Comparative Analysis Report

Prepared for the
Hampton Roads Sanitation District
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Rev Aug 2013

Brown AND Caldwell
301 Bendix Road, Ste. 400
Virginia Beach, VA 23452

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List of Abbreviations

CIP	Capital Improvement Plan
CD	Consent Decree
CHES	City of Chesapeake
DEQ	Department of Environmental Quality
DOJ	Department of Justice
EPA	Environmental Protection Agency
FM	Force Main
FPR	Flow, Pressure, and Rainfall
GIS	Geographic Information Systems
GLOU	Gloucester County
gpad	gallons per acre per day
gpd	gallons per day
HAMP	City of Hampton
HGL	Hydraulic Grade Line
HRPDC	Hampton Roads Planning District Commission
HRSD	Hampton Roads Sanitation District
I/I	Infiltration/Inflow
IDM	Inch diameter mile
IOW	Isle of Wight County
ISI	Interim System Improvements
IWD	Industrial Waste Dischargers
JCSA	James City Service Authority
lf	linear feet
LOS	Level of Service
MG	Million Gallons
NEWP	City of Newport News
NORF	City of Norfolk
NSF	Non-Single Family
P3	Pre-treatment and Pollution Prevention
PFC	Peak Flow Commitment
POQ	City of Poquoson
PORT	City of Portsmouth
PPFE	Preliminary Peak Flow Estimate
PRS	Pressure Reducing Station
PS	Pump Station
RHM	Regional Hydraulic Model
RWWMP	Regional Wet Weather Management Plan
SFR	Single Family Residential
SOC	Special Order by Consent
SMITH	Town of Smithfield
SSES	Sanitary Sewer Evaluation Survey
SSO	Sanitary Sewer Overflow
STP	Sewer Treatment Plant
SUFF	City of Suffolk
UAO	Unilateral Administrative Order
VAB	City of Virginia Beach
WILL	City of Williamsburg
WWMP	Wet Weather Management Plan
YORK	York County

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Executive Summary

Since 2010, the Hampton Roads Sanitation District (HRSD) has been implementing a Consent Decree with the United States Environmental Protection Agency (EPA) and Virginia Department of Environmental Quality (DEQ) to mitigate the occurrence of sanitary sewer overflows (SSO) in the region. HRSD provides wastewater conveyance and treatment to the southeastern portion of Virginia, serving the customers in 14 local governments (Localities), which each have their own sanitary collection system. One of the major requirements of the Consent Decree is the development of a Regional Wet Weather Management Plan (RWWMP), which will detail a program for increasing the capacity of the wastewater system to handle peak wet weather events to eliminate SSOs within a specific Level of Service (LOS).

Following completion of pipeline condition assessment and construction of a Regional Hydraulic Model (RHM) of the sewer pipeline and pump station network, HRSD proposed that regionalizing the 14 different wastewater utilities into a single entity might be a better solution for the ratepayers. As part of a Consent Decree Modification negotiated with the EPA and DEQ, the Localities and HRSD would conduct a Regionalization Study to evaluate this concept and make a recommendation for the Localities and HRSD to consider. Part of the Regionalization Study is a Comparative Analysis which investigates the capital costs for rehabilitation and wet weather management under the 2-year and 10-year peak flow recurrence representative events in the non-regionalized and regionalized scenarios. Brown and Caldwell (BC) has prepared this document to present the cost findings of that Comparative Analysis as well as other non-monetary factors to be weighed in the decision for regionalization. This work was completed with modeling efforts and wet weather improvement solution set development assistance of CDM Smith and HRSD staff.

ES.1 Approach to the Comparative Analysis of Rehabilitation and Wet Weather Solutions

The tasks associated with the Comparative Analysis can be divided into a few main sub-groups, and each of these sub-groups was evaluated for both the non-regionalized and regionalized scenarios.

- Committed projects are those that HRSD is either obligated to do as part of the Consent Decree or are already underway or completed that increase the capacity of the system
- Rehabilitation costs which include work on the public sewer assets (public-side) and private sewer assets (private-side) to reduce peak flows associated with wet weather events
- Locality capacity improvements
- Regional wet weather improvements

The rehabilitation costs and the preliminary peak flow estimates (PPFEs) associated with the public-side of the sewer system under the non-regionalized approach were obtained directly from the Localities. The private property infiltration/inflow (I/I) abatement program costs were developed based on where the Localities proposed rehabilitation with the assumption that HRSD would perform single family residential (SFR) rehabilitation work where the Locality performed comprehensive public-side rehabilitation, where there were known private defects, or where non-single family (NSF) work was determined to be cost-effective.

For the regionalized approach, a revised rehabilitation plan was developed by Brown and Caldwell for the public sewers, which focused on the leakiest basins. A private property I/I abatement program, similar to what was developed for the non-regionalized approach, was also developed.

Following development of the rehabilitation plan peak flow reduction estimates, Brown and Caldwell adjusted the hydrologic parameters for use in the RHM to simulate the same peak flow reductions. Post-rehab capacity assessments were performed to identify the capacity limitations in the system for each scenario. These capacity assessments provided a baseline for development of wet weather solutions beyond the committed projects already included in the RHM.

Brown and Caldwell, working with HRSD and CDM Smith, used a systematic approach to developing wet weather solutions to eliminate SSOs and surcharge criteria violations (as identified in the Regional Technical Standards in HRSD's Special Order by Consent with the DEQ), starting with the 2-year non-regionalized scenario. The solution set was then expanded to meet the 10-year representative event. Both the 2-year and 10-year non-regionalized solution sets formed the basis for the regionalized solution sets. These wet weather solutions included storage facilities, larger force mains and gravity mains, HRSD pump station and pressure reducing station capacity improvements, and Locality pump station improvements.

Locality capacity improvement costs were estimated in two ways. The Locality pump station improvement needs were identified from the RHM and the solution set development. A Locality pump station improvement was selected as part of the solution if it was more cost effective than a regional solution. The second type of Locality capacity improvement involved the upstream system of gravity collection pipes, lift stations, and Locality force mains not part of the RHM. If the Locality identified these assets as having insufficient capacity in their Preliminary Capacity Assessments, Brown and Caldwell assigned a cost for the Comparative Analysis.

Once the rehabilitation and capacity improvement solution sets were complete, capital cost estimates associated with the two approaches (Non-Regionalized and Regionalized) were developed. These costs were estimated robustly based on conceptual development of proposed improvements and high level unit costs. No detailed design or estimates were developed. All costs in this document are stated in 2013 dollars. Locality rehabilitation costs were provided by Localities and have been used without any independent review.

ES.2 Non-Regionalized Approach

For the Non-Regionalized approach, costs were developed at the Locality-level so that they could be incorporated into the Regionalization Study. HRSD was assigned all costs associated with the regional wet weather improvements and the private property I/I abatement program, while the rehabilitation costs were assigned to the applicable organization. As mentioned previously, the Locality capacity improvements include the Localities' terminal pump stations as well as upstream collection system improvements.

The Regionalization Study also requires an implementation schedule so that the estimation of rates can be made. A summary of the costs and implementation schedules under the 10-year non-regionalized approach are listed in Table ES-1. Costs associated with the 2-year peak flow recurrence non-regionalized scenario are provided later in this report.

Table ES-1. Capital Cost and Schedule for the 10-year Non-Regionalized Approach						
	Regional Wet Weather Improvements	Locality Capacity Improvements	Locality/HRSD Rehabilitation	Private Property I/I Abatement	Total	Implementation. Schedule (yrs)
CHES		$48,277,000	$271,751,000		$ 320,028,000	30
GLOU		$7,646,000	$7,516,000		$ 15,162,000	N/A
HAMP		$47,100,000	$155,666,000		$ 202,766,000	25
HRSD	$659,390,000	None	$173,338,000	$289,248,000	$ 1,121,976,000	10/20*
IOW		None	$150,000		$ 150,000	N/A
JCSA		$20,000,000	$63,626,000		$ 83,626,000	20
NEWP		$53,789,000	$125,806,000		$ 179,595,000	25
NORF		$16,318,000	N/A**		$ 16,318,000	N/A
POQ		$1,300,000	$14,004,000		$ 15,304,000	25
PORT		$53,694,000	$247,403,000		$ 301,097,000	30
SMITH		None	$3,814,000		$ 3,814,000	20
SUFF		$14,958,000	$29,331,000		$ 44,289,000	15
VAB		$69,400,000	$349,596,000		$ 418,996,000	30
WILL		$4,100,000	$17,000,000		$ 21,100,000	20
YORK		None	$72,500,000		$ 72,500,000	25
Grand Total	**$659,390,000**	**$336,582,000**	**$1,531,501,000**	**$289,248,000**	**$ 2,816,721,000**	

**HRSD's Rehab Plan has a 10-year implementation schedule and the RWWMP schedule is assumed to be 20 years.*

*N/A** - Norfolk's rehabilitation program falls outside of the Consent Order and their costs have not been collected.*

ES.3 Regionalized Approach

For the Regionalized Approach, the costs associated with reaching the 2-year and 10-year Levels of Service have been calculated. Rehabilitation costs were based on a revised approach to meet the previously determined optimal point in each treatment plant service area. In the table below, the column "Upstream Cap Improvements" replaces the Non-Regionalized approach table column "Locality Capacity Improvements." These costs remain broken out from "Regional Wet Weather Improvements" for comparative purposes between approaches and include improvements to upstream lift stations, gravity collection systems (not currently owned by HRSD), and terminal pumping stations (not currently owned by HRSD).

As there will be one entity in the Regionalized approach, the costs are presented at the system-wide level. Table ES-3 shows the total capital costs associated with the Regionalized 10-year level of service with the 2-year values provided later in this report. The implementation period for the regionalized approach is assumed to be 20 years.

Table ES-2. Capital Cost for 10-year Peak Flow Recurrence Regionalized Approach					
	Regional Wet Weather Improvements	Upstream Cap Improvements	Rehabilitation	Private Property I/I Abatement	Total
Total	**$635,138,000**	**$324,179,000**	**$1,005,256,000**	**$210,495,000**	**$2,175,068,000**

ES.4 Comparison of Capital Costs at 10-year Level of Service

A comparison of the 10-year costs for the Non-Regionalized and Regionalized scenarios is listed in Table ES-3.

Table ES-3. Comparison of Capital Costs at 10-year Level of Service

	Non-Regionalized	Regionalized	Delta	% Diff
Rehabilitation	$1,531,501,000	$1,005,256,000	$526,245,000	34%
Regional Wet Weather Improvements	$659,390,000	$635,138,000	$24,252,000	4%
Locality/Upstream Capacity Improvements	$336,582,000	$324,179,000	$12,403,000	4%
Private Property I/I Abatement Program	$289,248,000	$210,495,000	$78,753,000	27%
Grand Total	**$2,816,721,000**	**$2,175,068,000**	**$641,653,000**	**23%**

ES.5 Conclusion

The following are the principle conclusions drawn from this Comparative Analysis.

1. There is a substantial savings in capital costs of approximately $642 million associated with the Regionalized Alternative. As seen in the table above, this difference is largely due to rehabilitation and private property I/I abatement savings.
2. The incremental operations and maintenance expenses associated specifically with wet weather improvements are not significantly different between the regionalized and non-regionalized alternatives.
3. The allocation of risk associated with I/I removal and related sizing of wet weather improvements in the regionalized alternative is better aligned with the management of that risk.
4. Significant logistical and practical efficiencies are available in the regionalized alternative. Synchronization of rehabilitation, private property I/I abatement and wet weather improvements is greatly enhanced in the regionalized alternative.
5. Development and enforcement of flow agreements in the non-regionalized alternative creates complexities and dynamics that tend to increase costs and amplify the consequences of risk allocation. In addition, administering these flow agreements creates substantial further expense.
6. The non-regionalized alternative increases the risk of not achieving the desired LOS and creates the opportunity for finger pointing amongst Localities.
7. There is a greater risk of failing to achieve the desired LOS in the non-regionalized alternative due to the multiple Localities involved. Failure by one or more Locality to achieve their PFC will jeopardize reaching the LOS across an entire treatment plant service area.

Section 1

Introduction and Background

The Hampton Roads Sanitation District (HRSD) is the regional wastewater conveyance and treatment utility for the Hampton Roads region of Virginia, and serves customers in all the Localities in the region. It is a political sub-division of the Commonwealth of Virginia with a nine member Commission appointed by the Governor for 4 year terms. HRSD's total service population is approximately 1.6 million people and includes customers in:

- James City County (JCSA)
- Gloucester County (Glou)
- Isle of Wight County (IOW)
- Mathews County
- The City of Chesapeake (Ches)
- The City of Hampton (Hamp)
- The City of Newport News (Newp)
- The City of Norfolk (Norf)
- The City of Poquoson (Poq)
- The City of Portsmouth (Port)
- The Town of Smithfield (Smith)
- The City of Suffolk (Suff)
- The City of Virginia Beach (VAB)
- The City of Williamsburg (Will)
- York County (York)

These Localities each have their own wastewater collection systems (except for Mathews County served directly by HRSD) and their systems convey wastewater to HRSD's piping network for transmission to one of nine sewer treatment plants (STPs) operated by HRSD.

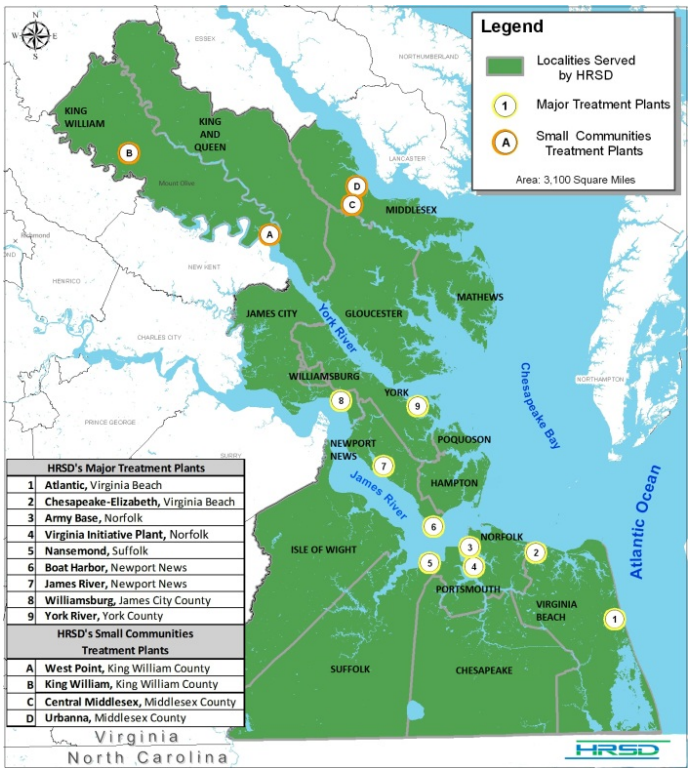

Figure 1-1. Locality Map

Currently, the Localities and HRSD have no formal flow agreements that govern flows delivered from the Localities to the HRSD system. As the wastewater system has aged in the Hampton Roads region, wastewater collection system defects have formed (e.g., cracks, offset joints, leaking manholes) which allows rain water runoff and groundwater infiltration into the pipes. During certain wet weather events, this additional external flow can exceed the capacity of the existing wastewater infrastructure leading to sanitary sewer overflows (SSOs) in both the Localities' systems and HRSD's system.

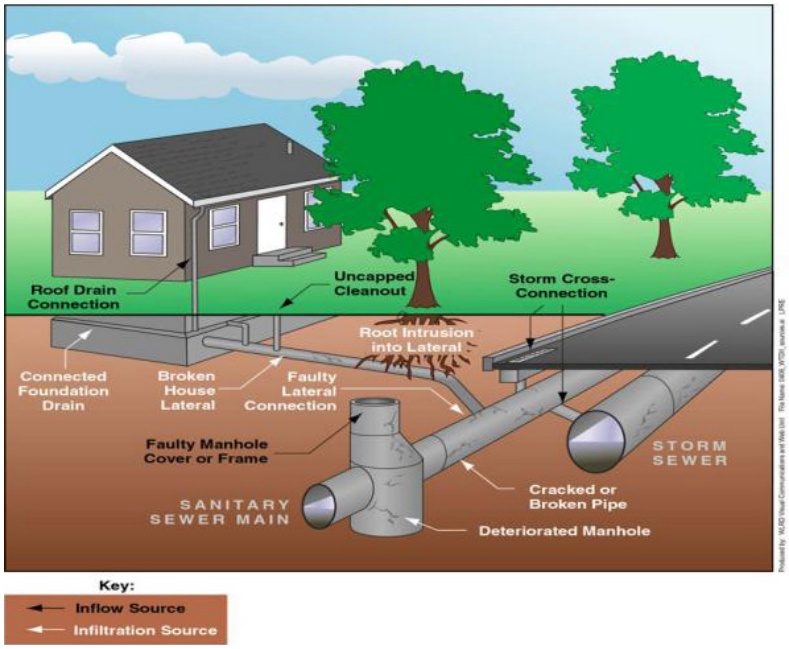

Figure 1-2. Sources of Infiltration/Inflow

As part of a comprehensive program to mitigate the occurrence of SSOs, HRSD and the Localities are working together to develop a two pronged approach. A rehabilitation program will reduce the peak wastewater flows by reducing infiltration and inflow and a wet weather management program (WWMP) to convey and treat the remaining peak flows to meet an agreed-upon level of service (LOS). During development of these programs, the concept of regionalizing the separate wastewater systems in the region into a single entity was born. This report will detail the results of a cost comparison between completing the rehabilitation program and WWMP in a non-regionalized approach versus a regionalized approach.

1.1 Consent Decree

In 2005, representatives of the United States Environmental Protection Agency, Region III, (EPA) notified the Localities and HRSD of their interest in the region and scrutiny of the SSOs on record. In response, thirteen of the Localities and HRSD began work on a Special Order by Consent (SOC) with the Virginia Department of Environmental Quality (DEQ) to develop a rehabilitation program and WWMP. Norfolk, which was already party to a Consent Order with the DEQ, and Mathews County, which was not part of the regional system at the time, were excluded from the SOC.

The SOC was completed and signed by HRSD, the Localities, and the DEQ in September 2007. It included requirements for HRSD and the Localities to complete flow monitoring and sewer system evaluation surveys (SSES), develop hydrologic and hydraulic computer models of the pump and piping network, prepare a rehabilitation plan with an affirmative peak flow commitment (PFC) for reducing wet weather peak flows, and develop a Regional Wet Weather Management Plan (RWWMP).

Directly before the SOC was finalized, the EPA issued a Unilateral Administrative Order (UAO) to HRSD dictating numerous requirements including a rehabilitation plan and WWMP. HRSD, the US Department of Justice (DOJ), and the EPA negotiated a Consent Decree (to replace the UAO) that was lodged with the court in 2009 and entered into record on February 23, 2010. The Consent Decree is very similar to the SOC but only HRSD (and not the Localities) is party to the document. The major product of the Consent Decree is a RWWMP designed to meet a proposed LOS between 2 years and 10 years. The RWWMP was due November 26, 2013, with an extension allowable to July 31, 2014, if agreed to by the EPA and HRSD. Unlike the SOC, the Consent Decree includes stipulated penalties should HRSD fail to meet the milestones and due dates specified by the document.

1.2 Consent Decree Modification

In early 2012, HRSD proposed the concept of regionalization in an effort to get a better solution for the region as a whole and with the expectation that there could be a potential for cost savings. It was believed that approaching rehabilitation and wet weather improvements irrespective of jurisdictional boundaries might yield lower capital costs.

HRSD proposed a Regionalization Study whereby the Hampton Roads Planning District Commission (HRPDC) would hire a team of consultants to evaluate the issues and make a recommendation to HRSD and the Localities on whether regionalization would be beneficial to the customers. The Localities and HRSD could then decide whether to proceed with the task of actually combining the systems into one regional entity.

Until the Regionalization Study is completed, finishing the Locality rehabilitation plans (originally due November 26, 2012) and the RWWMP according to the non-regionalized approach could potentially be a significant waste of effort. HRSD and the EPA have negotiated a modification to the Consent Decree that would allow for schedule relief to complete the Regionalization Study. In good faith, the EPA agreed to the extension for the RWWMP from November 2013 to July 2014, as specified in the existing Consent Decree, until the modification was completed. The modification was entered into the court record in June 2013.

This modification allows for an extension of the RWWMP to:

- April 2015 if the Regionalization Study does not recommend consolidation;
- October 2015 if the Regionalization Study recommends consolidation but the Localities or HRSD decide against it; or
- October 2016 if regionalization is agreed to by the Localities and HRSD.

The extension requires HRSD to complete a Comparative Analysis and evaluate the costs associated with implementing a non-regionalized and regionalized program at the 2-year and 10-year LOS. This Comparative Analysis would inform the Regionalization Study on the costs from each approach so that the impact on the customers can be evaluated.

1.2.1 Comparative Analysis of Rehabilitation and Wet Weather Solutions

The main focus of the Comparative Analysis is an economic evaluation to identify the total costs associated with rehabilitation (i.e., reducing infiltration/inflow (I/I) into the wastewater collection system) and capacity improvements required post-rehabilitation to meet the 2-year and 10-year LOS under both the non-regionalized and regionalized scenarios.

1.2.2 Comparative Analysis of Operation and Maintenance Practices, Efficiencies and Infrastructure

During the negotiation of the Consent Decree modification, questions were raised about possible efficiencies gained (or lost) through regionalization with respect to operations and maintenance. The Comparative Analysis report includes a section discussing these practices and efficiencies (see Section 4).

1.2.3 Final Recommendations and Report

As mentioned previously, the Consent Decree modification requires submission of the Regionalization Study which is due August 31, 2013. This document will include information provided in the Comparative Analysis as well as a recommendation on the subject of regionalization and total anticipated cost to the customers. These rates are based on operation and maintenance costs, debt service, administrative costs, and capital costs identified in the Comparative Analysis. The costs in the Comparative Analysis Report are in 2013 dollars and the projects are not scheduled or prioritized. It is also understood that the Comparative Analysis is not the RWWMP required by the Consent Decree, and projects will change, be deleted, or replaced in the final RWWMP.

1.3 Approach to the Comparative Analysis of Rehabilitation and Wet Weather Solutions

Generally, the costs were developed for the Comparative Analysis in a similar manner for both approaches in a simple and easy to apply methodology. The process is described here and expanded upon in subsequent sections of this report. First, the rehabilitation program was developed (either as provided by the Localities in the non-regionalized approach or as estimated for the regionalized approach) and an estimation of private property I/I abatement was added. These peak flow reductions for every sewer catchment were converted into hydrologic parameter reductions. The reduced parameters were used to simulate post-rehabilitation peak flows in the Regional Hydraulic Model (RHM) to assess the post-rehabilitation capacity limitations in the system under both the 2-year and 10-year events. Wet weather solutions were then developed for the 2-year representative event and then further enhanced to manage the 10-year representative event. This process is shown in Figure 1-3.

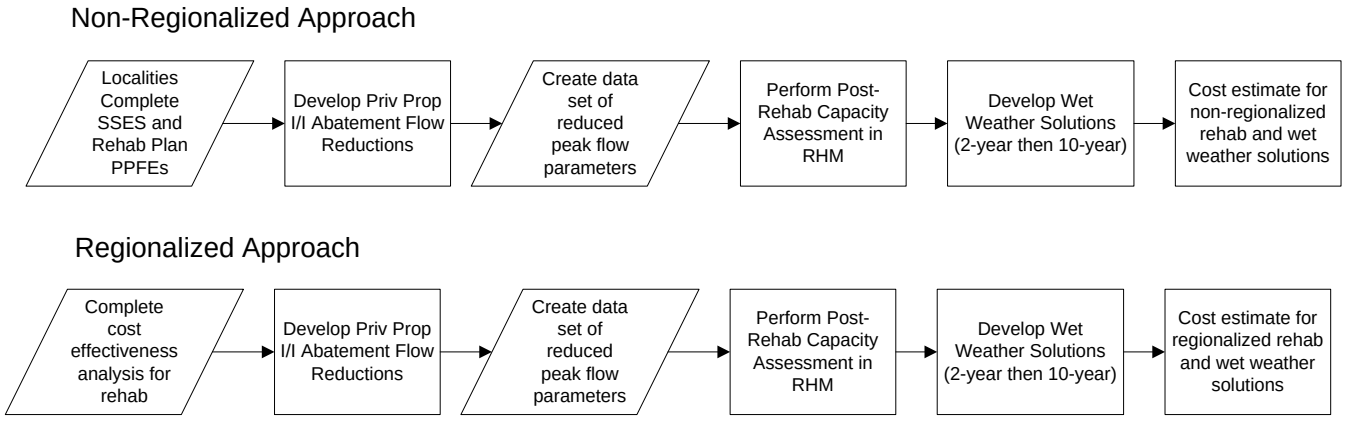

Figure 1-3. Comparative Analysis Process

Estimation of capacity improvements in the upstream parts of the collection system (not included in the RHM) was then calculated. Costs were assigned to all improvements for each of the four scenarios (regionalized and non-regionalized, 2-year and 10-year).

1.3.1 Baseline (Non-Regionalized) Alternative

The non-regionalized alternative is based on the Localities' estimation of peak flow reductions. In the original SOC, the Localities' Rehabilitation Plans with their PFCs were due to be submitted on November 26, 2012. Through Minor Revision No. 1 to the SOC, the DEQ allowed the Rehabilitation Plans to be submitted on the due date identified in the Consent Decree for the RWWMP. With the schedule modifications, this date will be at the earliest April 2015. The SOC revision maintained a requirement for the Localities to submit a Preliminary Peak Flow Estimate (PPFE) to HRSD by the original November 2012 deadline. These estimates were to be based on the draft Rehabilitation Plans prepared by each Locality and were to be submitted with expected program costs and schedule for completion. The planned areas of rehabilitation from the Localities were used to develop a private property I/I abatement program (described later) that worked in conjunction with the Localities' rehabilitation efforts. The remainder of the program and cost development was similar to the regionalized approach.

1.3.2 Regionalized Alternative

For the regionalized alternative, Brown and Caldwell used a cost effectiveness analysis (described later) to identify an optimal level of I/I reduction in each treatment plant service area. The most cost effective catchments for I/I removal were then targeted and an estimation of public-side peak flow reduction was made. An additional component was added to estimate the combined effectiveness of both public and private property I/I abatement in each of the cost effective catchments, and then hydrologic parameter reductions were made based on the peak flow reduction. The remainder of the program and cost development was similar to the non-regionalized approach.

1.3.3 Other Considerations

Several other items were considered during the development of the Comparative Analysis. These are described below.

1.3.3.1 Locality Capacity Assessments

A significant component of the overall program costs in each alternative was the capacity improvements in the areas of the collection system upstream of the RHM network. This typically included upstream lift stations, lift station force mains, and gravity sewer mains larger than 10 inches in diameter. These parts

of the system were evaluated by the Localities and the assessments were provided to HRSD. This information was used in the development of overall program costs as described later in this report.

1.3.3.2 HRSD Interim System Improvement Projects

The Consent Decree includes a section requiring HRSD to complete 33 specific Interim System Improvement (ISI) projects by February 2018. These projects had been identified in the negotiation process in 2008 and 2009 as necessary regardless of the outcome of the Rehabilitation Plan and RWWMP. An additional 18 projects (for a total of 51) were identified during the negotiation of the Consent Decree modification in 2012. Many of these projects have been completed since initiation of the Consent Decree work, and most of the remainder are either in design or construction. Due to the mandatory requirement that HRSD complete these projects, they have all been included in the modeling either as constructed/designed or have been sized in the Comparative Analysis modeling work. These projects represent a significant capital expense by HRSD and their costs have been included in the overall program totals, with the same amount represented in all scenarios. The projects are listed in the table below.

Table 1-1. Interim System Improvement Projects

CD Ref ID	Project Name	HRSD CIP
1	Claremont Avenue Pump Station Rehabilitation	BH-111
2	Atlantic Pressure Reducing Station Emergency Generator Replacement	AT-100
3	Lake Ridge Interceptor Force Main Section B - Contract 2 (Land)	AT-113-2
4	Big Bethel Road to J Clyde Morris Boulevard Interceptor Force Main Replacement	YR-100
5	Williamsburg-James River Connection Force Main Section II and Lucas Creek-Woodhaven Interceptor Force Main Replacements - Phase 1 & 2A	JR-109-1 and 2A
6	Route 171 Interceptor Force Main	YR-108
7	Kiln Creek Interceptor Force Main	YR-104
8	South Trunk Sewer Section F 20-Inch, Section H 8-Inch, and Section H 12-Inch Interceptor Force Main Replacement and Gravity Sewer Chesterfield Blvd. Replacement	VIP-120
9	Eastern Branch Sections A & B, Green Run Section C, and 24-Inch Kempsville Road Force Main Replacements	AT-108
10	North Trunk Sewer Section W 8-Inch and 12-Inch Force Mains and Larchmont Force Mains (Formerly Siphon Lines) Replacements	VIP-106
11	North Trunk Sewer Section R 6-Inch Interceptor Force Main and 10-Inch Gravity Replacement	VIP-105
12	North Trunk Sewer Section D 24-Inch Interceptor Force Main Replacement	VIP-104
13	Hilltop/Point O'Woods Interceptor Force Main Replacement - Phase I	AT-112-1
14	Hilltop/Point O'Woods Interceptor Force Main Replacement - Phase II	AT-112-2
15	Williamsburg Interceptor Force Main Contract A Replacement	WB-107
16	33rd Street Pump Station Replacement/Rehabilitation	BH-100

Table 1-1. Interim System Improvement Projects		
CD Ref ID	Project Name	HRSD CIP
17	Sanitary Sewer System Portsmouth VA Contract A Clifford Street Force Main	VIP-133
18	James River Diversion 35th Street Phase III and Boat Harbor Outlet Sewer Relocation I-664 Rehabilitation	BH-114
19	Hampton Trunk Sewer Division A Replacement	BH-112
20	Lucas Creek Pump Station Upgrade	JR-106
21	South Trunk Sewer Section C-42 inch Force Main Replacement	VIP-131
22	Section W Force Main Replacement	AB-105
23	Coliseum Drive Pressure Reducing Station & Offline Storage Tank	YR-101 and 121
24	Center Avenue Pump Station Replacement	JR-100
25	Norchester St Pump Station Replacement/Rehabilitation	VIP-130
26	Providence Road Interim Pressure Reducing Station	AT-114-1
27	58th Street Connecting Sewer Rehabilitation	BH-101
28	Bridge St. Pump Station Replacement/Rehabilitation	BH-116
29	South Trunk Sewer Section G 36-Inch and 30-Inch Force Main Replacement	VIP-132
30	Interceptor Systems Pump Station Control and SCADA Upgrades and Enhancements	GN-128
31	Wilroy Pressure Reducing Station, Pughsville PRS Upgrades, Suffolk PS Upgrades	NP-106
32	Army Base 24-Inch and 20-Inch Transmission Main Replacements	AB-100
32	Army Base 20-Inch Force Main Relocation	AB-100-1
33	Normandy Lane Interceptor Force Main Replacement	JR-108
34	Great Neck Road Interceptor Force Main Replacement Section A	AT-126
35	Military Highway Interim Pressure Reducing Station	AT-128
36	Hampton Trunk Sewer Extension Division E Gravity Replacement	BH-120
37	Victoria Boulevard Pump Station	BH-131
38	Ivy Home-Shell Road Sewer Extension Division I Replacement	BH-145
39	South Shore Interceptors Air Vent Rehabilitation	GN-139
40	North Shore Air Vent Replacements	GN-142
41	Center Avenue Pump Station Service Area I/I Remediation	JR-101
42	Middle Ground Boulevard – City Center Interconnect Force Main	JR-110
43	Center Ave I&I Remediation Phase II	JR-115
44	Jefferson Avenue Interceptor Force Main Replacement Phase I	JR-117-1
45	Warwick 36” PCCP – Scufflefield to Nettles Interceptor Force Main Replacement	JR-120
46	Holland Road 24” Interceptor Force Main – Section A	NP-118
47	Pughsville Pressure Reducing Station Upgrades	NP-122

Table 1-1. Interim System Improvement Projects		
CD Ref ID	Project Name	HRSD CIP
48	Sewerage System Improvements Division C, Phase I and Suction Lines Jefferson Street/Camden/Peachtree Portsmouth VA Replacements (I-264 Crossing)	VIP-115
49	Lafayette River Crossing / Norview – Estabrook Force Main Replacement	VIP-164
50	Courthouse Interim Pressure Reducing Station	AT-116-1
51	Hampton Pump Station 023 Upgrades and Discharge Force Main	YR-123

1.3.4 Cost Estimation

Cost estimation was performed at a Class 4 level representing concept study/feasibility level work. Typical costs were based on a unit value per foot of pipe (each diameter), per million gallons of storage, and per horsepower for pumping systems. Specific cost values were used (e.g., in Locality rehabilitation plan costs or ISI project costs) when they were available. For I/I abatement, in both the regionalized approach and for the private property I/I abatement program, estimates of pipeline rehabilitation/replacement were made. Based on unit costs, for all costs developed in the Comparative Analysis (i.e., not provided by Locality or through ISI), a 15% engineering cost was applied for planning, design, and construction administration. In addition, a 15% contingency cost was included for each of these projects.

1.3.5 Comparison of Approaches

Information is provided in this report to compare each of the scenarios at both the bottom line and the individual program component levels. During development of wet weather capacity improvement solution sets, a non-biased approach was taken to meet the same general LOS using the same general solutions. For example, if a new force main was proposed in the non-regionalized scenario, then that force main formed the basis of the solution set for the regionalized scenario, as opposed to using another type of improvement, such as a storage tank and pumping station. This same approach was also applied to the 2-year and 10-year comparison. The cost estimates are provided for each scenario in Sections 2.4.2 and 3.4.2 of this report. Discussion of non-monetary factors is included in Section 4.

Section 2

Non-Regionalized Scenario

This section of the report will focus on the development of the non-regionalized approach and provide an estimate of the costs associated with meeting the obligations of the SOC and the Consent Decree for the 2-year and 10-year LOS.

2.1 Rehabilitation Plans and Flow Parameter Development

Preparation of a RHM was a requirement of both the SOC and Consent Decree. It is based upon data provided by the Localities in the form of hydrologic flow parameters and system network infrastructure. The Localities conducted flow monitoring of their systems in 2008 (and later) to estimate the base sewer flow, dry weather infiltration, and wet weather peak flows. Each Locality used hydrologic modeling to develop calibrated parameters that simulate the peak flows from each sewer catchment for wet weather events. These parameters were provided to HRSD who calibrated the RHM with regional flow and pressure monitoring sensors to three wet weather events in 2010. The model calibration was complete and submitted to the EPA and DEQ in July 2011. The flow parameters used in the calibration of the RHM serve as the starting point basis for peak flow reductions from the Localities' rehabilitation plans. When the wet weather parameters are reduced, a lower peak flow than the original value reflecting the effect of rehabilitation is generated. The following sections of this report discuss the approach taken in the peak flow reductions.

2.1.1 Locality Rehabilitation Plans

As discussed previously, each Locality was tasked in the SOC with development of a Rehabilitation Plan with a PFC for every SSES basin. With the revision to the SOC, the Localities were allowed to delay submission of their Rehabilitation Plan with the PFCs to coincide with the submission of the RWWMP. Instead, the Localities were required to submit PPFEs as an interim value until the final PFCs are assigned.

2.1.1.1 Preliminary Peak Flow Estimates

Following completion of the SSES work, each Locality estimated the reduction in wet weather peak flows they expected to achieve as a result of rehabilitation. Their approaches varied in how they calculated this reduction but each Locality identified a value typically from 0% to 35% in peak flow reduction from the 10-year peak hour flow. These numbers are called Preliminary Peak Flow Estimates (PPFEs). The PPFE values aggregated at the Locality level for the SSES basins only are listed in Table 2-1 below.

Table 2-1. PPFE Values Aggregated at the Locality Level for SSES Basins Only

Locality	10-year Peak Flow (gpd)	10-year Peak Flow I/I (gpd)	PPFE (gpd)	GPD removed	I/I Reduction (%)
Chesapeake	82,440,714	77,183,810	67,254,035	15,577,731	20%
Gloucester	4,008,960	3,772,800	3,055,680	953,280	21%

Table 2-1. PPFE Values Aggregated at the Locality Level for SSES Basins Only					
Locality	10-year Peak Flow (gpd)	10-year Peak Flow I/I (gpd)	PPFE (gpd)	GPD removed	I/I Reduction (%)
Hampton	64,167,582	56,710,107	49,438,318	11,816,868	21%
Isle of Wight	348,480	283,392	305,971	42,509	15%
JCSA	54,622,080	50,463,360	41,998,964	12,623,116	25%
Newport News	83,416,000	77,081,757	68,812,700	14,603,300	19%
Poquoson	10,038,977	8,614,592	7,455,306	2,583,671	30%
Portsmouth	68,330,649	62,929,980	56,104,966	12,225,683	19%
Smithfield	2,418,463	1,973,851	1,935,758	482,705	24%
Suffolk	42,100,633	38,900,820	34,716,870	7,383,763	19%
Virginia Beach	162,076,600	145,774,600	143,809,350	18,267,250	13%
Williamsburg	14,015,520	12,384,000	11,773,440	2,242,000	22%
York	28,671,840	23,808,960	23,041,440	5,630,112	24%
Total	**616,656,498**	**559,882,029**	**509,702,798**	**104,431,988**	**19%**

2.1.1.2 Preliminary Cost Estimates and Schedule

As the Localities identified the rehabilitation efforts necessary to meet their PPFE, they also developed costs associated with the work. As with the PPFEs, the Localities prepared their costs in a variety of ways. Brown and Caldwell used these costs directly in the Comparative Analysis without any independent review or modification. Along with the total costs, the Localities provided HRSD with a rehabilitation program duration based on their expectations of affordability. The total rehabilitation costs and schedules provided by the Localities are listed in Table 2-2. These values are preliminary and will change before the Localities submit their Rehabilitation Plans to the DEQ; however, they are the best available information for this Comparative Analysis.

Table 2-2. Total Rehab Costs and Schedule		
Locality	Cost	Duration (years)
Chesapeake	$ 271,751,142	30
Gloucester	$ 7,516,000	N/A
Hampton	$ 155,665,783	25
Isle of Wight	$ 149,630	N/A
JCSA	$ 63,626,487	20
Newport News	$ 125,806,274	25
Poquoson	$ 14,003,770	25
Portsmouth	$ 247,403,473	30
Smithfield	$ 3,814,064	20
Suffolk	$ 29,331,103	15
Virginia Beach	$ 349,595,721	30

Table 2-2. Total Rehab Costs and Schedule		
Locality	Cost	Duration (years)
Williamsburg	$ 17,000,000	20
York	$ 72,500,000	25
Total	**$ 1,358,163,447**	

2.1.2 Development of Peak Flow Reductions

The next step in the process following receipt of the Locality PPFEs is to incorporate them along with other peak flow reductions into wet weather flow parameter adjustments. The PPFEs were generally provided as a single number in either gallons per day (gpd) or a reduction percentage of the existing peak hourly flow. These flows are generated through hydrologic modeling using many different parameters, including base sewer flow, dry weather infiltration, time-varying groundwater infiltration, and a series of wet weather parameters to simulate peak flow response to rainfall. In order to develop an estimate for private property I/I abatement, Brown and Caldwell used an approach with simplifying assumptions discussed in the following sections. The PPFEs and private property I/I reductions were combined into a single step of flow parameter reductions for the purpose of this analysis.

2.1.2.1 Estimation of Assets

To develop an estimate of private property I/I in each catchment, Brown and Caldwell identified the approximate amount of private piping and manholes through an extensive geographic information systems (GIS) effort. Each sewer catchment identified for rehabilitation by the Localities (i.e., the Sanitary Sewer Evaluation Survey (SSES) Basins) was evaluated for the number of parcels, size of parcels, land use, and other factors, to determine an estimate of public and private infrastructure piping. Algorithms were then established and calibrated based on parcel area. These tools were used to calculate private sewer lengths in selected areas to estimate sewer pipe lengths on private property throughout the region. Each Locality had provided HRSD with their sewer mapping GIS which included all known Locality sewer mains and manholes. Public laterals from the main sewer line to the property line were estimated using GIS.

Information was also gathered from GIS on pipeline diameter for the public system and assumptions were developed for diameters of public laterals, private laterals and private sewer systems. Inch-diameter-mile (IDM) values were then calculated for each catchment for the public and private assets.

2.1.2.2 Distribution of I/I

After removing the base sewer flow, the dry weather infiltration, time-varying groundwater, and wet weather I/I was distributed between public and private assets in each catchment based on the ratio of public to private IDM. The private I/I was further distributed, based on IDM to single family residential (SFR) laterals and to non-single family (NSF) piping. For purposes of the Comparative Analysis, NSF includes multi-family (e.g., apartment complexes), commercial, and industrial properties.

2.1.2.3 Development of Private Property I/I Reductions

The following sections describe the development of private property I/I flow reductions.

2.1.2.3.1 Single Family Residential

The general approach to addressing I/I from single family residential (SFR) properties was to “work where the Localities work.” With more than 460,000 customer connections to the regional wastewater collection system, it would be infeasible to test/rehabilitate every sewer lateral. Further, data from other rehabilitation programs across the country support the theory that I/I actually migrates from one location, or defect, to another, thus performing non-comprehensive rehabilitation would yield much lower

I/I reduction rates than anticipated. Thus, HRSD decided to only perform SFR rehabilitation work where the Localities performed comprehensive public-side rehabilitation or where they had identified private defects. Although known defects may not be part of a comprehensive rehabilitation area, these defects were typically identified via smoke testing, and thus were sources of inflow, which do not tend to exhibit the same migratory habits of infiltration.

