community Reconstruction Plan (CRP) under the Governor's Office of Storm Recovery's (GOSR) New York Rising Program to address areas that have been identified as historically vulnerable to localized flooding due to tidal backflow, limited drainage capacity/overflow, topographic low points or a combination thereof. Numerous drainage problem or focus areas were identified in the CRP as well as through meetings with community officials which warranted additional study before potential improvements could be recommended and implemented.

The primary purpose of the Five Towns Drainage Study was to first, document existing municipal stormwater drainage conditions and then, to identify potential drainage improvements or flood mitigation projects. This report documents the evaluation of potential drainage improvements within the Five Towns area.

The Villages of Woodsburgh and Hewlett Bay Park were not included in the original Five Towns CRP due to minimal damages as a result of Hurricane Sandy; however, they are included as part of this study for completeness in evaluating the region. Storm surges and stormwater impacts occur regardless of municipal boundaries.

Following the evaluation of existing conditions, drainage improvement plans were developed to limit stormwater flooding at high frequency events (i.e., 1" rainfall, 2" rainfall, etc.) rather than larger, low frequency rainfall events such as the 25-year rainfall, 50-year rainfall, and so on.

The inspection and evaluation of all stormwater locatable outfalls in the Five Towns region was included as part of the analysis. In many cases, the condition of the outfalls is a primary factor in how the upstream stormwater drainage system performs.

In addition to documenting the evaluation of potential drainage improvements within the Five Towns, this Drainage Study Report also presents a preliminary cost estimate for the recommended suite of improvements. This cost estimate and subsequent benefit-cost analysis helped serve as the basis for considering moving forward with the development of plans and specifications for further study and design.

Drainage Study

Major components of the existing municipal storm drainage systems were evaluated and potential improvements were developed. The systems were assembled using current Global Information System (GIS) data, existing hardcopy records, historical flooding information, and field investigations. Problem areas were identified from the CRP, by meeting with local municipal engineers and Nassau County Department of Public Works (DPW) staff, and through network analyses. Problem areas were segregated by drainage networks for analysis, with preliminary hydrologic and hydraulic computations to determine or confirm drainage conditions.

As part of the analysis, each of the stormwater discharges/outfalls within the project area was evaluated at the tidal interface. Digital and hardcopy information on outfalls in the project area was collected from the County, local municipalities, and other sources. Information received was consolidated into GIS format. Potential improvements, including the installation of backflow prevention devices were considered and used in the Drainage Study Report, where applicable.

Outreach and Coordination

Nassau County's ability to maintain coordination and communication with the affected communities and all stakeholders was recognized early on as a key determinant of an overall successful project. Coordination was established and maintained at the outset of the project between the County and community officials. Coordination occurred in the form of meetings, correspondence, and telephone calls.

- Multiple project coordination meetings were held at regular intervals between the County and the consultant team.
- The County and its consultants met with local community officials, municipal engineers, and Department of Public Works (DPW) staff at the project outset to identify problem areas.
- Public meetings are planned to present the findings of the drainage and flooding analysis.

Analysis Approach

Existing or Current Conditions

Stormwater drainage system models were assembled for each of the problem areas. Three tailwater conditions were evaluated in order to verify the performance of the drainage networks and to determine whether they represented what was actually occurring in each problem area. The three tailwater conditions were:

1) Low tide or free flowing outfall.
2) Typical tidal cycle with a spring tide peak.
3) High tide peak coincidental with peak rainfall (blocked outfall).

Once it was confirmed that the models reasonably represented the current conditions in the Project Area, the team developed potential plans to improve flooding conditions.

Design Rationale

General

Performance of the drainage networks under the three tailwater conditions helped to drive the design criteria. That is, if a drainage network performed well under low tide conditions but experienced moderate to severe flooding during other scenarios then the amount of flooding helped to define the type of improvements being considered.

Rainfall Amounts

As noted previously, smaller, more frequent rainfall events (and corresponding rainfall amounts) were the focus of the analyses. The communities were very consistent in their concerns regarding recurring flooding associated with more frequent, smaller rainfall events. Most understood that the larger, less frequent events (i.e., the 100-year storm, the 50-year storm, etc.) were large rainfall events which generally exceeded the design capacity of the installed networks and, therefore, some amount of flooding was to be expected during these more significant events. Furthermore, the infrastructure required to limit flooding during large rainfall events was expected to be sizable and its installation likely to exceed available funding. Therefore, the design team focused on smaller, frequent storm events to limit or eliminate recurring flooding in most tailwater conditions.

Cumulative Approach

Plans were developed in a cumulative manner; that is, improvements associated with a new plan were added to the previous plans. In that respect, simpler, less expensive plans were considered first, such as the installation of backflow prevention devices, followed by larger more costly items such increased pipe size, improved pipe networks, additional storage, green infrastructure, and finally a pump station.

Typical Improvements

The following typical drainage infrastructure improvements were considered for the Five Towns Project Area:

1) Backflow Prevention
2) Pipe Improvements
3) Inline Storage or Detention
4) Pressure Pipes or Diversion
5) Pump Stations
6) Green Infrastructure
7) Treatment Devices

Cost Development

The design of recommended improvements and associated construction costs were developed from calculated quantities, local unit costs, contingencies, additional engineering and design, construction management, and any real estate assessment, administration, and processing fees required.

Cost Benefit Summary

Benefits of the recommended plans for each community were developed. The costs for each recommended plan were presented following the discussion of the analysis and evaluation of each community's drainage conditions in the previous subsections. First costs have been amortized over the typical 25-year life cycle of plan elements using the current discount rate of 2.875%.

Quantitative benefits may be monthly, annually, or amortized depending on the nature of the damages prevented or the costs avoided, and have been described in detail in the report. Non-quantitative benefits have also been described. The current Federal discount rate is typically used for other Federal agencies' projects, such as FEMA and the U.S. Army Corps of Engineers (USACE).

Benefits of Recommended Improvements

The benefit-cost analysis results revealed that there are a number of viable drainage improvement plans that may be implemented in the Five Towns project area. These plans have benefit-to-cost rations (BCRs) significantly greater than unity or have non-quantified benefits which will significantly enhance the quality of life, and reduce risks to life and property for local residents and people transiting the project area during periods of flooding.

Sea Level Rise / Climate Change

Current guidance requires that climate change and future sea level change (SLC) projections must be incorporated into the planning and design of HUD-supported projects. Tide conditions at Sandy Hook (NOAA Station #8531680) best represent the conditions experienced in the Five Towns region to date. A 75-year record (1932 to 2006) of tide data gathered at Sandy Hook, NJ indicates a mean sea level trend of +3.9 mm/year or approximately 0.7 feet in 50-years. Current forecast models predict sea level rise of 1.01 feet to more than 3 feet over the next 50 years.

Sea level rise effects are not critical to the recommended projects' performance. However, the coincidental nature of flooding impacts due to high tide and rainfall events will be impacted by changes in sea level, and the associated change in high tide peaks and subsequently, the level of flooding as a result of high tide or frequent storm surges. Regardless of the change in sea level, it is expected that by limiting tide-induced drainage system surcharging the effects of sea level rise on the project performance will be significantly mitigated in the near future.

Resiliency

Resiliency is defined in the USACE-NOAA Infrastructures Systems Rebuilding Principles White Paper (2013) as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies". The recommended projects are designed to limit flooding from coincidental tidal and rainfall events, up to a 10-year rainfall event in many cases. Flooding impacts due to changes in sea level and/or changes in rainfall intensity will likely be mitigated for the life of the project features, making the communities more resilient than they would have been without the projects in place.

Sustainability

Sustainability is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). The recommended projects are mostly hard structures – backflow prevention devices, pipe systems, etc. – which, with proper maintenance will provide for the overall sustainability of the project over the 25-year project life and likely beyond, regardless of the level of sea level rise. The features recommended for construction represent a resilient and sustainable solution to mitigate recurring flooding in the Five Towns Project Area.

Summary of Recommended Improvements

Projects recommended for advancement to the engineering phase (final engineering, as needed, and the development of plans and specifications) are presented in Table ES1.

Table ES1: Summary of Recommended Projects

Community	Project Description	Total Project Cost	Total Community Project Cost	Total E&D/CM Cost **	Jurisdiction	Notes
Cedarhurst, Village of	Install 50 cfs pump w/ pump station on property next to Peninsula blvd	$2,737,000	$2,737,000	$598,800	Village of Cedarhurst	Pump station location to be confirmed
Hewlett, Hamlet of	Remove 45 ft. of 36" pipe @ outfall. Install 45ft. of 42" pipe; Remove 60 ft. of 30" pipe @ outfall. Install 60ft. of 42" pipe. Install 4 backflow prevention devices. Install 2 CDS units.	$336,000	$336,000	$73,600	Town of Hempstead	Outfalls to Doxey Brook, Brook functions as bio swale, minimal treatment proposed
Hewlett Bay Park, Village of*	2x In-line backflow prevention device on 36" dia. & 60" Outfalls	$221,000	$3,226,000	$705,600	Village of Hewlett Bay Park	Not in CRZ, ID funding source.
	Pipe Improvements	$3,005,000				
Hewlett Harbor, Village of	Separate GOSR CDBG-DR Project	N/A	N/A	N/A	Village of Hewlett Harbor	Separate GOSR CDBG-DR Project
Hewlett Neck, Village of	3 x 15", 1 x 24" 1 x 18" in-line backflow prevention	$108,000	$1,021,000	$223,300	Village of Hewlett Neck	Access to private property for installation
	Pipe/drainage Improvements; Woodbine Ditch	$913,000				
Inwood, Hamet of	Inline backflow prevention device + Install storage chamber under parking lot at the Inwood Marina, install treatment device to main line	$802,000	$802,000	$175,500	Town of Hempstead	Confirmation of groundwater elevations for project performance; treatment devices
Lawrence, Village of	Pipe Improvements Along Meadow Lane, Marbridge Road, Causeway Road, North Road, and Barrett Road.	$8,276,000	$8,276,000	$1,810,400	Village of Lawrence	Includes Treatment Devices
Woodmere, Hamlet of	16x In-line backflow prevention device on outfalls + 8 treatment devices for largest drainage areas	$921,000	$921,000	$201,500	Town of Hempstead	Outfalls to Cedar Point Lake; due to urban area and lake outfalls, recommended treatment devices on larger networks, not on smaller networks
Woodsburgh, Village of*	Pipe Improvements; 2x backflow prevention + CDS	$1,875,000	$1,875,000	$410,200	Village of Woodsburgh	Not in CRZ, ID funding source.

**Communities not part of the original Community Reconstruction Plan (CRP)*
***Engineering & Design (E&D), Construction Management (CM), includes contingency.*

1.0 INTRODUCTION

Nassau County's "Five Towns" region is comprised of nine jurisdictions on the south shore of western Long Island, at the head of the Far Rockaway Peninsula. Despite its name, the region is not comprised of five towns; rather, the full area lies within the Town of Hempstead, in southwestern Nassau County. The "Five Towns" designation dates back to the year 1931 when local fundraising organizations in Inwood, Lawrence, Cedarhurst, Woodmere, and Hewlett formed a joint entity dubbed the "Five Towns Community Chest". In the decades thereafter, the general public began referring to this geography of Nassau County as the "Five Towns". Today, the term encompasses the incorporated Villages of Cedarhurst, Lawrence, Hewlett Harbor, Hewlett Bay Park, Hewlett Neck and Woodsburgh; and the unincorporated Hamlets of Hewlett, Inwood, and Woodmere. The Five Towns region is largely surrounded by water including Jamaica Bay and Hewlett Bay, Reynolds Channel, and numerous tidal creeks and navigable canals. More than 49,000 people reside within the Five Towns. Land use is predominantly single-family residential. Other uses include commercial, retail, light industrial, and parkland/open space.

Flooding has historically occurred in the Five Towns during severe rainfall events, astronomical high tides, nor'easters, and tropical storms. The region's vulnerability to both tidal and stormwater flooding was highlighted during Superstorm Sandy in October of 2012 when significant tidal storm surge inundation combined with backwater flooding of municipal stormwater drainage systems to cause catastrophic inland flooding even in areas that were beyond the extent of the storm surge.

The Five Towns' flood vulnerability directly affects the quality of life of its residents. Stormwater flooding occurs frequently and coastal storm surges have become more frequent, and are expected to continue and get more severe further impacting residents' property, travel, and well-being.

1.1 Overview of the Problem

Stormwater infrastructure in the Five Towns consists of separate municipal storm sewer systems (MS4) under the jurisdiction and maintenance responsibility of the respective municipality (County, Village, or Town). In some cases, the individual systems are interconnected and mutually contribute stormwater to a single outfall. Private properties are required to maintain stormwater onsite and retention volume is governed by a local municipal ordinance and, in some cases, by the Nassau County Department of Public Works. Older commercial and industrial properties are generally brought into compliance with onsite drainage requirements during the design review process triggered by an expansion or redevelopment building permit application.

Flooding in the Five Towns Project Area occurs frequently during high tide events such as during tropical storms, nor'easters, and spring tides. Existing stormwater infrastructure is often considered inadequate to accommodate increased flows during periods of heavy rainfall, and flooding is exacerbated when stormwater outfalls, of varying condition and often absent of check valves, become submerged by high tides and experience backwater surcharging.

Many areas are built upon wetland areas that were filled in the late 1800's to accommodate development demands after the railroad opened up the region for a year-round, commuter population. These lands in particular are generally quite low and are naturally flood-prone.

Tropical Storm Irene in 2011 was primarily a rainfall event for the Five Towns area, with storm totals ranging from five to nine inches causing extreme stormwater flooding. The following year, in 2012, Superstorm Sandy brought with it a storm surge up to 10 feet NAVD88. As stormwater drainage system outfalls and areas along the coastline were submerged by tidal waters, widespread drainage system backups occurred causing extreme flooding well inland of coastal area.

Approximately 216 stormwater outfalls lie within the Five Towns project area. Most of these either lack backflow prevention devices altogether or currently have improperly functioning backflow prevention devices. Locations with improperly functioning devices are indicative of drainage system backups when outfalls become submerged, stormwater system surcharging and flooding of low lying areas.

When the existing drainage systems are at capacity, whether due to tidal backflow, stormwater inflow, or a combination of both, flooding occurs at existing system inlets (manholes and catch basins). Figures in each assessment section show key problem locations reported by public officials and/or the public. These locations were investigated as part of this drainage study to evaluate potential system upgrades and improvements.

1.2 Purpose and Scope of the Drainage Study

Municipal drainage improvement projects originated as a concept in the Five Towns' Community Reconstruction Plan (CRP) under the Governor's Office of Storm Recovery's (GOSR) New York Rising Program to address areas that have been identified as historically vulnerable to localized flooding due to tidal backflow, limited drainage capacity/overflow, topographic low points or a combination thereof. Numerous drainage problem or focus areas were identified in the CRP as well as through meetings with community officials which warranted additional study before potential improvements could be recommended and implemented.

The primary purpose of the Five Towns Drainage Study was to first, document existing municipal stormwater drainage conditions and then, to identify potential drainage improvements or flood mitigation projects. This report documents the recommended drainage improvements within the Five Towns area.

The Villages of Woodsburgh and Hewlett Bay Park were not included in the original Five Towns CRP due to minimal damages as a result of Hurricane Sandy; however, they are included as part of this study for completeness in evaluating the region. Storm surges and stormwater impacts occur regardless of municipal boundaries.

Following the evaluation of existing conditions, drainage improvement plans were developed to limit stormwater flooding at higher frequency events (i.e., 1" rainfall, 2" rainfalls, etc.) rather than larger, low frequency rainfall events such as the 25-year rainfall, 50-year rainfall, and so on.

The inspection and evaluation of all stormwater locatable outfalls in the Five Towns region was included as part of the analysis. In many cases, the condition of the outfalls is a primary factor in how the upstream stormwater drainage system performs.

The Drainage Study also included an evaluation of the feasibility of coastal protection for the Project Area. A coastal or seawall plan originated as a regional concept in the Five Towns CRP. The primary area of focus in the CRP was along State Route 878/Rockaway Boulevard and was initially conceived as a roadway elevation plan. Refinement of a more widespread conceptual plan was included in the Drainage

Study. The Seawall Feasibility Report in Appendix H documents the evaluation of a Five Towns regional plan to provide coastal flood protection / risk management to a Sandy-level surge event.

1.3 Project History

Between August of 2011 and October 2012, communities across New York State suffered significant impacts as a result of Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy. As communities began to pick up the pieces and rebuild their communities, many were in need of technical expertise to meet their goals of mitigating risk and increasing resiliency. In response to this need, the State developed the New York Rising Community Reconstruction Program (NYRCRP) in April of 2013. This program dedicated more than $650 million to affected communities to provide rebuilding and resiliency assistance. Nassau County's Five Towns was one of the communities selected to participate in this program.

As a NYRCRP community, the local leaders, community organizations, residents, business owners, and civic leaders from the Five Towns developed a Community Reconstruction Plan with technical support provided by staff from GOSR, planners from New York State (NYS) Department of State, NYS Department of Transportation, and consultants from firms specializing in planning, engineering, flood mitigation solutions, green infrastructure, and more.

The Five Towns NYRCRP Plan:

- Defines the scopes of the planning area, assesses storm damage, and identifies critical assets;
- Inventories critical assets and assesses the assets' exposure to risk;
- Describes recovery and resiliency needs and identifies opportunities;
- Develops a series of comprehensive reconstruction and resiliency strategies; and
- Identifies projects and implementation actions to fulfill these strategies.

One of three key strategies that emerged from the NYRCR process was a desire to:

> *"Increase the resilience to extreme weather in high risk coastal areas by addressing coastal protections and stormwater infrastructure."*

Plans for each of the Five Towns communities in the NYRCR included a stormwater infrastructure upgrade project to improve overall system capacity and/or system efficiency, which served as the basis for this drainage study.

1.4 Drainage Study

Major components of the existing municipal storm drainage systems were evaluated and potential improvements were developed. The systems were assembled using current Global Information System (GIS) data, existing hardcopy records, historical flooding information, and field investigations. Problem areas were identified from the CRP, by meeting with local municipal engineers and Nassau County Department of Public Works (DPW) staff, and through network analyses. Problem areas were segregated by drainage networks for analysis, with preliminary hydrologic and hydraulic computations to determine or confirm drainage conditions.

1.5 Outreach and Coordination

Nassau County's ability to maintain coordination and communication with the affected communities and all stakeholders was recognized early on as a key determinant of an overall successful project.

Coordination was established at the project outset between the County and community officials. Coordination occurred in the form of meetings, correspondence, and telephone calls.

- Multiple project coordination meetings were held at regular intervals between the County and the consultant team.
- The County and its consultants met with local community officials, municipal engineers, and Department of Public Works (DPW) staff at the project outset to identify problem areas.
- Public meetings are planned to present the findings of the drainage and flooding analysis.

Details of the project outreach and coordination are included in Appendix A, Outreach and Coordination.

2.0 REPORT ORGANIZATION

This report summarizes the plans developed during the Five Towns Drainage Study to help address recurring flooding problems in the Five Towns area. Introductory sections include:

Analysis Approach
Cost & Benefit Development
Recommended Project Summary

Following the introductory sections, a summary of recommended projects for each community are presented. Each community's section includes a description of the recommended projects/improvements, along with preliminary layouts of the project features followed by preliminary first costs and operation and maintenance (O&M) costs.

More detailed information is included in the following appendices:

Appendix A: Outreach and Coordination
Appendix B: Drainage Model Parameters and Design Criteria
Appendix C: Green Infrastructure and Environmental Features Assessment
Appendix D: Community Assessments
Appendix E: Cost / Benefit Details
Appendix F: Outfall Inspection Report
Appendix G: Stream Corridor Assessment
Appendix H: Seawall Feasibility Report

3.0 ANALYSIS APPROACH

As part of the analysis, each of the stormwater discharges/outfalls within the project area was evaluated at the tidal interface. Digital and hardcopy information on outfalls in the project area was collected from the County and local municipalities. Information received was consolidated into GIS format. Potential improvements, including the installation of backflow prevention devices were considered and used in the Drainage Study, where applicable. Details of the stormwater drainage model parameters are provided in Appendix B: Drainage Model Parameters and Design Criteria. The results of the analyses for each community are provided in Appendix D: Community Assessments.

3.1 Drainage Networks

The Project Area was divided into a north side and a south side based on the high ground elevation along the Long Island Railroad (LIRR) Right of Way in the center of the Five Towns Project Area. Overall, stormwater drained to the north or south of this line. Separate drainage system models were then developed for each problem area identified by the Project Area communities.

3.1.1 North

Six drainage areas, N-1 through N-6, were developed for the northern part of the Project Area in the Village of Cedarhurst and Hamlets of Inwood, Woodmere (three areas) and Hewlett. The north drainage areas are shown in Figure 1. The delineated areas represent the approximate extent of the drainage networks that were modeled.

3.1.2 South

Six named drainage areas were developed for the southern part of the Project Area (south of the LIRR) and named based on associated roadways: "Meadow" in the Village of Lawrence, "Keene" and "Broadway" in the Village of Woodsburgh, "Brower" in the Village of Hewlett Bay Park, "Waverly" in the Village of Hewlett Harbor, and "Hewlett Neck". The south drainage areas are shown in Figure 1. Like the north, the delineated areas represent the approximate extent of the drainage networks that were modeled. The drainage networks, model results, plans considered, and recommended actions are discussed in more detail under the applicable community sections below.

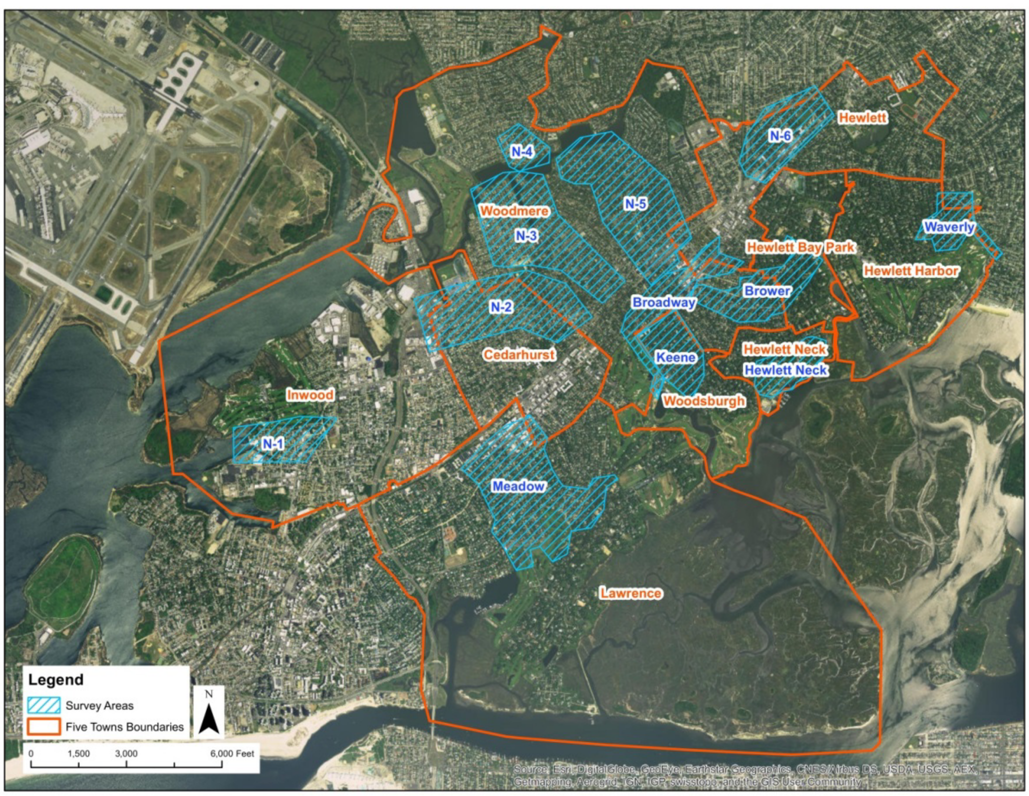


Figure 1: Modeled Drainage Areas

3.2 Summary of Analysis Parameters

3.2.1 Rainfall

Four 24-hour rainfall amounts were analyzed in detail during the study:

1) 1-inch
2) 2-inch
3) 1-year (2.8 inches)
4) 10-year (5.1 inches)

The 100-year rainfall event was originally considered as well; however, the 100-year rainfall event is 8.9 inches and far exceeds the designed stormwater capacity of the existing drainage systems, resulting in widespread flooding in all modeled conditions. Any drainage improvements that might mitigate flooding from such a large event would have significant costs and would likely be impractical to implement due to the size of pipes, pump stations, etc. required to mitigate flooding. Therefore, potential drainage improvements for large, low frequency events were not included in the analysis.

