Data Collection at Fifteen Selected Creeks in Support of Shallow Water Dredging on Virginia's Middle Peninsula

Methods & Data Report

September 2021

Data Collection at Fifteen Selected Creeks in Support of Shallow Water Dredging on Virginia's Middle Peninsula

Methods & Data Report

Nicholas J. DiNapoli
Donna A. Milligan
C. Scott Hardaway
Christine A. Wilcox
Cameron W. Green

Shoreline Studies Program
Virginia Institute of Marine Science
William & Mary

Scott Lerberg
Eduardo Miles
Alex Demeo
George Brooks

Chesapeake Bay National Estuarine Research Reserve

September 2021

Table of Contents

1 Introduction

1.1 Project Goals

Federal funding has been historically available for the Army Corps of Engineers for shallow draft navigation projects. However, past and recent subsidies have not provided ample funding at levels to sustain maintenance dredging for the 17 federal navigation channels on the Middle Peninsula. Further, funding for maintenance of non-federal channels has been historically neglected by the Commonwealth of Virginia until the Virginia General Assembly established the Virginia Waterway Maintenance Fund in 2018. For the past decade the Middle Peninsula Chesapeake Bay Public Access Authority, the Middle Peninsula Planning District Commission and its member jurisdictions, and the Virginia Institute of Marine Science Shoreline Studies Program have worked to advance local solutions and alternatives to address dredging needs in the Commonwealth.

Despite these efforts, funding levels and financing strategies make it difficult to address the pressing navigation channel maintenance needs on the Middle Peninsula in a cost- and time-effective manner. To facilitate dredging and beneficial reuse of material in the most cost-effective manner, a local government dredging implementation business plan was proposed for the Middle Peninsula (Figure 1). The proposed activities focus on the jurisdictions within the Middle Peninsula region including six counties (Gloucester, Mathews, Middlesex, Essex, King and Queen, and King William) and three incorporated towns (West Point, Urbanna, and Tappahannock). All navigable waterways important for commercial and recreational boating activity were considered in the project activities. The proposed activities focus on both federal and non-federal channels, including those with ATONs and those without which have received very little or no focus to date.

Previous research studies collected existing data in a Geographic Information System (GIS) for all the channels of the Middle Peninsula; this data was used to prioritize channels based on physical parameters (Milligan et al., 2021). Milligan et al. (2021) found that accurate existing data for creek and river channels is lacking in most locations. To provide needed data for the local government dredging implementation business plan, this research supported the plan development through collection of physical data for selected channels.

Milligan et al. (2021) listed all of the creeks and rivers on the Middle Peninsula. From this data, the localities prioritized the creeks and rivers that they feel should be at the top of the list for dredging funds (Figure 2). For these creeks, navigation channel condition assessments were conducted to resolve a critical element needed for the business plan which is filling data gaps for creeks lacking adequate bathymetric survey data and sediment types. This data report provides baseline information for fifteen selected creeks and rivers on the Middle Peninsula including bathymetry surveys, sediment assessment, and channel creation for non-federal channels.

1.2 Creek Selection and Tasks

The Middle Peninsula Planning District Commission (MPPDC) facilitated the selection of creeks for this project. Using data provided by Milligan et al. (2021), the localities prioritized the creeks and rivers that they wanted assessed. This assessment data was used as part of the dredging implementation business plan to determine the best use of available funding. The assessment tasks performed for this project include:

1) Federal versus non-federal channel determination
    - Federal channels have pre-defined parameters including dredge channel location, width, and depth, as well as pre-authorized disposal areas. This can make permitting easier.
    - For non-federal channels, actual channel dimensions were proposed. If ATONs exist, they typically mark the channel and potential shoals and were used as guidance when determining the channel location. For channels without ATONs, finding the natural channel was necessary. Nearby federal channels were used to determine needed channel widths and depths. These dimensions were dependent on the type of boat that could potentially use the channel. The channels were designed to be wide enough to allow for 2-way traffic of the potentially largest boats in the waterway.
2) Determined the amount of material that will be dredged: This is crucial to determining the size of the project and how much area will be needed for disposal of material.
3) Classified potential dredge material for sediment type: Sediment classification was a crucial component to the channel assessment as it adds an important level of understanding to the physical characteristics and general morphology of the selected creek beds. This was important for the maintenance of channels as well as any construction or removal of material that may be involved in potential dredging. Typically, only sandy material (>90% sand) can be placed along the shoreline. It also needs to have a minimum median grain size of 0.25 mm. Smaller, muddier material has to be placed in an upland disposal facility.

Table 1. Fifteen locations selected by the localities by county.

Gloucester County	**Mathews County**	**Middlesex County**	**King & Queen County**
Sarah Creek	Put in Creek	Broad Creek	Mattaponi River
Perrin River	Mill Creek 2	Bush Park Creek	
Free School Creek	Milford Haven	Mill Creek	
Whittaker Creek	Horn Harbor	Whiting Creek	
	Queens Creek	Robinson Creek	

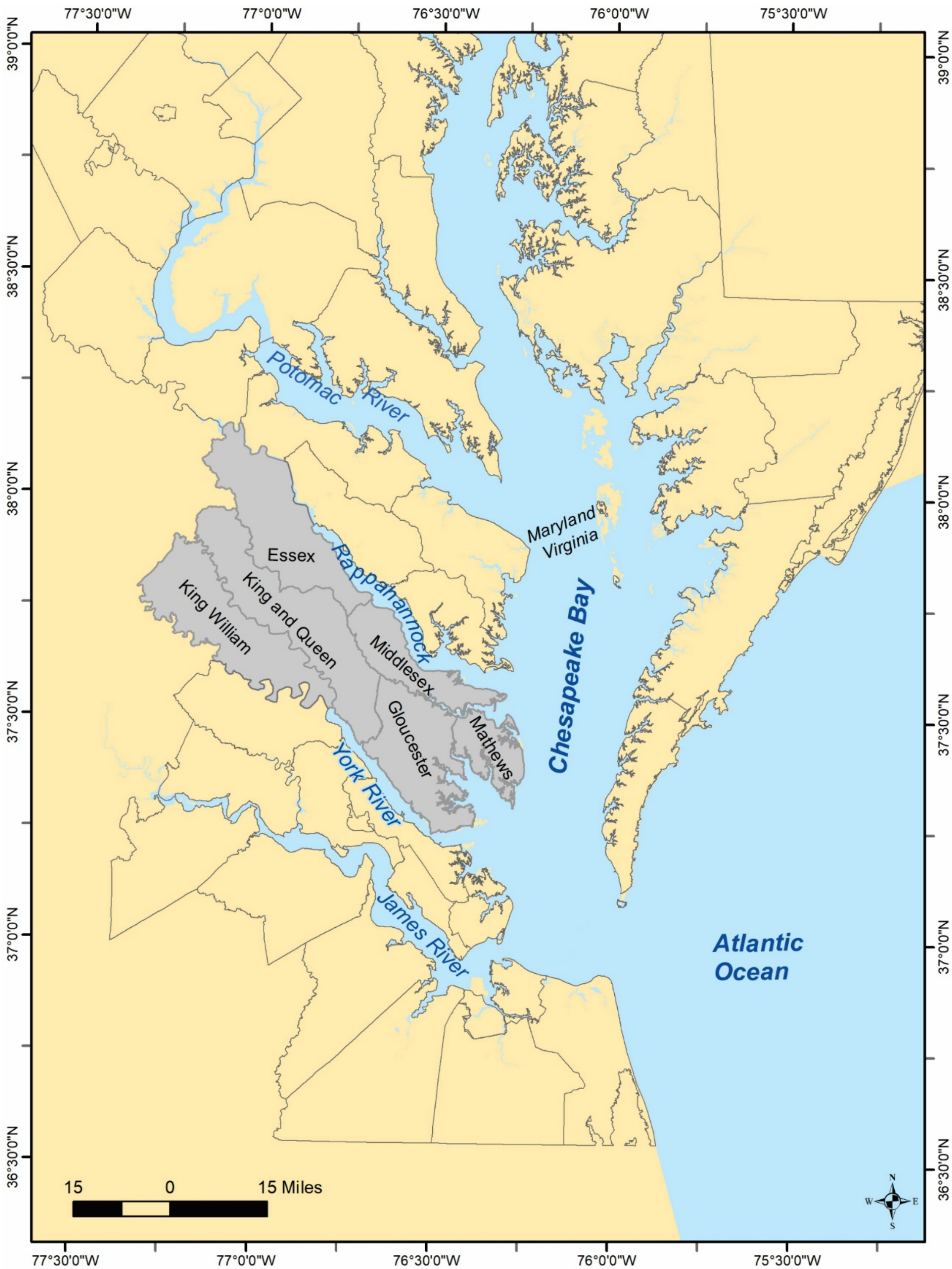


Figure 1. Location of the Middle Peninsula localities within the Chesapeake Bay estuarine system.

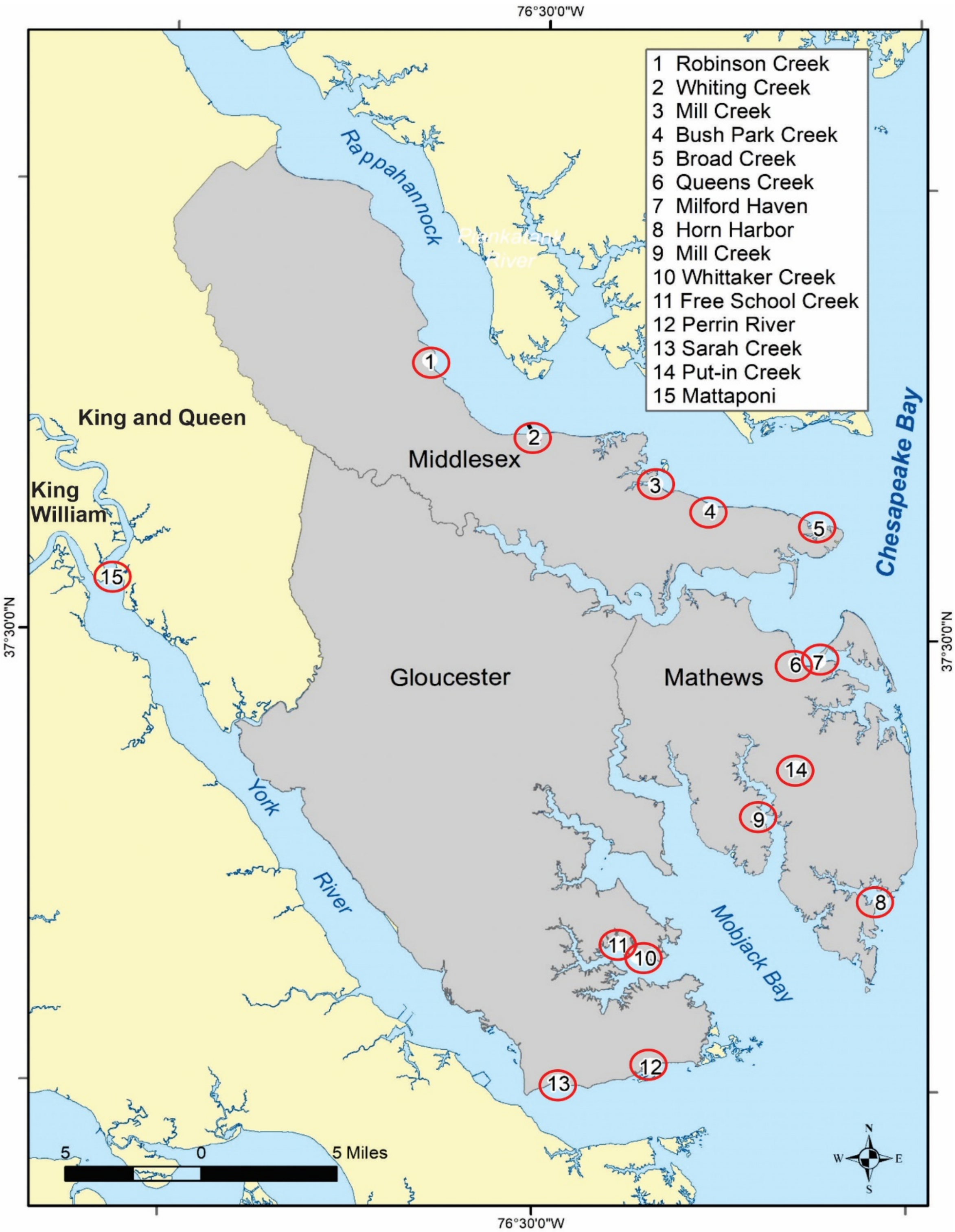


Figure 2. Location of creeks selected for assessment

2 Methods

2.1 Field Procedure for Bathymetric Survey

A bathymetric survey was performed of the potential channel area both inside and outside the creek. The survey utilized a depth transducer attached to a small vessel. This transducer data was tied manually to locally-obtained water level data. This was a scoping-level bathymetric mapping project to develop background data for each channel and to determine potential locations for shallow draft channels; it should not be used for the final design or dredging purposes. Personnel from the Chesapeake Bay National Estuarine Research Reserve (CBNERR) at VIMS performed these bathymetric surveys overseen by Director Willy Reay and Stewardship Coordinator Scott Lerberg.

Step One: Installing Tripod for Water Level Data

The first task once the field crew arrived to the sampling site was to install a specially designed tripod to house two In Situ water level instruments (Aquatroll 200), a barologger (In Situ Barotroll) and a static GPS Reciever (Trimble R8). The location to install the tide gauge was carefully selected to minimize interference, such us boat waves, to assure a stable installation. The water level instruments are used to measure water level variations, or changes in water level due to tides, during the bathymetry run. When post-processing the data, these varations were used to correct the bathymetry data.

The following was the series of steps taken when installing the tripod for water level data (See Appendix D and Figures 3 and 4).

- The tripod was secured in place to the sediment bottom in a sheltered environment by making sure the 3 legs at the bottom of the tripod were secure in sediment bottom.
    - Attached PVC Tubes (1.5 inch) on either side of the main stem of the tripod. The PVC tubes are drilled to allow water flow with a bolt through the bottom for copper tube to rest and hitch pins at the top to hold rope to drop and retrieve copper tube during each deployment.
    - The two In Situ Aqua Troll 200 units were placed in assigned tubes. To ensure consistency during each sampling run, the same Aquatroll 200 was placed in the same sampling tube during each deployment.
        - The AquaTroll 200 units are not vented to the atmosphere and thus measure the combined pressure of both the water column and the atmosphere. Because unvented transducers require barometric compensation to remove the effect of atmospheric pressure, barometric data must also be collected during each sampling run. In this study, an In Situ BaroTroll was mounted to the tripod to collect this information.
- Insert Pipe (for Original SET Design) was welded to the top of the tripod (see Figure 3) which was used to support a specialized SET adapter designed to hold the GPS Unit.
    - Insert Pipe: 2' long, 2" diameter, schedule 40 aluminum pipe with 4 or 8 notches (custom made).
- SET adapter placed into Insert Pipe and tightened with thumb screws.