Brown and Caldwell used the rehabilitation program information provided by the Localities to identify where comprehensive rehabilitation of the mainline sewer and public sewer laterals was being performed. The parcels adjacent to this work were assumed to have private laterals that connected to the rehabilitated public sewer, and were selected for inclusion in the private program. A private lateral length for each included parcel was calculated for use in cost estimating the rehabilitation. Assumptions were made on the distribution of I/I across a catchment service area, the lateral failure rate, and the rehabilitation success rate. These values were applied to each catchment to calculate an amount of peak flow reduction from the single family laterals.

2.1.2.3.2 Non-Single Family

The second component of the private property I/I program involved peak flow reduction from non-single family (NSF) properties. For the purposes of this Comparative Analysis, non-single family included multi-family residential (e.g., apartment complexes), private sewer systems in developments, commercial properties (e.g., shopping centers), schools, and small industrial facilities. Although Brown and Caldwell and HRSD are still developing the scope of the Private Property I/I Abatement Program for implementation, for this study it was assumed that these NSF properties were available to be tested and rehabilitated for peak flow reduction.

Similar to the single family approach, assumptions were made on the distribution of I/I based on IDM, the lateral failure rate, and rehabilitation success rate. Because of the big number of these properties in the HRSD service area (approximately 29,000 non-single family parcels), only those properties that were within an SSES basin and also greater than 1 acre in parcel size were considered available for investigation and rehabilitation. A threshold for cost-effectiveness was applied to each catchment to reduce the amount of money spent on less leaky sewer pipes. Using GIS data analysis, the number of parcels, length of private sewer on those parcels, and the total peak flow reduction estimation was calculated for each sewer catchment.

2.1.2.3.3 Industrial Waste Dischargers (IWD) and Federal Facilities

HRSD operates a Pre-treatment and Pollution Prevention (P3) Division that oversees and permits large industrial waste dischargers (IWD) and Federal Facilities to the HRSD network. Many of these facilities have a permanent discharge flow meter for billing purposes. During calibration of the RHM, the flow monitoring data from these facilities was evaluated and hydrologic flow parameters were developed. In cases where the 10-year peak hour flow exceeds the regional criteria for leakiness, Brown and Caldwell has assigned a general reduction percentage of 20% with the expectation that the work will be enforced through HRSD's P3 Program.

2.1.2.4 Development of HRSD I/I Reductions

The HRSD Rehabilitation Action Plan includes work on many of HRSD's gravity sewer pipelines. Relative to the HRSD force main network of more than 430 miles, the 50 miles of gravity sewer interceptors represents a very small fraction of the HRSD infrastructure, and an insignificant fraction of the thousands of miles of gravity sewer pipe owned and maintained by the Localities. Nevertheless, HRSD's gravity pipelines in some individual catchments represent a sufficiently large amount of the infrastructure to contribute a portion of the total peak hourly flow. These areas include the Jefferson Avenue corridor in Newport News, the Shingle Creek interceptor in Suffolk, and the gravity system along Bainbridge Boulevard in Chesapeake.

The HRSD Rehabilitation Action Plan was evaluated to identify which parts of the system were receiving comprehensive rehabilitation or where major sources of I/I directly to the HRSD system were found. In these areas, an additional reduction in peak hourly flow, associated with the rehabilitation of HRSD gravity sewers, was added to the private property I/I abatement values, and IWD/Federal Facility reductions and subtracted from the Locality provided PPFE to get the final remaining post-rehabilitation peak hourly flow.

2.1.3 Non-Regionalized Rehabilitation Plan

A summary of each component of the non-regionalized rehabilitation plan is presented below.

2.1.3.1 Pre- and Post-Rehabilitation Peak Flows

As detailed in the sections above, peak flow reduction estimations were made in each catchment for the Localities' public-side (based on PPFE), the private-side (SFR, NSF, IWD, and Federal Facilities), and HRSD's system contribution. These reduction values were combined and applied to the Localities hydrologic parameters in each catchment to develop a revised, post-rehabilitation set of hydrologic parameters. Hydrologic modeling was performed to determine the post-rehab total peak flow in each catchment using the 10-year and 2-year representative events including accommodation for growth. The comparison of pre-rehabilitation and post-rehabilitation peak flows by Locality and by treatment plant service area are listed in Tables 2-3, 2-4, 2-5 and 2-6.

Table 2-3. Comparison of Pre-Rehab and Post-Rehab 10-year Peak Flows by Locality

	Pre-Rehab		NON-REGIONALIZED		
Locality ID	2030 10-year Peak Flows (mgd)	10-year Peak Flow I/I (mgd)	PHF Reduction (mgd)	PHF Reduction (%)	Total 2030 PHF (mgd)
CHES	111.12	91.43	18.18	19.9%	92.94
GLOU	7.07	4.75	0.73	15.5%	6.34
HAMP	58.98	49.85	14.03	28.1%	44.96
IWD/ FEDERAL	57.42	42.96	8.32	19.4%	49.06
JCSA	39.57	31.60	7.42	23.5%	32.17
NEWP	98.96	81.61	19.14	23.4%	79.79
POQ	10.12	8.52	2.70	31.7%	7.42
PORT	65.72	57.46	13.19	22.9%	52.54
SMITH	2.81	2.12	0.29	13.8%	2.51
SUFF	54.58	39.57	6.82	17.2%	47.80
VAB	173.67	134.49	23.36	17.4%	150.32
WILL	11.10	8.85	1.06	12.0%	10.03
YORK	30.68	24.53	5.51	22.5%	25.15
IOW	6.38	3.67	0.03	0.8%	6.35
NORF	134.73	110.55	0.00	0.0%	134.73
Grand Total	**862.90**	**691.96**	**120.78**	**17.5%**	**742.12**

Table 2-4. Comparison of Pre-Rehab and Post-Rehab 10-year Peak Flows by Treatment Plant					
	Pre-Rehab		NON-REGIONALIZED		
Locality ID	2030 10-year Peak Flows (mgd)	10-year Peak Flow I/I (mgd)	PHF Reduction (mgd)	PHF Reduction (%)	Total 2030 PHF (mgd)
AB	42.71	34.23	1.95	5.7%	40.76
AT	230.09	181.71	31.92	17.6%	198.17
BH	71.54	61.14	20.89	34.2%	50.66
CE	64.51	52.74	6.21	11.8%	58.30
JR	73.68	59.45	11.09	18.7%	62.57
NA	104.25	77.56	14.16	18.3%	90.14
VIP	141.73	119.80	12.79	10.7%	128.94
WB	86.24	68.42	14.50	21.2%	71.76
YR	48.14	36.89	7.27	19.7%	40.83
Grand Total	**862.90**	**691.96**	**120.78**	**17.5%**	**742.12**

It should be noted that the peak flows and peak flow reduction percentages provided in these tables relate to the total flow from all catchments and include reductions from public and private sources. Other information provided in this document, such as Table 2-1, may relate to subsets (e.g., only SSES Basins) or only show reductions on the public-side.

Table 2-5. Comparison of Pre-Rehab and Post-Rehab 2-year Peak Flows by Locality					
	Pre-Rehab		NON-REGIONALIZED		
Locality ID	2030 2-year Peak Flows (mgd)	2-year Peak Flow I/I (mgd)	PHF Reduction (mgd)	PHF Reduction (%)	Total 2030 PHF (mgd)
CHES	82.91	63.22	12.81	20.3%	70.10
GLOU	5.70	3.42	0.50	14.7%	5.20
HAMP	47.38	38.27	10.06	26.3%	37.31
IWD/ FEDERAL	43.96	28.90	5.51	19.1%	38.51
JCSA	30.10	22.19	4.98	22.5%	25.12
NEWP	80.06	62.33	13.78	22.1%	66.31
POQ	7.02	5.44	1.71	31.4%	5.32
PORT	48.28	40.10	9.33	23.3%	38.95
SMITH	2.30	1.61	0.22	13.5%	2.08
SUFF	44.27	28.84	4.86	16.9%	39.41
VAB	126.74	87.55	15.76	18.0%	111.02
WILL	8.40	6.17	0.69	11.2%	7.71

Table 2-5. Comparison of Pre-Rehab and Post-Rehab 2-year Peak Flows by Locality					
	Pre-Rehab		NON-REGIONALIZED		
Locality ID	2030 2-year Peak Flows (mgd)	2-year Peak Flow I/I (mgd)	PHF Reduction (mgd)	PHF Reduction (%)	Total 2030 PHF (mgd)
YORK	22.52	16.41	3.66	22.3%	18.85
IOW	5.53	2.82	0.02	0.8%	5.51
NORF	97.63	73.58	0.00	0.0%	97.63
Grand Total	**652.8**	**480.9**	**83.9**	**17.4%**	**569.0**

Table 2-6. Comparison of Pre-Rehab and Post-Rehab 2-year Peak Flows by Treatment Plant					
	Pre-Rehab		NON-REGIONALIZED		
Locality ID	2030 2-year Peak Flows (mgd)	2-year Peak Flow I/I (mgd)	PHF Reduction (mgd)	PHF Reduction (%)	Total 2030 PHF (mgd)
AB	32.46	23.97	1.25	5.2%	31.21
AT	169.01	120.76	21.89	18.1%	147.16
BH	58.16	47.74	15.45	32.4%	42.71
CE	46.57	34.68	4.21	12.1%	42.36
JR	57.23	42.62	7.13	16.7%	50.20
NA	84.30	57.22	10.29	18.0%	74.02
VIP	100.84	79.08	8.83	11.2%	92.01
WB	67.57	49.62	10.20	20.6%	57.38
YR	36.66	25.18	4.65	18.5%	31.96
Grand Total	**652.8**	**480.9**	**83.9**	**17.4%**	**569.0**

2.1.3.2 Rehabilitation Costs

As mentioned previously, the Localities provided their estimate of rehabilitation costs to meet their PPFEs. These costs were applied without modification or comparison to other Localities estimates. To provide the complete rehabilitation program costs for the system, Brown and Caldwell developed cost estimates for the other portions of the program.

2.1.3.2.1 Single Family Residential (SFR)

Brown and Caldwell and HRSD have been piloting techniques for private property I/I abatement during 2011 and 2012. Investigation approaches, contracting methodologies, and costs estimates have been prepared and shared with the Localities during this pilot work. For preparing a cost estimate for the Comparative Analysis, the number and length of private sewer laterals in each catchment was calculated. Costs were developed for investigation and rehabilitation.

2.1.3.2.2 Non-Single Family (NSF)

NSF costs were developed very similar to the SFR with estimates made on number of NSF parcels and estimated length of sewer lines. For these systems, the pipe size was estimated to be larger (8-inch) with manholes and laterals included. Costs were developed for inspection of those NSF sewer lines identified as meeting the threshold criteria for size and leakiness in the SSES basins. Then, based on assumed failure rates, rehabilitation costs were calculated for the length of pipe addressed.

2.1.3.2.3 Industrial Waste Dischargers and Federal Facilities

Costs for IWD and Federal Facilities were based on flow monitoring and enforcement for each discharger. Pre- and post-rehabilitation flow monitoring was included as a cost for HRSD with an assumed level of HRSD administrative effort for enforcement at each location. The costs for rehabilitation were assumed to be borne by the facility and were external to this analysis.

2.1.3.2.4 HRSD Assets

The costs associated with reduction in peak flow from HRSD's assets are fully included in the Rehabilitation Action Plan. No separate additional costs have been programmed into the total.

2.2 Post-Rehabilitation Capacity Assessment

2.2.1 General Approach

As part of the Consent Decree, HRSD has completed a Preliminary Capacity Assessment using the RHM to identify the limitations in the existing system. This analysis was completed for moderate and maximum growth and used the dry weather infiltration, time-varying groundwater, and wet weather parameters from the RHM calibration (with a small number of changes provided by the Localities). The I/I peak flows generated from this modeling were defined as "pre-rehabilitation peak" flows. Before beginning development of wet weather solutions as part of this Comparative Analysis, a revised capacity assessment was performed that took into account the peak flow reduction from the rehabilitation efforts by the Localities and HRSD with respect to the 10-year and 2-year representative events (as detailed in Section 2.1 above). The results of this work provided a better understanding of what capacity limitations remained in the system and needed capacity improvements.

2.2.2 Modeled System Improvements

The Preliminary Capacity Assessment work completed in July 2012 for the Consent Decree and submitted to the EPA/DEQ was based on the RHM calibrated in July 2011 with some modifications. The original calibrated RHM included bypass pumps (where installed at Locality and HRSD pumping stations) and only infrastructure that was in place at the time. The Preliminary Capacity Assessment eliminated the bypass pumps and added a small number of Capital Improvement Program (CIP) projects that were completed or under construction since the RHM had been calibrated.

For the Comparative Analysis, a larger number of CIP projects have been completed and, as part of the Consent Decree's Interim System Improvements, HRSD is required to complete many more by February 2018. These original 33 projects, plus 18 additional projects identified in the Consent Decree Modification, range from size-on-size pipe replacements to pump station rehabilitation to installation of entirely new pressure reducing stations. Brown and Caldwell divided this list into two categories: 1. projects either constructed, in construction, or completed with design/sizing; and 2. projects not designed where the size has not been finalized. The first set of projects was added to the RHM for all scenarios, and included in the Post-Rehab Capacity Assessment. The second set was held in reserve and added during the wet weather solution development to address capacity issues, once sizing of these projects was better understood.

This same concept applied to several other projects in HRSD's CIP that are not Interim System Improvements but would have a significant benefit in wet weather capacity. Each of the projects added to the RHM for all scenarios is shown in Figures 2.2-BH10 through 2.2-VIP10 with a CIP number (e.g., AT-107) shown in the label box.

2.2.3 Representative Storm Events

During the Preliminary Capacity Assessment Report development, HRSD spent a significant effort to identify representative wet weather events that produce the 2-year, 5-year, and 10-year peak hour flow recurrence. This analysis was performed using a hydrologic model with the Locality provided flow parameters and 57 years of historical rainfall records. The peak flows were compared at numerous locations in each treatment plant service area to identify actual wet weather events in the 57 years of record that produced the 2-year, 5-year, and 10-year peak flows at the most locations for each service area. These events were sometimes the same, but more often different in each treatment plant service area for the various levels of service. Specific details of this selection process were included in the Preliminary Capacity Assessment Report.

2.2.4 Results

The representative events were applied to the modified RHM with modeled system improvements (Section 2.2.2) for the 10-year and 2-year levels of service to identify the remaining post-rehab capacity limitations. The results were evaluated to determine where SSOs were occurring as well as violations of the surcharge criteria (not exceeding 1.5 feet from any manhole/wet well rim in the model). Durations and volumes of SSOs were also calculated for use in the wet weather solution development. The following sections provide figures identifying the SSOs and surcharge criteria violations in each treatment plant service area for the 10-year and 2-year representative events. The number of post-rehabilitation SSOs and surcharge violations by STP service area are listed in Table 2-7.

Table 2-7. Modeled Non-Regionalized Post-Rehab Capacity Limitations

STP Service Area	10-Year SSOs	10-Year Surcharge Violations	2-Year SSOs	2-Year Surcharge Violations
AB	3	0	1	1
AT	33	2	24	6
BH	0	0	0	0
CE	0	0	0	0
JR	4	1	0	0
NA	20	0	12	1
VIP	11	4	3	4
WB	25	1	16	1
YR	6	0	4	1
TOTAL	102	8	60	14

2.2.4.1 North Shore- 10-year and 2-year

Figure 2.2-BH10

Figure 2.2-BH2

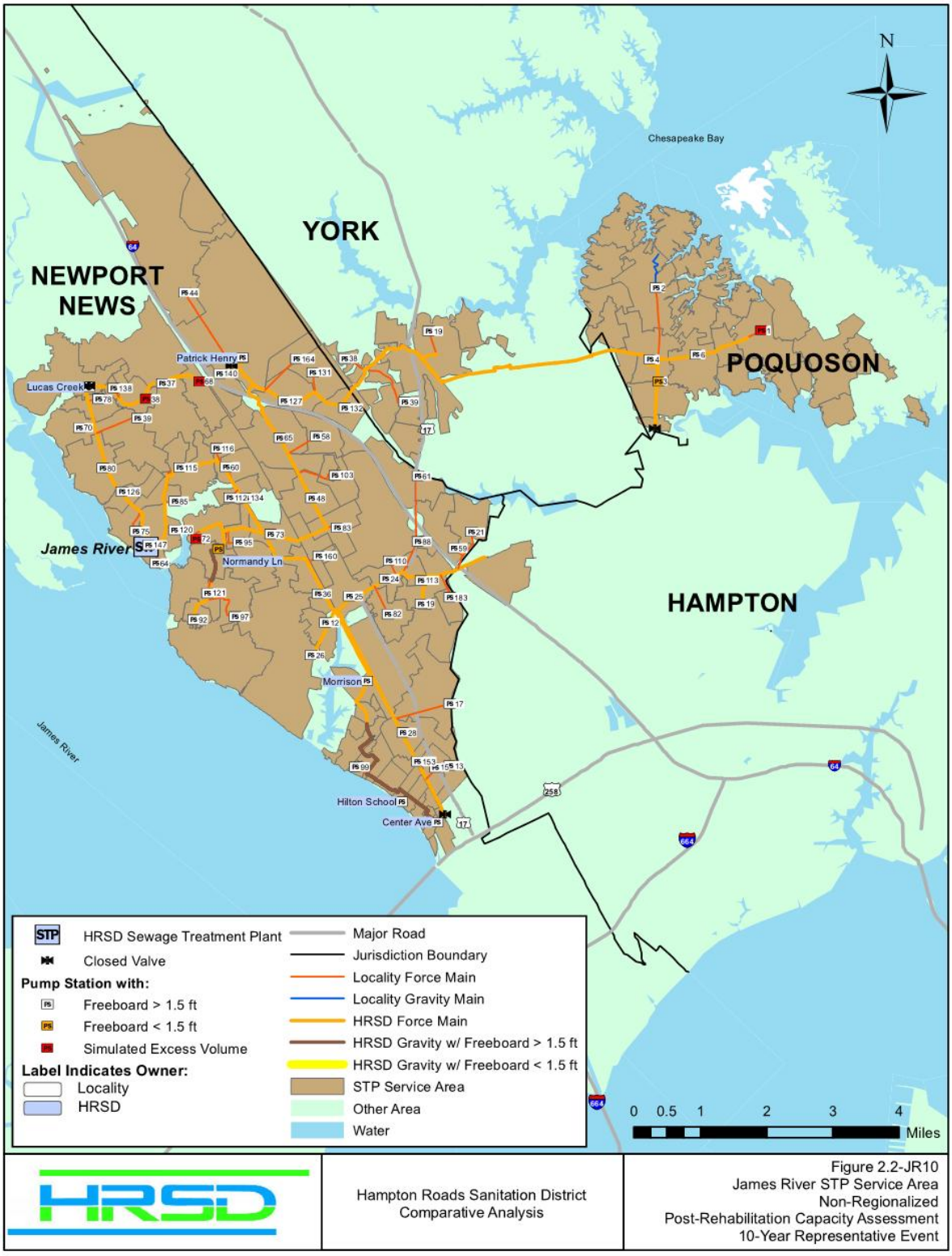

Figure 2.2-JR10

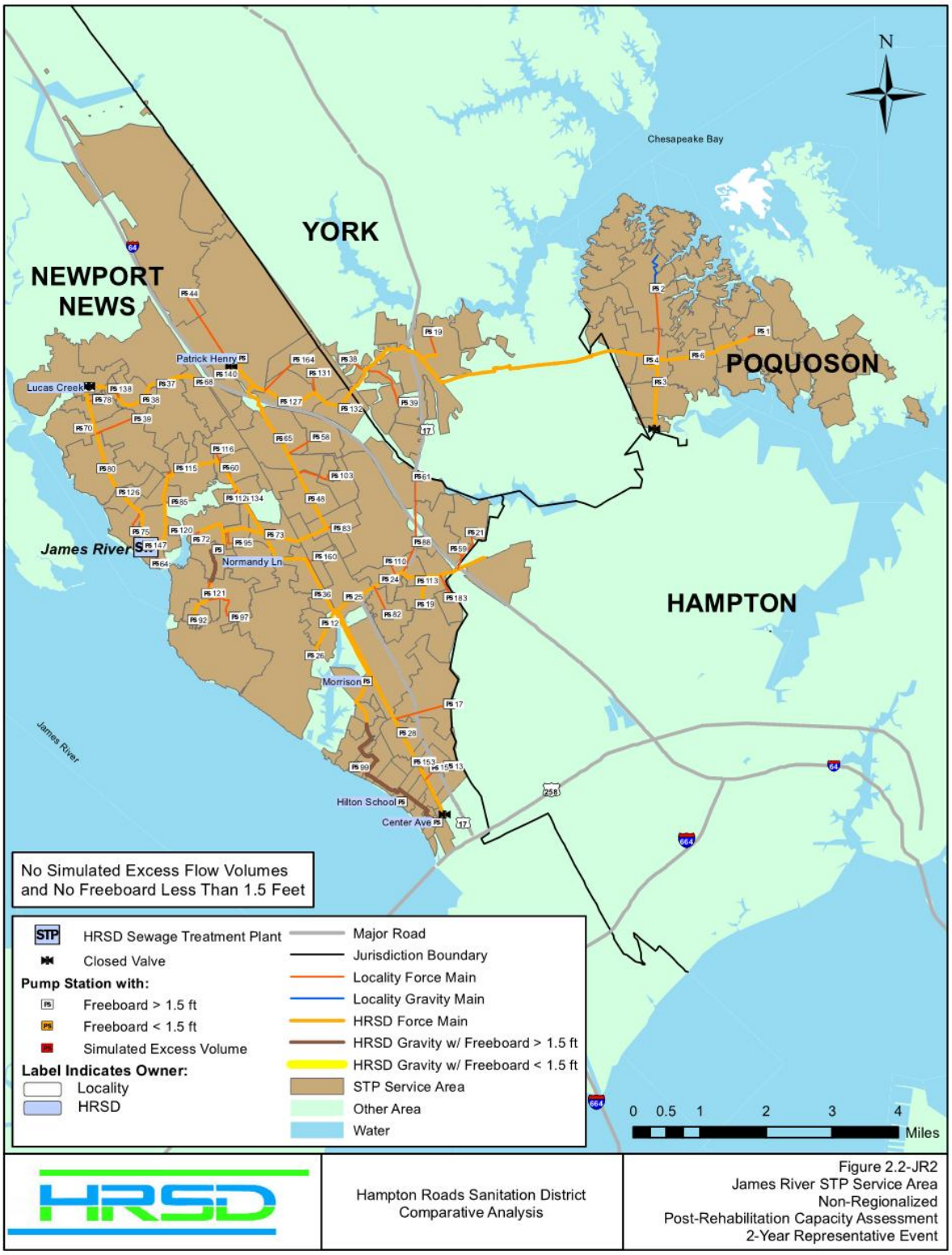

Figure 2.2-JR2

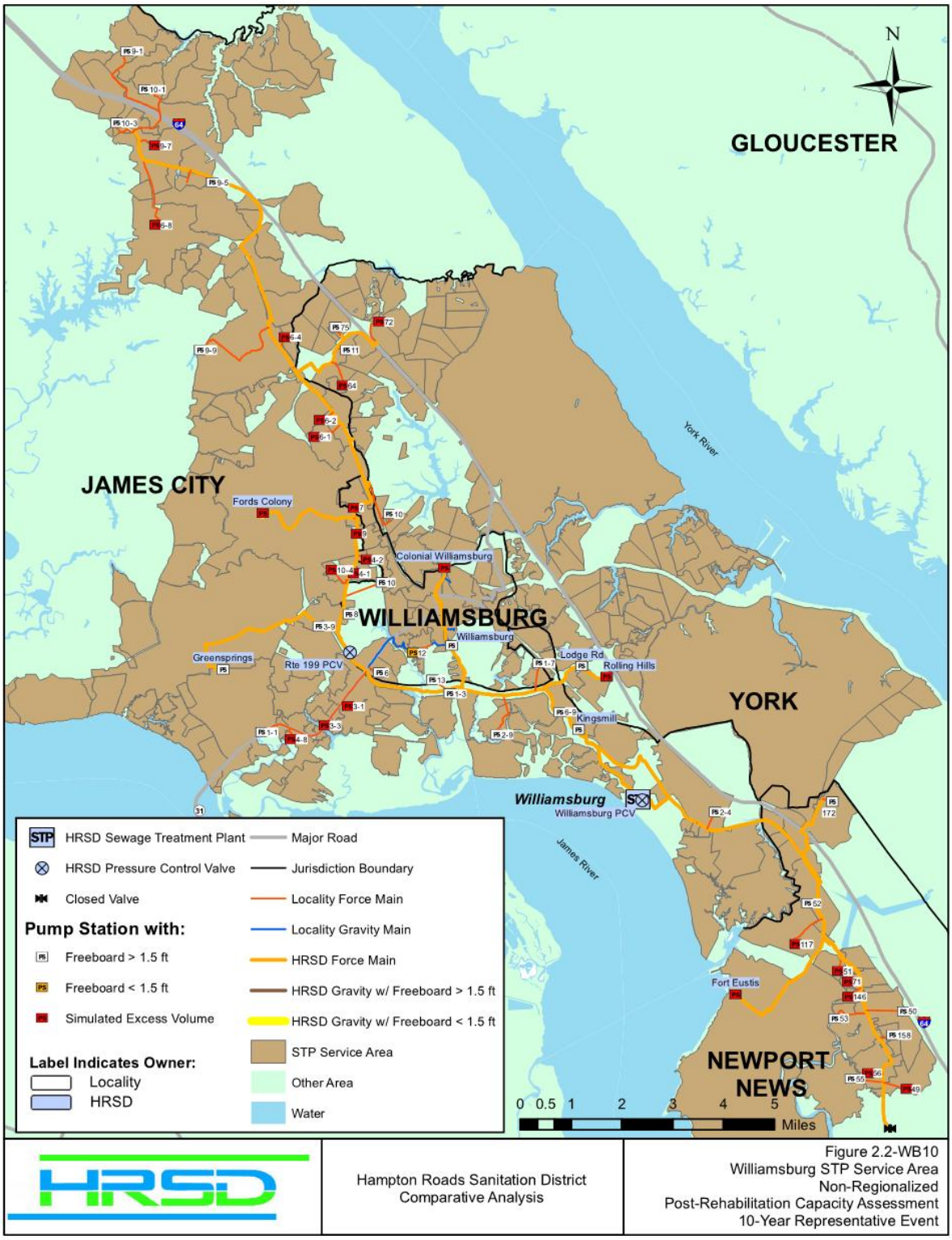

Figure 2.2-WB10

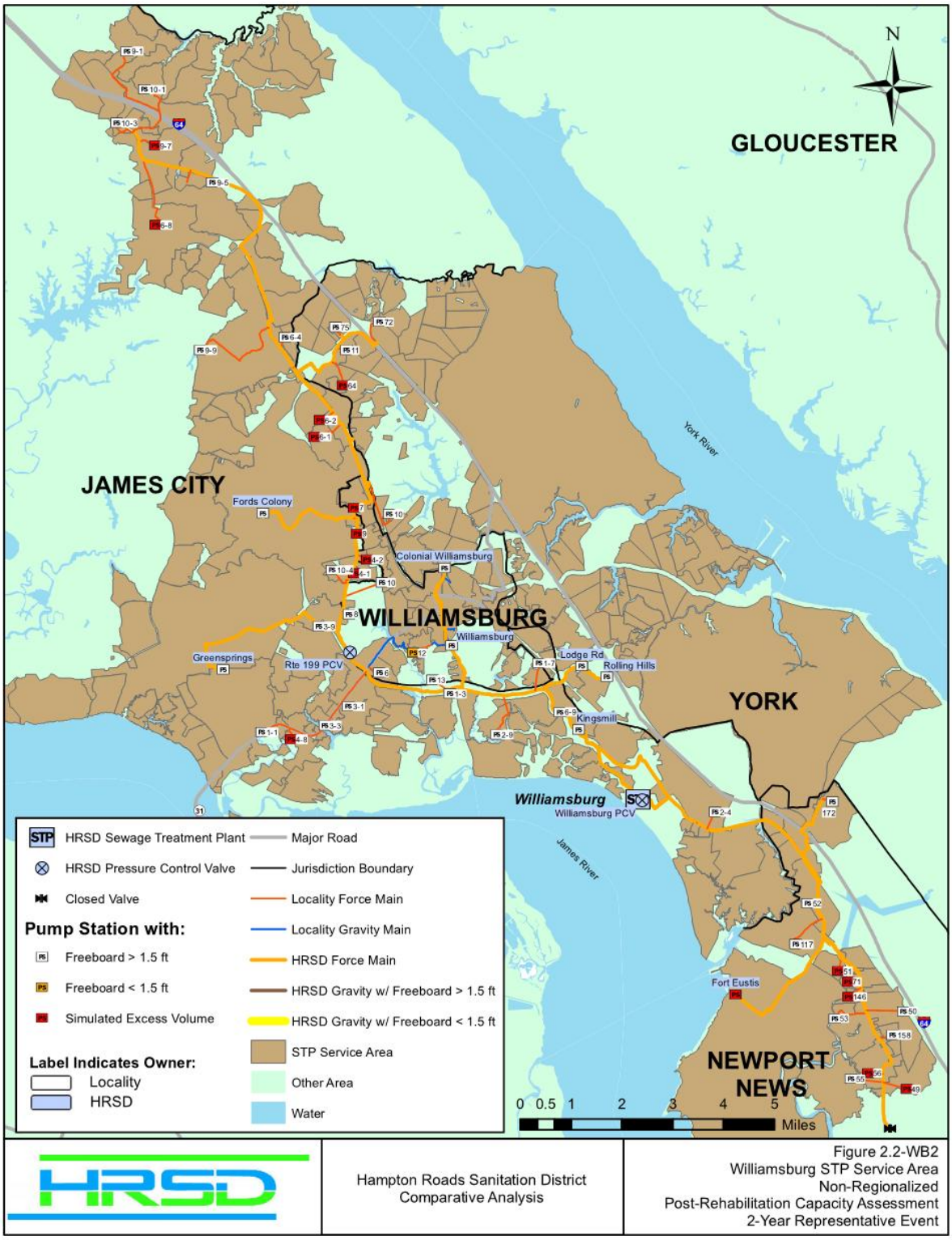

Figure 2.2-WB2

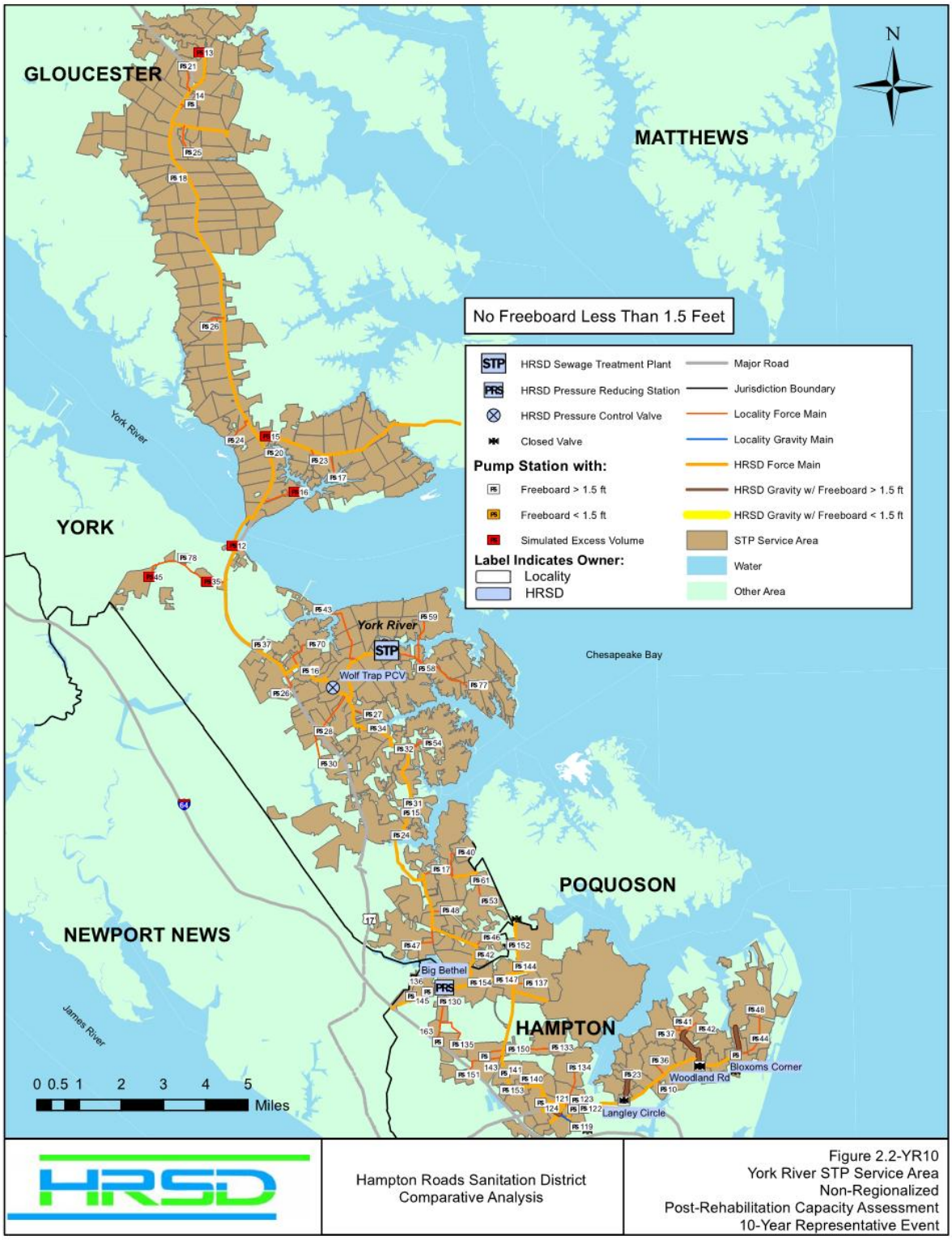

Figure 2.2-YR10

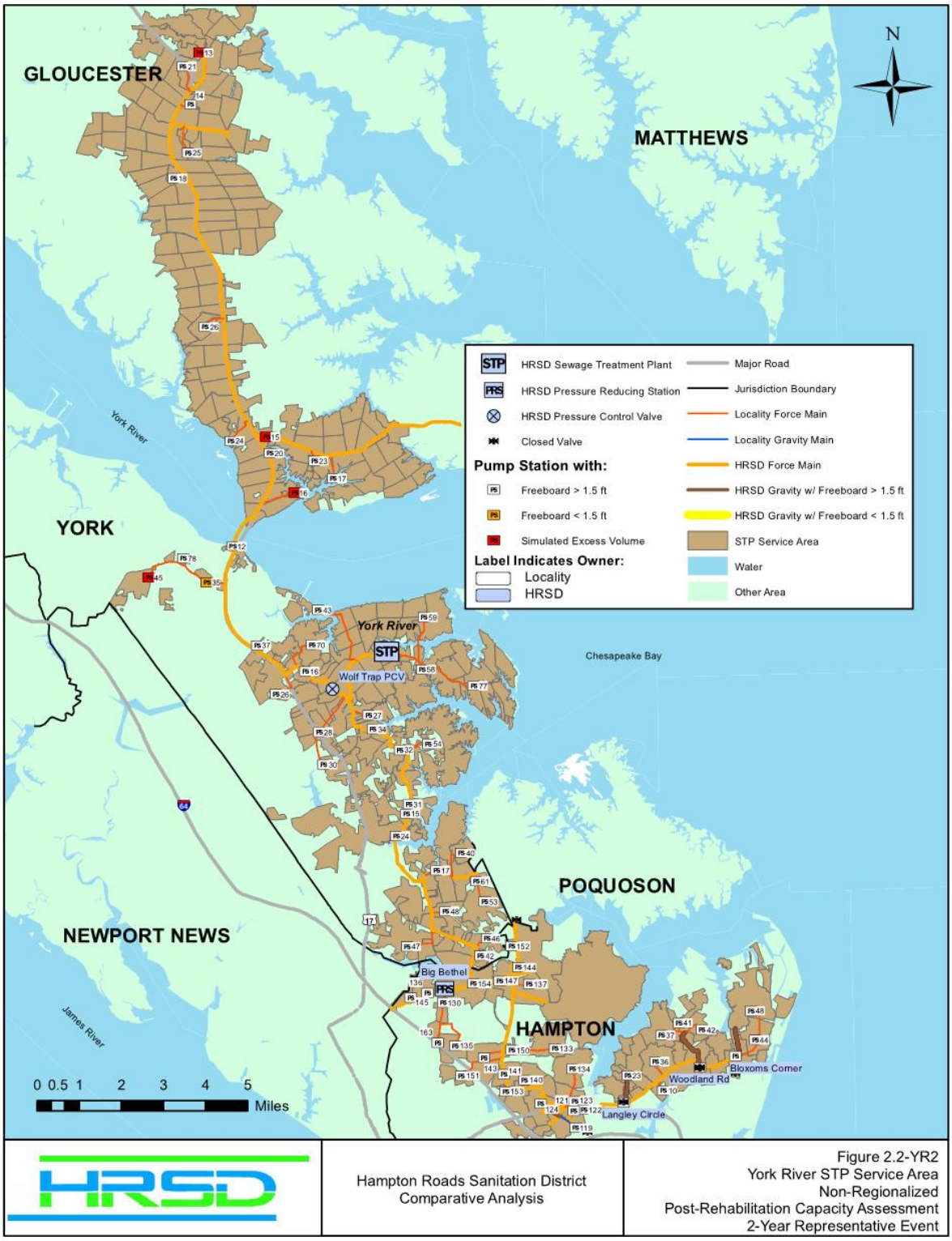

Figure 2.2-YR2

2.2.4.2 South Shore- 10-year and 2-year

Figure 2.2-AB10

Figure 2.2-AB2

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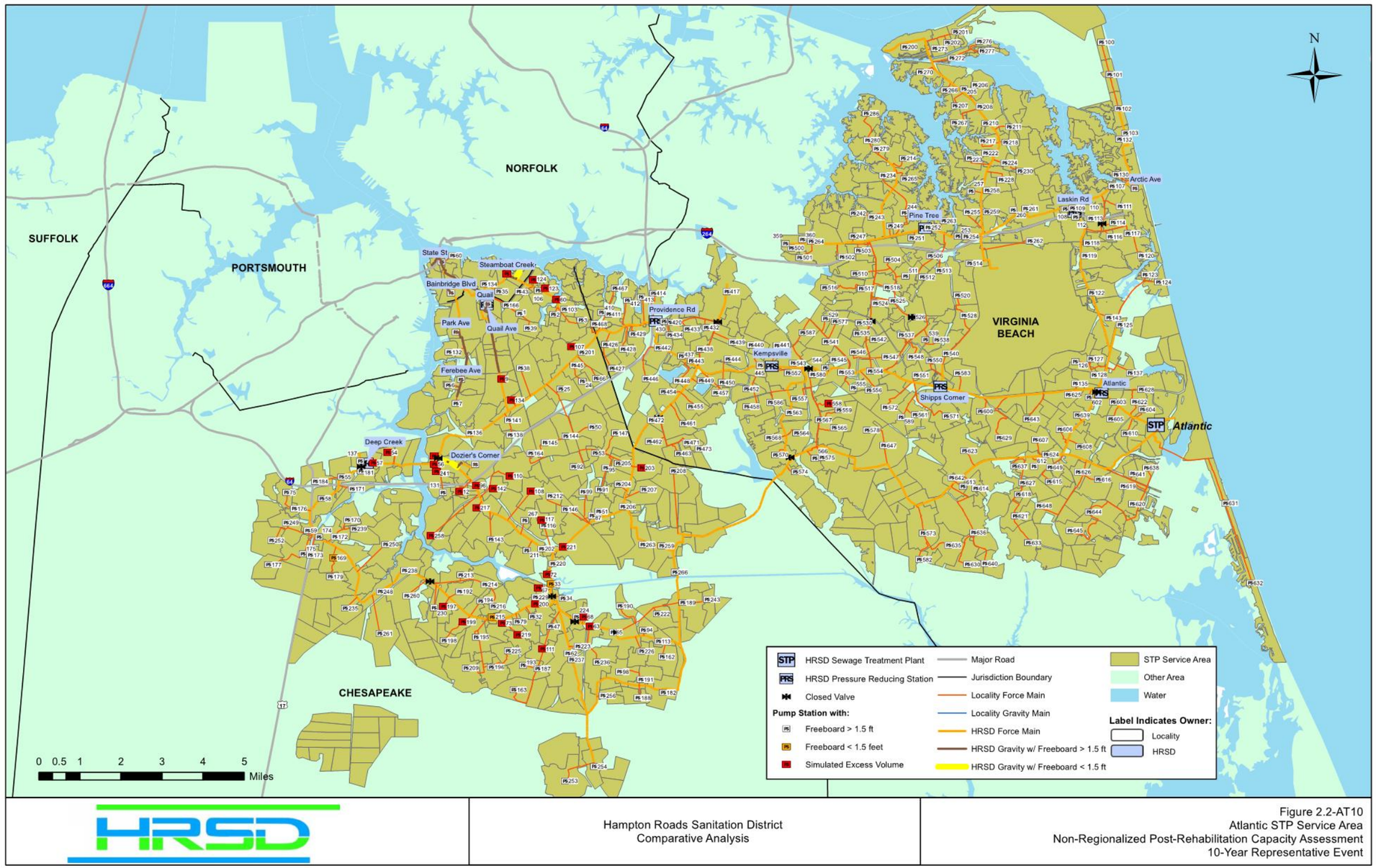

