Regional Wet Weather Management Plan

June 2020

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Executive Summary

EX.1 Background

HRSD (the Hampton Roads Sanitation District) is the regional wastewater agency in southeast Virginia providing services to 18 Localities (14 of these are within the scope of the Consent Decree) and an approximate population of 1.7 million people. Each of the Localities manages their own wastewater collection systems which discharge to HRSD's system of wastewater collection pipes, pumping stations, and treatment plants. The regional sanitary sewer system (Localities and HRSD) has varying levels of service to accommodate increased flows during wet weather events before sanitary sewer overflows (SSOs) occur.

A Consent Decree was entered between HRSD, the United States Environmental Protection Agency (EPA), and the Virginia Department of Environmental Quality (DEQ) in 2010 to perform tasks related to reducing the occurrence of SSOs in the regional system. The decree included a condition assessment program with associated rehabilitation actions, as well as the development of a Regional Wet Weather Management Plan (RWWMP). This document serves as the completion of the obligations to prepare the RWWMP and outlines HRSD's approach for capacity-related SSOs. mitigation.

EX.2 Adaptive Regional Plan

EPA has encouraged the use of adaptive management approaches in a wide variety of settings. Adaptive management features iterative decision making to manage uncertainty in addressing municipal environmental challenges. This approach has been particularly necessary with long-term community sewer rehabilitation and related programs. Almost every such program has needed multiple major modifications. In addition to responding to changing community circumstances, adaptive management also allows communities to continually prioritize the greatest public health and community benefits for the next public dollar invested. Given the scope, cost, complexity, and evolving nature of the challenges which HRSD and the Hampton Roads region face, this Plan necessarily features an adaptive management approach.

There are a number of other adaptive management factors that create significant uncertainties (and opportunities) about any infrastructure investment plan that spans more than a decade. These uncertainties/opportunities include:

- The impact of sea level rise and recurrent flooding on the region's infrastructure, land use patterns and economy;
- Understanding the system response to almost $700 million in wet weather capacity-related investments and evaluations completed over the past twelve years;
- Magnitude and spatial patterns of community growth and redevelopment;
- Future of the extensive Department of Defense (DoD) facilities in the Hampton Roads Region and HRSD priorities regarding these ubiquitous facilities throughout the service area;
- How effectively Locality and HRSD Management, Operations, and Maintenance (MOM) programs will address sewer system degradation and inflow/infiltration (I/I) levels;
- Regional economic vitality and household income and employment levels;

- Changing regional environmental and public health priorities, specifically post implementation evaluation of the Chesapeake Bay TMDL (Total Maximum Daily Load) after the 2025 completion;
- Changing technologies and opportunities to achieve multiple benefits for public sewer-related investments; and,
- Levels of federal and state financial support for unfunded environmental mandates across all media.

These uncertainties will have a profound effect on the location, volume, significance and priority of future wet weather capacity-related overflows. This will particularly be the case for the capacity-related investment for the period beyond 2040.

As part of HRSD's Adaptive Regional Plan, fifteen (15) High-Priority Projects will be constructed through 2040. This $410 million investment will reduce SSO volume during the 5-year peak flow event by 69% - a significant reduction. Figure EX-1 depicts this reduction in modeled SSO volume during the 5-year peak flow event. Efforts to address the minimal SSO volume remaining upon completion of the High-Priority Projects would be cost prohibitive and return marginal benefits for each dollar invested.

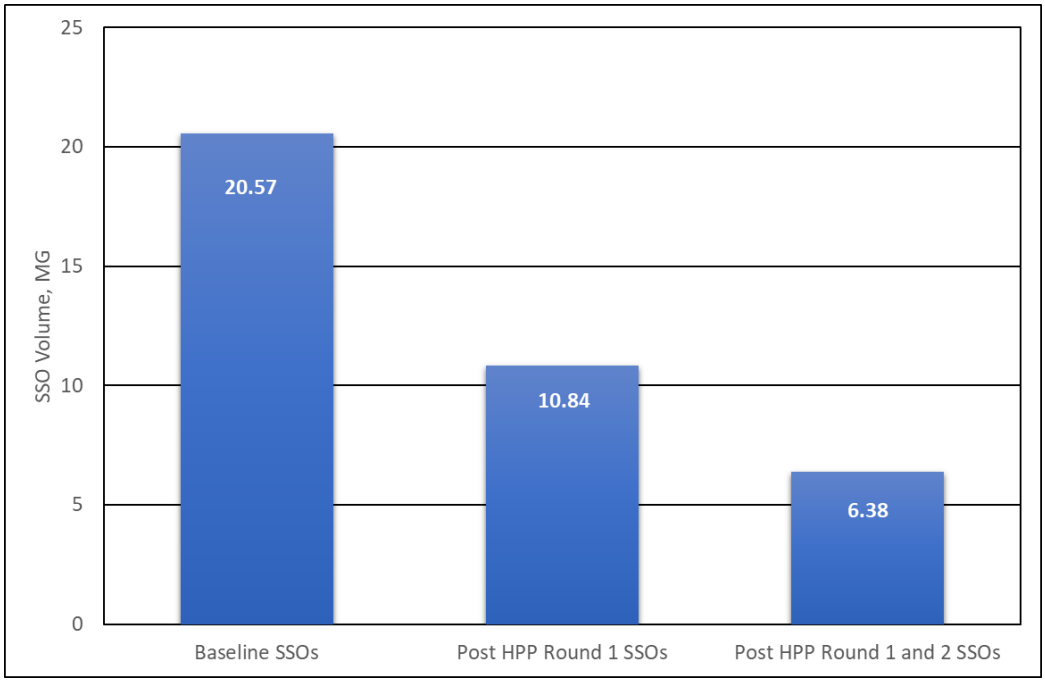

Figure EX-1. High-Priority Project Modeled SSO Reduction

The economic stress on the residents of the region, coupled with ever-changing environmental priorities, necessitate an adaptive management approach to allow the region to make wise future investments through understanding and responding to the conditions as they exist in that future timeframe.

Accordingly, HRSD's RWWMP features an Adaptive Regional Plan comprising four phases as follows:

Table EX-1. Four Phases of the Adaptive Regional Plan			
Phase	Description	Timeframe	Cost
1	Planning, Interim System Improvements, Condition Assessment and Repairs, Rehabilitation Action Plan	2008 – 2025	$700,000,000
2	Round 1 High-Priority Projects and Pathogen Source Tracking Program	2020 - 2030	$218,000,000
3	Round 2 High-Priority Projects and Pathogen Source Tracking Program	2030 - 2040	$212,000,000
4	Post-RWWMP Plan Performance Assessment	2040 – 2043	$2,000,000
	TOTAL		**$1,132,000,000**

Phase 1 includes the $700 million that HRSD will spend by 2025 in Interim System Improvements, Rehab Action Plan projects, Condition Assessment (including prompt repairs), and planning associated with development of the RWWMP Plan. Phase 2 includes the $208 million in Round 1 High-Priority Projects, and $10 million Pathogen Source Tracking Program. Phase 3 consists of an additional $202 million in Round 2 High-Priority Projects and $10 million for the continued Pathogen Source Tracking Program.

Phase 4 is a performance assessment upon completion of the work in Phases 2 and 3. This analysis will take place between 2040 and 2043 and will culminate in submittal of a Performance Assessment for the review and approval of EPA and DEQ by March 31, 2043.

EX.3 High-Priority Projects

HRSD identified a set of High-Priority Projects (HPPs) to achieve the maximum reduction in modeled overflow volume and the maximum environmental and public health benefit. Scoring criteria were established that considered SSO load reduction for each project, location of the affected SSOs, and reduction in I/I from each project.

After developing a full set of RWWMP solutions (comprised of more than 500 different elements), HRSD performed a modeling evaluation of each individual element to determine its effectiveness in SSO reduction as well as identifying the location of the affected SSOs. This information along with I/I reduction data was used to calculate the total score for each project, and $410 million worth of High-Priority Projects were selected. These projects included a variety of improvements and were located in nine different Localities. Although specific solutions were identified during modeling analysis, actual pipe footages, tank sizes, and pumping capabilities will be determined in final design. Table EX-2 shows the High-Priority Projects by Asset Type.

Table EX-2. High-Priority Projects by Asset Type				
Asset Type	Round 1		Round 2	
	Cost ($ Millions)	% of Total	Cost ($ Millions)	% of Total
PRS	$13.0	6.3%	$32.6	16.1%
Storage	$38.8	18.7%	$33.5	16.5%
HRSD Pump Station	$35.2	16.9%	$24.4	12.0%
HRSD Conveyance	$17.7	8.5%	$36.7	18.1%
Locality Pump Station	$12.6	6.0%	$7.6	3.7%
Locality Conveyance	$3.9	1.9%	$1.1	0.5%

Table EX-2. High-Priority Projects by Asset Type				
Asset Type	Round 1		Round 2	
	Cost ($ Millions)	% of Total	Cost ($ Millions)	% of Total
I/I Reduction	$86.5	41.7%	$66.6	32.9%
Total	**$207.7**	**100%**	**$202.4**	**100%**

The Round 1 High-Priority Projects are scheduled to be completed by 2030 and are estimated through modeling to reduce baseline SSO volume by approximately 47% for the 5-year peak flow recurrence event. Round 2 High-Priority Projects are projected to reduce baseline SSO volume by an additional 22% for the 5-year peak flow recurrence event and will be completed by 2040. Table EX-3 shows the effectiveness of the HPPs.

Table EX-3. SSO Volume Reduction Cost Comparison			
Improvement Phase	Cost ($Millions)	SSO Volume Reduction (MG)	Cost/Gal SSO Volume Reduced
HPP Round 1	$208	9.73	**$21**
HPP Round 2	$202	4.47	**$45**
Non- HPP Projects	$1,391	6.37	**$218**

While the HPPs are being implemented, HRSD intends to continue its Pathogen Source Tracking Program to address bacteria impairments in local water bodies. These efforts will focus on identifying, locating and eliminating chronic and persistent non-SSO-related sources of human-sourced bacteria. Many such projects are completed with several more on-going in several Localities in the system. These projects provide far greater public benefits than reducing SSOs during large storm events.

EX.4 Scheduling

High-Priority Projects were scheduled with consecutive 10-year implementation periods starting with Round 1 being completed between plan approval and 2030. At that time, HRSD will review the Round 2 projects to confirm that they are still expected to meet the desired result and confirm this in a check in with the EPA/DEQ. To modify the list of specific projects, HRSD will show that the revised set will attain a minimum of the same percent reduction, or better. Table EX-4 outlines the completion time frame for each set of High-Priority Projects.

Table EX-4. High-Priority Projects by Implementation Phase			
Phase	Completion Time Frame	Number of Projects	Total Costs ($ Millions)
Round 1 High-Priority Projects	2020 – 2030	6	$207.7
Round 2 High-Priority Projects	2030 - 2040	9	$202.4
	Total	15	$410.1

Following sequencing of the projects, they were scheduled to fit available cashflow in HRSD's Financial Plan. The complete set of Round 1 and 2 High-Priority Projects were scheduled with objectives of maintaining reasonable annual expenditures and sequences for hydraulically interconnected projects while balancing improvement activity across treatment plants. The schedule for High-Priority implementation also considers the total SSO load reduction of a project. The results of prioritization modeling were used to inform these criteria for sequencing.

Figure EX-2 shows the resulting distribution for HRSD and Locality/Private asset improvements within the overall cashflow for High-Priority Project implementation.

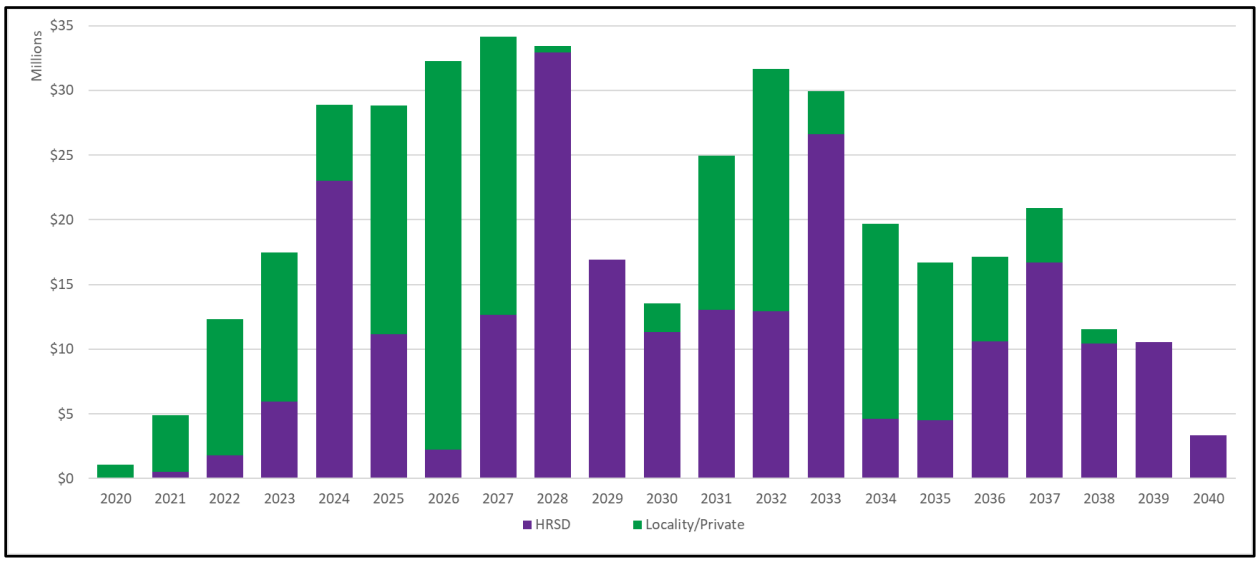

Figure EX-2. High-Priority Project Schedule Expenditure by Ownership

EX.6 Conclusion

The Adaptive Regional Plan proposed in this RWWMP is an environmental and economic necessity and is consistent with EPA policy and guidance on adaptive management. In this plan, HRSD will have spent $1.1 billion by 2040 addressing SSOs.

Section 1
Introduction

Since prior to 2007, HRSD (the Hampton Roads Sanitation District) has been working with the Commonwealth of Virginia Department of Environmental Quality (DEQ) and the United States Environmental Protection Agency (EPA) to fulfill regulatory compliance requirements to benefit public health and the environment.

The original 2007 Special Order by Consent (SOC) and the 2010 Consent Decree included a process for HRSD, working with the Hampton Roads localities, to evaluate the condition and capacity of the wastewater collection, transmission, and treatment facilities, and to develop a long-term rehabilitation action plan and wet weather management plan.

HRSD has met all compliance milestones related to the SOC and Consent Decree including the delivery of a Rehabilitation Action Plan (approved by the EPA in May 2015) and development of a Regional Wet Weather Management Plan (RWWMP) originally submitted in September 2017.

The Plan submitted in September 2017 prioritized a select list of High-Priority Projects with a capital cost of $208 million that are projected to reduce SSO volume in the 5-year peak flow event by 47%. This Adaptive Regional Plan approach is an environmental and economic necessity and is consistent with EPA policy and guidance on adaptive management.

The revised RWWMP Plan proposed in this document carries forward the same principles of the September 2017 submittal with an addition of $202 million in Round 2 High-Priority Projects. These are proposed to be completed between 2030 and 2040 (following the Round 1 High-Priority Projects to be completed by 2030) and are projected to reduce modeled SSO volume in the 5-year peak flow event by an additional 22% for a total of 69% between Rounds 1 and 2 of the High-Priority Projects.

The following sections of this RWWMP provide details the Pathogen Source Tracking Program, and the High-Priority Projects.,

1.1 HRSD System/Facilities Overview

1.1.1 Service Area Descriptions

HRSD's service area includes 18 cities and counties of southeast Virginia, an area of approximately 3,100 square miles with a population of approximately 1.7 million. To ensure responsive assistance and the ability to meet future needs, HRSD works closely with the communities it serves.

Table 1-1. Service Area Description	
Cities	Counties
Chesapeake	Gloucester
Hampton	Isle of Wight (including the Town of Smithfield)
Newport News	James City
Norfolk	King and Queen*
Poquoson	King William*
Portsmouth	Mathews*
Suffolk	Middlesex*
Virginia Beach	Surry*
Williamsburg	York

**Towns within the counties served by HRSD include Urbanna* and West Point*. These communities are part of the Small Communities Division which are not part of the Regional Wet Weather Management plan.*

1.1.2 Infrastructure Description

HRSD operates nine major treatment plants in Hampton Roads and four small facilities on the Middle Peninsula. These 13 plants are designed to treat 249 million gallons of wastewater each day.

The HRSD Interceptor System is comprised of two main subsystems: North Shore and South Shore, which are hydraulically separate with names reflecting their broad geographic relationships to the James River. HRSD interceptor system facilities between the York River and the James River, as well as those in Gloucester County, are part of the North Shore system. HRSD facilities in Mathews County are operated and maintained by the Small Communities Division but convey their flow to the North Shore system for ultimate transmission to the York River Treatment Plant. Facilities south of the James River are part of the South Shore system. This section provides an overview of the facilities managed, operated and maintained by HRSD.

The existing HRSD interceptor system is comprised of approximately 500 miles of pipelines and nearly 90 pumping stations in the systems covered by this document. The HRSD pumping station count is subject to change as pumping facilities are decommissioned, new pumping facilities are brought online and/or interim pumping facilities are deployed as necessary to assist the system.

1.1.3 Wastewater Treatment Plants

HRSD currently operates nine major treatment plants in Hampton Roads, five in the South Shore System and four in the North Shore System. In 2013, HRSD completed the Chesapeake-Elizabeth Treatment Plant Feasibility Study, which evaluated taking the treatment plant offline and diverting flow to other treatment plants. Using 2021 as the target closure date, the study determined that the HRSD interceptor system and remaining treatment plants have the ability and capacity to serve the current and projected needs of the Chesapeake-Elizabeth Treatment Plant service area and all other South Shore jurisdictions. This study projects significant capital and operations and maintenance savings to close the Chesapeake-Elizabeth Treatment Plant as compared to continuing operations. HRSD has accepted the findings of the study and is initiating steps necessary to close Chesapeake-Elizabeth Treatment Plant by December 2021. With implementation of this closure, HRSD will have four active treatment plants remaining on the South Shore.

1.1.4 Collection and Interceptor System

The collection and interceptor systems in Hampton Roads convey wastewater from the Localities to one of HRSD's wastewater treatment plants. HRSD and the Localities make every effort to convey water that enters the system, whether as sanitary sewage or from wet weather sources, to an HRSD treatment facility.

Wastewater generated by private residences and businesses usually flow through gravity pipelines owned by a Locality. From there, the wastewater typically flows to a Locality-owned pump station where it is then either lifted into another Locality gravity pipe or pumped via a Locality-owned force main into a large interceptor pipeline owned by HRSD. In a few areas, wastewater flows by gravity from the Locality system to an HRSD gravity pipe. Once in the HRSD collection system, the wastewater is typically pumped to a treatment plant where the wastewater is treated and discharged. The schematic below illustrates the wastewater flow path described above.

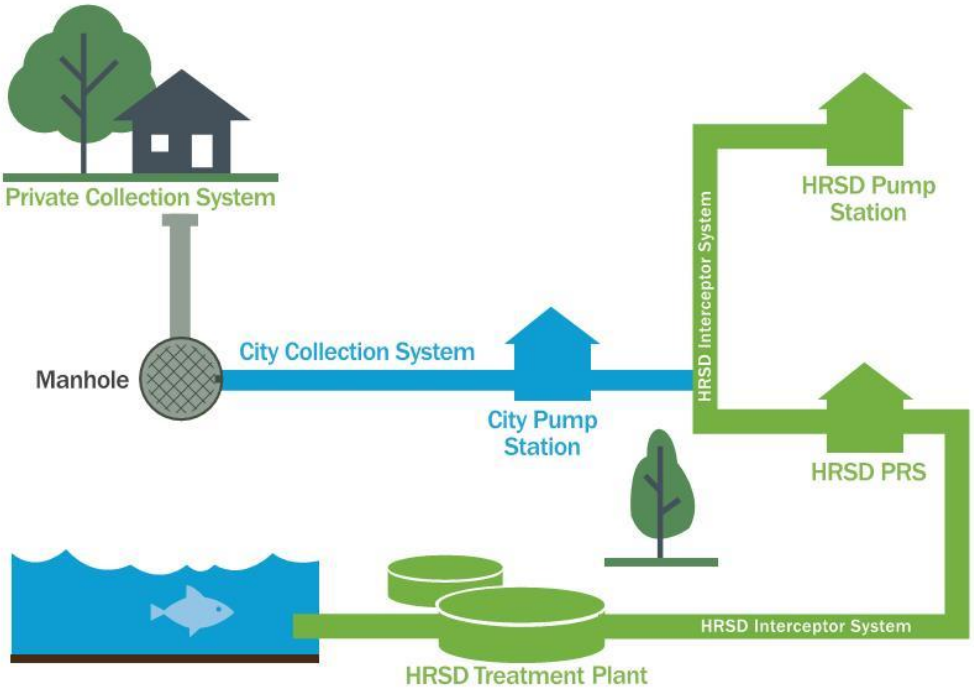

Figure 1-1. HRSD Wastewater Flow Path

The Hampton Roads topography is relatively flat, with many creeks, rivers, and a generally high water table. This topography makes deep gravity lines generally impractical to construct and necessitates the wide use of pumping, and often repumping, wastewater through the Locality collection systems and into the HRSD interceptor system. As a result, wastewater often has to be pumped several times before arriving at a treatment plant.