  - Specifications of SET Adapter: 316-L stainless steel rod S. E. T. adaptor with a 1" hole, 3.5" deep w/ 2 thumb screws holes on bottom, 5/8" NC hole on top w/ 4 thumb screw holes, & 6 -- 5/16 X1" stainless steel thumb screws w/ 1 - 5/8 NC all thread rod 2" long.
- Placed European Style Tribrach (without optical plummet) onto the top screw of SET Adapter.
- Placed rotating tribrach adapter into the European style tribrach.
- Screwed 4 Foot Range Pole onto the tribrach adapter.
- Screwed GPS Receiver onto top threads of range pole.
- The In Situ Barotroll was secured inside custom PVC tube with PVC tube secured to range pole (for GPS) using hose clamps.
- Secured external battery for Trimble R8 GPS Receiver using small bungee cord connected the PVC tube housing the Barotroll unit

Note: At the beginning of each sampling run, water level verification samples were taken from the water level surface to the top of the tube as a quality control check on the accuracy of the data from the AquaTroll 200 unit.

Step Two: Installing Transducer on VIMS Vessel and Performing Initial Checks

The vessels that were used to perform bathymetry had a special mount installed by vessel operations to attach the transducer to the boat. The two vessels used to perform the bathymetry runs were a 19 ft Carolina Skiff and a 22 ft C-Hawk. On the Carolina skiff the transducer was installed on the side of the boat and in the C-Hawk the transducer was installed on the bow (Figures 5 and 6).

At the beginning of each sampling run, the transducer was installed at a distance below the water level. The distance from the bottom of the transducer to the surface of the water was measured and recorded in the field sheet and assumed to be constant for each run. This measurement is important to ensure that bathymetry readings account for the entire water column and not just measurements from the bottom of the transducer. Once the transducer is set up, the GPSMAP was turned on and a depth verification sample was taken and registered. This was a check on the accuracy of the transducer.

Step Three: Collecting Bathymetry Data

The survey boundary for the creek to be survey was loaded into the GPSMAP at the lab the day prior to conducting the field work. In the field, single beam bathymetry coverage of the seafloor was acquired using a GPSMAP 1042XSV. Operating at a high frequency of 200 kHz, the GPSMAP 1042XSV collected digital depth along with date, time, and position for post processing. Travel speed was maintained at 3-5 mph to minimize: loss of depth signals, squat/settlement corrections, and other vessel dynamic offsets. Depths were recorded with the GPSMAP every 5 seconds and water depth verification measurements were taken with a meter stick at several locations during the day.

The survey tracks generally followed this pattern: the boundary of the creek was surveyed first, then the middle section of the boundary was sampled, and finally, transects were run in a perpendicular pattern along the boundary with enough transect spacing to avoid overlapping points and to have an adequate distance to allow distinguishable GPS coordinates.

Table 2. Survey locations including date conducted along with the number of bathymetry points and total time taken to complete survey.

County	Body of Water	Date Surveyed	Acres Surveyed	Final # of Bathymetry Points	Survey Duration (Hours:Minutes)
Gloucester	Sarah Creek	12/17/2020	71	2,468	5:30
Gloucester	Perrin River	01/07/2021	64	2,535	3:45
Gloucester	Free School Creek	12/18/2020	19.3	1,031	2:17
Gloucester	Whittaker Creek	01/04/2021	20	2,061	3:08
Mathews	Put in Creek	01/05/2021	14	1,734	2:41
Mathews	Mill Creek 2	01/06/2021	4.5	875	2:08
Mathews	Milford Haven	01/14/2021	39.8	1,394	3:41
Mathews	Horn Harbor	01/19/2021	155.5	2,463	3:58
Mathews	Queens Creek	01/15/2021	17.4	1,224	3:02
Middlesex	Broad Creek	01/22/2021	22	1,240	2:17
Middlesex	Bush Park Creek	01/26/2021	6.3	747	2:08
Middlesex	Mill Creek	01/13/2021	98	2,617	4:06
Middlesex	Whiting Creek	01/25/2021	11.8	880	1:47
Middlesex	Robinson Creek	01/12/2021	23.6	1,682	2:30
King & Queen	Mattaponi River	01/11/2021	193	2,841	4:38

Some general notes related to the collection of bathymetry data for this study:

- Acoustic bathymetry surveys use sonar systems to collect depth information using simple physics. A transducer emits a sound wave directly to the water's floor, and records the time for the sound wave to be reflected back after it strikes the bottom. Because sound travels at approximately 1500 m/s in water, calculating the depth is direct. Over the last 50 years, acoustic technology has been used as the primary tool to amp underwater surface channels, lakes, and oceans due to low cost.
- Acoustic surveys are typically time-consuming, as they tend to have a relatively narrow scope. Most acoustic surveys cover approximately 10% of the water depths in an area, leaving many gaps which need to be interpolated.
- Some factors which can influence the bathymetry data include bottom type, heave and tilt of the transducer, speed of the vessel, speed of sound in the water, tides, and positional accuracy.
- Some notes/assumptions from this study related to those factors affecting bathymetry readings:

- Factors such as waves and vessel speed were reduced by going only on good weather days and going at slow vessel speeds (3 to 5 mph or 2.6 to 4 knots).
- The impact of submerged aquatic vegetation (SAV) was not considered to be negligible due to the fact that the measurements were taken at the end of December and January, where SAV growth is negligible.
- The depth survey was conducted in protected, near shore waters under calm sea conditions, and correction for heave, the only motion correction applicable for a single-beam survey was assumed to be unnecessary
- As this was a scoping study, the following were not implemented:
  - No bar checks were performed to determine corrections for sound velocity
  - Squat and settlement calibration were not performed; this was considered minimal or negligible given the low boat speed.

Step Four: Data Processing of Water Level Data

For each sampling run, data related to water pressure (in MBAR), water temperature (°C), specific conductivity (in us/cm), water salinity (in PSU), water density (in g/m3), and water level (m) were collected by the Aquatroll 200 instrument. The water level data was specifically measured relative to a zero-offset value. Data was collected every 5 minutes for the first 8 creeks sampled in this project (Sarah Creek, Free School Creek, Whittaker Creek, Put in Creek, Mill Creek 2, Perrin River, Mattaponi River, and Robinson Creek) and then every minute for the remaining 7 creeks. It was determined that the minute level data was more useful in the tidal corrections.

Data were downloaded from the logger using Win-Situ software and processed in Microsoft Excel workbooks. The pressure readings were corrected for atmospheric pressure by using data logged by an InSitu BaroTROLL Instrument during the approximate time period.

This water level value, now compensated for changes in atmospheric pressure, is referenced to NAVD88 by using the data from Trimble GPS Receiver installed on tripod during each deployment (which is downloaded and submitted to OPUS) and using a known distance from the bottom of the GPS antennae to the pressure sensor on the Aquatroll 200 which has been deployed in the PVC tube on the tripod (Figures 3 and 4).

Steps for calculating the final water level measurements for each sampling run (water level corrected for atmospheric pressure and relative to the NAVD88 vertical datum):

- Water Level from Aquatroll 200 (meters): WL = LR + (((0.703073 * (Pm - Pr)/68.9475729) / (SG)
  - Level Surface (meters): WLt1
  - Level Reference SET: Lr (set to zero)
  - Converting PSI to Meters: 0.703073
  - Pressure Reading at Time of Sampling in mbar: Pm
  - Pressure Reading Initial (in mbar): Pr
  - Converting mbar to PSI: 68.948
  - Specific Gravity Factor: SG: Set to 1.012 (no units) for all deployments.

- Water Level Corrected for Barometric Pressure (WL(A)t1) (in meters) = WLt1 + (BPR-BPt1) /68.948)*(0.70307)/SG
    - BPR: Calculated value (mean) of 3 or 4 atmospheric pressure readings from Barotroll or SWMP Station Aquatroll was deployed in water (to serve as reference "zero" point).
    - BPt1: Atmospheric pressure measured by BaroTroll (or nearest SWMP) placed on the study tripod at Time 1
    - Converting PSI to Meters: 0.703073
    - Converting mbar to PSI: 68.948
    - Specific Gravity Factor: SG: Set to 1.012 (no units) for all deployments.
- Water Level Relative to NAVD88 (WTNAVD88) = (NAVD88 at GPS Bottom) – (Distance from GPS Bottom to Pressure Sensor on Aquatroll) + WL(A)t1.
    - NAVD88 at GPS Bottom (provides the OPUS solution (NAVD88 value) from the GPS observation relative to the bottom surface of the GPS receiver.
    - Distance from GPS bottom to Pressure Sensor on Aquatroll.

Step Five: Obtaining Tide Corrected Bathymetry Data

The bathymetry data collected with the GPSMAP 1042XSV was exported to a csv file using Home Port software. This file has four columns of data: latitude, longitude, time/date stamp and transducer depth in meters. The tide correction of the data is performed using this equation:

$$Depth\ (NAVD88)\ = Rec\_Depth_t + \Delta(MaxTV, TV_t) + TranDepth - MaxTV$$

Where:

- $Depth$ = Depth in meters referenced to NAV88
- Rec_Depth_t = Depth in meters measured by the transducer at time t (which is the distance from the bottom of the transducer to the channel bottom).
- $TranDepth$ = Depth in meters of the transducer (this is the depth from the water line to the bottom of the transducer). This is assumed to be a constant.
- $\Delta(MaxTV, TV_t)$ = difference between maximum tide value measured by the tide gauge and tide value at time t (this ensures all final readings are referenced to the same vertical datum).
- $MaxTV$ = Maximum tide value measure by the tide gauge referenced to NAVD88.

2.2 Sediment Sampling

Prior to departure, an aerial image containing the channel outline of the selected creek was printed and taken into the field. Once in the creek, the aerial image was used to aid in keeping auger sites within or relatively close to the proposed channel. In-situ bathymetry readings also were taken while slowly moving through each creek using a stadia rod. Using a combination of the aerial channel outline and bathymetry measurements recorded in the field, auger locations were selected. Locations were generally selected in shallow water relative to the surrounding water depths. An auger was used in order to effectively remove sediment from creek beds.

Once an auger site was determined, precise GPS coordinates were recorded using an iPhone via the application *Map Coordinates.* Water levels at each auger site were recorded in decimal feet using the stadia rod. The auger would then be turned into the creek bottom over the side of the boat, first at a depth of one foot below the sediment surface and then a second time at a depth of two feet below the sediment surface in the same location. After each grab, the sediment was brought to the surface and placed in sealable bags labeled with the creek name, date, and auger identification number (Figure 7).

For auger identification numbers, each auger sample was assigned an identification that began with the letter “B,” followed by a number that corresponded to the number of sites in a given creek. That number was then proceeded by a dash and either a one or a two, signifying the depth below the sediment surface that the auger was taken. As an example, the auger identification “B2-1” would signify that it was the second auger location at a given creek (B2) at a grade of one foot below the creek bottom (-1). Multiple auger sites were taken at each creek. The number of auger sites vary at each creek because of site specific parameters or limitations.

In the lab, a geotechnical gauge was used to classify sediments into categories of gravel, sand, silt, or clay. Creek names, auger identification numbers, recorded water levels, calculated auger depths, coordinates, and sediment classifications can be found in Appendix A.

2.3 Channel Creation & Volume Calculations

To calculate dredge volumes, recent survey data and channel outlines for each creek channel of interest are needed. Bathymetry data was taken as described in section 2.1 for use in the volume calculations. For the federally-authorized channels, the channel extents were downloaded from the US Army Corp of Engineers. For creeks with no existing defined channel, one was created from bathymetry data, ATONs (if they existed in the channel), and aerial imagery.

Once in GIS, the survey points were used to create a 5-foot grid cell digital elevation model (DEM). This DEM was adjusted to ignore any value below the given maintenance dredging depth. The channel polygons were also converted to a raster and given a constant dredge depth value equal to the maintenance depth. Once the DEM and the channel raster were created, the next step was to subtract the adjusted survey raster from the channel raster. The result was a DEM where each grid cell represented a depth value higher than the given maintenance depth, thus showing the areas that needed dredging. Symbolizing the dredge volume raster made it easier to visualize where in the channel dredging had to take place and how much dredge material in cubic yards had to be removed.

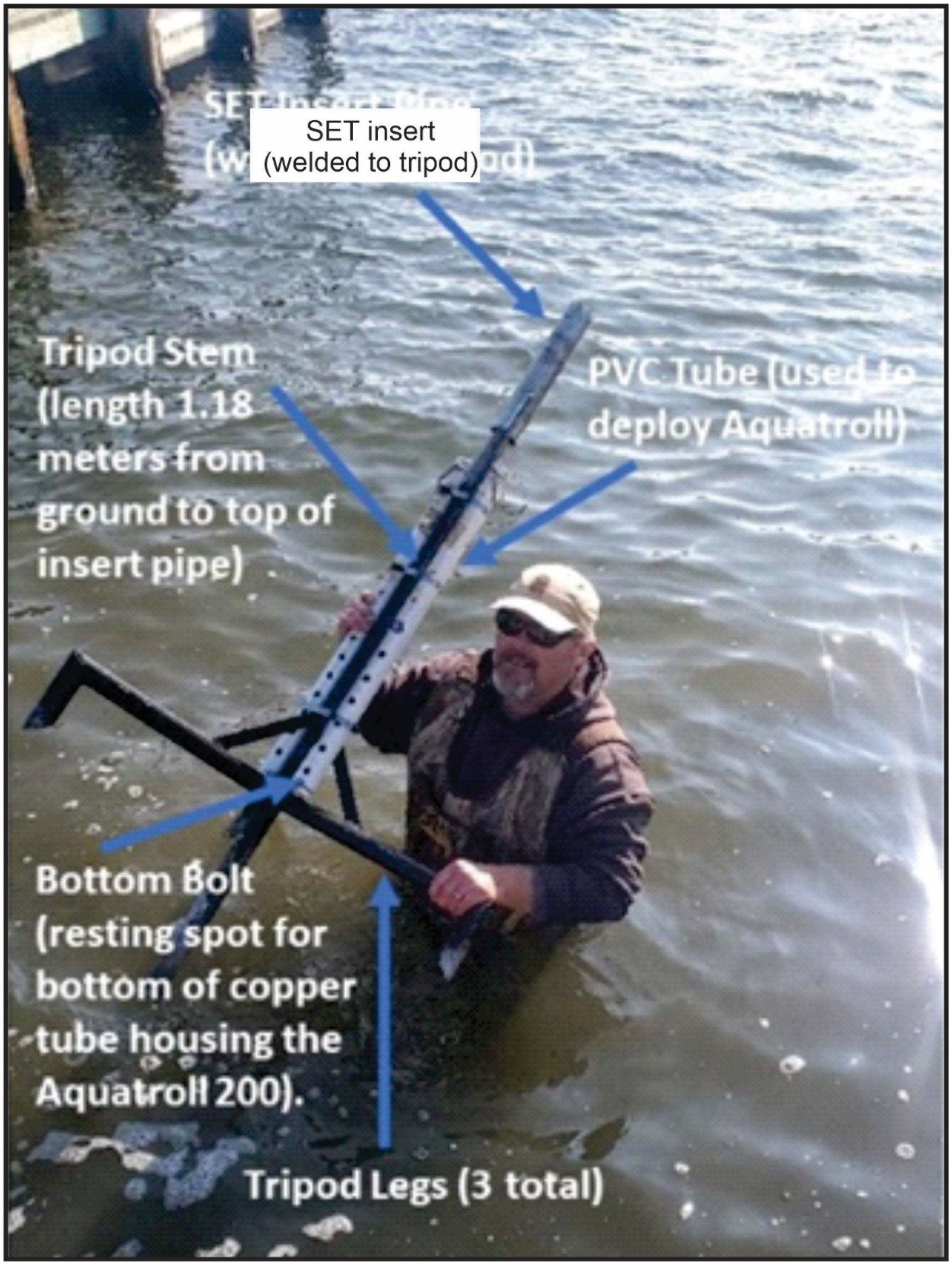


Figure 3. Installation of Water Level Tripod

Figure 4. Water Level Tripod with attached GPS Receiver

Figure 5. 19 ft Carolina Skiff with transducer attached to side.

