Eastern Shore

Sanitary Sewer Transmission Force Main Study

HRSD

April 5, 2019

Revised:

May 13, 2019

This page is intentionally left blank

Contents

This page is intentionally left blank

Summary

Within Northampton and Accomack Counties on the Eastern Shore of Virginia, there are sanitary sewer collection systems that serve the Towns of Nassawadox, Exmore, Onley, and Onancock. Commercial and industrial areas in Onley and Melfa are also serviced by collection systems and these flows are conveyed to the Town of Onancock for treatment. The Town of Onancock owns and operates an advanced wastewater treatment plant that provides state-of-the-art treatment of wastewater flows and there is substantial unused capacity in that plant. This provides the opportunity to improve the level of treatment and reduce the long-term cost of treatment for wastewater generated in northern Northampton County and southern Accomack County. Constructing a force main and pump stations to connect these existing collection systems and convey the flows to the Onancock Wastewater Treatment Plant (WWTP) is proposed.

HRSD tasked HDR and its subconsultant, Davis, Bowen & Friedel, Inc. (DBF), with performing a conceptual design for a new transmission force main extending from Nassawadox and Accomac to the Onancock WWTP. The force main is designed to connect to existing sanitary sewer collection systems along the route that serve Nassawadox, Exmore, and Accomac and has the capacity to convey future flows from these collection systems and from new service areas along the force main route based on population projections through 2050.

The commercial and government area south of Melfa and the commercial area in Onley are currently served by a force main that discharges to the Onancock WWTP. The conceptual design includes replacement of this force main in the initial project. Alternate projects are included in this study for connection of the Exmore New Roads system and a future Onley Central system. Also, the communities of Belle Haven, Painter, Keller and Melfa could connect to the new transmission force main in the future if they construct centralized sanitary sewer collection systems.

Wastewater Flows

Using information provided by the localities on current wastewater flows and population projections provided by the Accomack-Northampton Planning District Commission, Year 2050 flow projections were developed for the localities along this proposed force main corridor. Table 1 lists current and projected average daily wastewater flows. These flows are considered to be average daily flows during the maximum month condition.

Table 1: Wastewater Flow Projections, Maximum Month Average Daily Flow

Location	Current Flow (gal/day)	Year 2050 (gal/day)
Nassawadox	25,000	44,100
Exmore	40,000	191,200
Melfa (Commercial)	20,000	30,000
Onley	40,000	97,400
Accomac	18,000	72,200
Onancock	174,000	215,100
Current Unsewered Areas (1)	--	100,000
Total	317,000	750,000

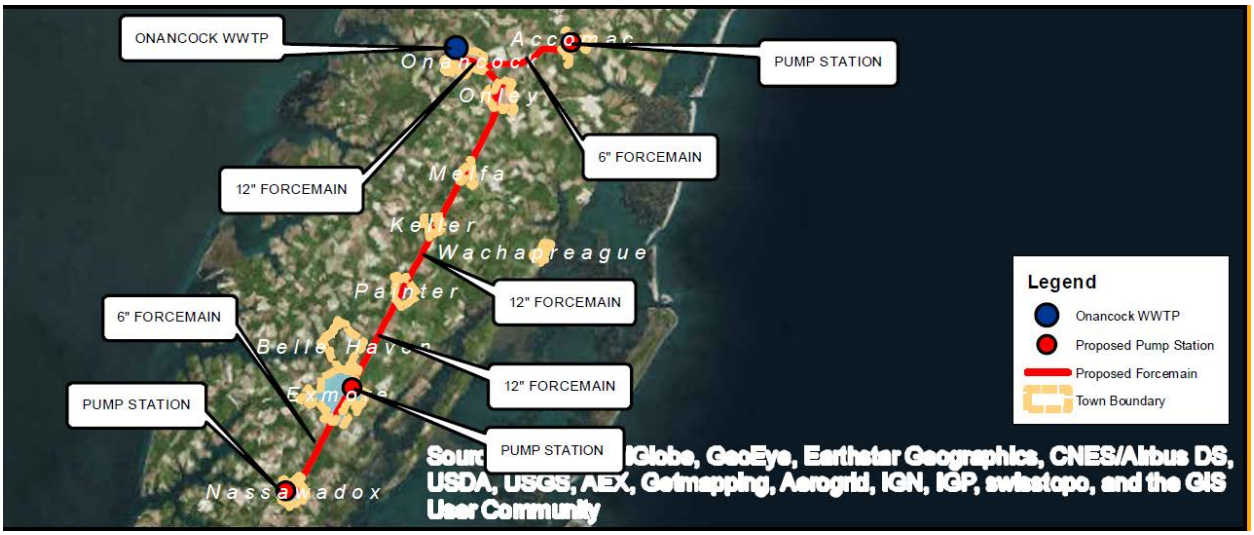
(1) Belle Haven, Painter, Keller, and Melfa (residential) areas.

The Year 2050 total flow is within the Onancock WWTP permitted design capacity of 750,000 gal/day. Peak daily and hourly flow projections were also developed and are presented in the report included as Attachment A.

Transmission Force Main System

A proposed transmission force main system is shown in Figure 1. It consists of 6- and 12-inch diameter pipe and three pump stations. One 182 gal/min pump station in Nassawadox, one 705 gal/min pump station in Exmore and one 205 gal/min pump station in Accomac. The force main is sized to convey the projected Year 2050 flows to the Onancock WWTP. In addition, the existing force main that serves the commercial and government area south of Melfa and the commercial area in Onley will be replaced. Alternatives have been developed to construct new pump stations and connections to the transmission force main from the Exmore New Roads system and the Onley residential area.

Figure 1: Proposed Transmission Force Main System



Onancock WWTP

An assessment was performed of the Onancock WWTP capacity to confirm that the treatment capacity of the plant is in accordance with its permitted design capacity and that the projected Year 2050 wastewater flows can be treated at this facility. The assessment concludes that the plant can treat the projected Year 2050 wastewater flows. However, additional wastewater monitoring is recommended to confirm that the raw wastewater characteristics will be within the Onancock WWTP's design basis. The assessment noted that the membrane units are near the end of their service life and will need replacement soon and there are some enhancements to unit process redundancy that should be considered. The capacity analysis is documented in a technical memorandum included as Attachment B.

Cost Estimates

An Opinion of Probable Project Cost has been prepared for the proposed transmission force main system as well as the two project alternatives. This is a Class 5 estimate as defined by AACE International and has an accuracy range of -25% to +50%. Table 2 lists these estimates.

Table 2: Opinion of Probable Project Cost

Project	Estimated Amount
6- and 12-inch Transmission Force Main, Three Pump Stations, and Existing Melfa-Onley Force Main Replacement	$22,200,000
Alternative – Exmore New Roads	$1,780,000
Alternative – Onley Central	$940,000

The projected annual operations and maintenance (O&M) cost of the transmission force main system is $75,630. This is for the force main and three pump stations only.

Attachment A

Eastern Shore Sanitary Sewer Transmission Force Main Study Engineering Report, prepared by Davis, Bowen & Friedel, Inc., dated May 8, 2019.

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS

NORTHAMPTON & ACCOMACK COUNTIES
EASTERN SHORE SANITARY SEWER TRANSMISSION FORCE MAIN STUDY

ENGINEERING STUDY

PREPARED FOR

HRSD

Prepared by:
DAVIS, BOWEN & FRIEDEL
601 E. Main Street, Suite 100
Salisbury, MD 21804
(410) 543-9091

May 8, 2019

3226A001.A01

EASTERN SHORE SANITARY SEWER TRANSMISSION FORCE MAIN STUDY

NORTHAMPTON & ACCOMACK COUNTIES

EASTERN SHORE OF VIRGINIA

STUDY PREPARED FOR HRSD

DBF #3226A001.A01

MAY 8, 2019

Appendix

List of Tables

List of Figures

List of Exhibits

INTRODUCTION

This study presents the findings for the feasibility of transmitting sewage from Nassawadox and Exmore to the existing Onancock Wastewater Treatment Plant (WWTP). The study also explores transmitting sewage from the Town of Accomac to the Onancock WWTP. All three communities have their own unique challenges for treating and disposing of their wastewater. Portions of Melfa and Onley are currently served by a sewage system operated by Accomack County. This study explores replacing this aging sewer system. See Exhibit 1 – Vicinity Map for the project planning area.

The Eastern Shore of Virginia is located on the southern portion of the Delmarva Peninsula. This land region is composed of two counties: Northampton and Accomack. Northampton is the southernmost county whereas Accomack is directly to the north. Both counties are included in this study.

Only a small portion of the Eastern Shore of Virginia is served by public sewer facilities, with many of the facilities requiring upgrades or alternatives. It is important to provide residents with reliable and environmentally friendly centralized sewers. The solution provided in this study would obtain that goal.

Document Path: Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Vicinity Map.mxd

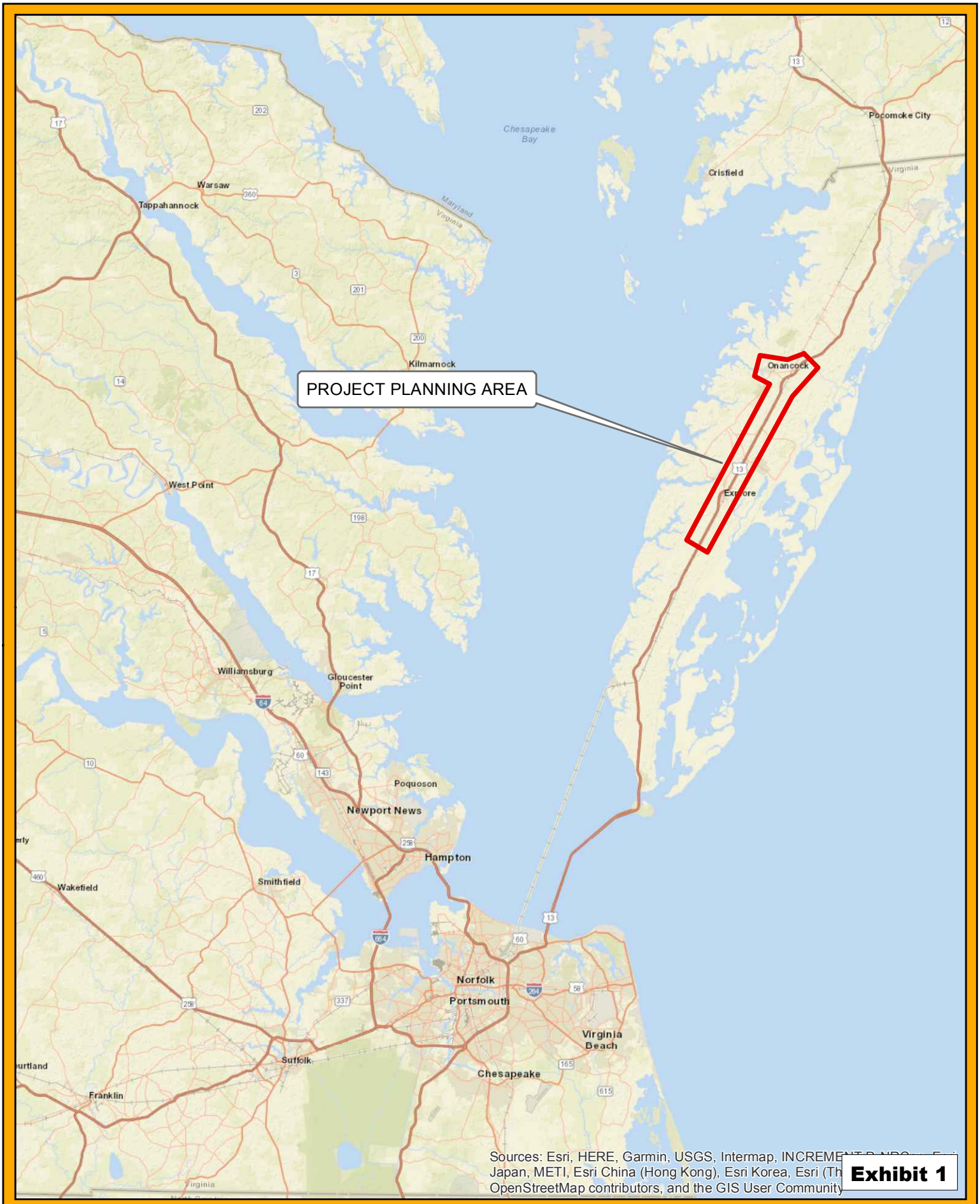


Exhibit 1

N W E S

February 2019

0 2.5 5 10 15 20 Miles

Vicinity Map

Eastern Shore Sanitary Sewer Transmission Force Main Study

DBF #3226A001.A01

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com

PROJECT PLANNING AND SERVICE AREAS

This study consists of serving the communities of Nassawadox, Exmore, and Accomac with sewage transmission facilities. The existing service areas of Melfa and Onley are also included. Additional service areas for the New Roads portion of Exmore and the unserved portions of the Town of Onley are provided as alternatives. Although not specifically studied, the communities of Belle Haven, Painter, Keller, and unserved portions of Melfa (residential) could potentially connect to the forcemain if they construct centralized sewage collection facilities. See Exhibit 2 – Sewer Service Area Map for a map showing the communities currently served and the communities to be served by this project.

The Town of Onancock currently has a centralized collection system and advanced wastewater treatment plant.

Exhibit 2

N W E S

February 2019

0 0.45 0.9 1.8 2.7 3.6 Miles

Sewer Service Area Map

Eastern Shore Sanitary Sewer Transmission Force Main Study

DBF #3226A001.A01

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com

Document Path: Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Sewer Service Area Map.mxd

EXISTING FACILITIES/NEED FOR THE PROJECT

A private wastewater collection and treatment system is currently in use in Nassawadox. The system is owned and operated by Riverside Health. The WWTP currently receives approximately 25,000 gallons per day (GPD). The treatment plant utilizes extended aeration for its treatment method and is only able to treat for conventional pollutants. The owner must purchase nutrient credits to offset their inability to treat to their permit requirements.

The Town of Exmore operates two independent wastewater collection and treatment systems. The main sewer system, and the focus of this study, is on the east side of Town, and is also called the "Downtown" system. The Downtown system is experiencing issues with their sequencing batch reactor (SBR). The system is only a single train and is unable to be disconnected for repairs or renovations. The western sewer system in Exmore is known as the "New Roads" system. Wastewater is discharged through a mass drainfield. Although it is in better condition, it is noted as an alternative in this project.

The Town of Accomac is currently served by septic systems. The Town and Accomack County desires to have centralized sewage collection facilities to serve the government buildings.

The Town of Onley currently has sewer service to the commercial properties along US Route 13. The sewer system is maintained by Accomack County. There are no centralized sewage facilities in the residential portions of the Town of Onley. Replacement of the sewer service to the commercial properties is provided in the base study. A centralized pump station for the unserved residential portions of Town are provided as an alternate.

The commercial area to the south of Melfa is served by public sewer and is maintained by Accomack County. The service area includes the airport, the businesses in the industrial park, and businesses along US Route 13. These commercial users flow wastewater to pumping stations in the industrial park or feed into the forcemain with grinder style pumping stations which ultimately flow to Onancock. Replacement of the piping is included as part of the base project.