HRSD's interceptor system consists primarily of force mains, which are pressurized pipelines, with pumped wastewater that is delivered to the treatment plants. HRSD's system includes some large gravity mains in a few older areas of Hampton Roads which convey flow to large pumping stations. Overall, approximately 90 percent of HRSD's interceptor system by pipe length is comprised of force mains with the remaining 10 percent consisting of gravity mains.

The interconnectivity of HRSD's force mains allows for certain, limited diversion of flows among treatment plants located within the same HRSD shore, as there is no hydraulic connection between the North Shore and South Shore subsystems. This capability allows for limited flexibility so flows can be diverted in different directions to enable the plants to utilize capacity to the fullest potential. If capacity is limited in one portion of the system, HRSD is sometimes able to redirect the flow to another treatment plant.

The HRSD system also utilizes a relatively unique feature for a collection system—pressure reducing stations (PRSs). These PRSs are in-line pumping stations that enable pressure reduction in force mains upstream of the PRS. HRSD PRSs are designed to provide pumping assistance to large portions of the force main system based on thorough evaluation of upstream lift station pumping capabilities and projected system demands. Their broad operational criteria establish the pressures expected in HRSD's system customized for the particular sub-portion of the system that each PRS serves.

The Locality collection systems that deliver the flow to the HRSD interceptor system are, by contrast, mostly comprised of gravity pipe. Overall, approximately 85 percent of the Locality collection systems are comprised of gravity mains and the remaining 15 percent consists of force mains. The Locality collection systems also contain nearly 1,900 active pump stations, of which approximately half are directly connected via force main to HRSD facilities and the remaining half are lift stations that deliver the flow to downstream Locality-owned facilities.

Many of the hundreds of pump stations, including the PRSs, are manifolded via a network of connected force mains. Each pump station also reacts to normal flow rate changes coming from its upstream service area as well as occasional higher flow rates during wet weather events. Pump stations manifolded together must also react to varying pressure conditions as various connected pump stations turn on and off. Given the scale of this regional system, with only some pump stations actively pumping at any given moment, the collection and interceptor system experiences a complex range of flows and pressures.

As a toolset for managing this complexity, HRSD has many flow and pressure meters within its system and at strategic locations in portions of the Locality collection systems. These installations are part of a Flow, Pressure and Rainfall (FPR) Monitoring system. This FPR system includes many flow, pressure and rainfall meters and gauges that enable HRSD to monitor, maintain and manage system performance and reliability as well as to calibrate and verify system hydraulic modeling.

Table 1-2 shows a summary of the active assets that HRSD currently owns and operates in its North Shore and South Shore systems:

Table 1-2. HRSD North Shore and South Shore Interceptor System Overview			
	North Shore System	South Shore System	Total System
Number of HRSD Pump Stations	33	37	70
Number of HRSD Pressure Reducing Stations	3	16	19
Total Length of HRSD Force Main (mi.)	193	294	487
Total Length of HRSD Gravity Main (mi.)	29	24	53
Number of HRSD Gravity Manholes	711	597	1,308

Table 1-3 shows a summary of the active assets that the Localities in the Hampton Roads region own and operate taken from the August 2016 information submitted by the Localities to HRSD.

Table 1-3. Locality Collection System Overview			
	North Shore System	South Shore System	Total Locality System
Number of Locality Pump Stations	648	1,235	1,883
Number of Locality Terminal Pump Stations	208	726	934
Total Length of Locality Force Main (ft.)	1,544,000	3,075,000	4,619,000
Total Length of Locality Gravity Main (ft.)	9,470,000	18,051,000	27,521,000
Number of Locality Gravity Manholes	48,300	77,900	126,200

Source: Hampton Roads regional sanitary sewer asset database maintained by HRSD (retrieved August 18, 2016)

The combination of Locality-owned collection system assets and HRSD interceptor assets provide continuous wastewater service to the Hampton Roads region through carefully coordinated planning, operation and maintenance. HRSD and Locality systems form the regional system evaluated for wet weather capacity for which improvement solutions were developed as a part of the RWWMP. As shown in Table 1-3, there are approximately 934 terminal Locality pump stations that discharge directly into HRSD's system which creates a complicated network to manage flows and pressures.

Even with the scale of this regional system, the historical performance of these systems has continuously improved over the more than 70 years that the regional system has been in place. Such ongoing improvement efforts have resulted in a present-day system with minimal SSO impacts to the surrounding communities in recent years. HRSD continues to partner with the Localities to maintain and improve these systems by application of best industry practices and responsible innovation to continue providing world-class wastewater collection and treatment service to the residents of Hampton Roads.

Maps of the North and South Shore interceptor systems are provided in Figures 1-2 and 1-3.

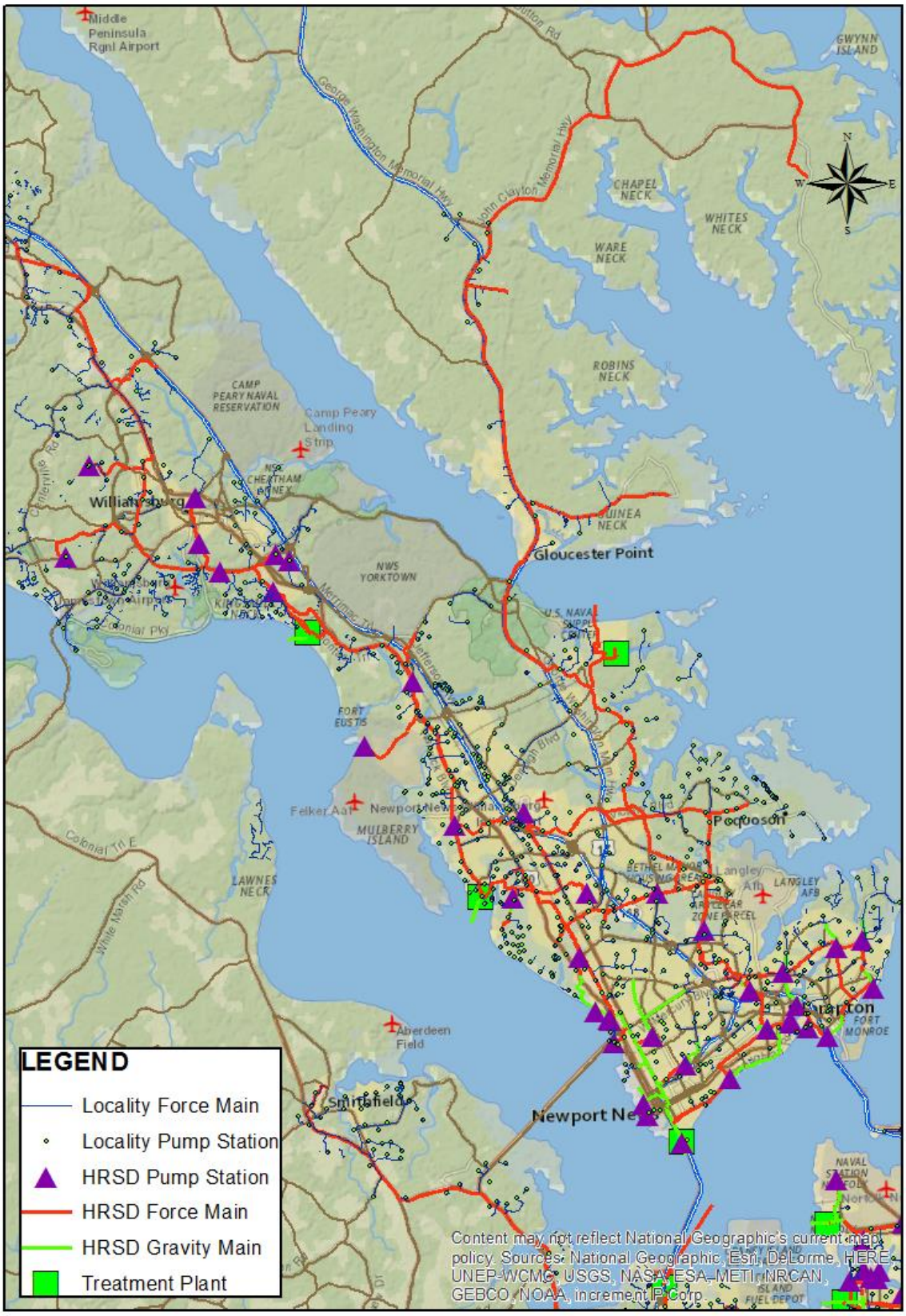

Figure 1-2. HRSD North Shore Interceptor System

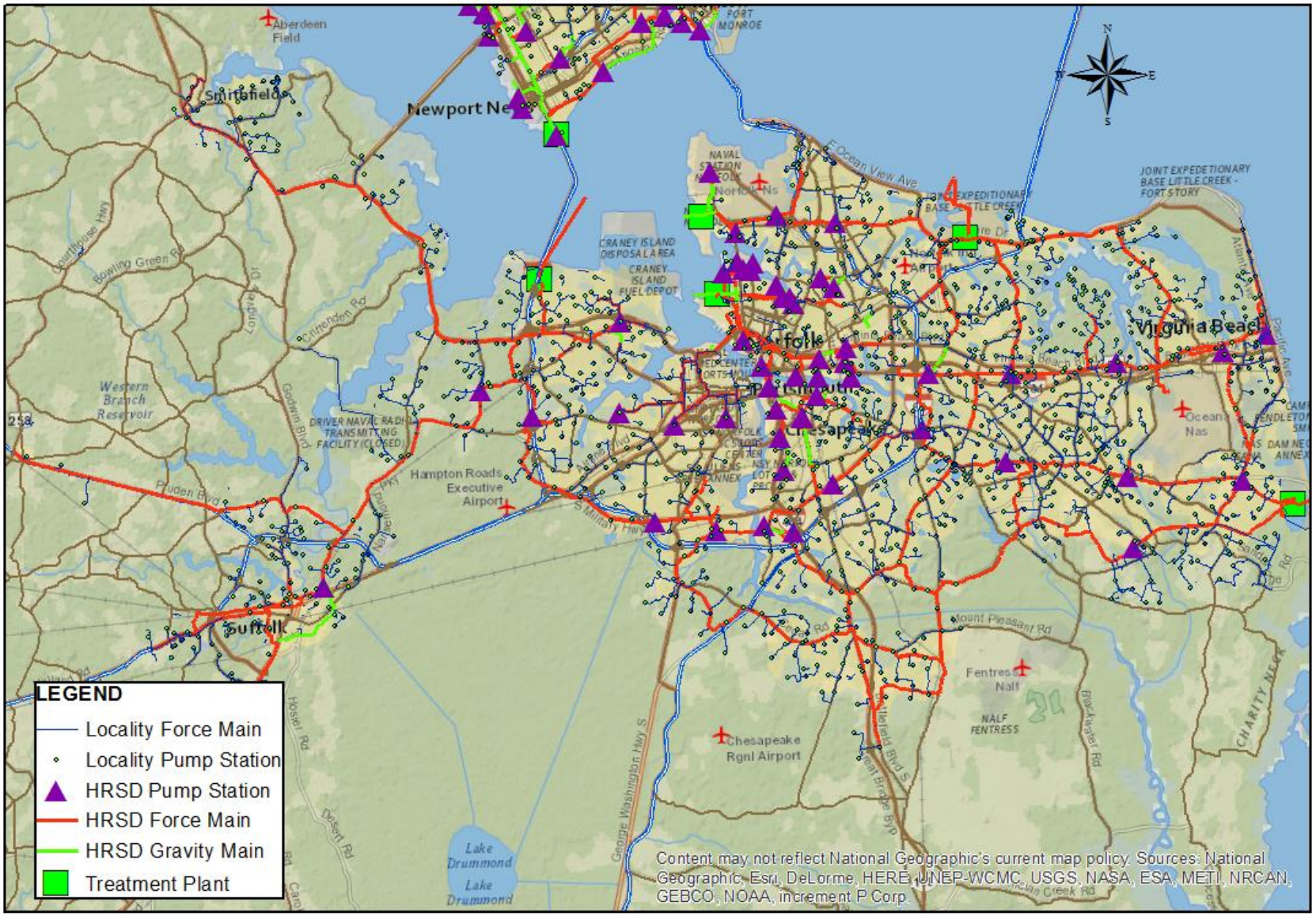

Figure 1-3. HRSD South Shore Interceptor System

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1.2 Aquifer Replenishment Program Implementation Schedule

ARP will be implemented through 2032, as currently planned. This is a very aggressive schedule and is dependent on getting the required approvals from EPA, Virginia Department of Health (VDH), DEQ and Locality authorities in a timely manner. Other potential critical path activities that could impact the schedule include land and easement acquisition. Several of the sites may need additional land for facilities. Most sites will need easements for piping and land for siting wellfields.

1.3 Unknowns and Uncertainties

The ARP is breaking new ground in Virginia for recycling and recharge. HRSD is in the planning and demonstration phase and there are unknowns and uncertainties that could impact HRSD's ability to complete the program as currently envisioned. The most prominent of these are discussed in the remainder of this section. HRSD's plan includes annual reports/briefings to EPA and DEQ with notification given for adverse developments. HRSD shall accelerate spending on the RWWMP if any of these or other unknowns comes to pass and causes HRSD to truncate or abandon part of or all of the ARP prior to 2032. (See Section 3.7 HPP Schedule Acceleration).

Aquifer Replenishment Performance

Fundamental to the success of the ARP is the ability to recharge the Potomac aquifer and reverse the historical depletion. This is largely dependent on aquifer hydraulic properties and geochemistry. HRSD will investigate each wellfield to identify the appropriate stratigraphic layers to screen the recharge wells to achieve the required recharge rates. Operations and maintenance practices are necessary to sustain recharge over the life of the wells. These activities include backflushing and periodic cleaning.

Well spacing is another variable that must be considered in the design and operation of the wellfields. This could vary from site to site and requires judgement and testing.

The risk to the program is that the recharge does not take the full amount of desired flow or the performance of the wells degrades over time.

Capital and Operations and Maintenance (O&M) Costs

HRSD has estimated capital and operations and maintenance costs for the ARP facilities and built a financial plan to cover these expenses; however, HRSD has not yet built or operated an ARP facility and there are a limited number of facilities like these nationally. Therefore, the capital and O&M costs are uncertain. ARP facilities will require concrete, steel and specialized process equipment to build and labor to operate and maintain, chemicals for the treatment system and power for the process – especially the UV system and ozone. If capital or O&M costs are much more expensive than planned, HRSD may not build all the facilities because of excessive impacts to ratepayers.

Opposition to ARP

Although HRSD has executed a thorough outreach program to stakeholders, including elected officials, regulators, the public, environmental groups, etc., there could be some future opposition to implementing ARP that affects the implementation timing and/or scope of the program.

Failure to Acquire Required Approvals

The ARP will require federal, state and local approvals and permits. At the federal level, EPA has primacy in Virginia for underground injection and will issue the Underground Injection Control (UIC) permit.

DEQ will review the facility plans and issue state permits to construct. VDH will be involved in both state and federal permitting and must be assured that public health and groundwater quality will be adequately protected.

Local permits include site plan approvals, stormwater permits, erosion and sediment control permits and building permits.

Any of these permits and approvals could present challenges. Failure to acquire these permits could cause delay or abandonment of that facility. However, coordination to date has not identified any non-starters.

Future Changes to Finished Water Standards

HRSD is in the process of establishing finished water standards that are protective of public health and the environment. Because reuse standards have not been previously established in Virginia for this type of activity, there is some possibility that additional or more stringent standards could be promulgated in the future. These could necessitate process and/or O&M changes that could be costly or difficult technically.

Section 2

Pathogen Source Tracking Program – Targeted Monitoring to Benefit Public Health

Restoring waterways impacted by bacteriological impairments requires a thorough understanding of the sources of bacteria contributing to the impairment. Several water bodies in the Hampton Roads region remain impaired by bacteria with elevated levels found in dry weather in areas that have no record of sewer overflow and in some cases, in areas without any public sewer infrastructure. Dry weather, ongoing, sources almost always present a greater impact to water quality than isolated wet weather-related sewer overflows. Surface water monitoring data following SSOs has indicated that the impacts of a transient SSO on the long-term impairment of a waterway are minimal, supporting the conclusion that waterway impairments in the Hampton Roads area are driven by chronic and persistent sources. Given that the regional sanitary sewer system has no chronic capacity-related overflow locations, the most effective approach toward achieving a higher degree of public health protection is to identify and eliminate the sources of bacterial contamination, specifically those that are known to represent the greatest risk to public health – human sources. To this end, HRSD has implemented its Pathogen Source Tracking Program. This focused water quality monitoring effort, in partnership with local governments and the Virginia Department of Health, has been successfully used to identify, locate, and eliminate chronic and persistent non-SSO-related sources of human-sourced bacteria. This program was instrumental in getting one local waterway, the Lafayette River, delisted for bacteria with work continuing on other bacteriologically impaired waterways in the region.

HRSD's Pathogen Source Tracking Program represents a significant investment in the development of novel molecular technologies for microbial source tracking. The human-specific molecular analyses conducted within HRSD's laboratory have a high degree of sensitivity and specificity allowing for the detection of human sources of bacteria in stormwater, surface water and sewer infrastructure samples. These molecular tools, when coupled with a thorough understanding of the wastewater and stormwater infrastructure, have successfully aided in identifying compromised infrastructure or in narrowing the human fecal contamination signal to a smaller, well defined area. Informed, adaptive results-based decisions used in tandem with local knowledge of sanitary sewer and storm water maps allow HRSD to back trace a human fecal signal to a point of origin.

Once the point of origin for the fecal signal is identified, corrective action measures are implemented, and subsequent monitoring is used to confirm successful elimination of the source. A tailored, adaptive program such as this represents a more cost-effective means of improving water quality and reducing risk to public health as opposed to broad brush approaches that fail to consider the unique characteristics of each waterway. For example, identifying and resolving a (1) residential connection to a storm sewer (instead of the sanitary sewer), (2) broken sewer line (public or private) near a stream, (3) failing septic facility, or (4) other continuous sources (straight pipe connection from private property to

local waterway) will yield far greater water quality and public health benefits that reducing large sewer overflows from major storms.

The program allows all stakeholders to target priority resources to address human-sourced bacteria. That said, other sources of bacteria to area waters (e.g., wildlife, dogs, etc.) are identified and can be targeted for reduction as well through programs such as providing dog waste bags in targeted public areas.

HRSD intends to continue to implement its Pathogen Source Tracking Program through 2040 and has estimated $20 million for these activities.