Figure 6. 22 ft C-Hawk with transducer attached to bow.

Figure 7. Sediment being removed from auger. Photo taken at Mill Creek in Middlesex County, VA.

3 Creek Descriptions & Potential Dredge Implications

3.1 Gloucester County

Sarah Creek

Sarah Creek is located on the York River in Gloucester County, Virginia (Appendix B). It has a restricted creek mouth that is over 50% shoaled. It is not a federal channel but has ATONs defining a channel. The creek is 287 acres and contains 14 marinas, 11 boat ramps, and 211 piers. The creek has multiple plots of private oyster leases primarily at the mouth of the creek and does not contain SAV coverage (Appendix A). Having easy access for boats in Sarah Creek is essential for homeowners and businesses and has boosted the economy of Gloucester County through tax revenues. It appears that only the mouth of the creek, where shoaling is occurring due to alongshore transport of material, would potentially need to be dredged. The shoreline adjacent to the creek on the York River could be used as a placement area for sandy dredge material (Milligan et al., 2021).

For potential dredging purposes, the proposed Sarah Creek channel was divided into four zones (Appendix C) with each zone containing a proposed maintenance dredge depth (the original dredge depth plus one foot), a proposed channel width, and the amount of material that would potentially need to be dredged in order to maintain the channel depth (Table 3). A mechanical or hydraulic dredging methods with dredge material being placed on shore or at an upland disposal site would be recommended for this location.

Table 3: Sarah Creek proposed dredging material by zone. The depth is the proposed defined-depth plus 1 foot of overdepth. This was done to determine the maximum potential amount of material that would have to be dredged.

Sarah Creek Zones	Proposed Maintenance Dredge Depth (ft MLLW)	Proposed Channel Width (ft)	Proposed Cubic Yards of Dredge Material
Zone 1	-7 (-6 ft + 1 ft OD)	80	1,010
Zone 2	-7 (-6 ft + 1 ft OD)	60	3,660
Zone 3	-7 (-6 ft + 1 ft OD)	60	4,830
Zone 4	-7 (-6 ft + 1 ft OD)	30	50
All Zones	-7 (-6 ft + 1 ft OD)		9,550

Perrin River

Perrin River is located on the York River in Gloucester County, Virginia (Appendix B). It has an open creek mouth that is less than 50% shoaled. It is not a federal channel but has ATONs defining a channel. The river is 94 acres and contains 3 marinas, 9 boat ramps, and 30 piers. The river contains multiple plots of private oyster leases, primarily in the northwestern portion of the channel and along the northeastern section outside of the channel closer to the mouth of the river. The river does not contain SAV coverage, but there is moderate density of SAV coverage in the York River where the two systems meet (Appendix A).

For potential dredging purposes, Perrin River was divided into four zones (Appendix C) with each zone containing a proposed maintenance dredge depth (the original dredge depth plus one foot), a proposed channel width, and the amount of material that would potentially need to be dredged in order to maintain the channel depth (Table 4). A hydraulic dredging method with dredge material being placed on shore or at an upland disposal site would be recommended for this location.

Table 4: Perrin River proposed dredging material by zone. The depth is the proposed defined-depth plus 1 foot of overdepth (OD). This was done to determine the maximum potential amount of material that would have to be dredged.

Perrin River Zones	Proposed Maintenance Dredge Depth (ft MLLW)	Proposed Channel Width (ft)	Proposed Cubic Yards of Dredge Material
Zone 1	-7 (-6 ft + 1 ft OD)	80	2,460
Zone 2	-7 (-6 ft + 1 ft OD)	80	8,640
Zone 3	-7 (-6 ft + 1 ft OD)	40	1,250
Zone 4	-7 (-6 ft + 1 ft OD)	40	2,250
All Zones	-7 (-6 ft + 1 ft OD)		14,600

Free School Creek

Free School Creek is located on the Severn River in Gloucester County, Virginia (Appendix B). It has a restricted creek mouth that is more than 50% shoaled and does not have a defined channel so one was proposed. The creek is 38 acres and does not contain marinas but does have 4 boat ramps and 19 piers. The entirety of the creek contains private oyster leases, but does not have SAV coverage (Appendix A).

For potential dredging purposes, Free School Creek has a proposed maintenance dredge depth of -4 feet MLLW with a potential for 1 ft overdepth dredging with a proposed channel width of 60 feet. Very little of the channel needs to be dredged. To maintain this dredge depth, 220 cubic yards of material would potentially need to be dredged from the creek. A mechanical dredge method with dredged material being placed at an upland disposal site would be recommended for this location.

Whittaker Creek

Whittaker Creek is located on the Severn River in Gloucester County, Virginia (Appendix B). It has an open creek mouth that is less than 50% shoaled and does not have a defined channel so one was proposed. The creek is 45 acres and does not contain marinas, but does have 1 boat ramp and 1 pier. There are private oyster leases in the Severn River from the mouth of Whittaker Creek north, but the leases end once the creek takes a sharp turn east and becomes much narrower. There is no SAV coverage in Whittaker Creek (Appendix A).

For potential dredging purposes, analysis for Whittaker Creek proposed three different maintenance dredge depths and the corresponding material that would need to be dredged to maintain those depths (Table 5). In each scenario, Whittaker Creek had a proposed channel width of 40 feet. A mechanical dredge method with dredged material being placed at an upland disposal site would be recommended for this location.

Table 5: Whittaker Creek proposed maintenance depths and cubic yards of material**.** The depth is the proposed defined-depth plus 1 foot of overdepth (OD). This was done to determine the maximum potential amount of material that would have to be dredged.

Proposed Maintenance Dredge Depth (ft MLLW)	Cubic Yards of Dredge Material
-3 (-2 ft + 1 ft OD)	3,020
-4 (-3 ft + 1 ft OD)	5,330
-5 (-4 ft + 1 ft OD)	8,950

3.2 Mathews County

Put in Creek

Put in Creek is located on the East River in Mathews County, Virginia (Appendix B). It has an open creek mouth with no visible shoaling and does not have a defined channel so one was proposed. The creek is 130 acres and does not contain marinas, but does have 1 boat ramp and 48 piers. Put in Creek does not have private oyster leases or contain SAV coverage (Appendix A).

For potential dredging purposes, Put in Creek was divided into two zones (Appendix C) with each zone containing a proposed maintenance dredge depth (the original dredge depth plus one foot), a proposed channel width, and the amount of material that would potentially need to be dredged in order to maintain the channel depth (Table 6). A mechanical dredging method with dredge material being placed at an upland disposal site would be recommended for this location.

Table 6: Put in Creek proposed dredging material by zone. The depth is the proposed defined-depth plus 1 foot of overdepth (OD). This was done to determine the maximum potential amount of material that would have to be dredged.

Put in Creek Zones	Proposed Maintenance Dredge Depth (ft MLLW)	Proposed Channel Width (ft)	Proposed Cubic Yards of Dredge Material
Zone 1	-5 (-4 ft +1 ft OD)	20	5,370
Zone 2	-3 (-3 ft +1 ft OD)	12	1,780
All Zones			7,150

Mill Creek 2

Mill Creek 2 is located on the East River in Mathews County, Virginia (Appendix B). It has an inlet creek mouth that is less than 50% shoaled and does not have a defined channel so one was proposed. The creek is 14 acres and does not contain any marinas, but does have 2 boat ramps and 8 piers. The creek contains private oyster leases on the eastern portion of the channel to enter the creek in the East River, but there are no private oyster leases further up creek. The creek does not have SAV coverage (Appendix A).

For potential dredging purposes, Mill Creek 2 has a proposed maintenance dredge depth of -4 feet MLLW with a potential for 1 ft overdepth dredging with a proposed channel width of 40 feet. To maintain this dredge depth, 1,130 cubic yards of material would potentially need to be dredged from the creek. A mechanical dredge method with dredged material being placed on shore would be recommended for this site.

Milford Haven

Milford Haven is a federally-defined channel located in Mathews County, Virginia (Appendix B). It has a restricted creek mouth that is more than 50% shoaled. The area surrounding the federal channel contains 2 marinas, 1 boat ramp or and numerous piers. Milford Haven contains private oyster leases along the eastern portion of the federal channel and along the southwestern portion outside of the channel. There is no SAV coverage throughout Milford Haven (Appendix A).

For potential dredging purposes, Milford Haven has a federally defined maintenance dredge depth of -10 feet MLLW with a potential for 1 ft overdepth dredging with a federally defined channel width of 200 feet. To maintain this dredge depth, 11,000 cubic yards of material would potentially need to be dredged from the creek. A mechanical or hydraulic dredge method with dredged material being placed on shore would be recommended for this site.

Horn Harbor

Horn Harbor is located on the Chesapeake Bay in Mathews County, Virginia (Appendix B). It has an open creek mouth that is less than 50% shoaled. It contains a federal channel at the entrance to the harbor in the Chesapeake Bay, but it transitions to a proposed non-federal channel with ATONs up creek. Horn Harbor is 745 acres and contains 3 marinas, 7 boat ramps, and 113 piers. It contains private oyster leases throughout half of the channel in the northwestern portion of the harbor, but there are no private oyster leases throughout the southeastern section of the channel as the harbor empties into the Chesapeake Bay. There is no SAV coverage contained within the channel, but there is sparse coverage along the northeastern side of the channel in the Chesapeake Bay (Appendix A).

For potential dredging purposes, Horn Harbor was divided into two zones (Appendix C) with each zone containing a proposed maintenance dredge depth (the original dredge depth plus one foot), a proposed channel width, and the amount of material that would potentially need to be dredged in order to maintain the channel depth (Table 7). Zone 1 is the already existing federal channel, and zone 2 is the proposed channel. A hydraulic dredging method with dredge material being placed on shore would be recommended for this site.

Table 7: Horn Harbor proposed dredge material by zone. The depth is the federally-defined depth plus 1 foot of over depth (OD). This was done to determine the maximum potential amount of material that would have to be dredged.

Horn Harbor Zones	Proposed Maintenance Dredge Depth (ft MLLW)	Proposed Channel Width (ft)	Proposed Cubic Yards of Dredge Material
Zone 1 (Federal)	-8 (-7 ft + 1 ft OD)	100	14,700
Zone 2 (Proposed)	-8 (-7 ft + 1 ft OD)	100	67,570
All Zones			82,270

Queens Creek

Queens Creek is a federally-defined channel located on Hills Bay in Mathews County, Virginia (Appendix B). It has a restricted creek mouth that is less than 50% shoaled. The creek is 188 acres and contains 1 marina, 4 boat ramps, and 145 piers. Queens Creek has private oyster leases along the western portion of the channel as well as leases on the eastern portion just outside the channel. There is no SAV coverage throughout the creek (Appendix A).

For potential dredging purposes, Queens Creek has a federally-defined maintenance dredge depth of -6 feet MLLW in the federally defined channel width of 60 feet. To maintain this dredge depth with a potential for 1 ft overdepth dredging (-7 ft MLLW total depth), 1,000 cubic yards of material would potentially need to be dredged from the creek. A hydraulic dredge method with dredged material being placed on shore would be recommended for this site.

3.3 Middlesex County

Broad Creek

Broad Creek is located on the Rappahannock River in Middlesex County, Virginia (Appendix B). It has a restricted creek mouth that is less than 50% shoaled. It has a federal channel that runs through the heart of the creek, as well as two non-federal channels defined by ATONs that run through the eastern and western branches of the creek. The creek is 79 acres and contains 8 marinas, 7 boat ramps, and 50 piers. It has private oyster leases along the northwestern side of the federal channel, most of which are in or near where the creek meets the Rappahannock River. There is no SAV coverage throughout the creek (Appendix A).

For potential dredging purposes, Broad Creek was divided into two zones (Appendix C) with each zone containing a proposed maintenance dredge depth (the original dredge depth plus one foot), a proposed channel width, and the amount of material that would potentially need to be dredged in order to maintain the channel depth (Table 8). Zone 1 is the already existing federal channel, and zone 2 is the proposed channel composed of both the eastern and western branches of the creek. A hydraulic dredging method with dredge material being placed on shore or at an upland disposal site would be recommended for this location.

Table 8: Broad Creek proposed dredge material by zone. The depth is the federally-defined depth plus 1 foot of over depth (OD). This was done to determine the maximum potential amount of material that would have to be dredged.

Broad Creek Zones	Proposed Maintenance Dredge Depth (ft MLLW)	Proposed Channel Width (ft)	Proposed Cubic Yards of Dredge Material
Zone 1 (Federal)	-8 (-7 ft + 1ft OD)	100	900
Zone 2 (Proposed)	-8 (-7 ft + 1ft OD)	100	6,250
All Zones			7,150

Bush Park Creek

Bush Park Creek is located on the Rappahannock River in Middlesex County, Virginia (Appendix B). It has an inlet creek mouth that is completely shoaled and does not have a defined channel so one was proposed. The creek is 77 acres and contains 5 marinas, 4 boat ramps, and 38 piers. Bush Park creek does not contain private oyster leases, but the very end of the channel located in the Rappahannock River has private oyster leases. There is no SAV coverage in the creek (Appendix A). Bush Park Creek has an extensive trailer park and campground with adequate water inside the creek. The channel has two wood jetties and is frequently dredged, mechanically, with the sandy material placed on the adjacent north coast. With a southerly net littoral drift that material soon returns to the channel but placing the material on the south side would impact the adjacent small creek inlet of Woods Creek (Milligan et al., 2021).