The wastewater treatment plant in Onancock will be discussed in other sections of this study.

Adequate sewage treatment facilities are essential for the environment and economy of Virginia's Eastern Shore. The reliance of septic systems and aging treatment facilities will certainly stifle the growth of the Eastern Shore. Planning for the future is critical.

POPULATION AND FLOWRATE PROJECTIONS

This study uses population projections for each town to 2050 as prepared by the Accomack-Northampton Planning District Commission. The Commission followed methods recommended by the Weldon Cooper Center for the projections. The population data was used to determine the average daily flow rates for each town. A calculation of 100 gallons per day per person was used as provided by Sewage Collection and Treatment Regulations (SCAT) Standards. Population and flow data are provided in the following table. Data as received by Accomack-Northampton Planning District Commission is provided in Appendix A.

Table 1: Population and Flowrate Projections

Location	Existing Average Daily Flow (GPD)	Future Population	Flow per Person (GPD/Person)	Future Flow Based on Future Population (GPD)	Proposed Average Daily Flow (GPD)
Nassawadox[1]	25,000	441	100	44,100	**44,100**
Exmore[2]	40,000	1,912	100	191,200	**191,200**
Melfa (Commercial)[3]	20,000	N/A	N/A	N/A	**30,000**
Onley[4]	40,000	574	100	57,400	**97,400**
Accomac[5]	18,000	722	100	72,200	**72,200**
Onancock[6]	174,000	1,614	100	161,400	**215,100**
Current Unsewered Areas[7]	-	1,000	100	100,000	**100,000**
			Total Future Average Daily Flow to Onancock WWTP		**750,000**

[1]Max population in year 2030, proposed average daily flow is based solely on future population.
[2]Max population in year 2030, proposed average daily flow is based solely on future population.
[3]Future flows include 50% increase.
[4]Max population in year 2050, proposed average daily flow is based on existing flows plus future population flows.
[5]Max population in year 2050, proposed average daily flow is based solely on future population.
[6]Remaining available capacity allocated to Onancock.
[7]Belle Haven, Painter, Keller, and Melfa (residential)

Nassawadox and Exmore proposed future flows are based on the future population. Melfa does not use population projections, as the existing sewer flows are commercial and government customers. Melfa was allocated a 50% increase in future flows. Onley future flows are based on the existing commercial customer flowrates and the flows resulting from the future population. Accomac flows are based on the future population. Current unsewered areas have been estimated based on the populations of Belle Haven, Painter, Keller, and Melfa. The remaining capacity is allocated to the Town of Onancock. The total flow is within the current allocated flowrate for the Onancock Wastewater Treatment Plant.

Additionally, peak daily flows and peak hourly flows were calculated. The data is provided in the following tables.

Table 2: Peak Daily Flowrate Projections

Location	Existing Average Daily Flow (GPD)	Proposed Average Daily Flow (GPD)	Proposed Peak Daily Flow (GPD)
Nassawadox	25,000	44,100	**88,200**
Exmore	40,000	191,200	**382,400**
Melfa (Commercial)	20,000	30,000	**60,000**
Onley	40,000	97,400	**194,800**
Accomac	18,000	72,200	**144,400**
Onancock	174,000	215,100	**430,200**
Current Unsewered Areas	-	100,000	**200,000**
Total Future Peak Daily Flow to Onancock WWTP			**1,500,000**

Table 3: Peak Hourly Flowrate Projections

Location	Existing Average Daily Flow (GPD)	Proposed Average Daily Flow (GPD)	Proposed Peak Hourly Flow (GPD)
Nassawadox	25,000	44,100	**110,250**
Exmore	40,000	191,200	**478,000**
Melfa (Commercial)	20,000	30,000	**75,000**
Onley	40,000	97,400	**243,500**
Accomac	18,000	72,200	**180,500**
Onancock	174,000	215,100	**537,750**
Current Unsewered Areas	-	100,000	**250,000**
Total Future Peak Hourly Flow to Onancock WWTP			**1,875,000**

PROPOSED PROJECT

Overview

The proposed project is to connect the Town of Nassawadox, Exmore, and Accomac to the existing Onancock Wastewater Treatment Plant. The commercial and government area south of Melfa is currently served by a pump station and forcemain. Additionally, the commercial area in Onley is also served by forcemains. Exhibit 3 – Forcemain Layout Map shows a detailed view of pump station locations, forcemain routing and sizing, and key areas. The Melfa and Onley commercial system is detailed in Exhibit 7 – Accomack County Layout Map.

In Nassawadox, a pump station is proposed to intercept wastewater flows to the existing wastewater treatment plant. See Exhibit 4 – Nassawadox Layout Map for the location of the pump station. The flows will be conveyed via a 6" forcemain following the railroad right-of-way along US Route 13. As the forcemain enters Exmore it will follow the railroad and Main Street then turning onto Virginia Avenue to Exmore's existing pump station. See Exhibit 5 – Exmore Layout Map for the location. The existing pump station in Exmore is planned to be completely replaced due to the condition of the station. The proposed pump station will transmit sewage with a 12" forcemain following the railroad right-of-way. The forcemain will pass near Belle Haven, Painter, Keller, Melfa (residential), and Onley. Once entering Onley, the forcemain will follow the US Route 13 alignment before crossing onto Route 179 – Market Street.

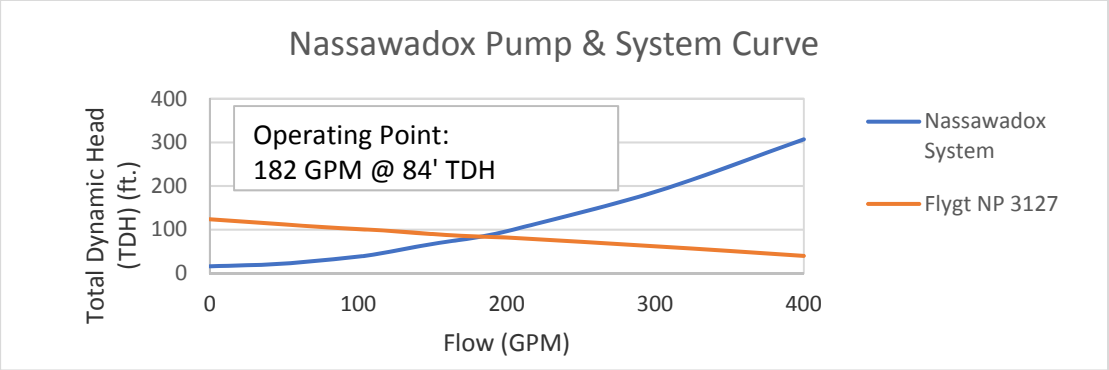
In Accomac, the proposed pump station is planned to be placed centrally near the Accomack County government buildings. See Exhibit 6 – Accomac Layout Map for the location. The forcemain will be 6" in diameter and will follow Front Street. The forcemain will be directionally drilled under US Route 13 and will run through Tasley on Tasley Road. A jack and bore is planned under the railroad in Tasley and an additional direction drill under the traffic circle for Route 126 and Business 13. The forcemain will manifold into the 12" forcemain from Nassawadox and Exmore.

The Melfa and Onley commercial systems will replace piping and connections in-kind. The pumping stations in the industrial park have been recently upgraded and will remain.

Pump Stations

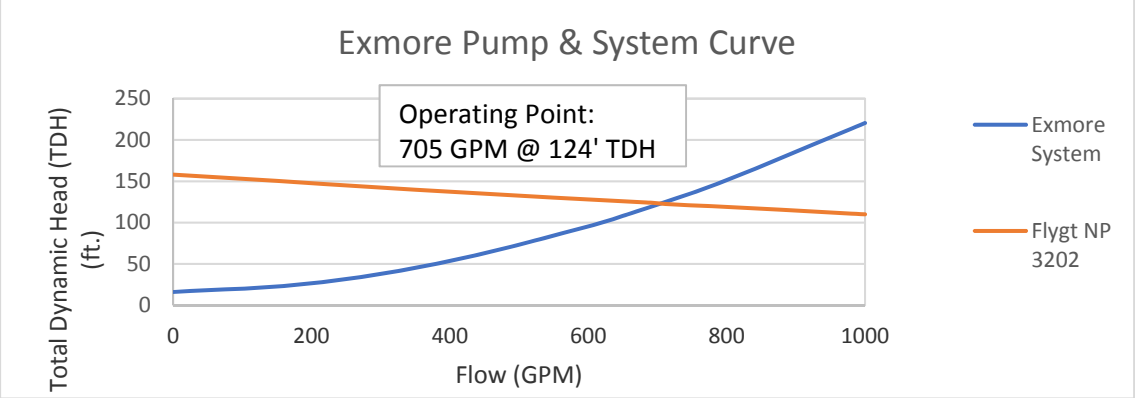
The Nassawadox pump station is proposed to be a duplex submersible pump station with an emergency generator, cellular telemetry, odor control system, and bypass connection. The pump station has a design flowrate of 123 GPM, however, due to high head conditions and necessary velocities, the pump station is proposed to operate at 182 GPM at 84 feet of total dynamic head (TDH). The forcemain will achieve 2.0 feet per second velocity and the pump station will have 10 horsepower pumps. For planning purposes, a Flygt NP 3127 submersible pump has been selected for this station.

Figure 1: Nassawadox Pump & System Curve



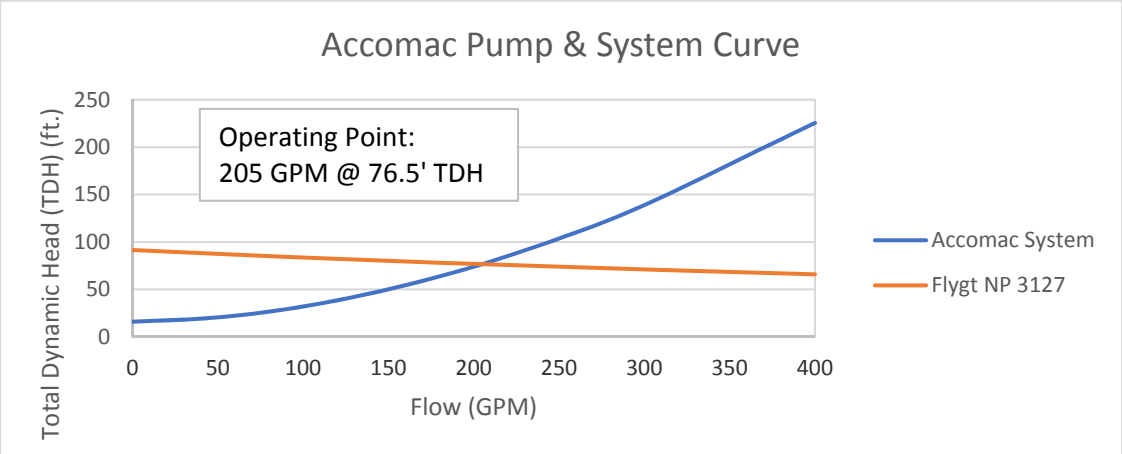
The Exmore pump station is much larger than Nassawadox. The pump station is proposed to be a duplex submersible with an emergency generator, cellular telemetry, odor control system, and a bypass connection. The design flowrate is 654 GPM, the pump selection has driven the operating flowrate up to 705 GPM at 124 feet TDH. The forcemain is planned to have 2.1 feet per second velocity and the pumps are 40 horsepower Flygt NP 3202.

Figure 2: Exmore Pump & System Curve



The Accomac pump station is similar to Nassawadox. It will be a duplex submersible station with an emergency generator, cellular telemetry, odor control system, and a bypass connection. The pump station has a design flowrate of 201 GPM. The operating point with the selected pump is 205 GPM at 77 feet TDH. The pump is a Flygt NP 3127 which is a 10 horsepower pump.

Figure 3: Accomac Pump & System Curve



A Typical Pump Station Site Plan and Typical Duplex Pump Station Elevation are provided as exhibits.

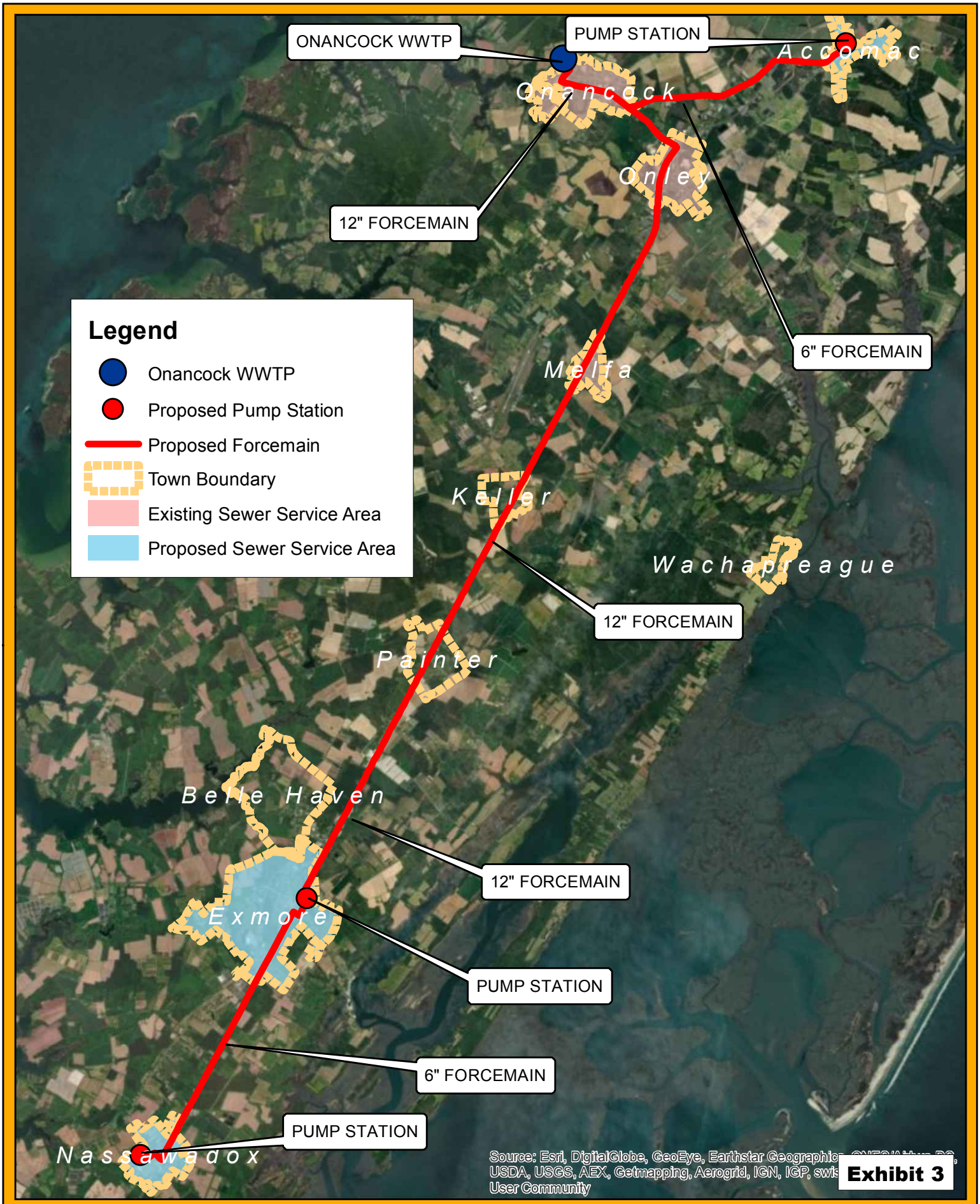
The pump stations and forcemains were modeled in SewerCAD to check the conditions when multiple pump stations are pumping. When Accomac and Exmore are pumping simultaneously, the Exmore pump station will see a 2.8% decrease in flowrate and a 1.0% increase in TDH. Similarly, the Accomac station will see a 10.0% decrease in flowrate and a 1.9% increase in TDH. These levels are considered acceptable and manifolding of these pump stations should be used.