Figure 2.2-AT10

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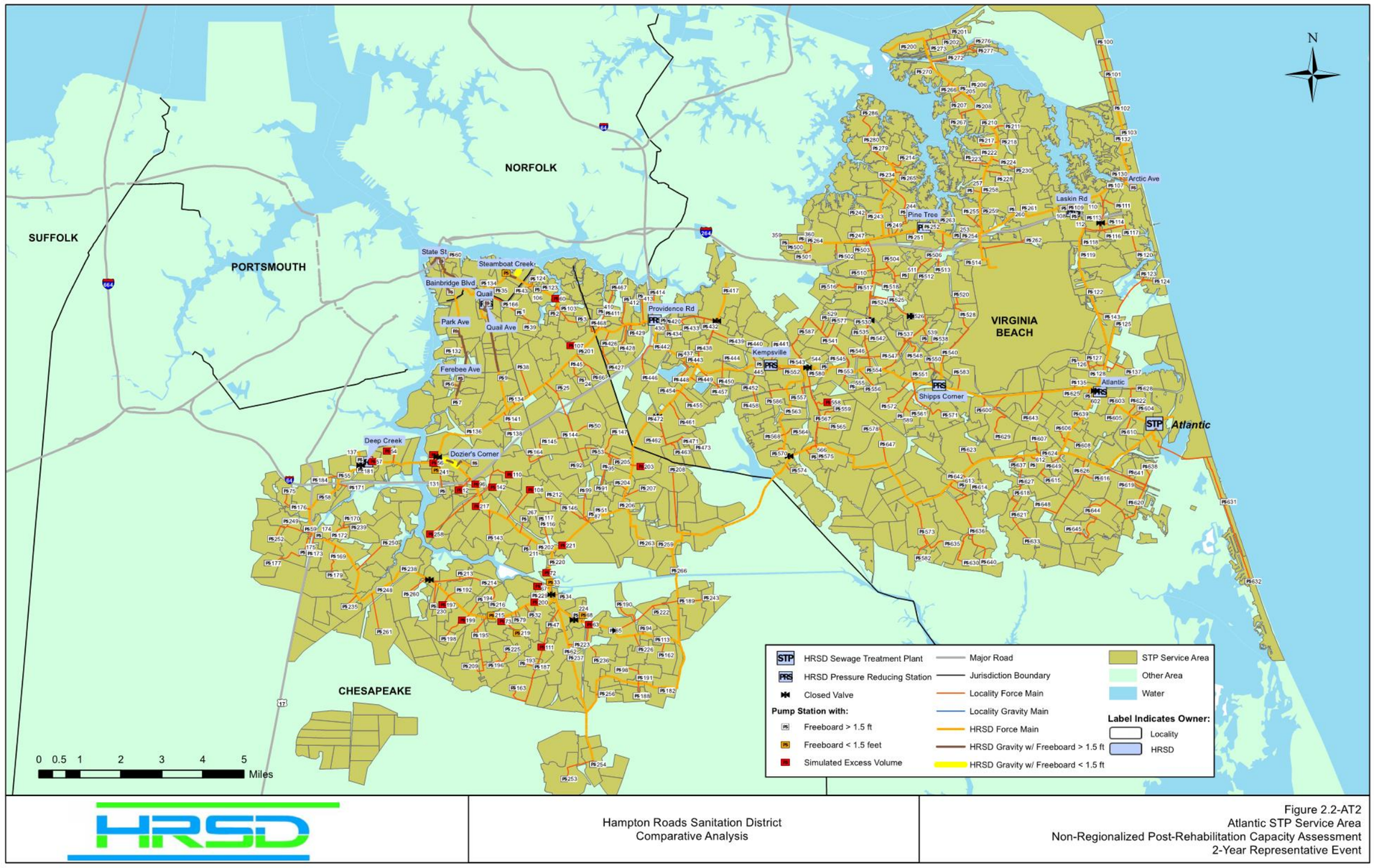

Figure 2.2-AT2

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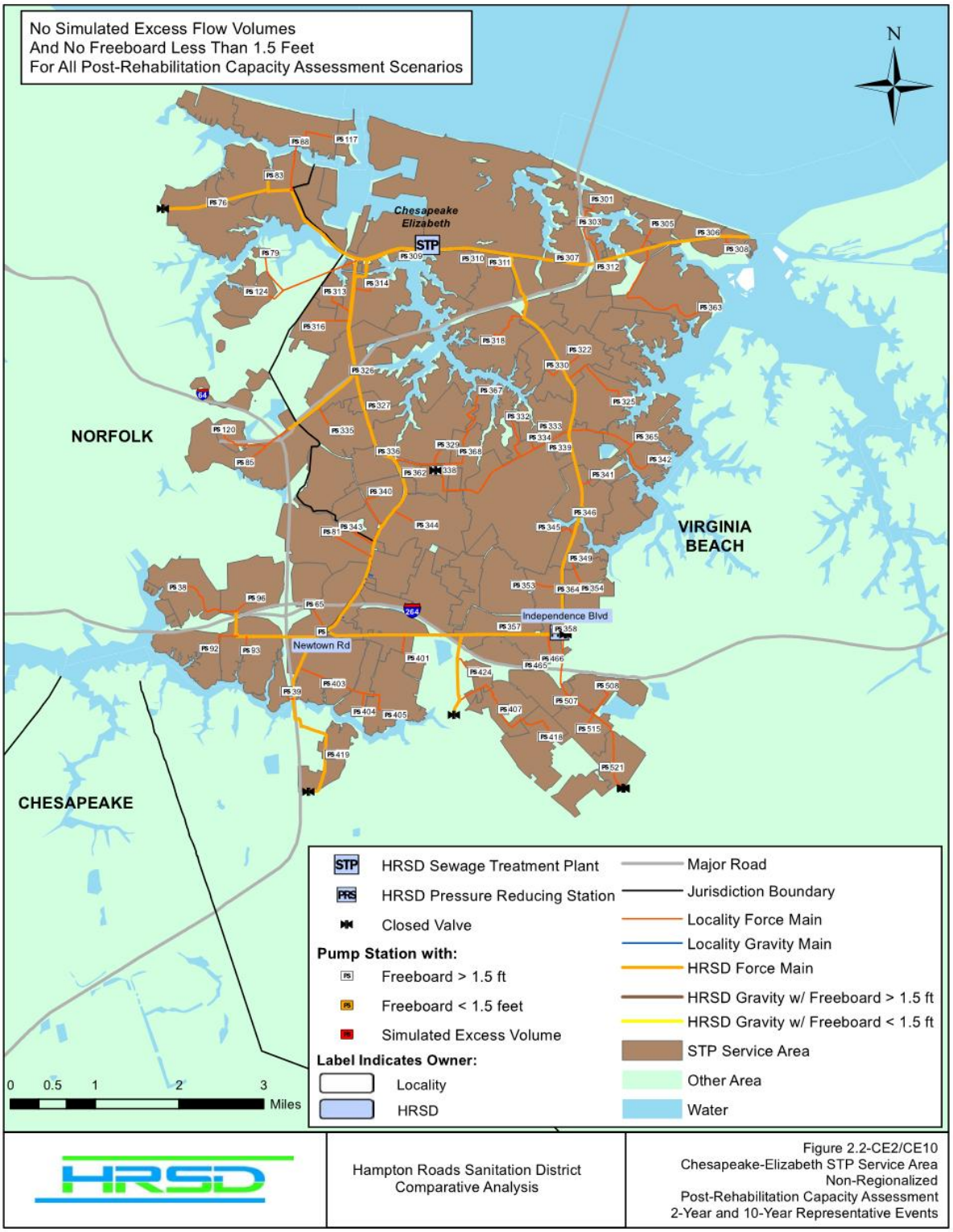

Figure 2.2-CE2/CE10

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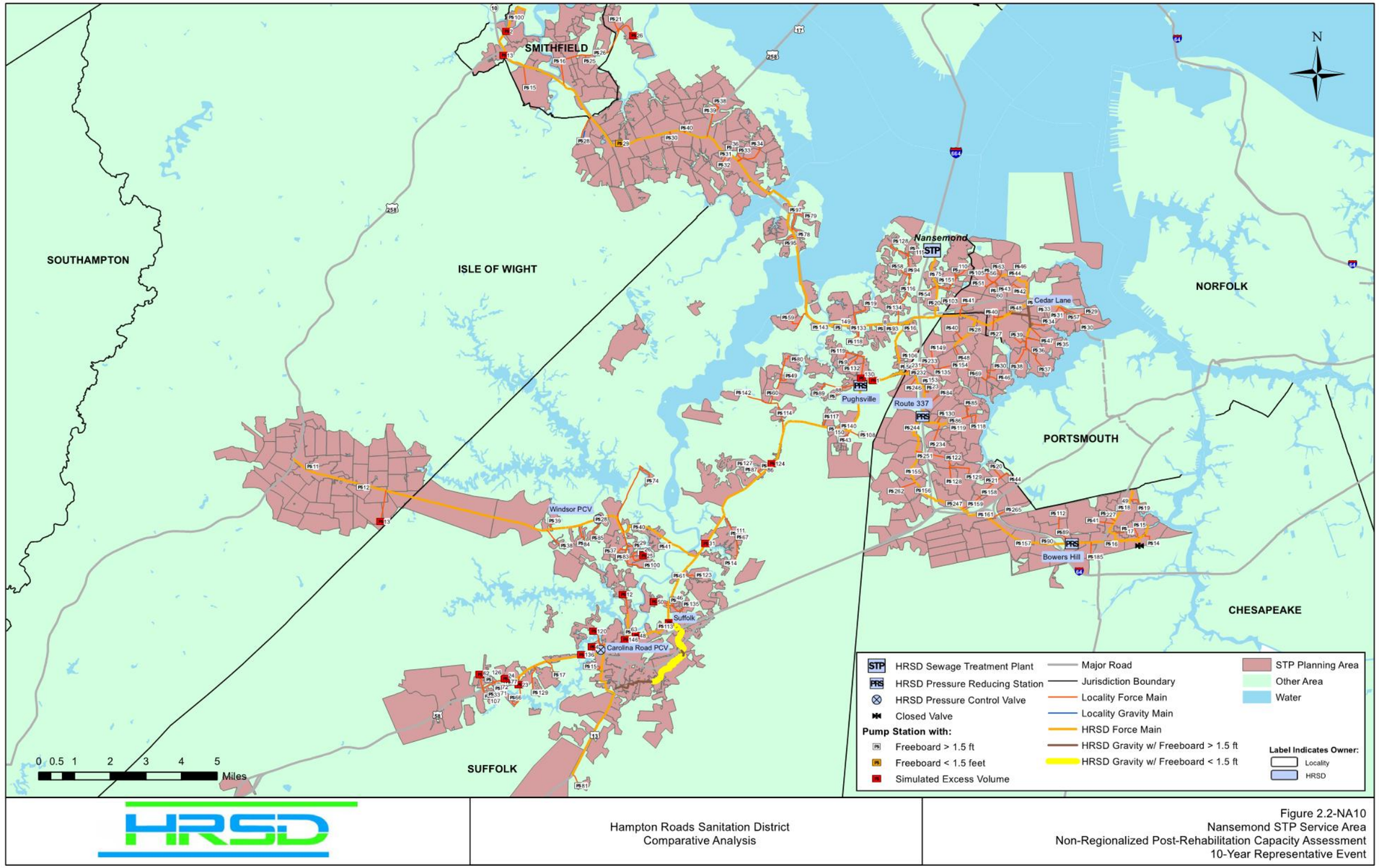

Figure 2.2-NA10

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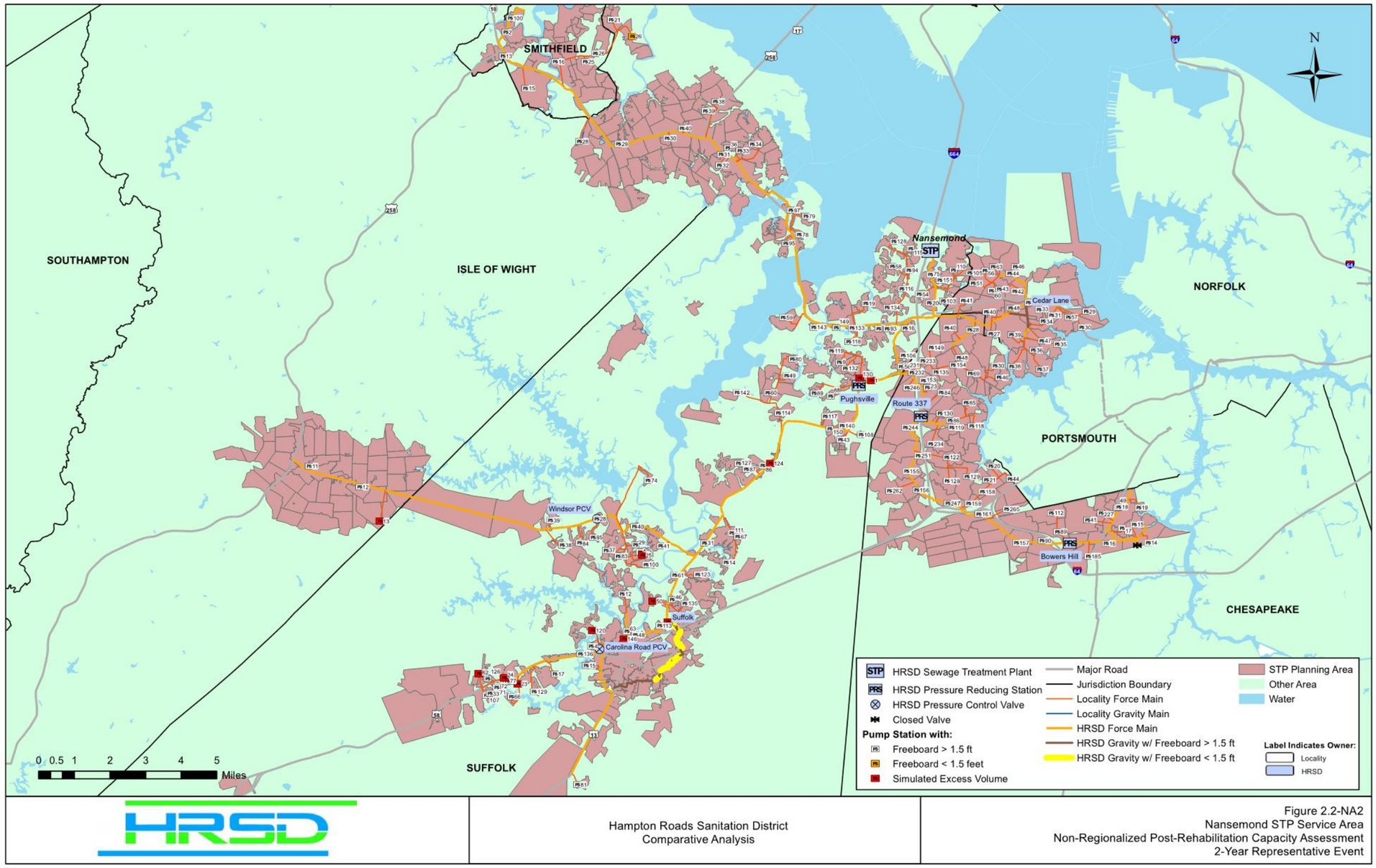

Figure 2.2-NA2

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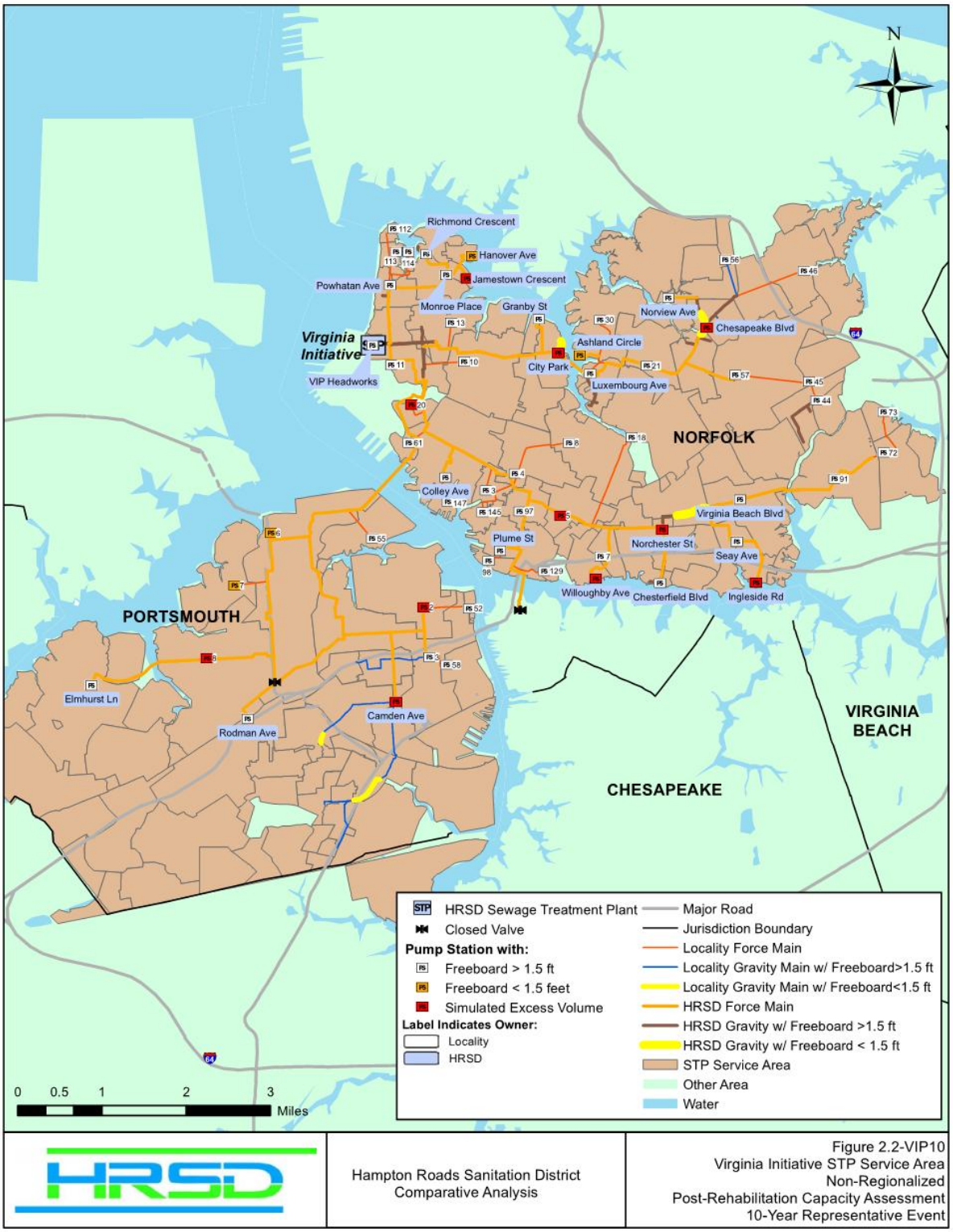

Figure 2.2-VIP10

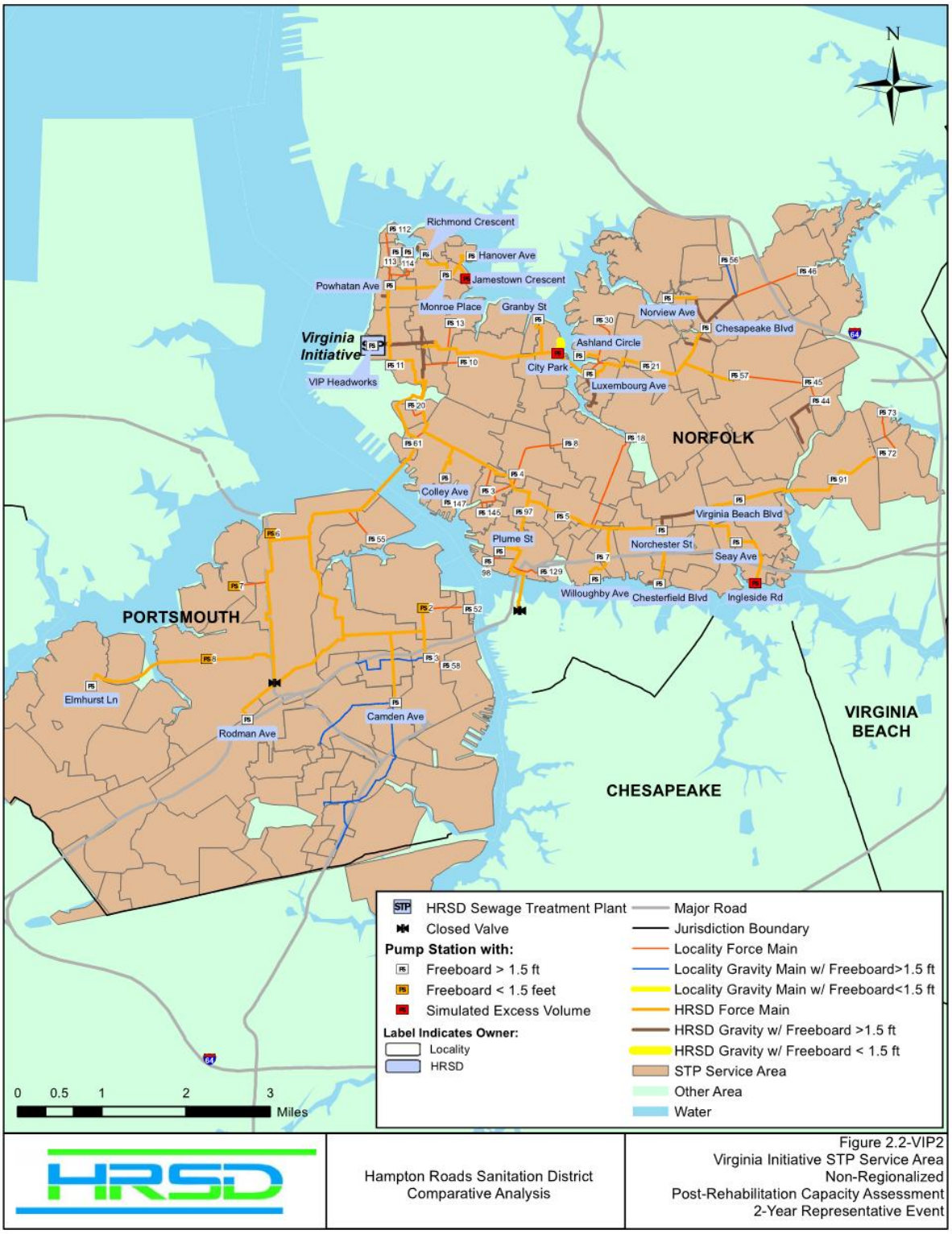

Figure 2.2-VIP2

2.3 Wet Weather Solution Sets

The development of wet weather solutions for both the regionalized and non-regionalized scenarios is discussed in the following sections.

2.3.1 Solution Set Evaluation Approach

Teams that consisted of HRSD, BC and CDM Smith convened to examine the potential combination of solutions that could be implemented to eliminate SSOs and surcharge violations for both the 10-year LOS as well as the 2-year LOS using non-regionalized post-rehab flows. Solutions included:

- Terminal and HRSD pump station upgrades
- Upgrades to existing pressure reducing stations (PRSs)
- Additional pressure reducing stations
- Storage tanks
- Force main upgrades
- Force main improvements for measured high head loss
- Force main valving modifications
- Gravity main upgrades

Solution sets were examined on a treatment plant service area basis with subset areas used in larger treatment plant service areas to focus on localized issues within the larger service area. Maps of the service areas and subsets are included in Sections 2.3.3.1 and 2.3.3.2.

Also included in the wet weather improvements are HRSD planned projects such as the 51 ISI projects identified in Section 1.3.3.2, as well as, other CIP projects that would improve the performance and capacity of the HRSD system.

2.3.2 Guidelines for WWMP Improvements

An analysis was performed of the resulting hydraulic grade line (HGL) passing all the generated peak flows with respect to existing terminal pump station shut off head limitations. Through implementation of the above-mentioned infrastructure improvements and modifications, solution sets were developed for the 2 and 10-year scenarios to reduce the hydraulic grade lines to accommodate most, if not all, of the existing terminal pump station limitations at peak flow conditions.

Generally, storage was considered to be the most cost effective improvement and therefore it was considered as an initial improvement to determine its feasibility to resolve the issues. Because of the relatively high cost of treatment plant improvements, storage in the conveyance system was considered preferentially. However, in cases where terminal pump stations had particularly low shut off head limitations, upgrading the pump station was often a more cost-effective solution than additional measures to reduce the hydraulic grade line (HGL).

2.3.3 Individual Sewer Treatment Plant (STP) Service Area Improvements

Because each treatment plant service area has unique conveyance flow characteristics, infrastructure capacity needs, geography and assets, each service area will have a unique solution set of capacity improvements to eliminate all SSOs and surcharge violations for a given level of service. These solution sets are discussed below for each scenario.

2.3.3.1 North Shore- 10-year and 2-year

The solution type and quantities associated with the North Shore solution sets developed in the non-regionalized approach are listed in Table 2-8. For maps of the North Shore non-regionalized wet weather

solutions for the 10 and 2-year scenarios, see Figures 2.3-BH10 through 2.3-YR2. As mentioned previously, projects identified on the map with a CIP designation in the label (e.g., BH-111) are projects that were already part of HRSD's CIP and not added as a wet weather solution during the Comparative Analysis.

Table 2-8. North Shore Solution Sets in Non-Regionalized Approach

TP	SOLUTION TYPE	10-YEAR SOLUTIONS	2-YEAR SOLUTIONS
BOAT HARBOR		NONE*	NONE*
JAMES RIVER	Upgrade PS	4	
	New PRS	1	
	Storage	1 site / 3.6 MG total	
WILLIAMSBURG	Upgrade PS	7	
	New PRS	2	1
	Upsize FM	5,537 LF of 36"	13,500 LF of 36"
		26,000 LF of 42"	26,000 LF of 42"
	Storage	3 sites / 7.5 MG total (includes 2.2 MG EQ at WBTP)	2 sites / 2.7 MG total
YORK RIVER	Upgrade PS	1	
	New PRS	1	
	Upsize FM	284 LF of 16"	284 LF of 16"
		26,200 LF of 24"	26,200 LF of 24"