Table 2-1. HRSD Pathogen Source Tracking Projects

Waterbody	Partner(s)	Watershed/Municipality	Status	Fecal Contamination Source	Corrective Action	Comments
Wayne Creek	City of Norfolk, Elizabeth River Project	Norfolk	Completed	Compromised Force Main	Immediate Repair	Repair confirmed
Newport News Channel	Southeast Care Coalition, City of Newport News	SE Newport News	Completed	Compromised Gravity Sewer affecting Newport News Creek	Immediate temporary fix, then permanent bypass of this area of collection system	Repair confirmed
Shingle Creek	City of Suffolk	Suffolk	Completed	Illicit connection to stormwater collection system	Plugged connection after identification of waste sources	Repair confirmed
Hilton Beach	City of Newport News, Virginia Department of Health, Greater Hilton Citizen Group	Hilton Neighborhood	Completed	Identification of multiple compromised private side laterals	Immediate Repairs	Repairs confirmed
Indian River	Elizbeth River Project, City of Chesapeake	Chesapeake	Completed	No human source identified; Identification of dog, goose, and environmental sources of bacteria	Public education regarding domestic pet waste	

Table 2-1. HRSD Pathogen Source Tracking Projects						
Waterbody	Partner(s)	Watershed/Municipality	Status	Fecal Contamination Source	Corrective Action	Comments
Nansemond River	City of Suffolk; Virginia Department of Health--Shellfish Safety (VDH-DSS); Nansemond River Preservation Alliance	Nansemond River Watershed; Suffolk	On-going	Already identified multiple collapsed or compromised gravity sewer pipes that caused sewage infiltration in the SW collection system; Several failing septic systems also identified	Gravity sewer system repairs/replacement. Local health department working with residents to repair failing septic systems	In-pipe Microbial Source Tracking underway. Multi-year project
Knitting Mill Creek	City of Norfolk, Lafayette Wetlands Partnership	Colonial Place and Ghent Norfolk	Completed	No apparent human fecal contamination identified; evidence of sporadic SSOs; Evidence of signal originating from Haven Creek	See Haven Creek	Confirmed no human associated marker present
Broad Creek	City of Norfolk, Elizabeth River Project	Norfolk	Completed	No significant dry weather human fecal contamination; Evidence of multiple wet weather sources of human fecal contamination	Delineated upstream sewershed of chronic wet weather sewer issues	Findings/ delineated infrastructure issues given to the City of Norfolk
Jack Frost Collection System	City of Virginia Beach	Jack Frost Neighborhood	Completed	Delineated Extent of SSO	N/A	
Haven Creek	City of Norfolk	Lafayette River	Completed	Multiple illicit connections to stormwater collection system from retirement community	Immediate disconnection and repair of stormwater collection system. Laterals connected to sewer system.	Repair confirmed
New Market Creek	City of Hampton	New Market Creek; Hampton	On-going	Already identified multiple compromised gravity infrastructure that caused sewage infiltration in the SW conveyance system	Immediate gravity sewer system repairs (by the Hampton) and follow-up confirmation by HRSD	HRSD will systematically evaluate all stormwater outfalls in the watershed, one-sub-watershed at a time
Buckroe Beach	City of Hampton	Buckroe Beach; Hampton	Completed	City of Hampton found and fixed compromised gravity sewer infrastructure		Hampton wants to confirm the integrity of the remaining sewershed

Table 2-1. HRSD Pathogen Source Tracking Projects						
Waterbody	Partner(s)	Watershed/Municipality	Status	Fecal Contamination Source	Corrective Action	Comments
Mill Dam Creek	City of Virginia Beach, VDH-DSS	Virginia Beach	On-going	Dry weather screening complete. One gravity issue identified and extent delineated	Virginia Beach is currently investigating the issue	Wet weather work is underway
Thalia Creek	City of Virginia Beach, VDH-DSS	Virginia Beach	On-going	Identified multiple hotspots of human fecal contamination	Virginia Beach and HRSD are currently delineating the hotspots. Potential issues identified	HRSD will systematically evaluate all stormwater outfalls in the watershed, one-sub-watershed at a time
Southern Branch of Elizabeth River	City of Chesapeake	Chesapeake	On-going	No significant/ chronic evidence of human fecal contamination during dry or wet weather	N/A (so far)	HRSD will systematically evaluate all stormwater outfalls in the sub-watershed
Lucas Creek	City of Newport News, USGS, Hampton Roads Planning District Commission	Newport News	On-going			HRSD will systematically evaluate all stormwater outfalls in the watershed, one-sub-watershed at a time
Buchanan Creek	City of Virginia Beach	Virginia Beach	On-going			City response to citizen concerns
Lakeshore Park	City of Chesapeake	BMP adjacent to Elizabeth River	On-going			Chronic algal blooms in BMP; Request to eliminate sewage as a catalyst
South Norfolk	City of Chesapeake	Elizabeth River	Planning			HRSD will systematically evaluate all stormwater outfalls in the sub-watershed

Section 3

High-Priority Projects

3.1 HPP Selection Methodology

HRSD has identified a set of High-Priority Projects (HPPs).. As part of Regional Wet Weather Management Plan (RWWMP) submitted to the DEQ and EPA in September 2017, HRSD developed an approach to recognize the highest-priority system improvements with the greatest relative environmental benefit.

After establishing a full set of RWWMP solutions (comprised of more than 500 different elements), HRSD performed a modeling evaluation of improvements to gauge effectiveness in SSO reduction as well as identifying the location of the affected SSOs. This information along with I/I reduction data was used to calculate the total score for each project and recognize the potential environmental benefit of solutions.

The initial Round 1 HPPs were identified in the RWWMP, submitted to EPA in September of 2017, and are scheduled to be constructed between plan approval and 2030.

Further review of RWWMP projects was conducted in 2019 to find beneficial solutions to implement as a second set of HPPs (identified as Round 2). Prioritization methodology, described in Section 3.1.2, was used to identify a candidate pool of improvements. Additional emphasis was applied to SSO volume changes in order to maximize overall potential load reduction.

Since individual testing had been conducted against the capacity assessment baseline, initial simulation results did not take impacts of Round 1 HPPs into account. As part of consideration when making Round 2 selections, projects that had significant benefit overlap with Round 1 were excluded since incremental reductions above the existing HPPs would be minimal.

A few projects, while beneficial and high in ranking, required additional modification of sequencing and grouping to offset potential negative system impacts. In order to optimize benefits of Round 2 HPPs, some selections include multiple elements identified as necessary to work in concert to achieve the desired SSO reductions.

Projects selected as Round 2 HPPs were then modeled to both quantify load reduction and verify that implementation would not create additional system stress if conducted apart from remaining RWWMP solutions. Associated modeling assumptions and selection results are outlined below in this section.

3.1.1 Modeling Approach and Assumptions

Major modeling approach details and assumptions are as follows:

- A modeling technique was utilized with progressively increasing system flows from the receiving treatment plant to each upstream terminal sewer catchment where full 5-year peak flows were loaded.
- The 5-year event utilized for the modeling is provided in Appendix B. Although the same rainfall hyetograph was used for all the modeling, spatial distribution factors (SDFs) that adjusted the rainfall totals were applied based on the modeled area size.

- Growth in the system was maintained with 2030 population and employment projections included.
- System valving was unchanged from the Round 1 HPP.
- Reductions in inflow/infiltration (I/I) were only included for identified areas within HPPs. The remainder of the system was modeled using pre-rehab flow parameters.
- The sizing and configuration of the High-Priority Projects were left the same with no further optimization of tank volumes or other changes.
- The model was run with the full set of Round 1 and Round 2 High-Priority Projects to evaluate the effectiveness in 5-year peak flow SSO volume reduction. The total SSO volume remaining from this model run was compared to the 'do no harm' results from Round 1 HPP to quantify incremental reduction impact for Round 2 HPP projects.

HRSD is taking action with numerous capital projects throughout the Atlantic Treatment Plant service area to accommodate the closure of the Ches-Liz Treatment Plant by December 31, 2021. Since the first RWWMP was submitted in 2017, HRSD has modified the set of projects required to close Ches-Liz Treatment Plant while maintaining similar levels of service.

3.1.2 Evaluation Criteria

Prioritization criteria used to establish a relative project ranking are listed in Table 3-1. These criteria were defined with the objective of highlighting which RWWMP projects could have the largest beneficial environmental impact.

The weight given to pollutant load reduction for screening recognizes the primary importance of water quality improvements. The secondary criterion, location, is scored and weighted to highlight spatial considerations of human health and living resource impacts. The final category focuses on I/I reduction due to the importance of relieving existing system capacity.

Table 3-1. Criteria to Identify High-Priority RWWMP Projects

Criteria				Scoring	Weight
1	Pollutant load reduced (Gallons)			Scaled rank order	0.5
2	SSO location	Tier 1	Proximity to water used for public beaches	5	0.3
		Tier 2	Proximity to public surface drinking water sources	1	
			Proximity to open shellfish grounds	1	
			Proximity to high-priority waters	1	
		Tier 3	Drains to bacteria- impaired or bacteria TMDL watershed	0.5	
	Project Location		Reduces I/I with affected shellfish grounds (Army Base, James River, VIP)	0.5	
3	I/I Reduction (peak gpd)			Scaled rank order	0.2

3.1.2.1 Load Reduction Estimation

For High-Priority project screening purposes, a baseline of SSO locations and volumes were identified using the Regional Hydraulic Model (RHM). Primary variables included for the baseline simulation areas are indicated below:

- 5-year peak flow recurrence event
- System valving configurations reflect the closure of the Ches-Liz Treatment Plant
- Infrastructure projects needed to take CE off-line were modeled as complete
- All improvements identified for the RWWMP were excluded for baseline results

Capacity improvement and I/I reduction elements were grouped for analysis per infrastructure connectivity, hydraulic interactions, and potential impact to location-critical baseline SSOs. Resulting High-Priority project groups were then modeled through a series of simulations to estimate a total potential load reduction against baseline overflows. Model results served as the basis of relative comparison between groups for load reduction criteria as well as providing a correlation to baseline SSOs for location ranking.

3.1.2.2 Project Scoring

Primary location ranking was based on the location of the affected SSOs rather than the location of the project itself. Simulated overflow points were evaluated with respect to proximity measures identified in Table 3-1 and assigned individual location scores. Project location scores were then developed for each group according to which baseline SSOs had reductions predicted from hydraulic model simulations. Additional location points were included for any project that also met the criteria of reducing I/I to a ARP-participating Treatment Plant with affected shellfish grounds.

Total net load reduction, location, and I/I reduction rankings were weighted and summed for all analyzed project groups. Criterion scores for each project were normalized to a scale of 0-100 based on the range of scores for all projects. An overall project score was obtained by multiplying each normalized criterion score by its respective weighting factor and summing the values. Analyzed projects were then ranked based on an overall (weighted) score. The highest-ranking projects were reviewed for selection.

Selective exclusion from consideration as a High-Priority project was implemented for cases where the impacted SSO locations and volume reductions overlapped significantly between project groups. In these cases, the lower ranking project was excluded as any incremental benefit would be slight after the higher-ranking project was executed. Additionally, simulation results indicated some individual projects to have potential adverse impact to system conditions when not executed in concert with numerous other RWWMP projects. These groupings were excluded from consideration in the ranking order in favor of projects without similar effects.

3.1.3 Project Selection Results

3.1.3.1 Round 1 HPP Selection Results

Six major project groups were identified as falling within the selection criteria for Round 1 HPPs. Table 3-2 provides a description of the initial High-Priority Projects.

Table 3-2. Round 1 Selected High-Priority Projects

Round 1 Project	High-Priority Project Group ID	TP	Location	General Description
1	VIP-05_06_07	VIP	Portsmouth	Camden Ave PS and GM Improvements; Portsmouth I/I Reduction; Locality PS Upgrades
2	NA-01	NA	Suffolk	Wilroy PRS and Storage
3	NA-08	NA	Chesapeake	Chesapeake I/I Reduction; Jumper FM
4	AT-02	AT	Chesapeake	Chesapeake I/I Reduction; Locality PS and FM Upgrades
5	BH-02_S	BH	Newport News/ Hampton	Claremont Ave GM, PS, and Siphon Improvements; 14th St Storage
6	VIP-11	VIP	Norfolk	State St PRS and Storage

A 'do no harm' model run was conducted to review the combined system impact of the selected projects. This effort was undertaken to both quantify SSO reduction estimates and to confirm that the sequence of High-Priority implementation did not exhibit significant negative system effects within the

model. Composite results of predicted SSO volume reduction are further discussed in Section 3.2. General project area locations and additional details for Round 1 HPPs are available in Section 3.3.

3.1.3.2 Round 2 HPP Selection Results

Nine projects have been identified as falling within the selection criteria for Round 2 HPPs. Table 3-3 provides a description of the additional High-Priority Projects. Due to sequencing and system interactivity, some groups were considered for selection only in combination with other tested groups. These multiple groupings are represented as a single project and would need to be constructed jointly to achieve the simulated reductions.

Table 3-3. Round 2 Selected High-Priority Projects

Round 2 Project	High-Priority Project Group ID	TP	Location	General Description
1	WB-04	WB	Williamsburg	Williamsburg Crossing PRS, Force Main and Storage Tank
	WB-13	WB	York County	York County I/I Reduction; Lodge Rd Extended wet well
	WB-03	WB	York County	York County I/I Reduction
2	AT-05	AT	Virginia Beach	Birdneck - General Booth Blvd. Force Main Improvements
3	BH-04	BH	Newport News	58th St Storage Tank
	BH-05	BH	Newport News/ Hampton	Newmarket Creek PS Upgrade and Gravity Main improvements
4	VIP-21	VIP	Norfolk	Norfolk I/I Reduction
	VIP-29	VIP	Norfolk	Norfolk I/I Reduction
5	VIP-08	VIP	Norfolk	May Ave. Storage Tank
	VIP-09	VIP	Norfolk	Willoughby Ave PS Upgrade; Victoria Ave FM; Norfolk PS149 Upgrade
6	JR-06	JR	Newport News	Newport News I/I Reduction
7	JR-04	JR	Newport News	Lucas Creek PRS Upgrade
8	NA-03	NA	Portsmouth	Cedar Lane Gravity Main Improvement; Cedar Lane PS Upgrade
	NA-04	NA	Chesapeake	Western Branch PRS; Chesapeake I/I Reduction
9	YR-04	YR*	York County	Tabb PRS and Storage

* Project modeled to send flow to YR instead of final RWWMP valving to JR

A second 'do no harm' model was run with the full set of Round 1 and Round 2 High-Priority Projects to evaluate the effectiveness in 5-year peak flow SSO volume reduction. Simulation results of predicted SSO volume reduction are outlined in Section 3.2. General project area locations and additional details for Round 2 HPPs are available in Section 3.4.

3.2 Potential HPP SSO Volume Reductions

Round 1 and Round 2 HPPs include system improvements distributed across nine localities and seven treatment plant service areas. For High-Priority Project analysis, the referenced baseline of modeled SSO locations and volumes was the same as were developed for the IP/RWWMP. All volumes depicted are correlated to overflows at a 5-year peak flow recurrence interval.

Simulation results from Round 1 and 2 HPPs are estimated to reduce the baseline overflow volumes by a total of 69%. Incremental net reductions for each phase of High-Priority Projects are attributed by treatment plant in Figure 3-1. A numerical breakdown of potential volume reductions, outlined by major subsystem, is provided in Table 3-4.

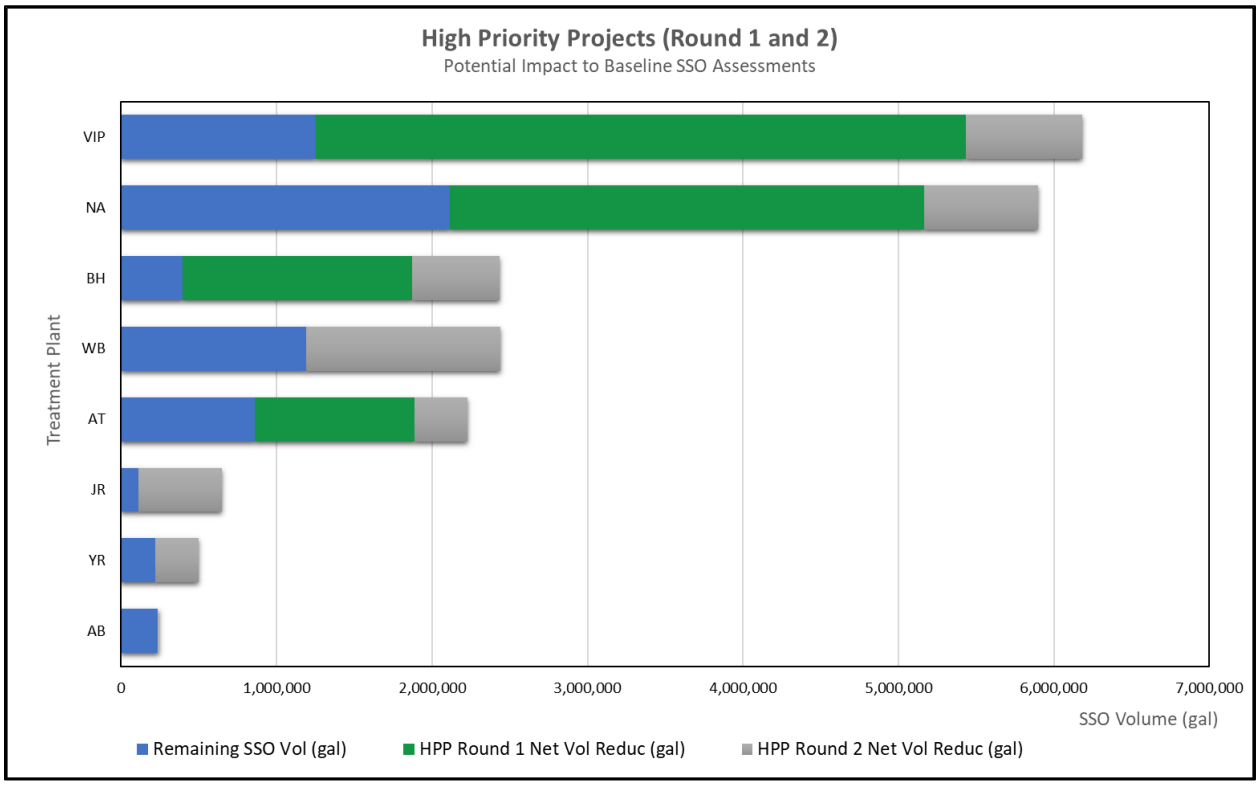

Figure 3-1. Round 1 and 2 High-Priority Project Impact by TP

Table 3-4. High-Priority Project Modeled Impact by Subsystem

	Baseline SSO Volume Spilled (gal)	HPP Round 1 Net Volume Reduction (gal)	HPP Round 2 Net Volume Reduction (gal)	Total HPP Load Reduction (gal)
North Shore	6,021,000	1,476,000	2,640,000	4,116,000
South Shore	14,547,000	8,256,000	1,827,000	10,083,000
Total (gal)	20,568,000	9,732,000	4,467,000	14,199,000
Total (%)		47.3%	21.7%	69.0%

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3.3 HPP Round 1

3.3.1 Project Elements

System improvement elements included in Round 1 High-Priority Projects are outlined in Table 3-5. Further technical and engineering analysis may result in a change in scope to these projects. If a project is reduced in scope by 20 percent or more, HRSD will notify the EPA/DEQ and explain the basis for the reduction in scope. For example, a change in scope may involve reduction in the length of a force main to be replaced, reduction in the pumping capacity of a pump station, or similar technical changes.

Table 3-5. Round 1 High-Priority Project Summary

High-Priority Project	Modeled HPP Group	RWWMP Project ID	Element Source	Asset Ownership	TP	Asset Type	Name
Round 1 HPP 1							
	VIP-05_06_07	VIP-RWWMP-04	I/I Program	PORT	VIP	I/I Reduc	PORT-01 Comprehensive I/I Reduction Plan
			I/I Program	PORT	VIP	I/I Reduc	PORT-02 General I/I Reduction Plan
			I/I Program	PORT	VIP	I/I Reduc	PORT-04 General I/I Reduction Plan
			I/I Program	PORT	VIP	I/I Reduc	PORT-04-LOP65-1 Data-Driven I/I Reduction Plan
			I/I Program	PORT	VIP	I/I Reduc	PORT-04-LOP65-2 Data-Driven I/I Reduction Plan
			I/I Program	PORT	VIP	I/I Reduc	PORT-04-LOP65-3 Data-Driven I/I Reduction Plan
			RHM	PORT	VIP	GM	Camden Ave. Gravity Main Improvement – I
			RHM	PORT	VIP	GM	Camden Ave. Gravity Main Improvement – II
			RHM	PORT	VIP	PS	PORT-PS-002 PS Upgrade
			RHM	PORT	VIP	PS	PORT-PS-008 PS Upgrade
			RHM	HRSD	VIP	PS	Camden Ave. PS Upgrade
Round 1 HPP 2							
	NA-01	NA-RWWMP-03	RHM	HRSD	NA	PRS	Wilroy PRS
			RHM	HRSD	NA	Storage	Wilroy Storage Facility
Round 1 HPP 3							
	NA-08	NA-RWWMP-01	I/I Program	CHES	NA	I/I Reduc	CHES-016 Comprehensive I/I Reduction Plan
			LHM	CHES	NA	GM	CHES-016 GM Improvement
			I/I Program	CHES	NA	I/I Reduc	CHES-018 Comprehensive I/I Reduction Plan
			I/I Program	CHES	NA	I/I Reduc	CHES-227 Data-Driven I/I Reduction Plan
			RHM	HRSD	NA	FM	Jumper FM CHES-PS-041

Table 3-5. Round 1 High-Priority Project Summary							
High-Priority Project	Modeled HPP Group	RWWMP Project ID	Element Source	Asset Ownership	TP	Asset Type	Name
Round 1 HPP 4							
	AT-02	AT-RWWMP-01	RHM	CHES	AT	FM	CHES-PS-067 FM
			RHM	CHES	AT	PS	CHES-PS-072 Upgrade
			I/I Program	CHES	AT	I/I Reduc	CHES-032 General I/I Reduction Plan
			I/I Program	CHES	AT	I/I Reduc	CHES-047 Data-Driven I/I Reduction Plan
			I/I Program	CHES	AT	I/I Reduc	CHES-067 Comprehensive I/I Reduction Plan
			LHM	CHES	AT	GM	CHES-067 Gravity Main Improvement - I
			LHM	CHES	AT	GM	CHES-067 Gravity Main Improvement – II
			I/I Program	CHES	AT	I/I Reduc	CHES-111 General I/I Reduction Plan
Round 1 HPP 5							
	BH-02_S	BH-RWWMP-01	RHM	HRSD	BH	GM	Claremont Ave Gravity Main Improvement -I
			RHM	HRSD	BH	GM	Claremont Ave Gravity Main Improvement -II
			RHM	HRSD	BH	PS	Claremont PS Upgrade
			RHM	HRSD	BH	Siphon	Claremont Siphon - Chesapeake Ave and Robinson Rd Upgrade
			RHM	HRSD	BH	Siphon	Claremont Siphon - Indian River Upgrade
			RHM	HRSD	BH	Storage	14th St Storage Facility
Round 1 HPP 6							
	VIP-11	VIP-RWWMP-05	RHM	HRSD	VIP	PRS	State St PRS
			RHM	HRSD	VIP	Storage	State Street Storage Facility

3.3.2 Project Location Map

General area locations for High-Priority Round 1 projects are displayed in Figure 3-2. Individual project maps can be referenced in Appendix A.