For potential dredging purposes, Bush Park Creek has a proposed maintenance dredge depth of -4 feet MLLW with a potential for 1 ft overdepth dredging and a proposed channel width of 40 feet. To maintain this dredge depth, 2,570 cubic yards of material would potentially need to be dredged from the creek. A mechanical dredge method with dredged material being placed on shore would be recommended for this site.

Mill Creek

Mill Creek is located on the Rappahannock River in Middlesex County, Virginia (Appendix B). It has an open creek mouth that is less than 50% shoaled and does not have a defined channel so one was proposed. Mill Creek is 75 acres and does not contain marinas but does have 2 boat ramps and 37 piers. There are private oyster leases to the east and west of the channel in Mill Creek, and it does not contain SAV coverage (Appendix A).

For potential dredging purposes, Mill Creek has a proposed maintenance dredge depth of -4 feet MLLW with a proposed 1 ft potential overdepth and a proposed channel width of 60 feet. To maintain this dredge depth, 480 cubic yards of material would potentially need to be dredged from the area adjacent to the boat ramp. A mechanical dredge method with dredged material being placed on shore would be recommended for this site.

Whiting Creek

Whiting Creek is located on the Rappahannock River in Middlesex County, Virginia (Appendix B). It has a restricted creek mouth that is completely shoaled and has a federal channel that has been maintained at -4 ft MLLW. The creek is 132 acres and does not contain marinas, but does have 1 boat ramp and 59 piers. There are no private oyster leases or SAV coverage throughout the creek (Appendix A). The creek has been dredged at least 4 times in 1956, 1962, 1970, and 1998. After 1970, dredging information is based on the VMRC permit database. In 1998, about 80,000 cubic yards (cy) of material was removed. Based on a 2017 survey by the US Army Corps of Engineers, the channel needs dredging again to maintain the channel (Milligan et al., 2021).

For potential dredging purposes, Whiting Creek was divided into two zones (Appendix C) with each zone containing a maintenance dredge depth (the original dredge depth plus one foot), a proposed channel width, and the amount of material that would potentially need to be dredged in order to maintain the channel depth (Table 9). Zone 1 is the already existing federal channel, and zone 2 is the proposed channel. In addition to the federally defined depths and proposed maintenance depths, a deeper dredge depth option for both zones is included. A hydraulic dredging method with dredge material being placed on shore or at an upland disposal site would be recommended for this location.

Table 9: Whiting Creek proposed dredge material by zone. The depth is the federally-defined depth plus 1 foot of over depth (OD). This was done to determine the maximum potential amount of material that would have to be dredged.

Whiting Creek Zones	Proposed Maintenance Dredge Depth (ft MLLW)	Proposed Channel Width (ft)	Proposed Cubic Yards of Dredge Material
Zone 1 (Federal)	-5 (-4 ft + 1ft OD)	70	9,170
Zone 2 (Proposed)	-5 (-4 ft + 1ft OD)	70	4,540
Zone 1 (Federal)	-7 (-6 ft + 1ft OD)	70	22,580
Zone 2 (Proposed)	-7 (-6 ft + 1ft OD)	70	9,070
All Zones (-5 ft MLLW)			13,710
All Zones (-7 ft MLLW)			31,650

Robinson Creek

Robinson Creek is located on the Rappahannock River in Middlesex County, Virginia (Appendix B). It has a restricted creek mouth that is completely shoaled and does not have a defined channel so one was proposed. The creek is 241 acres and contains 15 marinas, 5 boat ramps, and 111 piers. There are private oyster leases along the outside of the southwestern portion of the channel, as well as some leases near the mouth of the creek in or near the Rappahannock River. There is no SAV coverage throughout the creek (Appendix A). Though aerial photography shows a defined channel that could indicate that the channel is dredged, a review of the VMRC database did not show a permit since 2000 (Milligan et al., 2021).

For potential dredging purposes, Robinson Creek has a proposed maintenance dredge depth of -6 feet MLLW with a potential for 1 ft overdepth dredging and a proposed channel width of 80 feet. To maintain this dredge depth, 4,400 cubic yards of material would potentially need to be dredged from the creek. A mechanical dredge method with dredged material being placed at an upland disposal site or nearby shoreline would be recommended for this location.

3.4 King and Queen County

Mattaponi River Mouth

The mouth of the Mattaponi River is located between King and Queen County and King William County, Virginia at the Town of West Point (Appendix B). It has an open mouth with no visible shoaling and this section of the Mattaponi does not have a federal channel. It does not contain marinas but does have 1 boat ramp and 15 piers. One plot of oyster leases exists on the southeastern portion of the river close to where it empties into the York River. No SAV coverage occurs in the river (Appendix A).

For the Mattaponi River, dredging is not needed because the channel has depths well over 7 feet. The depth of the channel is also the reason that sediment data was unable to be obtained at this location, as the auger could not reach the river bed from the boat.

4 References

Hardaway, C. Scott Jr., D.A. Milligan., and C. Wilcox (2019). Rural Shallow Water Dredging: Channel Assessment and Disposal Strategies. Virginia Institute of Marine Science, William & Mary

Milligan, D. A., Hardaway, C., Wilcox, C. A., DiNapoli, N.J., (2021). Dredging Implementation Prioritization and Management for Middle Peninsula Shallow Draft Channels. Virginia Institute of Marine Science, William & Mary.

United States Army Corps of Engineers Norfolk District (USACE). Hydrographic surveys of deep and shallow draft projects. https://www.nao.usace.army.mil/HydroSurveys/

United States Army Corps of Engineers (USACE). Hydrographic surveys powered by eHydro. http://navigation.usace.army.mil/Survey/Hydro

United States Army Corps of Engineers (USACE), (1975). Dredging Quantities and Disposal Areas. United States Army Corps of Engineers.

Appendix A

Site Data by Creek

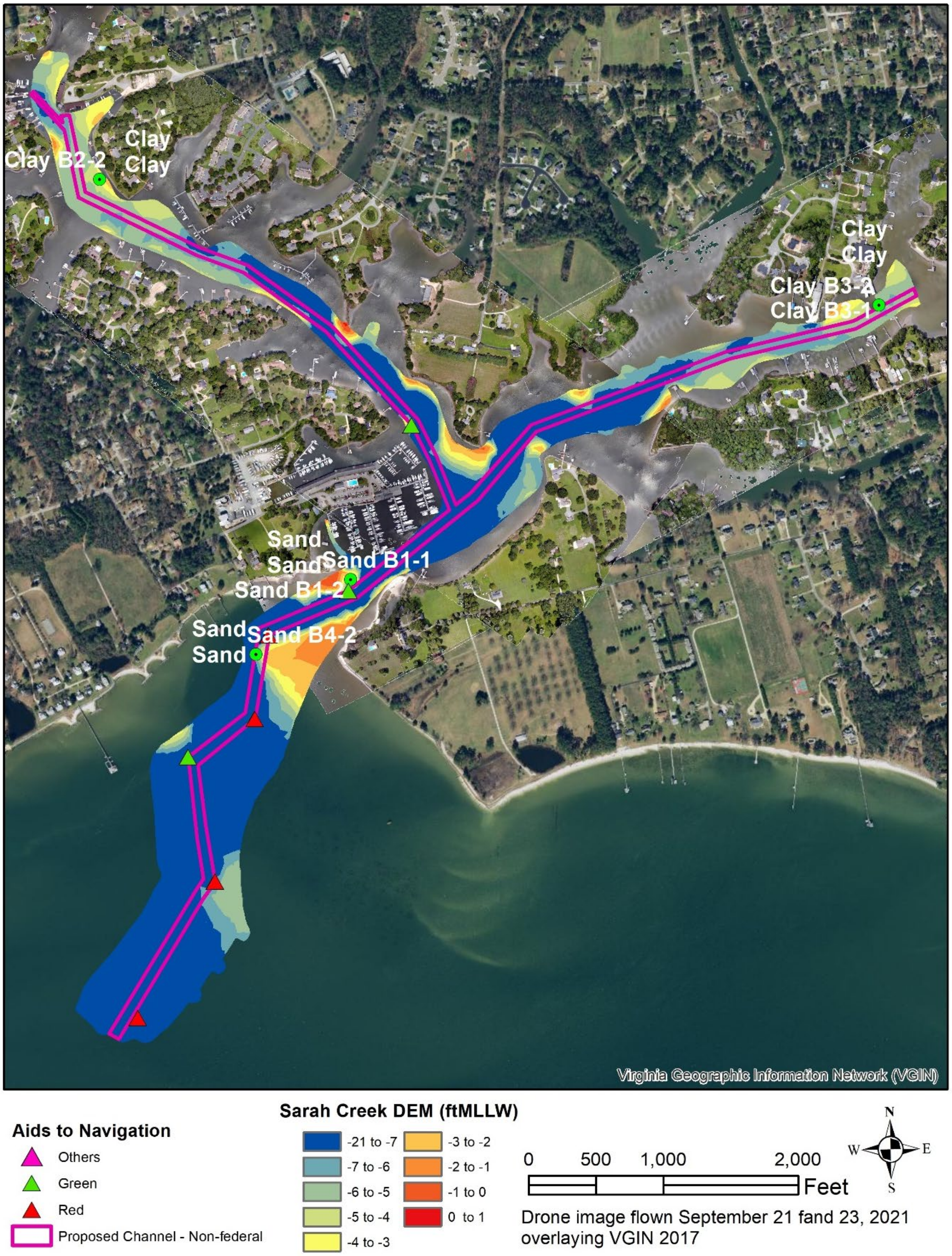
Table. Oyster leases and channel type by location.

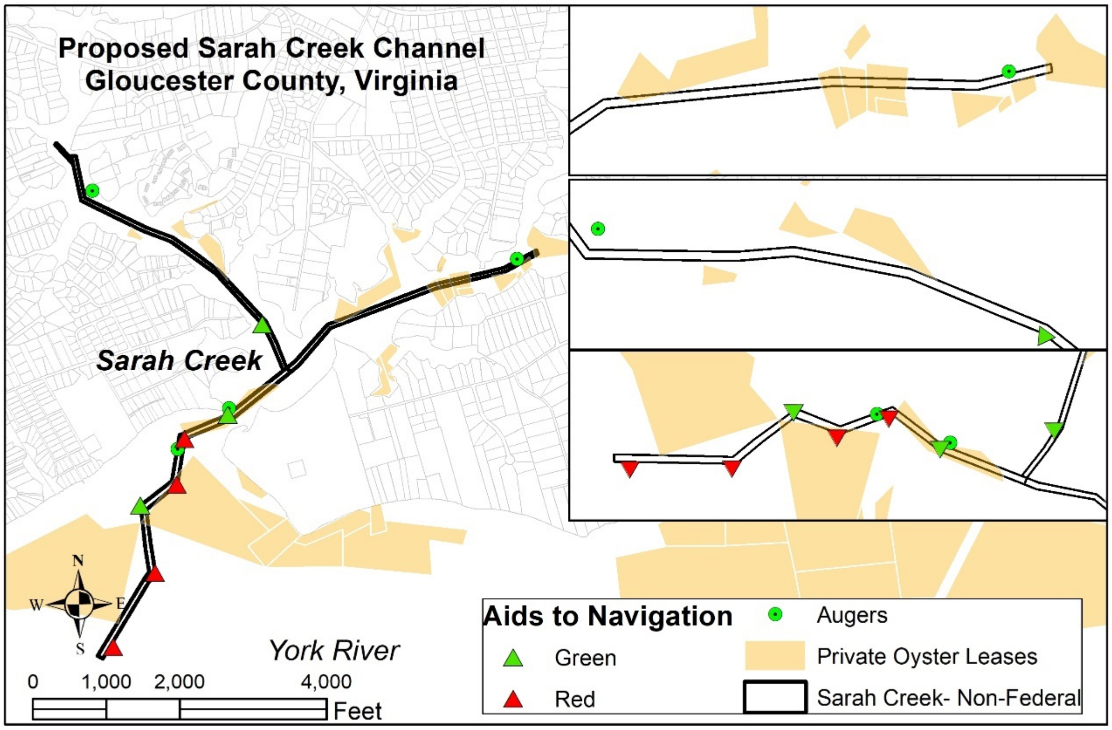
Site Name	Oyster Leases (Y/N)	Affected Leases (#)	Federal/Non-Federal
Broad Creek	Y	1	Federal
Bush Park Creek	Y	1	Non-Federal
Free School	Y	3	Non-Federal
Horn Harbor	Y	5	Federal
Mattaponi River	Y	1	Non-Federal
Milford Haven	Y	3	Federal
Mill Creek	Y	1	Non-Federal
Mill Creek 2	Y	1	Non-Federal
Perrin River	Y	3	Non-Federal
Put in Creek	N	0	Non-Federal
Queens Creek	Y	2	Federal
Robinson Creek	Y	1	Non-Federal
Sarah Creek	Y	10	Non-Federal
Whiting Creek	N	0	Federal
Whittaker Creek	Y	1	Non-Federal