3.2.2 Pipe Networks

Pipe networks were developed for each of the problem areas identified by the communities. These were typically limited to pipes 24 inches in diameter or greater moving upstream from the outfalls, unless the problem area drainage system consisted of smaller pipes. Network catch basins were surveyed and added to the networks; however, due to the limited number of surveyed structures in the project, not all catch basins were surveyed. If not surveyed, catch basin drainage areas were linked with the nearby manholes.

3.2.3 Tailwater Conditions

Stormwater drainage in the coastal areas of the Five Towns Project Area is directly impacted by local tidal elevations or the water surface elevation of Cedar Point Lake. While some outfalls are almost always in a submerged or partially submerged condition, most outfalls are free flowing at low tide and submerged, or blocked, during high tide. When those outfalls are submerged, stormwater outflow is slowed or in some cases completely blocked until the tide recedes. In cases where no backflow prevention device is installed, or in situations where a backflow prevention device is not working properly, the stormwater drainage systems become surcharged – that is, filled with bay water – during high tide conditions. In many cases, the surcharging of the drainage system during high or spring tides results in street flooding without the occurrence of rainfall. When rainfall occurs during that scenario, flooding is exacerbated by the lost pipe storage and slowed outflow.

Because the performance of the stormwater drainage system is extremely sensitive to the tidal tailwater conditions (downstream boundary) for any given rainfall frequency, it was important to account for tailwater conditions, both for existing conditions and conditions with potential drainage improvements in place. For instance, in a low tide or free flowing scenario (outfall unblocked), street flooding may not occur during moderate rainfall events, or a street flooding condition may be improved by increasing the size of the pipe or pipes draining the area. However, during a high tide or high water condition, larger pipes may do little more than provide some more underground stormwater storage, with little or no additional conveyance and limited flood mitigation.

Due to the typically small contributing drainage areas and dense suburban and commercial land use, peak runoff occurs quickly and, therefore, the performance of a municipal stormwater drainage system is highly dependent upon the tidal condition at the time of rainfall. Anecdotal information from the communities indicates that flooding is most often experienced or noticed when the tide is high. However, the actual coincidence of rainfall and tidal peak is random. In some cases, flooding occurs without rainfall as a direct result of the tide, especially in areas like Peninsula Boulevard in the Village of Cedarhurst, or in Woodmere during high water elevations on Cedar Point Lake.

To best understand the drainage conditions in each community, three tailwater scenarios were evaluated to confirm if potential improvements would reduce localized flooding:

1) **Low tide or free flowing outfall.** This is the best-case scenario as most outfalls are free flowing with no blockages or surcharging during low tide.
2) **Typical tidal marigram (cycle) with a spring tide peak.** The tidal marigram has a high tide at hour 1 and a second high tide at hour 13. The rainfall peak and correlating peak run off occurs just after hour 12 in the SCS Type III storm, when the tide was rising in this scenario. As noted above, the coincidence with peak rainfall is random and, therefore, the timing of the high tides was randomly selected.
3) **High tide peak coincidental with peak rainfall (blocked outfall).** Under this scenario, peak rainfall occurs at or near high tide (spring tide).

Stormwater drainage system performance was highly dependent on the tailwater scenario being used.

3.3 Summary of Typical Improvements

The following typical drainage infrastructure improvements were considered for the Five Towns Project Area.

1) Backflow Prevention
2) Pipe Improvements
3) Inline Storage or Detention
4) Pressure Pipes
5) Pump Stations
6) Green Infrastructure
7) Treatment Devices

The recommended improvements are discussed in more detail in Appendices B and C.

4.0 COST AND BENEFIT DEVELOPMENT

4.1 Cost Development

The design of recommended improvements and associated construction costs were developed from calculated quantities, unit costs, contingencies, additional engineering and design, construction management, and any real estate assessment, administration, and processing fees required.

The following percentages were used for cost estimating:

Engineering & Design (to Plans & Specs)………20%
Construction Management………………………..8%
Contingency…………………………………...25%

Project costs were developed based on published or local unit costs. Likewise, installation costs of various items, such as treatment devices, pipes, pavement, etc., were calculated based on the size of pipe. To assemble the final costs based on size, linear feet, number of units, etc., cost templates were developed from which to draw costs. These cost tables are included in Appendix D: Cost/Benefit Parameters and include:

1) Unit costs
2) Cost estimate assumptions
3) Continuous Deflection Separation (CDS) unit (Treatment Device) installation; treatment devices are sized for installation based on pipe size and/or design flow
4) Tideflex® backflow prevention device installation
5) Pipe removal costs
6) New pipe unit costs

4.2 Operation and Maintenance Costs

Stormwater infrastructure projects will continue to perform as designed if properly maintained during normal (non-flood) events and properly operated during flood events. The need for proper maintenance, especially of mechanical equipment, such as pumps, is critical given the potential damages to infrastructure if deterioration occurs due to lack of maintenance. Maintenance is defined as the upkeep and repair of structures to maintain the function of the structure after construction is complete. The operation and maintenance (O&M) regiment will be developed in detail during design and construction; however, a general outline is summarized below.

- **Outfalls:** Drainage outfalls must be maintained clear of debris which could restrict, damage, or jam backflow prevention devices.
- **Pump Stations:** Maintenance of pumps, moveable structures, elimination of rust, removal of debris, and servicing of auxiliary power will be required regularly to ensure proper operation.
- **Rehabilitation & Replacement:** Due to the steel construction of many of the pump station features and synthetic material in the backflow prevention devices, replacement or rehabilitation of these items is assumed to be required every 25 years. Replacement costs for the aforementioned items have been estimated using present worth calculations and are included in the O&M costs for each improvement plan.
- **Annual Costs:** Annualized costs, including rehabilitation/replacement costs, were developed using the current Federal Discount rate of 2.875%.

4.3 Potential Benefits

All Community Development Block Grant (CDBG) projects require supporting justification through a BCA. The methodology for calculating this project's BCA is consistent with OMB Circular A-94, as well as HUD Notice CPD-16-06 (April 20, 2016). Because all project benefits are not fully quantifiable, the

BCA will not serve as the sole determinant as to whether a project or plan may be justifiable under a HUD program; qualitative descriptions of benefits (and costs, if applicable) that cannot be monetized will be taken into account, as appropriate. Benefits considered include:

1) Resiliency Value
2) Social Value
3) Economic Revitalization
4) Quantified Benefits
5) Unquantified Benefits

The Study recommends an optional task of exploring peer-reviewed and accepted methods of ecosystem service valuation to assess monetary values of relevant environmental and social benefits generated by flood mitigation projects being considered for implementation.

5.0 RECOMMENDED PROJECTS COST SUMMARY

The recommended projects for each community are summarized in Tables 1 and 2 below. The tables list the project, unit costs, and total costs including any treatment devices. The costs shown reflect construction, engineering and design, and construction management costs. The projects and costs are discussed in more detail in the following report and the appendices.

Table 1: Cost Summary – Communities on North Side of the Project Area

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Inwood								
1	Backflow Prevention	1x In-line backflow prevention device on 42-54" dia outfall, 2x In-line backflow prevention device on 24" dia. Outfalls	54" dia tideflex	1	EA	$76,070	$76,070	**$268,000**
			24" dia tideflex	1	EA	$12,660	$12,660	
			24" dia tideflex	1	EA	$12,660	$12,660	
2	25 cfs pump	Install 25 cfs pump w/ pump station on open land in front of electrical tower on Bayswater blvd.	25 cfs pump	1	EA	$1,961,000	$1,961,000	**$1,961,000**
or 3	Storage Chamber	Install storage chamber under parking lot at the Inwood Marina	Storage Chamber	1	EA	$802,000	$802,000	**$802,000**
							First Cost:	**$482,000**
							Engineering & Design:	**$96,400**
							Constr. Management:	**$38,600**
							Design & Construction Contingency (30%):	**$185,100**
							TOTAL COST:	**$802,000**
Cedarhurst								
1	Backflow Prevention	4x In-line backflow prevention device on 24'' dia outfall	24" dia tideflex	4	EA	$12,660	$50,641	**$316,000**
		1x In-line backflow prevention device on 48'' dia outfall	48" dia tideflex	1	EA	$58,792	$58,792	
2	50 cfs pump	Install 50 cfs pump w/ pump station on property next to treatment plant on Peninsula blvd (incl 48" Tideflex)	50 cfs pump	1	EA	$2,737,000	$2,737,000	**$2,737,000**
							First Cost:	**$1,644,800**
							Engineering & Design:	**$329,000**
							Constr. Management:	**$131,600**
							Design & Construction Contingency (30%):	**$631,600**
							TOTAL COST:	**$2,737,000**
Woodmere 1 (N3)								
1	Backflow Prevention	3x In-line backflow prevention device on 24'' dia outfall	24" dia tideflex	3	EA	$12,660	$37,981	**$428,000**
		4x In-line backflow prevention device on 30'' dia outfall	30" dia tideflex	4	EA	$22,065	$88,258	
		1x In-line backflow prevention device on 36'' dia outfall	36" dia tideflex	1	EA	$25,859	$25,859	
2	Increase pipe size	Remove 280 ft. of 18" pipe @ <8ft depth. Install 280ft. of 24'' pipe @ <8ft. depth	18" pipe removal	280	LF	$108	$30,228	**$1,571,000**
			24" dia RCP installat	280	LF	$345	$96,710	
	Increase pipe size	Remove 130 ft. of 24" pipe @ <8ft depth. Install 130ft. of 30'' pipe @ <8ft. depth	24" pipe removal	130	LF	$131	$17,011	
			30" dia RCP installat	130	LF	$418	$54,301	
	Increase pipe size	Remove 365 ft. of 18" pipe @ <8ft depth. Install 365ft. of 24'' pipe @ <8ft. depth	18" pipe removal	365	LF	$108	$39,404	
			24" dia RCP installat	365	LF	$345	$126,068	
	Increase pipe size	Remove 150 ft. of 24" pipe @ <8ft depth. Install 150ft. of 30'' pipe @ <8ft. depth	24" pipe removal	150	LF	$131	$19,628	
			30" dia RCP installat	150	LF	$418	$62,655	
	Increase pipe size	Remove 93 ft. of 30" pipe @ <8ft depth. Install 93ft. of 36'' pipe @ <8ft. depth	30" pipe removal	93	LF	$158	$14,708	
			36" dia RCP installat	93	LF	$571	$53,131	
	Increase pipe size	Remove 186 ft. of 30" pipe @ <8ft depth. Install 186ft. of 36'' pipe @ <8ft. depth	30" pipe removal	186	LF	$158	$29,416	
			36" dia RCP installat	186	LF	$571	$106,262	
Woodmere 2 (N4)								
1	Backflow Prevention	1x In-line backflow prevention device on 24'' dia outfall	24" dia tideflex	1	EA	$12,660	$12,660	**$237,000**
		1x In-line backflow prevention device on 18'' dia outfall	18" dia tideflex	1	EA	$8,785	$8,785	
		1x In-line backflow prevention device on 18'' dia outfall + clearing	18" dia tideflex	1	EA	$28,785	$28,785	
		1x In-line backflow prevention device on 18'' dia outfall + repair	18" dia tideflex	1	EA	$58,785	$58,785	
Woodmere 3 (N5)								
1	Backflow Prevention	1x In-line backflow prevention device on 15'' dia outfall	15" dia tideflex	1	EA	$7,396	$7,396	**$256,000**
		1x In-line backflow prevention device on 24'' dia outfall	24" dia tideflex	1	EA	$12,660	$12,660	
		1x In-line backflow prevention device on 18'' dia outfall	18" dia tideflex	1	EA	$8,785	$8,785	
		1x In-line backflow prevention device on 60'' dia outfall	60" dia tideflex	1	EA	$116,263	$116,263	
2	Increase pipe size	Remove 130 ft. of 36" pipe @ <8ft depth. Install 130ft. of 42'' pipe @ <8ft. depth	36" pipe removal	130	LF	$174	$22,671	**$641,000**
			42" dia RCP installat	130	LF	$626	$81,408	
	Increase pipe size	Remove 300 ft. of 30" pipe @ <8ft depth. Install 300ft. of 36'' pipe @ <8ft. depth	30" pipe removal	300	LF	$158	$47,444	
			36" dia RCP installat	300	LF	$571	$171,390	
	Increase pipe size	Remove 140 ft. of 15" pipe @ <8ft depth. Install 140ft. of 24'' pipe @ <8ft. depth	15" pipe removal	140	LF	$100	$13,977	
			24" dia RCP installat	140	LF	$345	$48,355	
Woodmere - SUMMARY								
1	Backflow Prevention	Backflow Prevention (N3, N4, N5)						**$921,000**
2	Pipe Improvements and Backflow	Pipe Improvements + Backflow Prevention (N3, N4, N5)						**$2,449,000**
							First Cost:	**$553,500**
							Engineering & Design:	**$110,700**
							Constr. Management:	**$44,300**
							Design & Construction Contingency (30%):	**$212,600**
							TOTAL COST:	**$921,000**

Table 1: Cost Summary – Communities on North Side of the Project Area (cont.)

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett								
1	Backflow Prevention	2x In-line backflow prevention device on 36'' dia outfall	36" dia tideflex	2	EA	$25,859	$51,719	**$228,000**
		1x In-line backflow prevention device on 30'' dia outfall	30" dia tideflex	0	EA	$22,065	$0	
		2x In-line backflow prevention device on 18'' dia outfall	18" dia tideflex	2	EA	$8,785	$17,570	
2	Backflow Preven	2x In-line backflow prevention device on 42'' dia outfall	42" dia tideflex	2	EA	$38,369	$76,737	**$335,700**
	Backflow Preven	2x In-line backflow prevention device on 18'' dia outfall	18" dia tideflex	2	EA	$8,785	$17,570	
	Increase pipe size	Remove 45 ft. of 36" pipe @ <8ft depth. Install 45ft. of 42'' pipe @ <8ft. depth	36" pipe removal	45	LF	$174	$7,848	
			42" dia RCP installat	45	LF	$626	$28,180	
	Increase pipe size	Remove 60 ft. of 30" pipe @ <8ft depth. Install 60ft. of 42'' pipe @ <8ft. depth	30" pipe removal	60	LF	$158	$9,489	
			42" dia RCP installat	60	LF	$626	$37,573	
							First Cost:	**$201,700**
							Engineering & Design:	**$40,300**
							Constr. Management:	**$16,100**
							Design & Construction Contingency (30%):	**$77,400**
							TOTAL COST:	**$335,700**

Table 2: Cost Summary – Communities on South Side of the Project Area

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Woodsburgh (Broadway)								
1	Backflow Prevention	1x In-line backflow prevention device on 6ftx4ft ellipse Outfall	6'x4' tideflex	1	EA	$129,984	$129,984	**$209,000**
2	Backflow Prevention w/ increase pipe sizes & adjusted inverts	Remove 1,400 ft of 15 in dia. Pipe @<8' depth	15" pipe removal	1400	LF	$100	$139,767	**$836,000**
		Install 1,400 ft of 18 in dia. Pipe @ <8' depth	18" dia RCP installation	1400	LF	$264	$369,625	
		Adjust 8 manholes @ <8' depth	Manhole adjustment	8	EA	$14,697	$117,573	
Woodsburgh (Keene)								
3	Backflow Prevention	1x In-line backflow prevention device on 36" dia. Outfall	36" dia tideflex	1	EA	$25,859	$25,859	**$941,000**
4	Backflow Prevention w/ increase pipe sizes	Remove 1,100 ft of 30 in dia pipe @ <8' depth	30" pipe removal	1100	LF	$158	$173,963	**$1,875,000**
		Install 300 ft of 36 in dia pipe @ <8' depth	36" dia RCP installation	300	LF	$571	$171,390	
		Install 800 ft of 48 in dia pipe @ <8' depth	48" dia RCP installation	800	LF	$735	$588,318	
Woodsburgh - SUMMARY								
1	Backflow Prevention	Backflow Prevention						**$314,000**
2	Pipe Improvements and Backflow	Pipe Improvements + Backflow Prevention						**$1,875,000**
							First Cost:	**$1,126,800**
							Engineering & Design:	**$225,400**
							Constr. Management:	**$90,100**
							Design & Construction Contingency (30%):	**$432,700**
							TOTAL COST:	**$1,875,000**
Hewlett Bay Park (Brower)								
1	Backflow Prevention	2x In-line backflow prevention device on 36" dia. & 60" Outfalls	36" dia tideflex	1	EA	$25,859	$25,859	**$221,000**
			60" dia tideflex	1	EA	$116,263	$116,263	
2	Backflow Prevention w/ increase pipe sizes	Remove 510 ft of 12 in dia pipe @ <8' depth	12" pipe removal	510	LF	$88	$44,773	**$2,072,000**
		Remove 560 ft of 24 in dia pipe @ <8' depth	24" pipe removal	560	LF	$131	$73,278	
		Remove 1,500 ft of 36 in dia pipe @ <8' depth	36" pipe removal	1500	LF	$174	$261,588	
		Install 510 ft of 18 in dia pipe @ <8' depth	18" dia RCP installation	510	LF	$264	$134,649	
		Install 560 ft of 30 in dia pipe @ <8' depth	30" dia RCP installation	560	LF	$418	$233,913	
		Install 1,500 ft of 48 in dia pipe @ <8' depth	48" dia RCP installation	1500	LF	$735	$1,103,097	
3	Backflow Prevention w/ parallel pipe	Install 750 ft of 48 in dia pipe @ <8' depth	48" dia RCP	750	LF	$735	$551,548	**$2,654,000**
		Install 3 manholes @ <8' depth	Manholes	3	EA	$10,159	$30,477	
4	Backflow Prevention w/ invert adjustment	Adjust 7 manholes @ <8' depth	Manhole adjustment	7	EA	$14,697	$102,876	**$3,226,000**
		Remove 750' of 36" dia. pipe	36" pipe removal	750	LF	$174	$130,794	
		Remove 50' of 24" dia. pipe	24" pipe removal	50	LF	$131	$6,543	
		Install 550' of 36" dia. pipe	36" dia RCP installation	550	LF	$571	$314,214	
		Install 50' of 24" dia. pipe	24" dia RCP installation	50	LF	$345	$17,270	
							First Cost:	**$1,938,700**
							Engineering & Design:	**$387,700**
							Constr. Management:	**$155,100**
							Design & Construction Contingency (30%):	**$744,500**
							TOTAL COST:	**$3,226,000**
Hewlett Harbor (Waverly)								
1	Backflow Prevention	1x In-line backflow prevention device on 48" dia. Outfall installed with cofferdam	48" dia tideflex	1	EA	$58,792	$58,792	**$148,000**
			Cofferdam	0	EA	$64,535	$0	
2	Backflow Prevention w/ increased pipe sizes	1x In-line backflow prevention device on 48" dia. Outfall installed with cofferdam	48" dia tideflex	1	EA	$58,792	$58,792	**$1,480,000**
			Cofferdam	1	EA	$64,535	$64,535	
		Remove 1,200 ft of 48 in dia pipe @ <8' depth	48" pipe removal	1200	LF	$272	$326,106	
		Install 1,200 ft of 60 in dia pipe @ <8' depth	60" dia RCP installation	1200	LF	$793	$951,185	
							First Cost:	**$889,400**
							Engineering & Design:	**$177,900**
							Constr. Management:	**$71,200**
							Design & Construction Contingency (30%):	**$341,600**
							TOTAL COST:	**$1,480,000**

Table 2: Cost Summary – Communities on South Side of the Project Area (cont.)

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett Neck								
1	Backflow Prevention	3x15", 1x24", 1x8" in-line backflow prevention devices	15" dia tideflex	3	EA	$7,396	$22,188	**$108,000**
			24" dia tideflex	1	EA	$12,660	$12,660	
			8" dia tideflex	1	EA	$4,485	$4,485	
2 (Adams Ln)	Backflow Prevention w/ increased pipe sizes and adjusted invert	Remove 700 ft of 8 in dia pipe @ <8' depth	8" pipe removal	700	LF	$88	$61,453	**$676,000**
		Adjust 3 manholes @ <8' depth	Manhole adjustment	3	EA	$14,697	$44,090	
		Install new 30" outfall	30" outfall	1	EA	$197,434	$197,434	
		Install 80 ft of 30 in dia pipe @ <8' depth	30" dia RCP installation	80	LF	$418	$33,416	
		Install 620 ft of 24 in dia pipe @ <8' depth	24" dia RCP installation	620	LF	$345	$214,143	
or 2 (Woodbine Ditch)	Backflow Prevention w/ Woodbine Ditch and Easements Improvements	Remove and replace 4 manholes		4	EA	$14,697	$58,786	**$1,021,000**
		Install 5 manholes		5	EA	$10,159	$50,794	
		Remove 18" RCP		485	LF	$108	$52,358	
		Remove 24"RCP		245	LF	$131	$32,059	
		Install 18" RCP		1550	LF	$264	$409,228	
		Install 24" RCP		245	LF	$345	$84,621	
		Tree Removal (Clearing and Grubbing)	Assume 36" diameter	50	EA	$1,955	$97,743	
		Clearing and Grubbing	Small trees and brush	0.41	AC	$17,833	$7,312	
		Permits		1	LS	$20,000	$20,000	
		Real Estate access	Temporary access	1	LS	$100,000	$100,000	
3 (roadway)	Backflow Prevention w/ Resurfaced/Regraded Road and additional pipes	120,000 sq feet of resurfaced/graded roadway (2" Top, 3" Binder, 6" Base)	Resurfaced roadway	120000	SF	$8.0	$958,467	**$2,089,000**
		Install 5,100 LF of concrete curbs	Concrete curbs	5100	LF	$30.7	$156,339	**$2,542,000**
		Install 8 curb inlet catch basins @<8' depth	Curb inlet catch basins	8	EA	$10,159	$81,271	
		Install 1,520 ft of 12 in dia pipe @ <8' depth	24" dia RCP installation	620	LF	$195	$121,018	
			First Cost:					**$613,600**
			Engineering & Design:					**$122,700**
			Constr. Management:					**$49,100**
			Design & Construction Contingency (30%):					**$235,600**
			TOTAL COST:					**$1,021,000**

Table 2: Cost Summary – Communities on South Side of the Project Area (cont.)