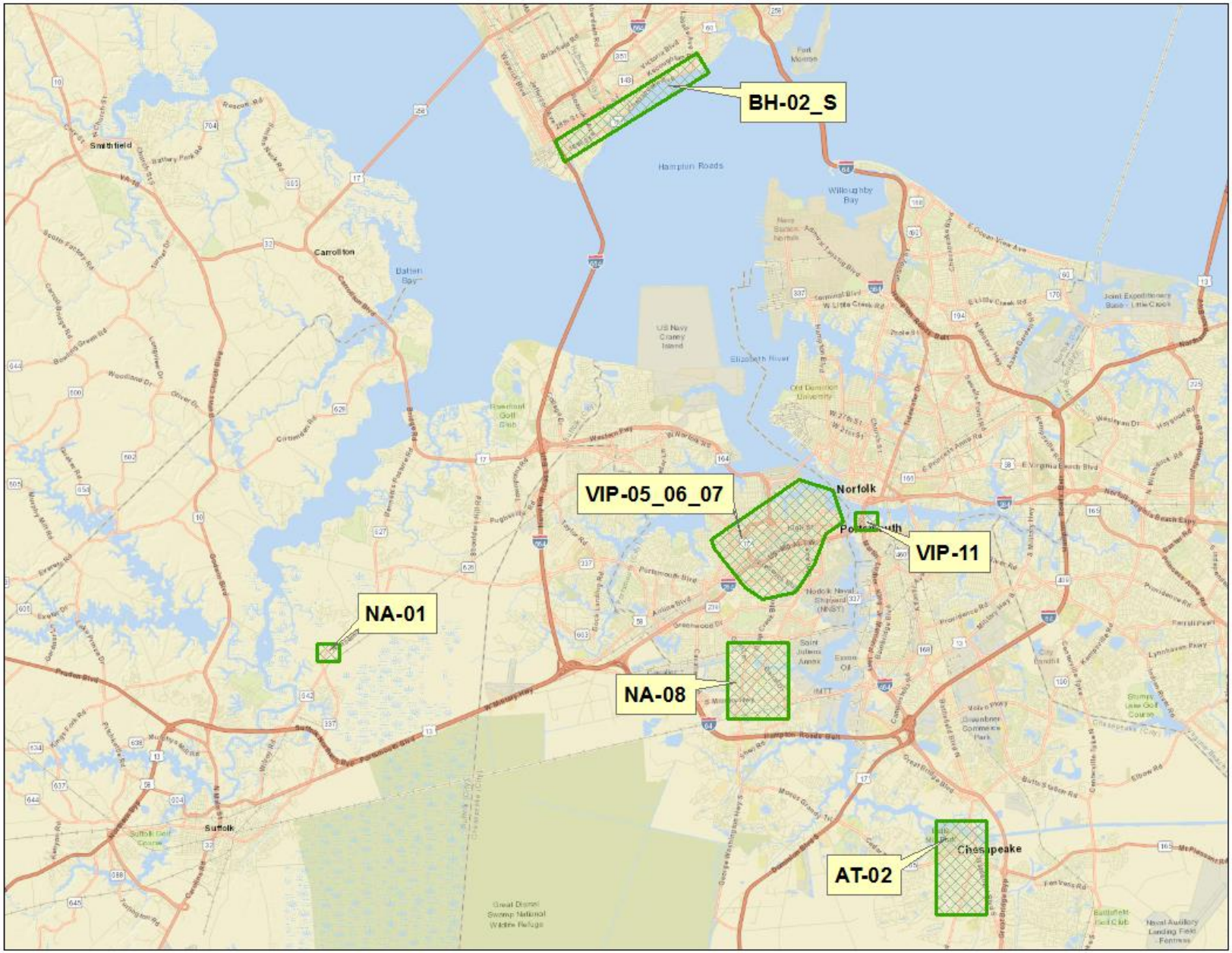

Figure 3-2. Round 1 High-Priority Project Locations

3.4 HPP Round 2

3.4.1 Project Elements

System improvement elements included in Round 2 High-Priority Projects are outlined in Table 3-6. Further technical and engineering analysis may result in a change in scope to these projects. If a project is reduced in scope by 20 percent or more, HRSD will notify the EPA/DEQ and explain the basis for the reduction in scope. For example, a change in scope may involve reduction in the length of a force main to be replaced, reduction in the pumping capacity of a pump station, or similar technical changes.

Table 3-6. Round 2 High-Priority Project Summary

High-Priority Project	Modeled HPP Group	RWWMP Project ID	Element Source	Asset Ownership	TP	Asset Type	Name
Round 2 HPP 1							
	WB-04	WB-RWWMP-02	RHM	HRSD	WB	FM	Williamsburg Crossing FM
			RHM	HRSD	WB	PRS	Williamsburg Crossing PRS
			RHM	HRSD	WB	Storage	Williamsburg Crossing Storage Facility
	WB-13	WB-RWWMP-07	LHM	YORK	WB	GM	YORK-006 Gravity Main Improvement
			I/I Program	YORK	WB	I/I Reduc	YORK-006 Comprehensive I/I Reduction Plan
		WB-RWWMP-14	I/I Program	YORK	WB	I/I Reduc	YORK-001 Comprehensive I/I Reduction Plan
			I/I Program	YORK	WB	I/I Reduc	YORK-003 Data-Driven I/I Reduction Plan
		WB-RWWMP-19	RHM	HRSD	WB	Storage	Lodge Rd. Extended Wet Well
	WB-03	WB-RWWMP-12	I/I Program	YORK	WB	I/I Reduc	YORK-229-2 Comprehensive I/I Reduction Plan
Round 2 HPP 2							
	AT-05	AT-RWWMP-06	RHM	HRSD	AT	FM	Birdneck - General Booth Blvd. FM - I
			RHM	HRSD	AT	FM	Birdneck - General Booth Blvd. FM - II
			RHM	HRSD	AT	FM	Birdneck - General Booth Blvd. FM - III
Round 2 HPP 3							
	BH-04	BH-RWWMP-04	RHM	HRSD	BH	Storage	58th St Storage Facility
	BH-05	BH-RWWMP-07	RHM	HRSD	BH	PS	Newmarket Creek PS Upgrade
		BH-RWWMP-08	RHM	HRSD	BH	GM	Mercury Blvd and Newmarket Gravity Main Improvement - I
			RHM	HRSD	BH	GM	Mercury Blvd and Newmarket Gravity Main Improvement - II

Table 3-6. Round 2 High-Priority Project Summary							
High-Priority Project	Modeled HPP Group	RWWMP Project ID	Element Source	Asset Ownership	TP	Asset Type	Name
Round 2 HPP 4							
	VIP-29	VIP-RWWMP-41	I/I Program	NORF	VIP	I/I Reduc	NORF-H-106 General I/I Reduction Plan
			I/I Program	NORF	VIP	I/I Reduc	NORF-H106-G1 General I/I Reduction Plan
			I/I Program	NORF	VIP	I/I Reduc	NORF-H-113 General I/I Reduction Plan
	VIP-21		I/I Program	NORF	VIP	I/I Reduc	NORF-H113-G1 Comprehensive I/I Reduction Plan
			I/I Program	NORF	VIP	I/I Reduc	NORF-H113-G2 General I/I Reduction Plan
Round 2 HPP 5							
	VIP-08	VIP-RWWMP-12	RHM	HRSD	VIP	Storage	May Ave. Storage Facility
	VIP-09	VIP-RWWMP-13	RHM	HRSD	VIP	PS	Willoughby Ave PS Upgrade
		VIP-RWWMP-14	RHM	NORF	VIP	FM	Victoria Ave FM
			RHM	NORF	VIP	PS	NORF-PS-149 Upgrade
Round 2 HPP 6							
	JR-06	JR-RWWMP-11	I/I Program	NEWP	JR	I/I Reduc	NEWP-WCPSA001575 General I/I Reduction Plan
			LHM	NEWP	JR	GM	NEWP-013 GM Improvement (NEWP-WCPSA001575)
			I/I Program	NEWP	JR	I/I Reduc	NEWP-WCPSA001600 Comprehensive I/I Reduction Plan
Round 2 HPP 7							
	JR-04	JR-RWWMP-04	RHM	HRSD	JR	PRS	Lucas Creek PRS Upgrade
Round 2 HPP 8							
	NA-03	NA-RWWMP-12	RHM	HRSD	NA	GM	Cedar Lane PS Gravity Main Improvement
		NA-RWWMP-14	RHM	HRSD	NA	PS	Cedar Lane PS Upgrade
	NA-04	NA-RWWMP-16	RHM	HRSD	NA	PRS	Western Branch PRS
		NA-RWWMP-18	I/I Program	CHES	NA	I/I Reduc	CHES-026 Comprehensive I/I Reduction Plan
		NA-RWWMP-19	RHM	CHES	NA	PS	CHES-PS-046 Upgrade
			RHM	CHES	NA	PS	CHES-PS-069 Upgrade
Round 2 HPP 9							
	YR-04	JR-RWWMP-02	RHM	HRSD	YR	PRS	Tabb PRS
			RHM	HRSD	YR	Storage	Tabb Storage Facility

3.4.2 Project Locations Map

General area locations for the elements that comprise Round 2 High-Priority Projects are displayed in Figure 3-3. Individual project maps can be referenced in Appendix A.

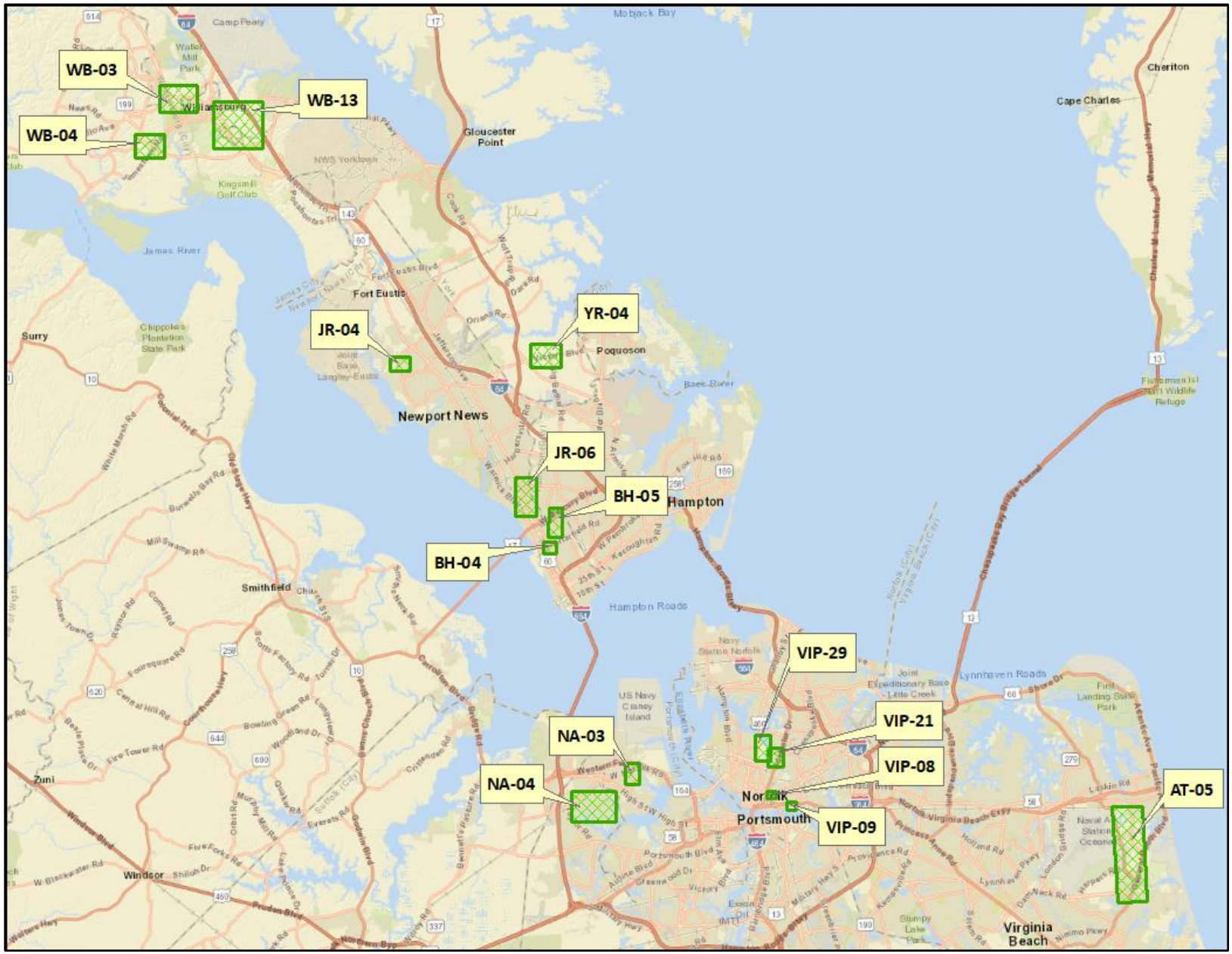

Figure 3-3. Round 2 High-Priority Project Locations

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3.5 HPP Cost Estimates

Cost estimation was performed at a Class 4 level representing concept study/feasibility of work. Total capital costs for High-Priority Project implementation, inclusive of both Round 1 and 2, is estimated at $410 million. A breakdown of anticipated spending by asset type is outlined in Table 3-7. Figure 3-4 provides the cost estimate allocated by asset ownership.

Table 3-7. High-Priority Projects by Asset Type

Asset Type	Round 1		Round 2	
	Cost ($ Millions)	% of Total	Cost ($ Millions)	% of Total
PRS	$13.0	6.3%	$32.6	16.1%
Storage	$38.8	18.7%	$33.5	16.5%
HRSD Pump Station	$35.2	16.9%	$24.4	12.0%
HRSD Conveyance	$17.7	8.5%	$36.7	18.1%
Locality Pump Station	$12.6	6.0%	$7.6	3.7%
Locality Conveyance	$3.9	1.9%	$1.1	0.5%
I/I Reduction	$86.5	41.7%	$66.6	32.9%
Total	**$207.7**	**100%**	**$202.4**	**100%**

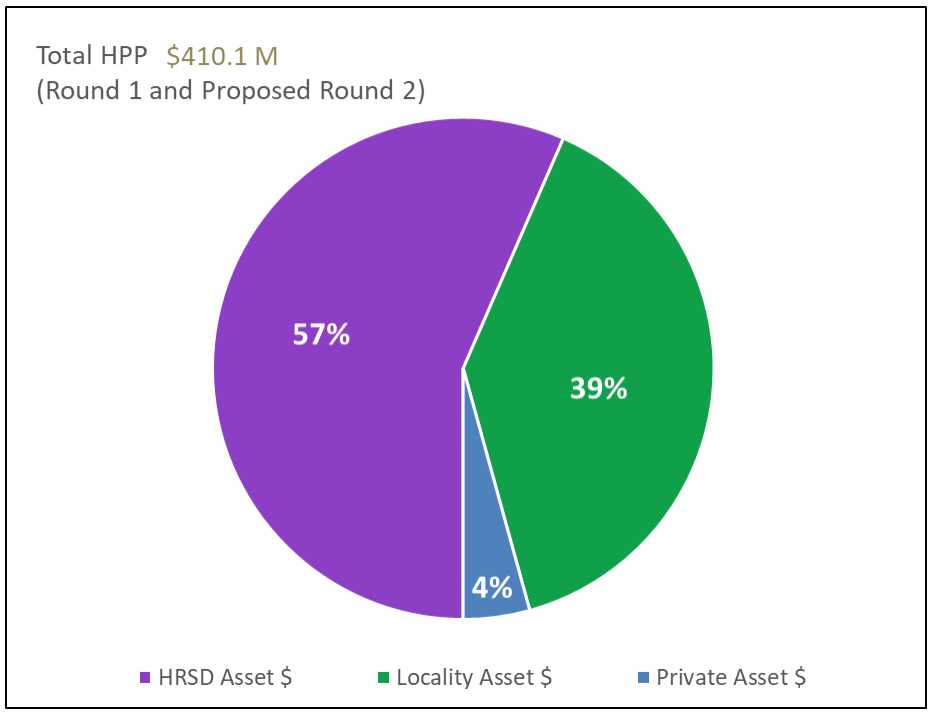

Figure 3-4. High-Priority Project Cost by Ownership

Capital cost estimates for identified improvements in Round 1 and 2 HPPs are provided in Tables 3-8 and 3-9, respectively.

Table 3-8. Round 1 High-Priority Project Cost Summary

Round 1 Project	High-Priority Project Group	RWWMP Project ID	TP	Location	Capital Cost Estimate ($M)	General Description
1	VIP-05_06_07	VIP-RWWMP-04	VIP	PORT	$64.11	• PS Capacity Improvements: PORT-PS-002, PORT-PS-008, Camden Ave PS • Camden Ave. GM Capacity Improvements • Portsmouth I/I Reduction
2	NA-01	NA-RWWMP-03	NA	SUFF	$19.42	• Wilroy PRS • Wilroy Storage Tank
3	NA-08	NA-RWWMP-01	NA	CHES	$36.17	• Jumper FM CHES-PS-041 • Chesapeake I/I Reduction
4	AT-02	AT-RWWMP-01	AT	CHES	$24.77	• PS Capacity Improvement: CHES-PS-072 • FM Capacity Improvement: CHES-PS-067 • Chesapeake I/I Reduction
5	BH-02_S	BH-RWWMP-01	BH	NEWP/ HAMP	$48.56	• 14th St. Storage Tank • PS Capacity Improvement: Claremont PS • Claremont GM Improvements • Siphon Upgrades
6	VIP-11	VIP-RWWMP-05	VIP	NORF	$14.66	• State St. PRS • State Street Storage Tank
				Total	$207.7	

Table 3-9. Round 2 High-Priority Project Cost Summary

Round 2 Project	High-Priority Project Group	RWWMP Project ID	TP	Location	Capital Cost Estimate ($M)	General Description
1	WB-04	WB-RWWMP-02	WB	WILL	$19.99	• Williamsburg Crossing PRS • Williamsburg Crossing FM • Williamsburg Crossing Storage Tank
	WB-13	WB-RWWMP-07	WB	YORK	$16.30	• York County I/I Reduction
		WB-RWWMP-14	WB	YORK	$9.17	• York County I/I Reduction
		WB-RWWMP-19	WB	YORK	$0.23	• Lodge Rd extended wet well
	WB-03	WB-RWWMP-12	WB	YORK	$7.72	• York County I/I Reduction Area
2	AT-05	AT-RWWMP-06	AT	VB	$26.85	• Birdneck - General Booth Blvd. FM Improvements
3	BH-04	BH-RWWMP-04	BH	NEWP	$11.46	• 58th St Storage Tank
	BH-05	BH-RWWMP-07	BH	NEWP/ HAMP	$7.65	• PS Capacity Improvement: Newmarket Creek PS
		BH-RWWMP-08	BH	NEWP/ HAMP	$7.27	• Newmarket Creek GM Improvements
4	VIP-21	VIP-RWWMP-41	VIP	NORF	$8.88	• Norfolk I/I Reduction
	VIP-29	VIP-RWWMP-41	VIP	NORF	$3.50	• Norfolk I/I Reduction
5	VIP-08	VIP-RWWMP-12	VIP	NORF	$8.28	• May Ave. Storage Tank
	VIP-09	VIP-RWWMP-14	VIP	NORF	$4.38	• Victoria Ave FM Improvement • PS Capacity Improvement: NORF-PS-149
		VIP-RWWMP-13	VIP	NORF	$2.28	• PS Capacity Improvement: Willoughby Ave PS
6	JR-06	JR-RWWMP-11	JR	NEWP	$17.09	• Newport News I/I Reduction
7	JR-04	JR-RWWMP-04	JR	NEWP	$13.20	• Lucas Creek PRS Upgrade
8	NA-03	NA-RWWMP-12	NA	PORT	$0.79	• Cedar Lane GM Improvement
		NA-RWWMP-14	NA	PORT	$14.46	• PS Capacity Improvement: Cedar Lane PS

Table 3-9. Round 2 High-Priority Project Cost Summary						
Round 2 Project	High-Priority Project Group	RWWMP Project ID	TP	Location	Capital Cost Estimate ($M)	General Description
	NA-04	NA-RWWMP-16	NA	CHES	$4.69	• Western Branch PRS
		NA-RWWMP-18	NA	CHES	$4.41	• Chesapeake I/I Reduction
		NA-RWWMP-19	NA	CHES	$3.80	• PS Capacity Improvement: CHES-PS-046, CHES-PS-069
9	YR-04	JR-RWWMP-02	YR*	YORK	$10.06	• Tabb PRS • Tabb Storage Tank
				Total	$202.4	

* Project modeled to send flow to YR instead of final RWWMP valving to JR

The relative cost efficiencies for High-Priority Project implementation are displayed in Table 3-10 for general reference purposes. There are severely diminishing returns in cost per gallon SSO reduced beyond High-Priority Round 2.