**All Locality reduced peak flows can reach the HRSD conveyance infrastructure without SSOs or surcharge violations.*

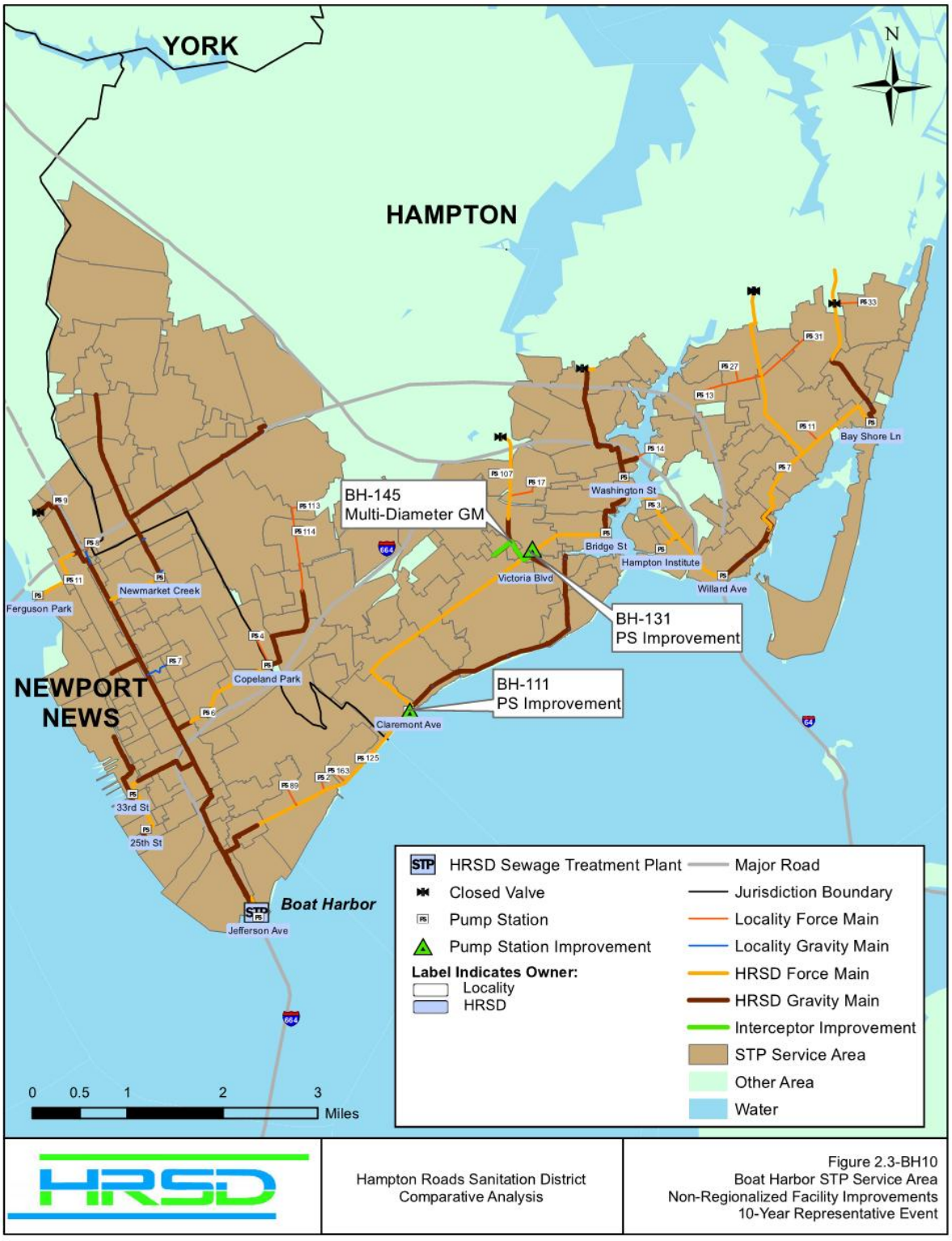

Figure 2.3-BH10

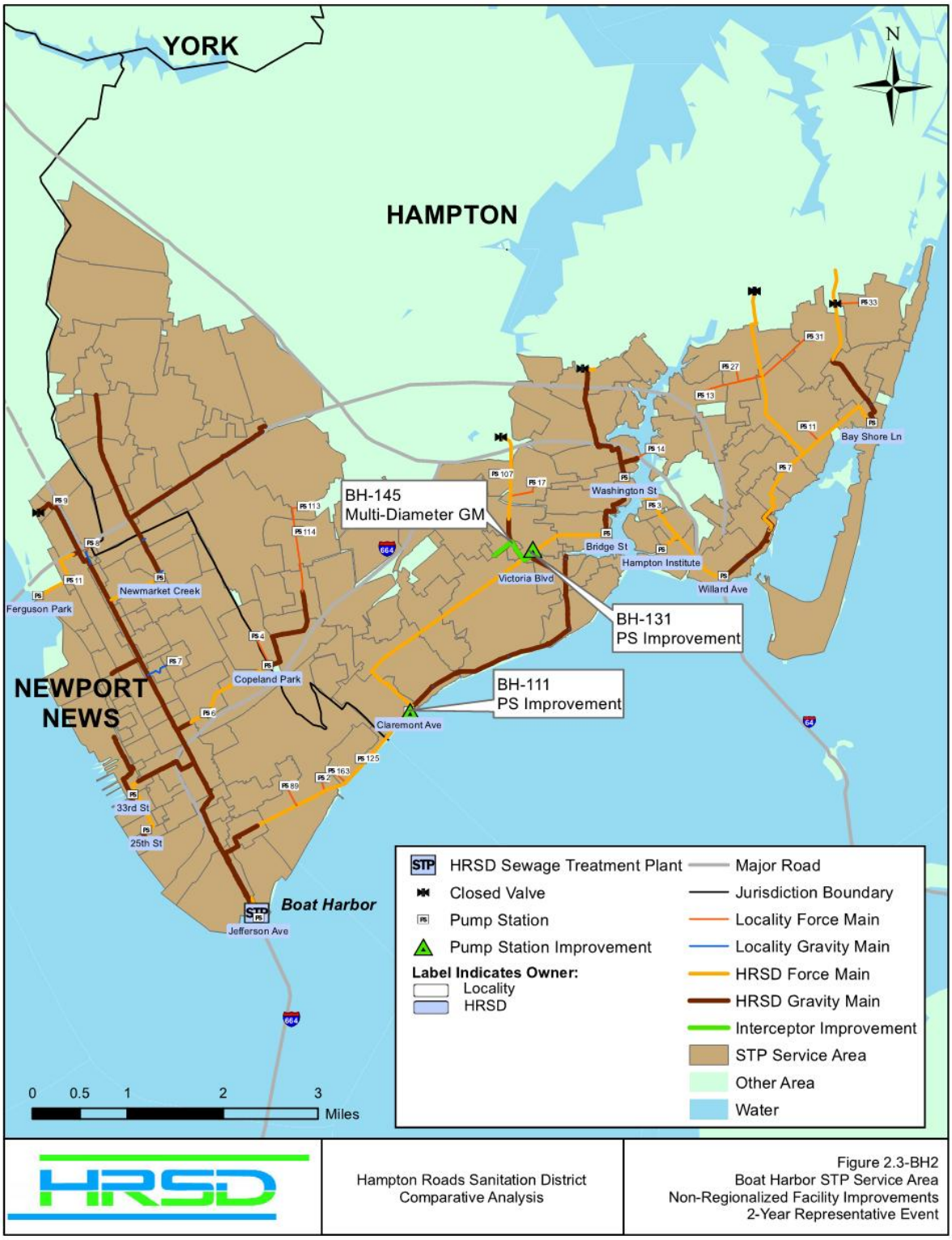

Figure 2.3-BH2

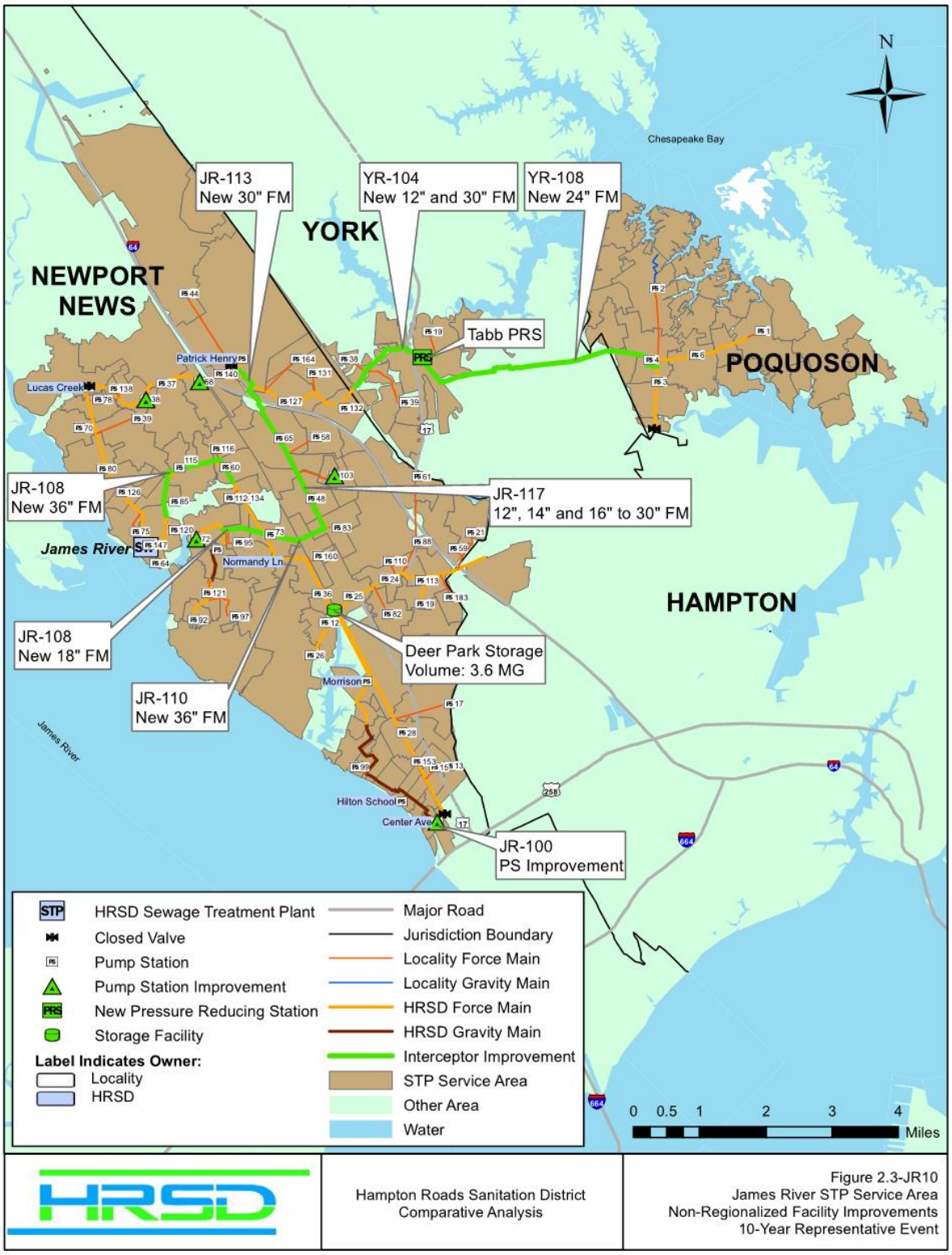

Figure 2.3-JR10

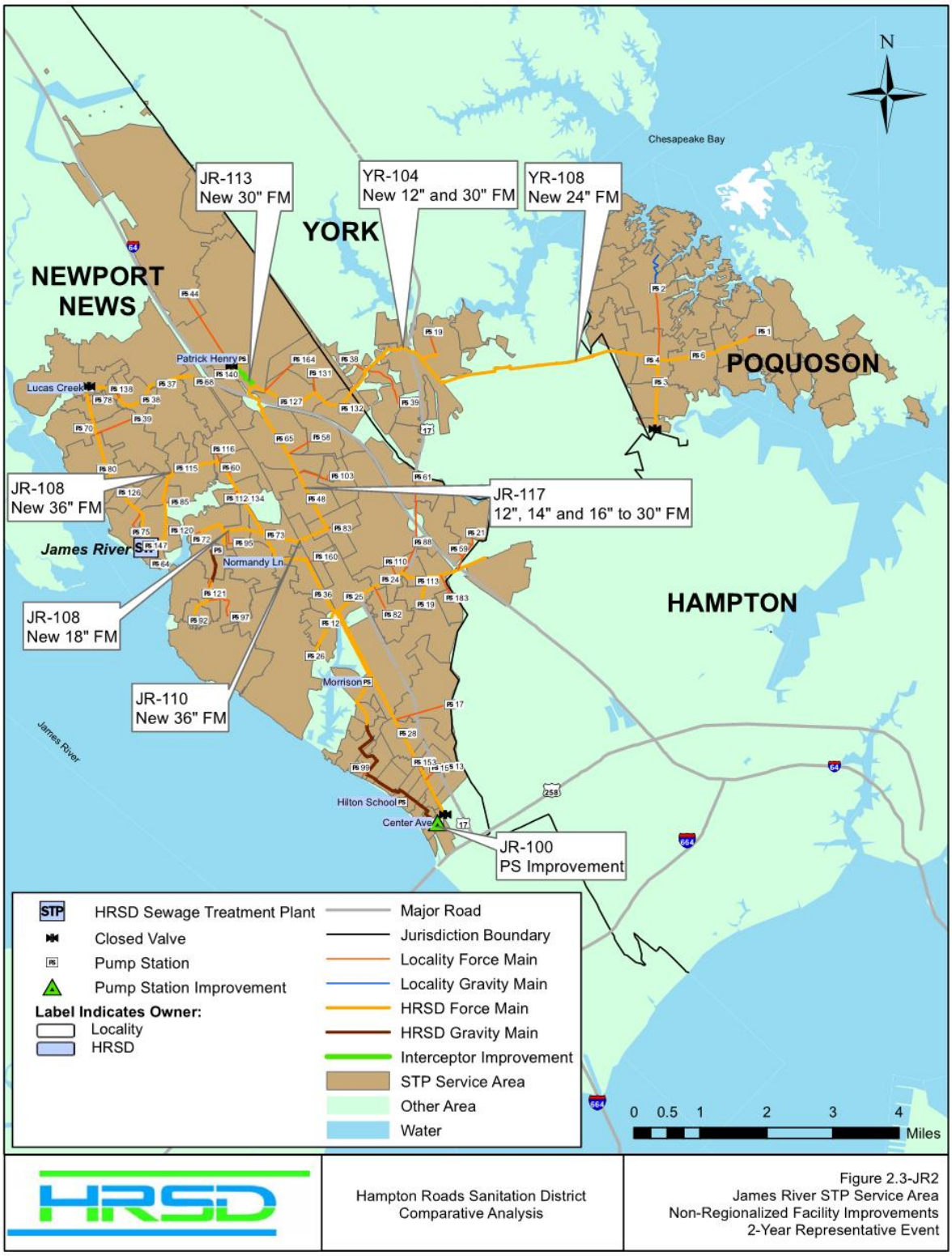

Figure 2.3-JR2

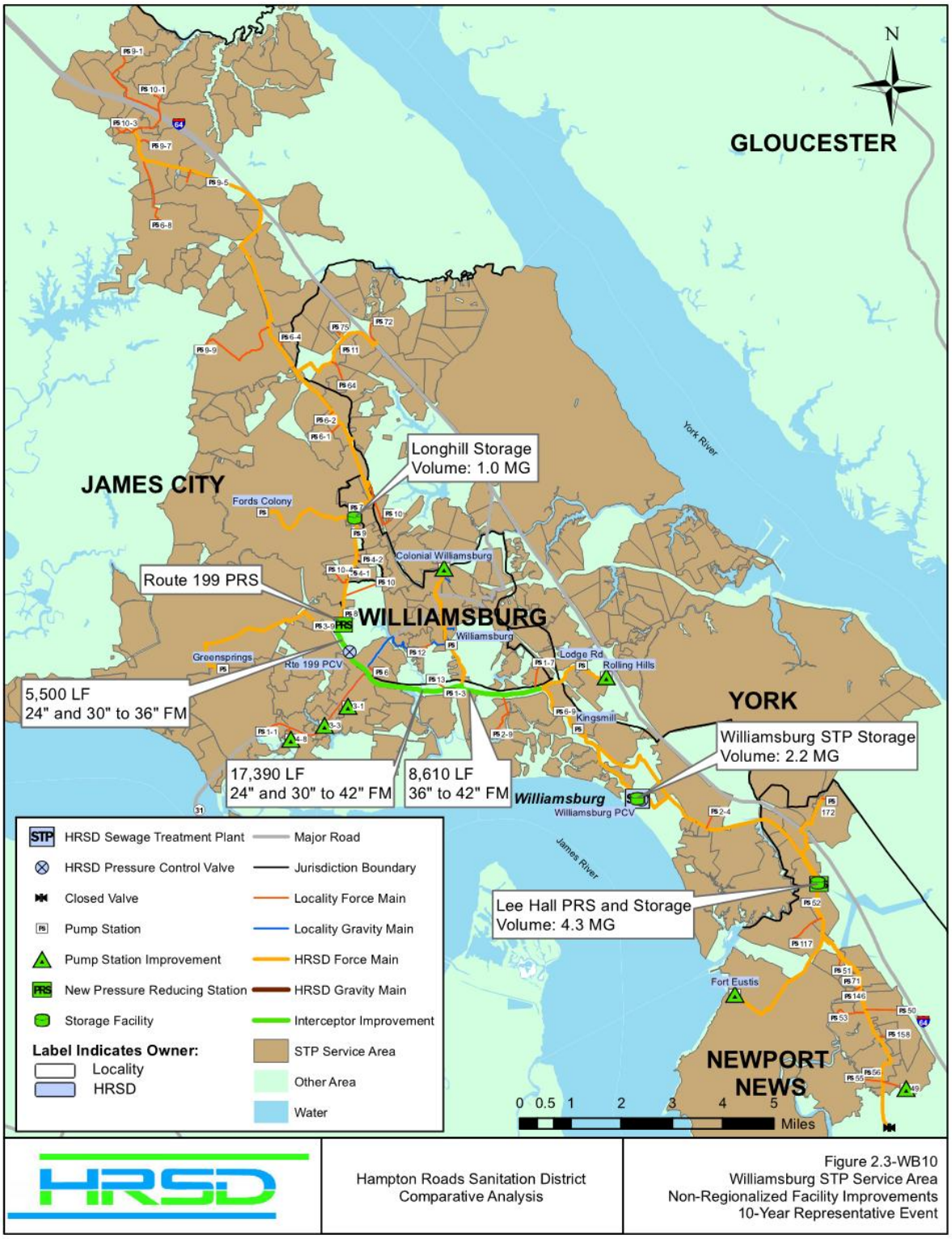

Figure 2.3-WB10

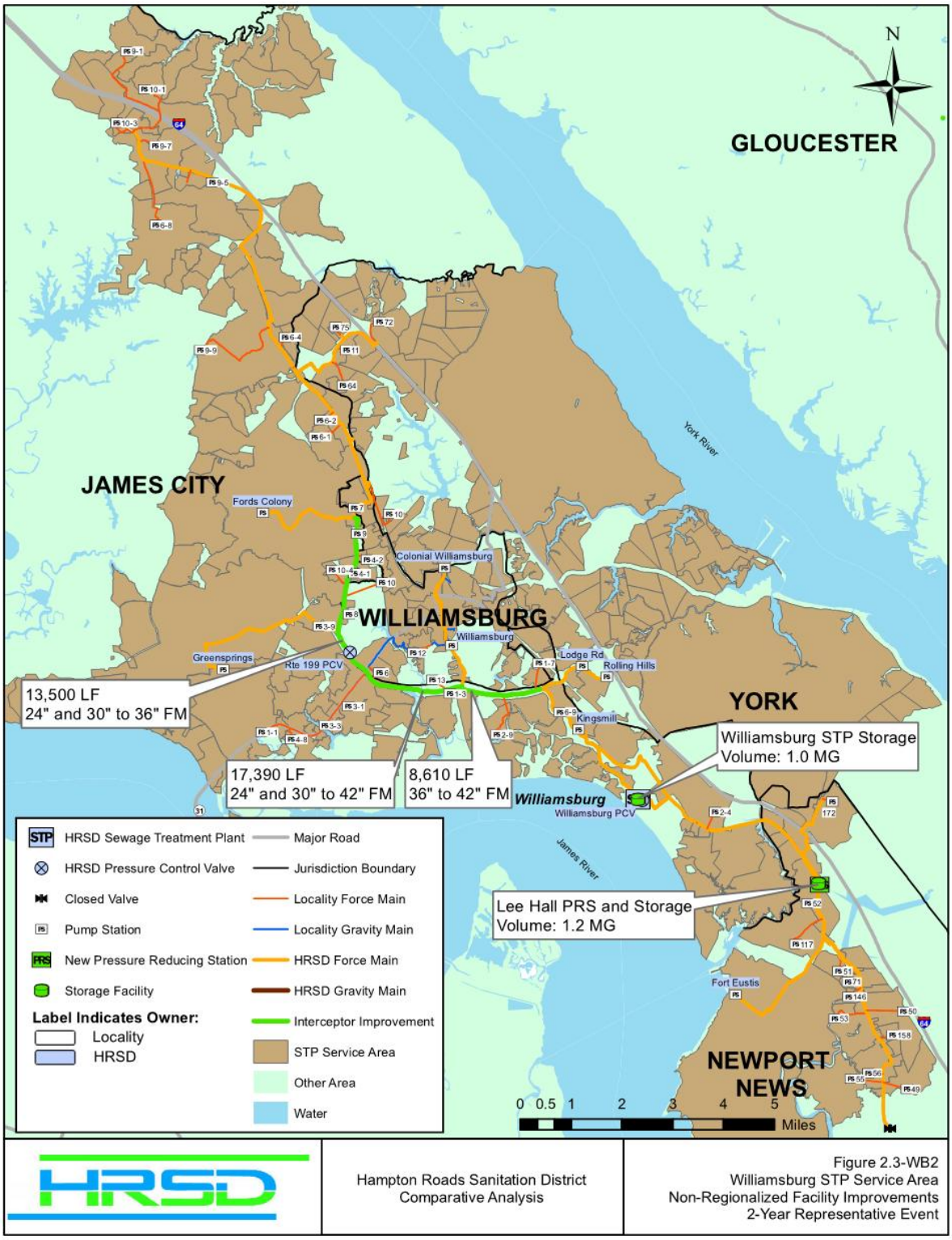

Figure 2.3-WB2

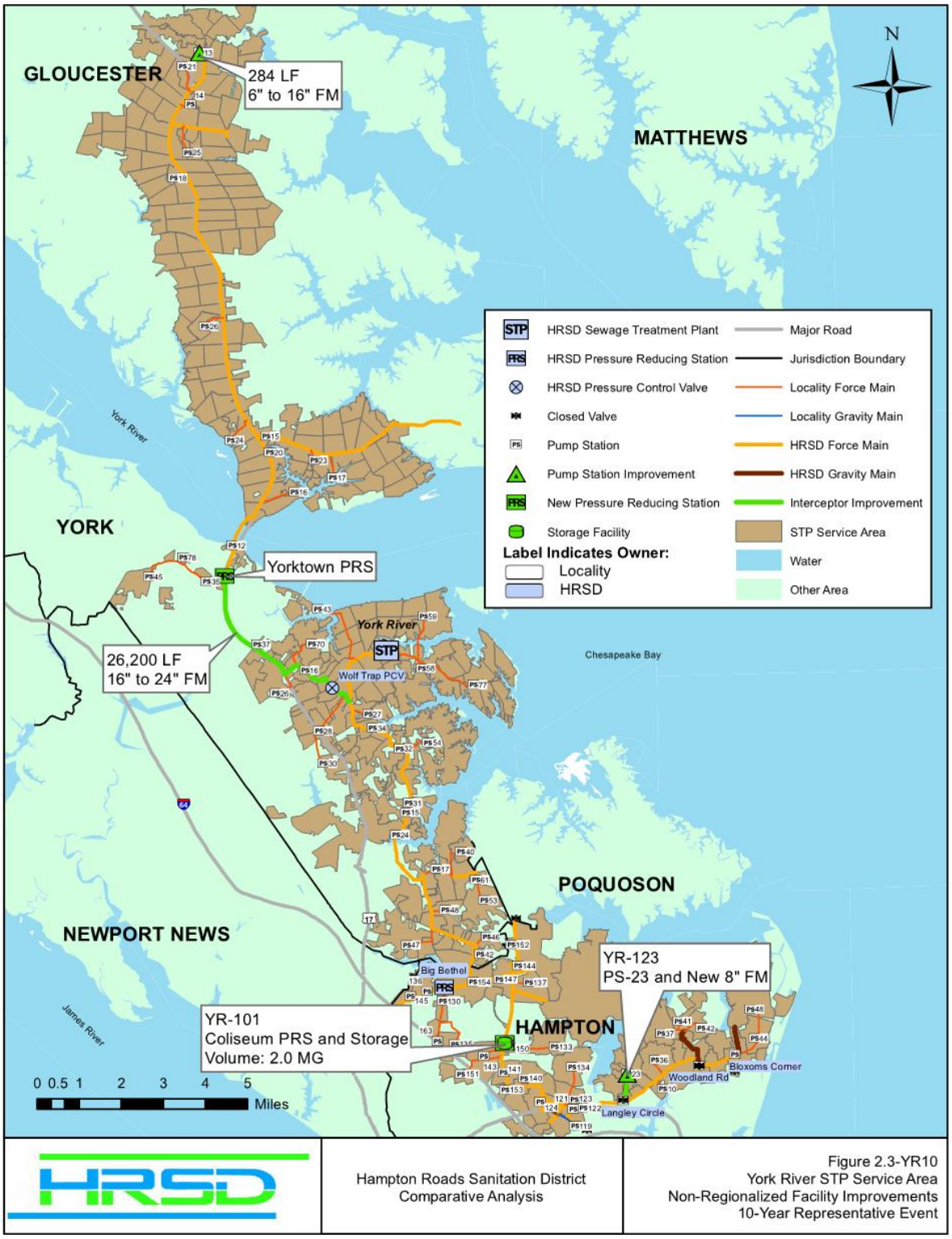

Figure 2.3-YR10

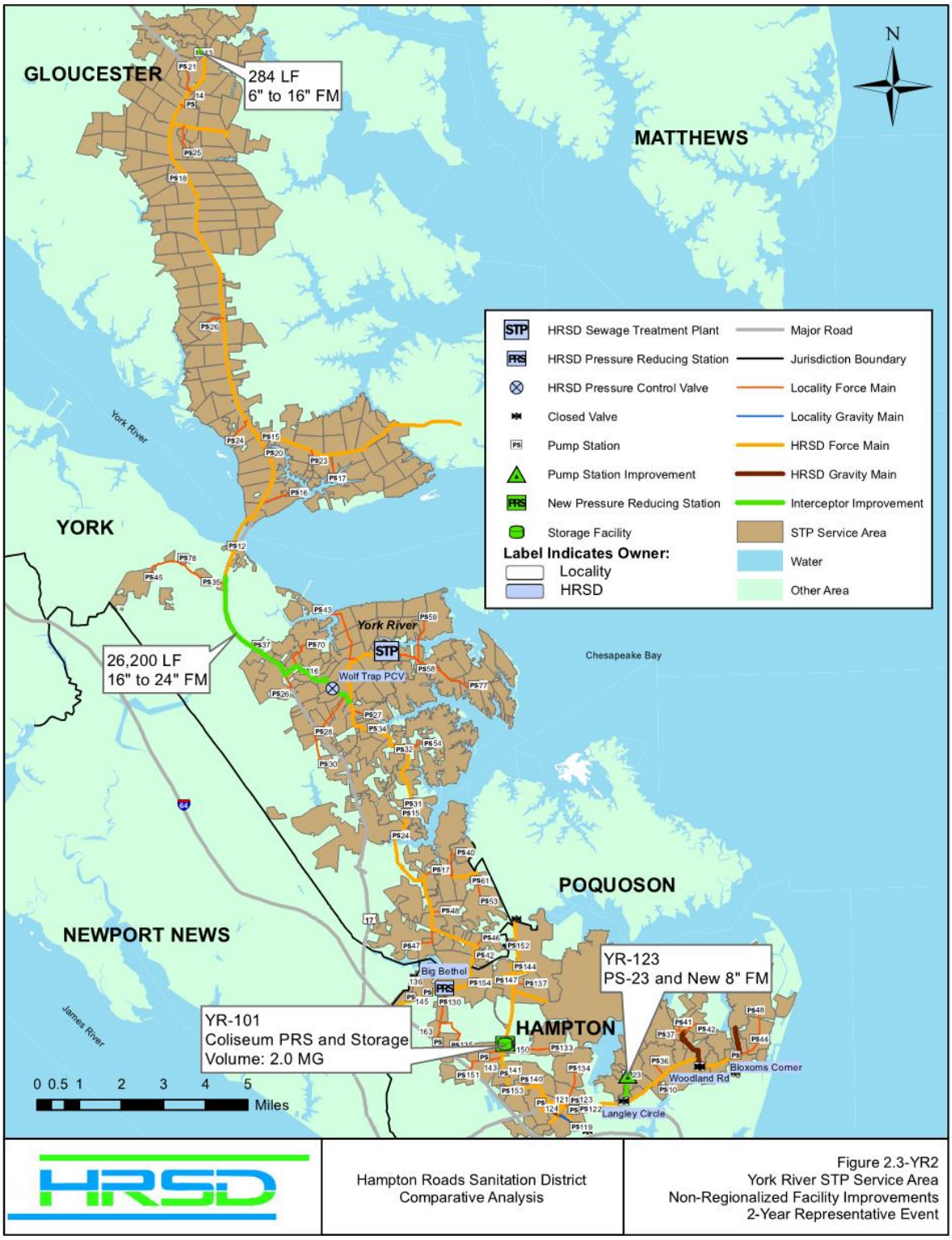

Figure 2.3-YR2

2.3.3.2 South Shore- 10-year and 2-year

The solution type and quantities associated with the South Shore solution sets developed in the non-regionalized approach are listed in Table 2-9. For maps of the South Shore non-regionalized wet weather solutions for the 10 and 2-year scenarios, see Figures 2.3-AB10 through 2.3-VIP2. See previous section regarding map label identification of CIP projects.

Table 2-9. South Shore Solution Sets in Non-Regionalized Approach

TP	SOLUTION TYPE	10-YEAR SOLUTIONS	2-YEAR SOLUTIONS
ARMY BASE	Upgrade PS	8	4
	Upsize FM	450 LF of 30” 20 LF of 20”	450 LF of 30” 20 LF of 20”
ATLANTIC	Upgrade PS	12	10
	Upgrade PRS	3	2
	New PRS	3	3
	Upsize FM	300 LF of 16” 1,850 LF of 16”	
	New force main	7,000’ of 12” 20,090’ of 24” (c factor adjustment)	7,000 LF of 12” 20,090 LF of 24” (c factor adjustment)
	Storage	5 sites / 13.6 MG total	3 sites / 3.3 MG total
CHES-ELIZ		NONE*	NONE*
NANSEMOND	Upgrade PS	4	5
	New PRS	1	1
	Upsize FM	45,600 LF 42” 8,500 LF of 48” 4,400 LF of 48” 3,000 LF of 54”	41,000 LF of 42” 8,500 LF of 48” 4,400 LF of 48”
	New force main	63,200 LF of 30” (c factor adjustment)	63,200 LF of 30” (c factor adjustment)
	Upsize gravity	8,600 LF of 24” 5,500 LF of 30”	3,600 LF of 24” 5,500 LF of 30”
	Storage	1 site / 1.9 MG total	
VIP	Upgrade PS	14	8
	Upsize FM	2,250 LF of 30”	
	Upsize gravity	3,754 LF of 30” 5,570 LF of 18”	5,570 LF of 18”
	Storage	2 sites / 2 MG	

**Ches-Eliz flows were significantly reduced on the 2030 valving configuration to meet nutrient removal requirements.*

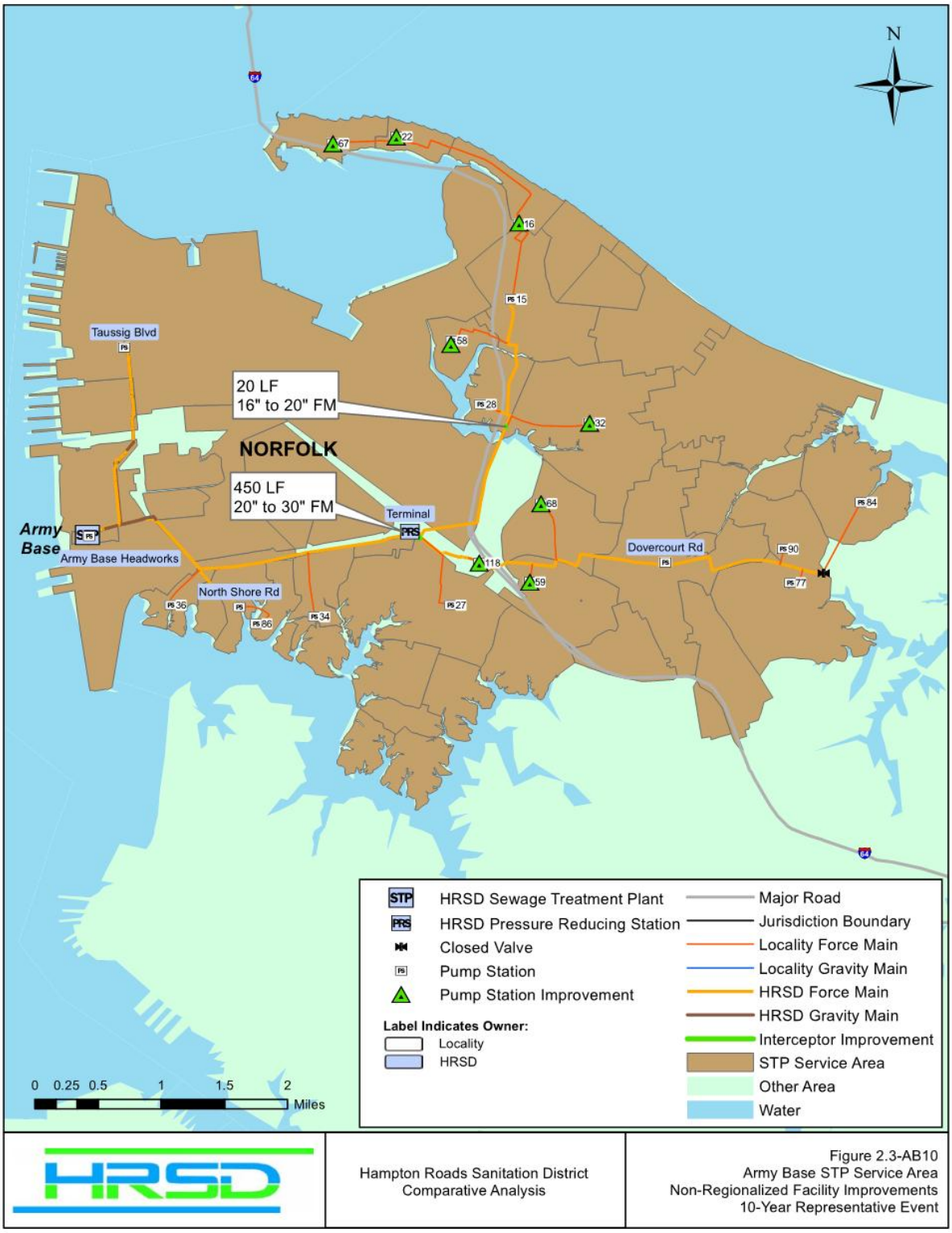

Figure 2.3-AB10

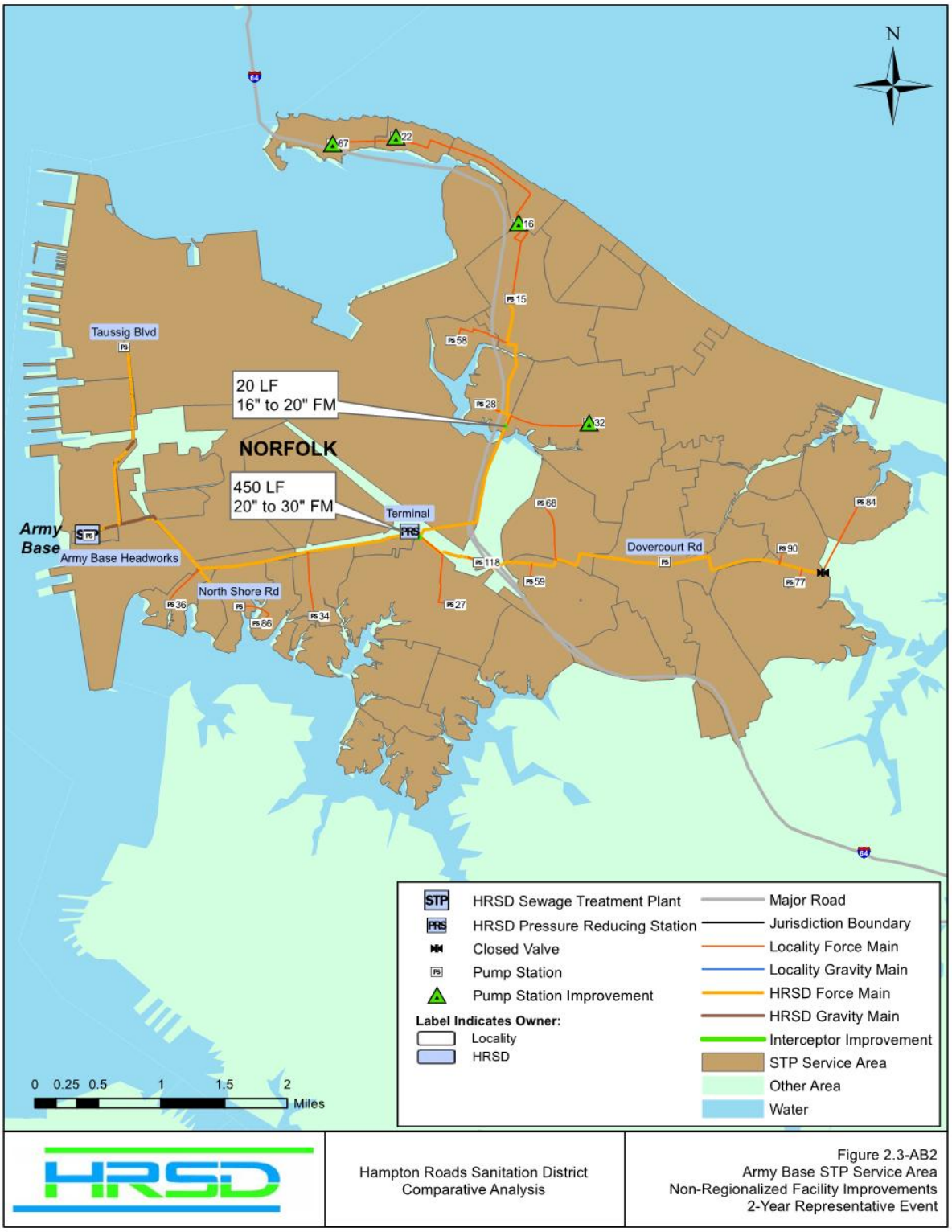

Figure 2.3-AB2

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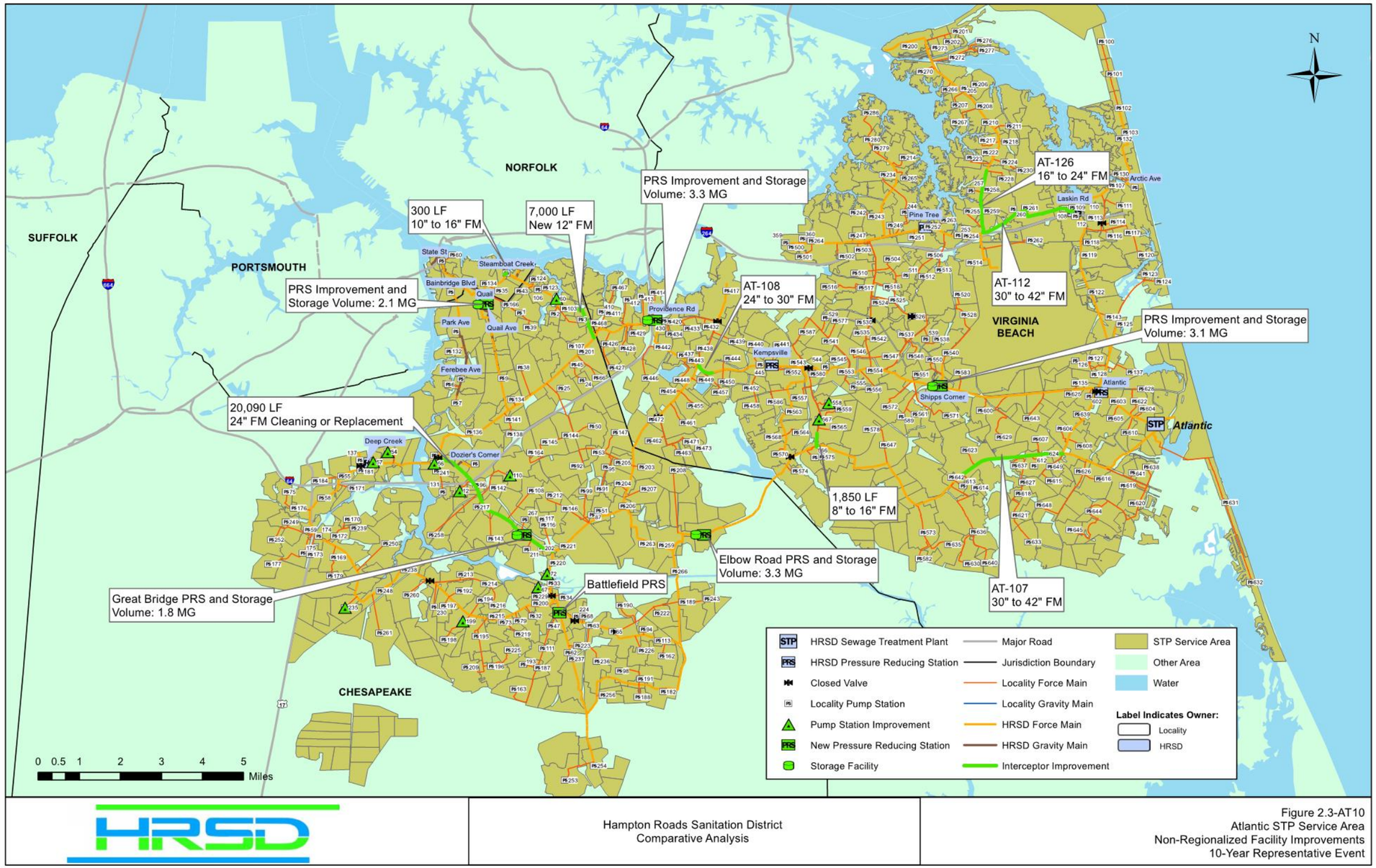

Figure 2.3-AT10

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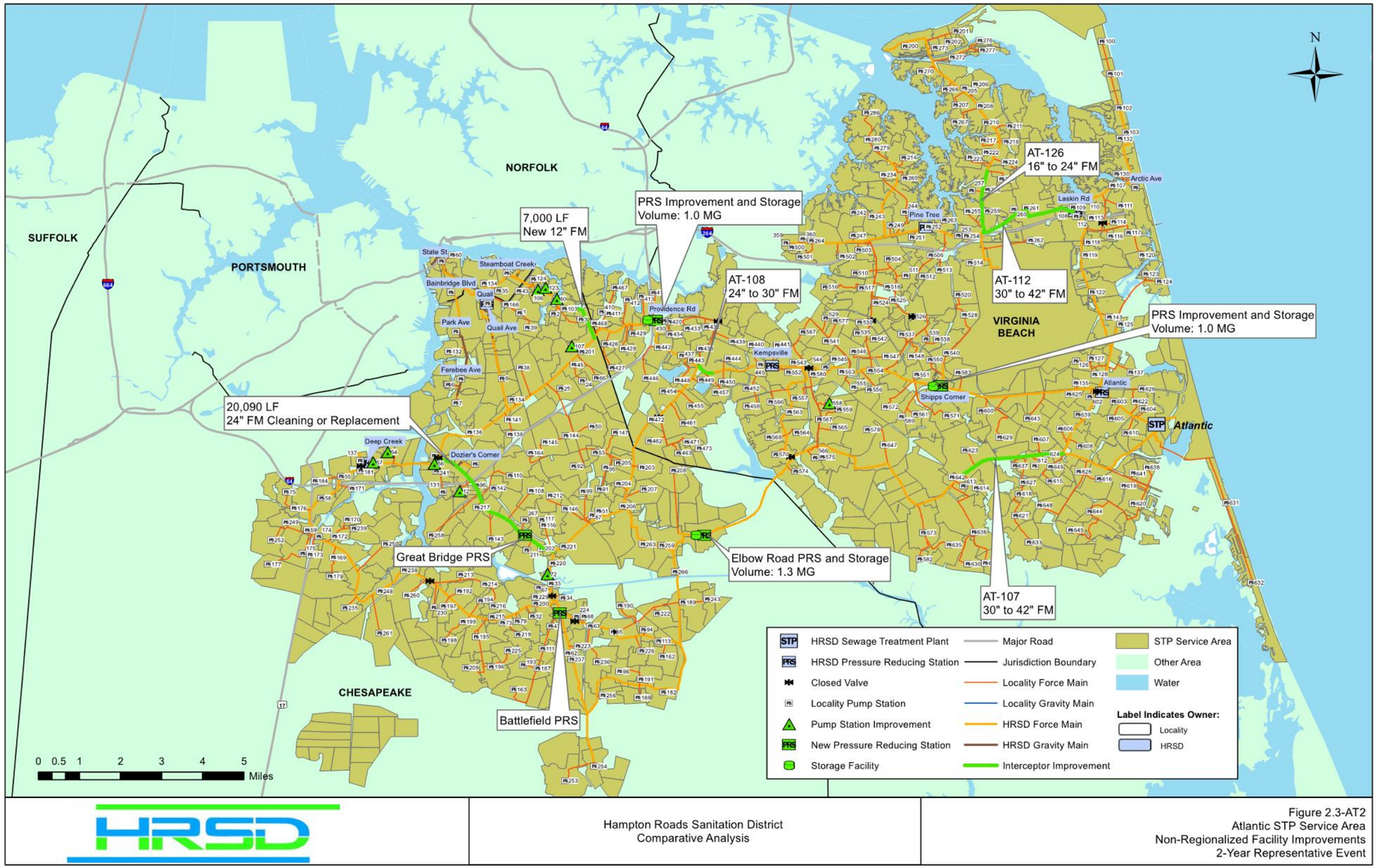

Figure 2.3-AT2

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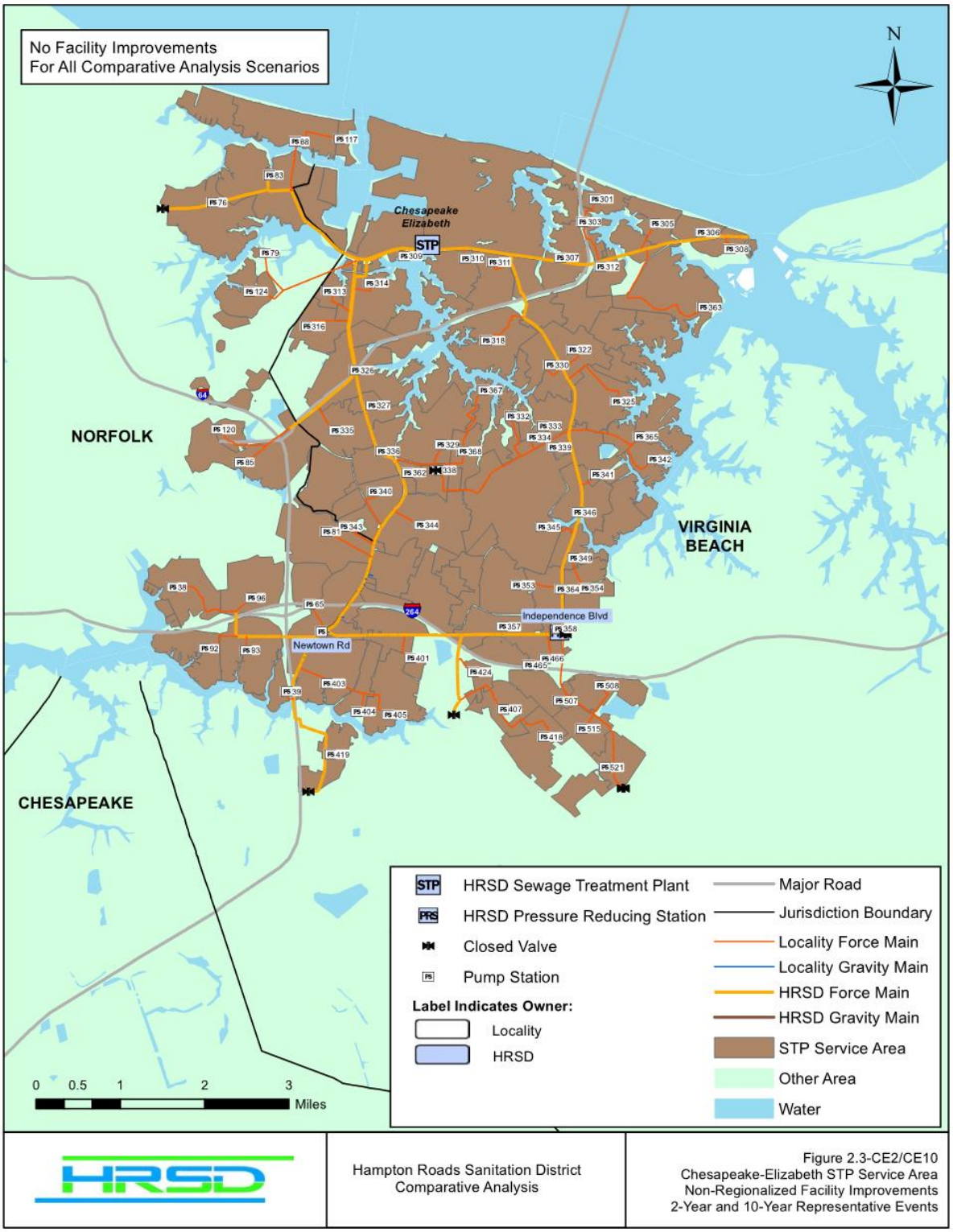

Figure 2.3-CE2/CE10

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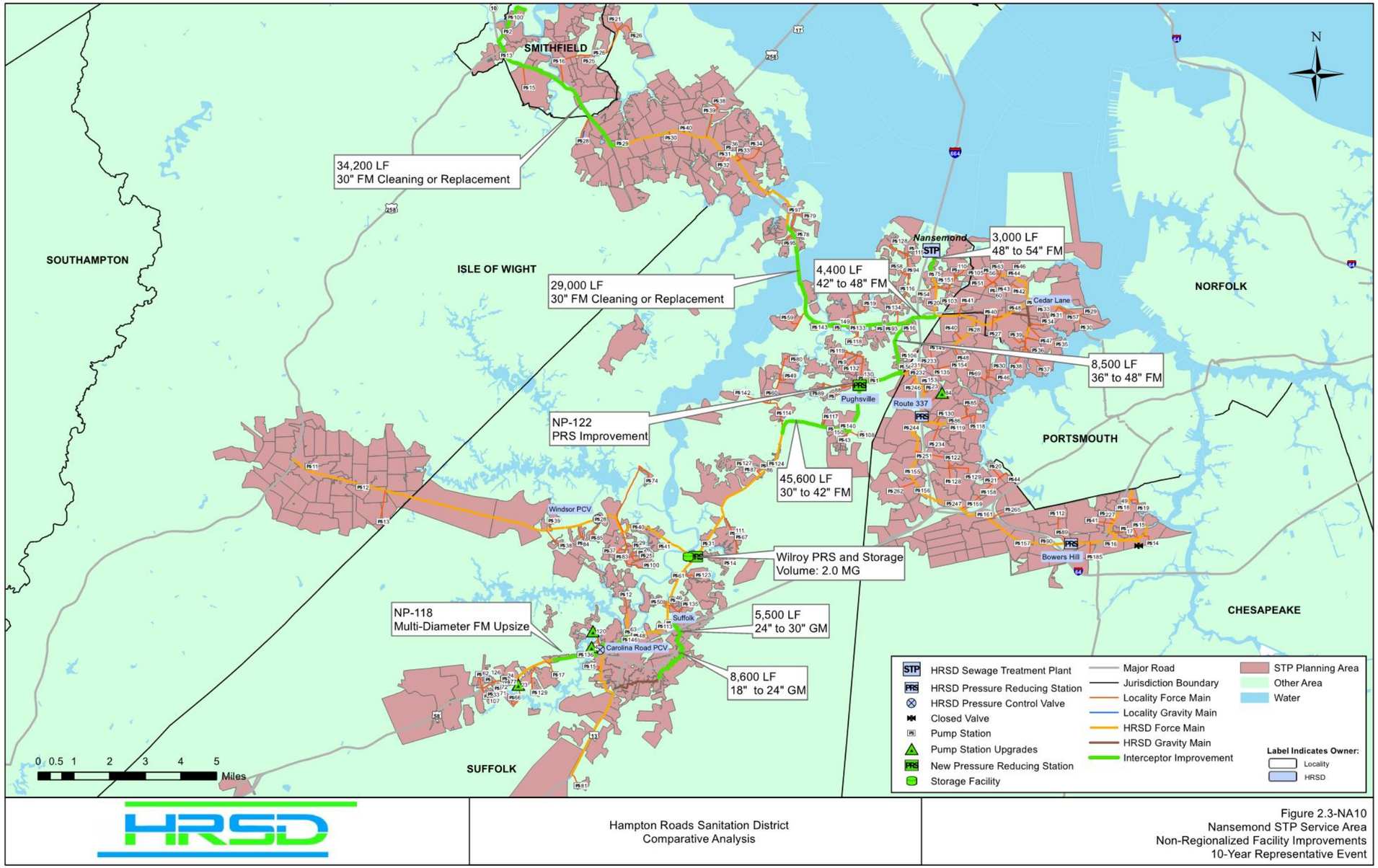

Hampton Roads Sanitation District
Comparative Analysis

Figure 2.3-NA10
Nansemond STP Service Area
Non-Regionalized Facility Improvements
10-Year Representative Event