Model Area / Plan	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Total Cost
Lawrence Proposed PRIMARY IMPROVEMENTS							
2	Remove flooding during 1 Year rain events at flood prone locations, Marbridge Rd, Hollywood Xing, and Broadway.	1x In-line backflow prevention device on 60" dia. Outfall (Causeway Rd)	60" dia tideflex	1	EA	$111,791	$111,791
		Remove and Install New Catch Basins	New Catch Basins	16	EA	$8,837	$141,399
		Adjust manholes @ <8' depth	Manhole adjustment	28	EA	$2,254	$63,125.29
		Remove 12 in dia pipe @ <8' depth	12" pipe removal	27	LF	$84	$2,268.50
		Remove 18 in dia pipe @ <8' depth	18" pipe removal	1367	LF	$103	$141,266.32
		Remove 24 in dia pipe @ <8' depth	24" pipe removal	924	LF	$125	$115,724.12
		Remove 30 in dia pipe @ <8' depth	30" pipe removal	1176	LF	$151	$177,923.78
		Remove 36 in dia pipe @ <8' depth	36" pipe removal	1048	LF	$167	$174,927.22
		Remove 60 in dia pipe @ <8' depth	60" pipe removal	267	LF	$259	$69,262.43
		Install 12" dia. pipe	12" dia RCP installation	27	LF	$147	$4,028.99
		Install 18" dia. pipe	18" dia RCP installation	68	LF	$212	$14,350.75
		Install 24" dia. pipe	24" dia RCP installation	0	LF	$290	$0.00
		Install 48" dia. pipe	48" dia RCP installation	153	LF	$660	$100,754.52
		Install 60" dia. pipe	60" dia RCP installation	1300	LF	$861	$1,119,071.72
		Install 72" dia. pipe	72" dia RCP installation	1625	LF	$1,049	$1,705,609.58
		Install 8x4 box culvert	8x4 box culvert install	1596	LF	$1,751	$2,795,393.03
		1x In-line backflow prevention device on 30" dia. Outfall (Meadow Drive)	30" dia tideflex	1	EA	$21,215.88	$21,215.88
		2x In-line backflow prevention device on 12" dia. Outfall (Victoria Place)	12" dia tideflex	2	EA	$4,312.56	$8,625.12
		Install CDS8 Units	CDS Unit	1	EA	$79,141.00	$79,141.00
		Utility Relocation	Utility Relocation	1	LS		$100,000.00
						Subtotal	**$6,946,000**
						First Cost:	$4,174,300
						Engineering & Design:	$834,900
						Constr. Management:	$333,900
						Design & Construction Contingency (30%):	$1,602,900
						SUBTOTAL COST:	**$6,946,000**
Lawrence Proposed UPSTREAM IMPROVEMENTS							
2	Remove flooding during 1 Year rain events at flood prone locations on Meadow Lane upstream of Marbridge Road.						
		Remove and Install New Catch Basins	New Catch Basins	12	EA	$8,837	$106,049
		Adjust manholes @ <8' depth	Manhole adjustment	10	EA	$2,254	$22,544.75
		Remove 18 in dia pipe @ <8' depth	18" pipe removal	263	LF	$103	$27,178.52
		Remove 24 in dia pipe @ <8' depth	24" pipe removal	1580	LF	$125	$197,883.24
		Install 24" dia. pipe	24" dia RCP installation	789	LF	$290	$228,686.35
		Install 48" dia. pipe	48" dia RCP installation	974	LF	$660	$643,043.72
		Install CDS8 Units	CDS Unit	1	EA	$79,141	$79,141.00
		Utility Relocation (larger Pipe Size)	Utility Relocation	1	LS		$25,000.00
						Subtotal	**$1,330,000**
						First Cost:	$799,300
						Engineering & Design:	$159,900
						Constr. Management:	$63,900
						Design & Construction Contingency (30%):	$306,900
						SUBTOTAL COST:	**$1,330,000**
						PROJECT TOTAL	**$8,276,000**
						Total First Cost:	$4,973,600
						Engineering & Design:	$994,700
						Constr. Management:	$397,900
						Design & Construction Contingency (30%):	$1,909,900
						TOTAL COST:	**$8,276,000**

6.0 VILLAGE OF CEDARHURST DRAINAGE ASSESSMENT

The Cedarhurst modeled stormwater system drainage area is shown in Figure 2 below. Only major pipes are shown.

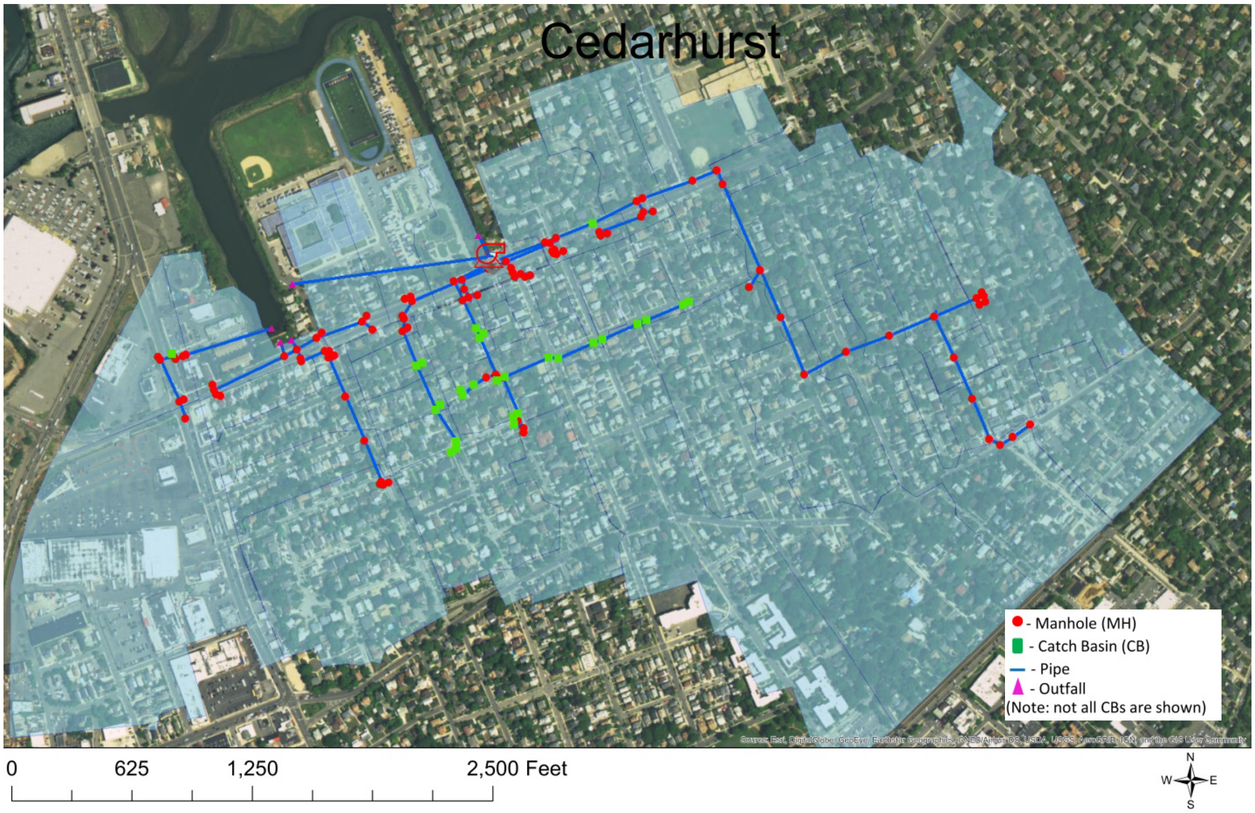


Figure 2: Cedarhurst Drainage Area

6.1 Recommended Cedarhurst Improvements

The following improvements are recommended to limit recurring flooding within the Village. *Throughout the 'Recommended Improvements' sections, the level of flood mitigation is noted in () after the improvement.*

1) **Plan 1: Backflow Prevention (≤2" rainfall) -** The backflow prevention devices at the outfalls at Johnny Jack Park are located upstream from the outfalls near the swirl separators. These devices appear to be functioning properly as upstream flooding during high tide in this area is negligible. However, the drainage networks leading to the outfalls near the old Water Pollution Control Plan (head of Bayview Avenue) are subject to frequent tidal surcharge. The four outfalls would be retrofitted with new, more effective backflow prevention devices to limit tidal surcharging and tidal flooding. Continuous Deflection Separation (CDS) treatment devices would be installed on the outfall lines.

2) **Plan 2: Pump Station (>10-year rainfall) -** The dense development and large drainage area of the Cedarhurst stormwater drainage network contributes a large amount of runoff that quickly

surpasses the capacity of the drainage system during large rainfall events, especially during tidally surcharged or blocked conditions. The most effective way to convey the runoff in those conditions is with a pump station. Several pump station configurations were evaluated with a goal of minimizing costs. The smallest pump station which provided measurable flood mitigation at events larger than a 1-year event (2.8" rainfall) was a 50 cubic feet per second (cfs) pump station. Installation of the pump station alleviates the need for three of the backflow prevention devices and treatment devices. The recommended pump station location is shown in Figure 4.

Recommended improvements are shown in the following figures.

Figure 3: Cedarhurst Plan 1 - Installation of Backflow Prevention

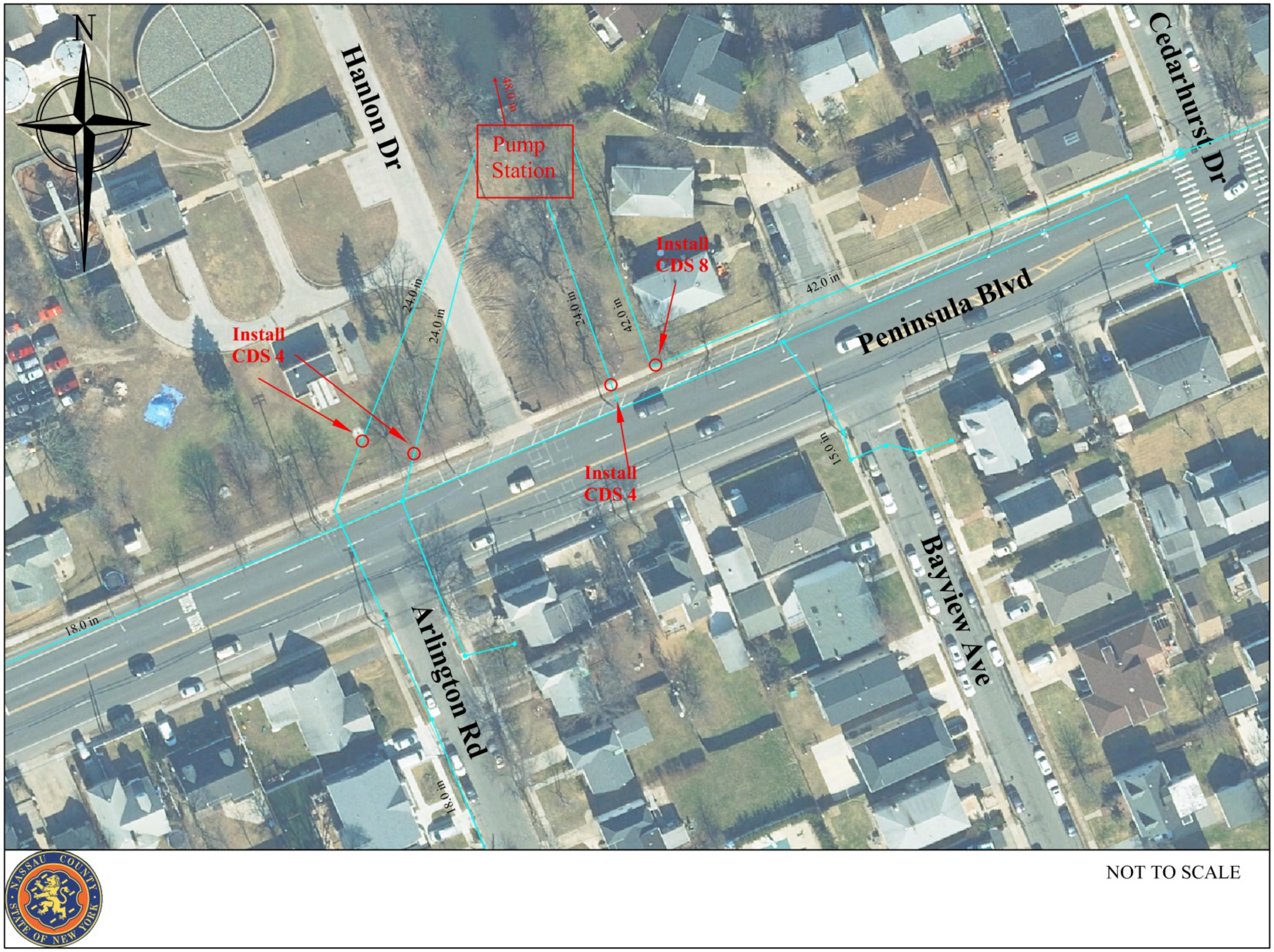


Figure 4: Cedarhurst Plan 2 - Recommended Pump Station

6.2 Cedarhurst Costs

Estimated design and construction costs for the Cedarhurst Plans 1 and 2 are shown below.

Table 3: Cost Estimate: Cedarhurst Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Cedarhurst								
1	Backflow Prevention	4x In-line backflow prevention device on 24'' dia outfall	24" dia tideflex	4	EA	$12,660	$178,507	$316,000
		1x In-line backflow prevention device on 48'' dia outfall	48" dia tideflex	1	EA	$58,792	$137,933	
							First Cost:	$189,900
							Engineering & Design:	$38,000
							Constr. Management:	$15,200
							Design & Construction Contingency (30%):	$72,900
							TOTAL COST:	$316,000

Table 4: Cost Estimate: Cedarhurst Plan 2 – 50 cfs Pump Station

Construction Costs	Description	Quantity	Unit	Unit Cost	Total Cost
02 Relocations	Relocations	Allotment			$50,000
13 Pumping Plants piping					
	Mob. Demob. Prep. Work	3.00%	Job		$46,993
	Traffic Maintenance	2.00%	Job		$31,329
	Excavation	1292.48	CY	$18.08	$23,368
	Filter Fabric	326.19	SY	$2.94	$959
	Riprap	5.00	CY	$71.43	$357
	Common Fill	868.13	CY	$13.79	$11,971
	4' wide pipe bedding, pipe size 24" dia	586.08	LF	$7.70	$4,512
	7' wide pipe bedding, pipe size 48" dia	84.48	LF	$11.75	$993
	Hauling	424.36	CY	$2.36	$1,001
	Disposal	424.36	CY	$25.00	$10,609
	Stripping	54.36	CY	$0.96	$52
	Top Soil	326.19	SY	$78.27	$25,531
	Seeding	2.94	MSF	$110.63	$325
	24" dia RCP	586.08	LF	$78.88	$46,233
	48" dia RCP	84.48	LF	$216.25	$18,269
	48" Tideflex	1.00	EA	$33,649.50	$33,650
	12" Tideflex	1.00	EA	$2,567.00	$2,567
	24" Tidelflex (Plaza Rd)	1.00	CY	$7,246.00	$7,246
13 Pumping Plants Station		50	cfs	Table	$1,328,785
Subtotal				**Construction**	$1,594,749
Subtotal				**Relocation/F&W**	$50,000
Subtotal			**Lands and Damages**		$0
30 Engineering and Design		20%			$328,950
31 Supervision and Admin		8%			$131,580
				Subtotal	$2,105,279
Contingency		30%			$631,584
				TOTAL	**$2,737,000**

6.3 Cedarhurst O&M Costs

Estimated O&M costs for the outfall protection and treatment devices are minor and included inspection and periodic cleaning/pumping. O&M costs for the pump station, which is expected to run frequently, are more significant and are shown in Table 5.

Table 5: Cedarhurst Pump Station O&M Costs

50 cfs Pump Station				
Two 25.00 cfs pumps =	125 hp x 2 pumps =		250	kw
Sump Pump +Misc. =	50 kw/pump * 2 pumps =		100.00	kw
Total power requirements for pump station =	total pump kw + 50 kw/pump [for sump pump, gate, misc.		350	kw
Annual Electrical Power Cost:				
Service Charge =	$450/mo. X 12mo. =	$	5,400	yr
Demand Charge =	$10.50/kw/mo x total required power (kw) x 12mo of use =	$	44,100	yr
Energy Charge =	$0.12/kwh x total required power (kw) x 624hrs =	$	26,208	yr
Total Power Cost =	Service Charge + Demand Charge + Energy Charge =	**$**	**75,700**	yr
Annual Labor Cost [for cleaning/minor repairs/operating pump station]*:				
Labor Cost	52 man days x $800 day =	**$**	**41,600**	yr
	*Includes salary for one person, along with general expenses. (gas, Truck etc.)			
Annualized Replacement Cost:				
Cost of Pumps =	$100,000 each*(2 pumps) + $25,000 =	$	225,000	project life
	project life $ x pwf x crf =	**$**	**4,204**	yr
	Sub-Total	$	121,504	yr
	Contingency		0%	
	Total O&M for 50cfs Pump Station:		**$122,000**	yr
1) All numbers for estimating purposes.				
2) Energy costs were derived from Shrewsbury River Basin; interior drainage annual cost.				
3) Energy charge assumes 4 storms/yr. x 24hrs/storm + 4 tests/yr. x 24hrs/test = 192hrs				
4) This estimate is also based on discussions with personel at Keansburg, NJ (500 cfs pump station).				

7.0 HAMLET OF INWOOD DRAINAGE ASSESSMENT

The Inwood (Town of Hempstead) stormwater system drainage area is shown in Figure 5 below.

Figure 5: Inwood Drainage Area

7.1 Recommended Inwood Improvements

The following improvements are recommended to limit recurring flooding within Inwood:

1) **Plan 1: Backflow Prevention (≤2" rainfall):** The installation of backflow prevention devices at the outfalls at Bayswater Boulevard, Walnut Road and the Chestnut Road/Maple Road system. These installations include the installation of CDS water quality treatment devices. These outfalls are shown in Figures 6 through 9.

Figure 6: Walnut Road Outfall

Figure 7: Maple Road Outfall

Figure 8: Bayswater Boulevard Outfall

2) **Plan 2: Pump Station (>10-year rainfall) -** A pump station at the end of Bayswater Boulevard would help alleviate much of the recurring flooding along that roadway. A 25 cfs pump eliminated much of the existing Bayswater flooding up to the 10-year flood event. However, space for a pump station is a concern. There appears to be adequate space on the Inwood Marina property; however, like the detention basin, an acceptable real estate agreement would be needed to allow for periodic maintenance of the station. A NYSDEC permit for an additional outfall would be required. A plan alignment that eliminates the additional outfall would include a pump station outfall that drains to the Bayswater line. An additional backflow prevention device would be needed upstream to prevent pump-induced backflow. The recommended pump station layout is shown in Figure 10.

3) **Plan 3: Detention Basin/Storage (>10-year rainfall) -** Additional detention was considered for the Bayswater Boulevard drainage line; however, open space is limited. Therefore, an underground system was considered, located under the Town of Hempstead's Inwood Marina parking lot. This underground detention structure would be 70 feet by 130 feet, with a depth of approximately 3 feet. The detention concept included an HDPE arched system, rather than a large concrete system, to allow for infiltration. Due to the narrow size of the drainage area, this

improvement does store a sufficient quantity of runoff to reduce flood elevations. An acceptable real estate agreement would be needed to allow for installation and periodic maintenance of the facility. A NYSDEC permit for an additional outfall would be required. A plan alignment that eliminates the additional outfall would include a storage chamber outfall that drains to the Bayswater line. The recommended layout is shown in Figure 11.

Plan 3 provides a level of flood mitigation similar to Plan 2 at a lower cost and with lower operating costs. **Backflow prevention and treatment systems for the outfalls are included in the pump station and detention plan's costs.**

Recommended improvements are shown in the following figures.

Figure 9: Inwood Plan 1 – Backflow Prevention

Figure 10: Inwood Plan 2 – 25 cfs Pump Station

Figure 11: Inwood Plan 3 – Detention / Storage

7.2 Inwood Costs

Estimated costs for the Inwood Plans 1 through 3 are shown below.

Table 6: Cost Estimate: Inwood Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Inwood								
1	Backflow Prevention	1x In-line backflow prevention device on 42-54" dia outfall, 2x In-line backflow prevention device on 24" dia. Outfalls	54" dia tideflex	1	EA	$76,070	$155,210	$268,000
			24" dia tideflex	1	EA	$12,660	$44,627	
			24" dia tideflex	1	EA	$12,660	$68,214	
							First Cost:	$161,100
							Engineering & Design:	$32,200
							Constr. Management:	$12,900
							Design & Construction Contingency (30%):	$61,900
							TOTAL COST:	$268,000

Table 7: Cost Estimate: Inwood Plan 2 – 25 CFS Pump Station

Construction Costs	Description	Quantity	Unit	Unit Cost	Total Cost
01 Lands and Damages					
	Temporary Easement	0.00		$5,000.00	$0
	Permanent Easement	0.25		$75,000.00	$18,750
Subtotal					**$18,750**
02 Relocations		Allotment			$50,000
13 Pumping Plants piping					
	Mob. Demob. Prep. Work	3.00%	Job		$28,651
	Traffic Maintenance	2.00%	Job		$19,101
	Excavation	783.27	CY	$18.08	$14,162
	Filter Fabric	70.58	SY	$2.94	$208
	Common Fill	123.51	CY	$13.79	$1,703
	2' wide pipe bedding, pipe size 12" dia	161.30	LF	$4.46	$720
	6' wide pipe bedding, pipe size 42" dia	566.90	LF	$21.08	$11,951
	Hauling	659.76	CY	$2.36	$1,557
	Disposal	659.76	CY	$25.00	$16,494
	Stripping	68.96	CY	$0.96	$66
	Top Soil	413.78	SY	$78.27	$32,386
	Seeding	3.72	MSF	$110.63	$412
	12" dia RCP	161	LF	$42.84	$6,911
	42" dia RCP	567		$183.61	$104,089
	12" Tideflex	1.00	EA	$4,485.06	$4,485
	42" Tideflex	1.00	EA	$38,368.51	$38,369
Subtotal				**Construction**	$952,798
Subtotal				**Relocation/F&W**	$50,000
Subtotal				**Lands and Damages**	$18,750
30 Engineering and Design		20%			$200,560
31 Supervision and Admin		8%			$80,224
				Subtotal	$1,302,331
Contingency		30%			$390,699
	Backflow Prevention & CDS	1.00	LS	$268,000.00	$268,000
	(2 x 24" + 42")				
				TOTAL	**$1,961,000**

Table 8: Cost Estimate: Inwood Plan 3 – Detention

Construction Costs	Description	Quantity	Unit	Unit Cost	Total Cost
01 Lands and Damages					$0
	Temporary Easement	0.00		$5,000.00	$0
	Permanent Easement	0.25		$75,000.00	$18,750
Subtotal					**$18,750**
02 Relocations		Allotment			$15,000
11 Drainage Structures					
	Mob. Demob. Prep. Work	3.00%	Job		$4,500
	Traffic Maintenance	2.00%	Job		$8,990
	Excavation	1509.33	CY	$18.08	$27,289
	Filter Fabric	111.11	SY	$2.94	$327
	Common Fill	90.74	CY	$13.79	$1,251
	4' wide pipe bedding, pipe size 24" dia	100.00	LF	$11.49	$1,149
	6' wide pipe bedding, pipe size 36" dia	100.00	LF	$21.08	$2,108
	Hauling	1418.59	CY	$2.36	$3,348
	Disposal	1418.59	CY	$25.00	$35,465
	Stripping	183.89	CY	$0.96	$177
	Top Soil	111.11	SY	$78.27	$8,697
	Seeding	1.00	MSF	$110.63	$111
	24" dia RCP	100.00	LF	$78.88	$7,888
	36" dia RCP	100.00	LF	$153.69	$15,369
	24" dia tideflex	1	EA	$7,246.00	$7,246
	crushed stone bedding	733.40	CY	$33.50	$24,569
	New manhole	1.00	EA	$6,105.08	$6,105
	Parking w/Asphaltic Concrete, 6" stone base, 3" binder course, 2" topping	4.71	SF	$8,930.00	$42,024
	Backflow Prevention & CDS	1.00	LS	$153,142.86	$153,143
	(2x24" + 42")				
	Addtl CDS4	1.00	LS	$19,210.62	$19,211
Stormwater Storage Chambers (23,000 CF)		79042.50	EA	1	$79,043
15 Floodway Control and Diversion					
				Construction	$448,008
Subtotal				**Relocation/F&W**	$15,000
Subtotal				**Lands and Damages**	$18,750
Subtotal					
30 Engineering and Design		20%			$96,352
31 Supervision and Admin		8%			$38,541
				Subtotal	$616,650
Contingency		30%			$184,995
				TOTAL	**$802,000**

7.3 Inwood O&M Costs

Estimated O&M costs for the outfall protection and treatment devices are minor. O&M costs for the pump station, which is expected to run frequently, are more significant and are shown in Table 9. O&M costs for the detention facility are shown in Table 10.