Forcemains

The basis of the design of the forcemains are DR-18 C-900 PVC with a nominal diameter of 6 and 12 inches for open cut trenches. DR-11 HDPE may also be considered for open cut use on this project.

Directional bores are planned to be DR-11 HDPE. Jack and bores are planned to be welded steel with 12" casing proposed for 6" pipes and 16" casings for 12" pipes.

A Pavement Restoration Detail and Typical Forcemain Alignment have been provided as exhibits.



N
W E
S

February 2019

0 0.4 0.8 1.6 2.4 3.2 Miles

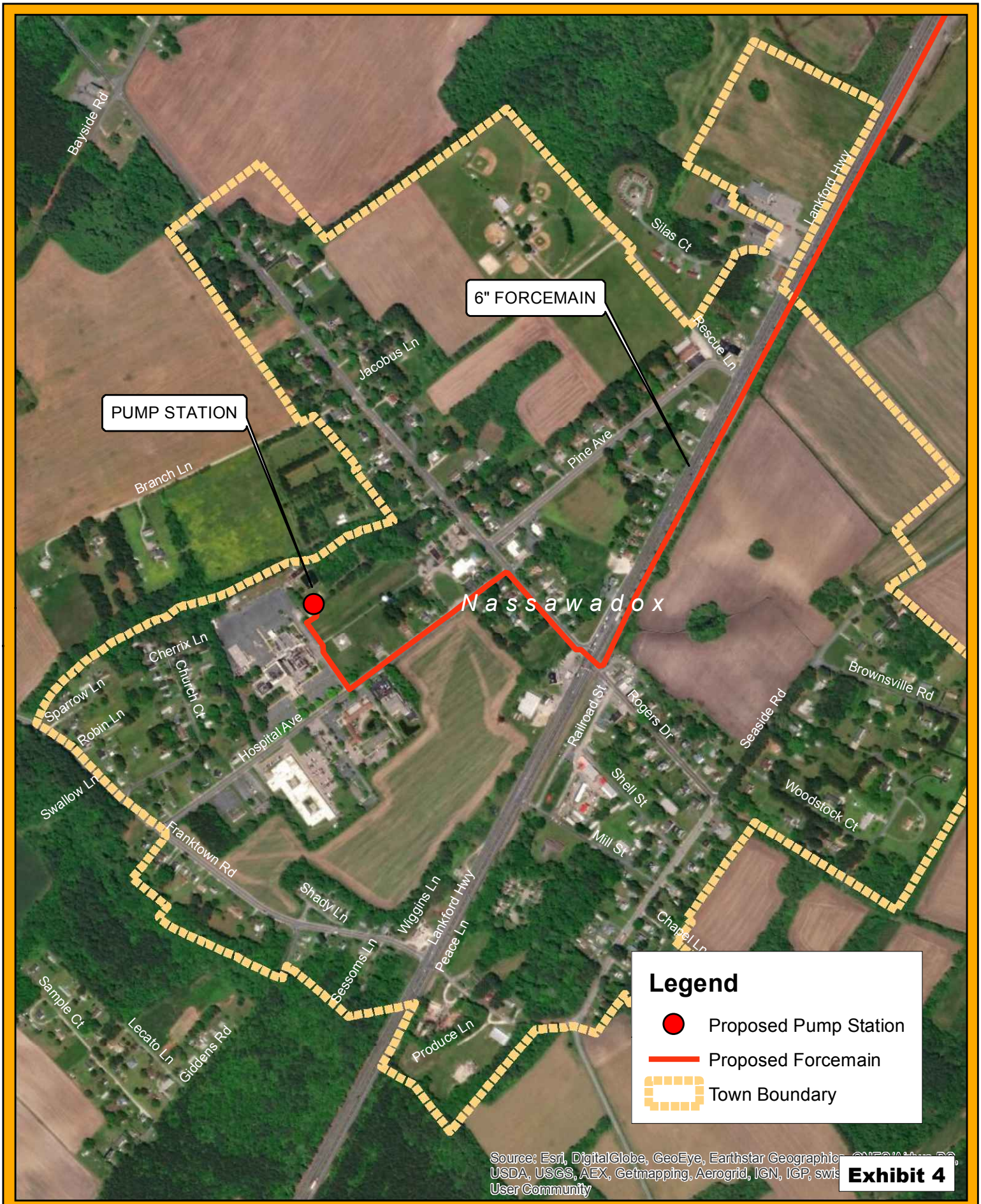
Forcemain Layout Map

DBF #3226A001.A01

Eastern Shore Sanitary Sewer Transmission Force Main Study

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com

Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Forcemain Layout Map.mxd



Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Nassawadox Layout Map.mxd

February 2019

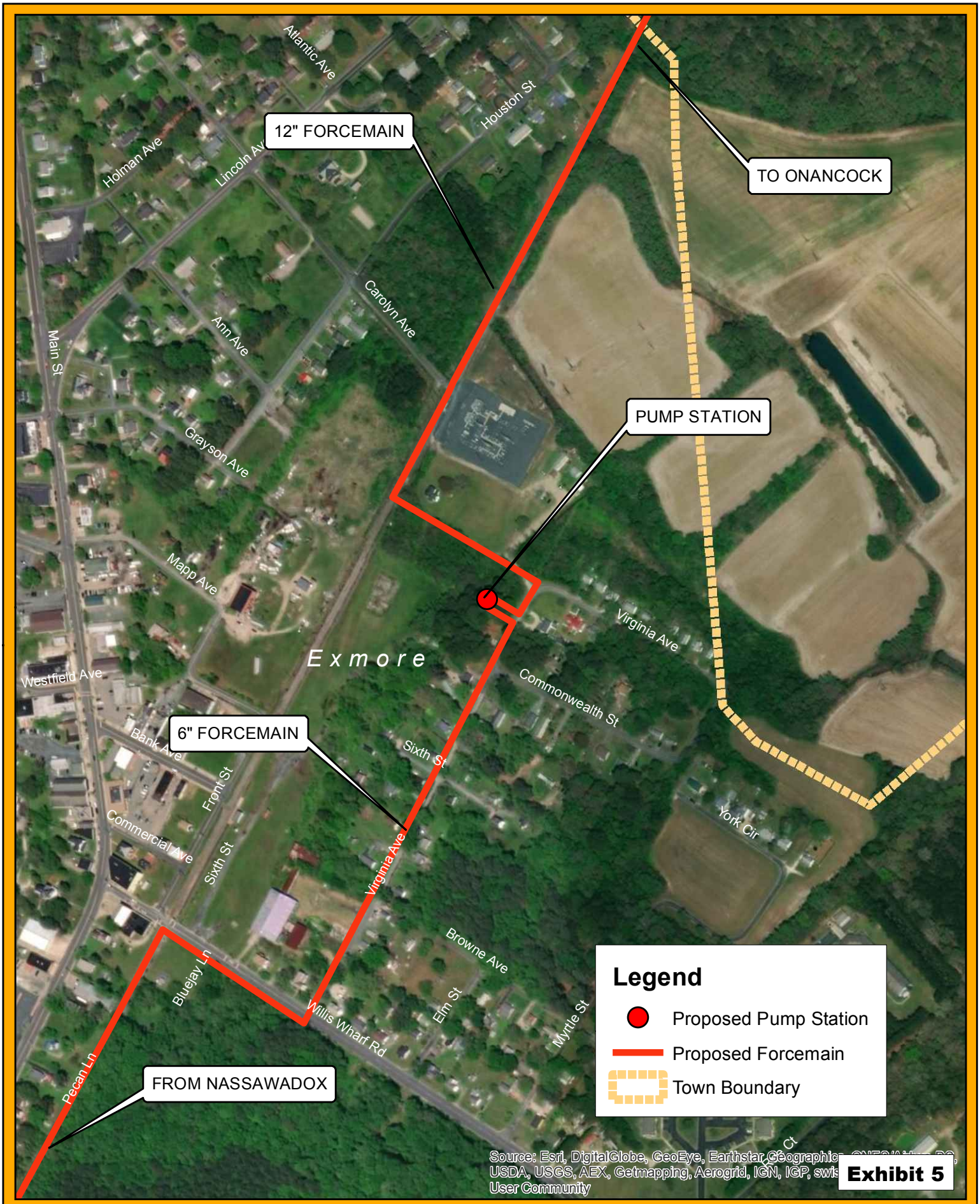
0 0.03 0.06 0.12 0.18 0.24 Miles

Nassawadox Layout Map

DBF #3226A001.A01

Eastern Shore Sanitary Sewer Transmission Force Main Study

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com



February 2019

0 0.015 0.03 0.06 0.09 0.12 Miles

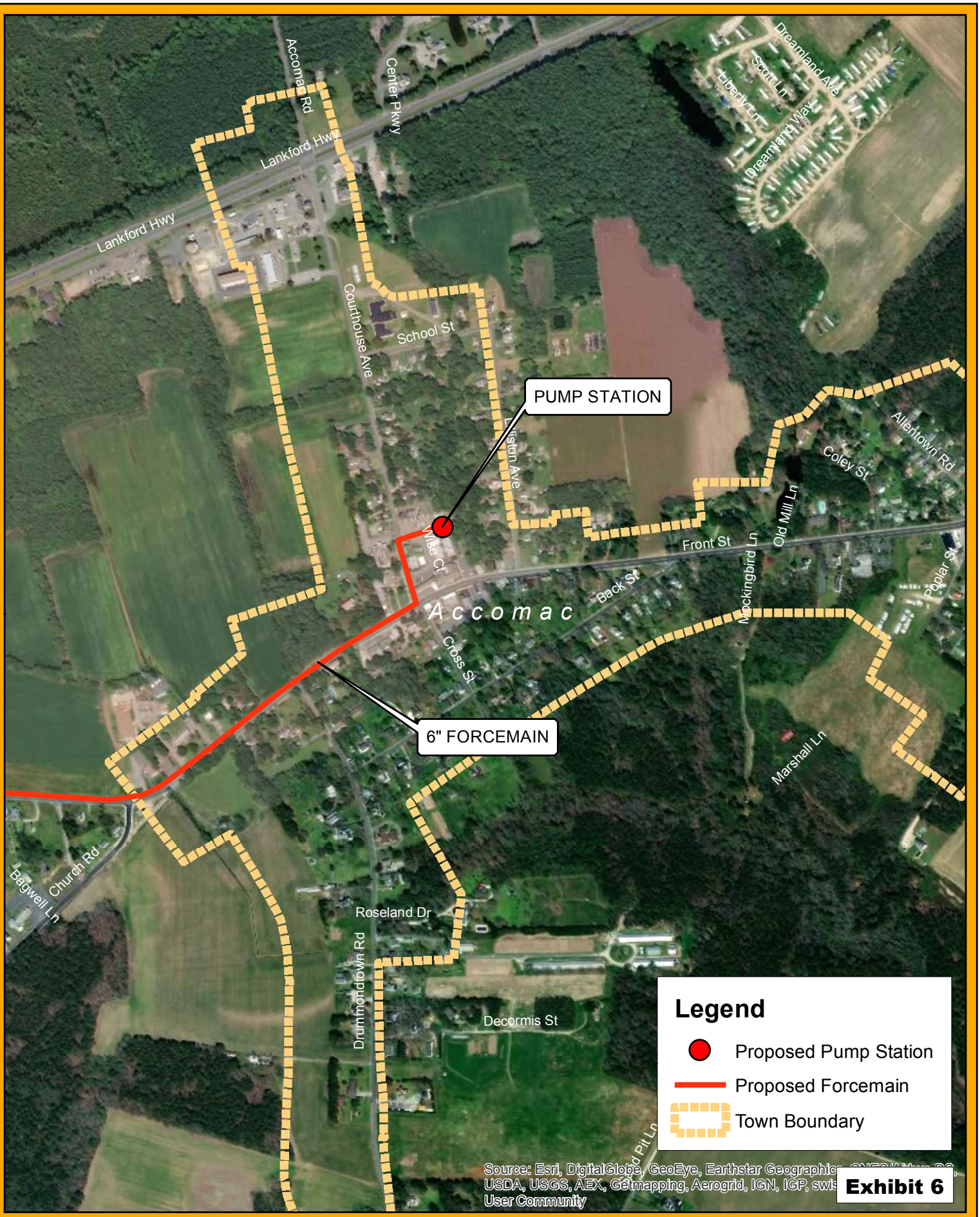
Exmore Layout Map

Eastern Shore Sanitary Sewer Transmission Force Main Study

DBF #3226A001.A01

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com

Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Exmore Layout Map.mxd



Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Accomac Layout Map.mxd