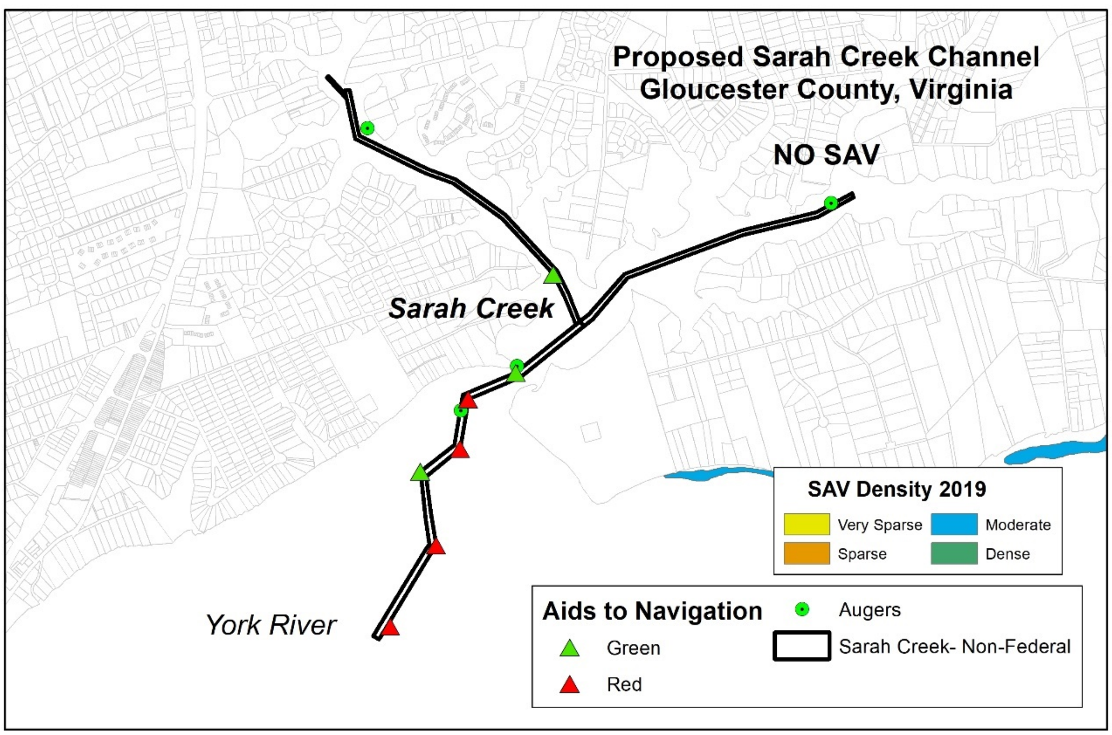
Table. Submerged Aquatic Vegetation by location

Site Name	SAV in Channel (Y/N)
Broad Creek	N
Bush Park Creek	N
Free School	N
Horn Harbor	Y
Mattaponi River	N
Milford Haven	N
Mill Creek	N
Mill Creek 2	N
Perrin River	N
Put in Creek	N
Queens Creek	N
Robinson Creek	N
Sarah Creek	N
Whiting Creek	N
Whittaker Creek	N

Sarah Creek Bathymetry



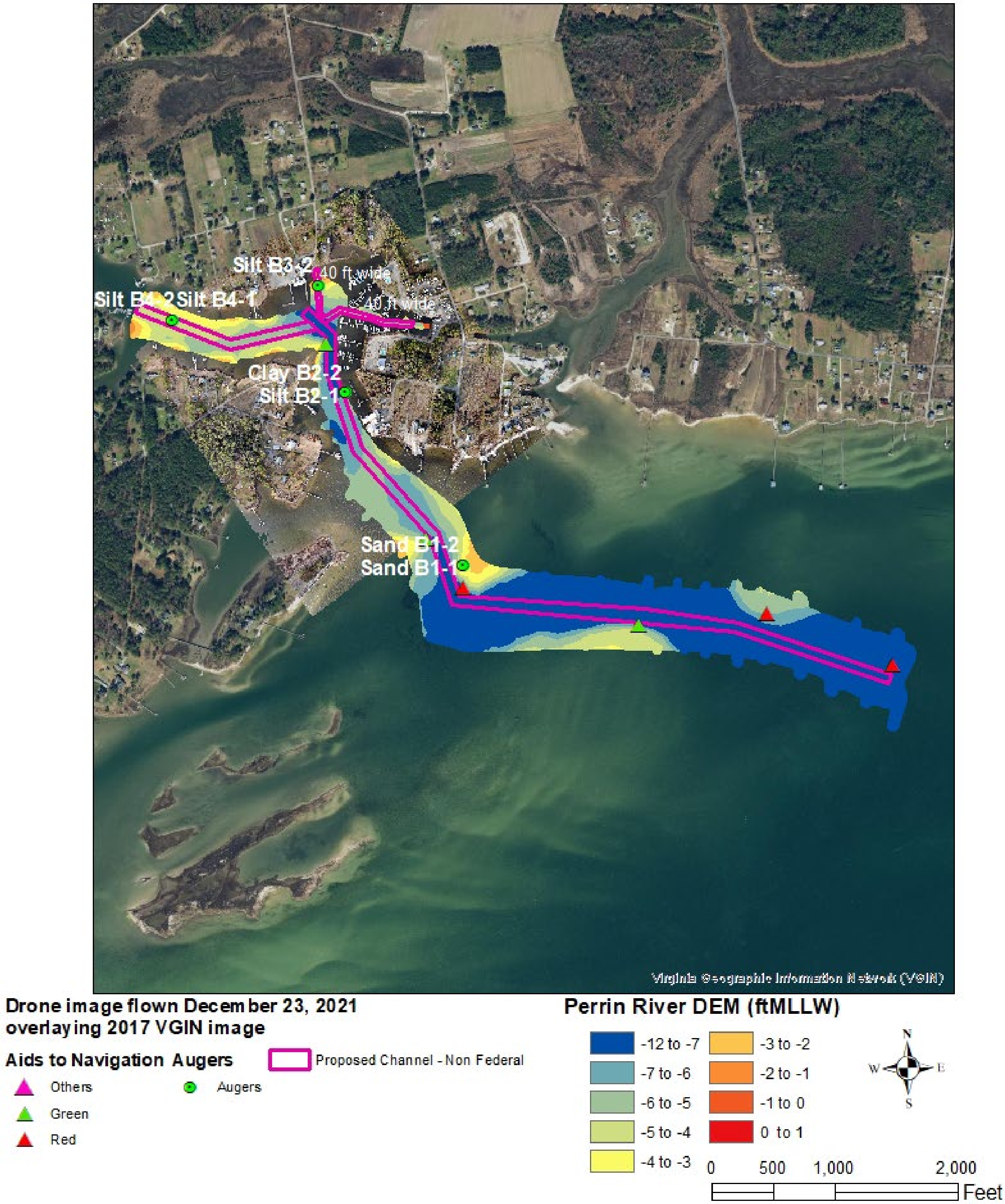

Proposed Sarah Creek Channel
Gloucester County, Virginia
Sarah Creek
York River
N
W
E
S
0
1,000
2,000
4,000
Feet
Aids to Navigation
Augers
Green
Red
Private Oyster Leases
Sarah Creek- Non-Federal

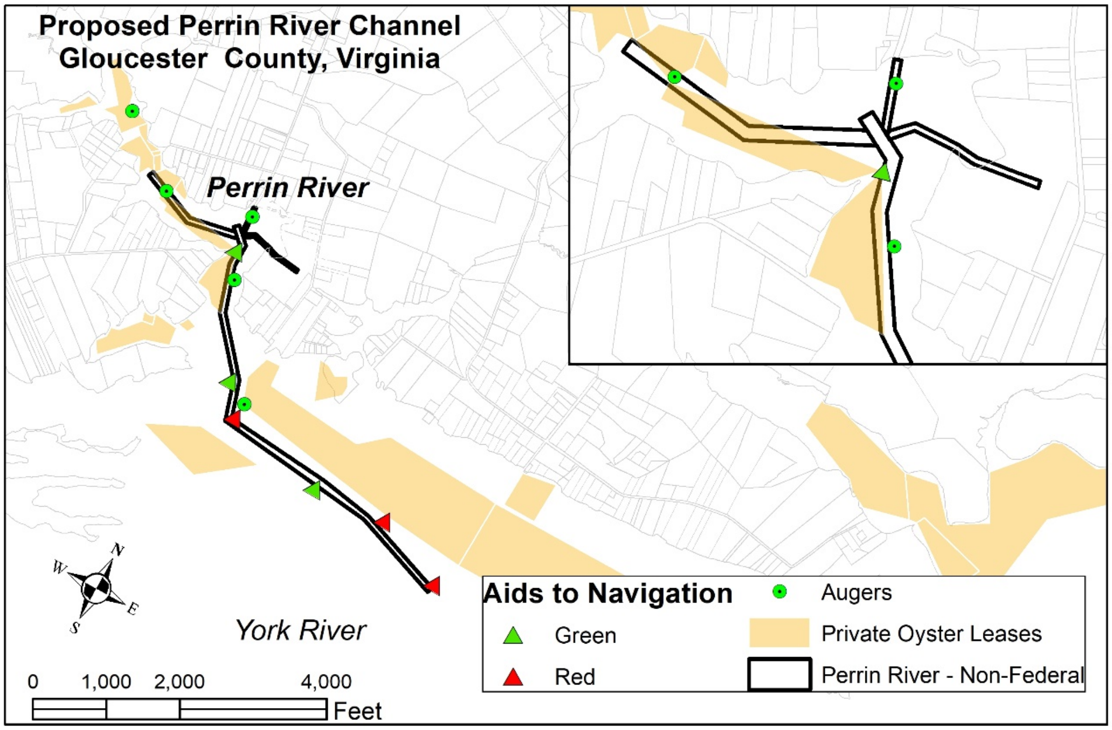

Proposed Sarah Creek Channel
Gloucester County, Virginia
NO SAV
Sarah Creek
York River
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Red
Sarah Creek- Non-Federal

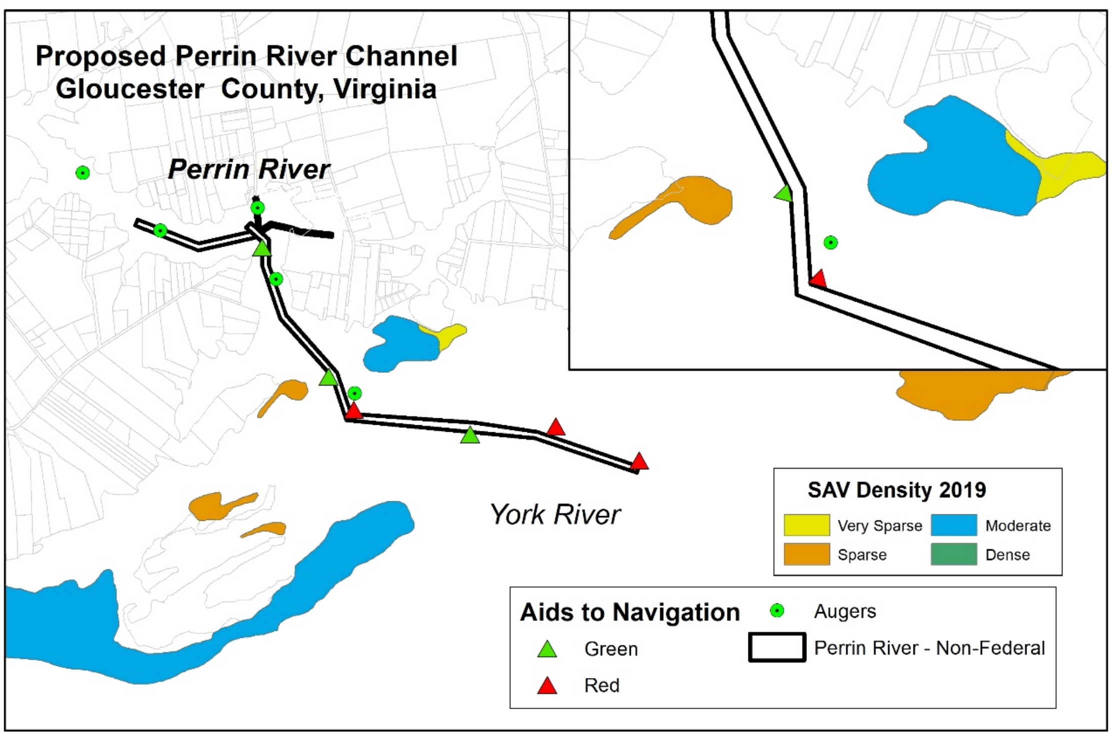
Sarah Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Sarah Creek	37.1518	-76.2849	B1-1	3.4	4.4		**SP**	Loose sand	Yellowish orange
Sarah Creek	37.1518	-76.2849	B1-2	3.4	5.4		**SP**	Loose sand	Yellowish orange
Sarah Creek	37.1548	-76.2912	B2-1	4.5	5.5		**CL**	Soft clay	Dark gray
Sarah Creek	37.1548	-76.2912	B2-2	4.5	6.5		**CL**	Soft clay	Dark gray
Sarah Creek	37.1537	-76.2800	B3-1	5.8	6.8		**CL**	Very soft clay	Dark gray
Sarah Creek	37.1537	-76.2800	B3-2	5.8	7.8		**CL**	Very soft clay	Dark gray
Sarah Creek	37.1512	-76.2858	B4-1	2.4	3.4		**SM**	Medium dense sand with trace silt and trace shell	Olive gray
Sarah Creek	37.1512	-76.2858	B4-2	2.4	4.4		**SM**	Medium dense sand with trace silt	Olive gray

Perrin River Bathymetry



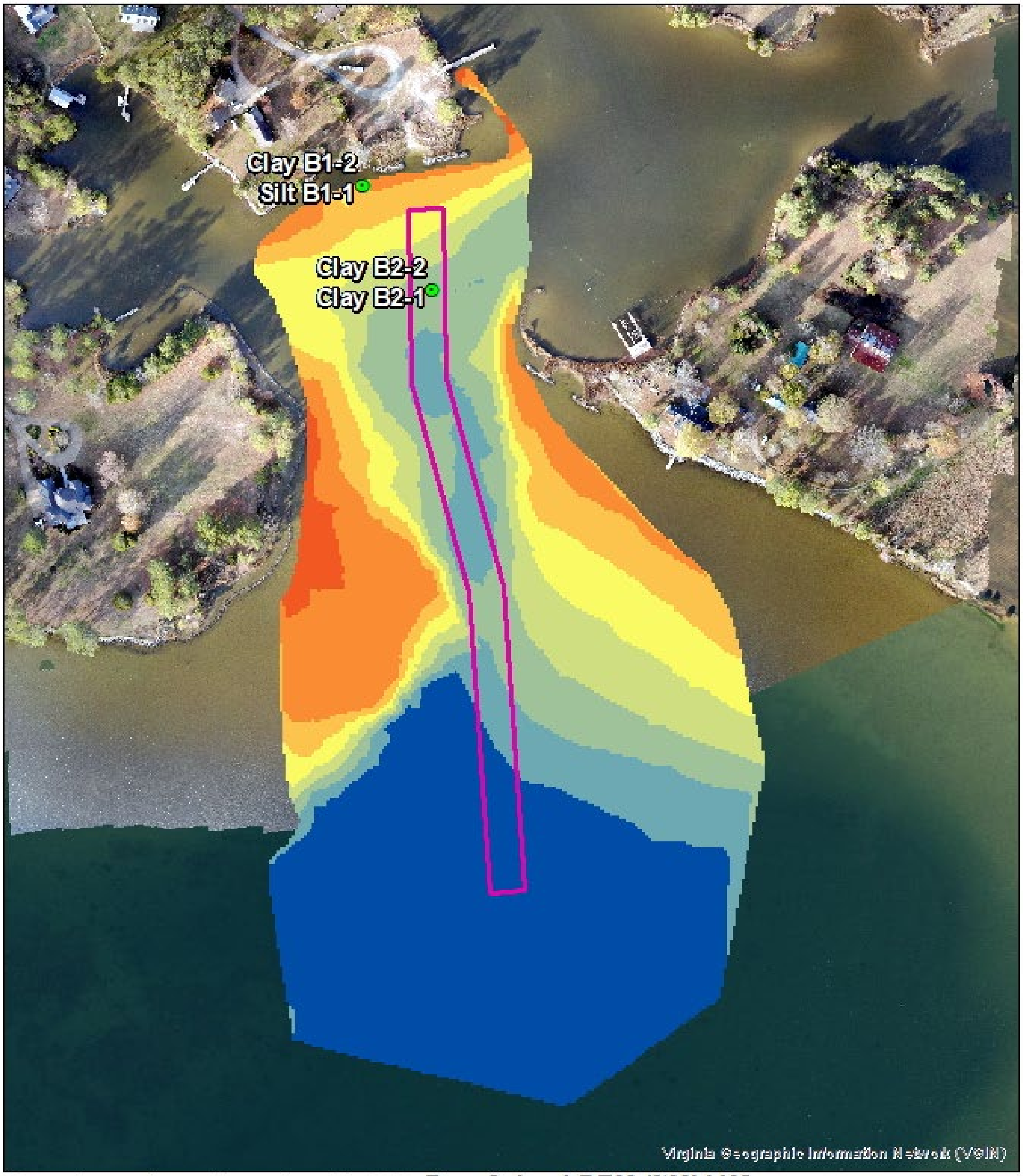

Proposed Perrin River Channel
Gloucester County, Virginia
Perrin River
York River
N
S
E
W
0
1,000
2,000
4,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Perrin River - Non-Federal