Table 3-10. SSO Volume Reduction Cost Comparison			
Improvement Phase	Cost ($Millions)	SSO Volume Reduction (MG)	Cost/Gal SSO Volume Reduced
HPP Round 1	$208	9.73	$21
HPP Round 2	$202	4.47	$45
Remaining Potential Projects	$1,391	6.37	$218

3.6 HPP Sequencing and Scheduling

High-Priority Projects were scheduled with consecutive 10-year implementation periods starting with Round 1 being completed between plan approval and 2030. At that time, HRSD will review the Round 2 projects to confirm that they are still expected to meet the desired result and confirm this in a check in with the EPA/DEQ. To modify the list of specific projects, HRSD will show that the revised set will attain a minimum of the same percent reduction, or better. Table 3-11 outlines the completion time frame for each set of High-Priority Projects.

Table 3-11. High-Priority Projects by Implementation Phase			
Phase	Completion Time Frame	Number of Projects	Total Costs ($ Millions)
Round 1 High-Priority Projects	2020 – 2030	6	$207.7
Round 2 High-Priority Projects	2030 – 2040	9	$202.4
	Total	15	$410.1

Durations of each project were initially established based on a template containing six generic phases: SSES, PER, Design, Pre-Construction, Construction and Flow Monitoring; however, not all phases are required for every element. For example, force main upsizing projects generally do not require SSES activities. Certain project types, such as I/I reduction efforts within project groups, required production rate assumptions and evaluation of an overall critical duration for their respective project group. An estimate of overall completion time for a project was generally based on the maximum duration within the project group. A minimum project length boundary of 3 years was also applied to allow sufficient time for planning.

The complete set of Round 1 and 2 High-Priority Projects were scheduled with objectives of maintaining reasonable annual expenditures and sequences for hydraulically interconnected projects while balancing improvement activity across treatment plants. The schedule for High-Priority implementation also considers the total SSO load reduction of a project. The results of prioritization modeling were used to inform these criteria for sequencing.

Figure 3-5 shows the resulting distribution for HRSD and Locality/Private asset improvements within the overall cashflow for High-Priority Project implementation.

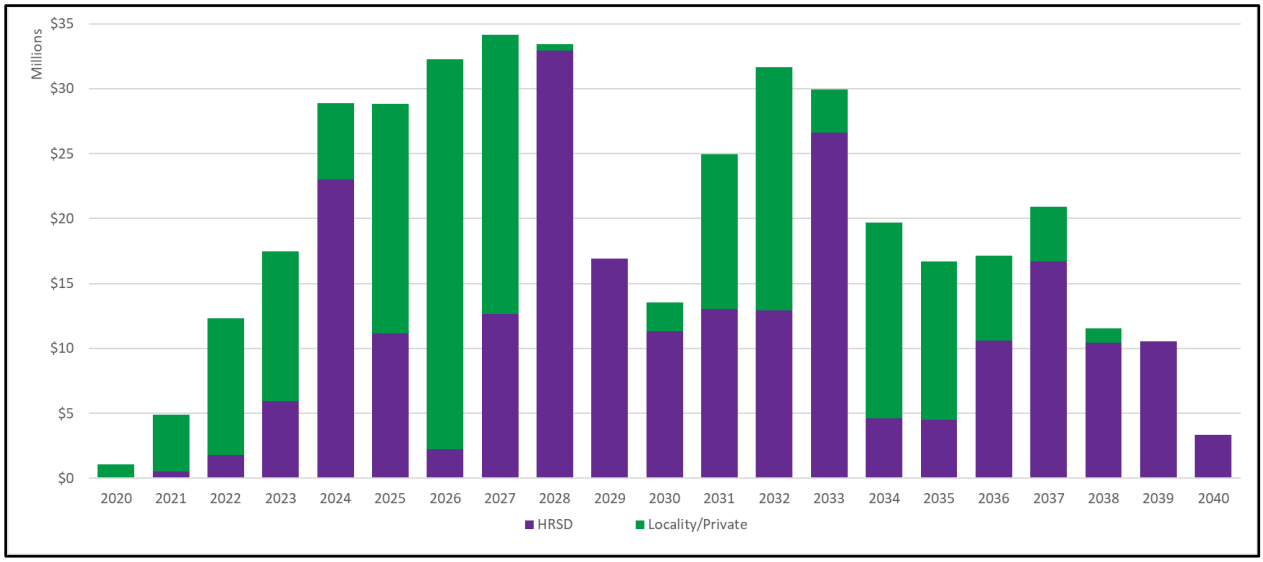

Figure 3-5. High-Priority Project Schedule Expenditure by Ownership

Table 3-12 outlines the proposed milestone commitments (substantial completion) for High-Priority Projects.

Table 3-12. High-Priority Project Milestones

Substantial Completion Date	HPP Project	Modeled HPP Group	RWWMP Project ID	TP	Location	General Description
12/31/2026	Round 1 HPP 2	NA-01	NA-RWWMP-03	NA	SUFF	Wilroy PRS and Storage Tank
12/31/2028	Round 1 HPP 1	VIP-05_06_07	VIP-RWWMP-04	VIP	PORT	Camden Ave PS and GM Improvements; Portsmouth I/I Reduction; Portsmouth City System Improvements
	Round 1 HPP 3	NA-08	NA-RWWMP-01	NA	CHES	Chesapeake I/I Reduction; Jumper FM CHES-PS-041
	Round 1 HPP 4	AT-02	AT-RWWMP-01	AT	CHES	Chesapeake I/I Reduction; Chesapeake City System Improvements
12/31/2030	Round 1 HPP 5	BH-02_S	BH-RWWMP-01	BH	NEWP/ HAMP	Claremont PS Upgrade; Chesapeake Ave. Pipe Improvements; 14th St Storage Tank
	Round 1 HPP 6	VIP-11	VIP-RWWMP-05	VIP	NORF	State Street PRS and Storage Tank
12/31/2032	Round 2 HPP 9	YR-04	JR-RWWMP-02	YR	YORK	Tabb PRS and Storage Tank

Table 3-12. High-Priority Project Milestones						
Substantial Completion Date	HPP Project	Modeled HPP Group	RWWMP Project ID	TP	Location	General Description
	Round 2 HPP 7	JR-04	JR-RWWMP-04	JR	NEWP	Lucas Creek PRS Upgrade
12/31/2034	Round 2 HPP 1	WB-04	WB-RWWMP-02	WB	WILL	Williamsburg Crossing PRS, Force Main and Storage Tank
		WB-13	WB-RWWMP-07	WB	YORK	York County I/I Reduction
			WB-RWWMP-14	WB	YORK	York County I/I Reduction
			WB-RWWMP-19	WB	YORK	Lodge Rd. PS Extended Wet Well
		WB-03	WB-RWWMP-12	WB	YORK	York County I/I Reduction
	Round 2 HPP 2	AT-05	AT-RWWMP-06	AT	VB	Birdneck-General Booth Blvd. FM Improvements
12/31/2036	Round 2 HPP 6	JR-06	JR-RWWMP-11	JR	NEWP	Newport News I/I Reduction
	Round 2 HPP 4	VIP-21 & VIP-29	VIP-RWWMP-41	VIP	NORF	Norfolk I/I Reduction
12/31/2038	Round 2 HPP 5	VIP-08	VIP-RWWMP-12	VIP	NORF	May Ave. Storage Tank
		VIP-09	VIP-RWWMP-14	VIP	NORF	Norfolk City System Improvements
			VIP-RWWMP-13	VIP	NORF	Willoughby Ave PS Upgrade
	Round 2 HPP 8	NA-03	NA-RWWMP-12	NA	PORT	Cedar Lane GM Improvement
			NA-RWWMP-14	NA	PORT	Cedar Lane PS Upgrade
		NA-04	NA-RWWMP-16	NA	CHES	Western Branch PRS
			NA-RWWMP-18	NA	CHES	Chesapeake I/I Reduction
			NA-RWWMP-19	NA	CHES	Chesapeake City System Improvements
12/31/2040	Round 2 HPP 3	BH-04	BH-RWWMP-04	BH	NEWP	58th St Storage Tank
		BH-05	BH-RWWMP-07	BH	NEWP/ HAMP	Newmarket Creek PS Upgrade
			BH-RWWMP-08	BH	NEWP/ HAMP	Mercury Blvd and Newmarket GM Improvements

3.7 HPP Schedule Acceleration

HRSD will accelerate expenditures on the High Priority Projects consistent with an updated Financial Capability Assessment (FCA) in the event that HRSD for any reason delays, decides not to pursue or otherwise abandons the implementation of the ARP. In such an event, HRSD shall identify an alternative accelerated schedule for the remaining HPPs that is as expeditious as possible. HRSD shall submit the accelerated schedule to Plaintiffs for review and approval.

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Section 4

Regional Wet Weather Management Plan Adaptive Planning Approach

The Hampton Roads region faces many uncertainties over the coming decades including recurrent flooding and sea level rise that will have profound effects on the area and will impact the regional sanitary sewer system. These factors, along with others, create substantial ambiguity as to what future environmental priorities will be in the Hampton Roads region..

4.1 Plan Overview (Adaptive Planning Approach)

EPA has encouraged the use of adaptive management approaches in a wide variety of settings. Adaptive management features iterative decision making to manage uncertainty in addressing municipal environmental challenges. This approach has been particularly necessary with long-term community sewer rehabilitation and related programs. Almost every such program has needed multiple major modifications. In addition to responding to changing community circumstances, adaptive management also allows communities to continually prioritize the greatest public health and community benefits for the next public dollar invested. Given the scope, cost, complexity, and evolving nature of the challenges which HRSD and the Hampton Roads region face, the RWWMP necessarily features an adaptive management approach.

One of the most significant evolving planning considerations which the Hampton Roads region faces is adaptation to rising sea level and increased frequency of recurrent flooding. The National Oceanic and Atmospheric Administration's Office for Coastal Management has identified Hampton Roads as experiencing the highest rate of sea level rise along the entire Atlantic seaboard and that the region is the second largest population center in the United States at risk due to the impacts of sea level rise. Addressing sea level rise poses enormous challenges for HRSD and all of the Hampton Roads communities. We must balance further investments in regional wet weather capacity with investment in adaptation and resiliency strategies, which will likely necessitate utility relocation and/or floodproofing.

Rising sea levels and the grave implications for Hampton Roads have really come into focus over the past decade since EPA began discussions with HRSD about the RWWMP. As frequency, the level and the amount of low-lying lands impacted by sea level rise continue to increase, larger portions of the regional sanitary sewer system are at risk. Traditional capacity management strategies may not be effective or appropriate in these areas and future investments may be needed to develop new systems that can function in areas frequently inundated until a managed infrastructure retreat/resiliency strategy is developed for coastal land.

Additionally, there are a number of other adaptive management factors that create significant uncertainties (and opportunities) about any infrastructure investment plan that spans more than a decade. These uncertainties/opportunities include:

- The impact of sea level rise and recurrent flooding in the region's infrastructure, land use patterns and economy;
- Understanding the system response to almost $700 million in wet weather capacity-related investments and evaluation completed over the past twelve years;
- Magnitude and spatial patterns of community growth and redevelopment;
- Future of the extensive DoD facilities in the Hampton Roads Region and HRSD priorities regarding these ubiquitous facilities throughout the service area;
- How effectively Locality and HRSD MOM programs will address sewer system degradation and I/I levels;
- Regional economic vitality and household income and employment levels;
- Changing regional environmental and public health priorities, specifically post implementation evaluation of the Chesapeake Bay TMDL after the 2025 completion;
- Changing technologies and opportunities to achieve multiple benefits for public sewer-related investments; and,
- Levels of federal and state financial support for unfunded environmental mandates across all media.

These uncertainties will have a profound effect on the location, volume, significance and priority of future wet weather capacity-related overflows. This will particularly be the case for the capacity-related investments for the period after 2030.

To address these uncertainties, HRSD's RWWMP features an Adaptive Regional Plan comprising four phases as follows:

Table 4-1. Four Phases of the Adaptive Regional Plan

Phase	Description	Timeframe	Cost ($ Millions)
1	Planning, Interim System Improvements, Condition Assessment and Repairs, Rehabilitation Action Plan	2008 – 2025	$700,000,000
2	Round 1 High-Priority Projects and Pathogen Source Tracking Program	2020 - 2030	$218,000,000
3	Round 2 High-Priority Projects and Pathogen Source Tracking Program	2030 - 2040	$212,000,000
4	Post-RWWMP Plan Performance Assessment	2040 – 2043	$2,000,000
	TOTAL		$2,408,400,000

4.1.1 Phase 1

Notwithstanding significant investments in prior years, Phase 1 of our regional wet weather program began during implementation of the Consent Decree in approximately 2008. Planning activities included implementation of a Flow, Pressure, and Rainfall Monitoring system and hydraulic modeling of HRSD and 14 Locality sewer systems. Spending on these activities exceeded $70 million.

Another Phase 1 activity, Interim System Improvement (ISI) projects, was completed in 2018. ISI projects consist of 45 conveyance and treatment projects that cost approximately $400 million.

Another major component of Phase 1 is the Condition Assessment Program and the related Sewer System Prompt Repairs. HRSD performed a comprehensive assessment of the condition of its conveyance assets. Assets with defects which met certain criteria were placed into a program to ensure prompt repair. More than 70 defects have been identified that meet the criteria and repairs have been complete or are under development. Estimated spending on these activities is approximately $50 million.

The other outcome of the Condition Assessment Program is preparation of a three-phase Rehabilitation Action Plan to be completed by 2025. Spending under the Plan is expected to cost approximately $180 million fully outside of the work identified in this RWWMP.

Finally, Phase 1 will see both HRSD and the localities continued implementation of their MOM programs to address sewer system operation, maintenance and reliability.

Phase 1 activities have improved HRSD's knowledge of the condition and performance of their system and led to the repair of assets with priority defects. By 2025, Phase 1 will see upwards of $700 million invested toward the improvement of the regional sewer system.

4.1.2 Phase 2

Phase 2 consists of constructing Round 1 High-Priority Projects, the Pathogen Source Tracking Program, and continued MOM implementation.

There are six (6) identified High-Priority Projects that are estimated to have a capital cost of $208 million. These projects will be built between plan approval and 2030, assuming that the RWWMP is approved and entered with the Court not later than July 1, 2020.

The Pathogen Source Tracking Program is estimated to cost $10 million through 2030. Finally, Phase 2 will see continued HRSD and Locality implementation of their MOM programs to address sewer system operation, maintenance and reliability.

4.1.3 Phase 3

Phase 3 consists of completing the remaining nine (9) Round 2 High-Priority Projects with an estimated capital cost of $202 million. These projects will be built between 2030 and 2040. It is anticipated that the Pathogen Source Tracking Program will continue at an estimated cost of $10 million from 2030 to 2040. HRSD and the Localities will also continue their respective MOM program implementation during Phase 3.

4.1.4 Phase 4

Phase 4 is a performance assessment upon completion of the work in Phases 2 and 3. This analysis will take place between 2040 and 2043 and will culminate in submittal of a Performance Assessment for the review and approval of EPA and DEQ by March 31, 2043. See Section 5 for details of this evaluation.

4.2 Schedule

The RWWMP proposed in this document is an aggressive plan to provide the greatest environmental and public health benefits as expeditiously as reasonable. In addition to the Phase 1 spending of more than $700 million (to be completed in 2025),the ongoing Pathogen Source Tracking, and $208 million in Round 1 High-Priority Project expenditures from 2020 to 2030 will strain the financial capability of HRSD. These capital projects will be layered on the ARP, existing renewal and replacement projects and other Capital Improvement Program (CIP) projects already part of HRSD's spending plan that fall

outside the Consent Decree obligations consuming all available financing capacity between 2020 and 2030.

The remaining $202 million in Round 2 High-Priority Projects along with the continuation of the Pathogen Source Tracking Program will require an implementation schedule of 2030 through 2040. The logistics of completing these projects will be limited by the contractor base in the region, land acquisition, and the design/construction schedule required for these complex projects.

HRSD will begin assessing the High-Priority Projects when they are completed; however, the full RWWMP Performance Assessment schedule will be limited by the completion date of the final High-Priority Project. An adequate amount of post-construction monitoring is necessary to determine the effectiveness of the projects, and therefore, the Performance Assessment cannot be completed prior to March 31, 2043.

With HRSD's RWWMP, fifteen (15) High-Priority Projects will be constructed through 2040. These projects were selected based on their ability to provide the greatest environmental and human health benefits. Further, this $410 million investment will reduce SSO volume during the 5-year peak flow event by 69% - a significant reduction. Figure 4-1 depicts this reduction in modeled SSO volume at the 5-year Level of Service. Efforts to address the minimal SSO volume remaining upon completion of the High-Priority Projects would be cost prohibitive and return marginal benefits for each dollar invested.

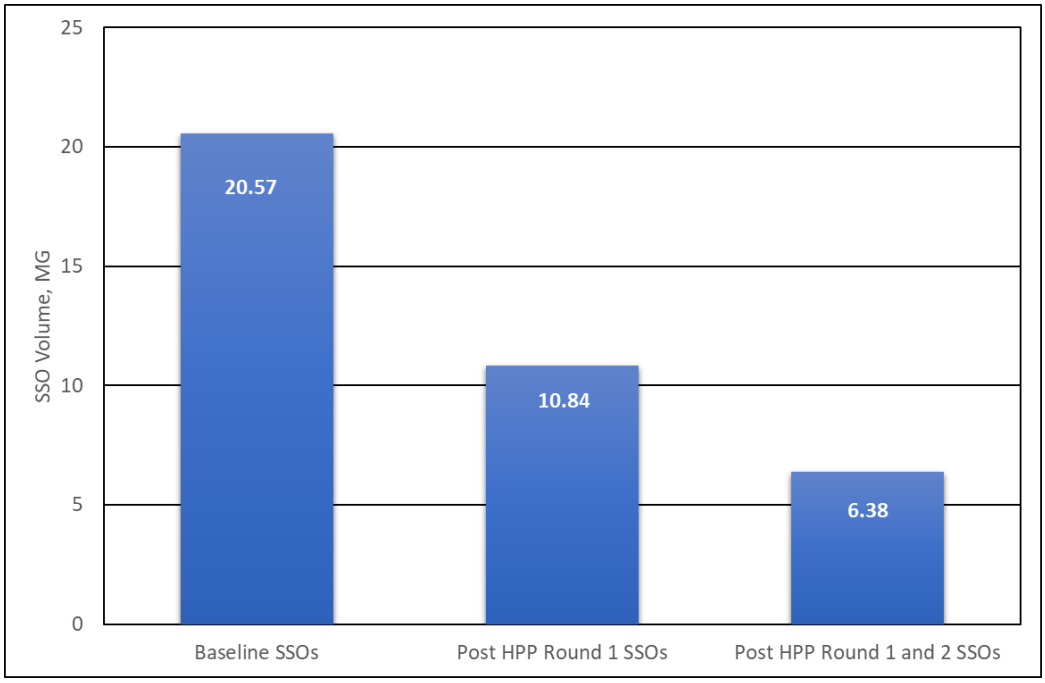

Figure 4-1. High-Priority Project Modeled SSO Reduction

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Section 5

Post-RWWMP Implementation Performance Assessment

5.1 Overview

As required by the Consent Decree, HRSD will evaluate the effectiveness of the work performed through a Post-RWWMP Implementation Performance Assessment. This evaluation will be conducted in consultation with the Localities and be performed following completion of the work in this plan. In general, HRSD will construct a hydrologic/hydraulic model of the system similar to the modeling used for the High Priority Projects to confirm whether the 69% reduction in SSO modeled volume has been achieved.

5.2 Proposed Monitoring Approach

HRSD operates an extensive flow, pressure, and rainfall (FPR) monitoring network in its system that relies on currently available FPR monitoring and modeling tools and techniques. There are more than 300 points throughout the HRSD network that are monitored and the Localities also maintain their own FPR monitoring systems.

Considering the advances in FPR monitoring tools as well as computer models over the past 20 years, it is difficult to predict what the tools and models will be capable of in the next 20 years. For this reason, HRSD is providing in this document a general approach that will be used for monitoring and the performance assessment.