N W E S

February 2019

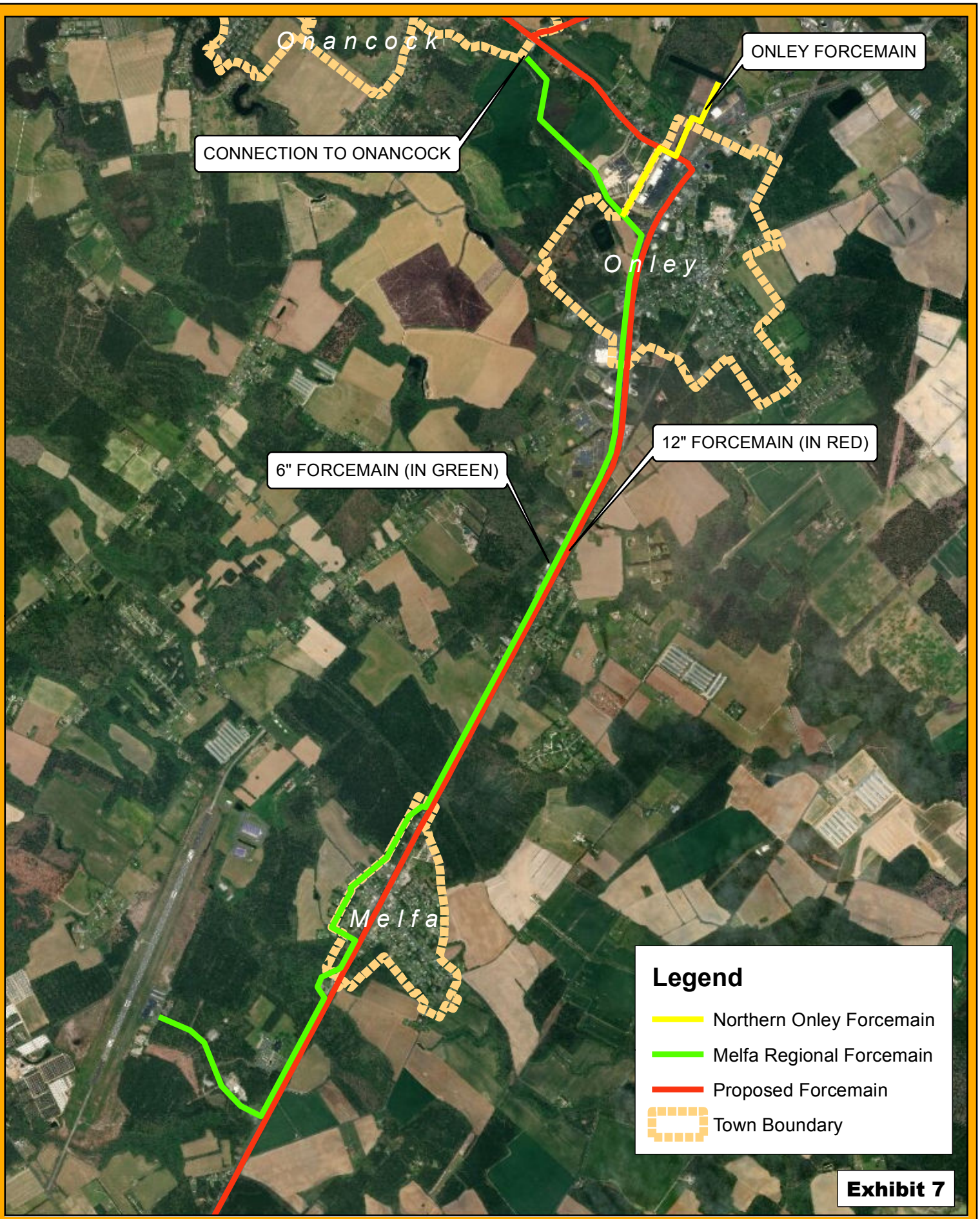
0 0.03 0.06 0.12 0.18 0.24 Miles

Accomac Layout Map

Eastern Shore Sanitary Sewer Transmission Force Main Study

DBF #3226A001.A01

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com



N
W E
S

February 2019

0 0.125 0.25 0.5 0.75 1 Miles

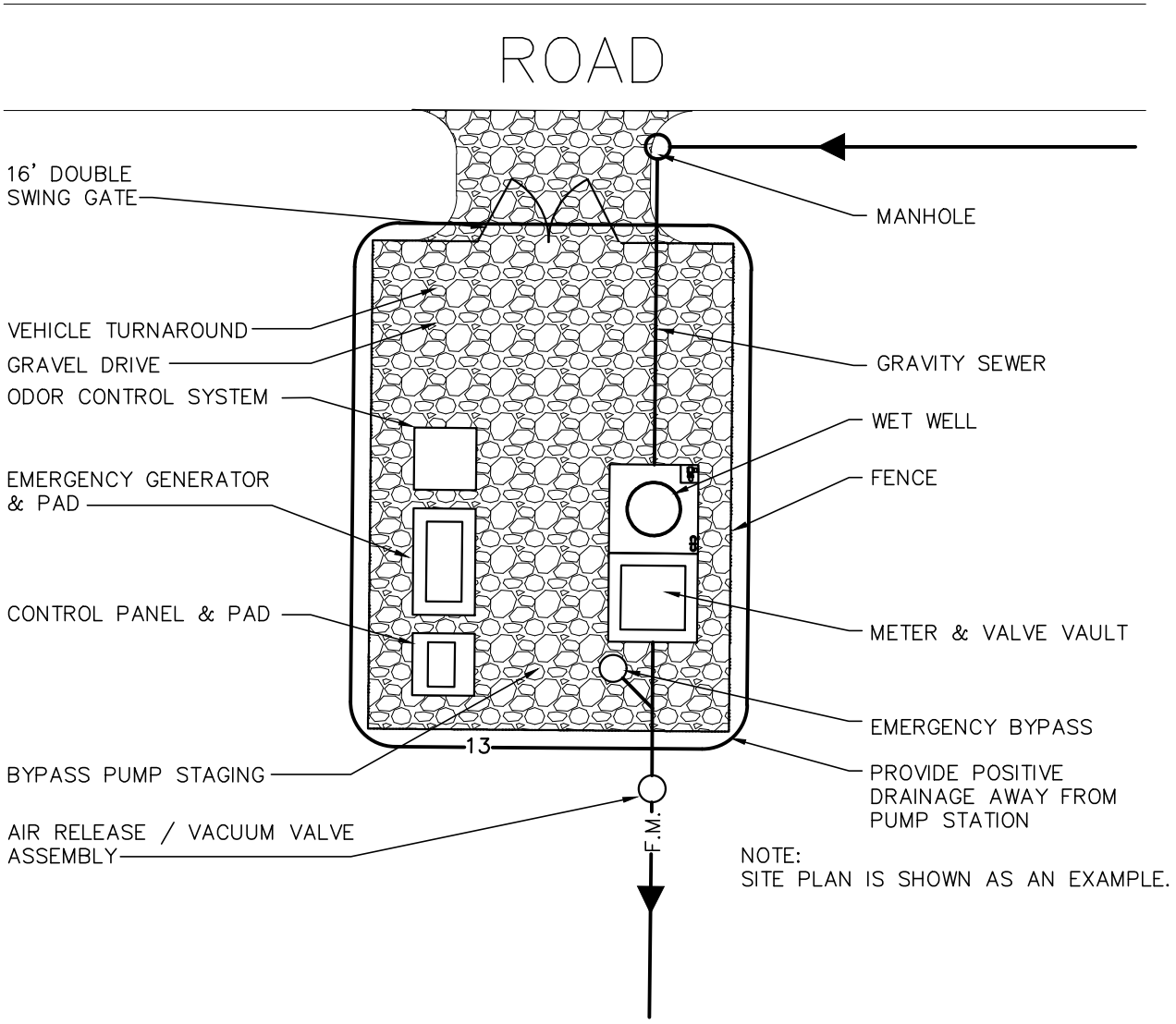
Accomack County Layout Map

DBF #3226A001.A01

Eastern Shore Sanitary Sewer Transmission Force Main Study

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com

Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Accomack County Layout Map.mxd



TYPICAL PUMP STATION SITE PLAN

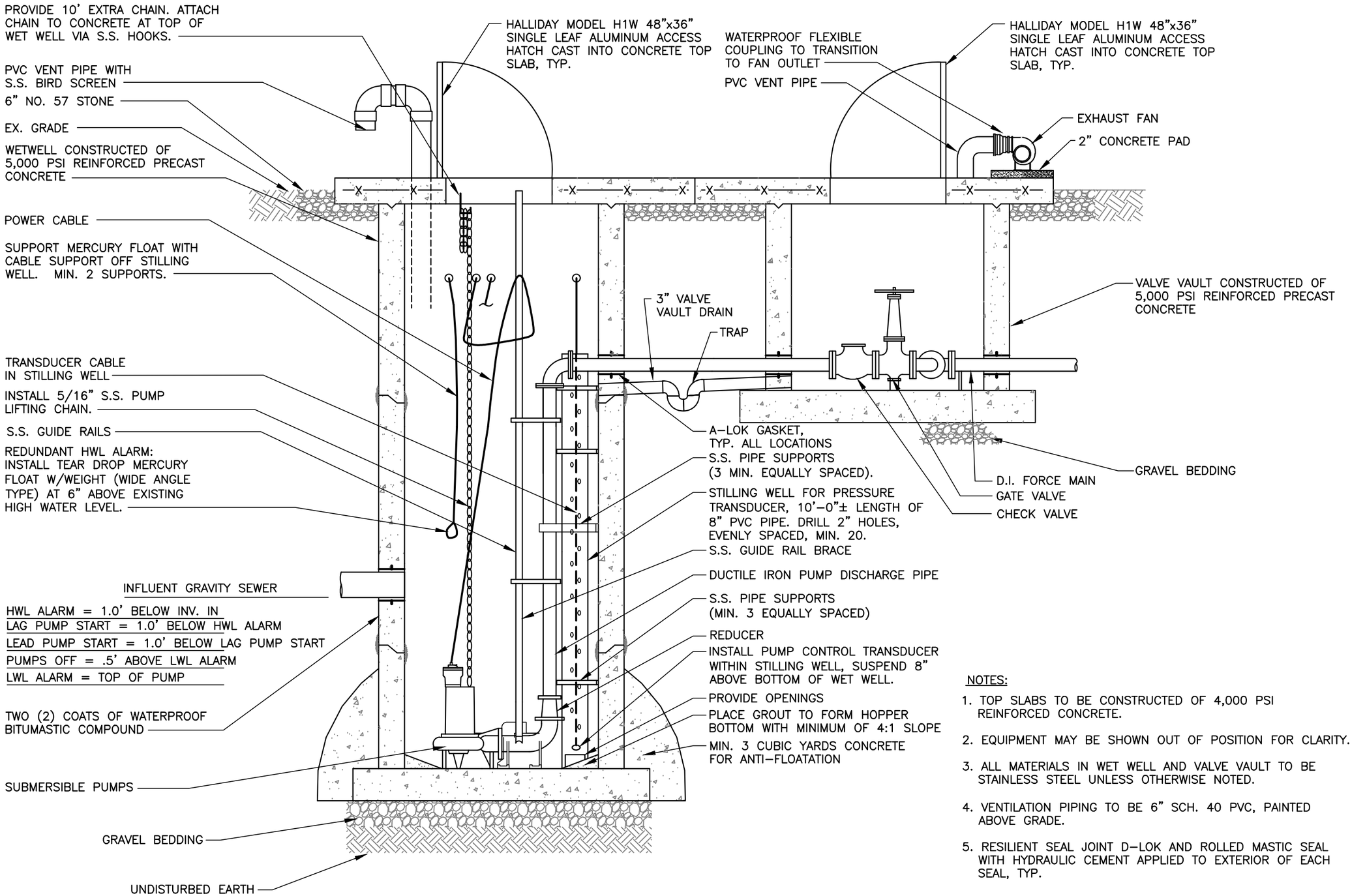
NOT TO SCALE

DAVIS, BOWEN & FRIEDEL, INC. ARCHITECTS ENGINEERS SURVEYORS

SALISBURY, MARYLAND (410) 543-9091
MILFORD, DELAWARE (302) 424-1441
EASTON, MARYLAND (410) 770-4744

EASTERN SHORE SEWER TRANSMISSION STUDY
ACCOMACK & NORTHAMPTON COUNTIES
EASTERN SHORE OF VIRGINIA

Date:	Scale:	Proj.No.:
FEB. 2019	N.T.S.	3226A001.A01



TYPICAL DUPLEX PUMP STATION ELEVATION

NOT TO SCALE

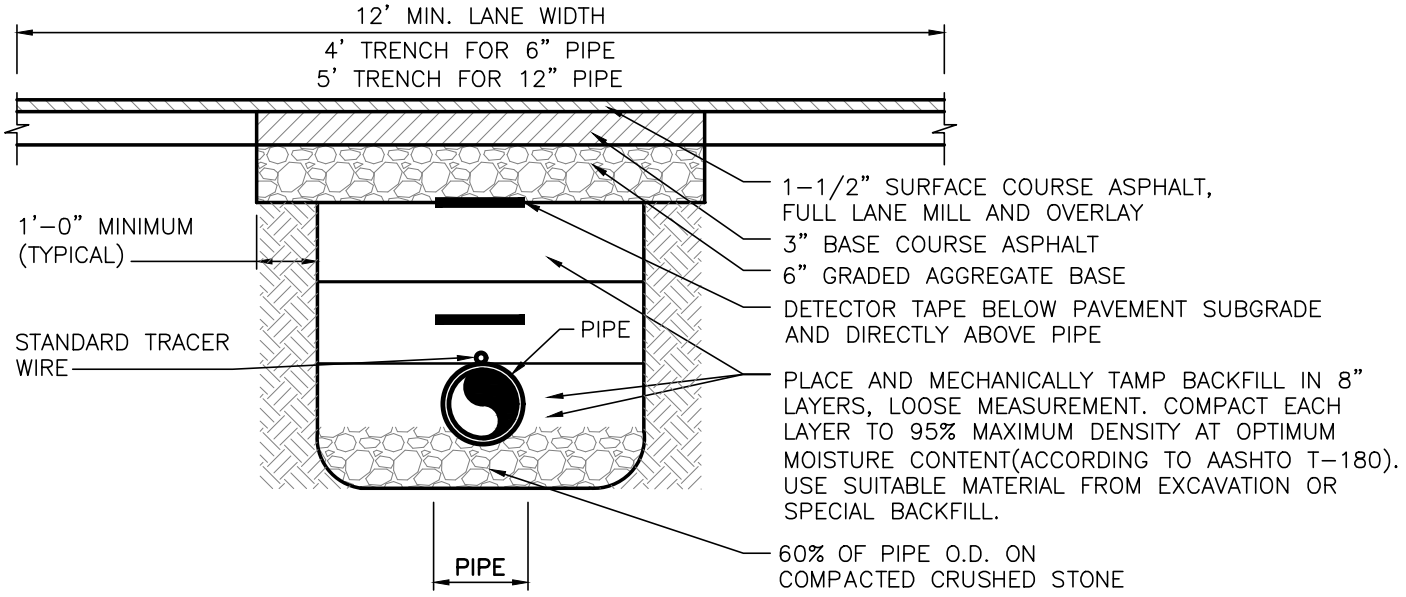
NOTES:

1. TOP SLABS TO BE CONSTRUCTED OF 4,000 PSI REINFORCED CONCRETE.
2. EQUIPMENT MAY BE SHOWN OUT OF POSITION FOR CLARITY.
3. ALL MATERIALS IN WET WELL AND VALVE VAULT TO BE STAINLESS STEEL UNLESS OTHERWISE NOTED.
4. VENTILATION PIPING TO BE 6" SCH. 40 PVC, PAINTED ABOVE GRADE.
5. RESILIENT SEAL JOINT D-LOK AND ROLLED MASTIC SEAL WITH HYDRAULIC CEMENT APPLIED TO EXTERIOR OF EACH SEAL, TYP.