Proposed Perrin River Channel
Gloucester County, Virginia
Perrin River
York River
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Perrin River - Non-Federal

Perrin River Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Perrin River	37.2618	-76.4205	B1-1	3.2	4.2		**SM**	Medium dense sand with little silt	Olive gray
Perrin River	37.2618	-76.4205	B1-2	3.2	5.2		**SM**	Medium dense sand with little silt	Olive gray
Perrin River	37.2657	-76.4237	B2-1	5.2	6.2		**ML**	Soft silty clay	Dark gray
Perrin River	37.2657	-76.4237	B2-2	5.2	7.2		**CL**	Medium stiff clay	Dark gray
Perrin River	37.2681	-76.4244	B3-1	3.0	4.0		**ML**	Medium stiff silt with little sand	Olive gray
Perrin River	37.2681	-76.4244	B3-2	3.0	5.0		**ML**	Medium stiff silt with little sand	Olive gray
Perrin River	37.2674	-76.4285	B4-1	4.4	5.4		**ML**	Soft silty clay	Olive gray
Perrin River	37.2674	-76.4285	B4-2	4.4	6.4		**ML**	Soft silty clay	Olive gray
Perrin River	37.2649	-76.4317	B5-1	3.0	4.0		**ML**	Soft silty clay	Olive gray
Perrin River	37.2649	-76.4317	B5-2	3.0	5.0		**CL**	Soft clay with trace silt	Olive gray

Free School Creek Bathymetry



Drone image flown November 24, 2020 overlaying 2017 VGIN image

Free School DEM (ftMLLW)

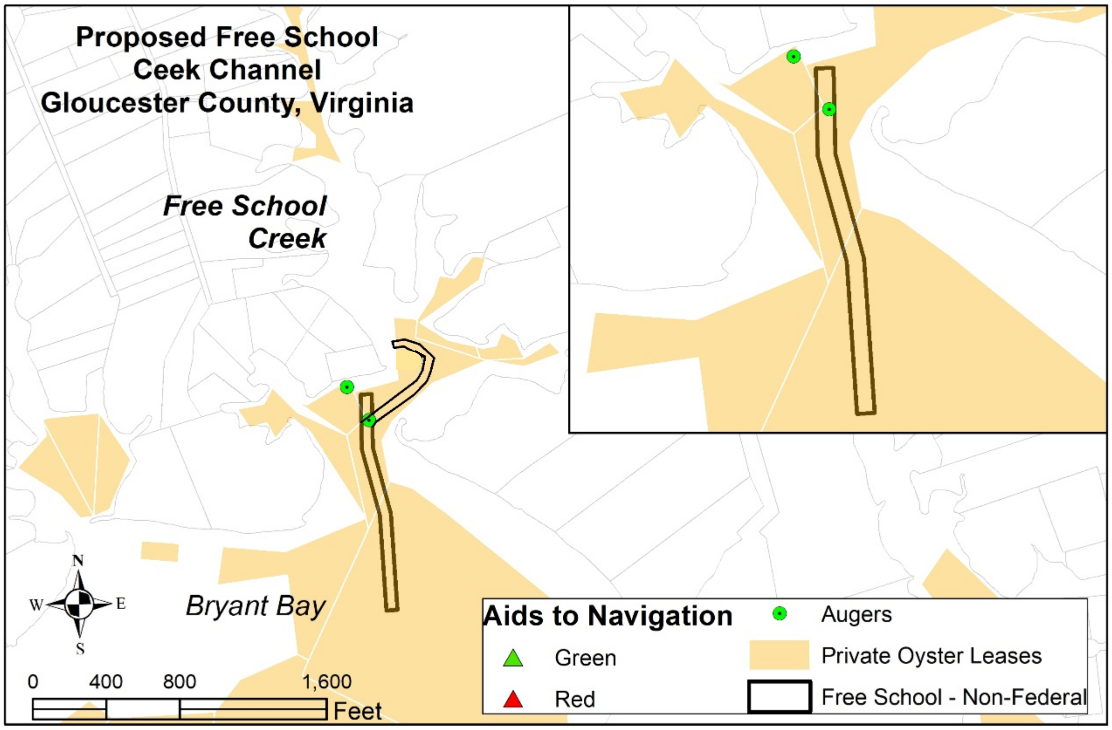
Augers

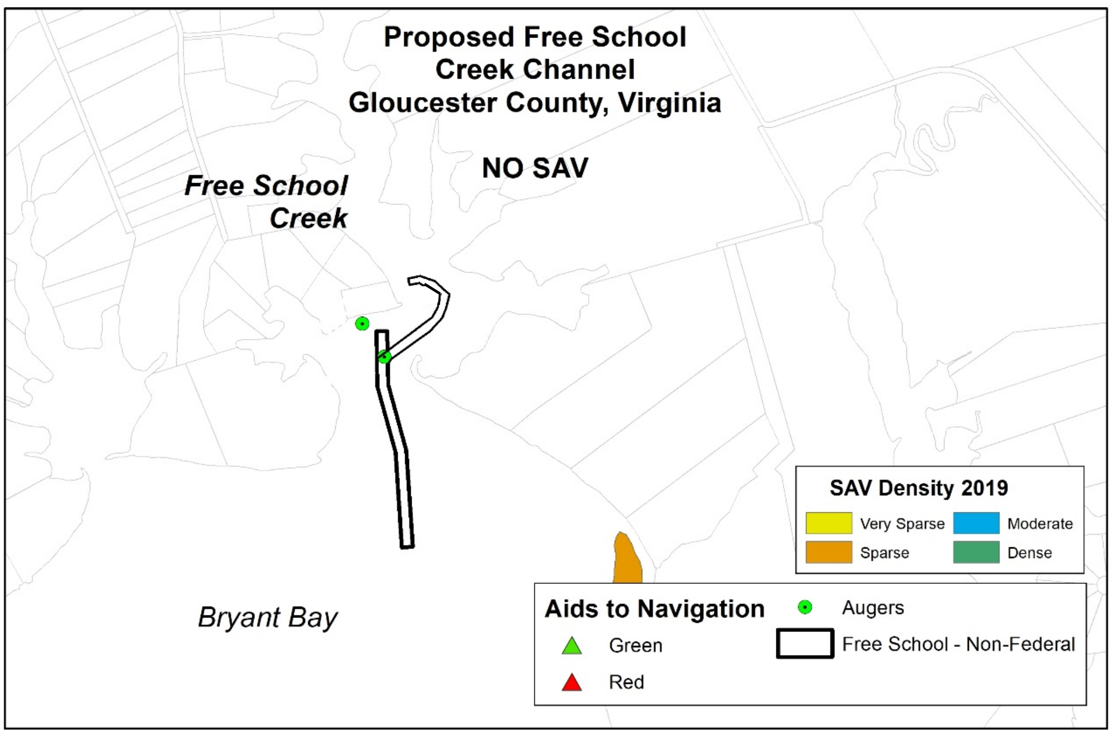
- Augers
- Proposed Channel - Non-federal

-9 to -7	-3 to -2
-7 to -6	-2 to -1
-6 to -5	-1 to 0
-5 to -4	0 to 1
-4 to -3	

N W E S

0 125 250 500 Feet

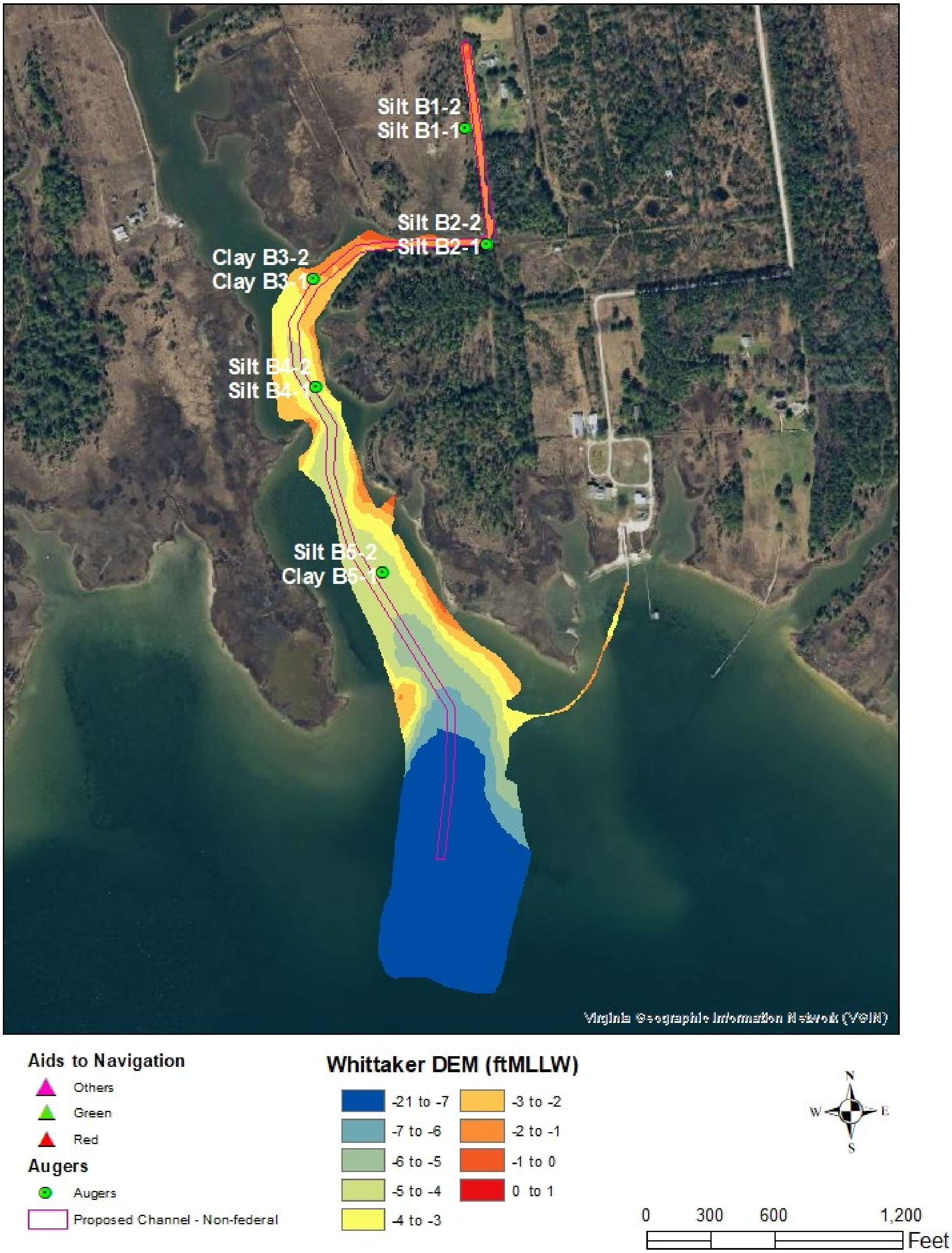

Proposed Free School
Ceek Channel
Gloucester County, Virginia
Free School
Creek
Bryant Bay
N
W
E
S
0
400
800
1,600
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Free School - Non-Federal

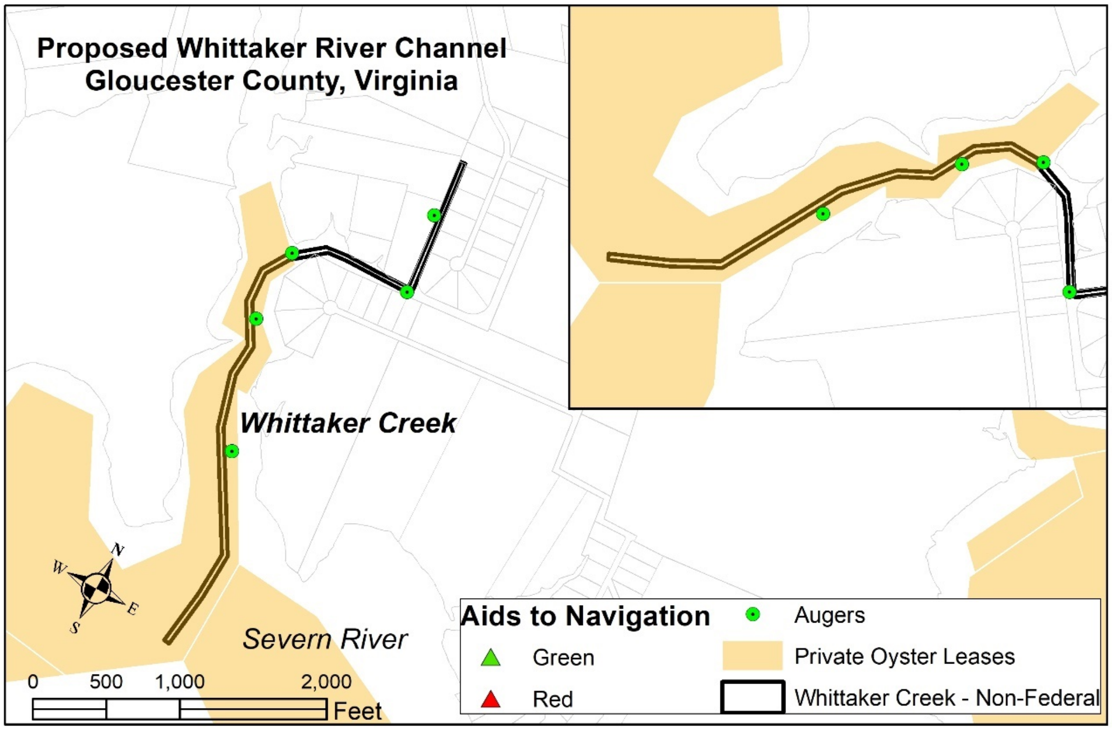

Proposed Free School
Creek Channel
Gloucester County, Virginia
NO SAV
Free School
Creek
Bryant Bay
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Free School - Non-Federal