As work is completed in sewer catchments, particularly I/I reduction, there will be site specific flow monitoring to confirm the post-reduction flow parameters. In addition, HRSD will establish a flow monitoring network based on major flow junction points, significant flow loading points, and major HRSD facilities like treatment plant, PRSs and storage facilities. Pressure will be monitored throughout the HRSD system at upstream end-of-line points, PRSs (upstream and downstream), and other major intermediate points in the network to provide sufficient coverage for model calibration. Rainfall tools will likely evolve as well, but HRSD will maintain sufficient gauge coverage to support modeling efforts.

Data will be collected in density at least equal to the current available tools at 2-minute points for flow and pressure (15-minute for rainfall) and will undergo a thorough data quality review process to flag unreliable information.

For data collected by Localities at the sewer catchment level, HRSD will coordinate with each to review the data and make any appropriate updates to flow parameters.

5.3 Proposed Performance Assessment

Collection of data is the first step in validating the performance and effectiveness of the work completed. Evaluation of modeled SSOs will determine whether the projects completed by HRSD have achieved the desired effectiveness.

5.3.1 Model Development and Calibration

Similar to the Proposed Monitoring Approach described previously, the technology and software for hydrologic and hydraulic wastewater system modeling is expected to significantly change by 2040. The intent of this Performance Assessment is to determine whether improvements to the system, operating under the same general conditions as the 2019 model, has produced the desired 69% reduction in modeled SSO volume.

HRSD will develop a system model calibrated using the data collected in the monitoring period. It will represent the conditions of 2040 which will include updated facility data, system valving, growth, changes in flow routing, and updates to flow parameters based on different inflow/infiltration characteristics. The model will be developed using the industry standards.

5.3.2 System Performance Modeling

Using the model developed for 2040 conditions, HRSD will run the 5-year wet weather event (hyetograph) under similar conditions as the 2019 modeling. This rainfall hyetograph is provided in Appendix B and was used for all High Priority Project model runs in 2017 and 2019. It was developed by rainfall and hydrologic prediction experts to accurately represent a typical 5-year rainfall event in the Hampton Roads area that would produce 5-year peak flow recurrence flows. The modeling will be conducted using appropriate spatial distribution factors to adjust the anticipated rainfall totals over different sized areas.

The total SSO volume estimated by the modeling will be documented for comparison to the 2019 baseline results (20.6 MG, 5-year event SSO volume).

5.3.3 Determination of Effectiveness

Upon evaluation of the data, HRSD will determine whether the projects completed by HRSD have achieved the desired reduction in total SSO volume of 69% from the 2019 baseline values.

5.3.4 Other Factors Considered

During the system analysis, several other factors may be considered:

- Evaluate updated regional growth results and spatial patterns versus 2019 projections; and,
- Collect and analyze available and updated data on sea level rise and groundwater conditions.

5.4 Schedule

HRSD will prepare a Post-RWWMP Implementation Performance Assessment upon completion of the projects in Phase 3 of the Adaptive Regional Plan (including post-I/I reduction flow monitoring). This will be an extensive effort but will be completed in an expeditious manner. The general steps required are as follows:

1. Conduct FPR monitoring –12 months
2. Develop updated hydrologic and hydraulic models including updated facilities data – Completed concurrently with FPR monitoring
3. Calibrate the model – 6 months
4. Conduct system performance model runs with the 5-year event – 6 months
5. Documentation – 3 months

In total, the performance assessment in each treatment plant service area is expected to take 27 months.The Performance Assessment will be submitted to the EPA/DEQ for review and approval by March 31, 2043.

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Appendix A: High-Priority Project Maps

Note that exact project locations, pipe footages, tank sizes, and pumping capabilities will be determined in final design of the High Priority Projects.

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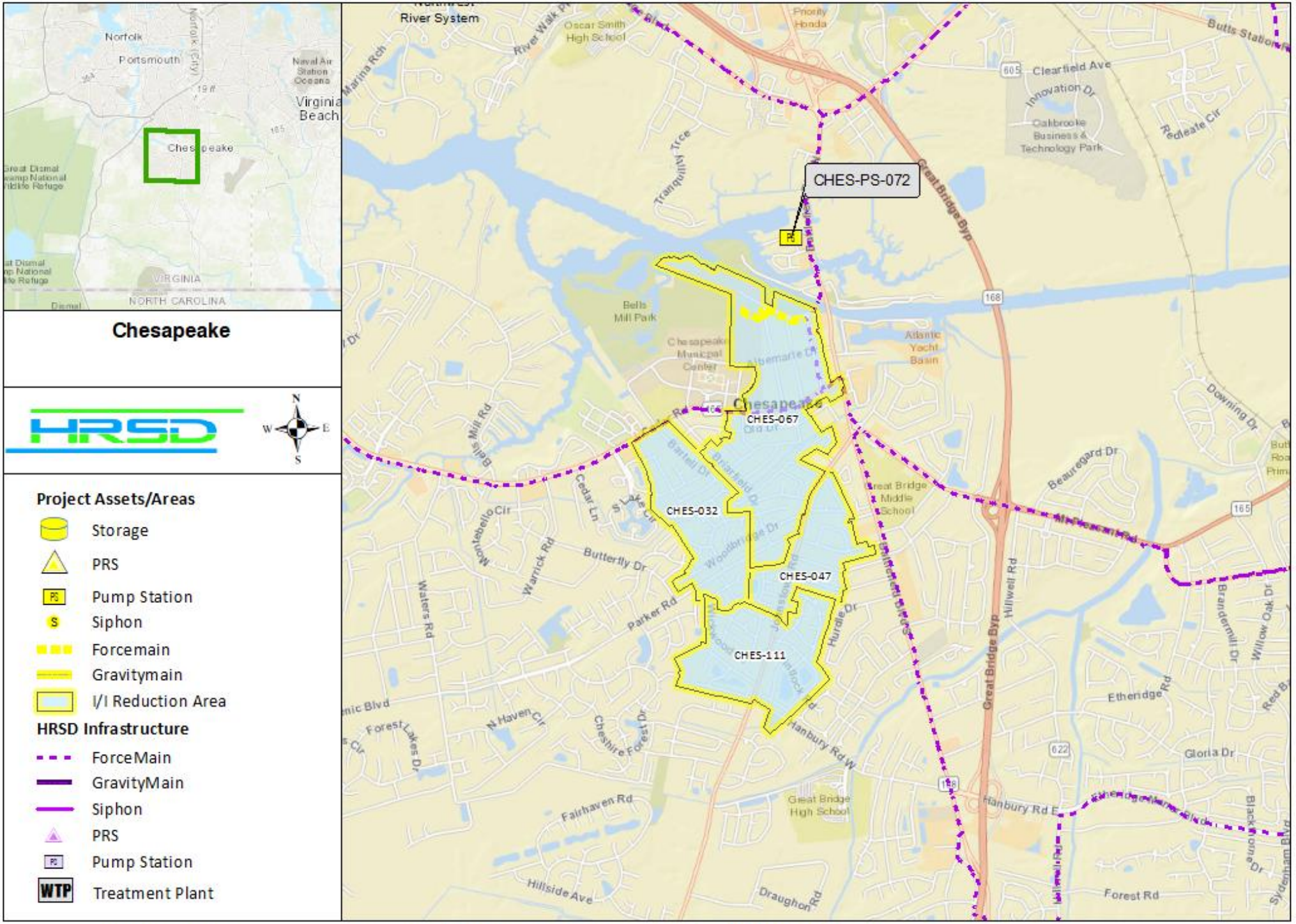
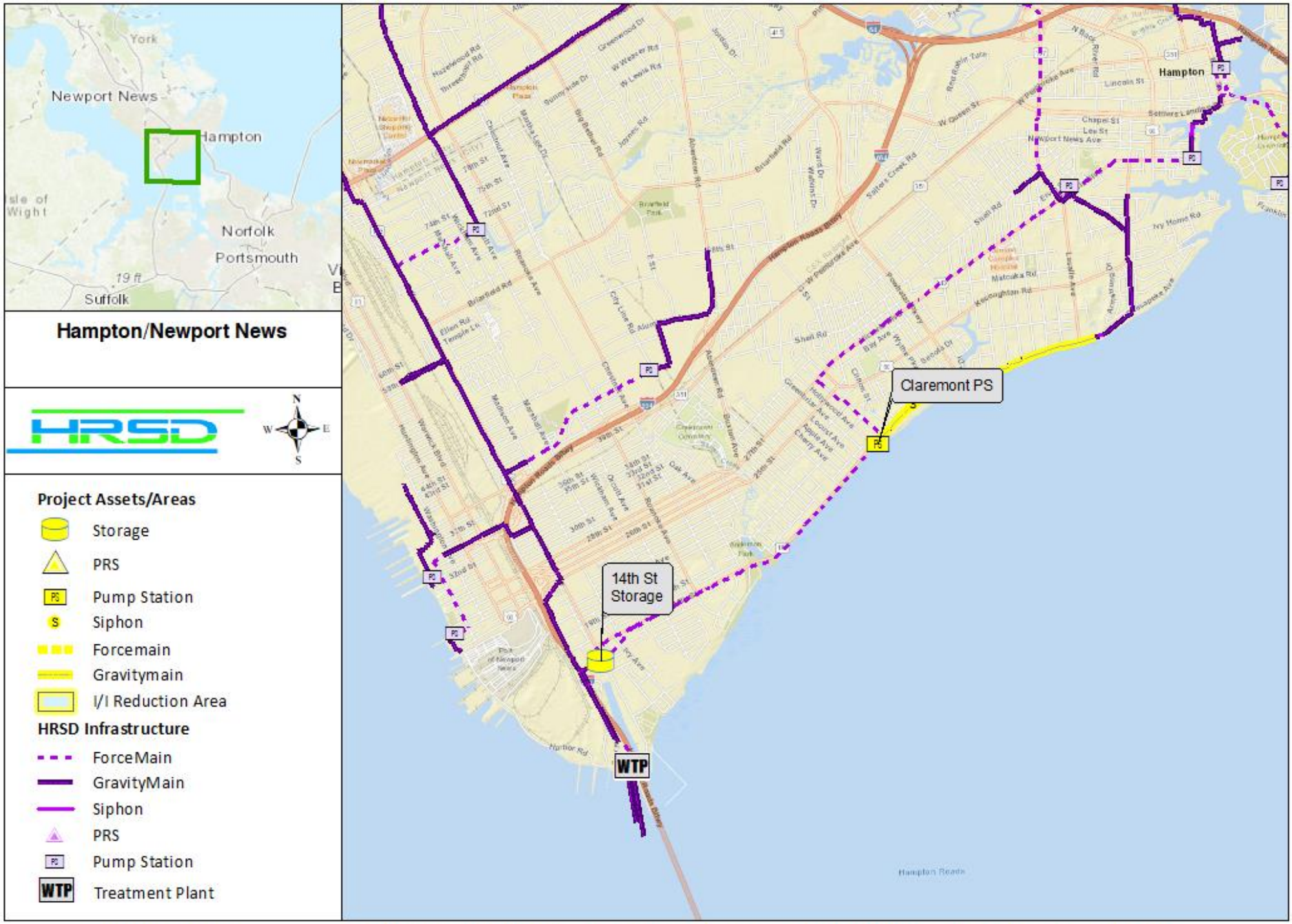


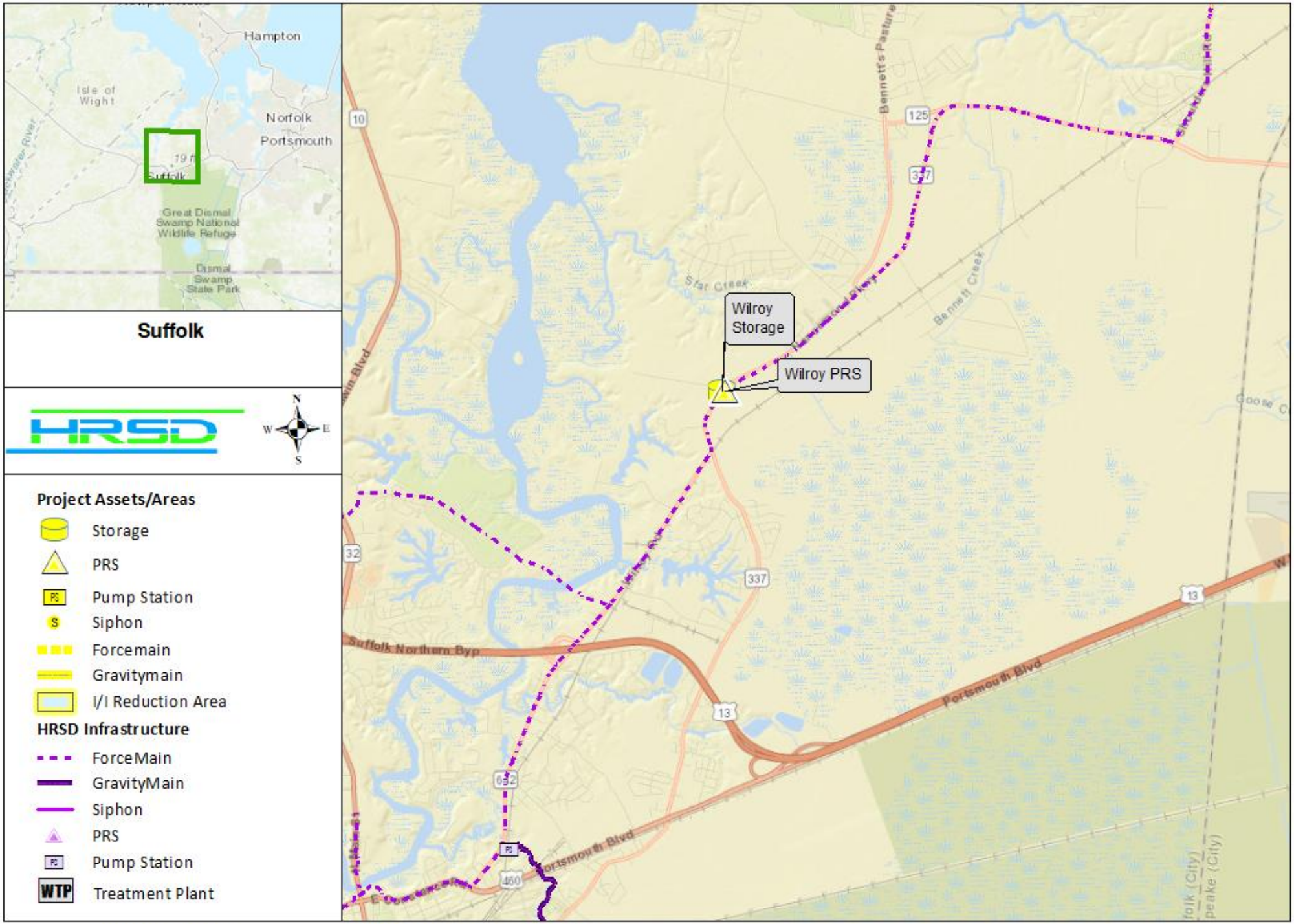
Round 1 HPP: AT-02

Chesapeake I/I Reduction; Locality PS and FM Upgrades



Round 1 HPP: BH-02_S

Claremont PS Upgrade, Chesapeake Ave. Pipe Improvements and 14th St Storage Tank



Round 1 HPP: NA-01

Wilroy PRS and Storage Tank

Chesapeake

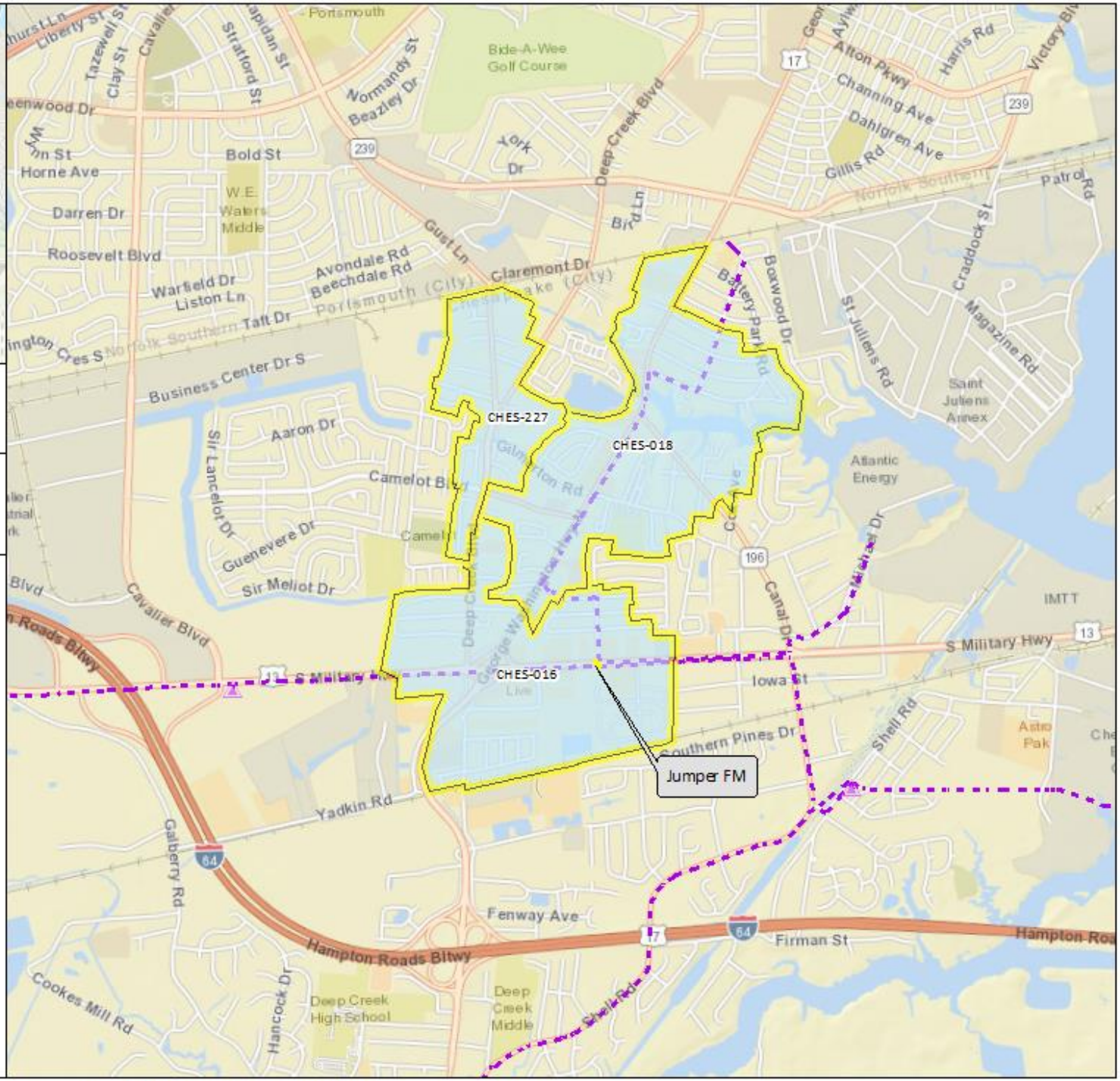
HRSD

Project Assets/Areas

- Storage
- PRS
- Pump Station
- Siphon
- Forcemain
- Gravitymain
- I/I Reduction Area