EASTERN SHORE SEWER TRANSMISSION STUDY
ACCOMACK & NORTHAMPTON COUNTIES
EASTERN SHORE OF VIRGINIA

Date: FEB. 2019 | Scale: N.T.S. | Proj.No.: 3226A001.A01

DAVIS, BOWEN & FRIEDEL, INC. ARCHITECTS ENGINEERS SURVEYORS
SALISBURY, MARYLAND (410) 543-9091
MILFORD, DELAWARE (302) 424-1441
EASTON, MARYLAND (410) 770-4515



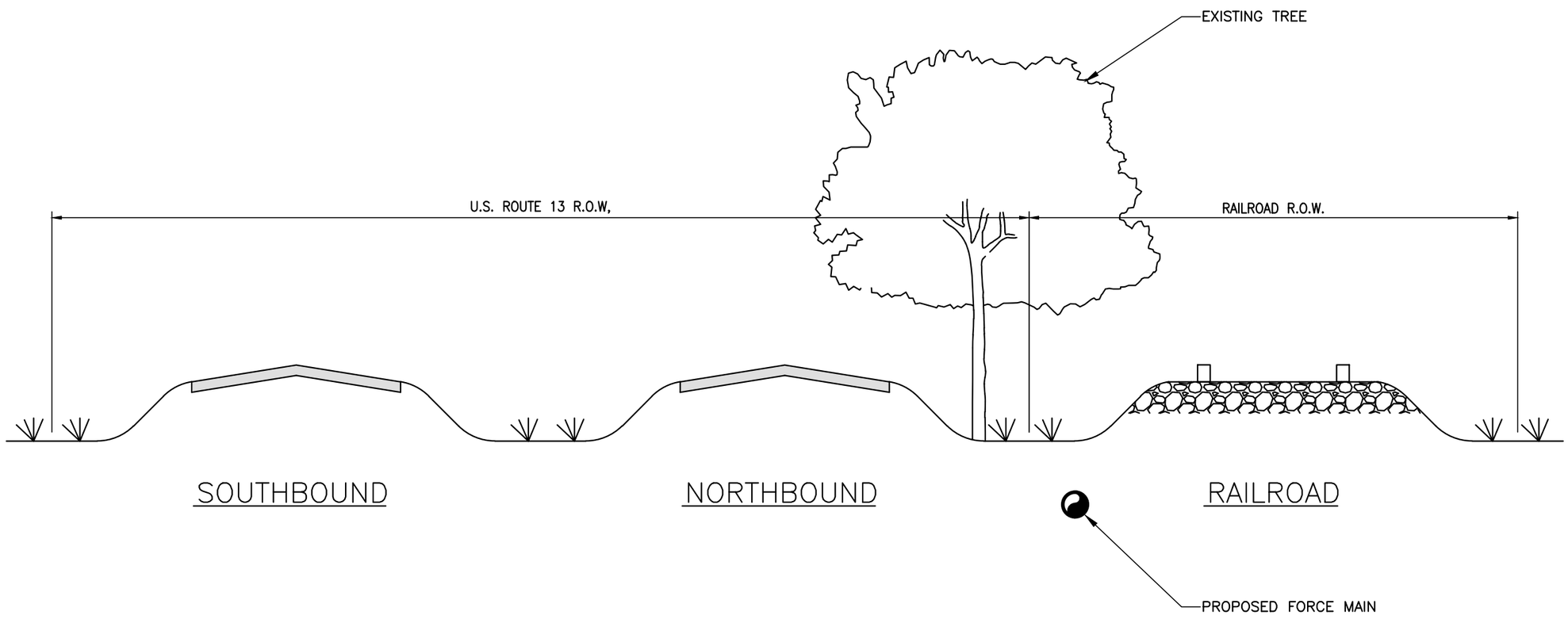
PAVEMENT RESTORATION DETAIL

NOT TO SCALE

DAVIS, BOWEN & FRIEDEL, INC. ARCHITECTS ENGINEERS SURVEYORS
SALISBURY, MARYLAND (410) 543-9091
MILFORD, DELAWARE (302) 424-1441
EASTON, MARYLAND (410) 770-4744

EASTERN SHORE SEWER TRANSMISSION STUDY
ACCOMACK & NORTHAMPTON COUNTIES
EASTERN SHORE OF VIRGINIA

Date:	Scale:	Proj.No.:
FEB. 2019	N.T.S.	3226A001.A01



TYPICAL FORCEMAIN ALIGNMENT

NOT TO SCALE

EASTERN SHORE SEWER TRANSMISSION STUDY
ACCOMACK & NORTHAMPTON COUNTIES
EASTERN SHORE OF VIRGINIA

Date: FEB. 2019 | Scale: N.T.S. | Proj.No.: 3226A001.A01

DAVIS, BOWEN & FRIEDEL, INC. ARCHITECTS ENGINEERS SURVEYORS
SALISBURY, MARYLAND (410) 543-9091
MILFORD, DELAWARE (302) 424-1441
EASTON, MARYLAND (410) 770-4515

PROJECT COSTS

Total Project Cost

The Total Project Cost includes: construction costs including mobilization and allowances; easements, legal and administrative costs; engineering survey, design and permitting; bidding administration services; contract administration and project inspection; and a program contingency. The project cost has been estimated to Class 5 as defined by AACE International with an accuracy range of -25% to +50%. The total project cost is estimated at $22,200,000.

A detailed estimate has been provided in Appendix B.

Operations & Maintenance Costs

Each of the three (3) proposed pump stations have been evaluated for monthly and annual costs. Energy usage, generator maintenance and fuel, replacement pumps and motors, and miscellaneous equipment replacement has been considered. Additionally, pipe repairs and maintenance of the system has been considered. Vehicle and fuel costs and a wastewater operator salary with a 50% full time equivalent has also been included. The total annual operations and maintenance cost is estimated to be $75,630. This amount considers the cost to operate the system and does not include the cost to treat the waste at the Onancock Wastewater Treatment Plant.

The detailed Operations & Maintenance Cost has been provided in Appendix C.

EASEMENTS, DEEDS, & RIGHT-OF-WAYS

The project will require significant coordination and will require easements, deeds, or right-of-way permission from property owners or authorizes. Accomack County has easements for the existing forcemain to be replaced from Melfa to Onley. The following table summarizes the property owners or authorities where coordination will be required.

Table 4: Easements, Deeds, & Right-of-Ways

Property Owner Name	Secondary Name	Tax Map #	Use	Approximate Size	Type
Northampton Accomack Memorial	Riverside Health	21A1-A-46	Nassawadox Pump Station	50'x50'	Deed or Easement
Northampton Accomack Memorial	Riverside Health	21A1-A-46	Forcemain	10' Wide Disturbed, 20' Wide Needed	Easement
Canonie Atlantic Co. (CAC)	Railroad	N/A	Forcemain	10' Wide Disturbed, 20' Wide Needed	ROW Permission
The Town of Exmore	Exmore	10A2-6-C-3	Exmore Pump Station	Full Size of Parcel	Deed or Easement
Virginia Department of Transportation	VDOT	Bus. 13, Rt. 13, 179, 126	Forcemain	10' Wide Disturbed, 20' Wide Needed	ROW Permission
Town of Onancock	Onancock	Rt. 658	Forcemain	10' Wide Disturbed, 20' Wide Needed	ROW Permission
Town of Onancock (WWTP)	Onancock	85-2-5	Forcemain	10' Wide Disturbed, 20' Wide Needed	Permission/ Easement
Accomack County	Accomack County	86A1-A-131	Accomac Pump Station	50'x50'	Deed or Easement
Accomack County Or Town of Accomac	Accomac/Accomack	Courthouse Rd.	Forcemain	10' Wide Disturbed, 20' Wide Needed	ROW Permission

PROJECT ALTERNATIVES

Exmore – New Roads

This study assessed the costs of transmitting wastewater from the Exmore New Roads wastewater system. For this alternative, a pump station would need to be installed in the vicinity of New Roads and a 6" forcemain would need to connect to the 12" forcemain. The pump station could be manifolded to the system, optionally, the pump station could discharge into the Exmore Pump Station on Virginia Avenue.

Exhibit 7 – Exmore New Roads Layout Map provides a map of the proposed pump station location and forcemain routing.

The total project cost for this alternative has been estimated to Class 5 as defined by AACE International. The total project cost for this alternative is $1,780,000. A detailed estimate has been provided as Appendix D.

Operations and maintenance costs for this system are estimated to be $7,200 annually. O&M costs do not include additional wastewater operator salary.

A deed or easement from the Town of Exmore or a nearby property owner would need to be obtained for the pump station site. The site is estimated to be 50'x50' at a minimum.

Onley Pump Station

This study has also reviewed the option of installing a central pumping station for the residential portions of Onley. The station would be centrally constructed to allow residents to connect to the station in the future. The pump station would pump to a 6" forcemain and connect to the 12" forcemain running north along US Route 13. The Town would need to construct a collection and conveyance system to collect wastewater from residents to the proposed pump station. These costs have not been included in this study.

Exhibit 8 – Onley Layout Map provides a map of the proposed pump station and forcemain routing.

The total project cost for this alternative has been estimated to Class 5 as defined by AACE International. The total project cost for this alternative is $940,000. A detailed estimate has been provided as Appendix E.

Operations and maintenance costs for this system are estimated to be $7,200 annually. O&M costs do not include additional wastewater operator salary.

A deed or easement from the Town of Onley or a nearby property owner would need to be obtained for the pump station site. The site is estimated to be 50'x50' at a minimum.

Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Exmore New Roads Layout Map.mxd

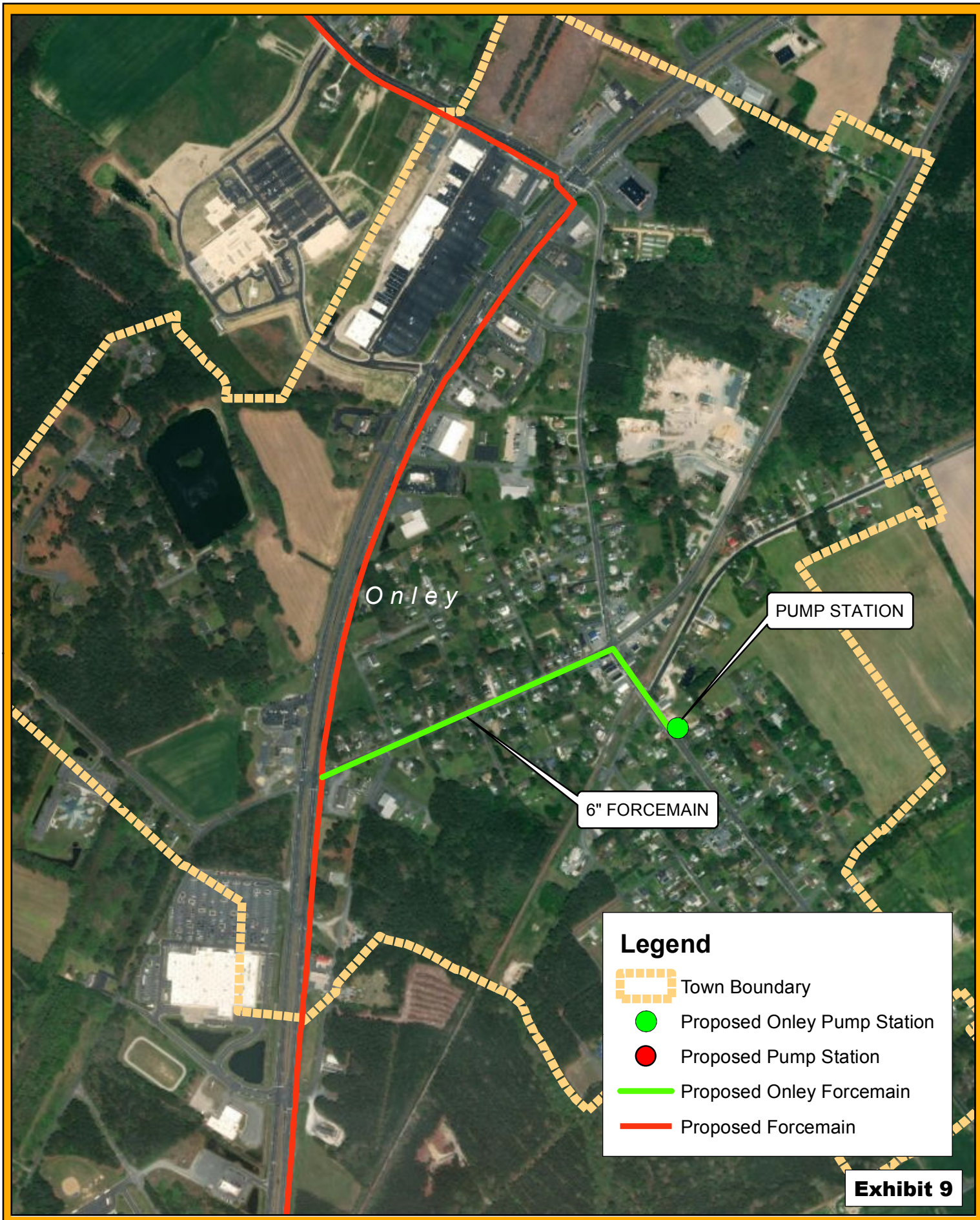
February 2019

0 0.0375 0.075 0.15 0.225 0.3 Miles

Exmore New Roads Layout Map DBF #3226A001.A01

Eastern Shore Sanitary Sewer Transmission Force Main Study

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com



N
W E
S

February 2019

0 0.03 0.06 0.12 0.18 0.24
Miles

Onley Layout Map

Eastern Shore Sanitary Sewer Transmission Force Main Study

DBF #3226A001.A01

DAVIS BOWEN & FRIEDEL, INC.
ARCHITECTS • ENGINEERS • SURVEYORS
www.dbfinc.com

Q:\3226\3226A001\GIS\MXD\Final\8.5X11-Onley Layout Map.mxd

APPENDIX A

Census of Population & Projected Populations

Census of Population & Housing Data

Onancock:

Year	Population
2010	1263
2000	1525
1990	1434
1980	1461
1970	1614

Accomac:

Year	Population
2010	519
2000	547
1990	466
1980	522
1970	373

Exmore:

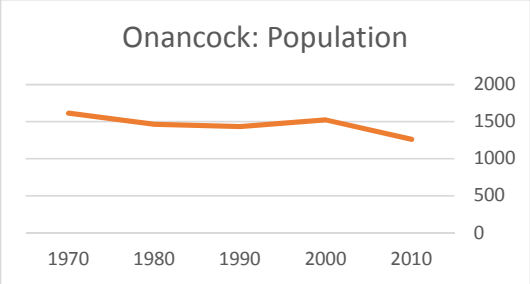
Year	Population
2010	1460
2000	1136
1990	1115
1980	1300
1970	1421

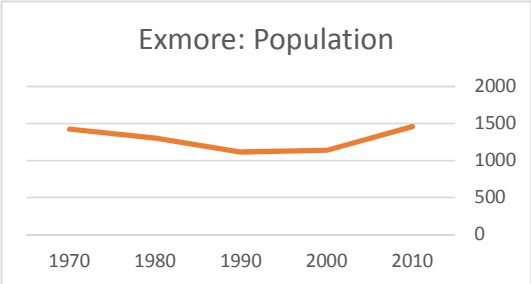
Nassawadox:

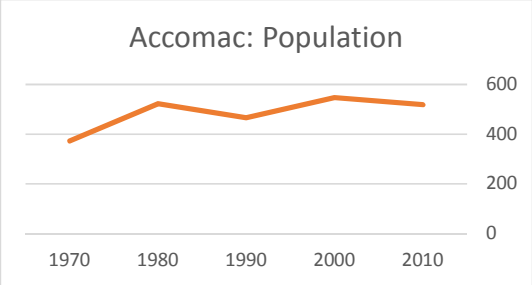
Year	Population
2010	499
2000	572
1990	564
1980	630
1970	591