Table 9: Inwood 25cfs Pump Station O&M Costs

25 cfs Pump Station			
One 25.00 cfs pumps =	125 hp x 1 pumps =	125	kw
Sump Pump +Misc. =	50 kw/pump * 1 pumps =	50.00	kw
Total power requirements for pump station =	total pump kw + 50 kw/pump [for sump pump, gate, misc.	175	kw
Annual Electrical Power Cost:			
Service Charge =	$450/mo. X 12mo. =	$ 5,400	yr
Demand Charge =	$10.50/kw/mo x total required power (kw) x 12mo of use =	$ 22,050	yr
Energy Charge =	$0.12/kwh x total required power (kw) x 624hrs =	$ 13,104	yr
Total Power Cost =	Service Charge + Demand Charge + Energy Charge =	**$ 40,600**	yr
Annual Labor Cost [for cleaning/minor repairs/operating pump station]*:			
Labor Cost	52 man days x $800 day =	**$ 41,600**	yr
	*Includes salary for one person, along with general expenses. (gas, Truck etc.)		
Annualized Replacement Cost:			
Cost of Pumps =	$100,000 each*(1 pumps) + $25,000 =	$ 125,000	project life
	project life $ x pwf x crf =	**$ 2,335**	yr
	Sub-Total	$ 84,535	yr
	Contingency	0%	
	Total O&M for 25cfs Pump Station:	**$85,000**	yr
1) All numbers are for estimating purposes.			
2) Energy costs were derived from Shrewsbury River Basin; interior drainage annual cost.			
3) Energy charge assumes 4 storms/yr. x 24hrs/storm + 4 tests/yr. x 24hrs/test = 192hrs			
4) This estimate is also based on discussions with personel at Keansburg, NJ (500 cfs pump station).			
	+ Backflow Prevention Maintenance	$8,200	
	Total Plan 2 O&M	**$93,200**	

Table 10: Inwood Detention Facility O&M Costs

Item	Cost	Present Worth	Capital Recovery	O&M	Notes	Int. Rate
		0.492	0.0379		25 yr	2.875%
Storage Chamber				$3,200	Assume 2 times per year, 1 day	
Storage Chamber	$802,000	$394,846	$14,984			
			TOTAL	**$18,200**		

8.0 HAMLET OF WOODMERE DRAINAGE ASSESSMENT

The Woodmere (Town of Hempstead) drainage system analysis involved the analysis of three distinct drainage networks, N1, N2, and N3 (also referred to as Woodmere1 (N3); Woodmere2 (N4) and Woodmere3 (N5)). The Woodmere stormwater system drainage areas are shown in the following figures.

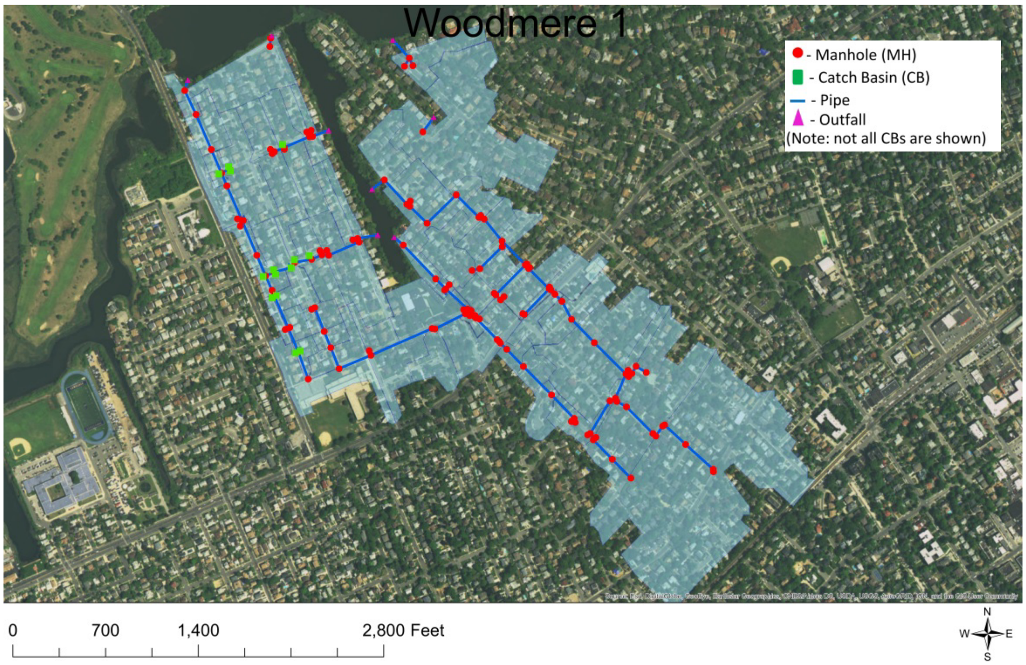


Figure 12: Woodmere1 (N3) Drainage Area

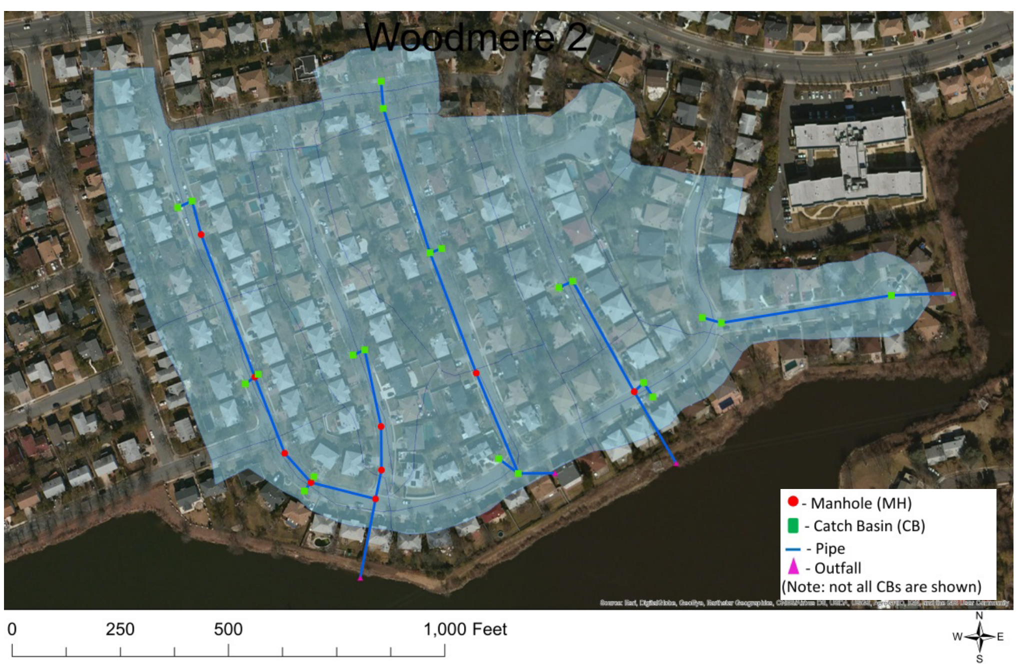


Figure 13: Woodmere2 (N4) Drainage Area

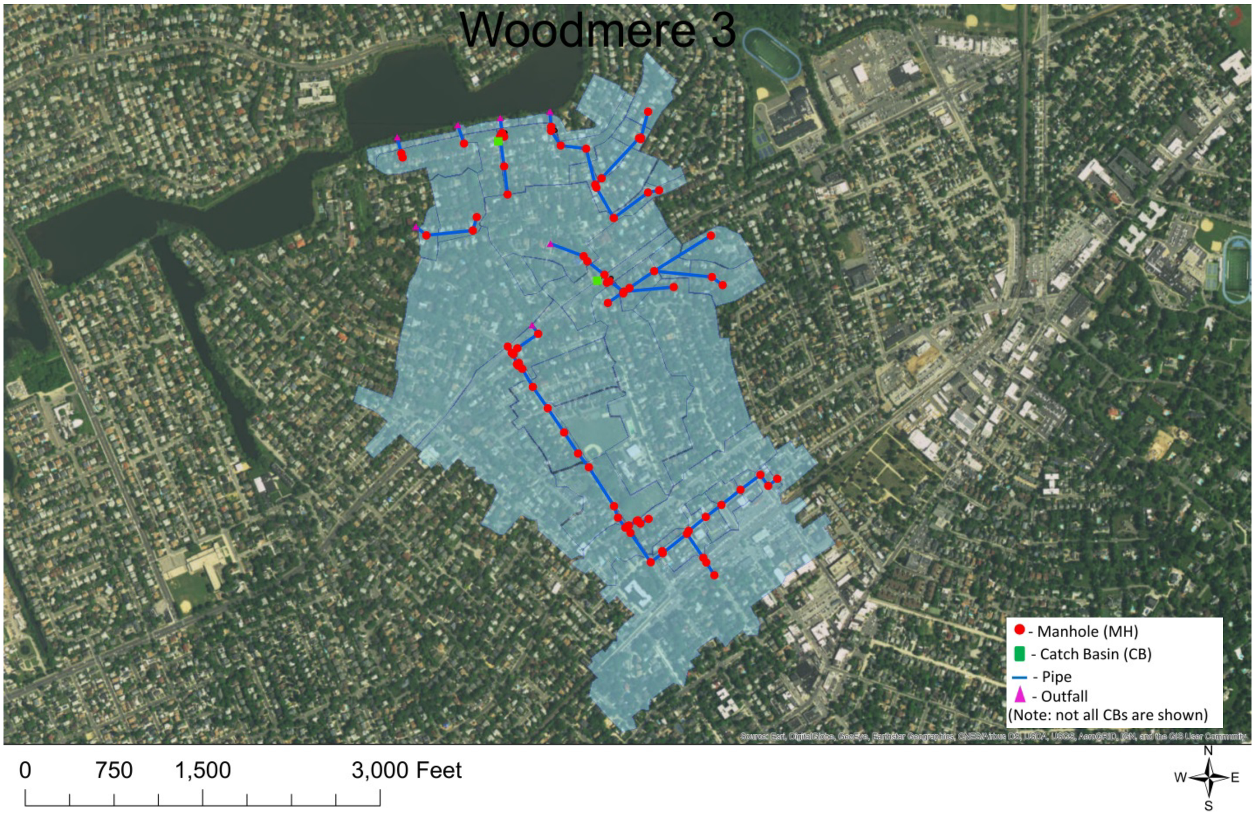


Figure 14: Woodmere3 (N5) Drainage Area

8.1 Recommended Woodmere Improvements

Woodmere is generally protected from large tidal surges by the Cedar Point Lake tide gates. The area is also protected from excessive backwater from the lake by the pump station adjacent to the gates. However, any time the lake level increases due to a large, intense rainfall event, the stormwater drainage system is subject to surcharging, which eliminates storage and risks street flooding at times of continued rainfall. Therefore, the following recommended improvements should limit potential flooding within areas of Woodmere adjacent to Cedar Point Lake:

1) **Plan 1: Backflow Prevention (N3, N4, N5) (≥1-year rainfall) -** The installation of 16 backflow prevention devices at outfalls at Cedar Point Lake (N3: 8 outfalls; N4: 4; N5: 4). The installation of backwater devices includes the installation of CDS treatment devices to treat stormwater effluent. Treatment devices are not added to smaller networks or pipes with small drainage areas (e.g., few catch basins).

2) **Plan 2: Pipe Improvements (N3) (>10-year rainfall) -** Pipe size improvements were evaluated for the Woodmere1 N3 network, primarily for the final pipe reach from the terminal manhole to the outfall, which is most often the controlling drainage feature. Improvements in pipe size will improve conveyance from the drainage network and limit flooding. Backflow prevention is included per Plan 1. In area N3, pipe improvements provide some flood elevation reduction at the 10-year event and may be considered.

3) **Plan 2: Additional Pipe Improvements (N5) (≥1-year rainfall) –** For N5, backflow prevention is included per Plan 1. Flooding conditions are improved in the N5 area through outfall pipe size improvements.

Recommended improvements are shown in the following figures.

Figure 15: Woodmere1 (N3) Plan 1 – Backflow Prevention (8 of 16 outfalls)

Figure 16: Woodmere2 (N4) Plan 1 – Backflow Prevention (4 of 16 outfalls)

Figure 17: Woodmere3 (N5) Plan 1 – Backflow Prevention (4 of 16 outfalls)

Pipe improvements in red.

Figure 18: Woodmere1 (N3) Plan 2 – Pipe Improvements

Pipe improvements in red.

Figure 19: Woodmere3 (N5) Plan 2 – Pipe Improvements

8.2 Woodmere Costs

Estimated costs for the Woodmere Plans 1 and 2 are shown below.

Table 11: Cost Estimate: Woodmere Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Woodmere 1 (N3)								
1	Backflow Prevention	3x In-line backflow prevention device on 24" dia outfall	24" dia tideflex	3	EA	$12,660	$37,981	**$428,000**
		4x In-line backflow prevention device on 30" dia outfall	30" dia tideflex	4	EA	$22,065	$88,258	
		1x In-line backflow prevention device on 36" dia outfall	36" dia tideflex	1	EA	$25,859	$25,859	
Woodmere 2 (N4)								
1	Backflow Prevention	1x In-line backflow prevention device on 24" dia outfall	24" dia tideflex	1	EA	$12,660	$12,660	**$237,000**
		1x In-line backflow prevention device on 18" dia outfall	18" dia tideflex	1	EA	$8,785	$8,785	
		1x In-line backflow prevention device on 18" dia outfall + clearing	18" dia tideflex	1	EA	$28,785	$28,785	
		1x In-line backflow prevention device on 18" dia outfall + repair	18" dia tideflex	1	EA	$58,785	$58,785	
Woodmere 3 (N5)								
1	Backflow Prevention	1x In-line backflow prevention device on 15" dia outfall	15" dia tideflex	1	EA	$7,396	$7,396	**$256,000**
		1x In-line backflow prevention device on 24" dia outfall	24" dia tideflex	1	EA	$12,660	$12,660	
		1x In-line backflow prevention device on 18" dia outfall	18" dia tideflex	1	EA	$8,785	$8,785	
		1x In-line backflow prevention device on 60" dia outfall	60" dia tideflex	1	EA	$116,263	$116,263	
Woodmere - SUMMARY								
1	Backflow Prevention	Backflow Prevention (N3, N4, N5)						**$921,000**
							First Cost:	**$553,500**
							Engineering & Design:	**$110,700**
							Constr. Management:	**$44,300**
							Design & Construction Contingency (30%):	**$212,600**
							TOTAL COST:	**$921,000**

Table 12: Cost Estimate: Woodmere1 (N3) Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Woodmere 1 (N3)								
2	Increase pipe size	Remove 280 ft. of 18" pipe @ <8ft depth. Install 280ft. of 24" pipe @ <8ft. depth	18" pipe removal	280	LF	$108	$30,228	**$1,571,000**
			24" dia RCP installat	280	LF	$345	$96,710	
	Increase pipe size	Remove 130 ft. of 24" pipe @ <8ft depth. Install 130ft. of 30" pipe @ <8ft. depth	24" pipe removal	130	LF	$131	$17,011	
			30" dia RCP installat	130	LF	$418	$54,301	
	Increase pipe size	Remove 365 ft. of 18" pipe @ <8ft depth. Install 365ft. of 24" pipe @ <8ft. depth	18" pipe removal	365	LF	$108	$39,404	
			24" dia RCP installat	365	LF	$345	$126,068	
	Increase pipe size	Remove 150 ft. of 24" pipe @ <8ft depth. Install 150ft. of 30" pipe @ <8ft. depth	24" pipe removal	150	LF	$131	$19,628	
			30" dia RCP installat	150	LF	$418	$62,655	
	Increase pipe size	Remove 93 ft. of 30" pipe @ <8ft depth. Install 93ft. of 36" pipe @ <8ft. depth	30" pipe removal	93	LF	$158	$14,708	
			36" dia RCP installat	93	LF	$571	$53,131	
	Increase pipe size	Remove 186 ft. of 30" pipe @ <8ft depth. Install 186ft. of 36" pipe @ <8ft. depth	30" pipe removal	186	LF	$158	$29,416	
			36" dia RCP installat	186	LF	$571	$106,262	
							First Cost:	**$944,100**
							Engineering & Design:	**$188,800**
							Constr. Management:	**$75,500**
							Design & Construction Contingency (30%):	**$362,500**
							TOTAL COST:	**$1,571,000**

Table 13: Cost Estimate: Woodmere3 (N5) Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Woodmere 3 (N5)								
2	Increase pipe size	Remove 130 ft. of 36" pipe @ <8ft depth. Install 130ft. of 42" pipe @ <8ft. depth	36" pipe removal	130	LF	$174	$22,671	**$641,000**
			42" dia RCP installat	130	LF	$626	$81,408	
	Increase pipe size	Remove 300 ft. of 30" pipe @ <8ft depth. Install 300ft. of 36" pipe @ <8ft. depth	30" pipe removal	300	LF	$158	$47,444	
			36" dia RCP installat	300	LF	$571	$171,390	
	Increase pipe size	Remove 140 ft. of 15" pipe @ <8ft depth. Install 140ft. of 24" pipe @ <8ft. depth	15" pipe removal	140	LF	$100	$13,977	
			24" dia RCP installat	140	LF	$345	$48,355	
							First Cost:	**$385,200**
							Engineering & Design:	**$77,000**
							Constr. Management:	**$30,800**
							Design & Construction Contingency (30%):	**$147,900**
							TOTAL COST:	**$641,000**

9.0 HAMLET OF HEWLETT DRAINAGE ASSESSMENT

The Hewlett drainage system includes drainage networks draining to Doxey Brook, which is normally almost dry except during periods of rain. For this analysis, tailwater within the Brook was used to simulate detrimental tailwater conditions. During the smaller events, flooding in Hewlett was limited or non-existent; flooding only really occurred during periods of high flow in the Brook coupled with rainfall in the drainage area. The Hewlett stormwater system drainage areas are shown in the Figure 20.

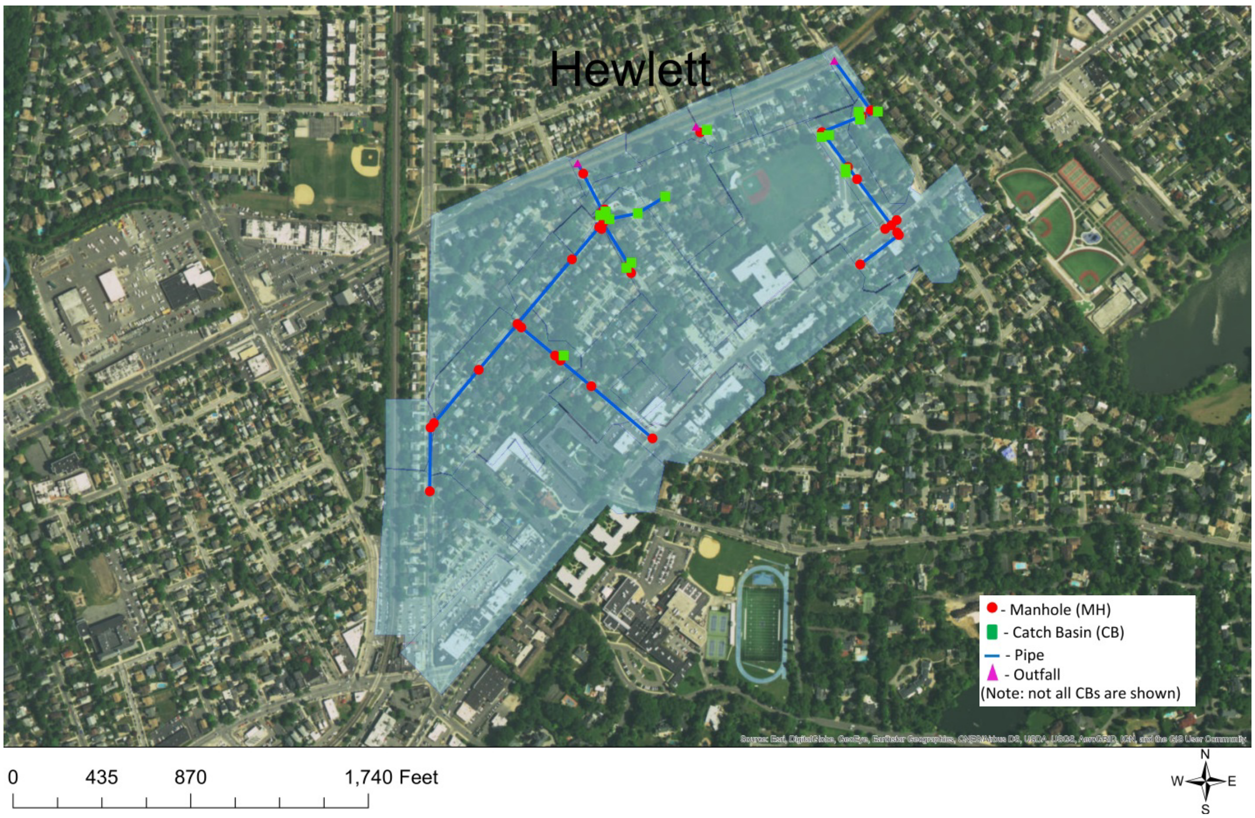


Figure 20: Hewlett Drainage Area

9.1 Recommended Hewlett Drainage Improvements

The following improvements are recommended to limit recurring flooding within the Village. The recommended project flood mitigation is greatest during high flows in Doxey Brook:

1) **Plan 1: Backflow Prevention -** The installation of backflow prevention devices at the outfalls along Doxey Brook, as shown in Figure 21. Small drainage areas will not receive treatment devices because the backwater impact is minimal.

2) **Plan 2: Pipe Improvements -** Pipe size improvements were evaluated for the Hewlett drainage networks. Pipe improvements include the outfall protection and treatment as shown in Plan 1. Changes to the outfall pipes provide some increased conveyance.

Recommended improvements are shown in the following figures.

Figure 21: Hewlett Plan 1 – Backflow Prevention

Pipe improvements in red.

Figure 22: Hewlett Plan 2 – Pipe Improvements

9.2 Hewlett Costs

Estimated costs for Plans 1 and 2 are shown below.

Table 14: Cost Estimate: Hewlett Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett								
1	Backflow Prevention	2x In-line backflow prevention device on 36'' dia outfall	36" dia tideflex	2	EA	$25,859	$210,001	$228,000
		2x In-line backflow prevention device on 18'' dia outfall	18" dia tideflex	2	EA	$8,785	$17,570	
							First Cost:	$137,000
							Engineering & Design:	$27,400
							Constr. Management:	$11,000
							Design & Construction Contingency (30%):	$52,600
							TOTAL COST:	$228,000

Table 15: Cost Estimate: Hewlett Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Detailed Description	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett								
2	Backflow Preven	2x In-line backflow prevention device on 42'' dia outfall	42" dia tideflex	2	EA	$38,369	$235,019	$335,700
	Backflow Preven	2x In-line backflow prevention device on 18'' dia outfall	18" dia tideflex	2	EA	$8,785	$17,570	
	Increase pipe size	Remove 45 ft. of 36'' pipe @ <8ft depth. Install 45ft. of 42'' pipe @ <8ft. depth	36" pipe removal	45	LF	$174	$7,848	
			42" dia RCP installat	45	LF	$626	$28,180	
	Increase pipe size	Remove 60 ft. of 30'' pipe @ <8ft depth. Install 60ft. of 42'' pipe @ <8ft. depth	30" pipe removal	60	LF	$158	$9,489	
			42" dia RCP installat	60	LF	$626	$37,573	
							First Cost:	$201,700
							Engineering & Design:	$40,300
							Constr. Management:	$16,100
							Design & Construction Contingency (30%):	$77,400
							TOTAL COST:	$335,700

10.0 VILLAGE OF LAWRENCE DRAINAGE ASSESSMENT

The Village of Lawrence stormwater system drainage area is shown in Figure 23 below.