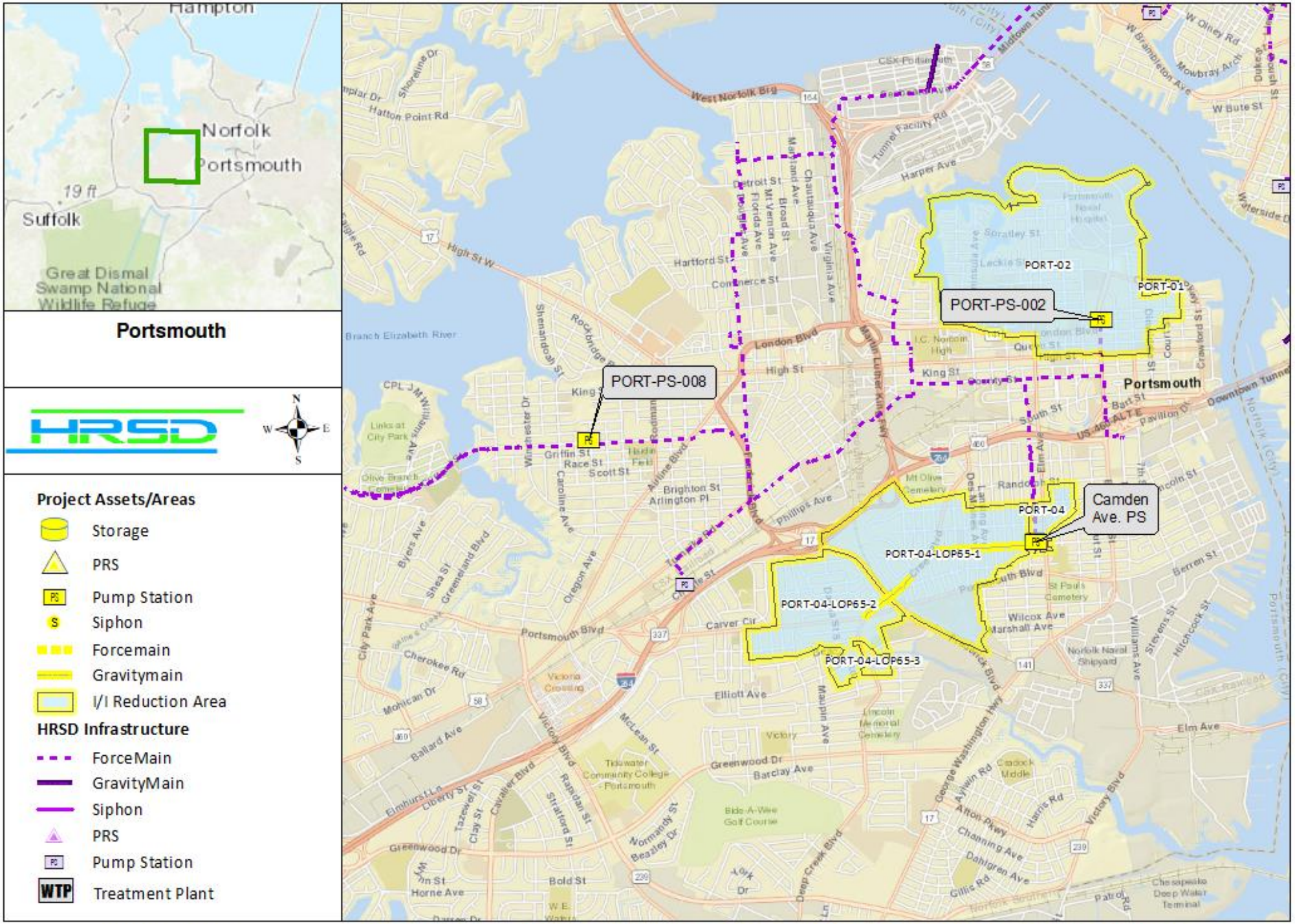
HRSD Infrastructure

- ForceMain
- GravityMain
- Siphon
- PRS
- Pump Station
- Treatment Plant



Round 1 HPP: NA-08

Chesapeake I/I Reduction; Jumper FM



Round 1 HPP: VIP-05_06_07

Camden Ave PS and GM Improvements; Portsmouth I/I Reduction; Locality PS Upgrades

Norfolk

HRSD

N
W E
S

Project Assets/Areas

- Storage
- PRS
- Pump Station
- Siphon
- Forcemain
- Gravitymain
- I/I Reduction Area

HRSD Infrastructure

- ForceMain
- GravityMain
- Siphon
- PRS
- Pump Station
- WTP Treatment Plant

State Street Storage

State St PRS

Round 1 HPP: VIP-11

State Street PRS and Storage Tank

Virginia Beach

HRSD

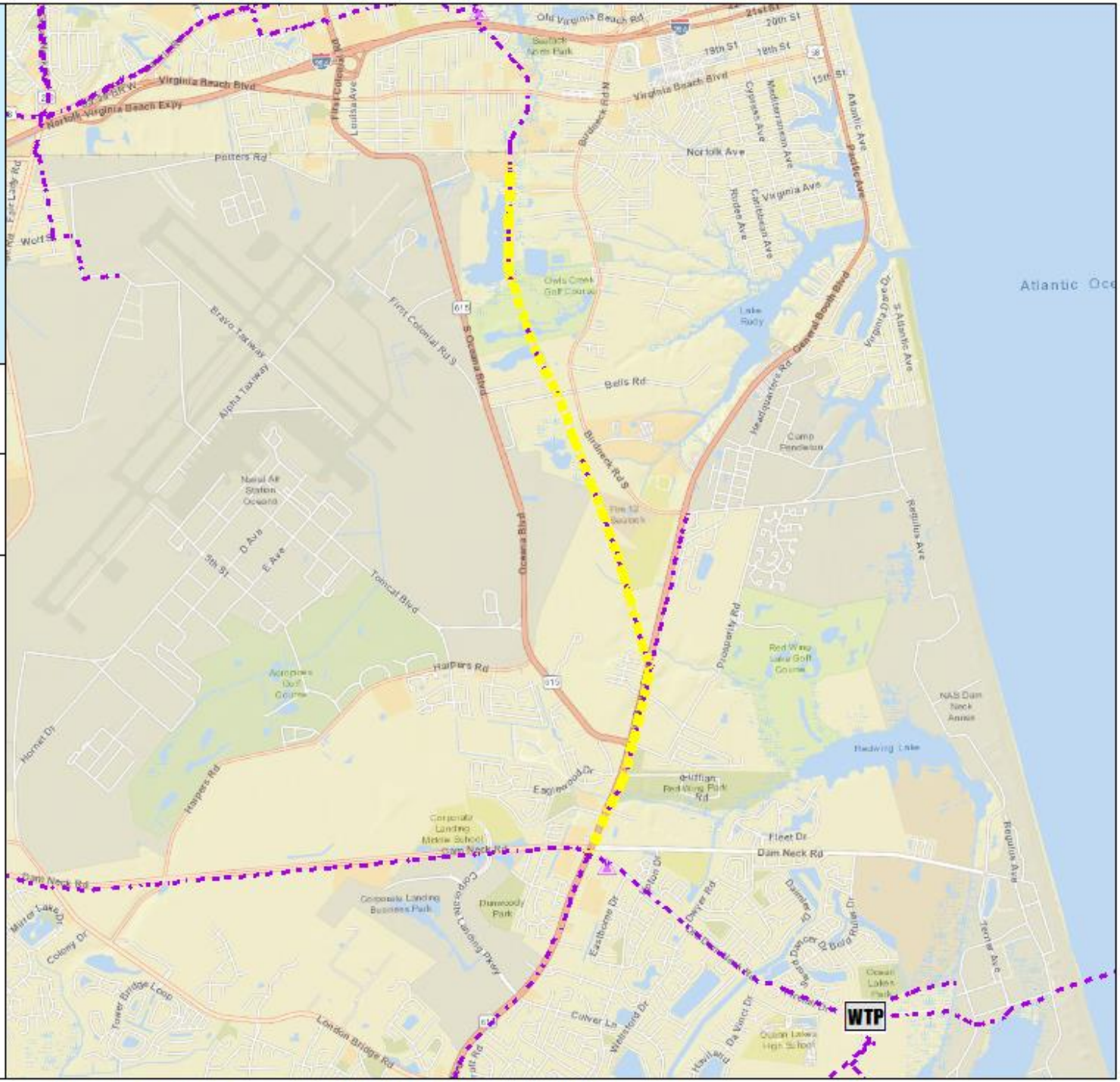
N
W E
S

Project Assets/Areas

- Storage
- PRS
- PS Pump Station
- S Siphon
- Forcemain
- Gravitymain
- I/I Reduction Area

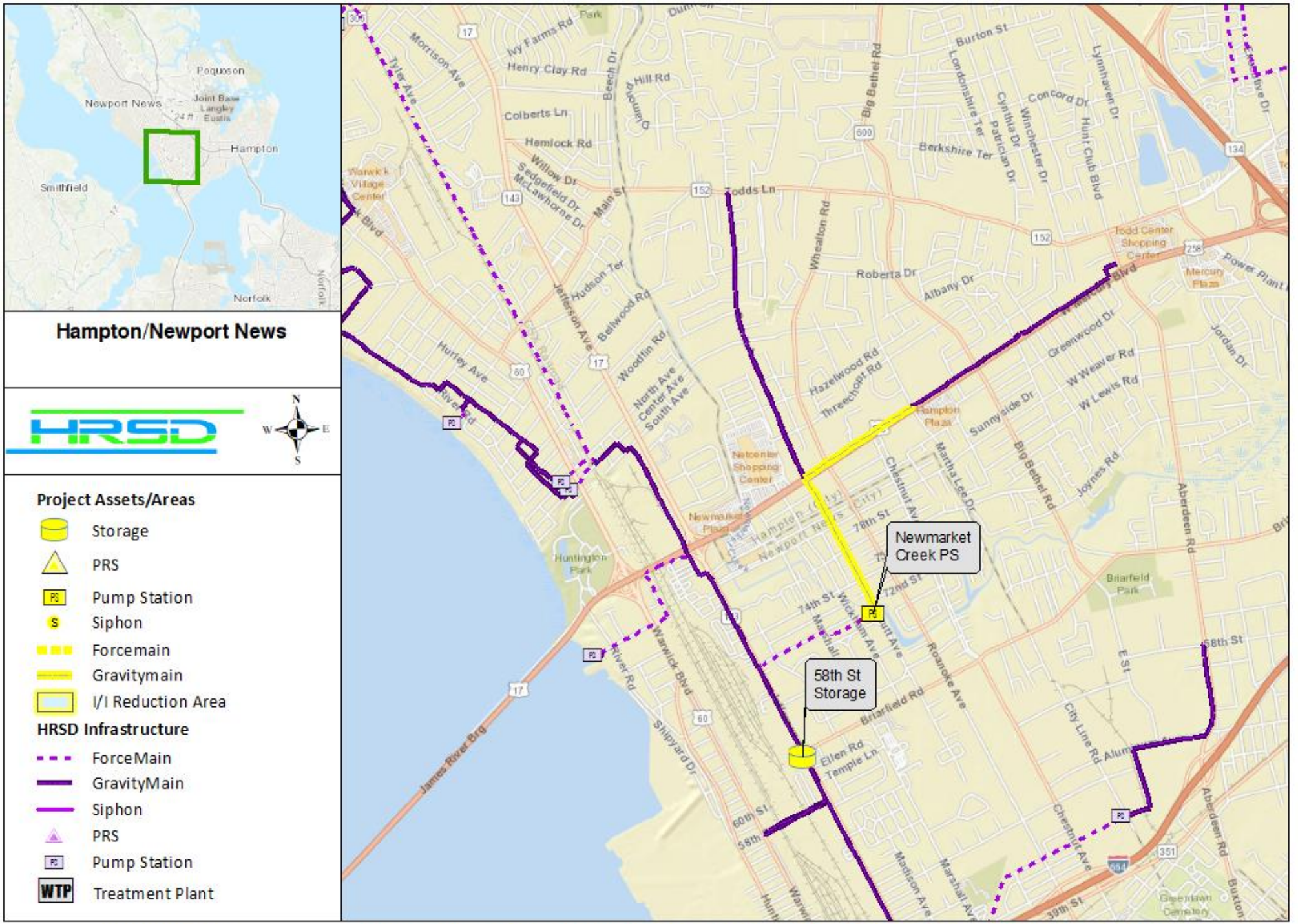
HRSD Infrastructure

- ForceMain
- GravityMain
- Siphon
- PRS
- PS Pump Station
- WTP Treatment Plant



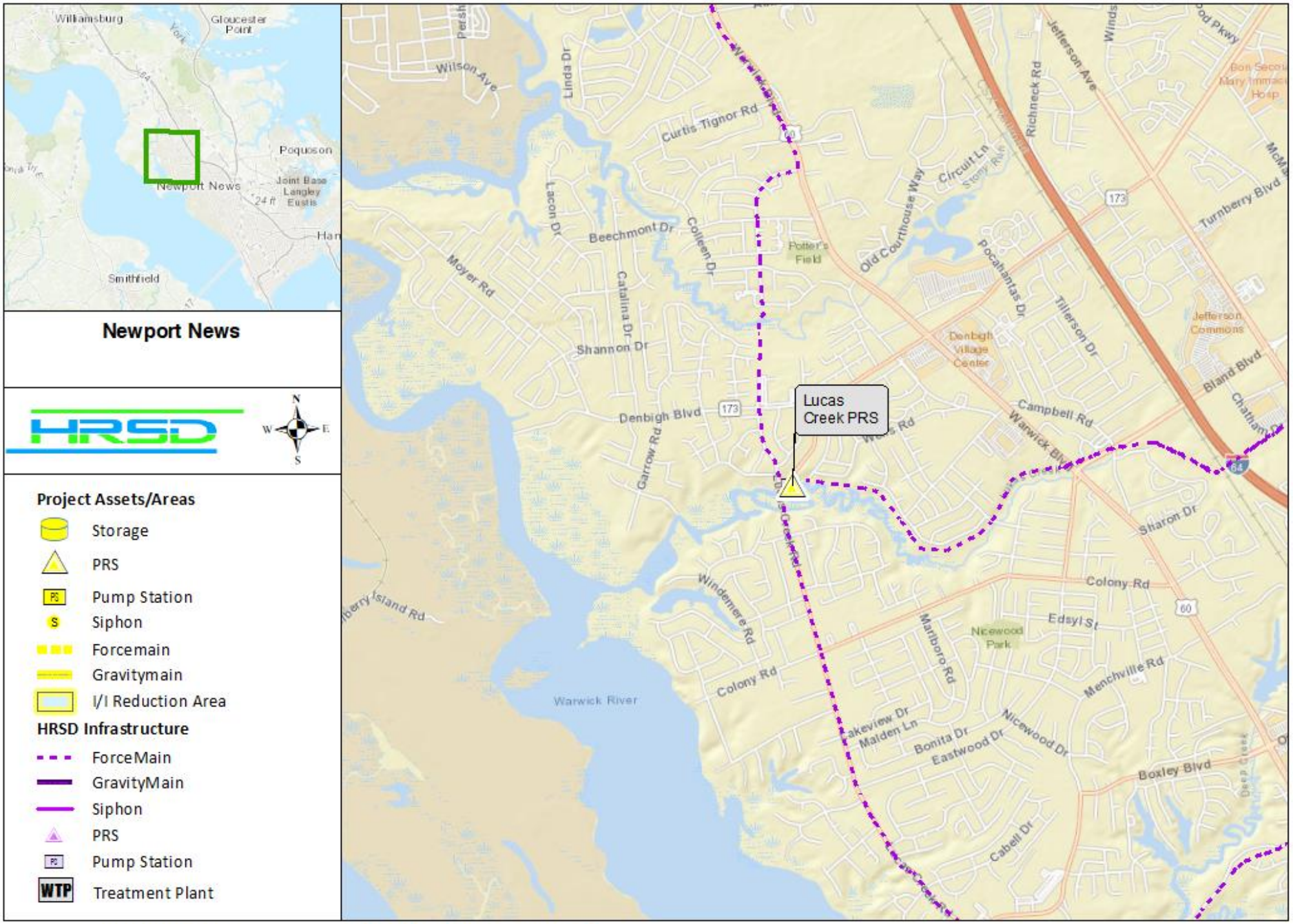
Round 2 HPP: AT-05

Birdneck-General Booth Blvd. Force Main Improvements



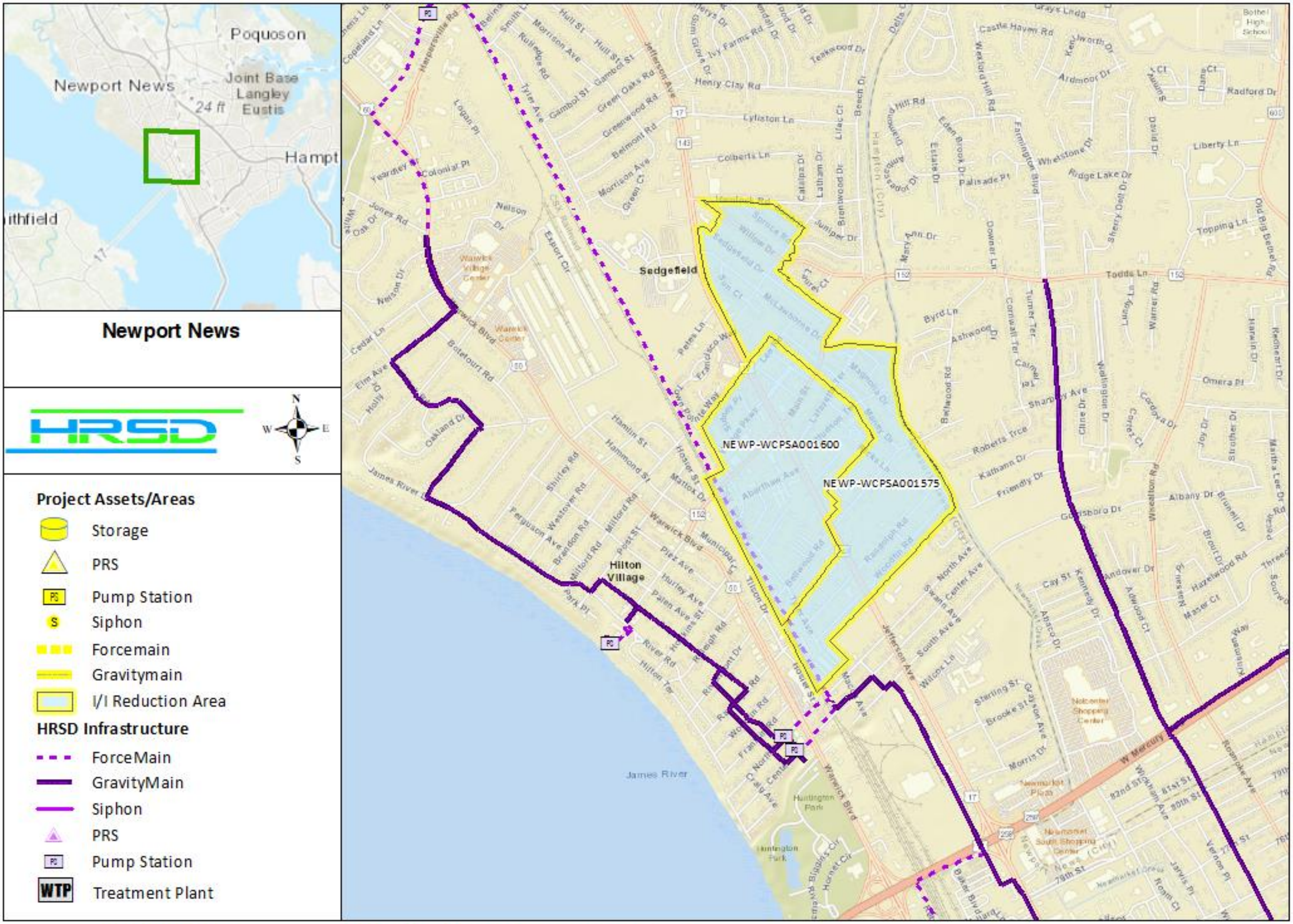
Round 2 HPP: BH-04 and BH-05

58th St Storage Tank; Mercury Blvd and Newmarket Gravity Main Improvements; Newmarket Creek PS Upgrade