Figure 2.3-NA10

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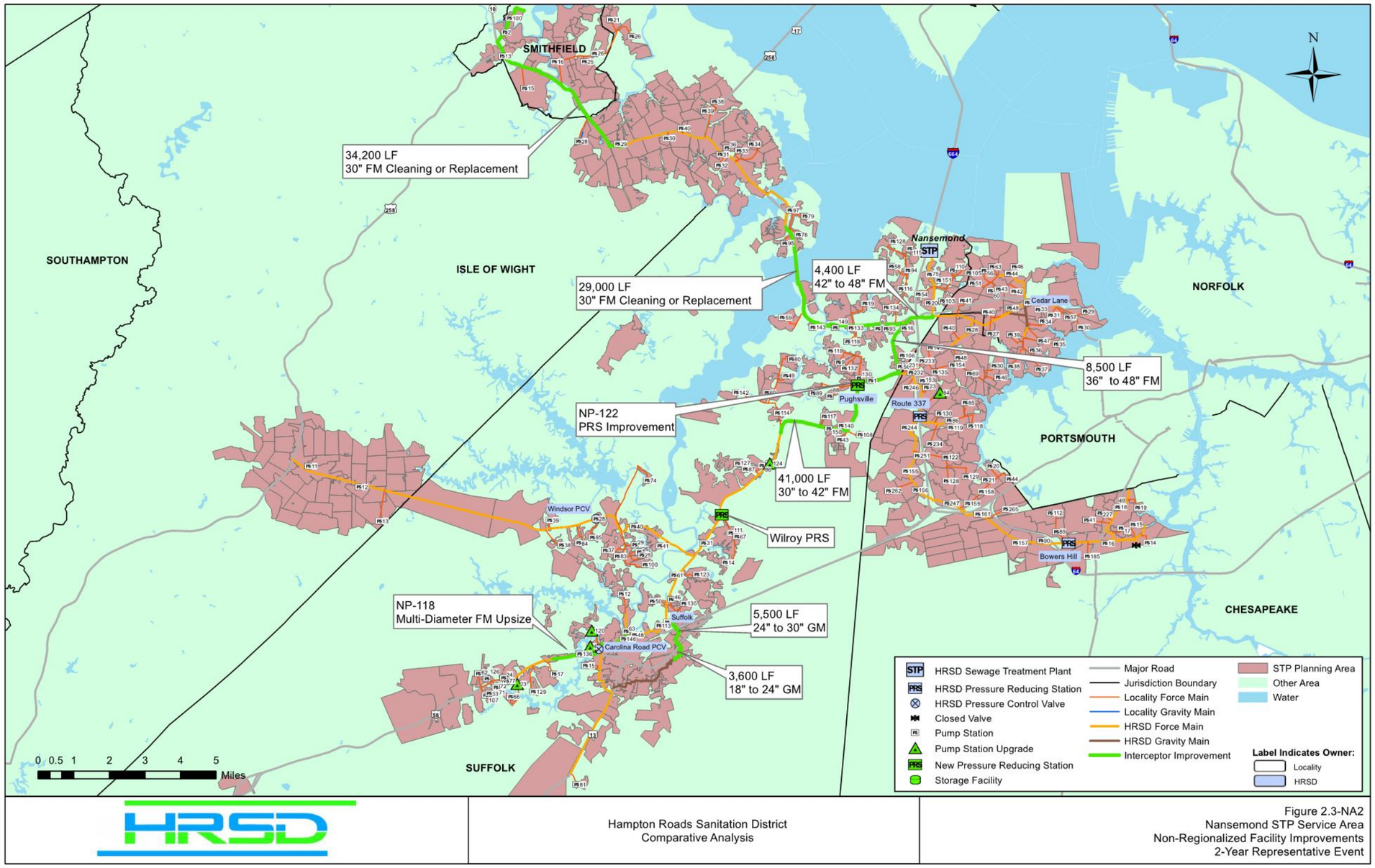

Hampton Roads Sanitation District
Comparative Analysis

Figure 2.3-NA2
Nansemond STP Service Area
Non-Regionalized Facility Improvements
2-Year Representative Event

Figure 2.3-NA2

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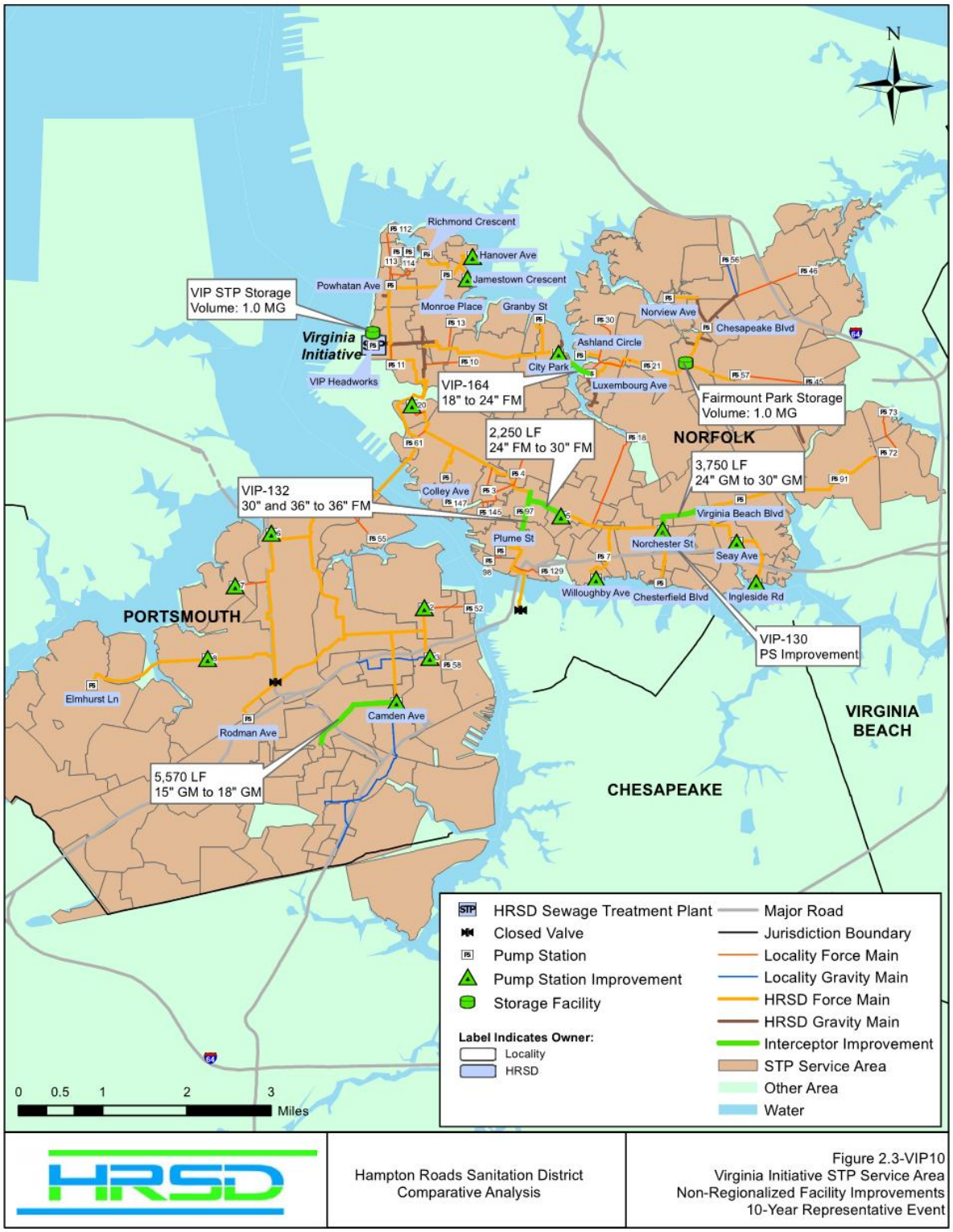

Figure 2.3-VIP10

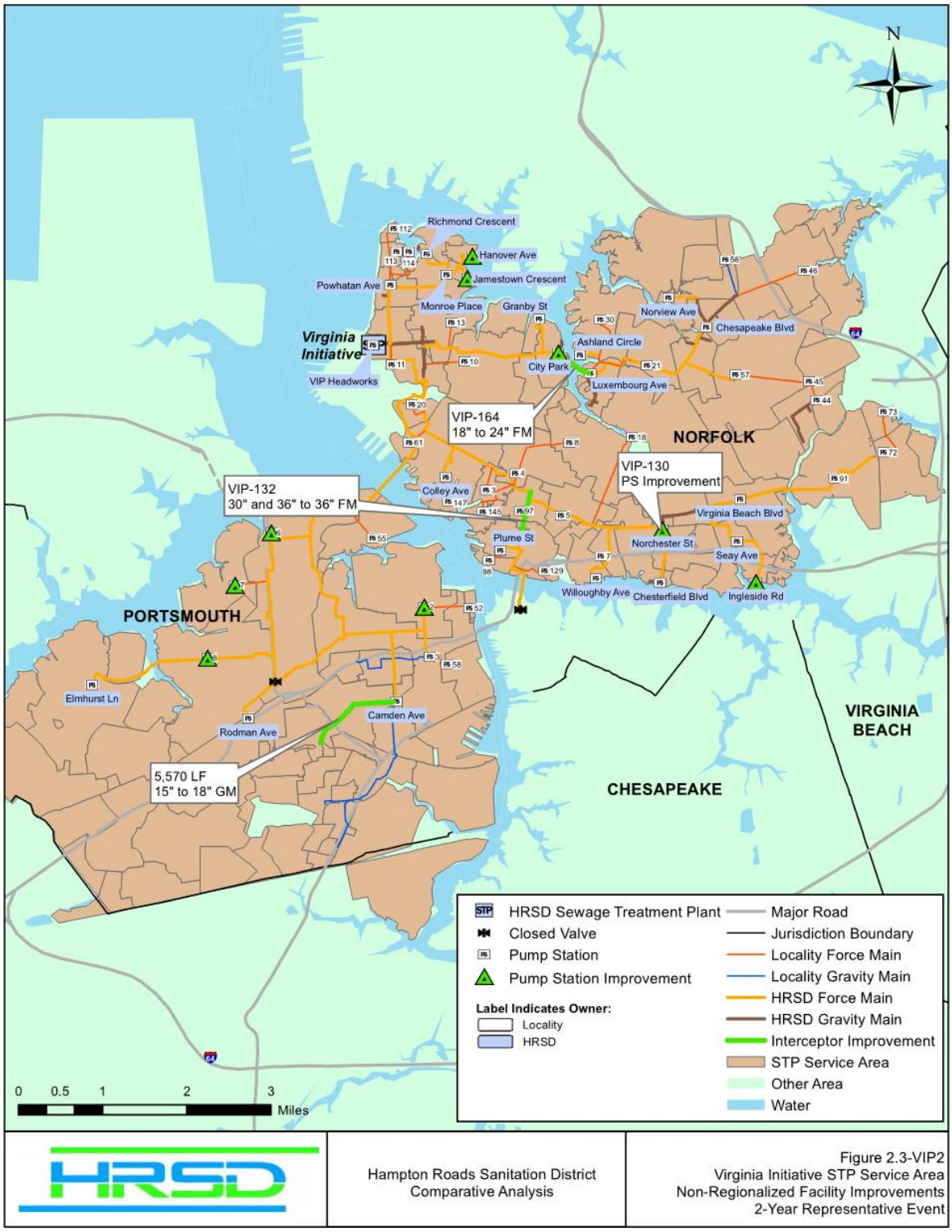

Figure 2.3-VIP2

2.3.4 Locality Capacity Improvements

The costs for improvements to the Locality sanitary sewer systems required to address SSOs and surcharge criteria violations are included in the Comparative Analysis. These costs include Locality gravity sewer improvements, terminal pump station improvements and lift station improvements. The basis for determining the need for improvements comes from the Localities' capacity assessment reports as well as the RHM for the terminal pump stations. Because the reports were done by various consultants serving various clients, there are significant differences in methodologies and information provided in the reports. The Comparative Analysis attempted to develop costs across Localities in a consistent manner based on the information that was available. The methodology was identical for the non-regionalized scenario as it was for the regionalized scenario described in Section 3.3.4.

2.3.4.1 Information Provided by Localities

The information provided in each Locality's capacity assessment report is listed in Table 2-10.

Table 2-10. Capacity Assessment Information Provided by Localities

Locality	Evaluate cause of SSO?	Costs developed?	RHM Conditions	Detail of Information Provided
Chesapeake	Yes	No	31-Oct-11	PS and SSO-Surcharge by catchment with map and tables
Gloucester	Yes	No	31-Oct-11	PS Only. No SSO-Surcharge in gravity system
Hampton	Yes	No	31-Oct-11	PS and SSO-Surcharge by catchment with map and tables
Isle of Wight	No	Yes = $0	31-Oct-11	Reported SSOs=0 and Surcharge violations =0
JCSA	Yes	No	31-Oct-11	PS and SSO-Surcharge by manhole and catchment with map and tables
Newport News	Only WB basins	Yes = $58M	31-May-12	PS and SSO-Surcharge by catchment with tables
Norfolk	No	No	N/A	N/A
Poquoson			31-Oct-11	
Portsmouth	Yes	No	31-Oct-11	PS and SSO-Surcharge by catchment with map and tables
Smithfield	No	No	N/A	N/A
Suffolk	No	Yes = $108M	31-Oct-11	PS and SSO-Surcharge by manhole with map and tables

Table 2-10. Capacity Assessment Information Provided by Localities				
Locality	Evaluate cause of SSO?	Costs developed?	RHM Conditions	Detail of Information Provided
Virginia Beach	No	No	31-Oct-11	PS and SSO-Surcharge by catchment with map and tables
Williamsburg	Only High FM Pressure	No	31-Oct-11	PS and SSO-Surcharge by catchment with tables
York County	No	No	N/A	N/A

2.3.4.2 Improvement Estimation Process

Costs were included for improving Locality gravity sanitary sewer infrastructure if the capacity assessment noted gravity sewer as the deficiency that caused an SSO or surcharge violation in a 10-year or 2-year peak flow scenario. A fixed 1,000 linear feet of piping and manholes were assumed to be replaced for each occurrence of a modeled SSO or surcharge violation attributed to a gravity capacity deficiency.

Likewise, if an upstream Locality lift station was noted as being capacity deficient for either scenario, a cost was programmed in to make the necessary improvement. A common assumption of $400,000 was made for the average cost to improve or replace an existing lift station. It was assumed that the typical lift station was a submersible, duplex configuration pump station with a precast wet well.

Terminal pump station improvements were included in the Locality capacity improvements; however, the determination of capacity was not based on the Locality capacity assessment, but by whether or not the terminal pump station had a modeled SSO or surcharge criteria violation in the RHM. Costs associated with terminal pump station improvements were calculated based on the required horsepower for the pump station in the RHM. The horsepower was determined based on the flow and head conditions modeled at that specific pump station in the RHM.

If a catchment was planned for significant rehabilitation to remove I/I in the non-regionalized scenario, a discount factor was applied to the costs for Locality improvements of gravity piping and upstream lift stations. This assumption was based on the concept that if a large amount of the pipe was being replaced for reduction in I/I flows, that it would likely provide an opportunity to upsize or improve the capacity of the pipe to convey flows and avert SSOs and surcharge violations without additional measures. Additionally, the large amount of flow reduction benefit from the rehabilitation would also relieve the system of some of the peak flows that were causing the SSOs and surcharge violations. Because of these benefits to the Locality capacity, if the rehabilitation was planned to remove 40% or more of the peak flow I/I, a reduction in cost of the gravity piping and lift station costs was taken at the same percentage as the I/I removal rate. The reductions were examined on a catchment level. The intent of this cost reduction procedure was to eliminate double counting I/I reduction and Locality improvement costs and recognize the benefits of the Localities' rehabilitation plans. No discount was applied where the I/I reduction was less than 40%.

2.3.5 Capital Costs for Improvements

Capital costs were calculated for the wet weather improvements and Locality capacity improvements based on local cost data. See cost estimation methodology in Section 1.3.4 for additional details. Typical linear footage costs for gravity sewer piping included costs for public laterals and manholes.

Force main linear footage costs included valves, bends, air vents and tees. Both gravity and force main linear footage costs included pavement saw cutting, demolition and repair. Costs for bypass pumping, dewatering and traffic control were also included in the linear footage costs of piping. Total costs per linear foot of gravity mains and force mains used in the comparative analysis are listed in Tables 2-11 and 2-12.

Table 2-11. Gravity Main Costs

Dia inches	Cost/LF
6	$ 240
8	$ 240
10	$ 325
12	$ 390
14	$ 455
16	$ 520
18	$ 585
20	$ 650
24	$ 780
30	$ 975
36	$ 1,170
42	$ 1,365
48	$ 1,560
54	$ 1,755

Table 2-12. Force Main Costs

Dia inches	Cost/LF
12	$ 390
16	$ 520
18	$ 585
20	$ 650
24	$ 780
30	$ 975
36	$ 1,170
42	$ 1,365

Costs for pump stations and PRSs were based on a calculation of horsepower using the flow and head at the pump station or PRS. Example costs for pump stations and PRSs are listed in Tables 2-13 and 2-14.

Table 2-13. Pump Station Costs

Horsepower	Cost
25	$ 956,394
50	$ 1,576,575
75	$ 2,185,544
100	$ 2,783,300
125	$ 3,369,844
150	$ 3,945,175
200	$ 5,062,200
250	$ 6,134,375
300	$ 7,161,700
350	$ 7,800,000

Table 2-14. PRS Costs

Horsepower	Cost
100	$ 3,770,000
150	$ 4,355,000
200	$ 4,940,000
250	$ 5,525,000
300	$ 6,110,000
350	$ 6,695,000
400	$ 7,280,000
450	$ 7,865,000
500	$ 8,450,000

Storage costs were assumed to be $2.50/gallon of storage with an additional cost of $250,000 per site included for land acquisition. Costs of potential storage facilities, including allowances of 15% for engineering and 15% contingency, are listed in Table 2-15.

Table 2-15. Storage Facilities Costs

Volume (MG)	Cost
1	$ 3,575,000
2	$ 6,825,000
3	$ 10,075,000
4	$ 13,325,000
5	$ 16,575,000

2.3.5.1 Regional Solutions and Locality Improvement Costs

By applying the cost functions to the wet weather solutions and Locality capacity improvements, costs were calculated by treatment plant service area as shown on Tables 2-16 and 2-17. Costs noted for "various" treatment plant service areas are HRSD ISI projects that cannot be assigned to any one service area such as SCADA system upgrades system wide and air vent replacements and rehabilitation. No regional wet weather improvements are needed in the Ches-Eliz treatment plant service area because no SSOs or surcharge violations were recorded in the 2030 RHM under either of the flow scenarios. Locality capacity improvements are shown in the Ches-Eliz service area because the Locality indicated deficiencies that cause SSOs or surcharge violations in upstream portions of the system that are not included in the RHM. These capacity limitations were considered in both the non-regionalized and regionalized scenarios.

Table 2-16. 10-year Non-Regionalized Capacity Improvements

STP Service Area	Regional Wet Weather Improvements	Locality Cap Improvements
AB	$ 10,320,000	$ 13,422,000
AT	$ 139,326,000	$ 96,847,000
BH	$ 21,572,000	$ 65,500,000
CE	$ -	$ 17,900,000
JR	$ 81,364,000	$ 20,413,000
NA	$ 165,573,000	$ 17,889,000
VIP	$ 67,530,000	$ 56,589,000
WB	$ 101,676,000	$ 33,777,000
YR	$ 52,179,000	$ 14,246,000
VARIOUS	$ 19,850,000	$ -
SUM	**$ 659,390,000**	**$ 336,582,000**

Table 2-17. 2-year Non-Regionalized Capacity Improvements		
STP Service Area	Regional Wet Weather Improvements	Locality Cap Improvements
AB	$ 10,320,000	$ 7,187,000
AT	$ 97,653,000	$ 50,114,000
BH	$ 21,572,000	$ 25,200,000
CE	$ -	$ 10,500,000
JR	$ 64,116,000	$ 7,300,000
NA	$ 144,591,000	$ 11,667,000
VIP	$ 42,598,000	$ 36,883,000
WB	$ 70,350,000	$ 7,600,000
YR	$ 48,877,000	$ 1,900,000
VARIOUS	$ 19,850,000	$ -
TOTAL	**$ 519,927,000**	**$ 158,351,000**

2.4 Summary of Non-Regionalized Scenario Rehabilitation and WWMP

2.4.1 Peak Flow Reductions

Locality-provided projections for rehabilitation including costs, 10-year flow reduction from Locality PPFEs in peak hour gpd and by percentage of I/I flow for the rehabilitation are listed in Table 2-18.

Table 2-18. Locality Provided Projections for Rehabilitation			
Locality	Cost	I/I Reduction (%)[2]	Peak Hour GPD removed[1]
Chesapeake	$ 271,751,142	20%	15,577,731
Gloucester	$ 7,516,000	21%	953,280
Hampton	$ 155,665,783	21%	11,816,868
Isle of Wight	$ 149,630	15%	42,509
JCSA	$ 63,626,487	25%	12,623,116
Newport News	$ 125,806,274	19%	14,603,300
Poquoson	$ 14,003,770	30%	2,583,671
Portsmouth	$ 247,403,473	19%	12,225,683
Smithfield	$ 3,814,064	24%	482,705
Suffolk	$ 29,331,103	19%	7,383,763
Virginia Beach	$ 349,595,721	13%	18,267,250
Williamsburg	$ 17,000,000	22%	2,242,000
York[3]	$ 72,500,000	24%	5,630,112
Total	**$ 1,358,163,447**	**19%**	**104,431,988**

1 As reported by Locality and for SSES basins only.

2 % I/I Reductions are weighted values.

3 York values are based on 2030 growth figures.

2.4.2 Capital Costs 10-year and 2-year

The total capital costs for the 10-year and 2-year non-regionalized scenario including Locality and HRSD rehabilitation by treatment plant service area are listed in Tables 2-19 through 2-21. Costs for rehabilitation are the same in the 2 and 10-year scenarios because the same scope of work would be performed. Because the flows are greater in the 10-year scenario, a larger peak flow rate reduction would be achieved by the same amount of rehabilitation. Rehabilitation and regional wet weather improvements costs shown in the "various" STP service area category are HRSD projects that span more than one service area (e.g., North Shore Manhole Rehab).

Table 2-19. Cost and Schedule for the 10-year Non-Regionalized Approach

	Regional Wet Weather Improvements	Locality Capacity Improvements	Locality/HRSD Rehabilitation	Private Property I/I Abatement	Total	Implementation. Schedule (yrs)
CHES		$48,277,000	$271,751,000		$ 320,028,000	30
GLOU		$7,646,000	$7,516,000		$ 15,162,000	N/A
HAMP		$47,100,000	$155,666,000		$ 202,766,000	25
HRSD	$659,390,000	None	$173,338,000	$289,248,000	$ 1,121,976,000	10/20*
IOW		None	$150,000		$ 150,000	N/A
JCSA		$20,000,000	$63,626,000		$ 83,626,000	20
NEWP		$53,789,000	$125,806,000		$ 179,595,000	25
NORF		$16,318,000	N/A**		$ 16,318,000	N/A
POQ		$1,300,000	$14,004,000		$ 15,304,000	25
PORT		$53,694,000	$247,403,000		$ 301,097,000	30
SMITH		None	$3,814,000		$ 3,814,000	20
SUFF		$14,958,000	$29,331,000		$ 44,289,000	15
VAB		$69,400,000	$349,596,000		$ 418,996,000	30
WILL		$4,100,000	$17,000,000		$ 21,100,000	20
YORK		None	$72,500,000		$ 72,500,000	25
Grand Total	**$659,390,000**	**$336,582,000**	**$1,531,501,000**	**$289,248,000**	**$ 2,816,721,000**	

**HRSD's Rehab Plan has a 10-year implementation schedule and the RWWMP schedule is assumed to be 20 years.*

*N/A** - Norfolk's rehabilitation program falls outside of the Consent Order and their costs have not been collected.*

Table 2-20. 10-year Non-Regionalized Scenario Costs					
	Regional Wet Weather Improvements	Locality Cap Improvements	Locality/HRSD Rehab	Private I/I	**Grand Total**
AB	$ 10,320,000	$ 13,422,000	$ 1,297,000	$ 140,000	$ 25,179,000
AT	$ 139,326,000	$ 96,847,000	$ 498,376,000	$ 91,628,000	$ 826,177,000
BH	$ 21,572,000	$ 65,500,000	$ 208,734,000	$ 48,560,000	$ 344,366,000
CE	$ -	$ 17,900,000	$ 80,016,000	$ 31,107,000	$ 129,023,000
JR	$ 81,364,000	$ 20,413,000	$ 89,240,000	$ 14,839,000	$ 205,856,000
NA	$ 165,573,000	$ 17,889,000	$ 150,558,000	$ 46,289,000	$ 380,309,000
VIP	$ 67,530,000	$ 56,589,000	$ 274,525,000	$ 15,710,000	$ 414,354,000
WB	$ 101,676,000	$ 33,777,000	$ 112,465,000	$ 18,914,000	$ 266,832,000
YR	$ 52,179,000	$ 14,245,000	$ 96,974,000	$ 22,061,000	$ 185,459,000
VARIOUS	$ 19,850,000	$ -	$ 19,316,000	$ -	$ 39,166,000
TOTAL	**$ 659,390,000**	**$ 336,582,000**	**$ 1,531,501,000**	**$ 289,248,000**	**$ 2,816,721,000**

Table 2-21. 2-year Non-Regionalized Scenario Costs					
	Regional Wet Weather Improvements	Locality Cap Improvements	Locality/HRSD Rehab	Private I/I	**Grand Total**
AB	$ 10,320,000	$ 7,187,000	$ 1,297,000	$ 140,000	$ 18,944,000
AT	$ 97,653,000	$ 50,114,000	$ 498,376,000	$ 91,628,000	$ 737,771,000
BH	$ 21,572,000	$ 25,200,000	$ 208,734,000	$ 48,560,000	$ 304,066,000
CE	$ -	$ 10,500,000	$ 80,016,000	$ 31,107,000	$ 121,623,000
JR	$ 64,116,000	$ 7,300,000	$ 89,240,000	$ 14,839,000	$ 175,495,000
NA	$ 144,591,000	$ 11,667,000	$ 150,558,000	$ 46,289,000	$ 353,105,000
VIP	$ 42,598,000	$ 36,883,000	$ 274,525,000	$ 15,710,000	$ 369,716,000
WB	$ 70,350,000	$ 7,600,000	$ 112,465,000	$ 18,914,000	$ 209,329,000
YR	$ 48,877,000	$ 1,900,000	$ 96,974,000	$ 22,061,000	$ 169,812,000
VARIOUS	$ 19,850,000	$ -	$ 19,316,000	$ -	$ 39,166,000
TOTAL	**$ 519,927,000**	**$ 158,351,000**	**$ 1,531,501,000**	**$ 289,248,000**	**$ 2,499,027,000**

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Section 3

Regionalized Scenario

Regionalization costs have been estimated with the understanding that all public sanitary sewer infrastructure in the HRSD service area would be owned and maintained by a single utility, removing political boundaries from the rehabilitation decision.

3.1 Rehabilitation Plan and Flow Parameter Development

For the regionalized scenario, the extent of rehabilitation is a function of the optimal level of I/I removal specific to each treatment plant service area. The cost effectiveness analysis identified the leakiest catchments and optimal removal rates per STP service area. Because each STP service area has its own unique set of characteristics with respect to flow, capacity, geography and density, the optimal removal rates are different for each treatment plant service area. Service areas with higher hydraulic capacity in the existing system had a lower optimal I/I removal rate than a service area that is at or near capacity. Additionally, the regionalized scenario was not limited to only the SSES Basins that the Localities were investigating, but also included some non-SSES Basins. Performing I/I reduction in a catchment that did not meet the definition of an SSES Basin in the SOC could be more cost effective than transporting and treating the peak I/I flows.

3.1.1 Cost Effectiveness Analysis

The cost effectiveness analysis established methodologies for determining system and treatment plant capacities, approximate pricing for I/I reduction and estimated pricing for conveyance, storage and treatment capacity. The study identified an optimal combination of I/I removal in conjunction with system capacity improvements based on the 10-year peak flow recurrence with moderate 2030 growth. Also, an allowance for degradation was included in catchments with peak flows below the Peak Flow Threshold of 775 gallons per day per equivalent residential unit (gpd/ERU) in each treatment plant service area.

The basis for the I/I removal curve is the concept that the higher the I/I density on a gallon per acre per day (gpad) in each basin, the lower the unit cost of removal. As an increment of I/I is removed, the flow in gpad is reduced and the cost of removing the next increment of flow increases. Because the peak flow rate in each catchment is different, it was assumed that the percentage of cost effective I/I removal would be different in every catchment. The purpose of this portion of the analysis was to estimate the costs and flows removed.

3.1.1.1 Catchment Reduction Estimates

The resulting optimal removal percentages and flows by STP service area are listed in Table 3-1. The percentage reduction is based on the total I/I flow for the STP service area inclusive of both SSES and non-SSES Basins.

Table 3-1. Estimated Regionalized Public I/I Reduction	
STP Service Area	% Reduction
AB	6.5%
AT	16.0%
BH	18.9%
CE	0.0%
JR	13.7%
NA	22.8%
VIP	13.7%
WB	21.2%
YR	16.6%
SUM	**16.5%**

Note that Ches-Eliz Treatment Plant has a 0% reduction since no capacity limitations were identified in the pre-rehabilitation capacity assessment modeling. Therefore, it would not be cost effective to perform any I/I removal; however, this is based on the valving used for this Comparative Analysis and the final RWWMP may produce a different outcome.

3.1.1.2 Preliminary Cost Estimates

To estimate the capital cost of I/I removal, several critical assumptions were made. First, based on previously completed local projects and experience from elsewhere, it was assumed that maximum amount of public removal was assumed to be 70% if 100% of the public gravity infrastructure in the catchment was rehabilitated. On the low end of the removal spectrum, it was noted that small amounts of rehabilitation would yield very little I/I reduction because the infiltration would simply find alternate adjacent opportunities to enter the system. Therefore, it was assumed that to achieve a 7% reduction in I/I flows, 30% of the public gravity infrastructure would need to be rehabilitated. I/I reductions between 7% and 70% would require proportional rehabilitation/replacement between 30% and 100%.

Based on the percent of rehabilitation required in each catchment, the linear footage of public gravity sewer assets in each catchment was calculated. By applying the unit costs for pipe replacement, an estimated cost was generated for the public rehabilitation. Quantities of public gravity sewer assets that are active and owned by the municipalities came from GIS shapefiles provided by the Localities. Pricing was applied based on pipe diameter per the cost schedule in Section 2.3.5. Costs were categorized by STP service area for comparison with the non-regionalized approach.

Estimated capital costs for regionalized rehabilitation are listed in Table 3-2. Since the Ches-Eliz Treatment Plant service area had a 0% optimal point for I/I reduction, there is no cost for that part of the system.

Table 3-2. Estimated Public Rehab Costs	
STP Service Area	Public Rehabilitation Costs
AB	$ 1,688,000
AT	$ 216,503,000
BH	$ 62,566,000

Table 3-2. Estimated Public Rehab Costs	
STP Service Area	Public Rehabilitation Costs
CE	$ -
JR	$ 71,321,000
NA	$ 161,640,000
VIP	$ 141,038,000
WB	$ 121,970,000
YR	$ 55,193,000
TOTAL	**$ 831,919,000**

**Does not include costs to rehabilitate HRSD existing assets.*

3.1.2 Development of Private Property I/I Reductions

Private property I/I reduction estimates were calculated as a piggy-back to the public I/I rehabilitation. For catchments with 70% public I/I removal, an additional 15% removal of I/I could be achieved when private rehabilitation was performed simultaneously with the public rehabilitation. For catchments with 7% public I/I removal, an additional 1.5% I/I could be achieved.

Additional I/I removal was considered for IWD sites and Federal Facilities. The methodology used to determine the flows and costs for these locations utilized leakiness criteria in terms of gallons per day per acre of sewered acreage as was used in the cost effectiveness analysis. If the 10-year peak hourly flow exceeds 2.5 times the average daily flow, then the location was programmed for rehabilitation. Rehabilitation was assumed to produce 20% I/I removal.

The cost estimate for IWD catchments was based on costs for investigation, flow monitoring and rehabilitation on a linear footage basis. Cost estimates for Federal Facilities were assumed to have a $20,000 cost for investigation but no cost for rehabilitation as it was assumed that the facility would perform the rehabilitation. This approach is identical between the non-regionalized and regionalized scenarios.

Costs for private property, IWD sites and Federal Facilities are listed in Table 3-3. The Ches-Eliz Treatment Plant service area has no cost for Private Property I/I Abatement since the optimal point for I/I removal is 0%.

Table 3-3. Estimated Rehab Costs for Private Property	
STP Service Area	Private I/I
AB	$ 203,000
AT	$ 59,239,000
BH	$ 16,962,000
CE	$ -
JR	$ 24,573,000
NA	$ 41,613,000
VIP	$ 17,018,000
WB	$ 41,551,000
YR	$ 9,336,000
TOTAL	**$ 210,495,000**

3.1.3 Development of HRSD I/I Reductions

The costs associated with reduction in peak flow from HRSD's assets are included in the Rehabilitation Action Plan. No additional costs have been programmed in to the total. This approach is identical between the non-regionalized and regionalized scenarios. The costs associated with those projects are listed in Table 3-4.

Table 3-4. Costs for Rehab Plan

STP Service Area	HRSD Rehab Costs
AB	$ 1,297,000
AT	$ 11,852,000
BH	$ 42,151,000
CE	$ 13,195,000
JR	$ 5,055,000
NA	$ 11,923,000
VIP	$ 64,460,000
WB	$ 696,000
YR	$ 3,393,000
VARIOUS	$ 19,316,000
TOTAL	**$ 173,338,000**

3.1.4 Regionalized Rehabilitation Plan

The total estimated costs from the regionalized rehabilitation program including private, IWD, Federal Facilities and public rehabilitation are listed in Table 3-5.

Table 3-5. Costs for Public and HRSD Rehab

STP Service Area	Regional/HRSD Rehab
AB	$ 2,985,000
AT	$ 228,355,000
BH	$ 104,717,000
CE	$ 13,195,000
JR	$ 76,375,000
NA	$ 173,563,000
VIP	$ 205,498,000
WB	$ 122,666,000
YR	$ 58,586,000
VARIOUS	$ 19,316,000
TOTAL	**$ 1,005,256,000**

3.2 Post-Rehabilitation Capacity Assessment

3.2.1 General Approach

The capacity assessment for the regionalized scenario was developed as consistently as possible with the assumptions under the non-regionalized scenario. Simulations in the RHM were performed with post-rehabilitation flow conditions. Once the rehabilitation extents and locations were determined, the accompanying flow parameters were input into the RHM for simulation of the 2- and 10-year peak hourly flow conditions. Results of the simulation provided the basis for determining what additional system capacity improvements were required to eliminate SSOs and freeboard violations in the 2- and 10-year scenarios. Resulting HGLs passing all the generated peak flows were studied to observe where system pressures exceeded terminal pump station shut off heads at peak flow conditions and plan for improvements accordingly.

To help ensure that the regionalized and non-regionalized approaches were designed with similar factors of safety and system capacities, the same hydraulic grade was achieved at the upstream end of each profile and had similar profiles. This allowed for similar terminal pump station improvements; however, the different I/I flow removal locations and extents under each scenario introduced some variability in the improvements needed to maintain similar HGL profiles.

3.2.2 Modeled System Improvements

The modeled system improvements took into consideration potential future nutrient valving configurations. Both scenarios included planned CIP improvements and the 51 ISI projects identified in Section 1.3.3.2. Refer to Section 2.2.2 for additional detail.

3.2.3 Representative Storm Events

The same representative storm events were used for the regionalized approach as the non-regionalized approach; therefore the same pre-rehabilitation flows were used in both scenarios. Refer to Section 2.2.3 for additional detail.

3.2.4 Results

The representative events were applied to the modified RHM with modeled system improvements (Section 2.2.2) for the 10-year and 2-year levels of service to identify the remaining post-rehab capacity limitations. The results were evaluated to determine where SSOs were occurring as well as violations of the surcharge criteria (not exceeding 1.5 feet from any manhole/wet well rim in the model). Durations and volumes of SSOs were also calculated for use in the wet weather solution development. Figures in the following Sections show the locations of SSOs and surcharge violations. The post-rehabilitation SSOs and surcharge violations by STP service area are listed in Table 3-6.

Table 3-6. Modeled Regionalized Post-Rehab Capacity Limitations				
STP Service Area	10-Year SSOs	10-Year Surcharge Violations	2-Year SSOs	2-Year Surcharge Violations
AB	4	2	3	0
AT	30	2	21	6
BH	0	1	0	0
CE	0	0	0	0
JR	7	0	0	1
NA	17	1	11	4
VIP	9	0	3	1
WB	23	0	16	2
YR	6	1	4	0
TOTAL	96	7	58	14