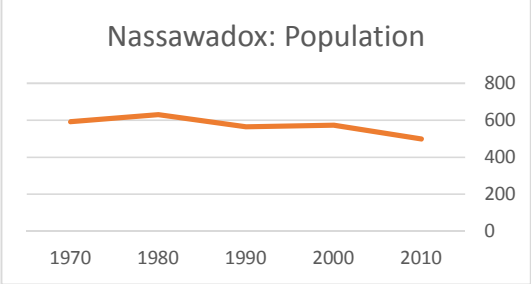
Onley:

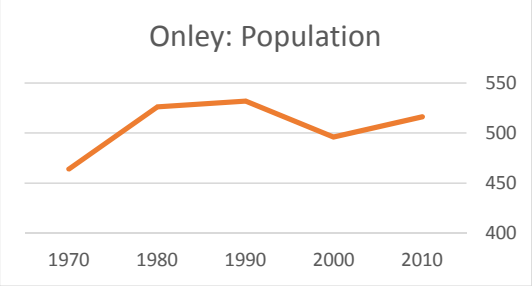
Year	Population
2010	516
2000	496
1990	532
1980	526
1970	464











Population Growth Rates*

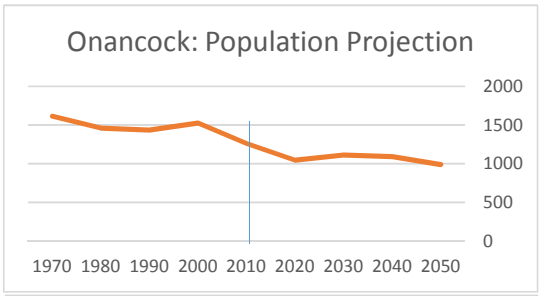
Onancock:		Accomac:		Exmore:		Nassawadox:		Onley:	
Year Range	**Growth Rate**	**Year Range**	**Growth Rate**	**Year Range**	**Growth Rate**	**Year Range**	**Growth Rate**	**Year Range**	**Growth Rate**
2000-2010	-17.18%	**2000-2010**	-5.12%	**2000-2010**	28.52%	**2000-2010**	-12.76%	**2000-2010**	4.03%
1990-2010	-11.92%	**1990-2010**	11.37%	**1990-2010**	30.94%	**1990-2010**	-11.52%	**1990-2010**	-3.01%
1980-2010	-13.55%	**1980-2010**	-0.57%	**1980-2010**	12.31%	**1980-2010**	-20.79%	**1980-2010**	-1.90%
1970-2010	-21.75%	**1970-2010**	39.14%	**1970-2010**	2.74%	**1970-2010**	-15.57%	**1970-2010**	11.21%

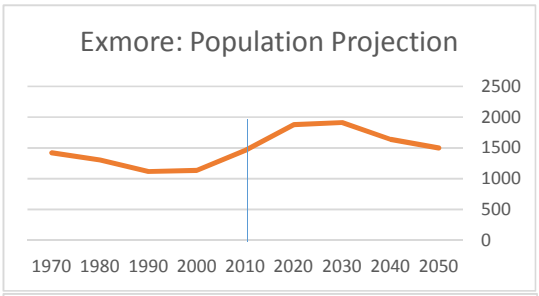
*Calculated using Census of Population & Housing Data

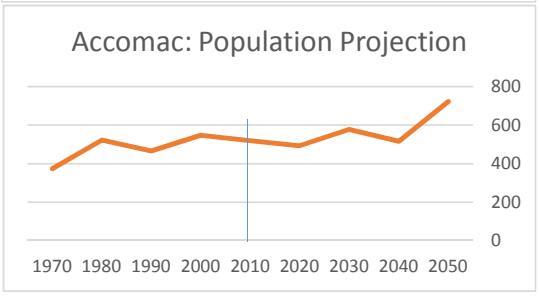
Projected Populations*

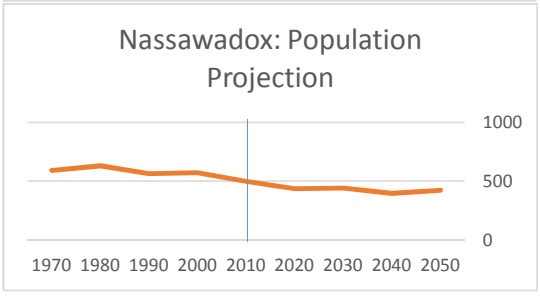
Onancock:		Accomac:		Exmore:		Nassawadox:		Onley:	
Year	Population Projection	Year	Population Projection	Year	Population Projection	Year	Population Projection	Year	Population Projection
2050	988	**2050**	722	**2050**	1500	**2050**	421	**2050**	574
2040	1092	**2040**	516	**2040**	1640	**2040**	395	**2040**	506
2030	1112	**2030**	578	**2030**	1912	**2030**	441	**2030**	500
2020	1046	**2020**	492	**2020**	1876	**2020**	435	**2020**	537
2010	1263	**2010**	519	**2010**	1460	**2010**	499	**2010**	516
2000	1525	**2000**	547	**2000**	1136	**2000**	572	**2000**	496
1990	1434	**1990**	466	**1990**	1115	**1990**	564	**1990**	532
1980	1461	**1980**	522	**1980**	1300	**1980**	630	**1980**	526
1970	1614	**1970**	373	**1970**	1421	**1970**	591	**1970**	464

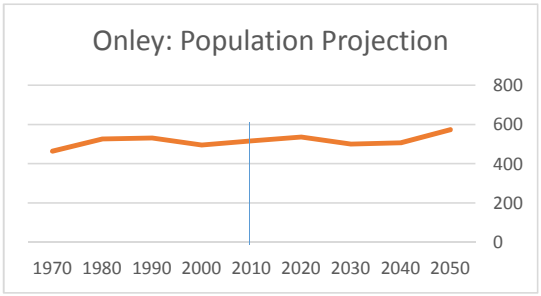
*Calculated using Census of Population & Housing Data











APPENDIX B

Engineer's Estimate – Base Project

Engineer's Estimate[1]

Eastern Shore Sanitary Sewer Transmission Force Main - Base Project

Northampton & Accomack Counties
Eastern Shore of Virginia
DBF #3226A001
May 8, 2019

Estimate includes the base project including the pump station in Nassawadox, the forcemain from Nassawadox to Exmore, the Exmore pump station, the forcemain from Exmore to the Onancock Wastewater Treatment Plant. The estimate also includes the pump station in Accomac and the forcemain to connect in Onancock. The costs for the forcemain replacement in Melfa and Onley (commercial) is provided as Bid Item No. 24.

ITEM NO.	DESCRIPTION OF WORK	SIZE OR DEPTH	UNIT	EST QTY	UNIT PRICE	TOTAL PRICE
1	Mobilization, Bonds, and Insurance (Max. 3% of Total Bid)	-	LS	-	-	$ 438,000.00
2	Provide Traffic Control Measures	-	LS	-	-	$ 200,000.00
3	Provide Erosion and Sediment Control Measures	-	LS	-	-	$ 133,000.00
4	Furnish and Install Automatic Air Release Valve and Vault	3"	EA	28	$ 16,000.00	$ 448,000.00
5	Furnish and Install Forcemain Valves	6"	EA	8	$ 4,000.00	$ 32,000.00
6	Furnish and Install Forcemain Valves	12"	EA	15	$ 6,000.00	$ 90,000.00
7	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Grassed and/or Non-Paved Areas	6"	LF	42000	$ 45.00	$ 1,890,000.00
8	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Grassed and/or Non-Paved Areas	12"	LF	68000	$ 75.00	$ 5,100,000.00
9	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Paved Areas, Roadway Restoration included in Price Bid	6"	LF	3700	$ 100.00	$ 370,000.00
10	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Paved Areas, Roadway Restoration included in Price Bid	12"	LF	8000	$ 145.00	$ 1,160,000.00
11	Furnish and Install HDPE Forcemain Pipe by Directional Drill	6"	LF	1000	$ 60.00	$ 60,000.00
12	Furnish and Install HDPE Forcemain Pipe by Directional Drill	12"	LF	4500	$ 90.00	$ 405,000.00
13	Furnish and Install PVC Forcemain Carrier Pipe and Welded Steel Casing Pipe by Jack and Bore Method (for Railroad Crossings)	12" Casing 6" Carrier	LF	180	$ 300.00	$ 54,000.00
14	Furnish and Install PVC Forcemain Carrier Pipe and Welded Steel Casing Pipe by Jack and Bore Method (for Railroad Crossings)	16" Casing 12" Carrier	LF	60	$ 350.00	$ 21,000.00
15	Furnish and Install Nassawadox Pumping Station Including Wet Well, Valve Vault, Emergency Generator, Electrical & Controls, Cellular Telemetry, Odor Control, Site Work & Paving, and Fencing	-	LS	-	-	$ 515,000.00
16	Furnish and Install Accomac Pumping Station Including Wet Well, Valve Vault, Emergency Generator, Electrical & Controls, Cellular Telemetry, Odor Control, Site Work & Paving, and Fencing	-	LS	-	-	$ 515,000.00

17	Furnish and Install Exmore Pumping Station Including Wet Well, Valve Vault, Emergency Generator, Electrical & Controls, Cellular Telemetry, Odor Control, Site Work & Paving, and Fencing near the Existing Virginia Street Pump Station	-	LS	-	-	$	650,000.00
18	Decommission Existing Nassawadox Wastewater Treatment Plant	-	LS	-	-	$	60,000.00
19	Decommission Existing Exmore Wastewater Treatment Plant	-	LS	-	-	$	70,000.00
20	Furnish and Install Connection to Existing Gravity Sewer System at the Onancock Wastewater Treatment Plant Influent Pump Station	-	LS	-	-	$	20,000.00
21	Divert Existing Influent Gravity Sewer at the Nassawadox WWTP to the Proposed Pump Station	-	LS	-	-	$	30,000.00
22	Decommission the Existing Virginia Street Pumping Station and Tanks in Exmore	-	LS	-	-	$	35,000.00
23	Divert Existing Influent Gravity Sewer at the Exmore Pump Station to the Proposed Pump Station	-	LS	-	-	$	30,000.00
24	Replacement of the Melfa & Onley Commercial Forcemain *(See excerpt on next page)*	-	LS	-	-	$	1,770,000.00
CONSTRUCTION ALLOWANCES							
25	Miscellaneous Excavation and Backfill for Test Pitting	--	CY	5000	$ 50.00	$	250,000.00
26	Excavation Below Subgrade and Gravel Refill	--	CY	7600	$ 35.00	$	266,000.00
27	Furnish & Place Select Backfill	--	CY	7600	$ 25.00	$	190,000.00
28	Furnish & Place 4,000 PSI Concrete	--	CY	1000	$ 225.00	$	225,000.00
					TOTAL CONSTRUCTION COSTS (ITEMS 1-28)	**$**	**15,027,000.00**
					EASEMENTS, LEGAL & ADMINISTRATIVE COSTS (1%)	**$**	**150,000.00**
					ENGINEERING SURVEY, DESIGN & PERMITTING	**$**	**1,555,000.00**
					BIDDING ADMINISTRATION SERVICES	**$**	**12,000.00**
					CONTRACT ADMINISTRATION & INSPECTION	**$**	**1,728,000.00**
					PROGRAM CONTINGENCY (20%)	**$**	**3,694,000.00**
					TOTAL ENGINEER'S ESTIMATE[2]	**$**	**22,200,000.00**

[1] Engineer's Estimate is a Class 5 Estimate as defined by AACE International. Accuracy Range -25% to +50%

[2] Total estimate has been rounded.

Engineer's Estimate[1]

Accomack County Melfa & Onley Commercial Replacement

Accomack County
Eastern Shore of Virginia
DBF #3226A001
May 8, 2019

This estimate is a breakdown of the costs for Bid Item No. 24 in the base project estimate.

ITEM NO.	DESCRIPTION OF WORK	SIZE OR DEPTH	UNIT	EST QTY	UNIT PRICE	TOTAL PRICE
1	Furnish and Install Automatic Air Release Valve and Vault	3"	EA	8	$ 16,000.00	$ 128,000.00
2	Furnish and Install Forcemain Valves	6"	EA	4	$ 2,500.00	$ 10,000.00
3	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Grassed and/or Non-Paved Areas	6"	LF	32979	$ 45.00	$ 1,484,037.00
4	Furnish and Install Connections to Forcemain	-	EA	37	$ 3,000.00	$ 111,000.00
CONSTRUCTION ALLOWANCES						
5	Miscellaneous Excavation and Backfill for Test Pitting	--	CY	140	$ 25.00	$ 3,500.00
6	Excavation Below Subgrade and Gravel Refill	--	CY	200	$ 35.00	$ 7,000.00
7	Furnish & Place Select Backfill	--	CY	140	$ 25.00	$ 3,500.00
8	Furnish & Place 4,000 PSI Concrete	--	CY	102	$ 225.00	$ 23,000.00
				TOTAL CONSTRUCTION COSTS (ITEMS 1-8)		**$ 1,770,000.00**

Note: *Cost is include in Base Project.*

[1] *Engineer's Estimate is a Class 5 Estimate as defined by AACE International. Accuracy Range -25% to +50%*

[2] *Total estimate has been rounded.*

APPENDIX C

Operations & Maintenance Cost – Base Project

Engineer's Estimate

Operations & Maintenance Cost - Base Project

Northampton & Accomack Counties
Eastern Shore of Virginia
DBF #3226A001
March 1, 2019

This estimate includes operations & maintenance costs for the base project.

ITEM NO.	DESCRIPTION OF WORK	MONTHLY COST	ANNUAL COST
	Nassawadox Pumping Station		
1	Nassawadox Pumping Station Energy Usage including Pumps/Motors, Electrical Panels, Unit Heater, Ventilation, and Site Lighting	$ 200.00	$ 2,400.00
2	Nassawadox Generator Maintenance and Fuel	$ 50.00	$ 600.00
3	Nassawadox Replacement Pumps & Motors	$ 250.00	$ 3,000.00
4	Nassawadox Miscellaneous Equipment Replacement and Maintenance	$ 100.00	$ 1,200.00
	Exmore Pumping Station		
5	Exmore Pumping Station Energy Usage including Pumps/Motors, Electrical Panels, Unit Heater, Ventilation, and Site Lighting	$ 350.00	$ 4,200.00
6	Exmore Generator Maintenance and Fuel	$ 65.00	$ 780.00
7	Exmore Replacement Pumps & Motors	$ 300.00	$ 3,600.00
8	Exmore Miscellaneous Equipment Replacement and Maintenance	$ 125.00	$ 1,500.00
	Accomac Pumping Station		
9	Accomac Pumping Station Energy Usage including Pumps/Motors, Electrical Panels, Unit Heater, Ventilation, and Site Lighting	$ 200.00	$ 2,400.00
10	Accomac Generator Maintenance and Fuel	$ 50.00	$ 600.00
11	Accomac Replacement Pumps & Motors	$ 250.00	$ 3,000.00
12	Accomac Miscellaneous Equipment Replacement and Maintenance	$ 100.00	$ 1,200.00
	General Costs		
13	Pipe Repairs and Maintenance	$ 400.00	$ 4,800.00
14	Vehicle and Fuel for Operator	$ 300.00	$ 3,600.00
15	Wastewater Operator Salary with 0.9 Burden Rate and 50% Full Time Equivalent	$ 3,562.50	$ 42,750.00
	TOTAL ANNUAL O&M COSTS		**$ 75,630.00**

APPENDIX D

Engineer's Estimate – Exmore New Roads Alternative

Engineer's Estimate[1]

Exmore New Roads Alternative

Northampton County
Eastern Shore of Virginia
DBF #3226A001
March 1, 2019

This estimate only includes connecting the New Roads sewage system in Exmore to this regional sewage transmission project.