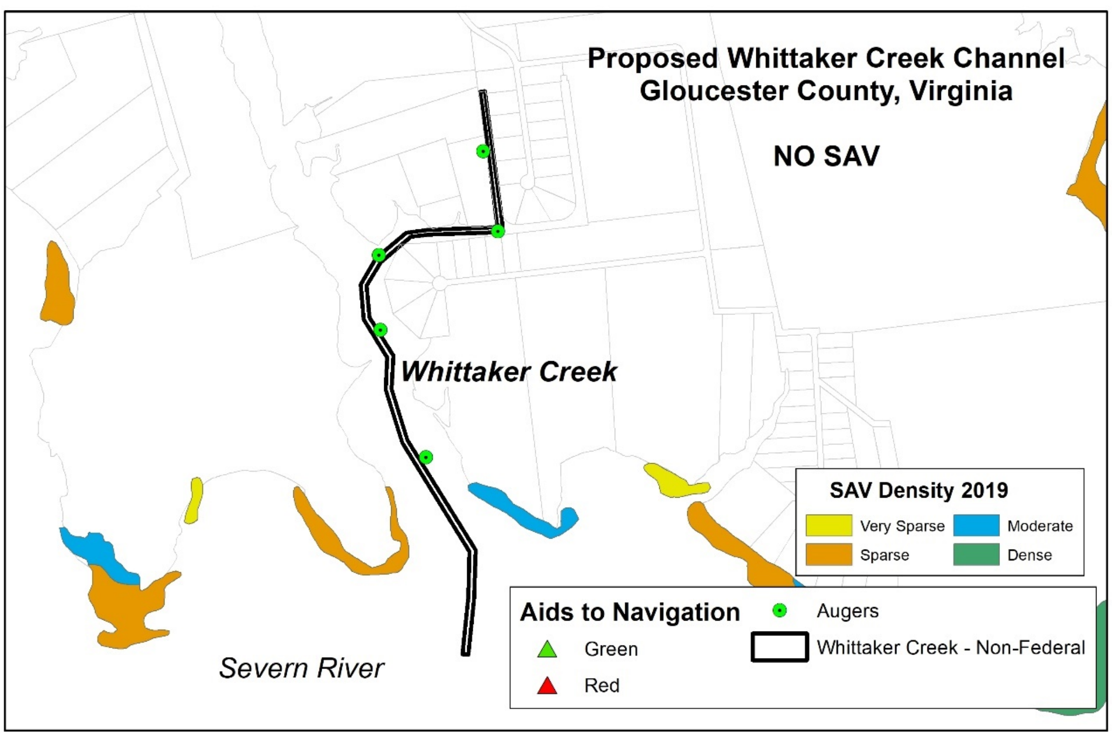
Free School Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Free School Creek	37.3318	-76.4452	B1-1	1.9	2.9		**ML**	Soft silt with trace sand and little broken shell	Olive gray
Free School Creek	37.3318	-76.4452	B1-2	1.9	3.9		**CL**	Medium stiff clay with little shell	Olive gray
Free School Creek	37.3313	-76.4448	B2-1	5.2	6.2		**CL**	Soft clay	Olive gray
Free School Creek	37.3313	-76.4448	B2-2	5.2	7.2		**CL**	Medium stiff clay	Olive gray

Whittaker Creek Bathymetry



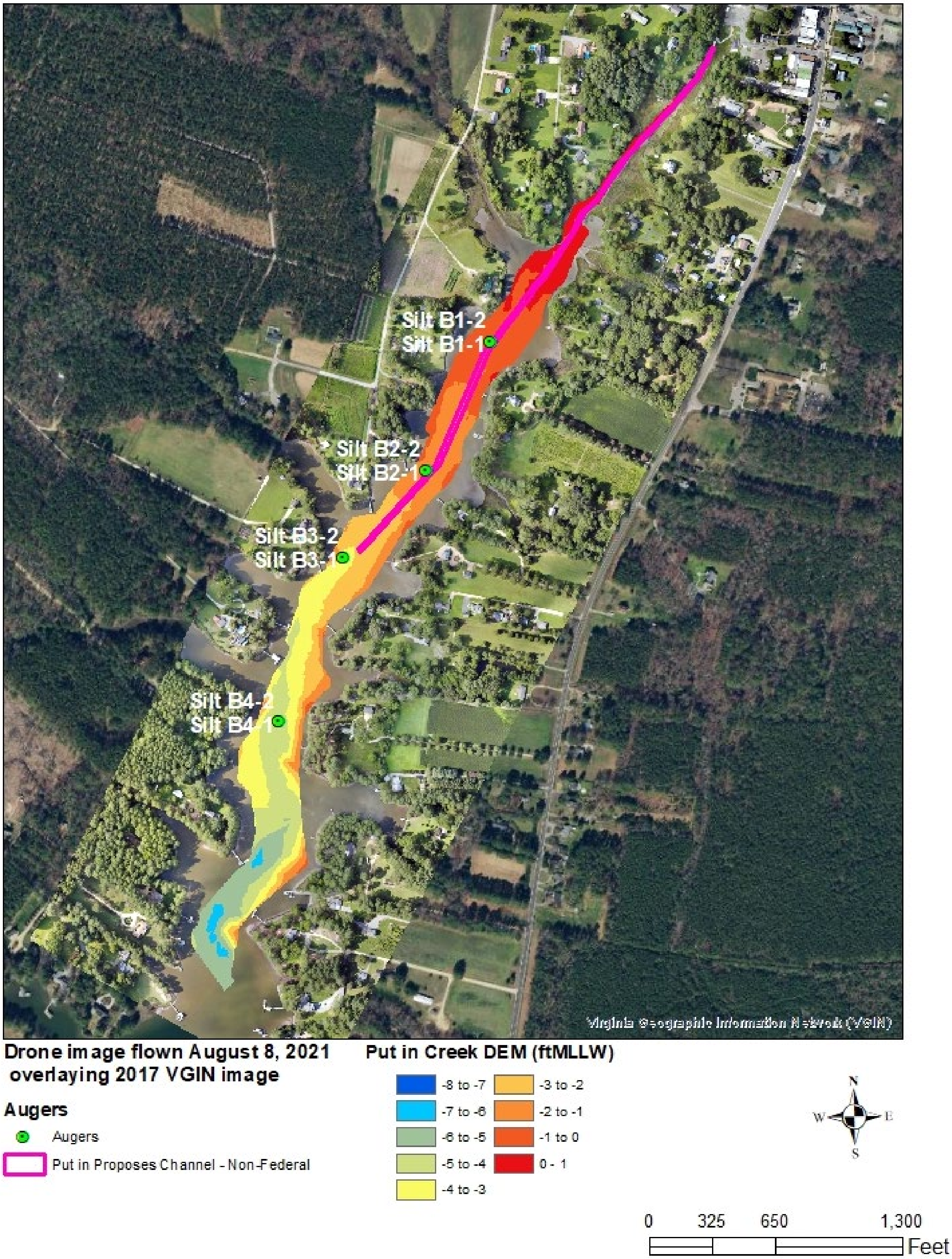

Proposed Whittaker River Channel
Gloucester County, Virginia
Whittaker Creek
Severn River
N
W
E
S
0
500
1,000
2,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Whittaker Creek - Non-Federal

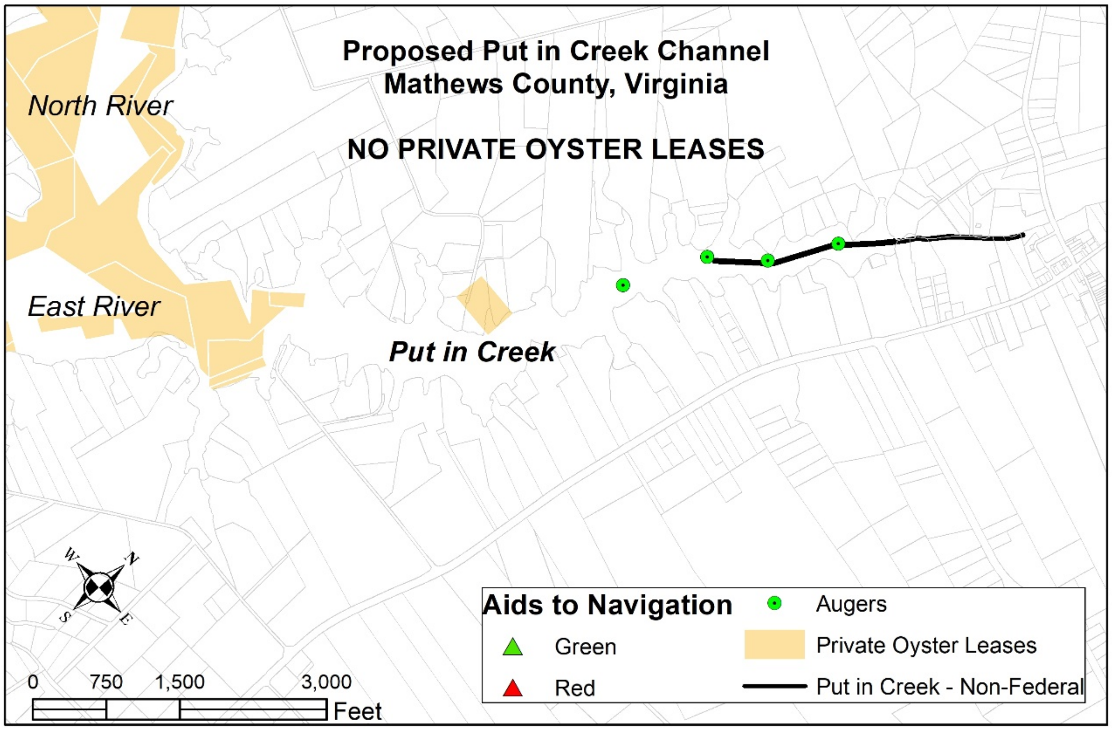

Proposed Whittaker Creek Channel
Gloucester County, Virginia
NO SAV
Whittaker Creek
Severn River
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Whittaker Creek - Non-Federal

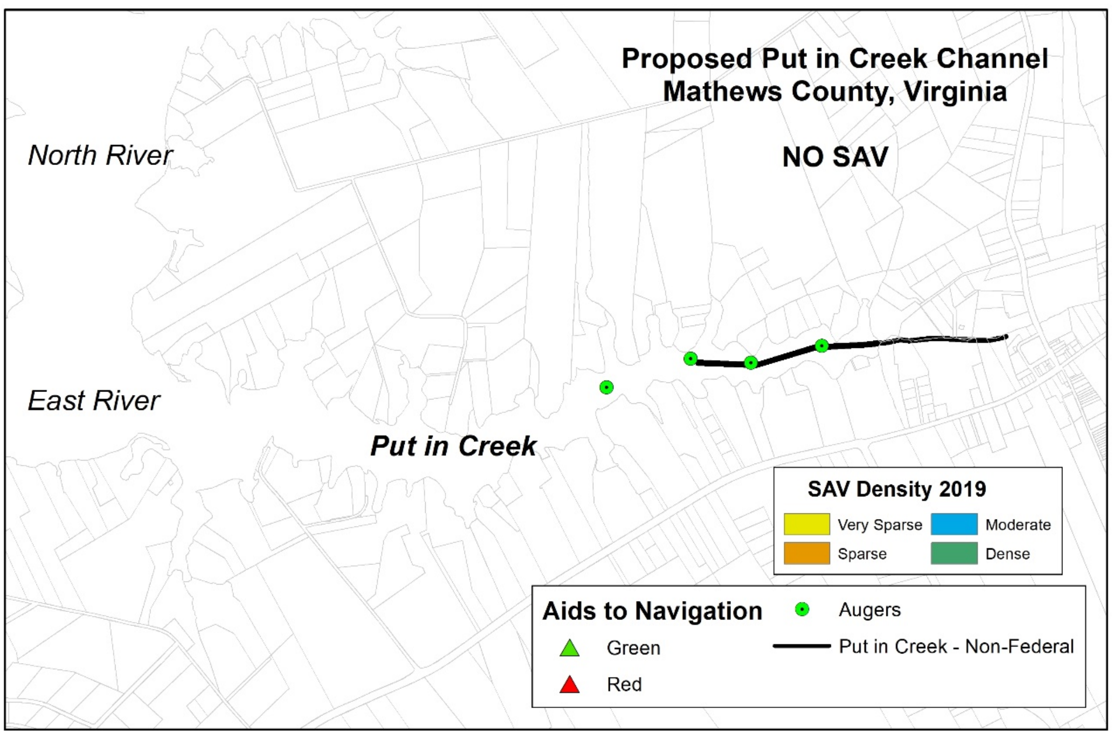
Whittaker Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Whittaker Creek	37.3301	-76.4303	B1-1	1.6	2.6		**ML**	Soft silt	Olive gray
Whittaker Creek	37.3301	-76.4303	B1-2	1.6	3.6		**ML**	Soft silt	Olive gray
Whittaker Creek	37.3286	-76.4300	B2-1	1.3	2.3		**ML**	Soft silt	Olive gray
Whittaker Creek	37.3286	-76.4300	B2-2	1.3	3.3		**ML**	Soft silt with trace sand	Olive gray
Whittaker Creek	37.3282	-76.4328	B3-1	2.2	3.2		**CL**	Stiff clay	Olive gray
Whittaker Creek	37.3282	-76.4328	B3-2	2.2	4.2		**CL**	Stiff clay with trace silt	Olive gray
Whittaker Creek	37.3268	-76.4328	B4-1	3.0	4.0		**ML**	Medium stiff silt	Olive gray
Whittaker Creek	37.3268	-76.4328	B4-2	3.0	5.0		**ML**	Medium stiff silt	Olive gray
Whittaker Creek	37.3244	-76.4318	B5-1	4.4	5.4		**CL**	Medium stiff clay	Olive gray
Whittaker Creek	37.3244	-76.4318	B5-2	4.4	6.4		**ML**	Soft silt	Olive gray