3.2.4.1 North Shore- 10-year and 2-year

Figure 3.2-BH10

Figure 3.2-BH2

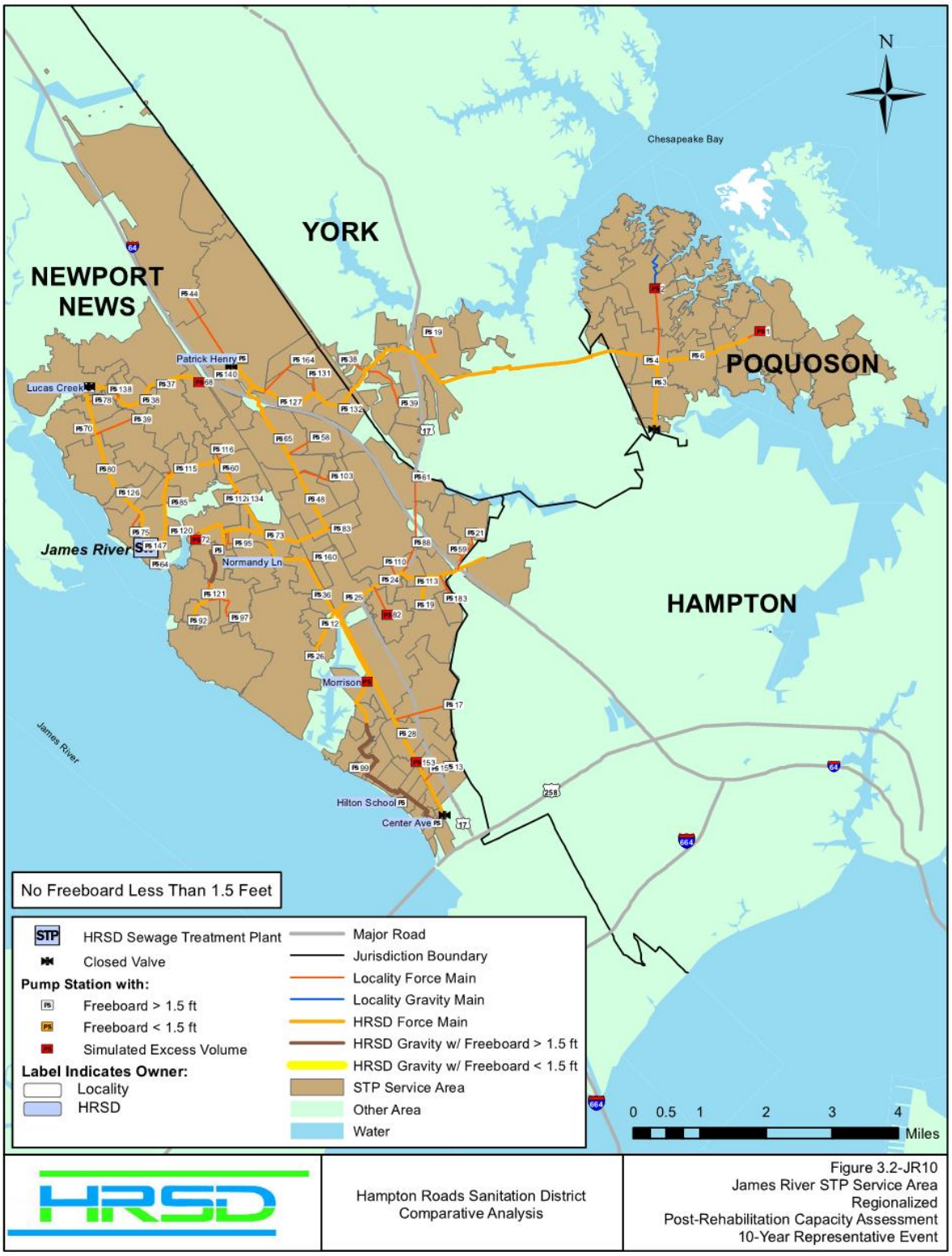


Figure 3.2-JR10

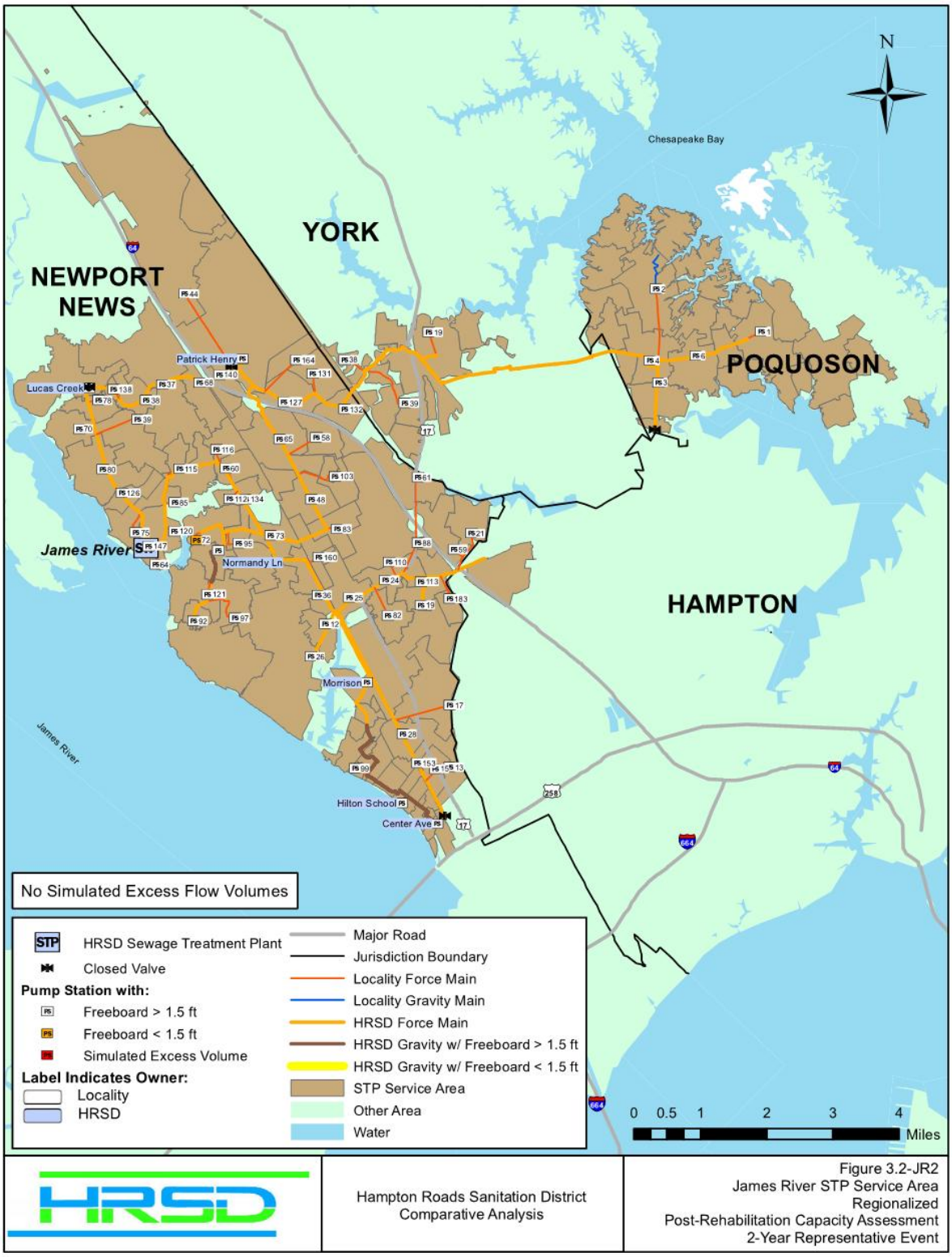


Figure 3.2-JR2

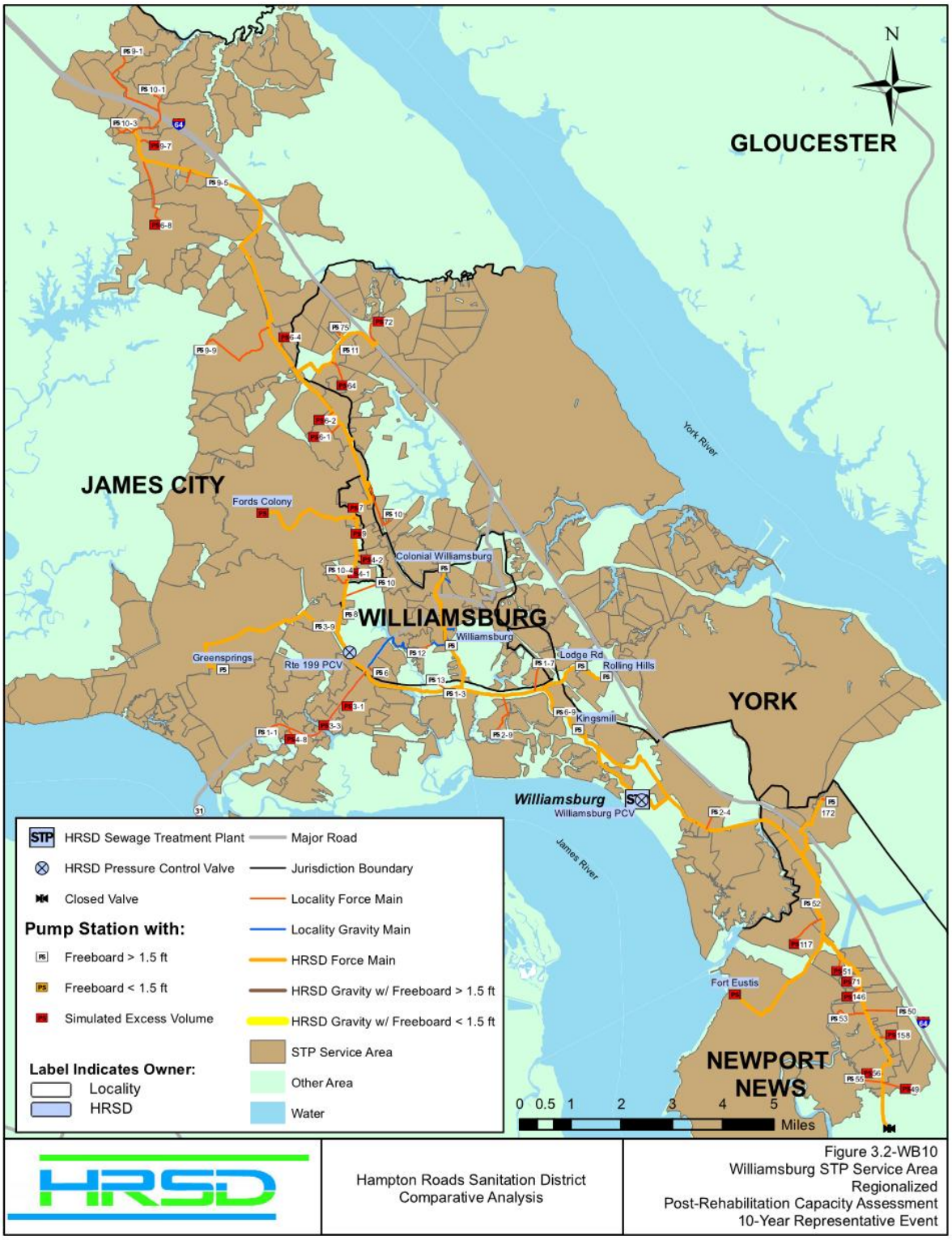


Figure 3.2-WB10

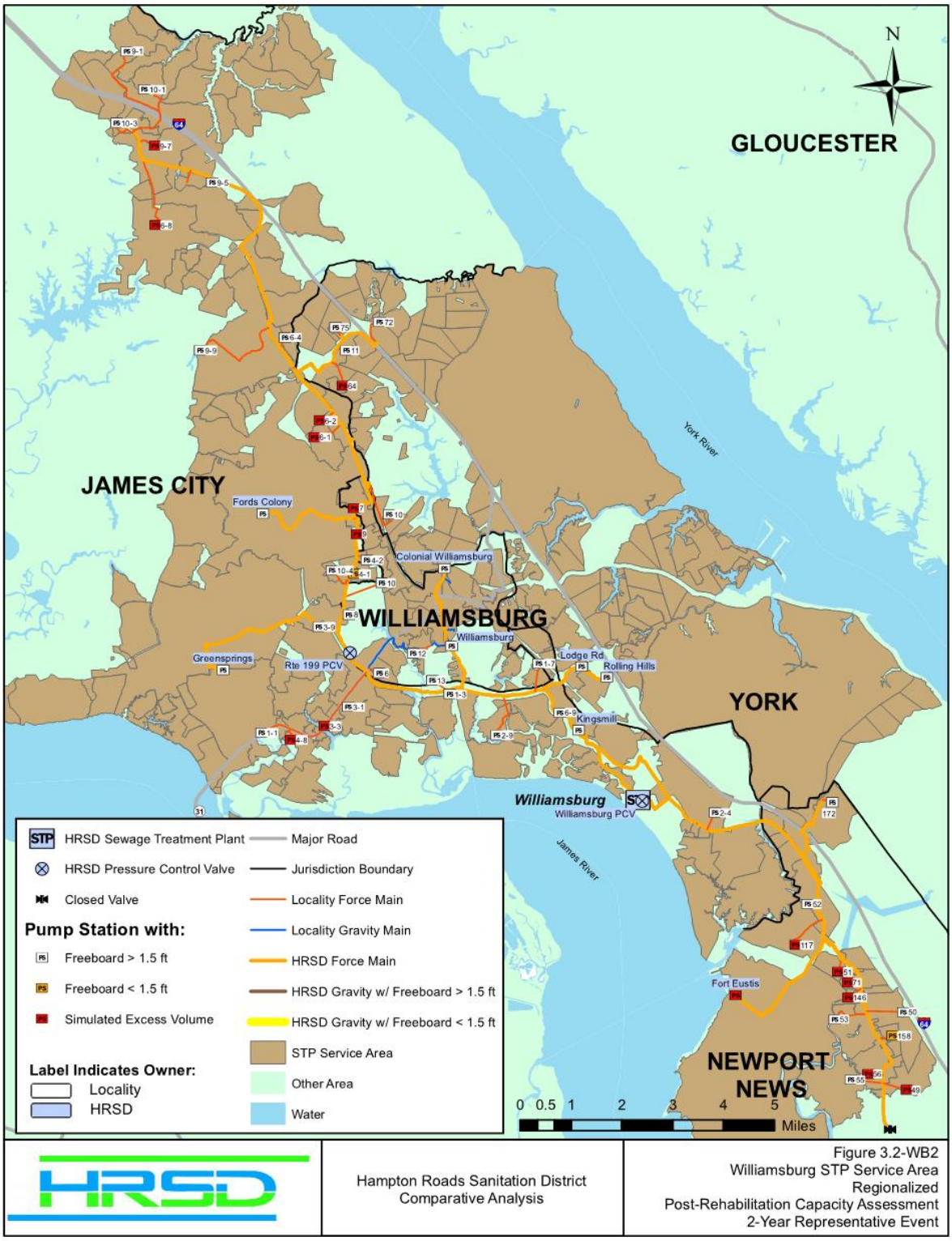


Figure 3.2-WB2

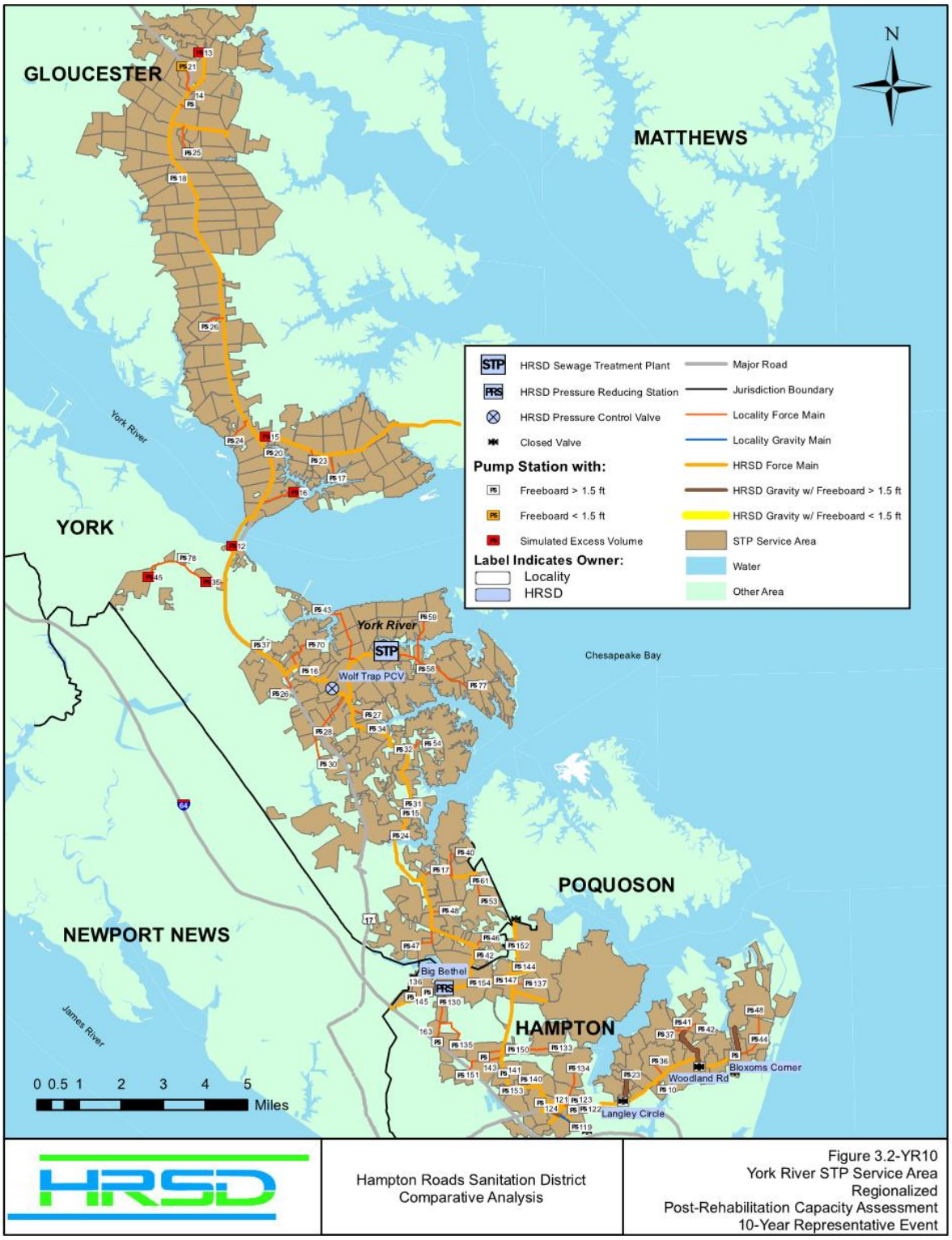


Figure 3.2-YR10

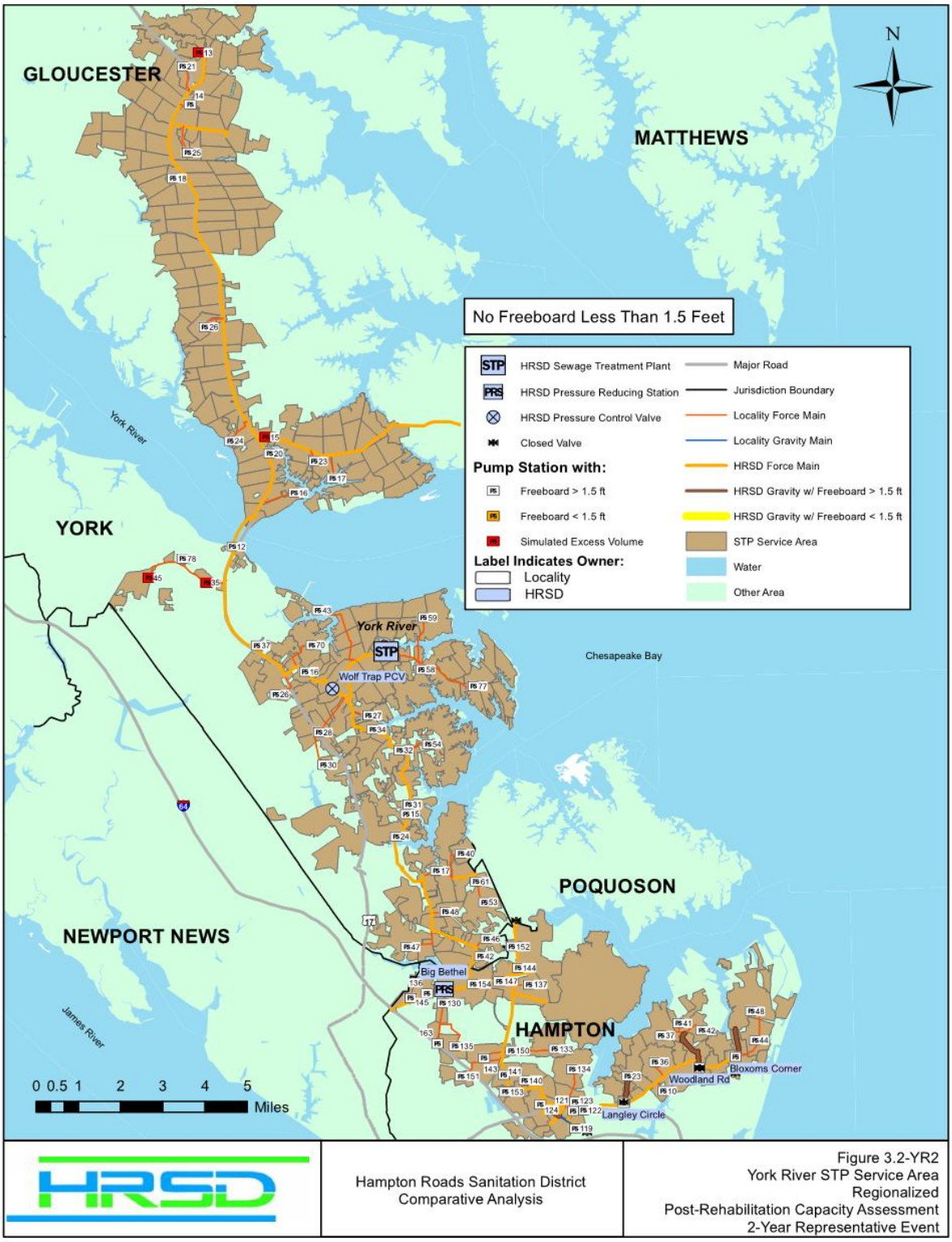
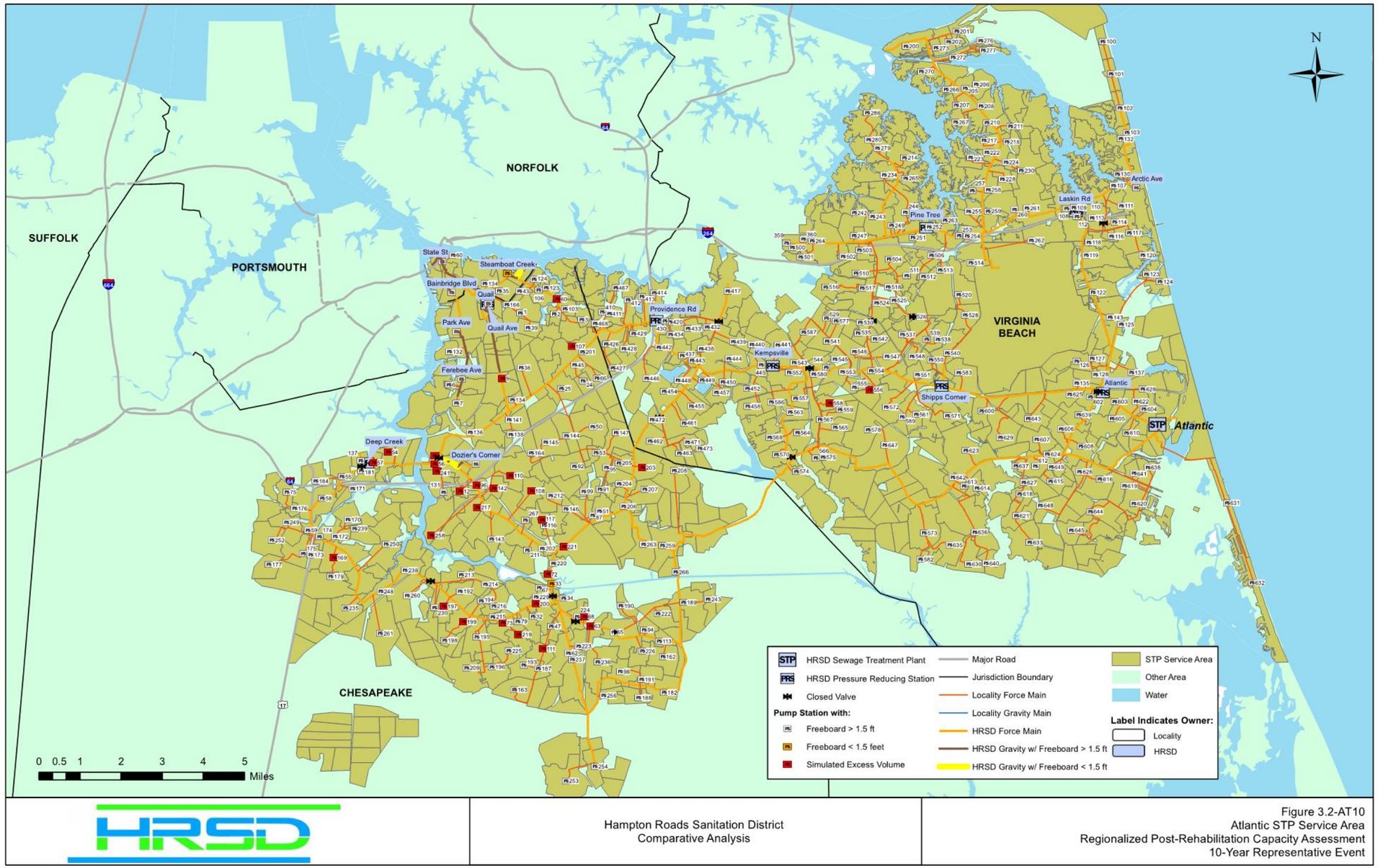


Figure 3.2-YR2

3.2.4.2 South Shore- 10-year and 2-year

Figure 3.2-AB10

Figure 3.2-AB2



Hampton Roads Sanitation District
Comparative Analysis

Figure 3.2-AT10
Atlantic STP Service Area
Regionalized Post-Rehabilitation Capacity Assessment
10-Year Representative Event

Figure 3.2-AT10

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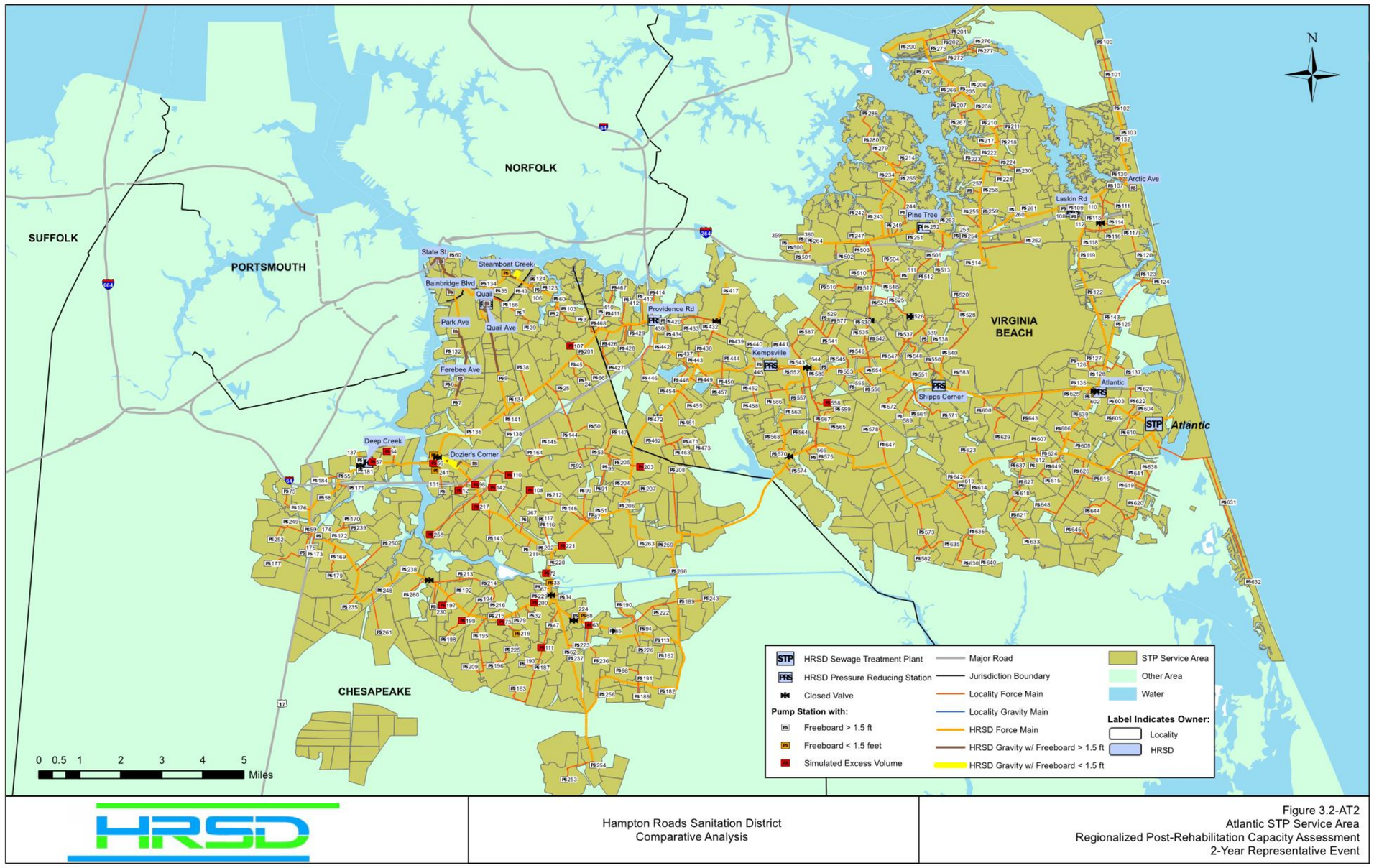

Figure 3.2-AT2

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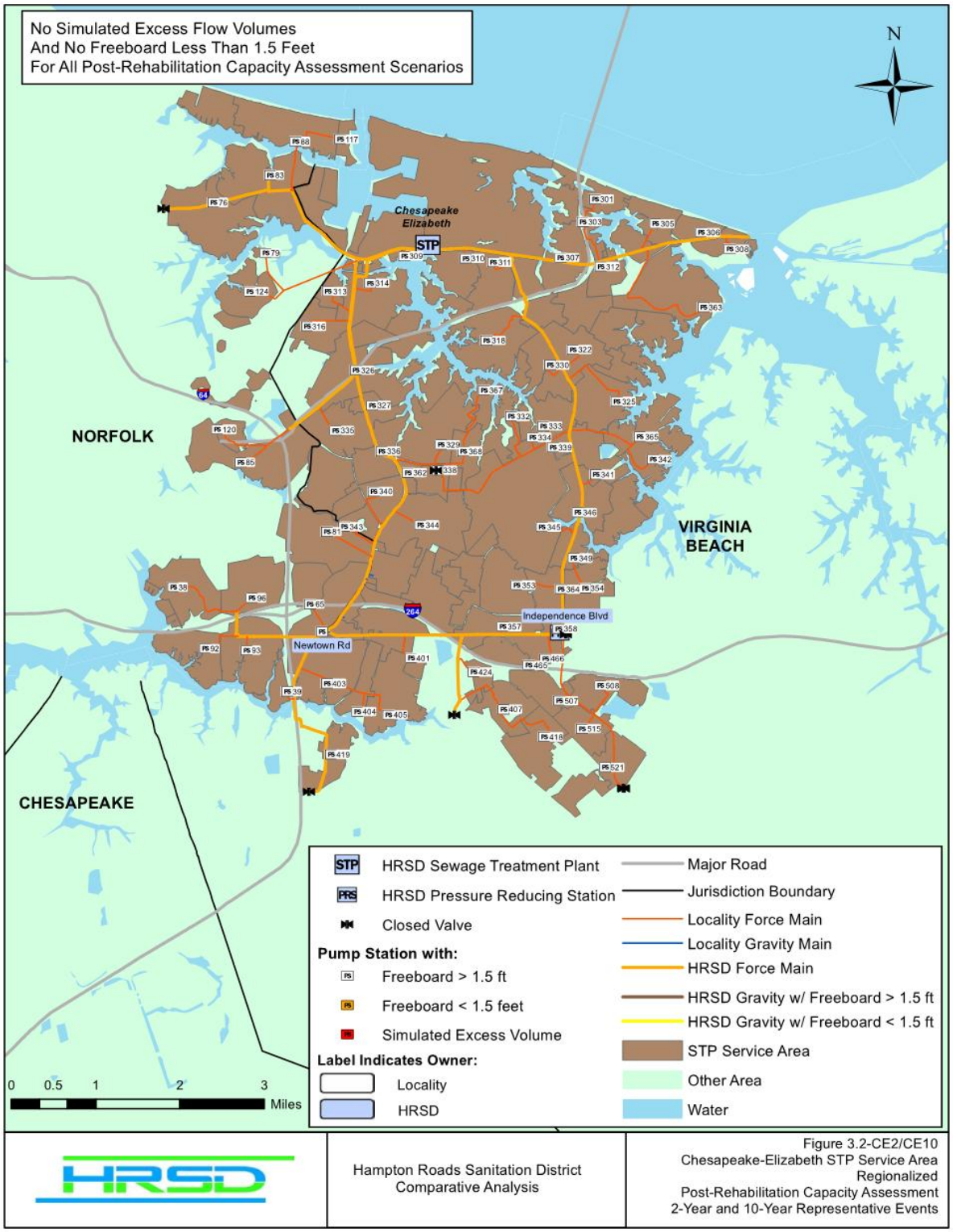

Figure 3.2-CE2/CE10

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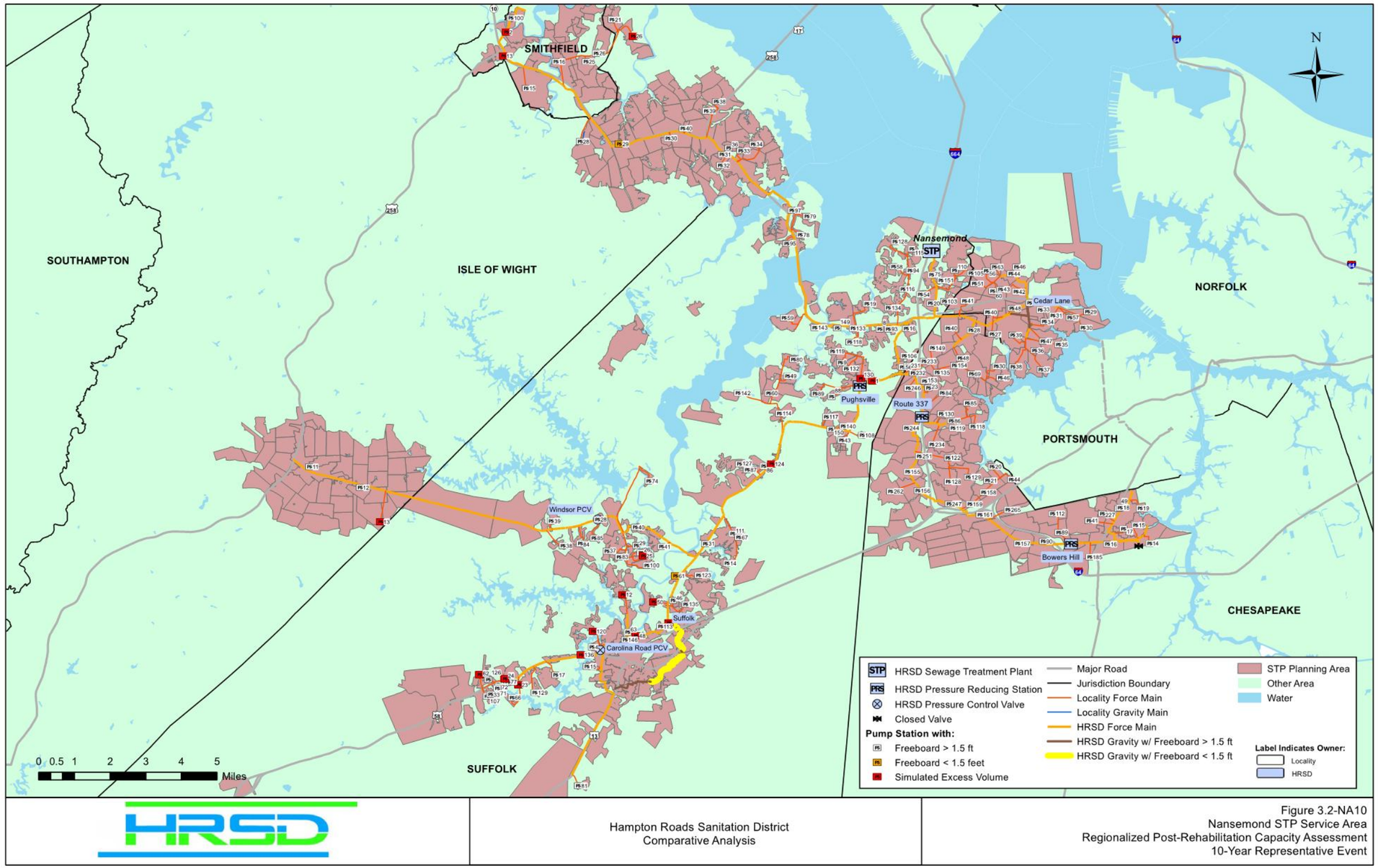

Figure 3.2-NA10

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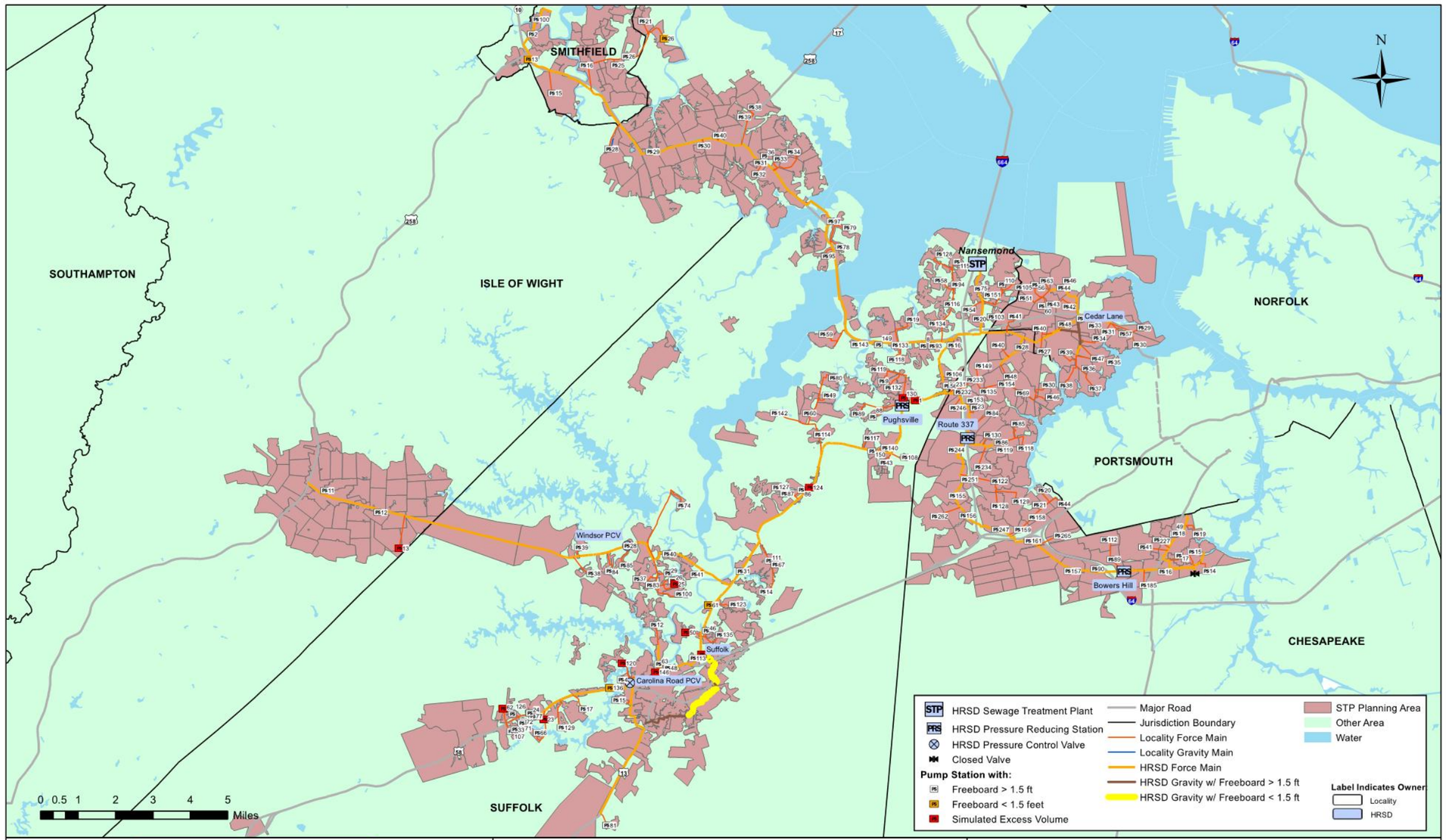

HRSD

Hampton Roads Sanitation District
Comparative Analysis

Figure 3.2-NA2
Nansemond STP Service Area
Regionalized Post-Rehabilitation Capacity Assessment
2-Year Representative Event

Figure 3.2-NA2

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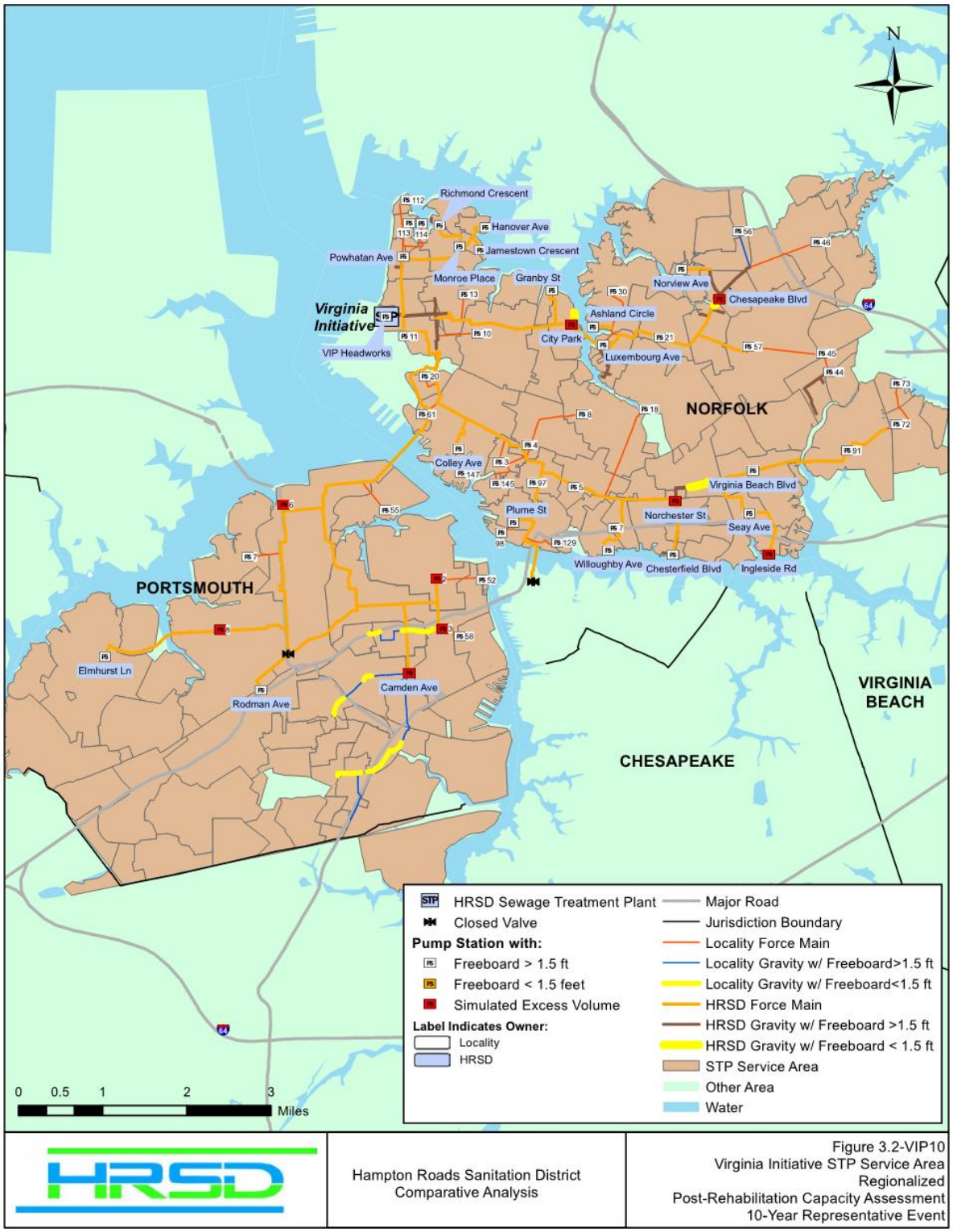

Figure 3.2-VIP10

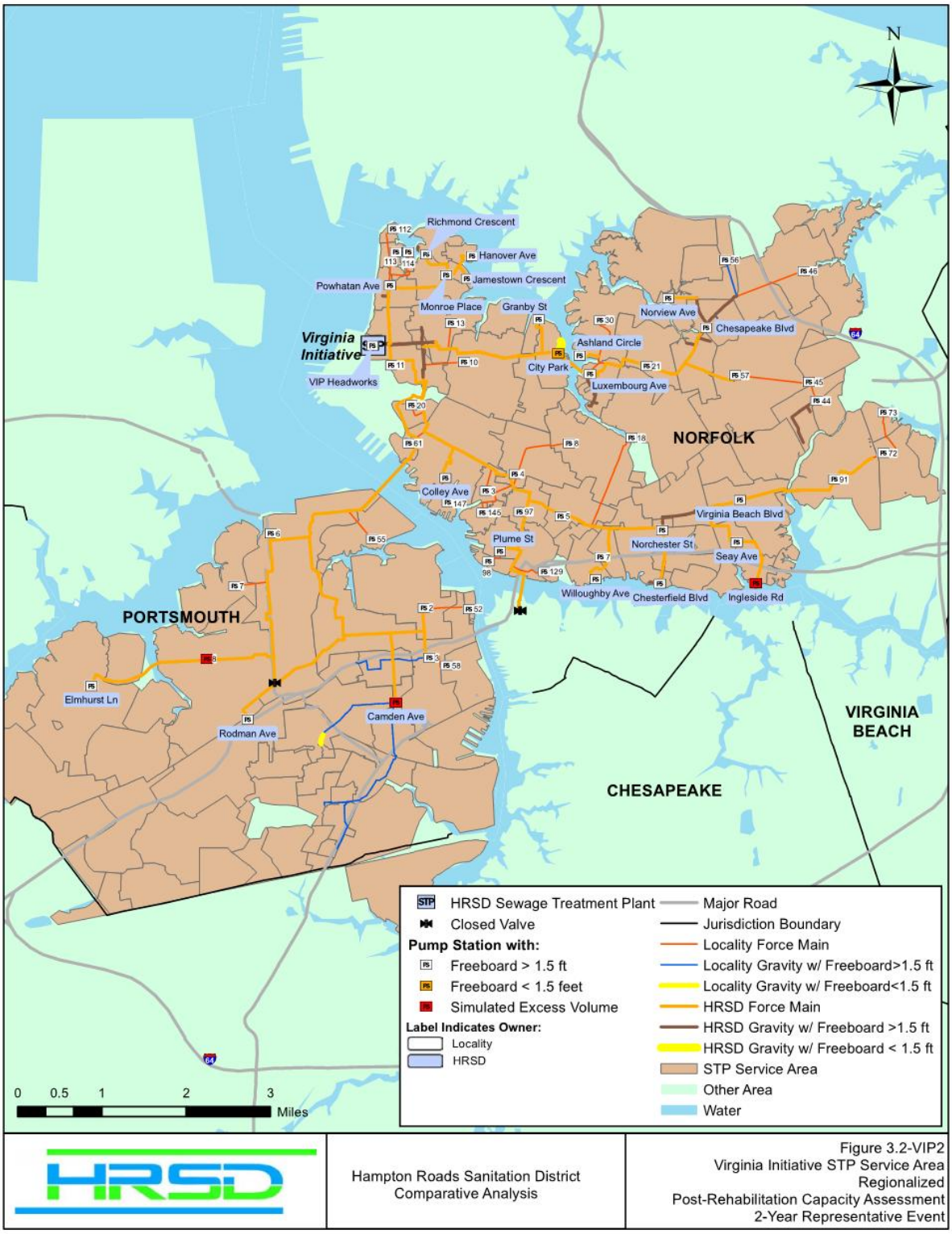

Figure 3.2-VIP2

3.3 Wet Weather Solution Sets

3.3.1 Solution Set Evaluation Approach

Teams that consisted of HRSD, BC and CDM Smith convened to examine the potential combination of solutions that could be implemented to eliminate SSOs and surcharge violations for both the 10-year level of service as well as the 2-year level of service using regionalized flow parameters. Solutions included:

- Terminal and HRSD pump station upgrades
- Upgrades or new pressure reducing stations
- Storage tanks
- Force main upgrades
- Force main improvements for measured high head loss
- Force main valving modifications
- Gravity main upgrades

Solution sets were examined on a treatment plant service area basis with subset areas used in larger treatment plant service areas to focus on localized issues within the larger service area. Maps of the service areas and subsets are included in Sections 3.3.3.