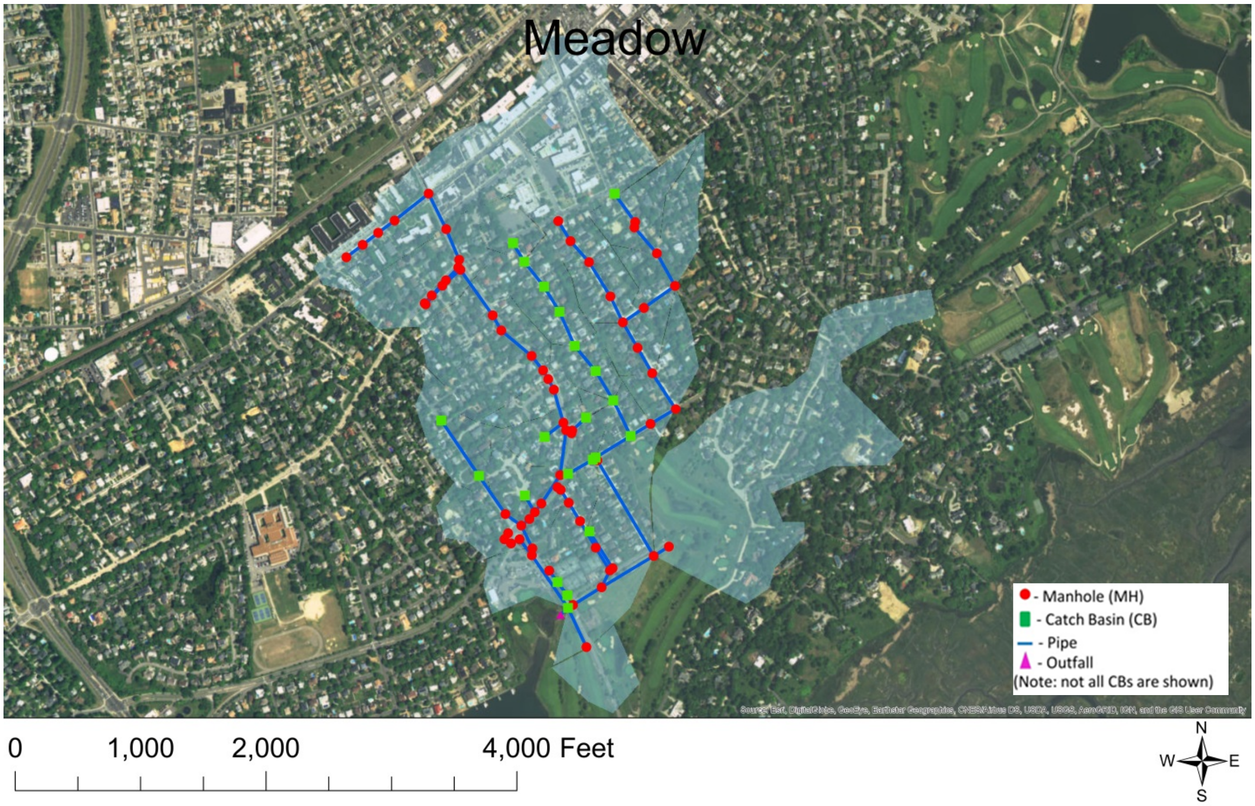


Figure 23: Lawrence Drainage Area

10.1 Recommended Lawrence Improvements

The following improvements to the existing storm water collection system are recommended to limit recurring flooding within the Village:

1) **Plan 1: Backflow Prevention (1-year rainfall) -** The installation of a new backflow prevention device at the 60" dia. outfall near Causeway Road and North Street. This will be in addition to the backflow device downstream on the pond outfall. The additional backflow device will protect the system from surcharging from overtopping or flanking of the golf cart path. Additional backflow prevention devices are recommended for the small pipes at Albert Place and Meadow Drive as shown in the figures.

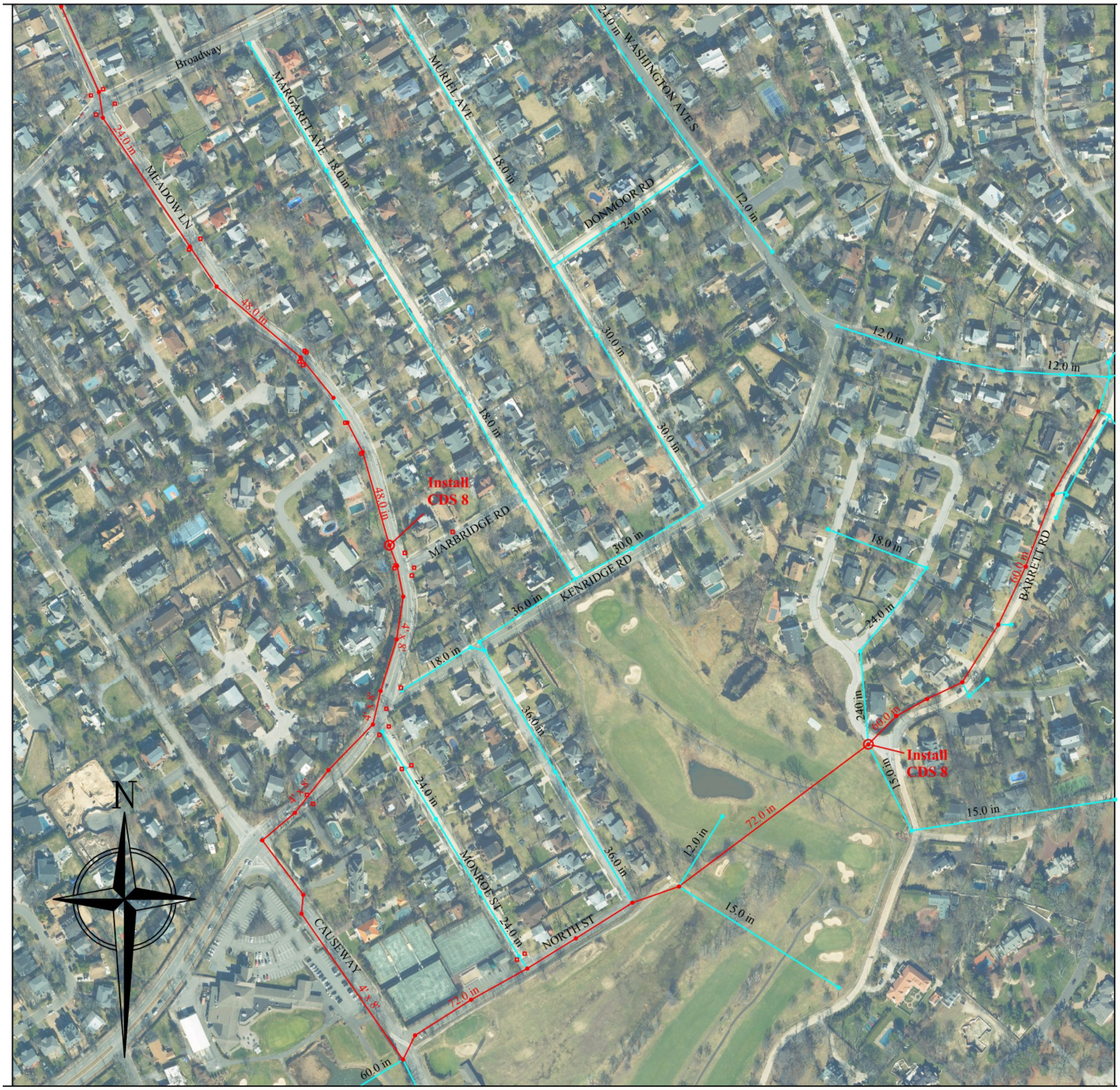
2) **Plan 2: Pipe Improvements (1-year rainfall) -** Pipe size improvements were evaluated for the Lawrence storm water drainage network which included the increase of diameters for those sections of piping that were at capacity and/or surcharged during normal rain events. Additionally, pipe slopes were evaluated, based on the elevation of the outfall, to have proper slopes for adequate drainage, and catch basins that were determined to be inadequate to collect surface flow during rain events were located and should be replaced with new properly installed catch basins. The Pipe Improvement Plan includes two components: the Primary Improvements and Upstream Improvements.

Recommended improvements are shown in the following figures.

Figure 24: Lawrence Plan 1 – 60" Backflow Prevention and CDS

Figure 25: Lawrence Plan 1 – Backflow Prevention at Albert Place

Figure 26: Lawrence Plan 1 – Backflow Prevention at Meadow Drive



Pipe improvements in red.

Figure 27: Lawrence Plan 2 – Pipe Improvements (Complete Plan)

Pipe improvements in red.

Figure 28: Lawrence Plan 2 –Pipe Improvements (Primary Plan)

Pipe improvements in red.

Figure 29: Lawrence Plan 2 – Pipe Improvements (Upstream Portion)

10.2 Lawrence Costs

Estimated costs for Lawrence Plans 1 and 2 are shown below.

Table 16: Cost Estimate: Lawrence Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Lawrence (Meadow)								
1	Backflow Prevention	1x In-line backflow prevention device on 60" dia. Outfall + 1 x 24" dia. Outfalls + 2 x 12" dia. Outfalls	Tideflex	1	EA	$137,893	$383,695	**$384,000**
							First Cost:	**$230,800**
							Engineering & Design:	**$46,200**
							Constr. Management:	**$18,500**
							Design & Construction Contingency (30%):	**$88,700**
							TOTAL COST:	**$384,000**

Table 17: Cost Estimate: Lawrence Plan 2 – Pipe Improvements (All)

Model Area / Plan	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Total Cost
Lawrence Proposed PRIMARY IMPROVEMENTS							
2	Remove flooding during 1 Year rain events at flood prone locations, Marbridge Rd, Hollywood Xing, and Broadway.	1x In-line backflow prevention device on 60" dia. Outfall (Causeway Rd)	60" dia tideflex	1	EA	$111,791	$111,791
		Remove and Install New Catch Basins	New Catch Basins	16	EA	$8,837	$141,399
		Adjust manholes @ <8' depth	Manhole adjustment	28	EA	$2,254	$63,125.29
		Remove 12 in dia pipe @ <8' depth	12" pipe removal	27	LF	$84	$2,268.50
		Remove 18 in dia pipe @ <8' depth	18" pipe removal	1367	LF	$103	$141,266.32
		Remove 24 in dia pipe @ <8' depth	24" pipe removal	924	LF	$125	$115,724.12
		Remove 30 in dia pipe @ <8' depth	30" pipe removal	1176	LF	$151	$177,923.78
		Remove 36 in dia pipe @ <8' depth	36" pipe removal	1048	LF	$167	$174,927.22
		Remove 60 in dia pipe @ <8' depth	60" pipe removal	267	LF	$259	$69,262.43
		Install 12” dia. pipe	12" dia RCP installation	27	LF	$147	$4,028.99
		Install 18” dia. pipe	18" dia RCP installation	68	LF	$212	$14,350.75
		Install 24” dia. pipe	24" dia RCP installation	0	LF	$290	$0.00
		Install 48” dia. pipe	48" dia RCP installation	153	LF	$660	$100,754.52
		Install 60” dia. pipe	60" dia RCP installation	1300	LF	$861	$1,119,071.72
		Install 72” dia. pipe	72" dia RCP installation	1625	LF	$1,049	$1,705,609.58
		Install 8x4 box culvert	8x4 box culvert install	1596	LF	$1,751	$2,795,393.03
		1x In-line backflow prevention device on 30" dia. Outfall (Meadow Drive)	30" dia tideflex	1	EA	$21,215.88	$21,215.88
		2x In-line backflow prevention device on 12" dia. Outfall (Victoria Place)	12" dia tideflex	2	EA	$4,312.56	$8,625.12
		Install CDS8 Units	CDS Unit	1	EA	$79,141.00	$79,141.00
		Utility Relocation	Utility Relocation	1	LS		$100,000.00
Lawrence Proposed UPSTREAM IMPROVEMENTS							
2	Remove flooding during 1 Year rain events at flood prone locations on Meadow Lane upstream of Marbridge Road.						
		Remove and Install New Catch Basins	New Catch Basins	12	EA	$8,837	$106,049
		Adjust manholes @ <8' depth	Manhole adjustment	10	EA	$2,254	$22,544.75
		Remove 18 in dia pipe @ <8' depth	18" pipe removal	263	LF	$103	$27,178.52
		Remove 24 in dia pipe @ <8' depth	24" pipe removal	1580	LF	$125	$197,883.24
		Install 24” dia. pipe	24" dia RCP installation	789	LF	$290	$228,686.35
		Install 48” dia. pipe	48" dia RCP installation	974	LF	$660	$643,043.72
		Install CDS8 Units	CDS Unit	1	EA	$79,141	$79,141.00
		Utility Relocation (larger Pipe Size)	Utility Relocation	1	LS		$25,000.00
						Total First Cost:	$4,973,600
						Engineering & Design:	$994,700
						Constr. Management:	$397,900
						Design & Construction Contingency (30%):	$1,909,900
						TOTAL COST:	**$8,276,000**

Table 18: Cost Estimate: Lawrence Plan 2 – Pipe Improvements (Primary Plan)

Model Area / Plan	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Total Cost
Lawrence Proposed PRIMARY IMPROVEMENTS							
2	Remove flooding during 1 Year rain events at flood prone locations, Marbridge Rd, Hollywood Xing, and Broadway.	1x In-line backflow prevention device on 60" dia. Outfall (Causeway Rd)	60" dia tideflex	1	EA	$111,791	$111,791
		Remove and Install New Catch Basins	New Catch Basins	16	EA	$8,837	$141,399
		Adjust manholes @ <8' depth	Manhole adjustment	28	EA	$2,254	$63,125.29
		Remove 12 in dia pipe @ <8' depth	12" pipe removal	27	LF	$84	$2,268.50
		Remove 18 in dia pipe @ <8' depth	18" pipe removal	1367	LF	$103	$141,266.32
		Remove 24 in dia pipe @ <8' depth	24" pipe removal	924	LF	$125	$115,724.12
		Remove 30 in dia pipe @ <8' depth	30" pipe removal	1176	LF	$151	$177,923.78
		Remove 36 in dia pipe @ <8' depth	36" pipe removal	1048	LF	$167	$174,927.22
		Remove 60 in dia pipe @ <8' depth	60" pipe removal	267	LF	$259	$69,262.43
		Install 12" dia. pipe	12" dia RCP installation	27	LF	$147	$4,028.99
		Install 18" dia. pipe	18" dia RCP installation	68	LF	$212	$14,350.75
		Install 24" dia. pipe	24" dia RCP installation	0	LF	$290	$0.00
		Install 48" dia. pipe	48" dia RCP installation	153	LF	$660	$100,754.52
		Install 60" dia. pipe	60" dia RCP installation	1300	LF	$861	$1,119,071.72
		Install 72" dia. pipe	72" dia RCP installation	1625	LF	$1,049	$1,705,609.58
		Install 8x4 box culvert	8x4 box culvert install	1596	LF	$1,751	$2,795,393.03
		1x In-line backflow prevention device on 30" dia. Outfall (Meadow Drive)	30" dia tideflex	1	EA	$21,215.88	$21,215.88
		2x In-line backflow prevention device on 12" dia. Outfall (Victoria Place)	12" dia tideflex	2	EA	$4,312.56	$8,625.12
		Install CDS8 Units	CDS Unit	1	EA	$79,141.00	$79,141.00
		Utility Relocation	Utility Relocation	1	LS		$100,000.00
						Subtotal	**$6,946,000**
						First Cost:	$4,174,300
						Engineering & Design:	$834,900
						Constr. Management:	$333,900
						Design & Construction Contingency (30%):	$1,602,900
						SUBTOTAL COST:	**$6,946,000**

Table 19: Cost Estimate: Lawrence Plan 2 – Pipe Improvements (Upstream Portion)

Model Area / Plan	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Total Cost
Lawrence Proposed UPSTREAM IMPROVEMENTS							
2	Remove flooding during 1 Year rain events at flood prone locations on Meadow Lane upstream of Marbridge Road.	Remove and Install New Catch Basins	New Catch Basins	12	EA	$8,837	$106,049
		Adjust manholes @ <8' depth	Manhole adjustment	10	EA	$2,254	$22,544.75
		Remove 18 in dia pipe @ <8' depth	18" pipe removal	263	LF	$103	$27,178.52
		Remove 24 in dia pipe @ <8' depth	24" pipe removal	1580	LF	$125	$197,883.24
		Install 24" dia. pipe	24" dia RCP installation	789	LF	$290	$228,686.35
		Install 48" dia. pipe	48" dia RCP installation	974	LF	$660	$643,043.72
		Install CDS8 Units	CDS Unit	1	EA	$79,141	$79,141.00
		Utility Relocation (larger Pipe Size)	Utility Relocation	1	LS		$25,000.00
						Subtotal	**$1,330,000**
						First Cost:	$799,300
						Engineering & Design:	$159,900
						Constr. Management:	$63,900
						Design & Construction Contingency (30%):	$306,900
						SUBTOTAL COST:	**$1,330,000**

11.0 VILLAGE OF WOODSBURGH DRAINAGE ASSESSMENT

The Woodsburgh stormwater system drainage areas are shown in Figures 30 and 31 below.

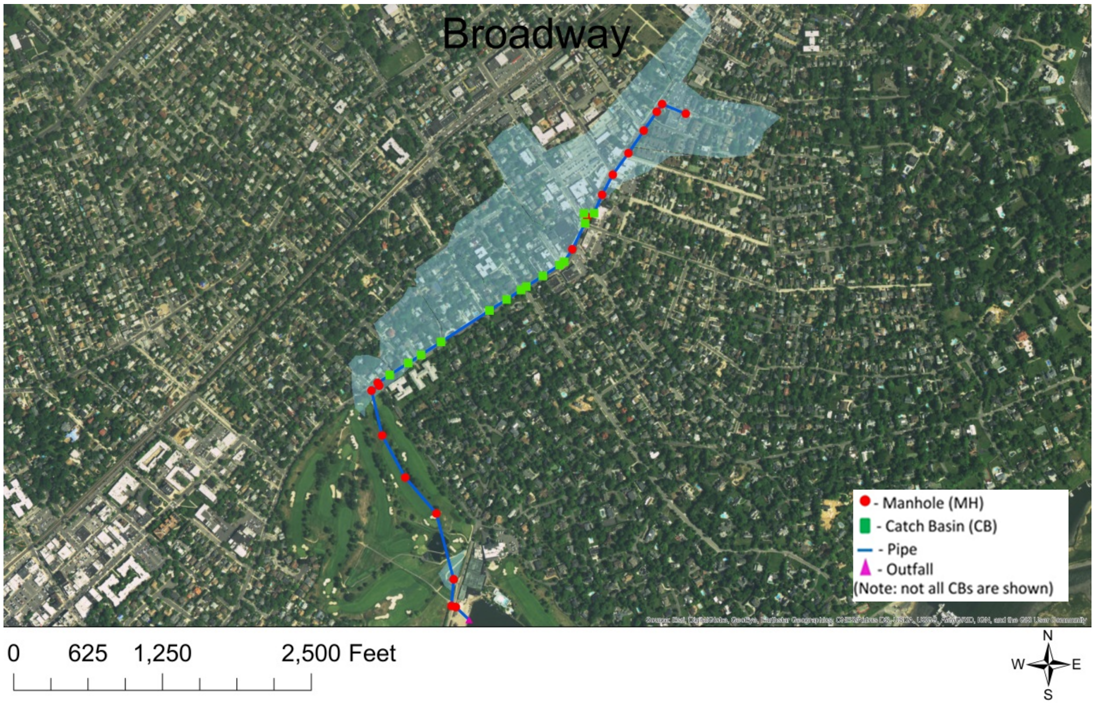


Figure 30: Woodsburgh (Broadway) Drainage Area

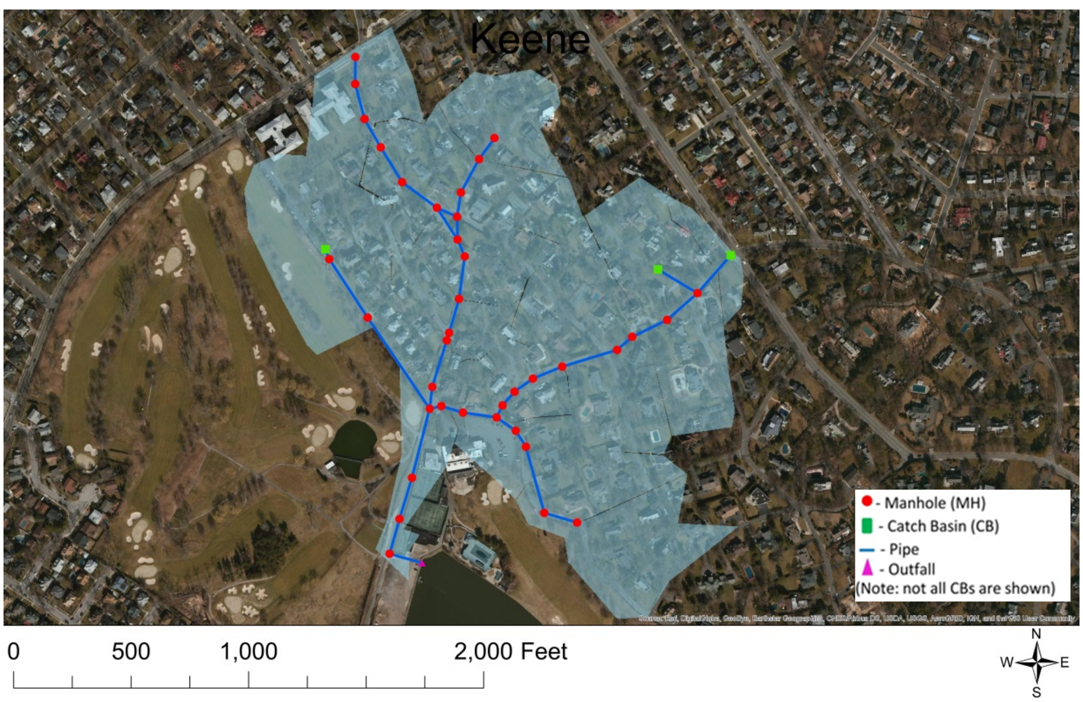


Figure 31: Woodsburgh (Keene) Drainage Area

11.1 Recommended Woodsburgh Improvements

The following improvements are recommended to limit recurring flooding within the Village. The plans and subsequent costs are cumulative:

1) **Plan 1: Backflow Prevention (60" Outfall) (≤10-year rainfall) -** The installation of new backflow prevention device at the 60" outfall on Railroad Avenue. A CDS treatment device is to be installed upstream.
2) **Plan 2: Pipe Improvements (≤10-year rainfall) -** Pipe size improvements were evaluated for the drainage network which served the 60"t outfall, and included the increase of pipe diameters that were at capacity and/or surcharged during normal rain events as well as providing proper slopes for adequate drainage. Backflow prevention and CDS installation are included.
3) **Plan 3: Backflow Prevention (36" Outfall) (≤10-year rainfall) -** The installation of new backflow prevention device at the 36" outfall also at Railroad Avenue. A CDS treatment device is to be installed upstream.
4) **Plan 4: Pipe Improvements (≤10-year rainfall) -** Pipe size improvements were evaluated for the drainage network which served the 36" outfall, and included the increase of pipe diameters that were at capacity and/or surcharged during normal rain events as well as providing proper slopes for adequate drainage. Backflow prevention and CDS installation are included.

Recommended improvements are shown in the following figures.

Figure 32: Woodsburgh (Broadway) Plan 1 – Backflow Prevention

Pipe improvements in red.