ITEM NO.	DESCRIPTION OF WORK	SIZE OR DEPTH	UNIT	EST QTY	UNIT PRICE	TOTAL PRICE
1	Mobilization, Bonds, and Insurance (Max. 3% of Total Bid)	-	LS	-	-	$ 35,000.00
2	Provide Traffic Control Measures	-	LS	-	-	$ 17,000.00
3	Provide Erosion and Sediment Control Measures	-	LS	-	-	$ 11,000.00
4	Furnish and Install Automatic Air Release Valve and Vault	3"	EA	3	$ 16,000.00	$ 48,000.00
5	Furnish and Install Forcemain Valves	6"	EA	2	$ 4,000.00	$ 8,000.00
6	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Grassed and/or Non-Paved Areas	6"	LF	1800	$ 45.00	$ 81,000.00
7	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Paved Areas, Roadway Restoration included in Price Bid	6"	LF	3700	$ 100.00	$ 370,000.00
8	Furnish and Install New Roads Pumping Station Including Wet Well, Valve Vault, Emergency Generator, Electrical & Controls, Cellular Telemetry, Odor Control, Site Work & Paving, and Fencing	-	LS	-	-	$ 515,000.00
9	Decommission Existing New Roads Wastewater System	-	LS	-	-	$ 50,000.00
10	Divert Existing Influent Sewer to New Roads Wastewater System to the Proposed Pump Station	-	LS	-	-	$ 30,000.00
CONSTRUCTION ALLOWANCES						
11	Miscellaneous Excavation and Backfill for Test Pitting	--	CY	200	$ 25.00	$ 5,000.00
12	Excavation Below Subgrade and Gravel Refill	--	CY	200	$ 35.00	$ 7,000.00
13	Furnish & Place Select Backfill	--	CY	200	$ 25.00	$ 5,000.00
14	Furnish & Place 4,000 PSI Concrete	--	CY	102	$ 225.00	$ 23,000.00
					TOTAL CONSTRUCTION COSTS (ITEMS 1-14)	**$ 1,205,000.00**
					EASEMENTS, LEGAL & ADMINISTRATIVE COSTS (1%)	**$ 12,000.00**
					ENGINEERING SURVEY, DESIGN & PERMITTING	**$ 125,000.00**
					CONTRACT ADMINISTRATION & INSPECTION	**$ 139,000.00**
					PROGRAM CONTINGENCY (20%)	**296,000.00**
					TOTAL ENGINEER'S ESTIMATE[2]	**$ 1,780,000.00**

[1] Engineer's Estimate is a Class 5 Estimate as defined by AACE International. Accuracy Range -25% to +50%

[2] Total estimate has been rounded.

APPENDIX E

Engineer's Estimate – Onley Central Pumping Station Alternative

Engineer's Estimate[1]

Onley Central Pumping Station Alternate

Accomack County
Eastern Shore of Virginia
DBF #3226A001
March 1, 2019

This estimate includes building a centralized pumping station in Onley to connect to this regional sewage transmission project.

ITEM NO.	DESCRIPTION OF WORK	SIZE OR DEPTH	UNIT	EST QTY	UNIT PRICE	TOTAL PRICE
1	Mobilization, Bonds, and Insurance (Max. 3% of Total Bid)	-	LS	-	-	$ 19,000.00
2	Provide Traffic Control Measures	-	LS	-	-	$ 9,000.00
3	Provide Erosion and Sediment Control Measures	-	LS	-	-	$ 6,000.00
4	Furnish and Install Automatic Air Release Valve and Vault	3"	EA	1	$ 16,000.00	$ 16,000.00
5	Furnish and Install Forcemain Valves	6"	EA	2	$ 4,000.00	$ 8,000.00
6	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Grassed and/or Non-Paved Areas	6"	LF	200	$ 45.00	$ 9,000.00
7	Furnish and Install PVC Forcemain Pipe, Fittings, and Appurtenances in Paved Areas, Roadway Restoration included in Price Bid	6"	LF	200	$ 100.00	$ 20,000.00
8	Furnish and Install Onley Pumping Station Including Wet Well, Valve Vault, Emergency Generator, Electrical & Controls, Cellular Telemetry, Odor Control, Site Work & Paving, and Fencing	-	LS	-	-	$ 515,000.00
CONSTRUCTION ALLOWANCES						
9	Miscellaneous Excavation and Backfill for Test Pitting	--	CY	160	$ 25.00	$ 4,000.00
10	Excavation Below Subgrade and Gravel Refill	--	CY	200	$ 35.00	$ 7,000.00
11	Furnish & Place Select Backfill	--	CY	160	$ 25.00	$ 4,000.00
12	Furnish & Place 4,000 PSI Concrete	--	CY	102	$ 225.00	$ 23,000.00
					TOTAL CONSTRUCTION COSTS (ITEMS 1-12)	**$ 640,000.00**
					EASEMENTS, LEGAL & ADMINISTRATIVE COSTS (1%)	**$ 6,000.00**
					ENGINEERING SURVEY, DESIGN & PERMITTING	**$ 66,000.00**
					CONTRACT ADMINISTRATION & INSPECTION	**$ 74,000.00**
					PROGRAM CONTINGENCY (20%)	**$ 157,000.00**
					TOTAL ENGINEER'S ESTIMATE[2]	**$ 940,000.00**

[1] Engineer's Estimate is a Class 5 Estimate as defined by AACE International. Accuracy Range -25% to +50%

[2] Total estimate has been rounded.

Attachment B

Onancock WWTP Capacity Analysis, Technical Memorandum, prepared by HDR, dated March 18, 2019.

Technical Memorandum

Date:	Monday, March 18, 2019
Project:	Eastern Shore Sanitary Sewer Transmission Force Main Study
To:	Bill M'Coy, HDR
From:	Deepthi Kalyanam, HDR
Subject:	Onancock WWTP Capacity Analysis

1.0 Introduction

This technical memorandum (TM) summarizes the results of the fatal flaw capacity analysis of the Onancock Wastewater Treatment Plant (WWTP) to confirm its ability to accept the plant's design flows and loads. This assessment of treatment process capacity was performed by HDR referencing the Virginia Sewage Collection and Treatment (SCAT) Regulations and other recommended standards and guidelines for wastewater treatment facilities, such as those published by the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (often referred as "10-State Standards"), Design Guidelines for Wastewater Facilities by Maryland Department of Engineering (MDE) and the Water Environment Federation Manual of Practice (WEF MOP) 8 for unit processes not covered by the SCAT Regulations.

2.0 Background

The Onancock WWTP is located at 23656 North Street (State Road 653) in Accomack County, Virginia. The original plant facilities date back to the 1960s and 1970s. The Town of Onancock completed the plant's most recent expansion and upgrade in 2012 increasing the permitted design maximum monthly average flow capacity to 0.75 million gallons per day (MGD). Limited flow monitoring data provided by the plant operation indicates that the plant is currently operating at about 27 percent of its design flow capacity based on a maximum monthly flow of 0.205 MGD reported for July 2018.

The treatment plant consists of an influent pump station, screening and grit facility, a Four Stage Bardenpho / Membrane Bioreactor treatment process consisting of two identical trains and a UV disinfection unit. The plant's solids handling facilities consist of two gravity thickeners integral within the two aerobic digesters and a belt filter press for sludge dewatering. Based on discussion with plant staff, it is our understanding that the plant has historically met all its operating objectives and achieved compliance with the conditions of its discharge permit.

2.1 Influent Wastewater Characteristics and Permit Limitations

Table 1 summarizes the plant's design basis flows and influent concentrations as documented from the 2012 expansion and upgrade, which were used for this evaluation.

Table 1: Influent Wastewater Design Basis[1]	
Parameter	**Value**
Maximum Monthly Average Flow, MGD	0.75
Maximum Day Flow, MGD	1.5
Peak Hour Flow, MGD	1.875
BOD, milligram/liter (mg/L)	265
TSS, mg/L	200
TKN, mg/L	40
NH3-N, mg/L	25
TP, mg/L	7
Alkalinity, mg/L	220

[1] From Design memorandum in Appendix B of O&M Manual. All concentrations are based on the max month design flow of 0.75 MGD.

Influent wastewater characteristics have not been routinely monitored at the Onancock WWTP. Therefore, HRSD monitored the influent wastewater characteristics during February 2019. Results of this monitoring indicate that the current influent wastewater characteristics are well below the design basis values listed in Table 1. Available data from the other sanitary sewer systems were reviewed to compare with the plant's design basis. Data from Nassawadox was not made available and Accomac does not have a centralized collection system at this time, so not data is available. Exmore provided data from their Downtown system (sequencing batch reactor), which indicates the nitrogen concentrations are relatively high. However, given the low concentrations currently entering the Onancock WWTP, it is expected that the wastewater characteristics will remain at or below the plant's design basis even with these new wastewater sources. Further efforts to monitor and verify the wastewater characteristics of the service areas is beyond the scope of this study, but should be performed to confirm the conclusions of this analysis. For this capacity analysis, the design basis values listed in Table 1 were used.

The Onancock WWTP discharges its effluent to Onancock Creek, which is a tributary to the Chesapeake Bay, under VPDES Permit No. VA0021253. Nutrient waste load allocations are regulated through the Chesapeake Bay Watershed General Permit. Table 2 presents a summary of the permitted monthly effluent limits for the Onancock WWTP.

Table 2: Effluent Permit Limit Summary	
Parameter	**Value[1]**
CBOD, mg/L	<10
TSS, mg/L	<10
TN, pounds/year (lb/yr)	9,138
TN, mg/L	4
TP, lbs/yr	684
TP, mg/L	0.3
NH3-N, mg/L (Apr 1-Oct 31)	0.9
NH3-N, mg/L (Nov 1-Mar 31)	2.0
Total recoverable copper, microgram/liter (ug/L)	12

[1] Concentration values listed are monthly average

2.2 Treatment Process Units

The plant consists of the following processes and each of them have been evaluated for their capacity to treat the design basis flows and loads as listed in Table 1 and 2 above.

1. One Mechanical Bar Screen
2. One Influent Pump Station, with three submersible pumps
3. Two 2-mm Rotating Drum Fine Screens with integral washer/compactors
4. One Vortex Grit Removal Unit
5. One Influent Equalization Tank
6. Two Four Stage Bardenpho Process Trains each consisting of an Anoxic Tank, a Swing Tank (anoxic or aerobic), an Aerobic Tank and a Post Anoxic Tank
7. Three Membrane Bioreactor (MBR) process skids
8. One Ultraviolet (UV) Disinfection
9. Two Aerobic Digesters
10. Two Gravity Thickeners (integral with the digesters)
11. One Belt Filter Press
12. Chemical Feed System: Alum Feed, Citric Acid, Micro C, Sodium Hypochlorite

2.3 Treatment Process Description

Each unit process is described in this section and Figure 1 provides an overall flow schematic.

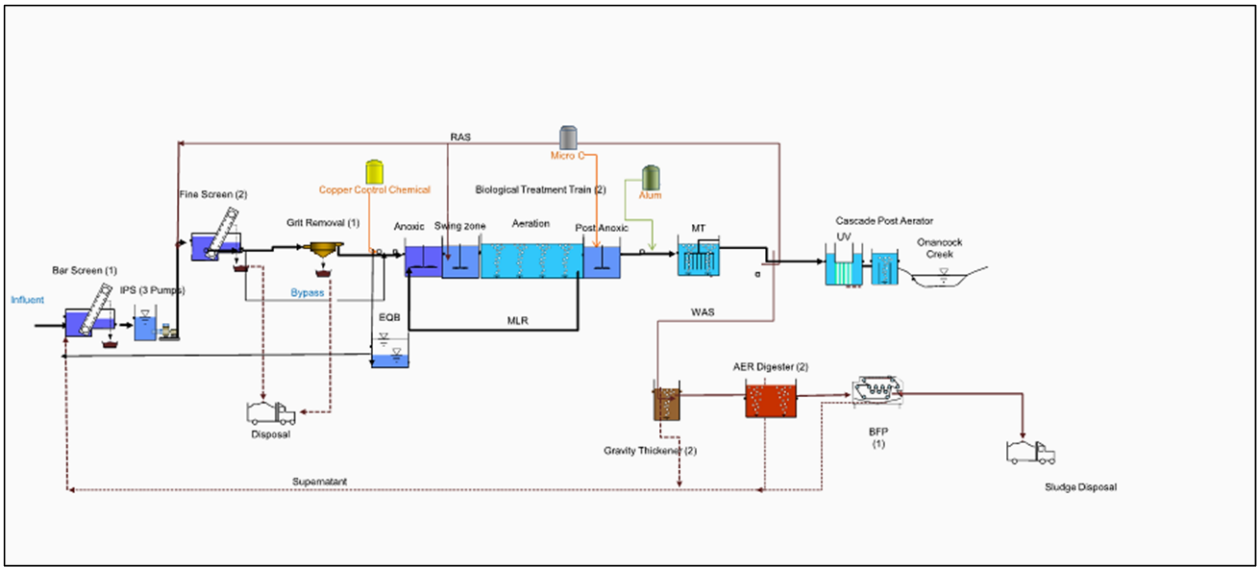


Figure 1: Process Flow Schematic

A. Preliminary Treatment:

Influent wastewater enters the plant through a 16-inch diameter sewer which discharges flow by gravity to the Mechanical Bar Screen Chamber. After this initial screening, influent wastewater flows into the Influent Pump Station wet well and is pumped to one of two rotating drum fine screens installed in parallel. The effluent from the fine screens flows into a vortex grit separator for grit removal. The screened and de-gritted wastewater flows by gravity to a bioreactor flow splitter box that divides the flow evenly to the two bioreactor trains. The splitter box has an overflow weir that directs any flow above the average daily maximum month flow to the Equalization Basin which returns flow to the Influent Pump Station (IPS) and overflows to the Emergency Holding Pond.