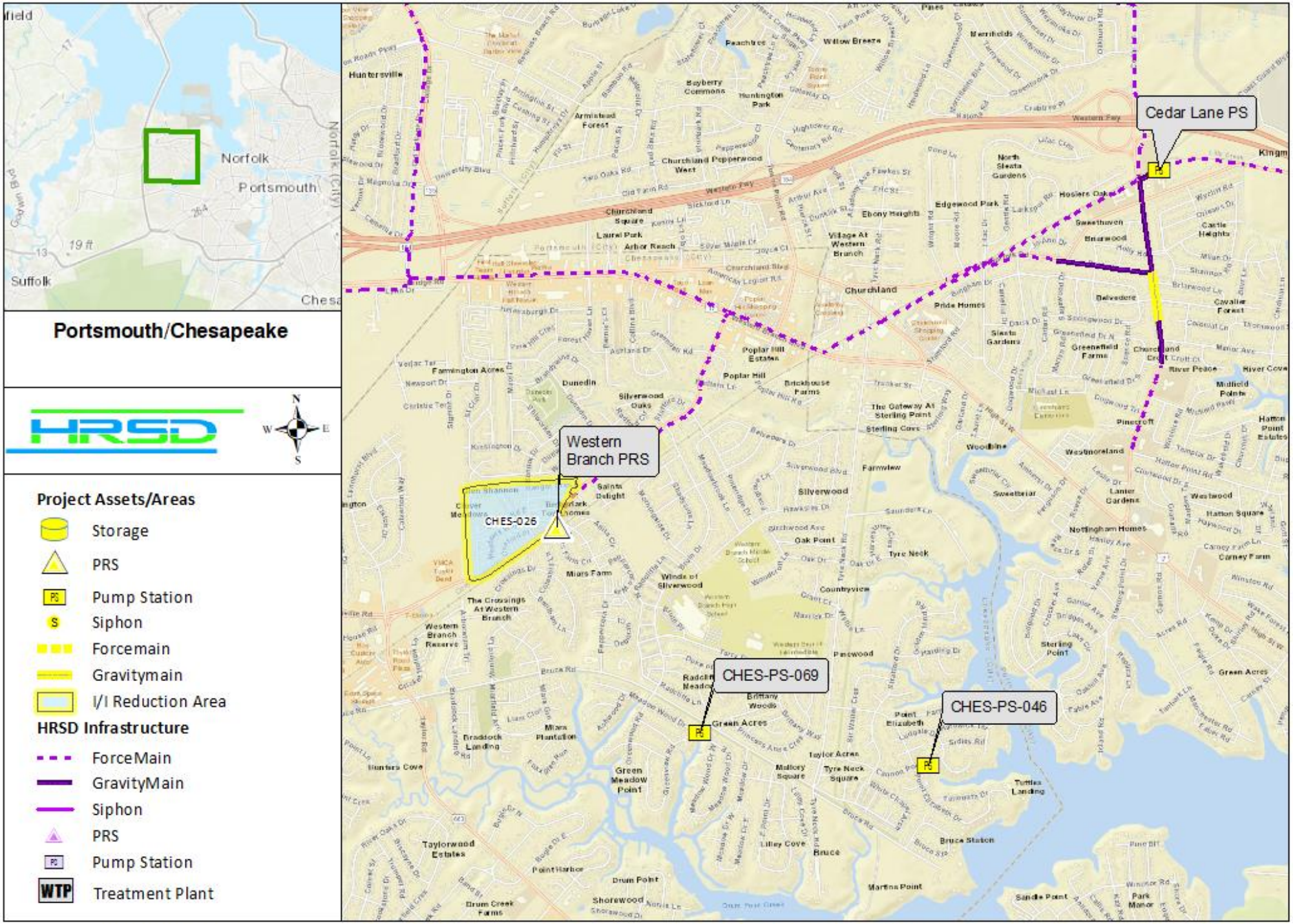
Round 2 HPP: JR-04

Lucas Creek PRS Upgrade



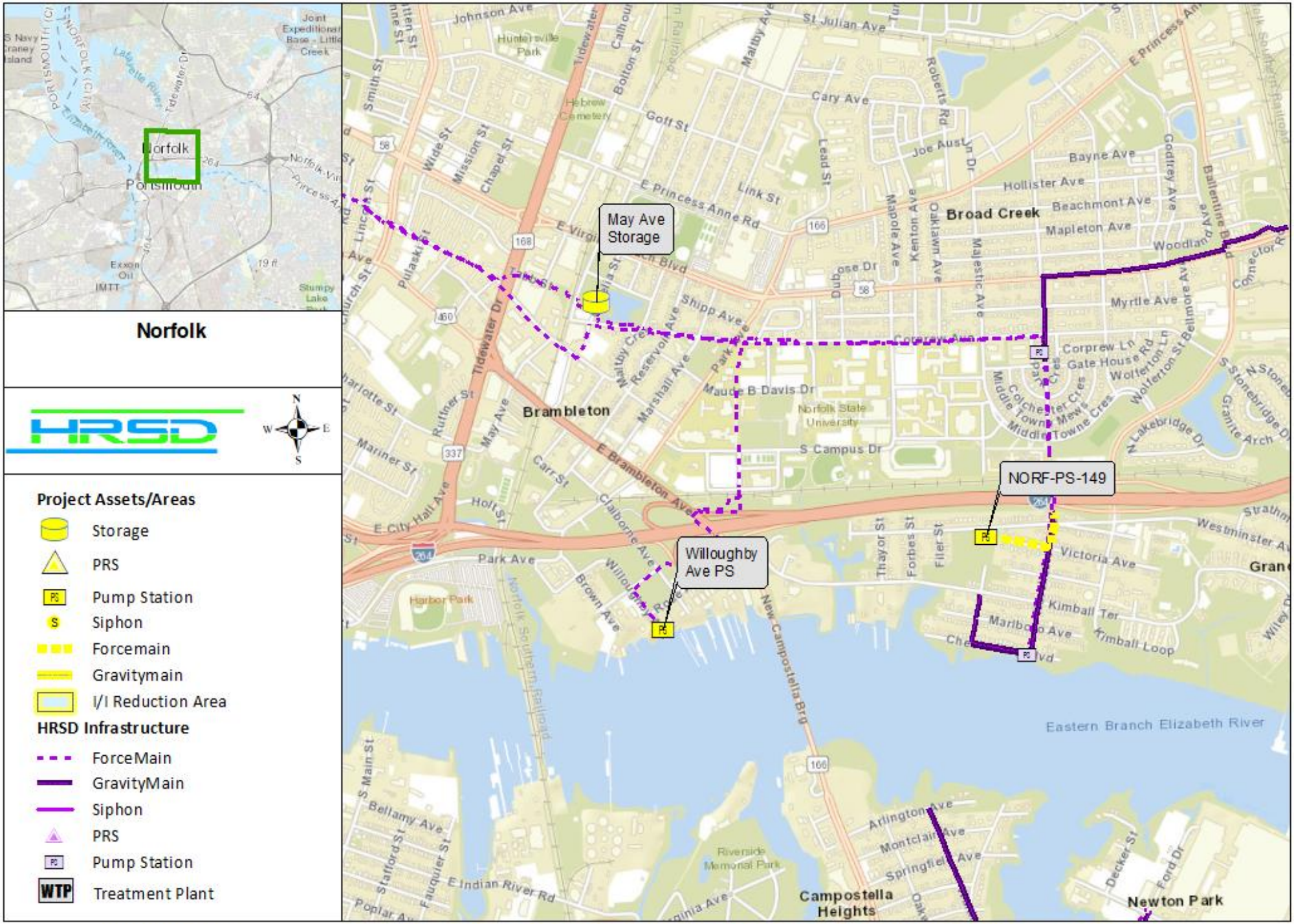
Round 2 HPP: JR-06

Newport News I/I Reduction Project



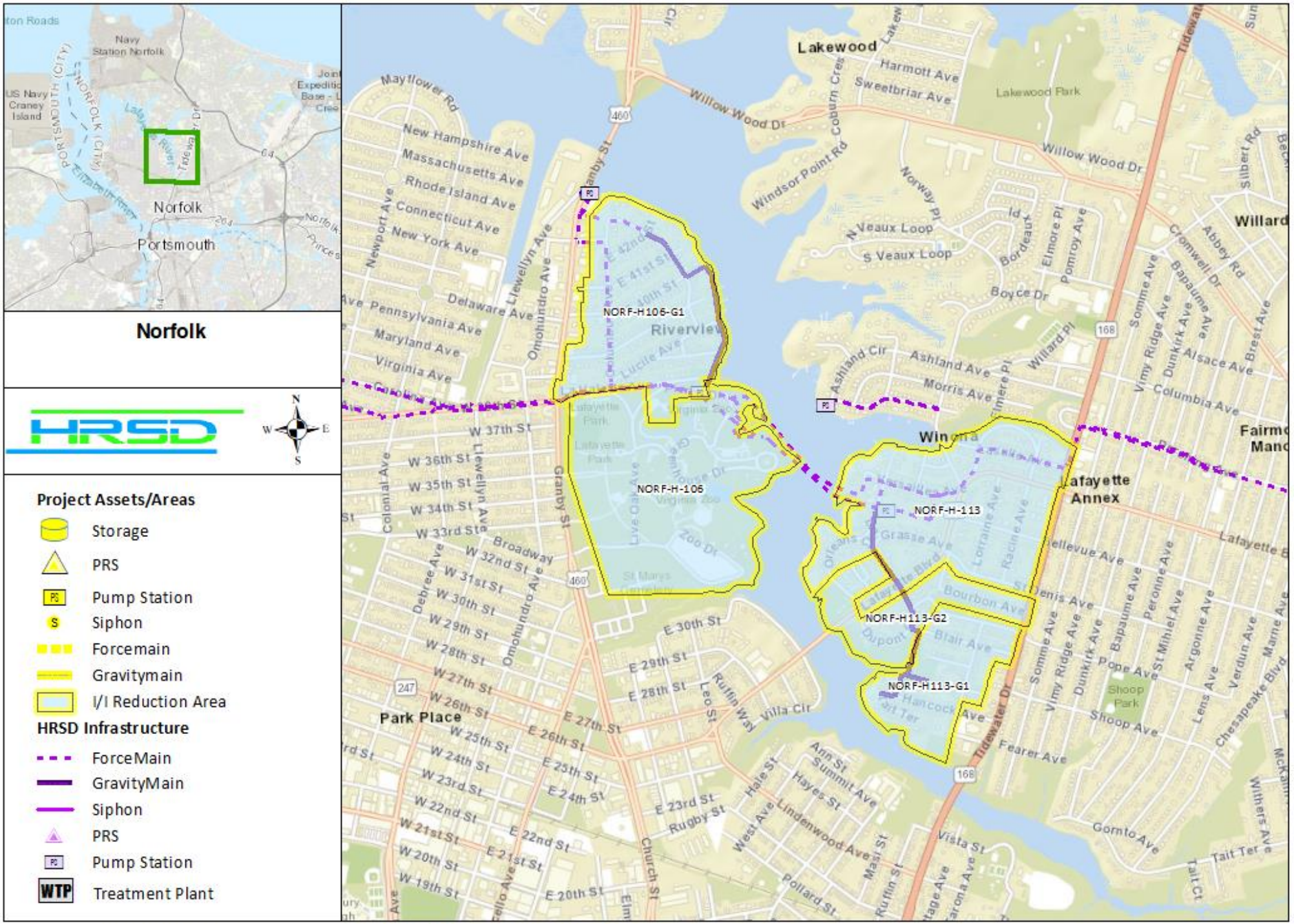
Round 2 HPP:
NA-03 and NA-04

Cedar Lane Gravity Main Improvement; Cedar Lane PS; Western Branch PRS; Chesapeake City System Improvements; Chesapeake I/I Reduction Project



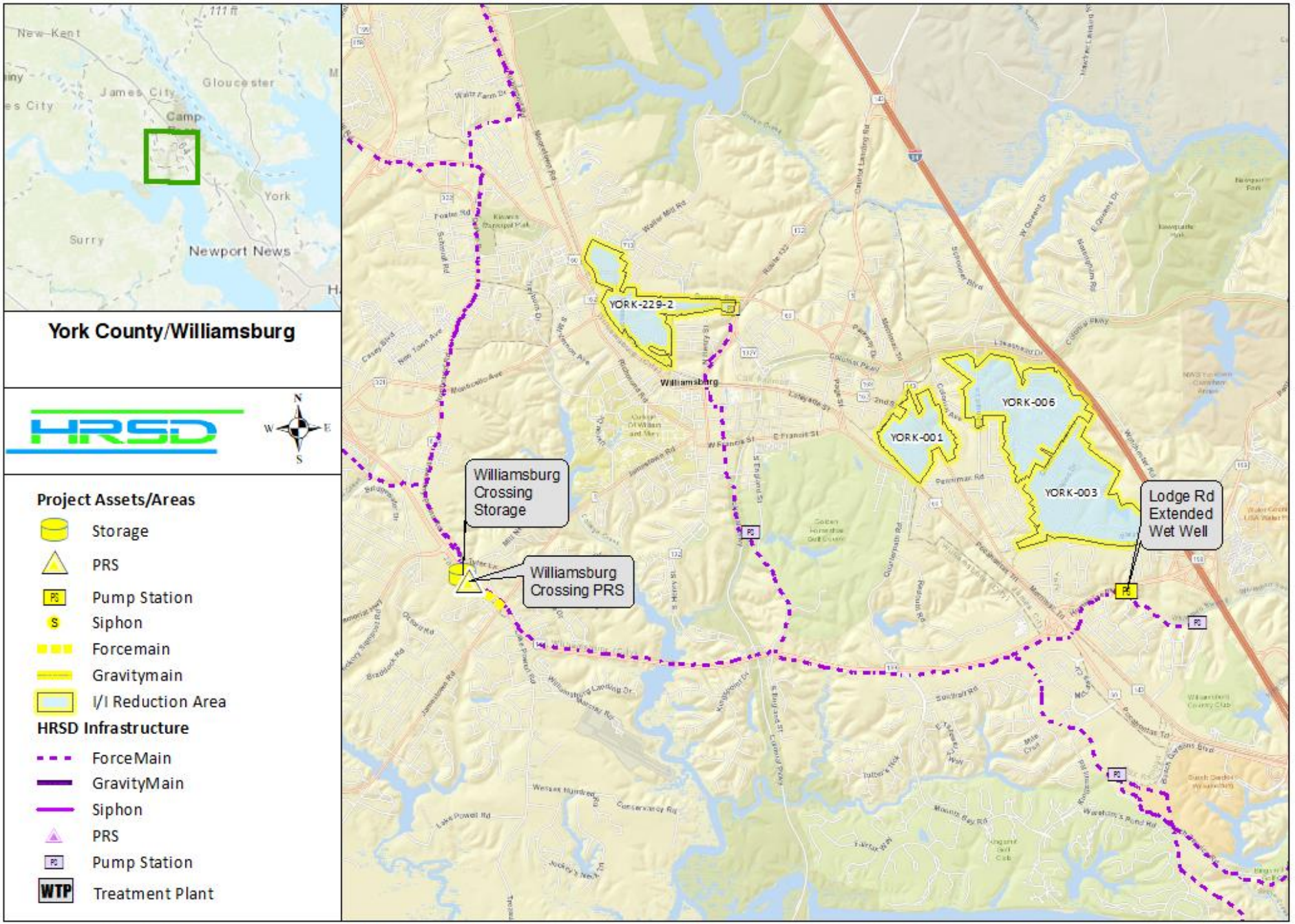
Round 2 HPP:
VIP-08 and VIP-09

May Ave. Storage Tank; Willoughby Ave PS Upgrade; Norfolk City System Improvements



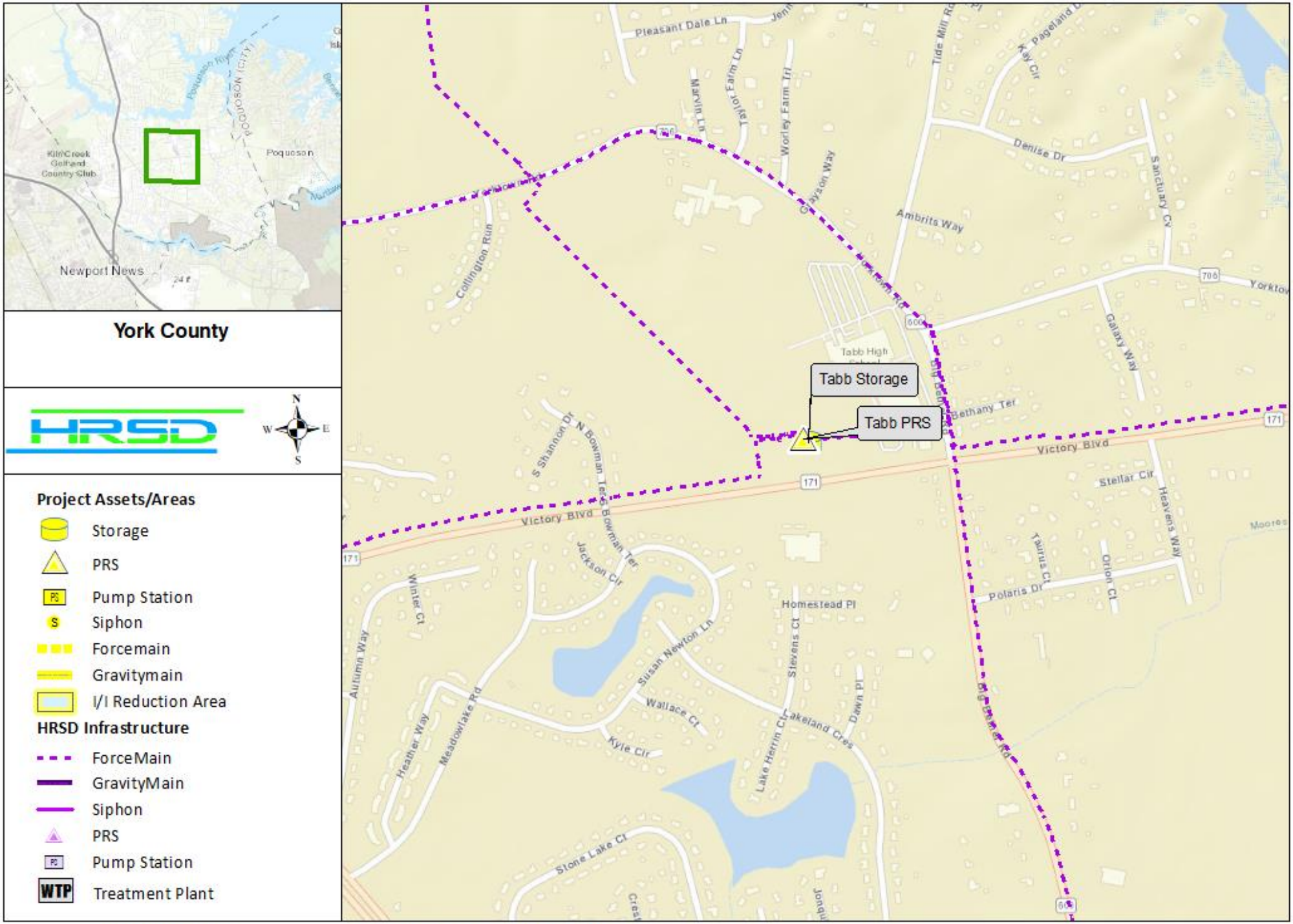
Round 2 HPP:
VIP-21 and VIP-29

Norfolk I/I Reduction Project



Round 2 HPP:
WB-04, WB-13, and WB-03

Williamsburg Crossing PRS, Force Main and Storage Tank; York County I/I Reduction Projects; Lodge Rd. PS Extended Wet Well



Round 2 HPP: YR-04

Tabb PRS and Storage Tank

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Appendix B: 5-Year Rainfall Hyetograph

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Time Stamp	5-yr, 4-hr Rainfall	5-yr, 4-hr Cumulative Rainfall
1/1/30 8:55	0.000	0.000
1/1/30 9:00	0.015	0.015
1/1/30 9:05	0.019	0.033
1/1/30 9:10	0.019	0.052
1/1/30 9:15	0.019	0.071
1/1/30 9:20	0.019	0.089
1/1/30 9:25	0.020	0.110
1/1/30 9:30	0.022	0.132
1/1/30 9:35	0.026	0.158
1/1/30 9:40	0.031	0.189
1/1/30 9:45	0.037	0.226
1/1/30 9:50	0.043	0.269
1/1/30 9:55	0.051	0.320
1/1/30 10:00	0.059	0.379
1/1/30 10:05	0.069	0.449
1/1/30 10:10	0.080	0.529
1/1/30 10:15	0.092	0.621
1/1/30 10:20	0.105	0.726
1/1/30 10:25	0.119	0.845
1/1/30 10:30	0.133	0.978
1/1/30 10:35	0.147	1.125
1/1/30 10:40	0.160	1.285
1/1/30 10:45	0.171	1.456
1/1/30 10:50	0.181	1.637
1/1/30 10:55	0.185	1.822
1/1/30 11:00	0.188	2.010
1/1/30 11:05	0.185	2.195
1/1/30 11:10	0.179	2.374
1/1/30 11:15	0.168	2.542
1/1/30 11:20	0.156	2.698
1/1/30 11:25	0.141	2.839
1/1/30 11:30	0.125	2.964
1/1/30 11:35	0.109	3.074
1/1/30 11:40	0.094	3.167
1/1/30 11:45	0.080	3.247
1/1/30 11:50	0.066	3.314
1/1/30 11:55	0.056	3.369
1/1/30 12:00	0.045	3.414
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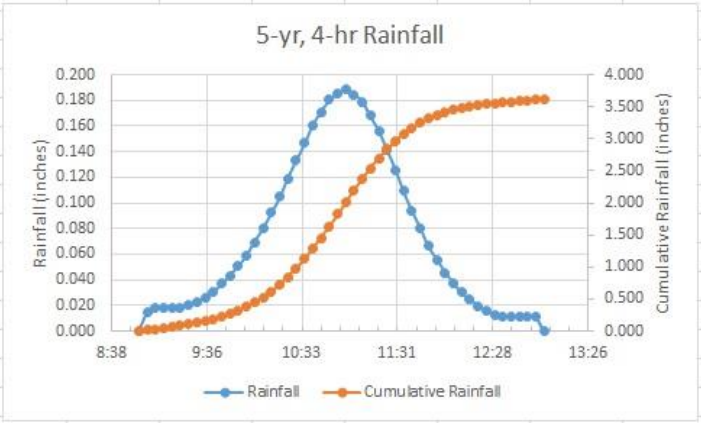
1/1/30 12:10	0.030	3.482
1/1/30 12:15	0.025	3.506
1/1/30 12:20	0.020	3.526
1/1/30 12:25	0.016	3.542
1/1/30 12:30	0.013	3.555
1/1/30 12:35	0.011	3.566
1/1/30 12:40	0.011	3.577
1/1/30 12:45	0.011	3.588
1/1/30 12:50	0.011	3.599
1/1/30 12:55	0.011	3.610
1/1/30 13:00	0.000	3.610



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