Figure 33: Woodsburgh (Broadway) Plan 2 – Pipe Improvements

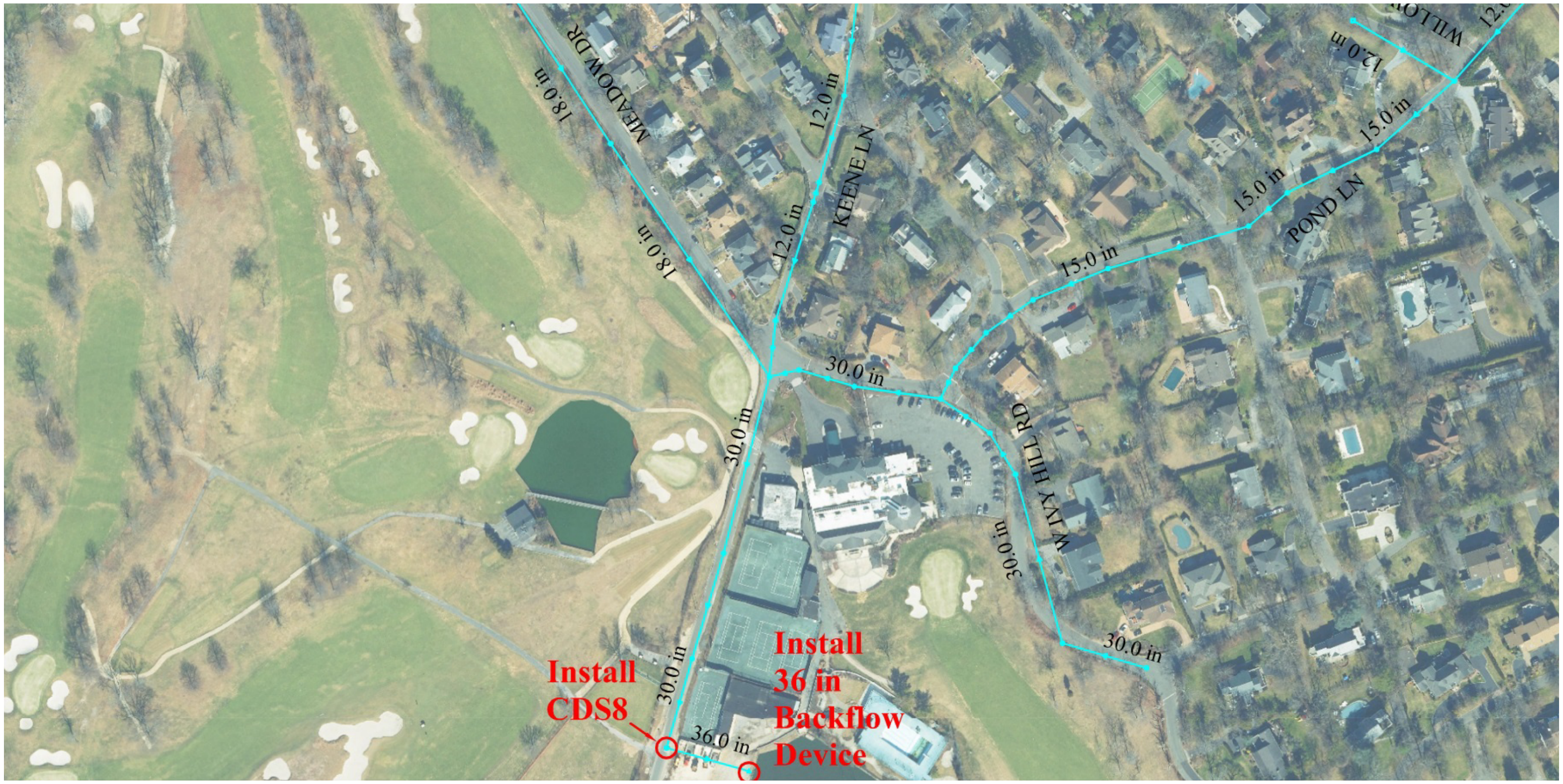
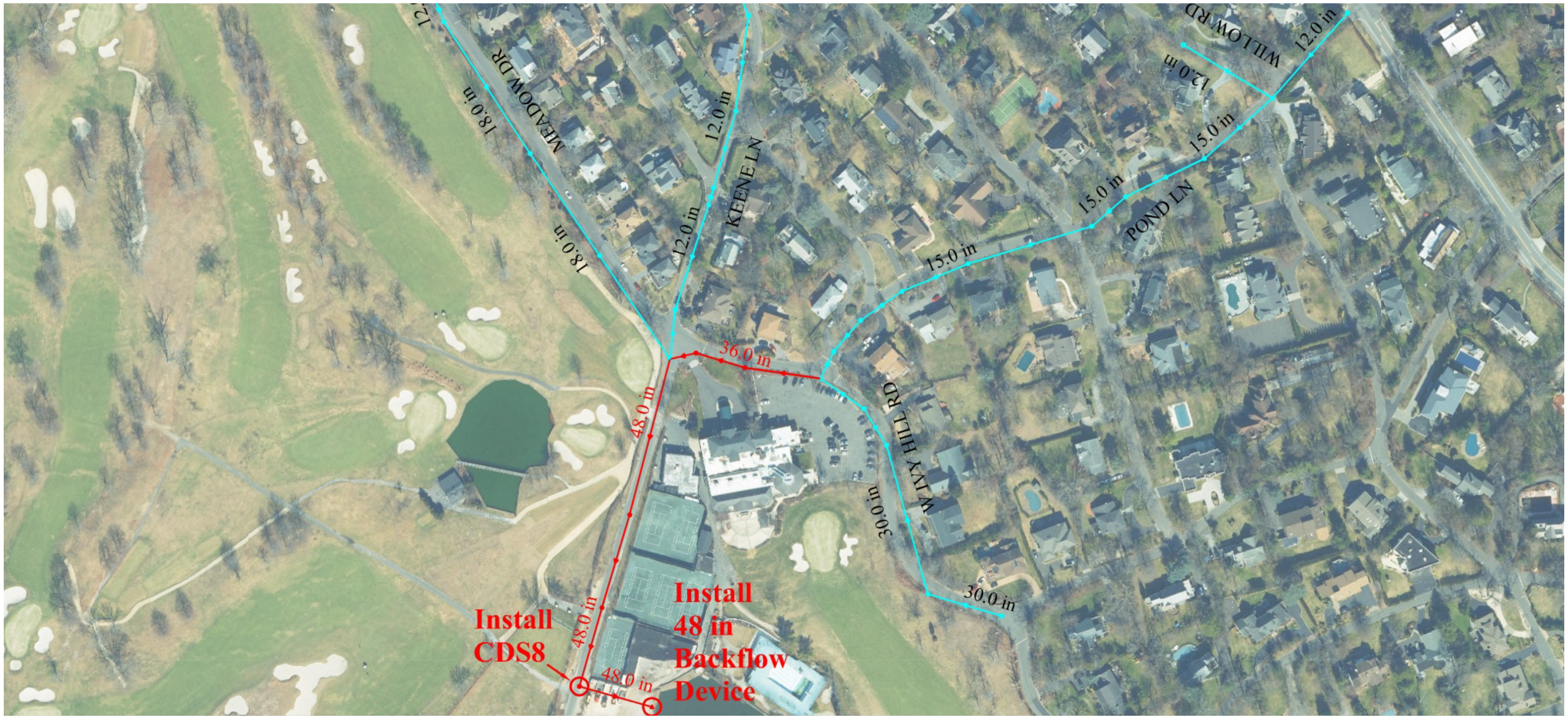


Figure 34: Woodsburgh (Keene) Plan 3 – 36" Backflow Prevention



Pipe improvements in red.

Figure 35: Woodsburgh (Keene) Plan 4 – Pipe Improvements

11.2 Woodsburgh Costs

Estimated costs for Woodsburgh plans 1 through 4 are shown below. These plan costs are cumulative.

Table 20: Cost Estimate: Woodsburgh Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
Woodsburgh (Broadway)										
1	Backflow Prevention	1x In-line backflow prevention device on 6ftx4ft ellipse Outfall	6'x4' tideflex	1	EA	$129,984	$129,984	**$209,000**	$79,141	CDS8
							First Cost:	**$125,600**		
							Engineering & Design:	**$25,100**		
							Constr. Management:	**$10,000**		
							Design & Construction Contingency (30%):	**$48,200**		
							TOTAL COST:	**$209,000**		

Table 21: Cost Estimate: Woodsburgh Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
2	Backflow Prevention w/ increase pipe sizes & adjusted inverts	Remove 1,400 ft of 15 in dia. Pipe @<8' depth	15" pipe removal	1400	LF	$100	$139,767	**$836,000**
		Install 1,400 ft of 18 in dia. Pipe @ <8' depth	18" dia RCP installation	1400	LF	$264	$369,625	
		Adjust 8 manholes @ <8' depth	Manhole adjustment	8	EA	$14,697	$117,573	
							First Cost:	**$502,400**
							Engineering & Design:	**$100,500**
							Constr. Management:	**$40,200**
							Design & Construction Contingency (30%):	**$192,900**
							TOTAL COST:	**$836,000**

Table 22: Cost Estimate: Woodsburgh Plan 3 – Backflow Prevention & Plan 2

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
Woodsburgh (Keene)										
3	Backflow Prevention	1x In-line backflow prevention device on 36" dia. Outfall	36" dia tideflex	1	EA	$25,859	$25,859	**$941,000**	$79,141	CDS 8
							First Cost:	**$565,500**		
							Engineering & Design:	**$113,100**		
							Constr. Management:	**$45,200**		
							Design & Construction Contingency (30%):	**$217,100**		
							TOTAL COST:	**$941,000**		

Table 23: Cost Estimate: Woodsburgh Plan 4 – Combined Pipe Improvements & Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Woodsburgh (Keene)								
4	Backflow Prevention w/ increase pipe sizes	Remove 1,100 ft of 30 in dia pipe @ <8' depth	30" pipe removal	1100	LF	$158	$173,963	**$1,875,000**
		Install 300 ft of 36 in dia pipe @ <8' depth	36" dia RCP installation	300	LF	$571	$171,390	
		Install 800 ft of 48 in dia pipe @ <8' depth	48" dia RCP installation	800	LF	$735	$588,318	
							First Cost:	**$1,126,800**
							Engineering & Design:	**$225,400**
							Constr. Management:	**$90,100**
							Design & Construction Contingency (30%):	**$432,700**
							TOTAL COST:	**$1,875,000**

12.0 VILLAGE OF HEWLETT BAY PARK DRAINAGE ASSESSMENT

The Hewlett Bay Park stormwater system drainage area is shown in Figure 36 below.

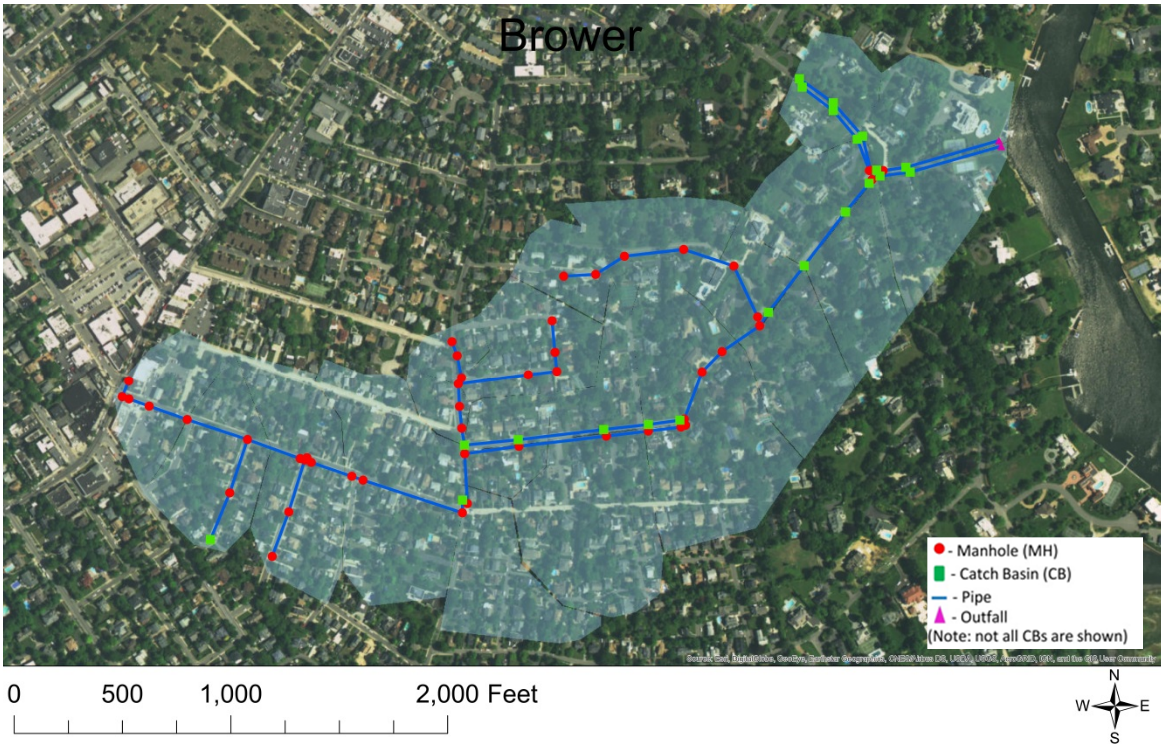


Figure 36: Hewlett Bay Park Drainage Area

12.1 Recommended Hewlett Bay Park Improvements

The following improvements are recommended to limit recurring flooding within the Village:

1) **Plan 1: Backflow Prevention (≤10-year rainfall) -** The installation of backflow prevention devices at the 60" diameter outfall and 36" diameter outfall at the terminus of Lefferts Road. This plan includes the installation of a CDS treatment device on the 36" outfall. A CDS cannot be installed on the 60" outfall due to excessive flows during the water quality storm event.

2) **Plan 2: Pipe Improvements (≤10-year rainfall) -** Pipe size improvements were evaluated for the Hewlett Bay Park drainage network which included the increase of pipe diameters that were at capacity and/or surcharged during normal rain events. Pipe improvements include the installation of backflow prevention and the treatment device in Plan 1.

3) **Plan 3: Additional Storage Improvements (≥1-year rainfall):** Parallel pipes were added to supplement pipes that were determined to be at capacity and/or surcharged during normal rain events, but could not be considered for diameter increase and slope adjustment

4) **Plan 4: Additional Pipe Improvements (≥1-year rainfall):** Pipe slopes were evaluated, based on the elevation of the outfall, the existing piping have proper slopes for adequate drainage.

Recommended improvements are shown in the following figures.

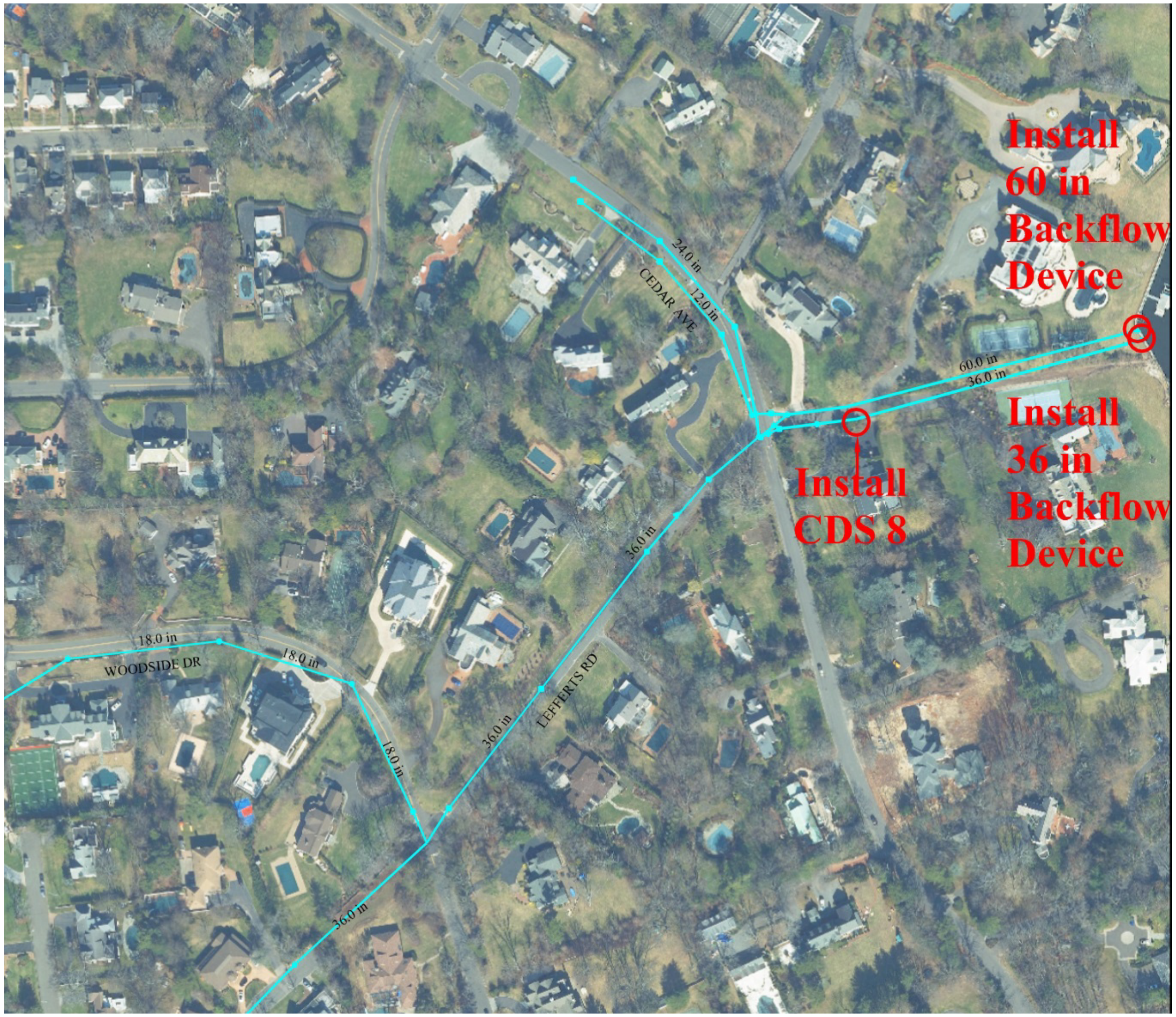
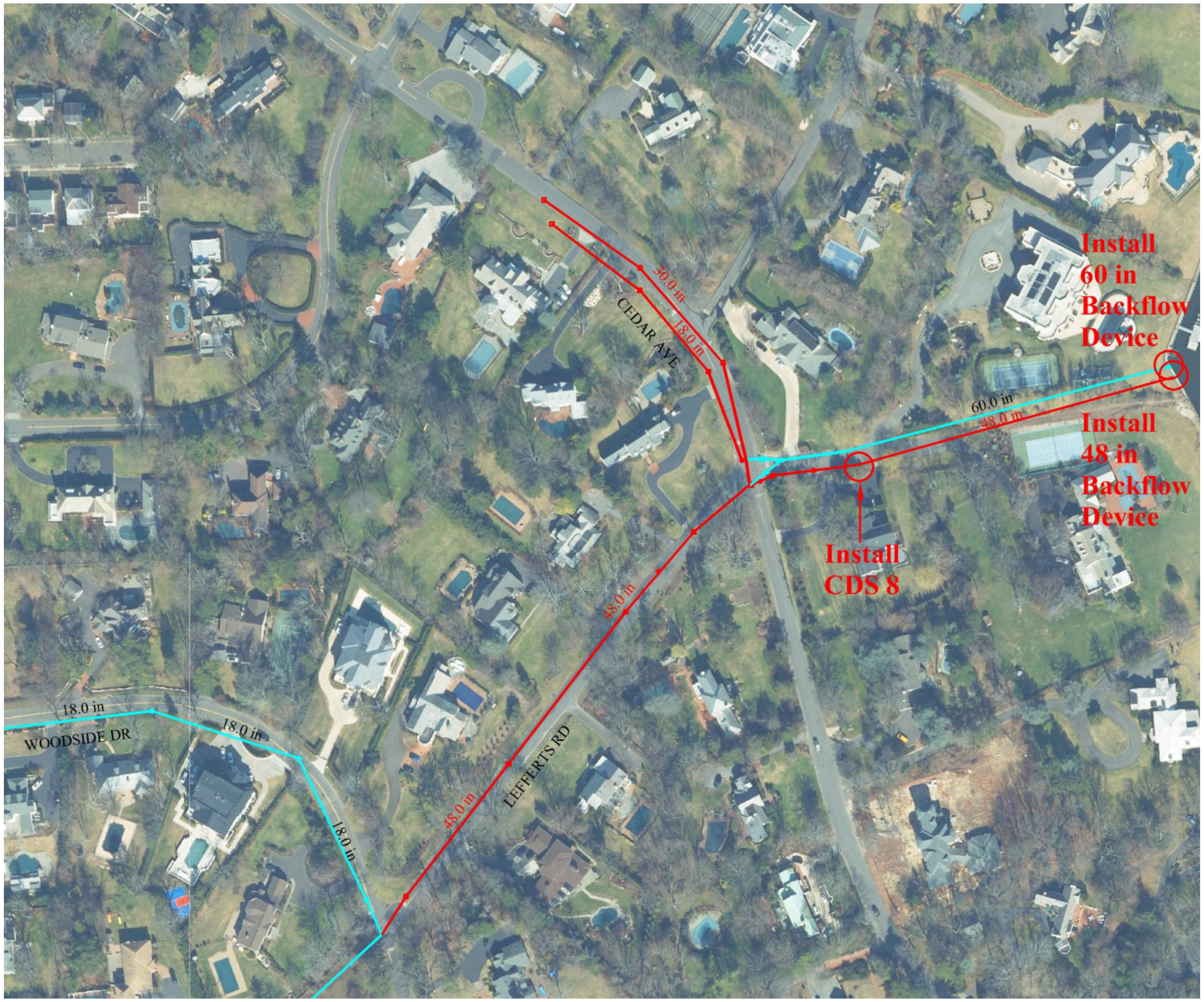
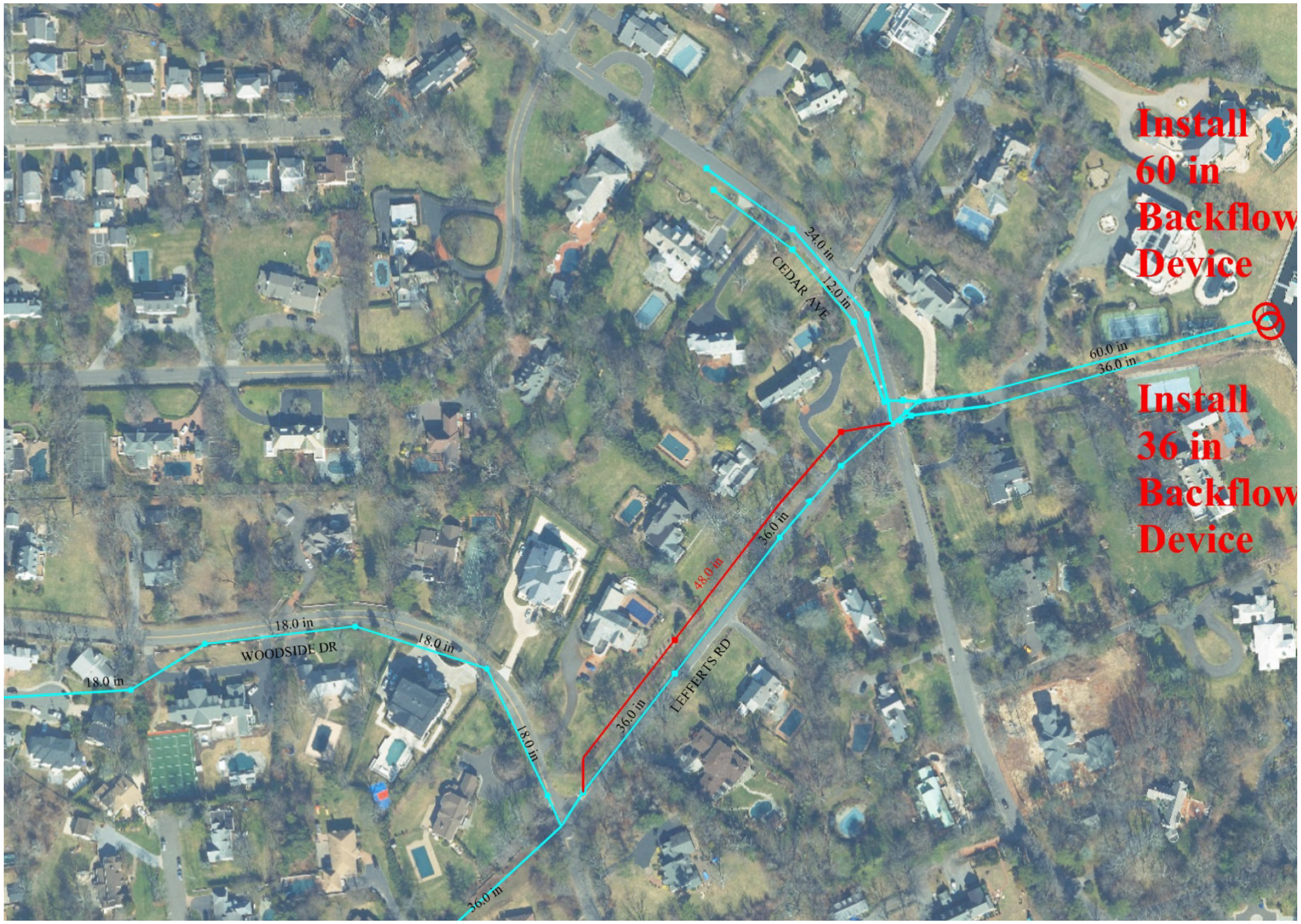


Figure 37: Hewlett Bay Park Plan 1 – Backflow Prevention



Pipe improvements in red.

Figure 38: Hewlett Bay Park Plan 2 – Pipe Improvements



Pipe improvements in red.

Figure 39: Hewlett Bay Park Plan 3 – Parallel Pipe

Pipe improvements in red.

Figure 40: Hewlett Bay Park Plan 4 – Pipe Improvements

12.2 Hewlett Bay Park Costs

Estimated costs for the Hewlett Bay Park plans 1 through 4 are shown below. Plan costs are cumulative from 1 to 4.