B. Secondary Treatment:

Downstream of the overflow weir, the flow is split to either or both bioreactor trains. Each train is designed to handle the maximum month flow of 0.75 MGD to the plant. The influent to the bioreactors passes through four stages: Anoxic, Aerobic/Anoxic (Swing), Aerobic and Post Anoxic. Internal recycle (MLR) is provided from the 3rd Aerobic zone to first Anoxic zone for de-nitrification. The Swing zone is typically operated as Aerobic zone. Submersible mixers are provided in the Anoxic zones, Swing zones (when not operated aerobically), and Post-Anoxic zones to keep the mixed liquor in suspension and properly mixed. The Aerobic zone and Swing zones (when operated aerobically) have fine bubble diffusers for nitrification. Micro C is used as

a supplemental carbon source for de-nitrification and is added to the Post Anoxic zone. Mixed liquor (MLSS) flows from the biological reactors to the membrane skids by gravity. The membrane skids use hollow-fiber membranes to separate any particles, including suspended solids and pathogenic bacteria, from the treated wastewater. Permeate pumps (one per membrane skid) produce a vacuum on the hollow core of the membranes which draws the MLSS to the surface of the membranes. The pore size of the membranes allow the "clean" water molecules to pass through the pores and be drawn off by the permeate pumps, leaving the activated sludge solids behind. The MBR effluent is pumped by permeate pumps into the backpulse tank where it flows by gravity to the UV disinfection channel. Each membrane skid is aerated by coarse bubble diffusers which scrub the outer surface of the membranes to re-suspend the sludge solids. The remaining MLSS is returned to the Swing Tanks by the return activated sludge pumps (RAS) via the common RAS line. Membrane maintenance is performed using citric acid and sodium hypochlorite solutions. The plant also used sodium hydroxide solution to raise the pH of the raw influent in order to optimize the removal of copper.

C. Disinfection Treatment:

The wastewater passes through the UV Disinfection channel where it receives the proper dosage of UV light used for the destruction of pathogenic bacteria present. After disinfection, the final effluent flows by gravity to the cascade post-aerator and through a 16-inch diameter line to Onancock Creek.

D. Solids Handling Processes:

Excess sludge not needed for the treatment process is periodically drawn from the RAS flow and pumped to the Gravity Thickeners for thickening before being transferred to the Aerobic Digesters via an air lift pump. From the digesters, the sludge is sent to the Belt Filter Press for dewatering and trucked offsite for final disposal. Supernatant from the thickeners, digesters and belt filter press is returned to the head of the plant.

3.0 Capacity Analysis

As described previously, the capacity analysis was performed based on the assumption that the influent concentrations do not exceed the design basis of the plant as listed in Table 1. Each unit process was evaluated against the SCAT Regulations or other accepted industry standards where SCAT Regulations are not available. Table 3 documents the capacity analysis by unit process. Since the SCAT Regulations do not have criteria for MBR treatment processes, Section B of Table 3 uses the MDE and 10 States Standards for evaluating the MBR processes. The MDE guidelines were used for this process, since neither the SCAT nor the 10 States Standards address MBR process design.

Table 3: Comparison Sizing and Design Criteria			
A. Preliminary Treatment			
Treatment Component	**Equipment Info**	**Plant Permitted Capacity**	**SCAT Compliance**
Mechanical Cleaned Bar Screen	1 mechanical bar screen with capacity operating at all times	ADF: 0.75 MGD PHF: 1.875 MGD	**Yes** *Criteria: The single mechanically cleaned screen can be manually cleaned upon mechanical failure.* *9VAC25-790-500*
Influent Pump Station	PS Capacity = 2.3 MGD = 3 pumps at 800 Gallons Per Minute (GPM) at 58 feet head each (2 running, 1 standby)	ADF: 0.75 MGD PHF: 1.875 MGD	**Yes** *Criteria: Capacity with any one unit out of service to handle maximum sewage flow or a minimum of 2.5 times average design flow* *9VAC25-790-380*
Influent Screens - Fine Screens	2 fine screens with capacity = 1.875 MGD each (1 operating, 1 standby)	ADF: 0.75 MGD PHF: 1.875 MGD	**Yes** *Criteria: Provide for taking any unit out of service without sacrificing capability to handle peak design flow* *9VAC25-790-500*
Grit Removal Units	1 vortex grit unit with 1 classifier with capacity = 1.875 MGD	ADF: 0.75 MGD PHF: 1.875 MGD	**Yes** *Criteria: At least one mechanically cleaned unit with a unit bypass.* *9VAC25-790-510*

Table 3: Comparison Sizing and Design Criteria			
B. Secondary Treatment at Plant Max. Month Design Flow of 0.75 MGD			
Volume of Bioreactors Two Trains each designed to treat ADF of 0.75 MGD meets the SCAT Criteria (VAC25-790-490) BNR and MBR designed to treat Max. flow rate (PHF) of 1.5 MGD for 1 hour		Volume of bioreactor tanks (each train): 1st Anoxic Stage = 25x15x18 ft = 0.0505 MG each 2nd Stage Anoxic/Aerobic= 25x15x18 ft = 0.0505 MG each 3rd Stage Aerobic = 25x15x18 ft = 0.0505 MG each 4th Stage Anoxic = 9x15x18 ft = 0.0303 MG each Membrane Bioreactors (3 tanks) = 0.014 MG each	
Process Parameter	**Industry Recommended Standard from MDE Design Guidelines for Four Stage MBR Treatment System at Plant Design Flow**	**Calculated Value at Plant's Max Month Design Flow of 0.75 MGD with One BNR Train in Service, 2 MBR Tanks in Service**	**Meets the Recommended Criteria**
Detention Time	6-15 hours	7	**Yes**
Internal Recycle Flow (MLR)	300-400% of Influent Flow rate	Internal Recycle Flow: 2 pumps, 2600 GPM which is equivalent to 5Q	**Yes**
Total SRT	12-20 days	13	**Yes**
BOD Loading	30-60 lbs/1000 cubic feet/d	59	**Yes**
MLSS	8,000-10,000 mg/l	8,000-10,000	**Yes**
F:M Ratio[1]	0.05-0.2 lb BOD lbs/ MLVSS/day	0.12	**Yes**
Flux	8-15 gallons per day/square feet, gpd/sq.ft (at 12 degree C)	13.8 gpd/sq.ft	**Yes (See Section 5.0 for membrane performance recommendation)**
Return Activated Sludge Pumps	3-6Q	3 pumps at 80-820 gpm (2 operating, 1 standby) = 3Q	**Yes**
DO, mg/L[2]	Anoxic: 0-0.5	0.0	**Yes**
	Aerobic: 1.5-3.0	2-3	**Yes**
	Membrane: 2-6	4.0	**Yes**
Air Demands[3] 1. 4 Stage Bioreactors 2. MBR Tanks	1.2 lbs of O2/lb of BOD, 4.6 lbs of O2/lb of NH3-N 1. 4 Stage Bioreactors = 970 scfm 2. MBR Tanks = based on vendor recommendation for membrane scour air demand	1. Three blowers with 2 blowers each at 1040 cfm, 3rd blower with 360 cfm 2. Three blowers each at 572 cfm	**Process Air = Yes** **MBR = Not Calculated (**based on vendor recommendation for membrane scour air demand**)**
Pre-Treatment for Membranes 1. Fine Screens 2. Flow Equalization	1. 1-3millimeter (mm) 2. EQ Tank for PF above 1.5-2.0	1. 2.0 mm 2. 95,000 gallons, 6 hours DT	**Yes**

Table 3: Comparison Sizing and Design Criteria			
Treatment Component	**Required Capacity**	**Plant Permitted Capacity**	**SCAT Compliance**
C. Final Treatment			
UV Disinfection[4]	Peak Design Flow: 1.5 MGD, UV transmittance 254 nanometers (nm) Two Channels for Process Redundancy	Two Banks each capable of treating 1.5 MGD each. Additional flows directed to EQ Basin (if needed) UV transmittance 254 nm, Dosage: 50,000 milli Watt second per square centimeter (mWs/sq.cm) UV Cleaning (it is assumed that periodic cleaning is performed as per the UV O&M manual)	**Yes** *Criteria: Transmittance 253.7 nm* *Dosage: 50,000 mWs/sq.cm* *UV Cleaning with proper acid/detergent cleanser 9VAC25-790-770*
D. Solids Handling at Plant Max. Month Design Flow of 0.75 MGD			
Gravity Thickeners	From PER: WAS = 1300 lbs/day, 1.0% solids, Thickener volume needed: 15,600 gallons WEF MOP-8: 4-8 lb/d/sf Solids Loading Rate for WAS only thickening	Two Thickeners: 21 ft diameter (ea) x 13 ft SWD 33,700 gallons each Surface Overflowrate: 45 gpd/sqft. The plant uses dilution water supply to maintain minimum overflow rates and minimize septicity. Solids Loading Rate = 3.8 lb/d/sf	**Yes** *Criteria: Alternate storage required. Continuous return of supernatant,* *Surface Overflow rate: 400-800 gpd/sq.ft 9VAC25-790-600; WEF MOP-8: 4-8 lb/d/sf Solids Loading Rate for WAS only thickening*
Aerobic Digesters	From PER: WAS leaving from gravity thickener = 1300 lbs/day, 2.5% solids, 20 days SRT for Class B Solids per M&E 4th Edition Air Volume Needed = 1100 scfm (two blowers, 1 operating, 1 standby) (30 cfm per 1000 cu.ft: 10 State Standards)	Two 30 foot diameter x 26' SWD (ea) digesters with total volume = 275,000 gallons, HRT = 22 days for Class B Solids 3 blowers at 4,337 scfm, 300 Hp each (from equipment O&M manual)	**Yes** *Criteria: Multiple tanks required based on the added sludge volume, % volatile solids, Class B Disposal 9VAC25-790-560*
Sludge Dewatering	From PER, Based on WAS = 1,300 lbs/day with 38% VSS reduction, 905 lbs/day leaving the digester for dewatering. 1.0 % solids, dewatering needed = 42 gpm 2.0% solids, dewatering needed = 22 gpm	One Belt Filter Press 1.0 m with 50 gpm capacity Operating at 6 hours/day 5 days a week Five 20'x48' Sand Drying Beds serve as a backup to the solids dewatering process	**Yes** *Criteria: At least two units unless adequate storage or an alternative means of sludge handling is provided. Operate less than 60 hours/6 days* *Facility shall be capable of dewater in excess of 50% of the average design sludge flow with largest unit out of service.* *All units to have bypass. 9VAC25-790-610*

Table 3: Comparison Sizing and Design Criteria			
E. Chemical Handling at Plant Max. Month Design Flow of 0.75 MGD			
Alum	1,232 gallons required for 30 days storage to remove TP from 2.0 mg/l to 0.3 mg/l (Assumption: BNR plant is able to biologically remove phosphorus to 2.0 mg/l)	One 1500 gallon tank onsite plus 60 gallons day tank 3 peristaltic pumps: Dose: 0.4-2.07 gallons per hour (gph) (MBR tanks) 0.01-1.28 gph (WAS) 0.1-0.31 gph (Digesters)	**Yes** *Criteria: Space shall be provided for 30 Days storage, liquid level indicator* *Chemical Feed: Feeders shall be able to supply at all times the necessary amounts of chemicals at an accurate rate throughout the range of feed. A minimum of two chemical feeders shall be provided (1 operating, 1 standby) 9VAC25-790-840*
Micro C	430 gallons required for 30 days storage as supplemental carbon source (Assumption: BNR plant is able to biologically remove total nitrogen to 5.0 mg/l)	Two 250 gallons Totes onsite 2 peristaltic pumps: 0.1-1.07 gph	**Yes** *Criteria: Space shall be provided for 30 Days storage, liquid level indicator* *Chemical Feed: Feeders shall be able to supply at all times the necessary amounts of chemicals at an accurate rate throughout the range of feed. A minimum of two chemical feeders shall be provided (1 operating, 1 standby) 9VAC25-790-840*
Sodium Trithiocarbonate	Supplemental Copper Conversion: Soluble to Particulate From Biowin report in O&M manual: 102 gallons average month dosage	Two 55 gallon drums 2 peristaltic pumps: 0.01-0.21 gph	**Yes** *Criteria: Space shall be provided for 30 Days storage, liquid level indicator* *Chemical Feed: Feeders shall be able to supply at all times the necessary amounts of chemicals at an accurate rate throughout the range of feed. A minimum of two chemical feeders shall be provided (1 operating, 1 standby) 9VAC25-790-840*
Sodium Hydroxide	Used to maintain pH level and add alkalinity. Based on plant requirement	Two 350 gallons Totes onsite 2 peristaltic pumps: 0.01-0.21 gph	**N/A**

[1] Based on plant operator's input: MLSS = 10,000 mg/l, MLVSS = 8,000 mg/l.
[2] Based on plant operator's input
[3] Air demands are calculated using Sanitaire's diffused aeration design guide
[4] UV dosage and transmittance is from equipment O&M manual

4.0 Effluent Permit Compliance

As discussed in Section 2, the Onancock WWTP is required to meet its effluent permit discharge limitations as per VPDES Permit No. VA0021253. The plant Discharge monitoring reports (DMRs) for 2018 were reviewed to confirm the plant's compliance with its discharge permit.

Table 4 presents calculated annual loadings for TN and TP compared with the plant's nutrient load allocation based on the provided DMR data.

Table 4: Total Annual Loads for TN and TP

Parameter	2018 Loadings[1]	Wasteload Allocation
TN, lbs/yr	1,094	9,138
TP, lb/yr	85	684

[1] Calculated for Period: January-December 2018

It is clear from the table above, the loadings for TN and TP are well below the plant's nutrient discharge allocation, even when considered the plant is operating at well below its design flow capacity.

It is to be noted that the average monthly influent flow rate for November 2018 was reported as 0.92 MGD in its DMR. This number appears to be an error since the effluent spreadsheet provided by the plant operator lists the average flow for November 2018 as 0.178 MGD. Also, the DMR lists the maximum month flow for November 2018 as 0.256 MGD indicating that the 0.92 MGD value for a monthly average is in error. Therefore, for the above TN and TP loading calculation, an average flow rate of 0.178 MGD was used for the month of November 2018.

The reported effluent values in the DMRs for cBOD (mg/l), TSS (mg/l), Fecal Coliform (n/100 ml), Total Recoverable Copper (ug/l) indicate that the plant is in compliance with its discharge permit conditions. Ammonia concentration for July 2018 was reported as 6.16 mg/l which exceeds the permit limitation of 0.9 mg/l. It is assumed that this high ammonia level is due to an operational issue or contamination of sample.

5.0 Conclusions

A review of each unit process at the Onancock WWTP indicates that the plant is capable of treating its design basis flows and loads. The BOD loading on the bioreactors is within typical design criteria, but on the high end of the range. The value of 59 lbs/1000 cubic feet/d calculated in this analysis is higher than the 43 lbs/1000 cubic feet/d listed in the plant's O&M manual. This discrepancy should be further investigated to confirm the actual design basis BOD loading.

It is to be noted that this analysis is based on the membranes operating within their design capacity range. Typically, membranes are replaced every 10 years depending on their maintenance and operating conditions. The membranes were installed in 2012, so it may be estimated that the membranes may need to be replaced in the next 3 years or earlier (based on their performance data). It is recommended that the treatment performance of the membrane bioreactors be monitored to establish their remaining useful life.

Sampling and analysis of the pollutant concentrations of the available raw influent flow streams in Nassawadox, Exmore and Accomac should be conducted to verify the assumptions that the Onancock WWTP influent concentrations will be within the plant's design basis values once the transmission force main system is placed into operation.

While the plant unit processes are sized to treat the design basis flows and loads, there are several areas where improved redundancy would enhance the reliability of the plant and should be consider for implementation:

- A redundant influent bar screen or bypass in the event the existing unit fails
- A redundant belt filter press