Also included in the wet weather improvements are HRSD planned projects such as the 51 Interim System Improvements identified in Section 1.3.3.2 as well as other Capital Improvement Plan projects that would improve the performance and capacity of the HRSD system.

3.3.2 Guidelines for WWMP Improvements

Analysis was performed of the resulting hydraulic grade line passing all the generated peak flows with respect to existing terminal pump station shut off head limitations. Through implementation of the above-mentioned infrastructure improvements and modifications, solution sets were developed for the 10-year and 2-year scenarios to reduce the hydraulic grade lines to accommodate most, if not all, of the existing terminal pump station limitations at peak flow conditions. In cases where terminal pump stations had particularly low shut off head limitations, upgrading the pump station was a better solution than additional measures to reduce the HGL.

Storage was considered to be the most cost effective improvement and therefore was generally considered as an initial improvement to determine its feasibility to resolve the issues. Because of the relatively high cost of treatment plant improvements, storage was considered preferentially.

3.3.3 Individual STP Service Area Improvements

Because each treatment plant service area has unique conveyance flow characteristics, infrastructure capacity, geography and assets, each service area will have a unique solution set of capacity improvements to eliminate all SSOs and surcharge violations for a given level of service.

3.3.3.1 North Shore- 10-year and 2-year

The solution types and quantities associated with the North Shore solution sets developed in the regionalized approach are listed in Table 3-7. For maps of the North Shore regionalized wet weather solutions for the 2 and 10-year scenarios, see Figures 3.3-BH10 through 3.3-YR2.

Table 3-7. North Shore Solution Sets in Regionalized Approach			
TP	SOLUTION TYPE	10-YEAR SOLUTIONS	2-YEAR SOLUTIONS
BOAT HARBOR	Upsize FM	2,500 LF 18"	NONE
JAMES RIVER	Upgrade PS	2	1
	New PRS	1	
	Storage	1 site / 1.9 MG total	
WILLIAMSBURG	Upgrade PS	6	
	New PRS	2	1
	Upsize FM	5,537 LF of 36” 26,000 LF of 42”	13,500 LF of 36” 26,000 LF of 42”
	Storage	3 sites / 5.9 MG total (includes 1.4 MG EQ at WBTP)	2 sites / 2.0 MG total
YORK RIVER	Upgrade PS	1	
	New PRS	1	
	Upsize FM	284 LF of 16” 26,200 LF of 24”	284 LF of 16” 26,200 LF of 24”

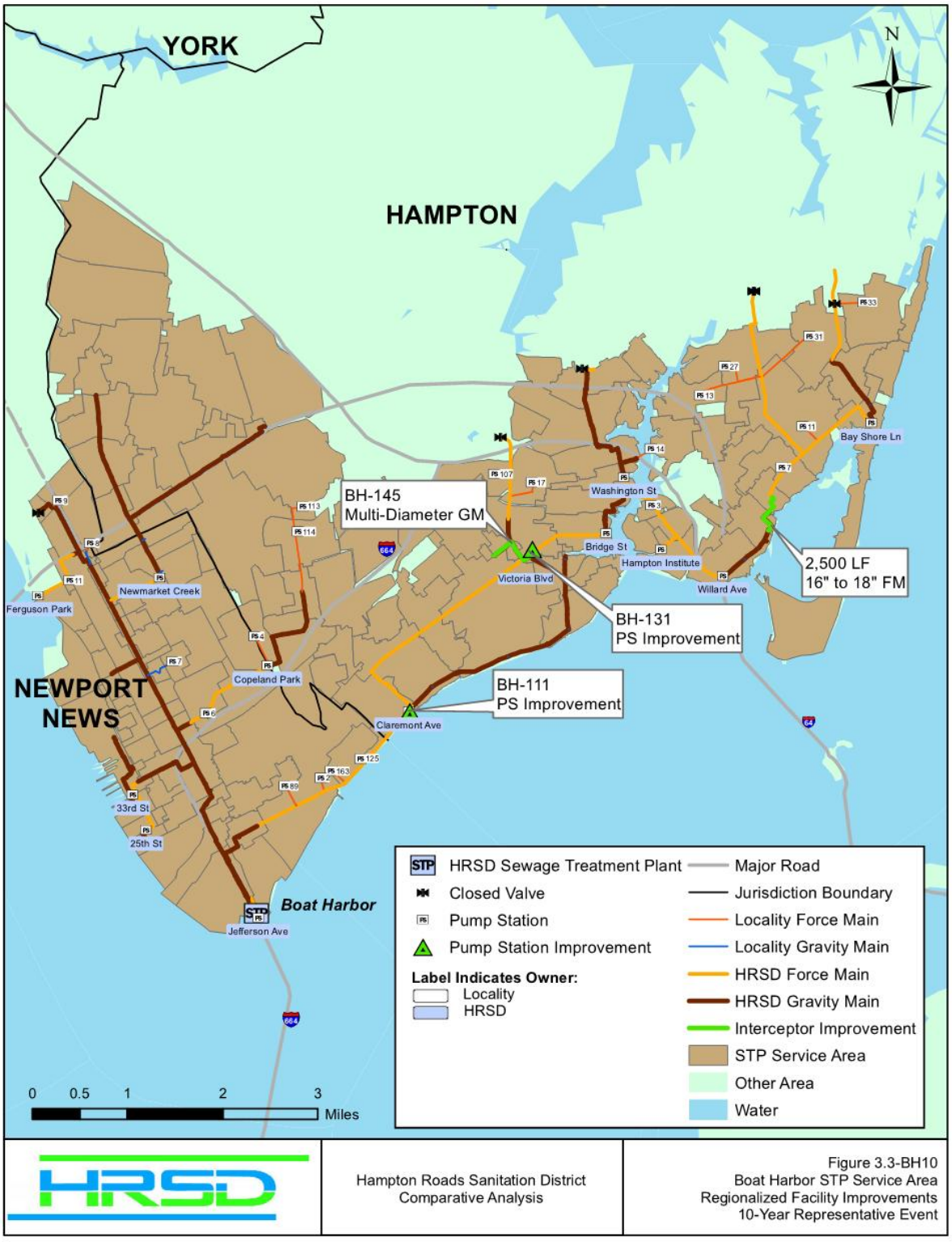

Figure 3.3-BH10

Figure 3.3-BH2

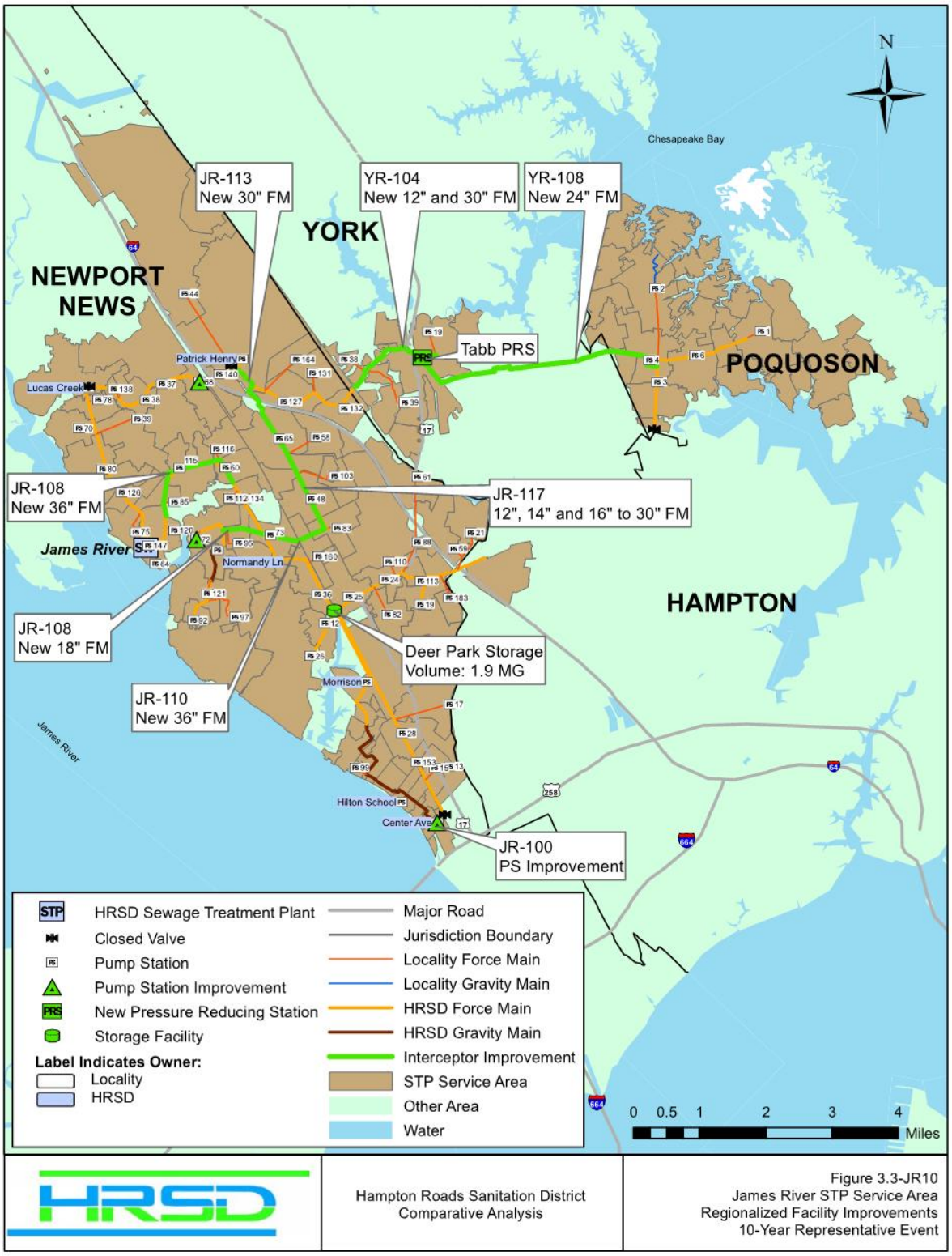

Figure 3.3-JR10

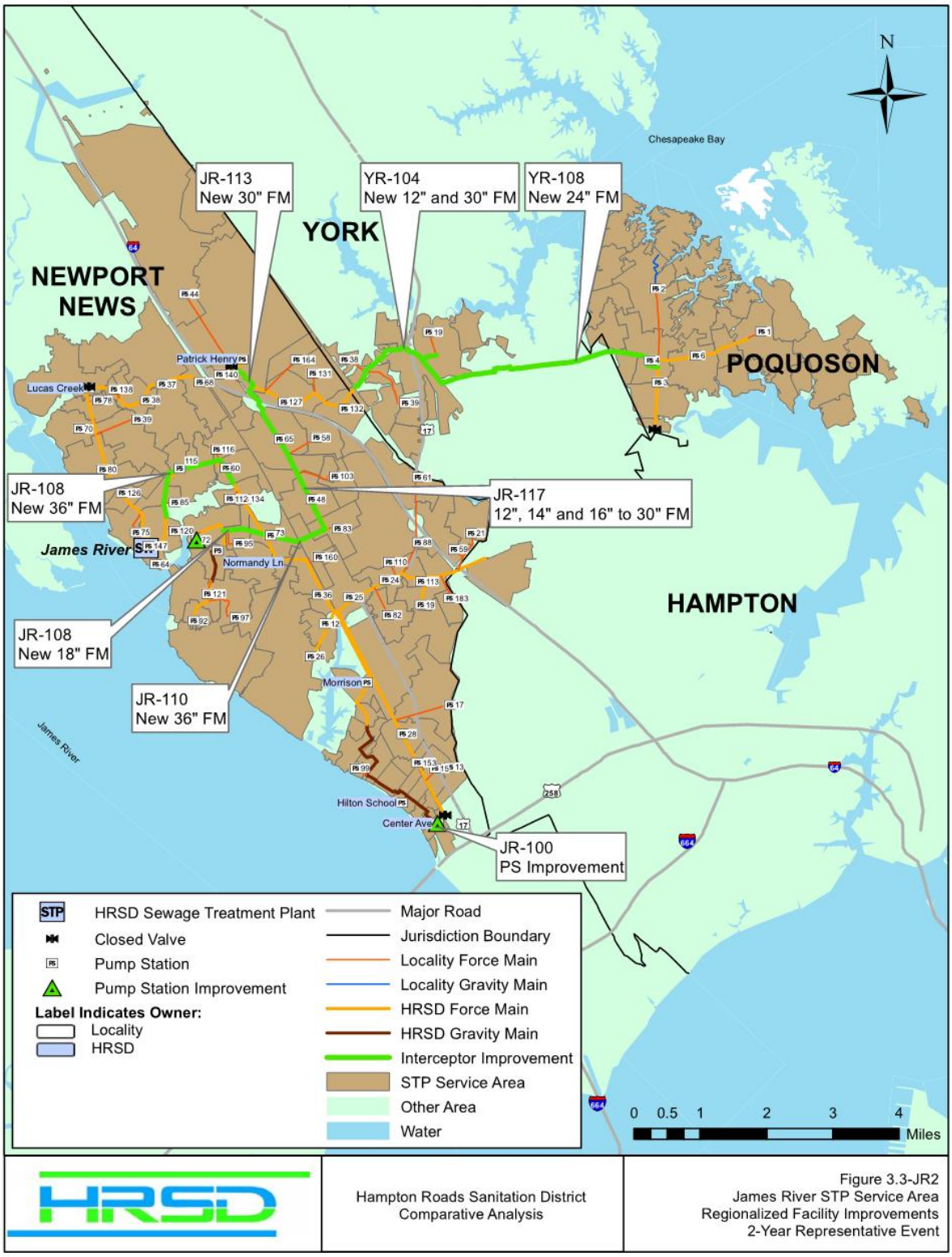

Figure 3.3-JR2

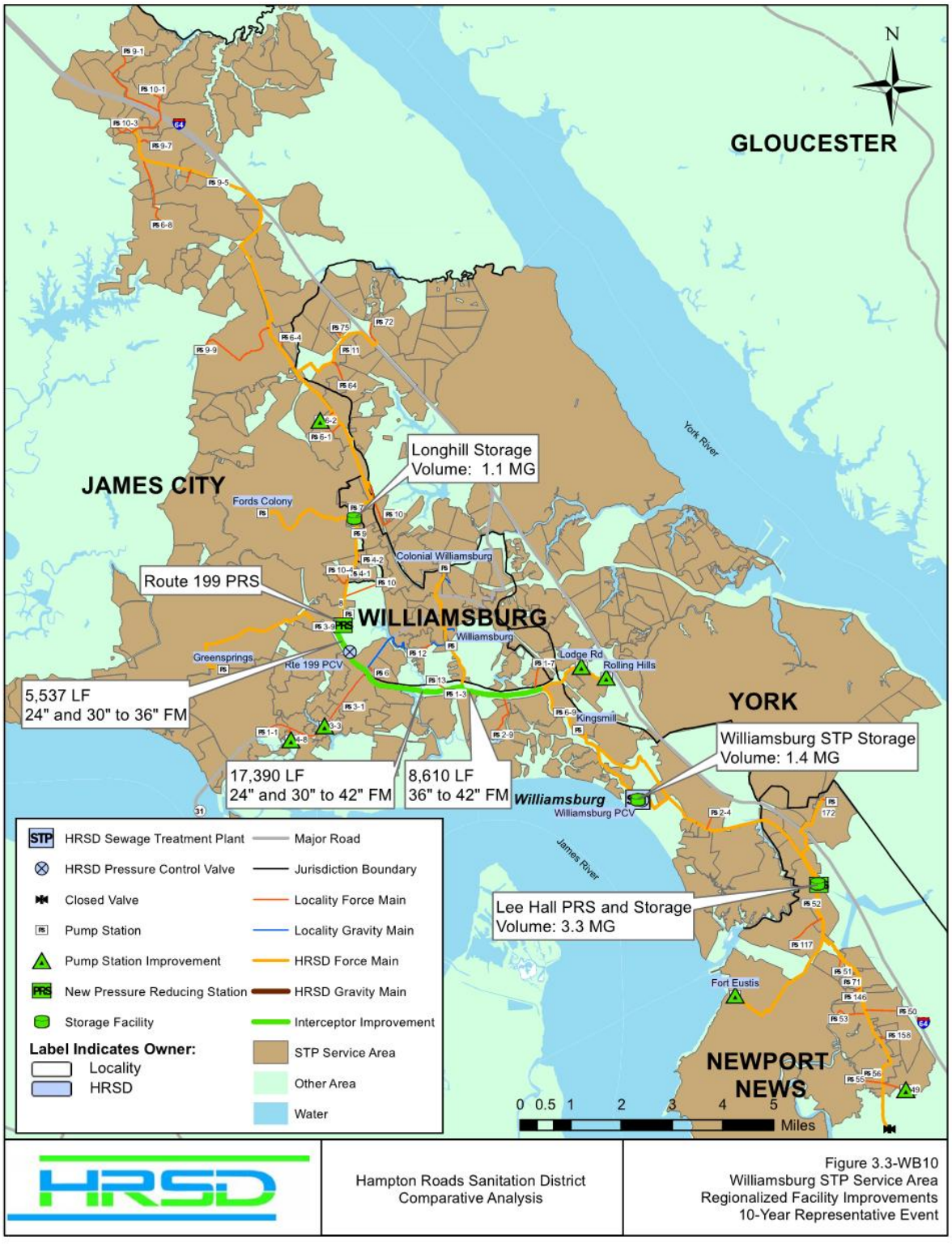

Figure 3.3-WB10

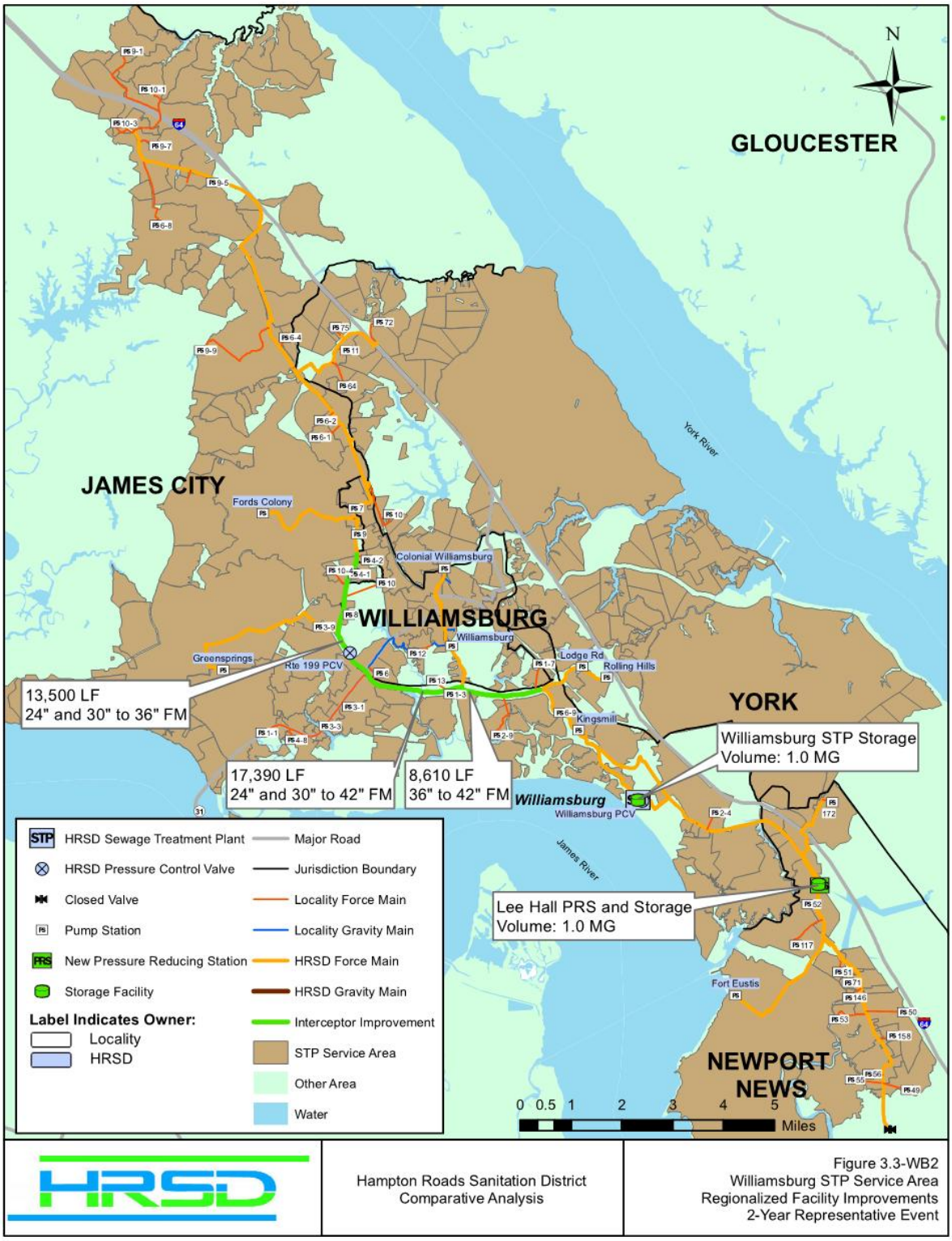

Figure 3.3-WB2

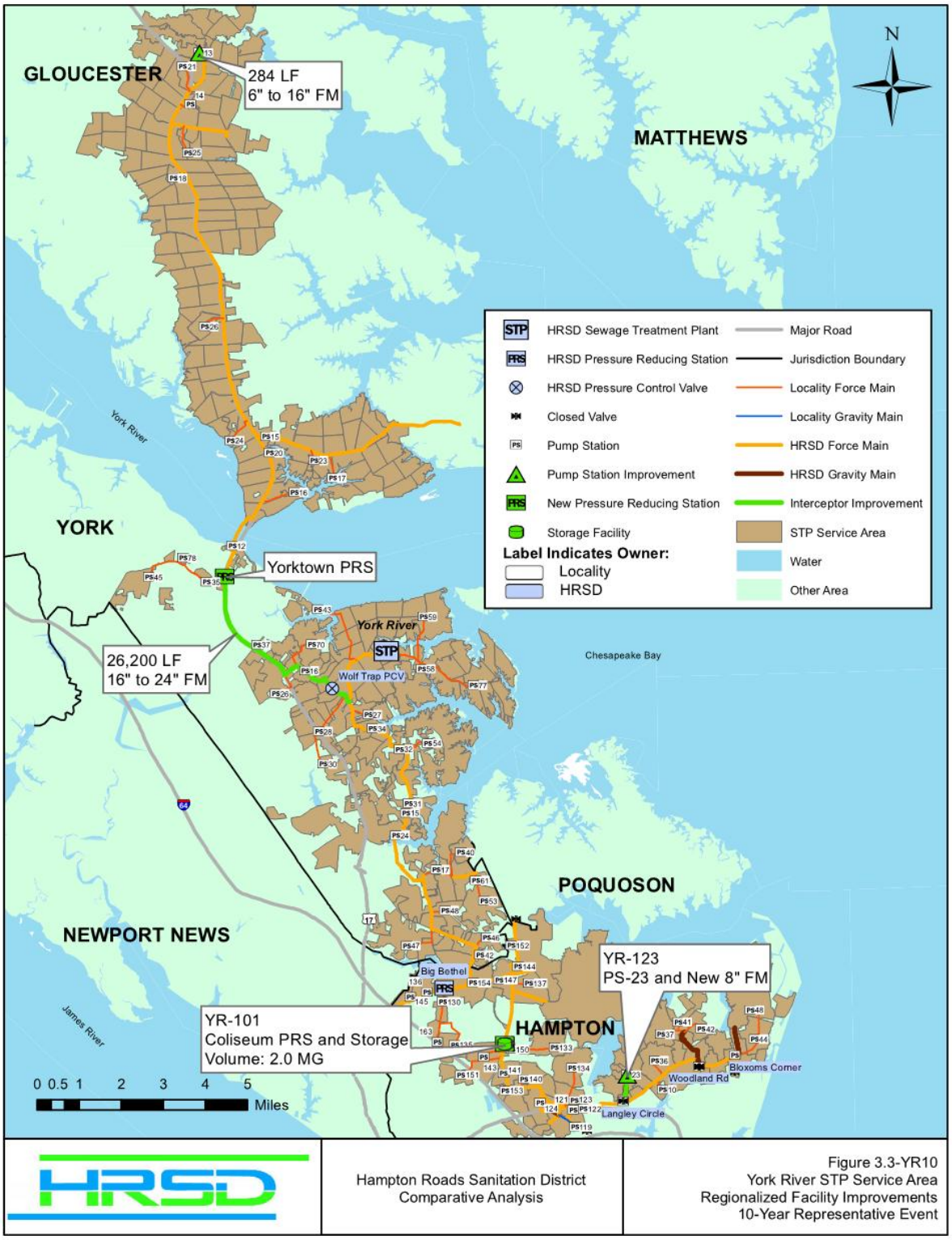

Figure 3.3-YR10

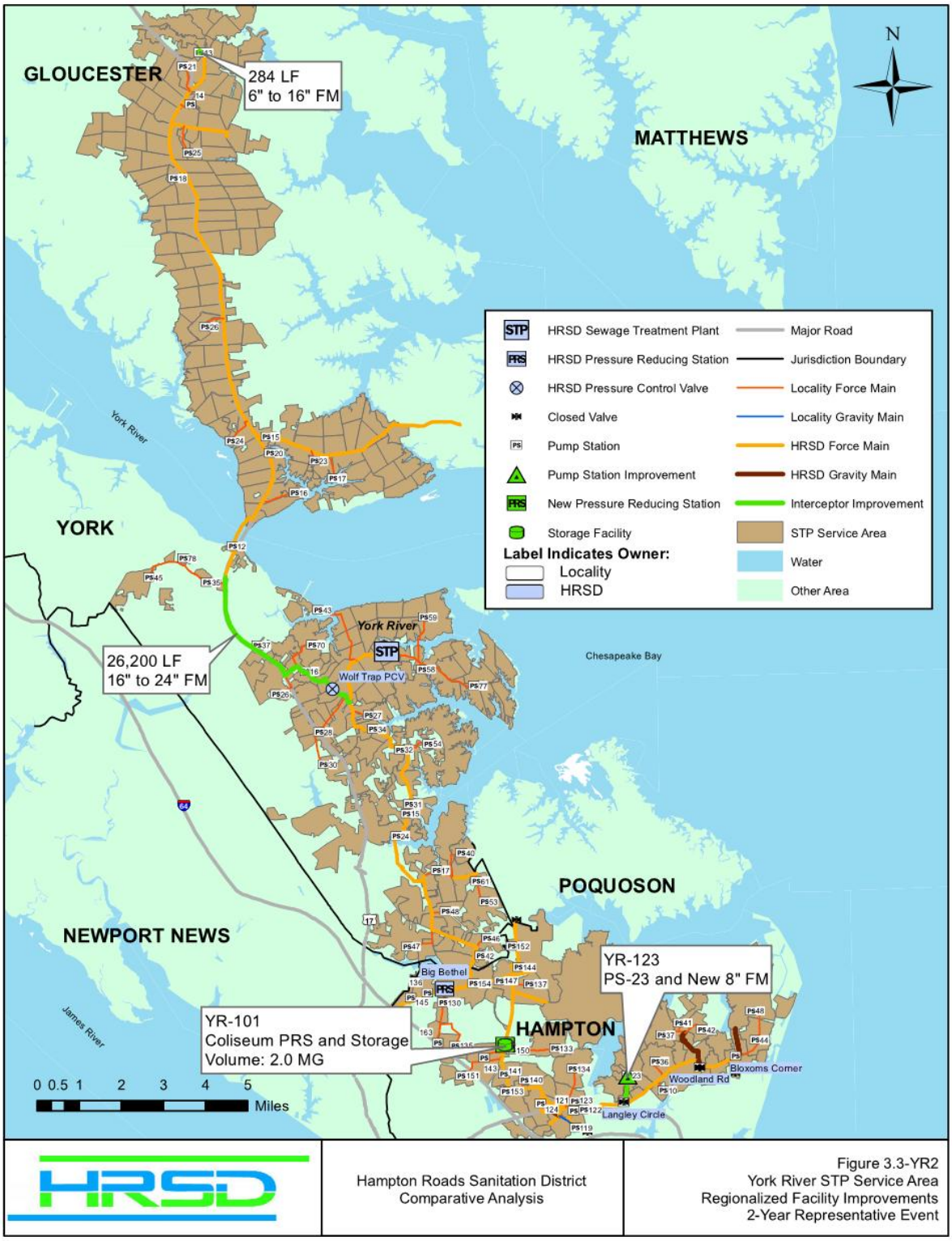

Figure 3.3-YR2

3.3.3.2 South Shore- 10-year and 2-year

The quantities associated with the South Shore solution sets developed in the regionalized approach are listed in Table 3-8. For maps of the South Shore regionalized wet weather solutions for the 10-year and 2-year scenarios, see Figures 3.3-AB10 through 3.3-VIP2.

Table 3-8. South Shore Solution Sets in Regionalized Approach

TP	SOLUTION TYPE	10-YEAR SOLUTIONS	2-YEAR SOLUTIONS
ARMY BASE	Upgrade PS	8	5
	Upsize FM	450 LF of 30” 20 LF of 20”	450 LF of 30” 20 LF of 20”
ATLANTIC	Upgrade PS	12	9
	Upgrade PRS	3	1
	New PRS	3	3
	Upsize FM	1,850 LF of 16”	
	New force main	20,090’ of 24” (c factor adjustment)	20,090 LF of 24” (c factor adjustment)
	Storage	5 sites / 16.6 MG total	3 sites / 4.9 MG total
CHES-ELIZ		NONE	NONE
NANSEMOND	Upgrade PS	2	1
	New PRS	1	1
	Upsize FM	32,230 LF 42” 8,500 LF of 48” 4,400 LF of 48” 3,000 LF of 54”	32,230 LF of 42” 8,500 LF of 48” 4,400 LF of 48”
	New force main	63,200 LF of 30” (c factor adjustment)	63,200 LF of 30” (c factor adjustment)
	Upsize gravity	8,600 LF of 24” 5,500 LF of 30”	3,600 LF of 24” 5,500 LF of 30”
	Storage	1 site / 2.3 MG total	1 site / 1 MG total
VIP	Upgrade PS	12	7
	Upsize FM	2,250 LF of 30”	
	Upsize gravity	3,030 LF of 30” 5,570 LF of 18”	5,570 LF of 18”
	Storage	3 sites / 3.5 MG	

**Ches-Eliz flows were significantly reduced on the 2030 valving configuration to meet nutrient removal requirements.*

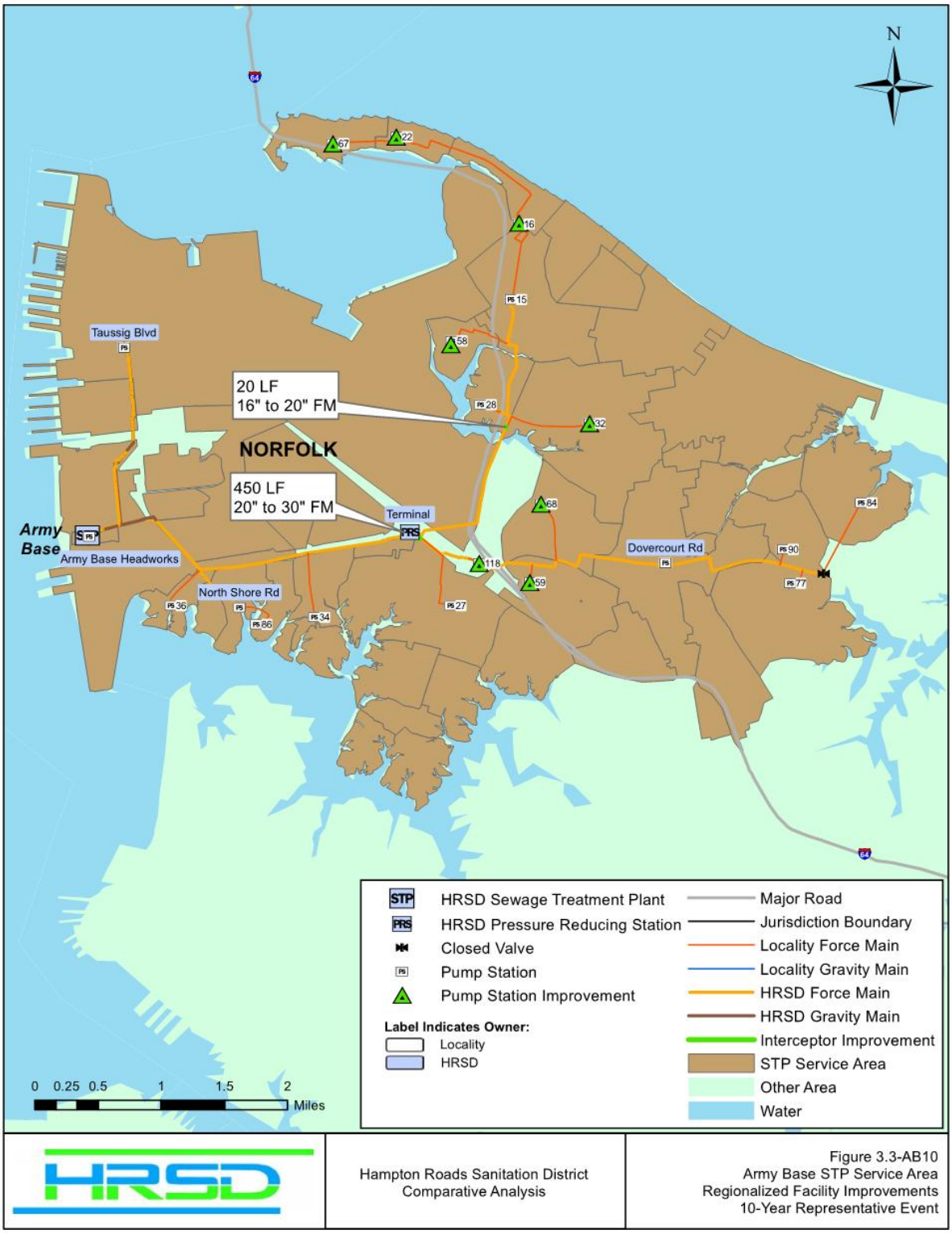

Figure 3.3-AB10

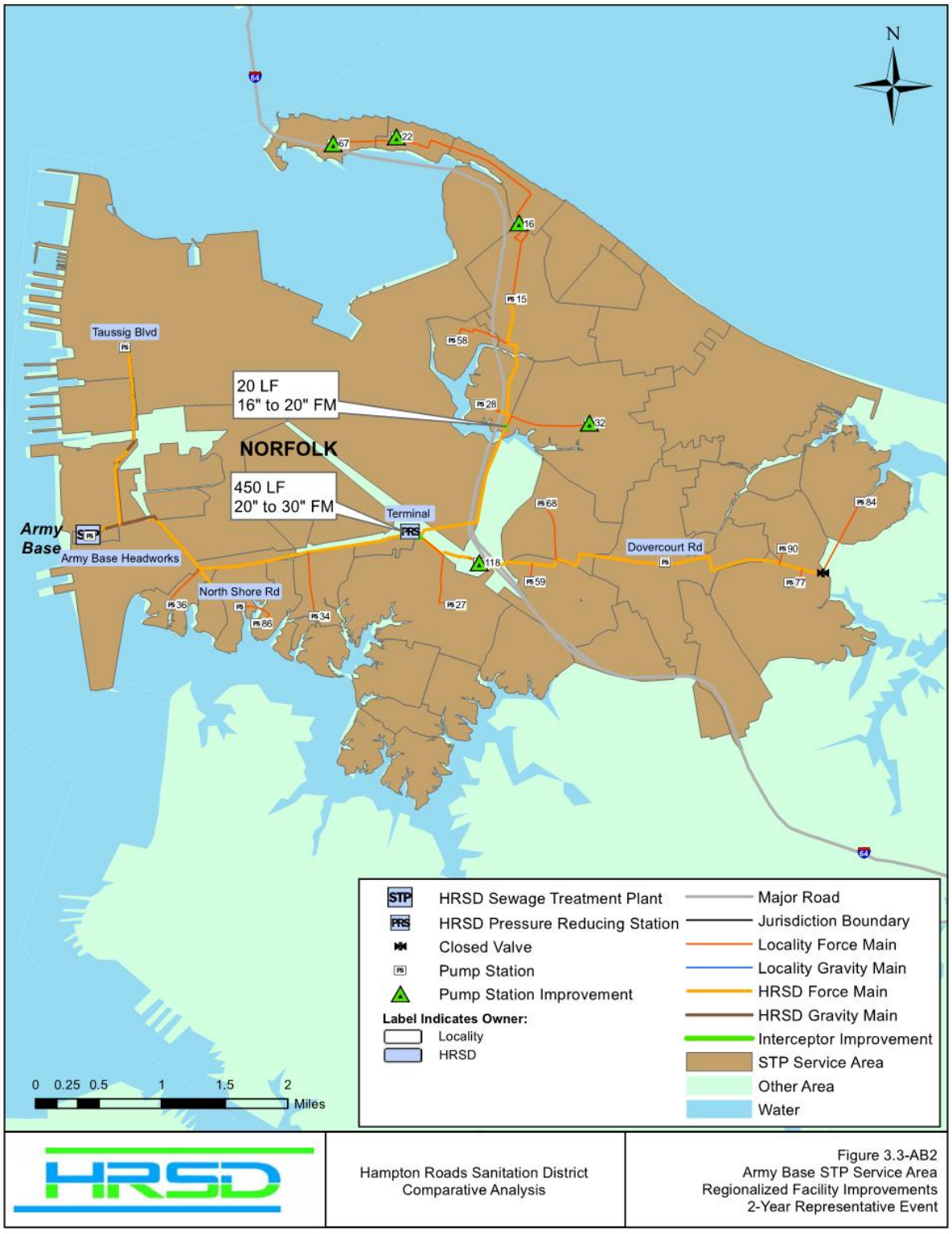

Figure 3.3-AB2

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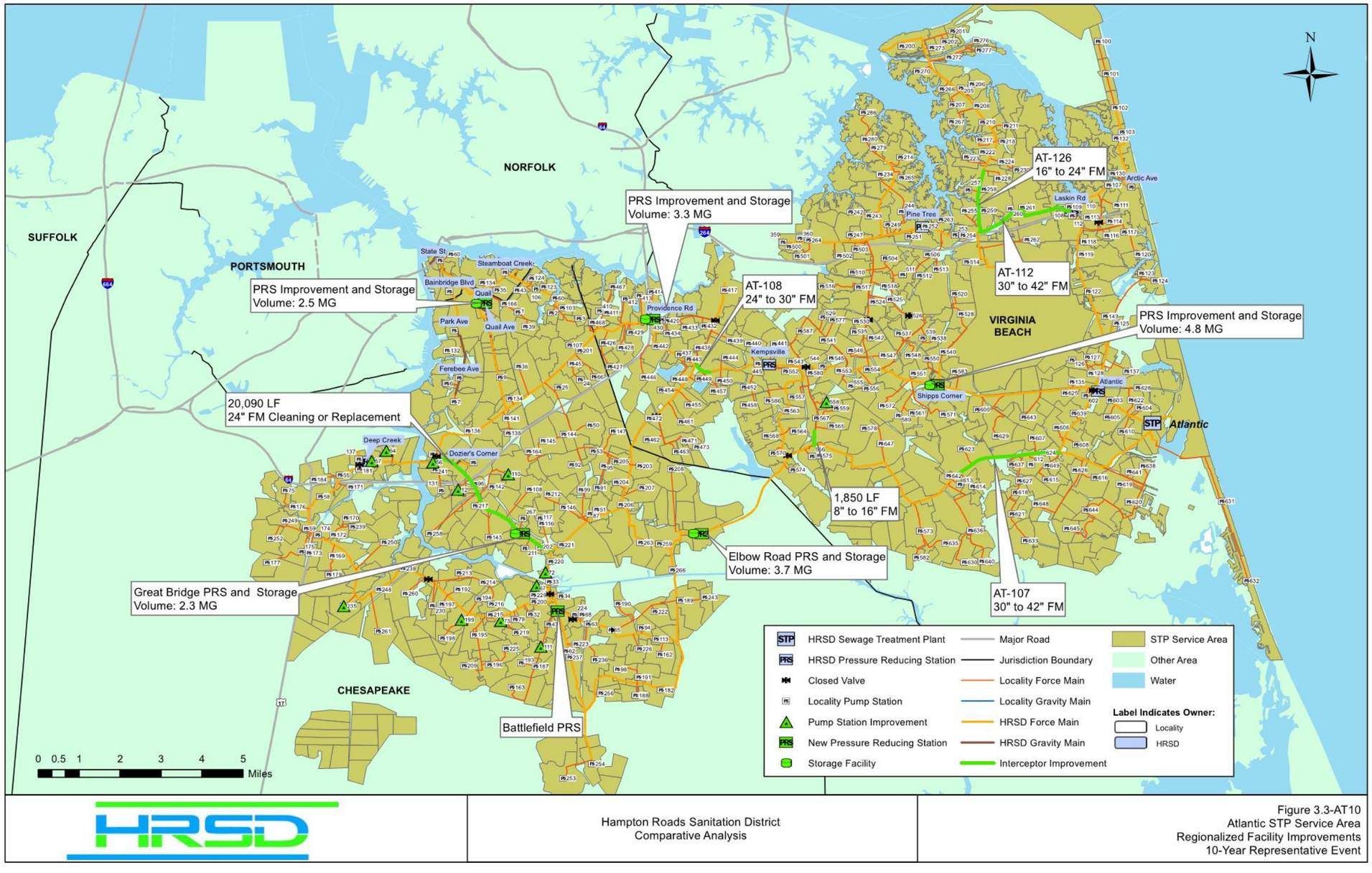