Table 24: Cost Estimate: Hewlett Bay Park Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
Hewlett Bay Park (Brower)										
1	Backflow Prevention	2x In-line backflow prevention device on 36" dia. & 60" Outfalls	36" dia tideflex	1	EA	$25,859	$25,859	$221,000	$79,141	CDS 8
			60" dia tideflex	1	EA	$116,263	$116,263		No device for 60" flows too high	
							First Cost:	$132,800		
							Engineering & Design:	$26,600		
							Constr. Management:	$10,600		
							Design & Construction Contingency (30%):	$51,000		
							TOTAL COST:	$221,000		

Table 25: Cost Estimate: Hewlett Bay Park Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett Bay Park (Brower)								
2	Backflow Prevention w/ increase pipe sizes	Remove 510 ft of 12 in dia pipe @ <8' depth	12" pipe removal	510	LF	$88	$44,773	$2,072,000
		Remove 560 ft of 24 in dia pipe @ <8' depth	24" pipe removal	560	LF	$131	$73,278	
		Remove 1,500 ft of 36 in dia pipe @ <8' depth	36" pipe removal	1500	LF	$174	$261,588	
		Install 510 ft of 18 in dia pipe @ <8' depth	18" dia RCP installation	510	LF	$264	$134,649	
		Install 560 ft of 30 in dia pipe @ <8' depth	30" dia RCP installation	560	LF	$418	$233,913	
		Install 1,500 ft of 48 in dia pipe @ <8' depth	48" dia RCP installation	1500	LF	$735	$1,103,097	
							First Cost:	$1,245,200
							Engineering & Design:	$249,000
							Constr. Management:	$99,600
							Design & Construction Contingency (30%):	$478,100
							TOTAL COST:	$2,072,000

Table 26: Cost Estimate: Hewlett Bay Park Plan 3 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett Bay Park (Brower)								
3	Backflow Prevention w/ parallel pipe	Install 750 ft of 48 in dia pipe @ <8' depth	48" dia RCP	750	LF	$735	$551,548	$2,654,000
		Install 3 manholes @ <8' depth	Manholes	3	EA	$10,159	$30,477	
							First Cost:	$1,595,000
							Engineering & Design:	$319,000
							Constr. Management:	$127,600
							Design & Construction Contingency (30%):	$612,500
							TOTAL COST:	$2,654,000

Table 27: Cost Estimate: Hewlett Bay Park Plan 4 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett Bay Park (Brower)								
4	Backflow Prevention w/ invert adjustment	Adjust 7 manholes @ <8' depth	Manhole adjustment	7	EA	$14,697	$102,876	$3,226,000
		Remove 750’ of 36” dia. pipe	36" pipe removal	750	LF	$174	$130,794	
		Remove 50’ of 24” dia. pipe	24" pipe removal	50	LF	$131	$6,543	
		Install 550’ of 36” dia. pipe	36" dia RCP installation	550	LF	$571	$314,214	
		Install 50’ of 24” dia. pipe	24" dia RCP installation	50	LF	$345	$17,270	
							First Cost:	$1,938,700
							Engineering & Design:	$387,700
							Constr. Management:	$155,100
							Design & Construction Contingency (30%):	$744,500
							TOTAL COST:	$3,226,000

13.0 VILLAGE OF HEWLETT HARBOR DRAINAGE ASSESSMENT

The Hewlett Harbor stormwater system drainage area is shown in Figure 41 below.

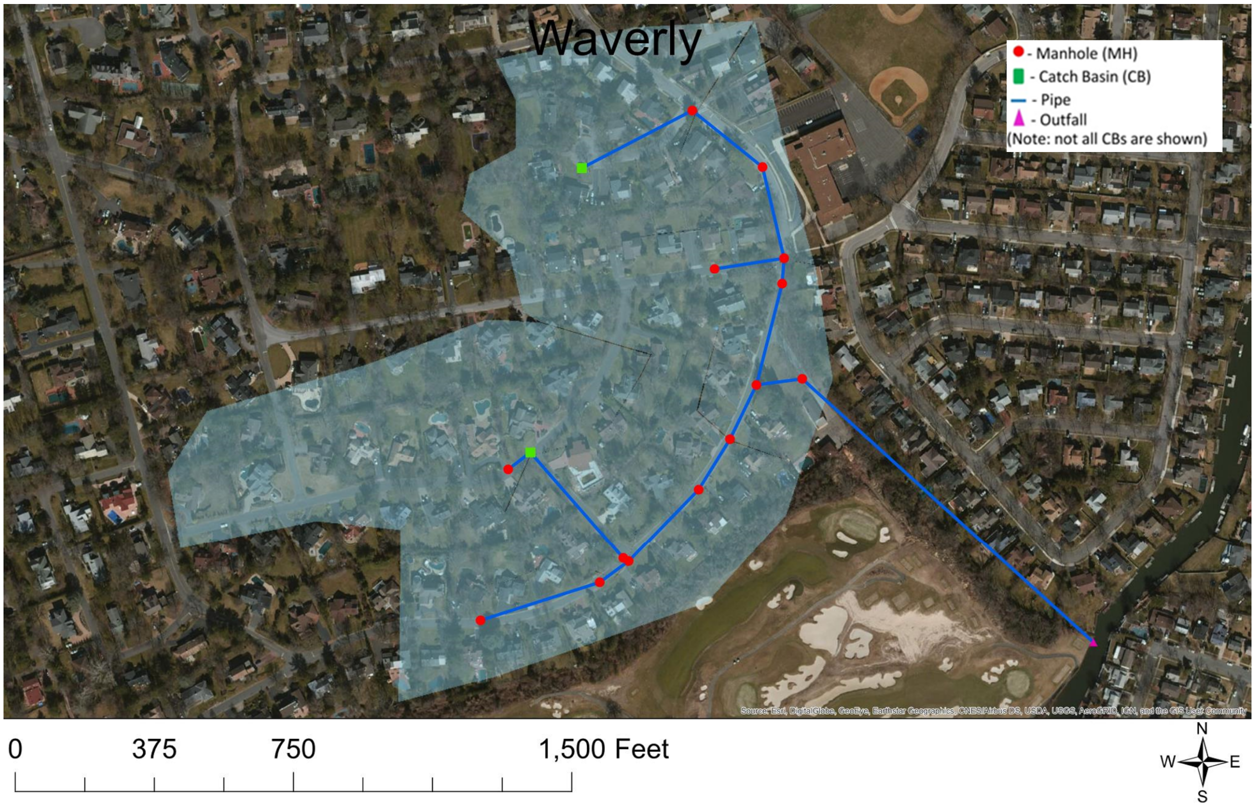


Figure 41: Hewlett Harbor Drainage Area

13.1 Recommended Hewlett Harbor Improvements

The following improvements are recommended to limit recurring flooding within the Village:

1) **Plan 1: Backflow Prevention (≤10-year rainfall) -** The installation of backflow prevention device at the 48 inch diameter outfall and install a treatment device.
2) **Plan 2: Pipe Improvements (≥10-year rainfall) -** Pipe size improvements were evaluated for the drainage networks which included the increase of pipe diameters that were at capacity and/or surcharged during normal rain events as well as providing proper slopes for adequate drainage.

Recommended improvements are shown in the following figures.

Figure 42: Hewlett Harbor Plan 1 – Backflow Prevention

Pipe improvements in red.

Figure 43: Hewlett Harbor Plan 2 – Pipe Improvements

13.2 Hewlett Harbor Costs

Estimated costs for Hewlett Harbor plans 1 and 2 are shown below. Plans are cumulative.

Table 28: Cost Estimate: Hewlett Harbor Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
Hewlett Harbor (Waverly)										
1	Backflow Prevention	1x In-line backflow prevention device on 48" dia. Outfall installed with cofferdam	48" dia tideflex	1	EA	$58,792	$58,792	$148,000	$79,141	CDS 8
			Cofferdam	0	EA	$64,535	$0		assume cofferdam no needed	
							First Cost:	**$88,900**		
							Engineering & Design:	**$17,800**		
							Constr. Management:	**$7,100**		
							Design & Construction Contingency (30%):	**$34,100**		
							TOTAL COST:	**$148,000**		

Table 29: Cost Estimate: Hewlett Harbor Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
2	Backflow Prevention w/ increased pipe sizes	1x In-line backflow prevention device on 48" dia. Outfall installed with cofferdam	48" dia tideflex	1	EA	$58,792	$58,792	$1,480,000	$79,141	CDS 8
			Cofferdam	1	EA	$64,535	$64,535		assume cofferdam no needed	
		Remove 1,200 ft of 48 in dia pipe @ <8' depth	48" pipe removal	1200	LF	$272	$326,106			
		Install 1,200 ft of 60 in dia pipe @ <8' depth	60" dia RCP installation	1200	LF	$793	$951,185			
							First Cost:	**$889,400**		
							Engineering & Design:	**$177,900**		
							Constr. Management:	**$71,200**		
							Design & Construction Contingency (30%):	**$341,600**		
							TOTAL COST:	**$1,480,000**		

14.0 VILLAGE OF HEWLETT NECK DRAINAGE ASSESSMENT

The Hewlett Neck stormwater system drainage area is shown in Figure 44 below.

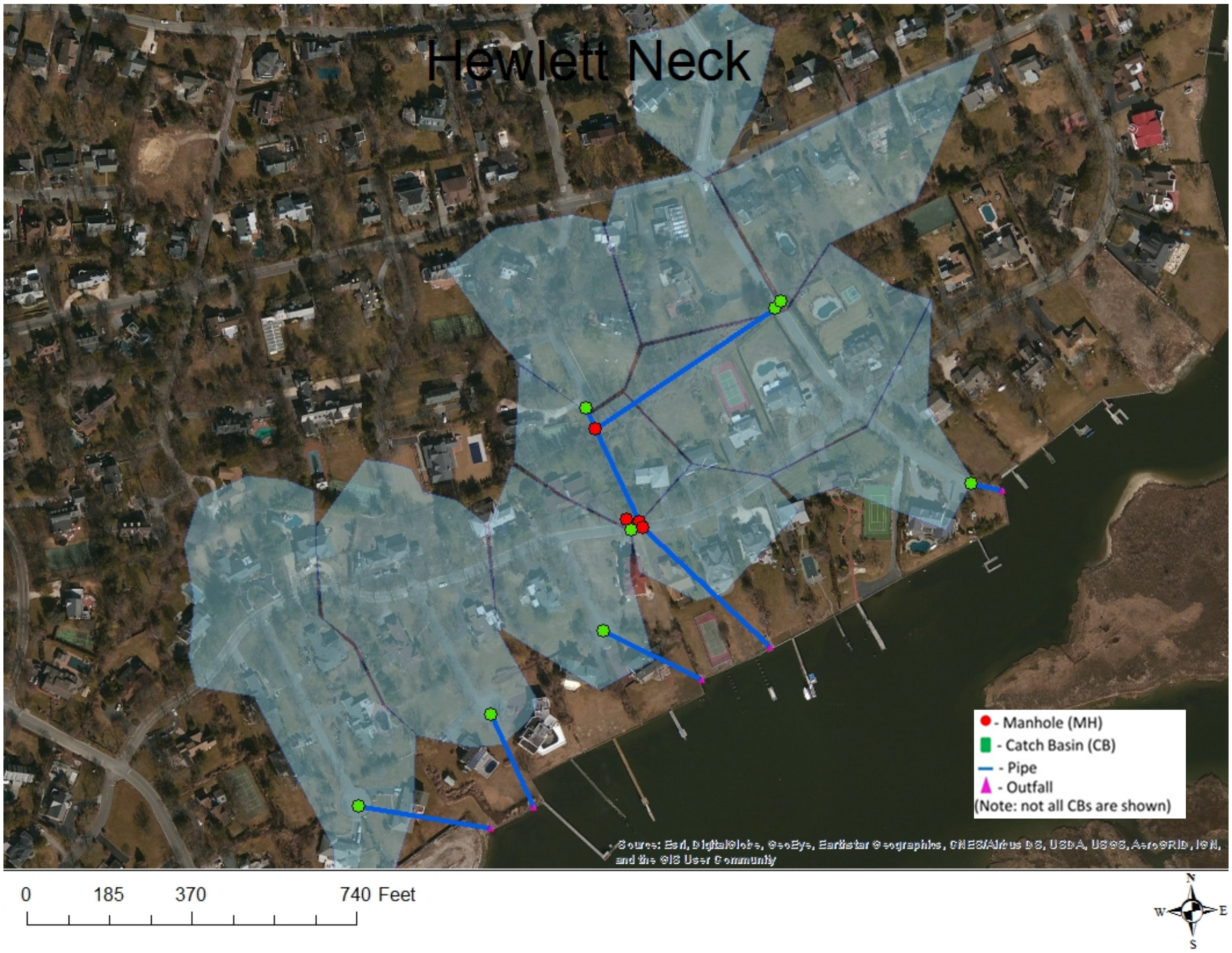


Figure 44: Hewlett Neck Drainage Area

14.1 Recommended Hewlett Neck Improvements

The following improvements are recommended to limit recurring flooding within the Village:

1) **Plan 1: Backflow Prevention (≤1-year rainfall) -** The installation of backflow prevention device at one 8-inch diameter, three 15-inch diameter and one 24-inch diameter outfall, plus the installation of treatment devices.

2) **Plan 2: Pipe Improvements (≥1-year rainfall) –** Plan 2 calls for the installation of a new drainage pipe along Adams Lane from Woodbine Ditch to the outfall, which would alleviate some of the poor drainage in Woodbine Ditch.

3) **Plan 2 (Option): Pipe Improvements:** Optional Plan 2 pipe improvements include installing new drainage pipes along Woodbine Ditch from Adams Lane to the end of Madison Street, and new or replaced drainage pipes along the Village easement from the end of Madison Street to the end of Monroe Lane.

4) **Plan 3: Road Improvements (≥1-year rainfall) -** The roads were evaluated for the proper runoff providing the networks, while including increase of pipe diameters that were at capacity and/or surcharged during normal rain events as well as providing proper placement of catch basins to collect surface storm water. The expansion of the pipe network warrants the installation of additional treatment devices.

Recommended improvements are shown in the following figures.

Figure 45: Hewlett Neck Plan 1 – Backflow Prevention

Pipe improvements in red.

Figure 46: Hewlett Neck Plan 2 – Pipe Improvements

Pipe improvements in red.

Figure 47: Hewlett Neck Plan 2 (Option) – Woodbine Ditch Drainage Improvements

Pipe improvements in red.

Figure 48: Hewlett Neck Plan 3 – Pipe and Roadway Improvements

14.2 Hewlett Neck Costs

Estimated costs for Hewlett Neck plans 1 through 3 are shown below.

Table 30: Cost Estimate: Hewlett Neck Plan 1 – Backflow Prevention

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
Hewlett Neck										
1	Backflow Prevention	3x15", 1x24", 1x8" in-line backflow prevention devices	15" dia tideflex	3	EA	$7,396	$22,188	**$108,000**	$63,933	plus $5K for temp access to properties
			24" dia tideflex	1	EA	$12,660	$12,660			2xCDS4
			8" dia tideflex	1	EA	$4,485	$4,485		others outfall DA's too small	
							First Cost:	**$64,900**		
							Engineering & Design:	**$13,000**		
							Constr. Management:	**$5,200**		
							Design & Construction Contingency (30%):	**$24,900**		
							TOTAL COST:	**$108,000**		

Table 31: Cost Estimate: Hewlett Neck Plan 2 – Pipe Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett Neck								
2 (Adams Ln)	Backflow Prevention w/ increased pipe sizes and adjusted invert	Remove 700 ft of 8 in dia pipe @ <8' depth	8" pipe removal	700	LF	$88	$61,453	**$676,000**
		Adjust 3 manholes @ <8' depth	Manhole adjustment	3	EA	$14,697	$44,090	
		Install new 30" outfall	30" outfall	1	EA	$197,434	$197,434	
		Install 80 ft of 30 in dia pipe @ <8' depth	30" dia RCP installation	80	LF	$418	$33,416	
		Install 620 ft of 24 in dia pipe @ <8' depth	24" dia RCP installation	620	LF	$345	$214,143	
							First Cost:	**$406,300**
							Engineering & Design:	**$81,300**
							Constr. Management:	**$32,500**
							Design & Construction Contingency (30%):	**$156,000**
							TOTAL COST:	**$676,000**

Table 32: Cost Estimate: Hewlett Neck Plan 2 (Option) – Pipe Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)
Hewlett Neck								
2 or (Woodbine Ditch)	Backflow Prevention w/ Woodbine Ditch and Easements Improvements	Remove and replace 4 manholes		4	EA	$14,697	$58,786	**$1,021,000**
		Install 5 manholes		5	EA	$10,159	$50,794	
		Remove 18" RCP		485	LF	$108	$52,358	
		Remove 24"RCP		245	LF	$131	$32,059	
		Install 18" RCP		1550	LF	$264	$409,228	
		Install 24" RCP		245	LF	$345	$84,621	
		Tree Removal (Clearing and Grubbing)	Assume 36" diameter	50	EA	$1,955	$97,743	
		Clearing and Grubbing	Small trees and brush	0.41	AC	$17,833	$7,312	
		Permits		1	LS	$20,000	$20,000	
		Real Estate access	Temporary access	1	LS	$100,000	$100,000	
							First Cost:	**$613,600**
							Engineering & Design:	**$122,700**
							Constr. Management:	**$49,100**
							Design & Construction Contingency (30%):	**$235,600**
							TOTAL COST:	**$1,021,000**

Table 33: Cost Estimate: Hewlett Neck Plan 3 – Pipe and Roadway Improvements

Community / Plan / Phase	Area Solutions	Remove/Replace	Description	Quantity	Unit	Unit Cost	Subtotal Cost	Total Cost (incl. treatment)	Treatment Devices	Size
Hewlett Neck										
3 (roadway)	Backflow Prevention w/ Resurfaced/Regraded Road and additional pipes	120,000 sq feet of resurfaced/graded roadway (2" Top, 3" Binder, 6" Base)	Resurfaced roadway	120000	SF	$8.0	$958,467	**$2,089,000**	$95,899	5xCDS4
		Install 5,100 LF of concrete curbs	Concrete curbs	5100	LF	$30.7	$156,339	**$2,542,000**	w/Woodbine and backflow	
		Install 8 curb inlet catch basins @<8' depth	Curb inlet catch basins	8	EA	$10,159	$81,271		increase in pipe network warrant	
		Install 1,520 ft of 12 in dia pipe @ <8' depth	24" dia RCP installation	620	LF	$195	$121,018		addtl CDSs	
							First Cost:	**$1,527,600**		
							Engineering & Design:	**$305,500**		
							Constr. Management:	**$122,200**		
							Design & Construction Contingency (30%):	**$586,600**		
							TOTAL COST:	**$2,542,000**		

15.0 SEA LEVEL RISE, RESILIENCY, AND SUSTAINABILITY

As sea level rises, the frequency and severity of coincidental flooding in many areas will increase. Forecast sea level rise and its impacts were not directly considered in the technical analysis of the recommended plans; however, potential improvements are expected to help mitigate the effects of sea level rise on future flood conditions.

15.1 Sea Level Rise / Climate Change

Current guidance requires that climate change and future sea level change (SLC) projections must be incorporated into the planning and design of HUD-supported projects. Tide conditions at Sandy Hook (NOAA Station #8531680) best represent the conditions experienced in the Five Towns region to date. A 75-year record (1932 to 2006) of tide data gathered at Sandy Hook, NJ indicates a mean sea level trend of +3.9 mm/year or approximately 0.7 feet in 50-years. Current forecast models predict sea level rise of 1.01 feet to more than 3 feet over the next 50 years.

Sea level rise effects are not critical to the recommended projects' performance However, the coincidental nature of flooding impacts due to high tide and rainfall events will be impacted by changes in sea level, and the associated change in high tide peaks and subsequently, the level of flooding as a result of high tide or frequent storm surges. Regardless of the change in sea level, it is expected that by limiting tide-induced drainage system surcharging the effects of sea level rise on the project performance will be significantly mitigated in the near future.

15.2 Resiliency

Resiliency is defined in the USACE-NOAA Infrastructures Systems Rebuilding Principles White Paper (2013) as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies". The recommended projects are designed to limit flooding from coincidental tidal and rainfall events, up to a 10-year rainfall event in many cases. Flooding impacts due to changes in sea level and/or changes in rainfall intensity will likely be mitigated for the life of the project features, making the communities more resilient than they would have been without the projects in place.

15.3 Sustainability

Sustainability is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). The recommended projects are mostly hard structures – backflow prevention devices, pipe systems, etc. – which, with proper maintenance will provide for the overall sustainability of the project over the 25-year project life and likely beyond, regardless of the level of sea level rise. The features recommended for construction represent resilient and sustainable solutions to mitigate recurring flooding in the Five Towns Project Area.

16.0 RISKS OF NON-IMPLEMENTATION

Without the recommended projects' implementation, the communities in the Five Towns Project Area would continue to experience recurring flooding into the foreseeable future, which would be exacerbated by the expected increased rainfall frequency and intensity, coupled with forecast sea level rise.

16.1 Stormwater Runoff

Peak discharges of precipitation events are expected to increase for each return frequency within the Project Area as a result of climate change impacts, exacerbating flooding associated with stormwater drainage systems problems.

16.2 Coastal Flooding

Recent studies by multiple agencies indicate that storm surge flooding is expected to worsen as a result of sea level change. Sea level change would likely further adversely impact stormwater drainage in the Project Area. Although there is no correlation between tidal surges and rainfall events in the Project Area, increased sea levels could increase the frequency and duration that stormwater outfalls are blocked (i.e., submerged) during high tide and tidal surges. If stormwater outfalls are submerged during an intense precipitation event, increased flooding in those respective drainage basins within the Project Area is likely.

16.3 Property Value

Areas subject to recurring stormwater flooding typically experience a decrease in property values. An increase in the frequency of flooding in flood prone areas may further depress property values.

16.4 Emergency Access Routes

Several of the recommended projects help to limit flooding along Evacuation Routes or limit flooding on primary or heavily traveled thoroughfares. Should these areas flood more frequently and to greater depths, evacuation from and emergency access to portions of the Project Area will continue to be negatively impacted.

17.0 ANTICIPATED PROJECT BENEFITS

The benefits analysis revealed that there are a number of viable drainage improvement plans that may be implemented in the Five Towns project area. These plans have BCRs significantly greater than unity or have non-quantified benefits which will significantly enhance the quality of life, and reduce risks to life and property for local residents and people transiting the project area during periods of flooding. These benefits include:

17.1 Resiliency Value

Resiliency Value/Benefits include protection from the effects of future flooding and include:

1) Reduction in vehicle damage and maintenance (as measured by vehicle damage and increased repair costs).
2) Reduction in catch basin maintenance requirements due to limiting sea water/lake water intrusion into the drainage system.
3) Reduction in costs associated with the deployment of DPW protective/warning barricades (and their removal).
4) Improved access during flood events for emergency services vehicles.

17.2 Social Value

Social Value/Benefits include those that would further community development and include:

1) Reducing the frequency of flooding that restricts access to residential homes.
2) Reducing associated anxiety and fears regarding residents' emergency access, property damage, and potential isolation.
3) Potentially improving property values in flood prone areas.
4) Potentially eliminating safety concerns regarding ponding on busy roadways and the associated impacts on traffic and traffic risks.

17.3 Economic Revitalization

The elimination of recurring flooding associated with high tides and rainfall may immediately improve property values in floodprone areas, and may influence long-term property values in areas impacted by sea level rise.

17.4 Quantified Benefits

The following benefits were quantified for incorporation into the BCA. These benefits were considered on a plan-by-plan or community-by-community basis.

1) Public Works Barriers. The deployment (and removal) of public works barricades on flooded roads and intersections. Benefits were calculated as costs avoided based on a typical three-man crew for deployment. For each community or size of flooded area, an estimate of the hours and frequency (i.e., monthly or quarterly) of deployment was made.
2) Catch Basin Cleaning. The installation of backflow prevention devices will help limit sea water and lake water intrusion and suspended sediment into the drainage systems. Benefits reflect catch basin cleaning costs avoided, based on costs avoided every 10 years.
3) Lost Labor. While difficult to quantify, the analysis assumes some lost labor time due to employees (residents) being unable to leave their homes for work through flooded streets and restricted property access, to businesses whose employees cannot enter flooded lots. Because this analysis is a tidal and stormwater analysis, it was assumed that delays were experienced as a result of the tidal cycle and therefore did not exceed three hours per person, using an average rate of $25 per hour.
4) Auto Replacement (one time event). Based on anecdotal information from residents regarding previous flood events, it was estimated that three automobiles per location would be severely damaged in a 25 year period due to one extreme tide and rainfall event resulting in two or more feet of flooding. This damage avoided was used for areas subject to less frequent stormwater flooding (i.e., Woodmere).
5) Increased Auto Repair Costs. Many of the areas subject to flooding are subject to shallow flooding through which cars continue to drive. However, driving through salt or brackish water on a regular basis (i.e., residents) will subject typical vehicles' peripheral components, especially brake systems, to accelerated rust and deterioration. This cost avoided includes costs for major reconstruction of braking systems for five cars every five years.

6) Regular Auto Damage. The risk of a large rainfall event and storm induced tidal surge is present annually. However, this analysis is limited to coincidental stormwater surge and not extreme storm surge, as discussed previously. Therefore, an evaluation of the potential number of vehicles that may be impacted by a larger event was conducted. The potential number of vehicles that may be impacted was estimated using existing statistical data. The approximate percentage of vehicles that would be moved to high ground was calculated and that percentage was used to adjust the average vehicle costs. The percent of damage to the remaining vehicles for a 1.5 foot flood was then calculated. This value was amortized over the project life (25 years). Flooding over 1.5 feet was expected to occur when a tidal surge exceeded the bulkhead or high ground and caused widespread flooding; therefore, damage prevented by the recommended drainage improvements was truncated at that depth.

17.5 Unquantified Benefits

The following benefits were not quantified but warrant consideration in the analysis of the performance of the recommended drainage improvement plans.

1) A reduction in recurring flooding will help ensure emergency vehicle/first responder access to floodprone areas.
2) Many areas are subject to recurring flooding on a monthly or more frequent basis. They often have limited access (or egress) to their streets and homes during flood events. Eliminating or reducing the recurrence of flood events will greatly improve the quality of life for local residents.
3) Limiting flooding of busy streets, such as Peninsula Boulevard in Cedarhurst, will help reduce the risk of traffic accidents and related injuries. Ponding water poses significant traffic risks, especially at night.
4) Property values in areas subject to recurring tidal and stormwater flooding may increase as a result of the elimination or reduction in frequent flooding.

18.0 PROJECT SELECTION

18.1 Benefit Cost Analysis

An initial benefit-cost analysis was conducted to help identify which projects should be recommended to move forward for design and construction. Because many of the problem areas within the Five Towns primarily experience stormwater drainage problems, the focus of the drainage study's benefit-cost analysis was mitigating the recurring flooding. The recurring stormwater flooding, while posing risks to vehicles, limiting home access, potentially impacting evacuation routes, etc., did not typically pose a direct threat to real estate and as such a usual flood damage benefit-cost analysis was not possible.

Rather, the benefit-cost analysis focused on recurring damage to vehicles, costs experienced (and avoided) by local Department of Public Works (DPW) departments, maintenance costs avoided, etc., as described in Section 16.0.

Resiliency benefits were calculated quantitatively as described in Section 16.0. Other unquantified benefits, including resident access during flooding, changes in social values, and economic benefits/ revitalization were estimated qualitatively.

A summary of the costs and benefits (quantitative and qualitative) are shown in Table 34. Quantified benefits are shown as "Estimated Annual Benefits" and are based on a reduction in potential damages, costs avoided, lost wages, etc., amortized as appropriate. The Benefit-to-Cost Ratio (BCR) was calculated using only quantified benefits and did not incorporate unquantified benefits. The "BCR (2.875%)" lists the BCR based solely on those quantified benefits. The "Benefit Evaluation" notes whether there are significant unquantified benefits associated with the recommended plan. "Y" represents known unquantified benefits, "Y+" represents significant unquantified benefits, and "Y++" represents significant unquantified benefits with public safety implications.

18.2 Projects to Move Forward

Plans with a BCR of close to unity or greater show definite positive benefits and will move forward, unless they represent an incremental plan and the next cumulative also has a BCR close to unity or greater. Those plans with marginal BCRs but with unquantified benefits, or significant unquantified benefits should also move forward with the concurrence of community officials.

18.3 Project Review Meetings

Meetings were held with representatives of the Town of Hempstead (representing Inwood, Woodmere, and Hewlett), Cedarhurst, Lawrence, and Hewlett Neck prior to the September 27, 2017 public meeting to review any community concerns, review the recommended plans, receive final community input, and get official feedback on the recommended plans.

Following those meetings and the Public Meeting, the plans in Section 18 were selected to move forward to the next phase of design, pending final identification of a designated subrecipient.

(This page intentionally left blank.)

Table 34: Benefit-Cost Analysis Results

Community / Plan / Phase	Plan Summary	Plan Description	Jurisdiction	Total Cost	Annualized Cost	O&M	Total Annual Cost	Benefits	Esimated Annual Benefits	BCR (2.875%)	Benefit Evaluation	Flood Reduction (Coincidetal Event)	Unquantified Benefits
Hamlet of Inwood					**Hamlet of Inwood**								
1	Backflow Prevention	3x In-line backflow prevention device on various dia outfall, install treatment device + treatment	Town of Hempstead	$268,000	$9,900	$8,200	$18,100	Barriers (14mos), lost labor, catchbasins, auto replacement, auto repairs	$100,000	5.5	Y	≤ 2" Rainfall	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events. May improve property values. Better emergency access during flood events.
2	25 cfs Pump Station	In line backflow prevention device + Install 25 cfs pump w/ pump station on open land in front of electrical tower on Bayswater blvd (incl. backflow on main line + treatment)	Town of Hempstead	$1,961,000	$72,300	$93,200	$165,500	Barriers (14mos), lost labor, catchbasins, auto replacement, auto repairs	$100,000	0.6	Y	≥10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events. May improve property values. Better emergency access during flood events.
or 3	Storage Chamber	Inline backflow prevention device + Install storage chamber under parking lot at the Inwood Marina, install treatment device to main line	Town of Hempstead	$802,000	$29,600	$18,200	$47,800	Barriers (14mos), lost labor, catchbasins, auto replacement (2), auto repairs	$100,000	2.1	Y	≥10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events. May improve property values. Better emergency access during flood events.
Village of Cedarhurst					**Village of Cedarhurst**								
1	Backflow Prevention	4x In-line backflow prevention devices + treatment devices	Village of Cedarhurst	$316,000	$11,700	$9,100	$20,800	Barriers (14mos), lost labor, catchbasins, auto replacement, auto repairs	$131,400	6.3	Y	≤ 2" Rainfall	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events. May improve property values. Improves safety of busy county road (Peninsula Blvd), and intersections. Due to low lying area, will provide additional benefits as sea level rises. Improves emergency access during flooding.
2	50 cfs Pump Station	Install 50 cfs pump w/ pump station on property next to Peninsula blvd	Village of Cedarhurst	$2,737,000	$101,000	$131,100	$232,100	Barriers (14mos), lost labor, catchbasins, auto replacement, auto repairs	$131,400	0.6	Y++	≥10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events. May improve property values. Improves safety of busy county road and evacuation route (Peninsula Blvd), and intersections. Due to low lying area, will provide additional benefits as sea level rises. Improves emergency access during flooding.
Hamlet of Woodmere					**Hamlet of Woodmere**								
1	Backflow Prevention	16x In-line backflow prevention device on outfalls + 8 treatment devices for largest drainage areas	Town of Hempstead	$921,000	$34,000	$26,800	$60,800	Barriers (2), catchbasins, auto replacement (3)	$17,900	0.3	Y	≥1-year event	Improves quality of life: Reduces residents' anxiety associated with weak Nor-easters and large rainfall events. Flooding may be infrequent but is significant during large rainfall events.
(N-3 area pipes + all backflow)	Increase pipe size + backflow	Remove pipe @ <8ft depth. Install various pipe @ <8ft. depth	Town of Hempstead	$1,571,000	$58,000	$26,800	$84,800	Barriers (2), catchbasins, auto replacement (3)	$17,900	0.2	Y+	>10 year event	Backflow prevention installation will help eliminate pipe and outlet silting and poor performance of system.
2	Increase pipe size + backflow	Backflow + Increase pipes (N3, N4, N5)	Town of Hempstead	$2,449,000	$90,300	$26,800	$117,100	Barriers (2), catchbasins, auto replacement (3)	$17,900	0.2	Y+	≥1-year event	Backflow prevention installation will help eliminate pipe and outlet silting and poor performance of system.
Hamlet of Hewlett					**Hamlet of Hewlett (Doxey Brook area)**								
1	Backflow Prevention	4x In-line backflow prevention device on various dia outfall (no treatment)	Town of Hempstead	$228,000	$8,400	$5,900	$14,300	Barriers (2), catchbasins, auto replacement (3)	$10,300	0.7	Y	some at all events	Backflow prevention installation will improve resident's peace of mind when Doxey Brook is flowing full from major rainfall events.
2	Increase pipe size + backflow	Remove 45 ft. of 36" pipe @ outfall. Install 45ft. of 42'' pipe; Remove 60 ft. of 30" pipe @ outfall. Install 60ft. of 42'' pipe. Install 4 backflow prevention devices. Install 2 CDS units.	Town of Hempstead	$336,000	$12,400	$5,900	$18,300	Barriers (2), catchbasins, auto replacement (3)	$10,300	0.6	Y	some at all events	Backflow prevention installation will improve resident's peace of mind when Doxey Brook is flowing full from major rainfall events.

Table 34: Benefit-Cost Analysis Results (cont.)

Community / Plan / Phase	Plan Summary	Plan Description	Jurisdiction	Total Cost	Annualized Cost	O&M	Total Annual Cost	Benefits	Esimated Annual Benefits	BCR (2.875%)	Benefit Evaluation	Flood Reduction (Coincidetal Event)	Unquantified Benefits
Village of Woodsburgh					**Village of Woodsburgh**				**(Broadway Model + Keene Model)**				
1	Backflow Prevention	1x In-line backflow prevention device on 6ftx4ft ellipse outfall (Broadway) + treatment	Village of Woodburg	$209,000	$7,700	$4,700	$12,400	Barriers (14mos), catchbasins, auto replacement (3)	$37,200	3.0	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events.
2	Backflow Prevention w/ increase pipe sizes & adjusted inverts	1x In-line backflow prevention device on 6ftx4ft ellipse outfall + treatment; Remove 1,400 ft of 15 in dia. Pipe @<8' depth; Install 1,400 ft of 18 in dia. Pipe @ <8' depth; Adjust 8 manholes @ <8' depth	Village of Woodburg	$836,000	$30,800	$4,700	$35,500	Barriers (14mos), catchbasins, auto replacement (3)	$37,200	1.0	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events.
3	Backflow Prevention	1x In-line backflow prevention device on 36" dia. Outfall + treatment	Village of Woodburg	$105,000	$3,900	$2,800	$6,700	Barriers (14mos), catchbasins, auto replacement (3)	$37,200	5.6	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events.
4	Backflow Prevention w/ increase pipe sizes	1x In-line backflow prevention device on 36" dia. Outfall + treatment; Remove 1,100 ft of 30 in dia pipe @ <8' depth; Install 300 ft of 36 in dia pipe @ <8' depth; Install 800 ft of 48 in dia pipe @ <8' depth	Village of Woodburg	$933,700	$34,400	$2,800	$37,200	Barriers (14mos), catchbasins, auto replacement (3)	$37,200	1.0	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events.
Village of Woodsburgh - SUMMARY					**Village of Woodsburgh - SUMMARY**								
1	Backflow Prevention	Backflow summary	Village of Woodburg	$314,000	$11,600	$7,500	$19,100	Barriers (14mos), catchbasins, auto replacement (3)	$37,200	1.9	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events.
2	Backflow Prevention w/ increase pipe sizes & adjusted inverts	Pipe Improvements + Backflow Prevention	Village of Woodburg	$1,875,000	$69,200	$7,500	$76,700	Barriers (14mos), catchbasins, auto replacement (3)	$37,200	0.5	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and weak Nor-easters, and other events.
Village of Hewlett Bay Park					**Village of Hewlett Bay Park**				**(Brower Model)**				
1	Backflow Prevention	2x In-line backflow prevention device on 36" dia. & 60" Outfalls	Village of Hewlett Bay Park	$221,000	$8,200	$4,900	$13,100	Barriers (4), catchbasins, auto replacement (3)	$8,400	0.6	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
2	Backflow Prevention w/ increase pipe sizes	2x In-line backflow prevention device on 36" dia. & 60" Outfalls; Remove 510 ft of 12 in dia pipe @ <8' depth; Remove 560 ft of 24 in dia pipe @ <8' depth; Remove 1,500 ft of 36 in dia pipe @ <8' depth; Install 510 ft of 18 in dia pipe @ <8' depth; Install 560 ft of 30 in dia pipe @ <8' depth; Install 1,500 ft of 48 in dia pipe @ <8' depth	Village of Hewlett Bay Park	$2,072,000	$76,400	$4,900	$81,300	Barriers (4), catchbasins, auto replacement (3)	$8,400	0.1	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
3	Backflow Prevention w/ parallel pipe	2x In-line backflow prevention device on 36" dia. & 60" Outfalls; Install 750 ft of 48 in dia pipe @ <8' depth; Install 3 manholes @ <8' depth	Village of Hewlett Bay Park	$2,654,000	$97,900	$4,900	$102,800	Barriers (4), catchbasins, auto replacement (3)	$8,400	0.1	N	≥1-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
4	Backflow Prevention w/ invert adjustment	2x In-line backflow prevention device on 36" dia. & 60" Outfalls; Adjust 7 manholes @ <8' depth; pipe improvements	Village of Hewlett Bay Park	$3,226,000	$119,000	$4,900	$123,900	Barriers (4), catchbasins, auto replacement (3)	$8,400	0.1	N	≥1-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.

Table 34: Benefit-Cost Analysis Results (cont.)

Community / Plan / Phase	Plan Summary	Plan Description	Jurisdiction	Total Cost	Annualized Cost	O&M	Total Annual Cost	Benefits	Esimated Annual Benefits	BCR (2.875%)	Benefit Evaluation	Flood Reduction (Coincidetal Event)	Unquantified Benefits
Village of Lawrence					**Village of Lawrence**			**(Meadow Model)**					
1	Backflow Prevention	1x In-line backflow prevention device on 60" dia. Outfall and 2 x 24" outfall	Village of Lawrence	$384,000	$14,200	$8,800	$23,000	Barriers (4), catchbasins, auto replacement (3)	$32,700	1.4	Y	≤ 2" Rainfall	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
2	Backflow Prevention w/ increase pipe sizes	Pipe Improvements Along Meadow Lane, Marbridge Road, Causeway Road, North Road, and Barrett Road.	Village of Lawrence	$8,276,000	$305,300	$8,800	$314,100	Barriers (4), catchbasins, auto replacement (3)	$32,700	0.1	Y+	≥ 1-year Rainfall	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events. Provides drainage improvements to eliminate frequent nuisance flooding at Mabridge Rd, and Barrett/Hollywood.
Village of Hewlett Harbor					**Village of Hewlett Harbor**			**(Waverly Model)**					
1	Backflow Prevention	1x In-line backflow prevention device on 48" dia outfall + treatment	Village of Hewlett Harbor	$148,000	$5,500	$3,600	$9,100	Barriers (4), catchbasins, auto replacement (3)	$8,400	0.9	Y	≤10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
2	Backflow Prevention w/ increased pipe sizes	1x In-line backflow prevention device on 48" dia outfall + treatment; Remove 1,200 ft of 48 in dia pipe @ <8' depth; Install 1,200 ft of 60 in dia pipe @ <8' depth	Village of Hewlett Harbor	$1,480,000	$54,600	$3,600	$58,200	Barriers (4), catchbasins, auto replacement (3)	$8,400	0.1	Y	≥10-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
Village of Hewlett Neck													
1	Backflow Prevention	3 x 15", 1 x 24" 1 x 18" in-line backflow prevention	Village of Hewlett Neck	$108,000	$4,000	$2,800	$6,800	catchbasins, labor, auto repair	$4,400	0.6	Y	≤ 1-year Rainfall	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
2 (Adams)	Backflow prevention w/ increased pipe and adjusted culvert	3x15", 1x24", 1x30" in-line backflow prevention devices; Remove 700 ft of 8 in dia pipe @ <8' depth; Adjust 3 manholes @ <8' depth; Install new 30" outfall; Install 80 ft of 30 in dia pipe @ <8' depth; Install 620 ft of 24 in dia pipe @ <8' depth	Village of Hewlett Neck	$676,000	$24,900	$2,800	$27,700	catchbasins, labor, auto repair	$4,400	0.2	N	≥1-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
or 2 (Woodbine)	Backflow prevention w/ increased pipe and adjusted culvert	Pipe improvements in Woodbine Ditch and adjacent roadway ends (Madison, Monroe, Smith)	Village of Hewlett Neck	$1,021,000	$37,700	$2,800	$40,500	catchbasins, labor, auto repair	$4,400	0.1	Y	≥1-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.
3	Backflow prevention w/Resurfaced/ Regraded Road and additional pipe	3x15", 1x24", 1x30" in-line backflow prevention devices: 120,000 sq feet of resurfaced/graded roadway (2" Top, 3" Binder, 6" Base); Install 5,100 LF of concrete curbs; Install 8 curb inlet catch basins @<8' depth; Install 1,520 ft of 12 in dia pipe @ <8' depth; Pipe improvements ate Woodbine Ditch	Village of Hewlett Neck	$2,542,000	$93,800	$2,800	$96,600	catchbasins, labor, auto repair	$4,400	0.0	N	≥1-year event	Improves quality of life: Reduces residents' monthly anxiety associated with spring tide and approaching Nor-easters, and other events.

19.0 SUMMARY OF RECOMMENDED PROJECTS

Projects recommended for advancement to the engineering phase (final engineering, as needed, and the development of plans and specifications) are presented in Table 35.

Table 35: Summary of Recommended Projects

Community	Project Description	Total Project Cost	Total Community Project Cost	Total E&D/CM Cost **	Jurisdiction	Notes
Cedarhurst, Village of	Install 50 cfs pump w/ pump station on property next to Peninsula blvd	$2,737,000	$2,737,000	$598,800	Village of Cedarhurst	Pump station location to be confirmed
Hewlett, Hamlet of	Remove 45 ft. of 36" pipe @ outfall. Install 45ft. of 42" pipe; Remove 60 ft. of 30" pipe @ outfall. Install 60ft. of 42" pipe. Install 4 backflow prevention devices. Install 2 CDS units.	$336,000	$336,000	$73,600	Town of Hempstead	Outfalls to Doxey Brook, Brook functions as bio swale, minimal treatment proposed
Hewlett Bay Park, Village of*	2x In-line backflow prevention device on 36" dia. & 60" Outfalls	$221,000	$3,226,000	$705,600	Village of Hewlett Bay Park	Not in CRZ, ID funding source.
	Pipe Improvements	$3,005,000				
Hewlett Harbor, Village of	Separate GOSR CDBG-DR Project	N/A	N/A	N/A	Village of Hewlett Harbor	Separate GOSR CDBG-DR Project
Hewlett Neck, Village of	3 x 15", 1 x 24" 1 x 18" in-line backflow prevention	$108,000	$1,021,000	$223,300	Village of Hewlett Neck	Access to private property for installation
	Pipe/drainage Improvements; Woodbine Ditch	$913,000				
Inwood, Hamet of	Inline backflow prevention device + Install storage chamber under parking lot at the Inwood Marina, install treatment device to main line	$802,000	$802,000	$175,500	Town of Hempstead	Confirmation of groundwater elevations for project performance; treatment devices
Lawrence, Village of	Pipe Improvements Along Meadow Lane, Marbridge Road, Causeway Road, North Road, and Barrett Road.	$8,276,000	$8,276,000	$1,810,400	Village of Lawrence	Includes Treatment Devices
Woodmere, Hamlet of	16x In-line backflow prevention device on outfalls + 8 treatment devices for largest drainage areas	$921,000	$921,000	$201,500	Town of Hempstead	Outfalls to Cedar Point Lake; due to urban area and lake outfalls, recommended treatment devices on larger networks, not on smaller networks
Woodsburgh, Village of*	Pipe Improvements; 2x backflow prevention + CDS	$1,875,000	$1,875,000	$410,200	Village of Woodsburgh	Not in CRZ, ID funding source.

**Communities not part of the original Community Reconstruction Plan (CRP).*
***Engineering & Design (E&D), Construction Management (CM), includes contingency.*

20.0 IMPLEMENTATION CONCERNS

The following are potential concerns, listed by community, which may need to be addressed prior to or during final design and construction:

1) General considerations:

   a) Confirm the sizing of CDS treatment units before installation (may be coordinated with vendor engineers). The CDS sizes indicated in the preliminary costs are based on pipe size and modeled flows during the typical water quality design storm (1" rainfall used in lieu of the 1.2" Nassau County Water Quality design storm) with additional height for bypassing larger events. Final size selection can be coordinated with the vendor. This is included as part of Engineering & Design (E&D) costs.

   b) As part of design, confirm the backflow prevention unit type to be installed (sleeved, insert, or thimble). This will be confirmed during E&D; the outfall inspection report provides preliminary information.

   c) Any pipe improvement or CDS installation location should have a verification survey of existing structure conditions. A local structure confirmation survey is included as part of E&D costs.

   d) It is assumed that any increase in the size of an outfall through increasing the upstream pipe size will not be considered a new outfall by the NYSDEC and, therefore, would not require additional permitting. However, typical permitting is included in the E&D percentage costs.

2) Cedarhurst:

   a) Confirmation (survey) of the pipes to be demolished and rerouted to the pump station. Included in E&D.

   b) Any property concerns related to the pump station real estate costs. Costs are not included for pump station property; it is assumed that the newly acquired land at the WWTP site will be donated by the Village.

   c) Pump station O&M costs. As noted, approximately $89,000 per year; however, it does not account for energy cost increases over time.

   d) Assumption of O&M. Typical O&M for pipes, CDS units, and backflow prevention at outfalls is nominal. However, a pump station requires significant O&M to ensure operation. It should be understood who will provide funding and who will perform the O&M prior to construction of a pump station.

3) Inwood:

   a) Confirmation of the ground water table at the Town marina parking lot for the detention plan. This is included in E&D; however, a high ground water table may preclude implementation of the plan.

   b) Any property concerns related to the detention or pump station siting. The marina property is owned by the Town of Hempstead, who will have to agree to the detention or pump station siting on the property.

c) Confirm preliminary NYSDEC approval of additional outfall(s). This is a permitting issue and not a cost issue. If an additional outfall cannot be permitted, the detention facility outfall may be rerouted back to the Bayswater outfall pipe, eliminating the additional outfall. This approach may be addressed in final design.

4) Hewlett Bay Park: Stormwater treatment on the 60" outfall is not cost effective and is not included in the preliminary designs: the high flows during the design storm prevent a small scale application such as a CDS. Retrofitting a larger, Vortech-type (chamber) unit would be a significant cost, upwards of $100,000 for the current design flow.

5) Hewlett Harbor:

a) Confirm whether backflow prevention can be installed without a cofferdam at the outfall. This is an approximately $61,000 additional cost. However, the vendor has indicated that if the pipe is exposed at low tide it can be installed in the wet.

b) The initial GOSR drainage project proposed plans for Hewlett Harbor were reviewed. The plans presented for Hewlett Harbor as part of this study address some of the problems associated with recurring flooding; however, they may not address the larger, less frequent events that the initial GOSR project targeted.

6) Hewlett Neck:

a) Backflow Prevention. Resolve any access agreements prior to installation; access to outfalls requires access to private property. Costs have been included for temporary access easements to private property to install backflow prevention.

b) Woodbine Ditch Improvements. Resolve easement access/use and clearing and grubbing requirements for drainage pipe and structure installations.

21.0 REGULATORY PERMITTING

The following is a list of permits and/or approvals that may be required prior to implementation of work at any of the recommended project sites. Construction activities would be conducted in accordance with applicable regulations or permits that may be required for these activities.

- New York State Tidal Wetlands Permit
- NYSDEC State Pollution Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity (No. GP-02-01)
- Clean Water Act Section 401 Water Quality Certificate
- Clean Water Act Section 404 Permit from US Army Corps of Engineers
- Coastal Consistency Determination under the NYC Waterfront Revitalization Program from the New York City Department of City Planning
- Coastal Consistency Determination under the NYS Department of State Coastal Zone Management Program

- Stormwater Pollution Prevention Plan: A stormwater pollution prevention plan would be developed to address potential issues associated with construction activities in accordance with NYSDEC requirements.