Figure 3.3-AT10

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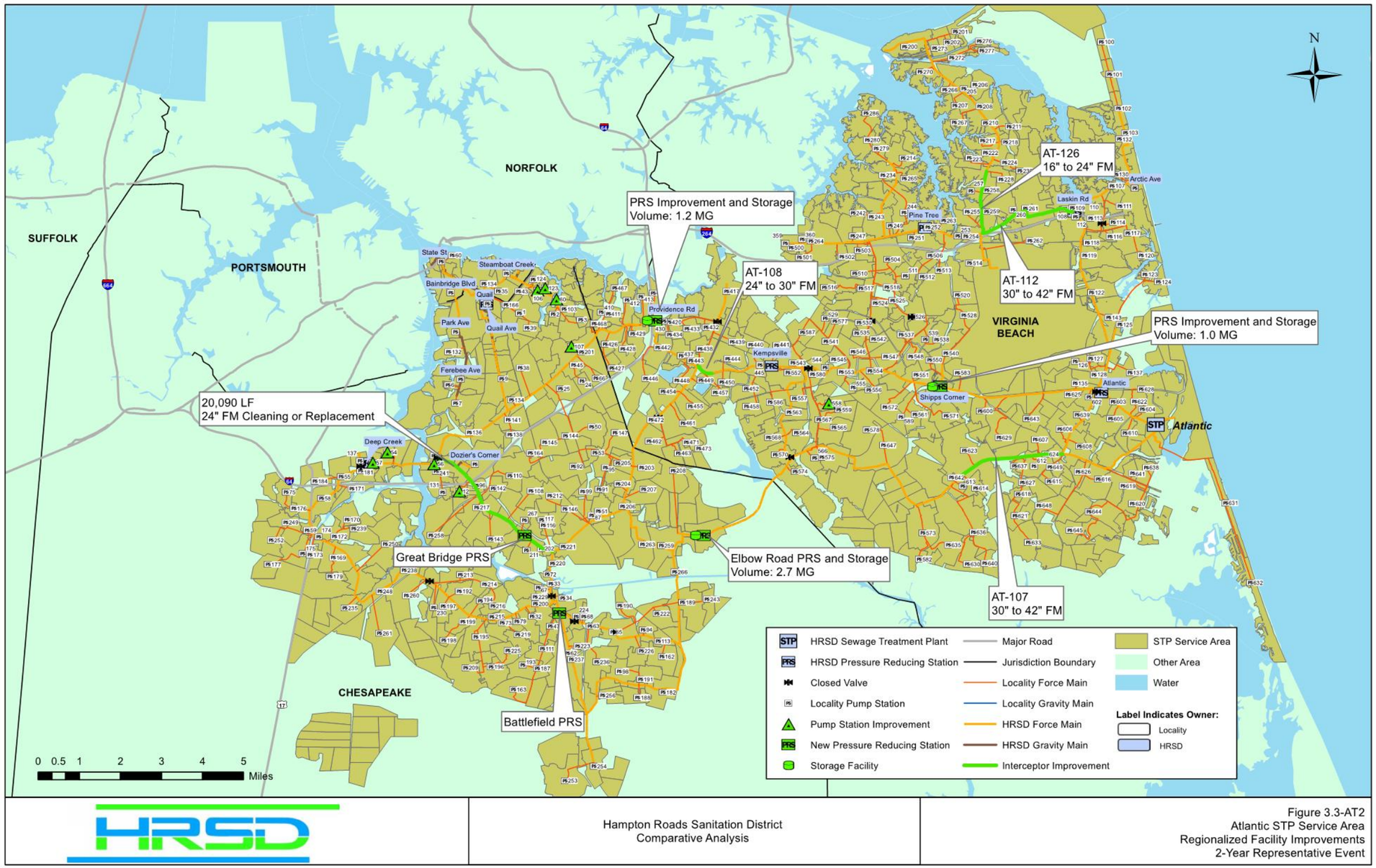

Figure 3.3-AT2

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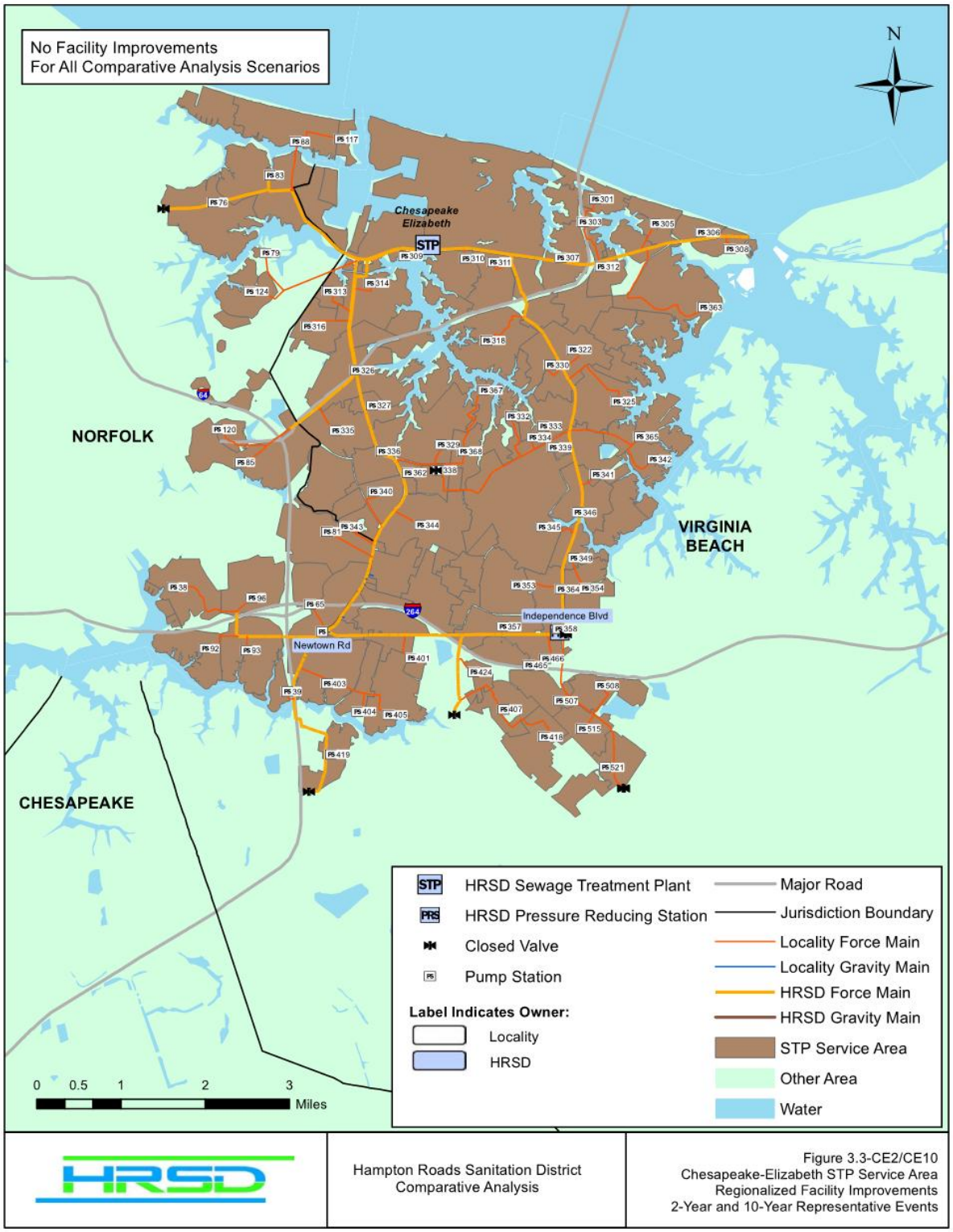

Figure 3.3-CE2/CE10

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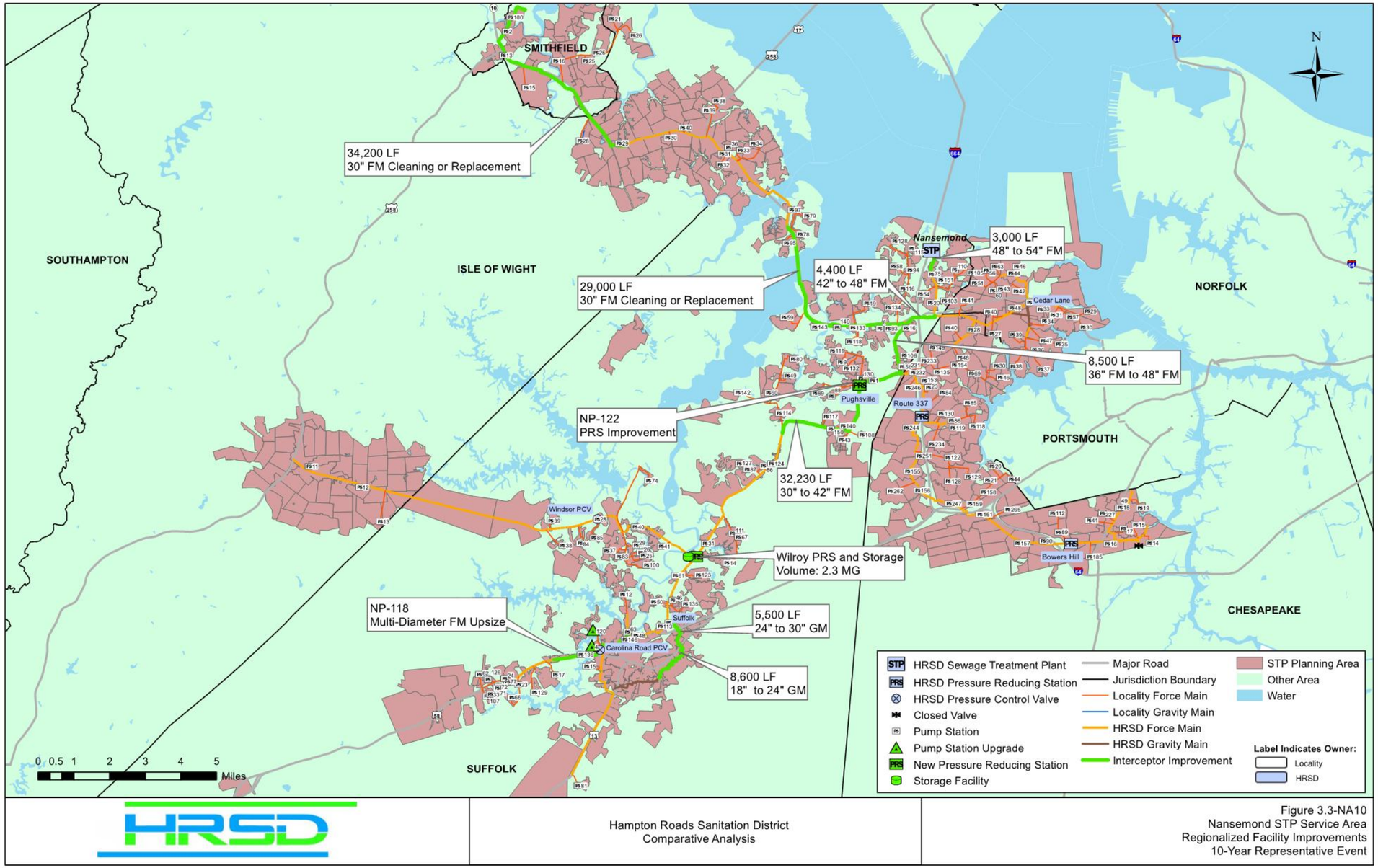

Figure 3.3-NA10

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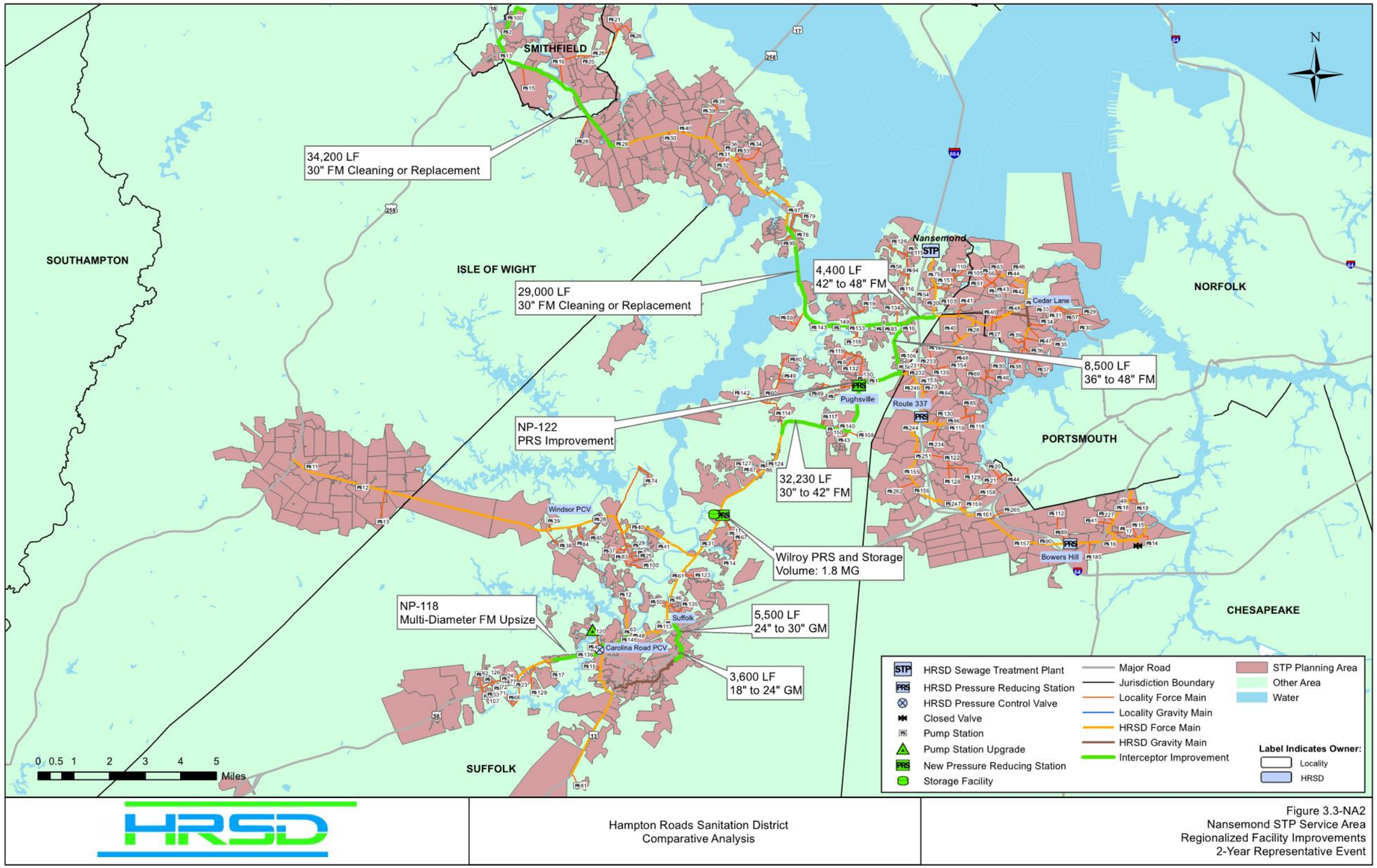

Figure 3.3-NA2

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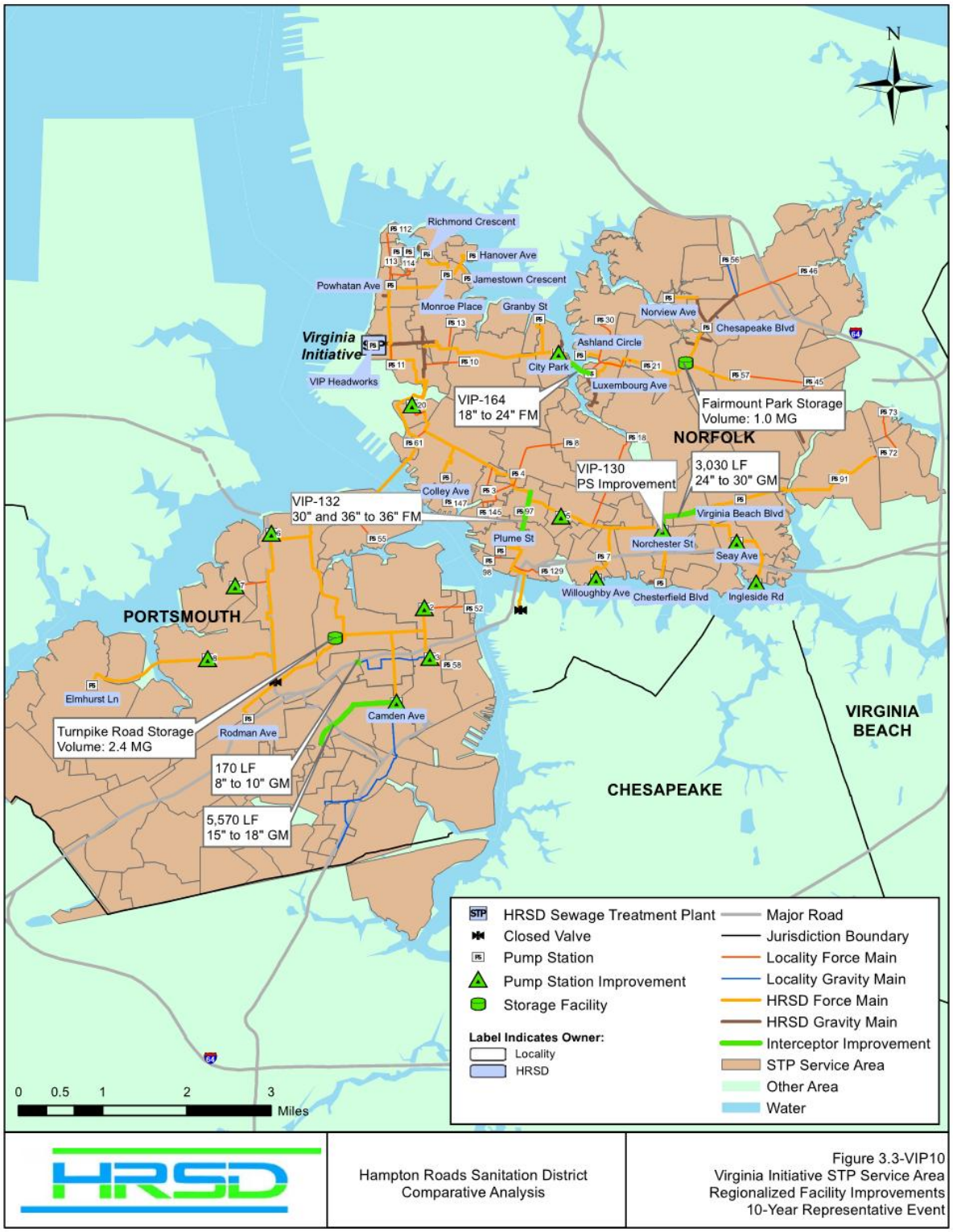

Figure 3.3-VIP10

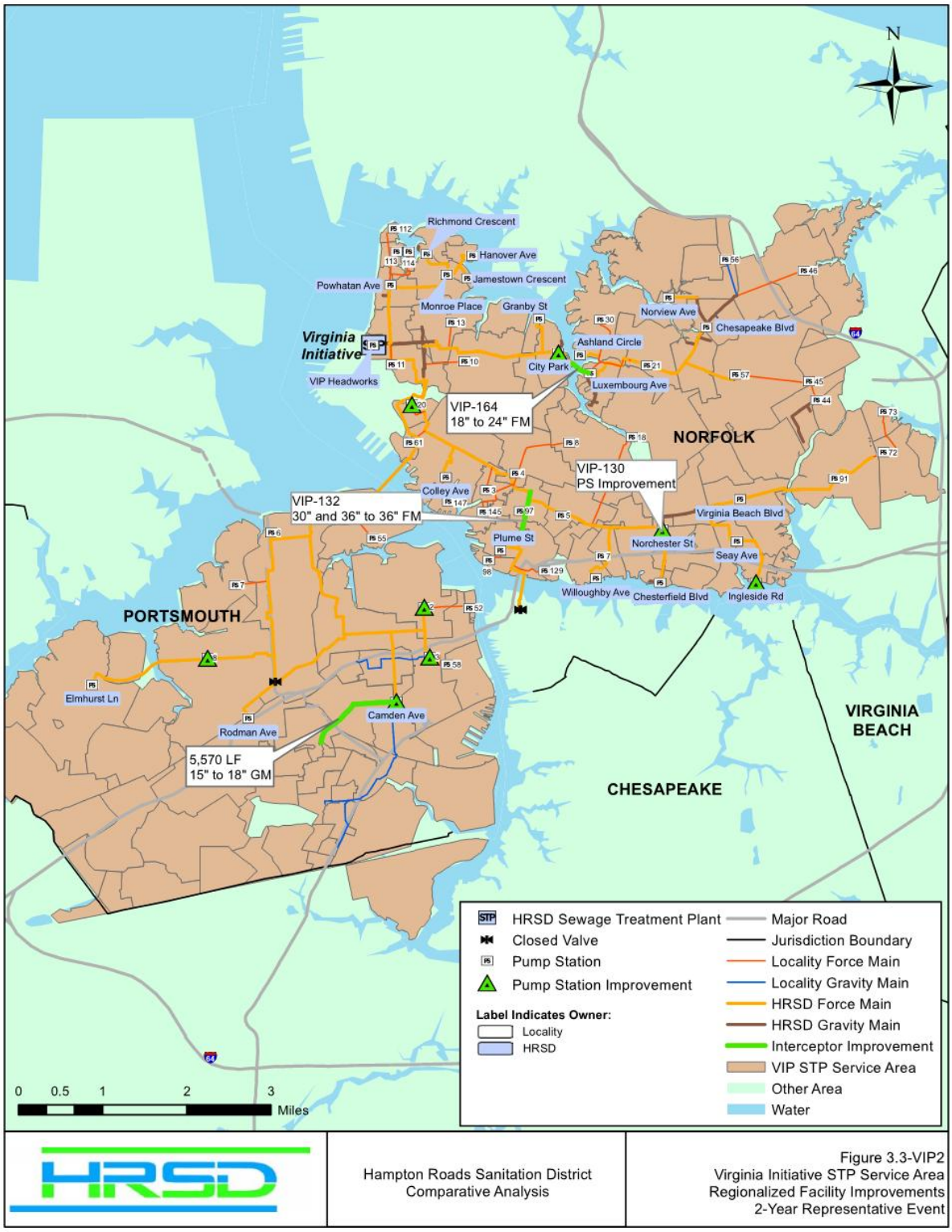

Figure 3.3-VIP2

3.3.4 Upstream Capacity Improvements

The costs for improvements to the sanitary sewer systems upstream from the RHM needed to address SSOs and freeboard violations are included in the Comparative Analysis. These costs include gravity sewer improvements, terminal pump station improvements and lift station improvements. The basis for determining the need for improvements came from the Localities' capacity assessment reports. Because the reports were done by various consultants serving various clients, there are significant differences in methodologies and information provided in the reports. The Comparative Analysis attempted to develop costs across Localities in a uniform manner based on the information that was available. The methodology was identical for the regionalized scenario as it was for the non-regionalized scenario described in Section 2.3.4.

3.3.5 Cost for Improvements

Costs were calculated for the wet weather improvements and upstream capacity improvements based on local cost data. See cost estimation methodology in Section 1.3.4 and 2.3.5 for additional details. By applying the cost functions to the wet weather solutions and upstream capacity improvements, costs were calculated by treatment plant service area as shown on Tables 3-9 and 3-10. Costs noted for various treatment plant service areas are HRSD ISI projects that cannot be assigned to any one service area such as SCADA system upgrades and air vent replacements and rehabilitation. No regional wet weather improvements were needed in the Ches-Eliz treatment plant service area because no SSOs or surcharge violations were recorded in the RHM. Upstream capacity improvements are shown in the Ches-Eliz service area because the Locality indicated deficiencies that cause SSOs or surcharge violations in upstream portions of the system that are not included in the RHM. The cost for that location is slightly higher than the non-regionalized scenario since there is no I/I abatement in this scenario which would have reduced the amount of Upstream Capacity Improvements.

Table 3-9. 10-year Regionalized Capacity Improvements

STP Service Area	Regional Wet Weather Improvements	Upstream Cap Improvements
AB	$ 10,320,000	$ 13,669,000
AT	$ 143,382,000	$ 86,822,000
BH	$ 23,035,000	$ 75,000,000
CE	$ -	$ 18,800,000
JR	$ 75,838,000	$ 20,109,000
NA	$ 148,414,000	$ 8,612,000
VIP	$ 68,696,000	$ 56,592,000
WB	$ 93,658,000	$ 33,330,000
YR	$ 51,945,000	$ 11,245,000
VARIOUS	$ 19,850,000	$ -
TOTAL	**$ 635,138,000**	**$ 324,179,000**

Table 3-10. 2-year Regionalized Capacity Improvements		
STP Service Area	Regional Wet Weather Improvements	Upstream Cap Improvements
AB	$ 10,320,000	$ 8,017,000
AT	$ 98,337,000	$ 41,126,000
BH	$ 21,572,000	$ 27,100,000
CE	$ -	$ 10,700,000
JR	$ 64,116,000	$ 7,579,000
NA	$ 139,779,000	$ 4,681,000
VIP	$ 50,398,000	$ 41,524,000
WB	$ 69,641,000	$ 8,800,000
YR	$ 48,877,000	$ 1,400,000
VARIOUS	$ 19,850,000	$ -
TOTAL	**$ 522,890,000**	**$ 150,927,000**

3.4 Summary of Regionalized Scenario WWMP

3.4.1 Peak Flow Reductions

The projections for rehabilitation including estimated costs, proposed regionalized flow reductions in peak hour MGD and by percentage of I/I flow and an associated cost per gpd for the public rehabilitation for the 10-year and 2-year scenarios are listed in Tables 3-11 and 3-12.

Table 3-11. 10-year Flows for Regionalized Scenario					
TREATMENT PLANT ID	Pre-Rehab		REGIONALIZED		
	2030 10-year Peak Flows (mgd)	10-year Peak Flow I/I (mgd)	Peak Flow Reduction (mgd)	Peak Flow I/I Reduction (%)	2030 10-year Reduced Peak Flows (mgd)
AB	42.71	34.23	2.12	6.2%	40.59
AT	230.09	181.71	33.96	18.7%	196.14
BH	71.54	61.14	14.32	23.4%	57.23
CE	64.51	52.74	0.00	0.0%	64.51
JR	73.68	59.45	10.10	17.0%	63.59
NA	104.25	77.56	22.45	28.9%	81.85
VIP	141.73	119.80	19.69	16.4%	122.04
WB	86.24	68.42	16.76	24.5%	69.51
YR	48.14	36.89	7.89	21.4%	40.21
Grand Total	**862.90**	**691.96**	**127.28**	**18.4%**	**735.65**
Notes:	*I/I reduction from HRSD gravity pipes is included as part of the Public PHF Reduction values.*				
	Peak flows were calculated as the sum of the 10-year peak flow from each catchment.				

Table 3-12. 2-year Flows for Regionalized Scenario					
	Pre-Rehab		REGIONALIZED		
TREATMENT PLANT ID	2030 10-year Peak Flows (mgd)	10-year Peak Flow I/I (mgd)	Peak Flow Reduction (mgd)	Peak Flow I/I Reduction (%)	2030 10-year Reduced Peak Flows (mgd)
AB	32.46	23.97	1.36	5.7%	31.10
AT	169.01	120.76	23.18	19.2%	145.81
BH	58.16	47.74	10.69	22.4%	47.47
CE	46.57	34.68	0.00	0.0%	46.57
JR	57.23	42.62	6.81	16.0%	50.44
NA	84.30	57.22	16.34	28.6%	67.97
VIP	100.84	79.08	12.79	16.2%	88.05
WB	67.57	49.62	12.11	24.4%	55.47
YR	36.66	25.18	5.21	20.7%	31.40
Grand Total	**652.8**	**480.9**	**88.5**	**18.4%**	**564.3**

3.4.2 Costs 10-year and 2-year

The total costs for the 10-year and 2-year regionalized scenario including rehabilitation by treatment plant service area are listed in Tables 3-13 and 3-14. Because the flows are greater in the 10-year scenario, a greater reduction in flow rate would be achieved by the same amount of rehabilitation. Rehabilitation and regional wet weather improvements costs shown in the "various" STP service area category are projects that span more than one service area.

Table 3-13. 10-year Regionalized Scenario Costs					
	Regional Wet Weather Improvements	Upstream Cap Improvements	Rehab	Private I/I	Grand Total
AB	$ 10,320,000	$ 13,669,000	$ 2,985,000	$ 203,000	$ 27,177,000
AT	$ 143,382,000	$ 86,822,000	$ 228,355,000	$ 59,239,000	$ 517,798,000
BH	$ 23,035,000	$ 75,000,000	$ 104,717,000	$ 16,962,000	$ 219,714,000
CE	$ -	$ 18,800,000	$ 13,195,000	$ -	$ 31,995,000
JR	$ 75,838,000	$ 20,109,000	$ 76,375,000	$ 24,573,000	$ 196,895,000
NA	$ 148,414,000	$ 8,612,000	$ 173,563,000	$ 41,613,000	$ 372,202,000
VIP	$ 68,696,000	$ 56,592,000	$ 205,498,000	$ 17,018,000	$ 347,804,000
WB	$ 93,658,000	$ 33,330,000	$ 122,666,000	$ 41,551,000	$ 291,205,000
YR	$ 51,945,000	$ 11,245,000	$ 58,586,000	$ 9,336,000	$ 131,112,000
VARIOUS	$ 19,850,000	$ -	$ 19,316,000	$ -	$ 39,166,000
SUM	**$ 635,138,000**	**$ 324,179,000**	**$ 1,005,256,000**	**$ 210,495,000**	**$ 2,175,068,000**

Table 3-14. 2-year Regionalized Scenario Costs					
	Regional Wet Weather Improvements	Upstream Cap Improvements	Rehab	Private I/I	Grand Total
AB	$ 10,320,000	$ 8,017,000	$ 2,985,000	$ 203,000	$ 21,525,000
AT	$ 98,337,000	$ 41,126,000	$ 228,355,000	$ 59,239,000	$ 427,057,000
BH	$ 21,572,000	$ 27,100,000	$ 104,717,000	$ 16,962,000	$ 170,351,000
CE	$ -	$ 10,700,000	$ 13,195,000	$ -	$ 23,895,000
JR	$ 64,116,000	$ 7,579,000	$ 76,375,000	$ 24,573,000	$ 172,643,000
NA	$ 139,779,000	$ 4,681,000	$ 173,563,000	$ 41,613,000	$ 359,636,000
VIP	$ 50,398,000	$ 41,524,000	$ 205,498,000	$ 17,018,000	$ 314,438,000
WB	$ 69,641,000	$ 8,800,000	$ 122,666,000	$ 41,551,000	$ 242,658,000
YR	$ 48,877,000	$ 1,400,000	$ 58,586,000	$ 9,336,000	$ 118,199,000
VARIOUS	$ 19,850,000	$ -	$ 19,316,000	$ -	$ 39,166,000
TOTAL	**$ 522,890,000**	**$ 150,927,000**	**$ 1,005,256,000**	**$ 210,495,000**	**$ 1,889,568,000**

Section 4

Conclusion

The preceding analysis demonstrates that there are substantial capital cost savings available to ratepayers from regionalizing the sanitary sewer system under a single entity. At a 10-year level of service, these savings amount to $642 million across the region. This represents a substantial 23% reduction in costs from the non-regionalized alternative. A summary comparison of the 10-year costs for the Non-Regionalized and Regionalized scenarios is listed in Table 4-1.

Table 4-1. Comparison of Capital Costs at 10-year Level of Service

	Non-Regionalized	Regionalized	Delta	% Diff
Rehabilitation	$1,531,501,000	$1,005,256,000	$526,245,000	34%
Regional Wet Weather Improvements	$659,390,000	$635,138,000	$24,252,000	4%
Locality/Upstream Capacity Improvements	$336,582,000	$324,179,000	$12,403,000	4%
Private Property I/I Abatement Program	$289,248,000	$210,495,000	$78,753,000	27%
Grand Total	**$2,816,721,000**	**$2,175,068,000**	**$641,653,000**	**23%**

4.1 Risk and Logistical Challenges

In addition to the cost advantage of regionalization, there are other non-monetary advantages that should be considered in the decision process. One area of considerable difference is in the risk of achieving the required outcomes from rehabilitation and wet weather improvements. At the core of the Federal Consent Decree is the requirement to achieve a selected level of service for managing wet weather flows. The following provides a contrast of the two alternatives with respect to the logistical and institutional challenges in achieving the selected level of service.

4.1.1 Non-Regionalized Alternative

The Localities are bound by the SOC to develop and implement Rehabilitation Plans with a goal of reducing I/I in SSES basins. Collectively, the Localities have estimated that they will spend $1.36 billion in these efforts over a 20 to 30 year time period. Per the SOC requirements, each Locality will make a PFC that represents the flow that will be delivered to the regional HRSD system after completion of the rehabilitation. HRSD will rely upon these PFCs to size its infrastructure – interceptors, pump stations, pressure reducing stations, storage facilities and treatment plants. HRSD's ability to achieve the selected LOS in its system is dependent on the Localities ability to meet their PFCs.

Because of the importance of the PFCs, the magnitude of investments necessary for wet weather improvements and the regulatory risk of not achieving the selected LOS, HRSD has indicated that they will implement flow agreements with each of the Localities that memorializes the PFCs and provides processes to resolve situations where the PFC is not achieved. The need for flow agreements is clear and this creates incentives for Localities to be conservative in the estimation of their PFCs. There is an incentive to underestimate the level of I/I removal which can be achieved so as to increase the

probability of meeting the PFCs. When looked at across the region, at each and every catchment, this effect is compounded. This conservatism has the effect of potentially inflating remaining peak flows and increasing the cost of wet weather improvements in the RWWMP.

Implementation of the Rehabilitation Plans and Regional Wet Weather Management Plan under the non-regionalized alternative is complex and requires a high degree of coordination. Localities must perform rehabilitation across more than 750 catchments. In each catchment, the Locality must perform the work, institute flow monitoring and demonstrate that they have achieved the PFC. If they fail to do so, the Locality will be required to perform additional rehabilitation work in that catchment until the PFC is achieved. HRSD will perform private property I/I abatement work after the Locality demonstrates achievement of the PFC. Within a sewage treatment plant (STP) service area there will be multiple jurisdictions conducting rehab and demonstrating achievement of the PFCs.

Meanwhile, HRSD will be building wet weather improvements that should be synchronized with the Localities' rehab work and PFC demonstration. This is very challenging as most of the Localities are proposing long implementation schedules (20 to 30 years). Therefore, the effectiveness of their efforts will not be known prior to the construction of HRSD wet weather improvements. If one of more Localities gets behind schedule this could create impacts to HRSD's work and ultimately to their requirement for Post RWWMP demonstration of achievement of the approved LOS (a Federal Consent Decree requirement). In addition, changes in Localities rehabilitation construction schedules could impact other Localities that send flow to the same treatment plant.

Failure by one or more Localities to achieve their PFCs could also create adverse consequences for other Localities that pump flow into the same interceptor. Increased flows above planned levels would increase system pressures at a given LOS. This could create diminished LOS and/or SSOs in other Localities.

Risk is allocated to each Locality for achieving its PFC. Importantly, this risk is shared by other Localities that send flow to the same HRSD facilities. In addition, HRSD shares this risk because the sizing of improvements is dependent on the achievement of the PFC. While neighboring Localities and HRSD share this risk, neither has any real control of the risk because the Locality controls how it performs rehabilitation and whether the PFC is achieved. HRSD's only means of managing the risk is through vigorous enforcement of the Flow Agreement. This creates a massive undertaking in accounting for planned and actual results in more than 750 catchments.

4.1.2 Regionalized Alternative

In the regionalized alternative, risk is allocated to a single party that controls the scheduling and effectiveness of rehabilitation at removing I/I. The regionalized alternative is structured around performing intensive rehabilitation efforts in only the leakiest basins by sewage treatment plant service area. The Regionalized Utility can be reasonable (i.e., not overly conservative) in its estimation of I/I removal because it assumes the control to manage performance risks. Synchronization of improvements becomes much simpler than in the non-regionalized alternative. The Regionalized Utility could elect to sequence the work so that actual reductions in I/I are known prior to construction of wet weather improvements in a given area. This would allow for adjustments in the sizing of these improvements to maintain the desired LOS.

The topic of flow agreements becomes moot in the regionalized alternative. The Regionalized Utility controls all aspects of collection, conveyance and treatment and can make appropriate trade-offs as necessary to manage its business. This also improves future flexibility. For instance, nutrient requirements could change in the future, creating a need to redirect flows from one treatment plant to another. In the regionalized approach, The Regionalized Utility can make these decisions based on the best outcome for regional ratepayers without concern for the impact on individual jurisdictions.

Verifying I/I reduction is also greatly simplified. HRSD has invested in an extensive network of flow, pressure and rainfall (FPR) monitors across its system. These monitoring points can be used to follow up and demonstrate achievement of the planned post rehabilitation flows across an aggregation of catchments. This could be supplemented by catchment level temporary flow monitoring if sub regional results do not reflect planned flows. This approach will be less expensive and less cumbersome than the non-regionalized approach which requires flow monitoring and demonstration of the PFC at each and every catchment.

4.2 Conclusions

The following are the principle conclusions drawn from this Comparative Analysis.

1. There is a substantial savings in capital costs of $642 million associated with the Regionalized Alternative.
2. The incremental operations and maintenance expenses associated with wet weather improvements are not significantly different between the regionalized and non-regionalized alternatives.
3. The allocation of risk associated with I/I removal and related sizing of wet weather improvements in the regionalized alternative is better aligned with the management of that risk.
4. Significant logistical and practical efficiencies are available in the regionalized alternative. Synchronization of rehabilitation, private property I/I abatement and wet weather improvements is greatly enhanced in the regionalized alternative.
5. Development and enforcement of flow agreements in the non-regionalized alternative creates complexities and dynamics that tend to increase costs and amplify the consequences of risk allocation. In addition, administering these flow agreements creates substantial further expense.
6. The non-regionalized alternative increases the risk of not achieving the desired LOS and creates the opportunity for finger pointing amongst Localities.
7. There is a greater risk of failing to achieve the desired LOS in the non-regionalized alternative due to the multiple Localities involved. Failure by one or more Locality to achieve their PFC will jeopardize reaching the LOS across an entire treatment plant service area.

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Section 5

Limitations

This document was prepared solely for Hampton Roads Sanitation District in accordance with professional standards at the time the services were performed and in accordance with the contract between Hampton Roads Sanitation District and Brown and Caldwell dated April 28, 2012. This document is governed by the specific scope of work authorized by Hampton Roads Sanitation District; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Hampton Roads Sanitation District and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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