Put in Creek Bathymetry



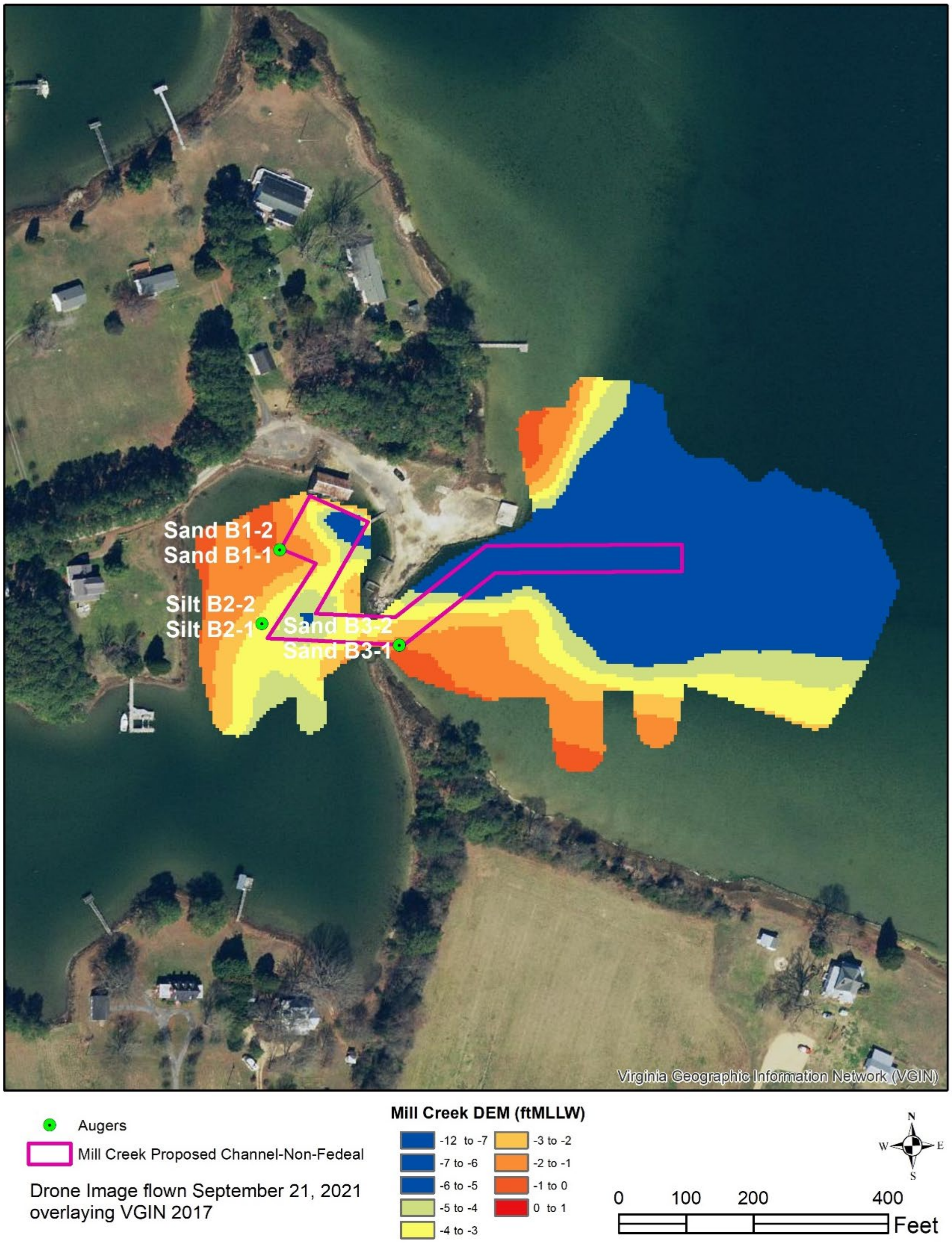

Proposed Put in Creek Channel
Mathews County, Virginia
NO PRIVATE OYSTER LEASES
North River
East River
Put in Creek
W
N
S
E
0
750
1,500
3,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Put in Creek - Non-Federal

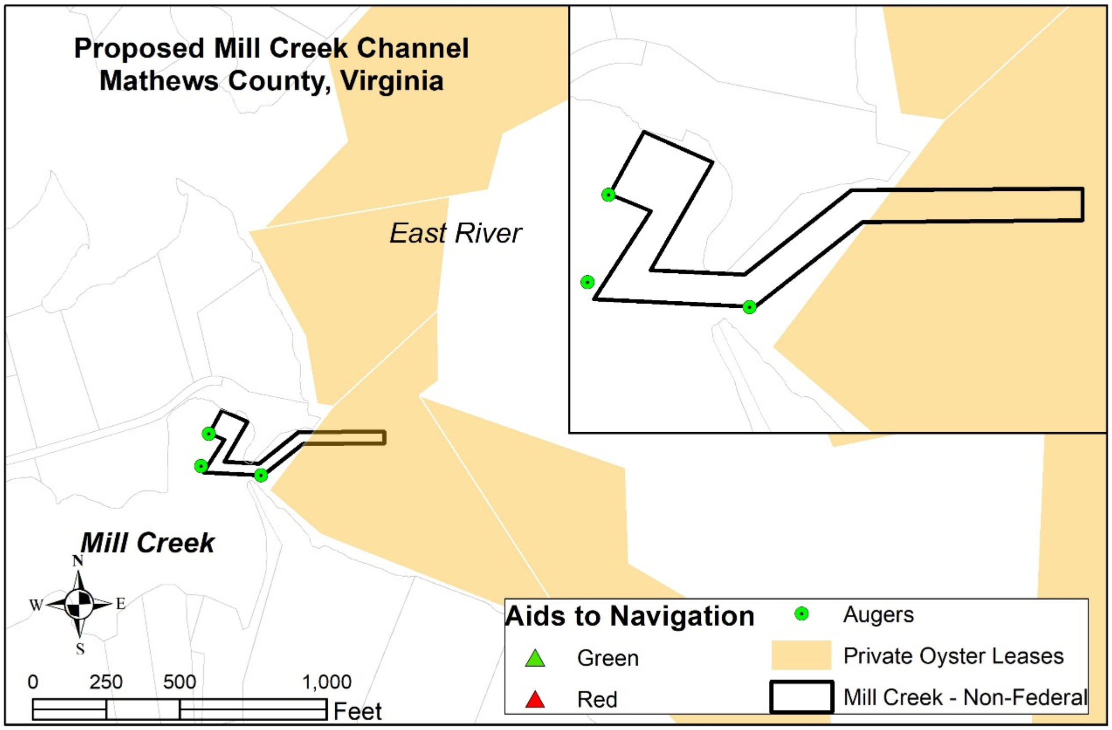

Proposed Put in Creek Channel
Mathews County, Virginia
NO SAV
North River
East River
Put in Creek
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Put in Creek - Non-Federal

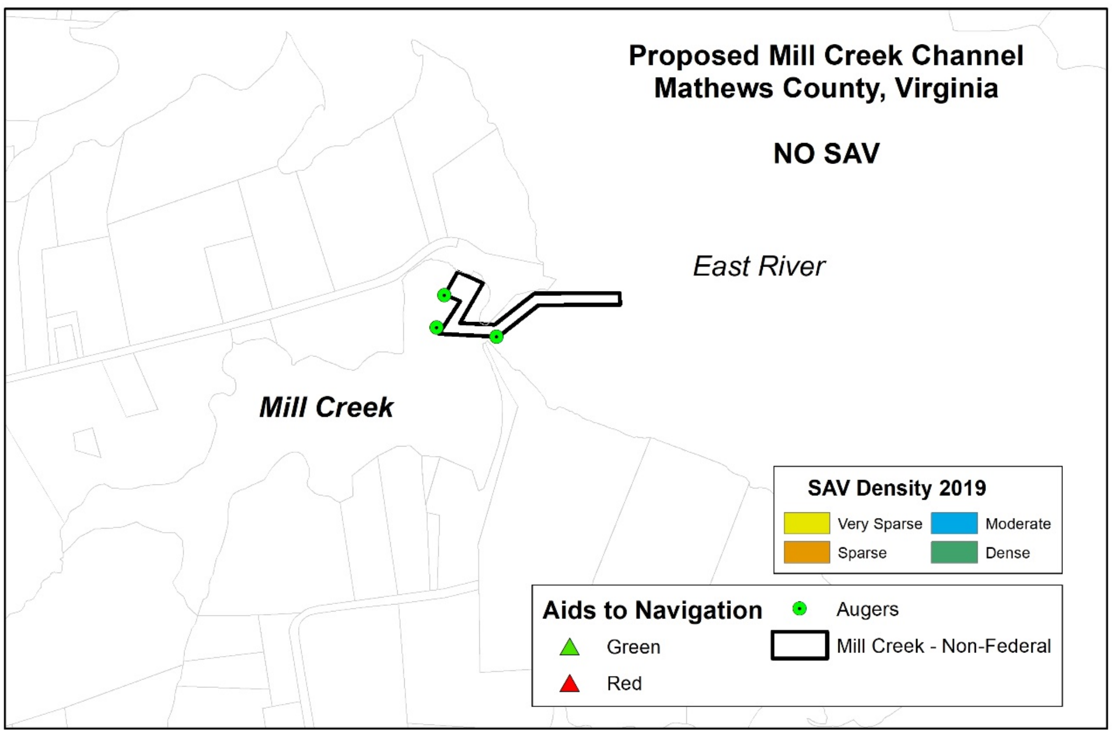
Put in Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Put in Creek	37.4291	-76.3271	B1-1	1.0	2.0		**ML**	Soft silt	Olive gray
Put in Creek	37.4291	-76.3271	B1-2	1.0	3.0		**ML**	Soft silt	Olive gray
Put in Creek	37.4273	-76.3283	B2-1	2.4	3.4		**ML**	Soft silt	Olive gray
Put n Creek	37.4273	-76.3283	B2-2	2.4	4.4		**ML**	Soft silt	Olive gray
Put in Creek	37.4261	-76.3298	B3-1	4.1	5.1		**ML**	Very soft silt	Olive gray
Put in Creek	37.4261	-76.3298	B3-2	4.1	6.1		**ML**	Very soft silt	Olive gray
Put in Creek	37.4238	-76.3310	B4-1	4.9	5.9		**ML**	Very soft silt	Dark gray
Put in Creek	37.4238	-76.3310	B4-2	4.9	6.9		**ML**	Very soft silt	Dark gray

Mill Creek 2 Bathymetry



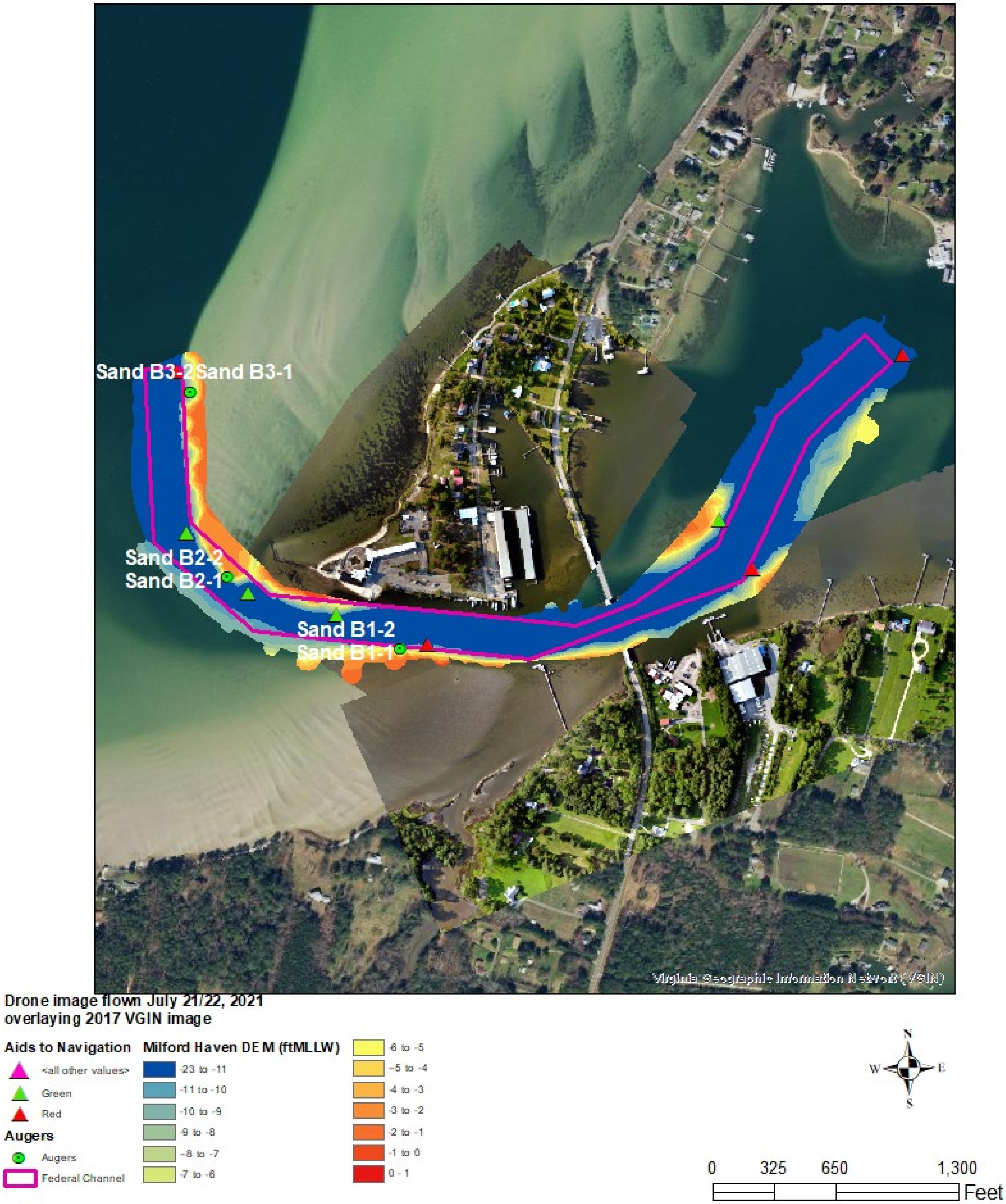

Proposed Mill Creek Channel
Mathews County, Virginia
East River
Mill Creek
N
W
E
S
0
250
500
1,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Mill Creek - Non-Federal

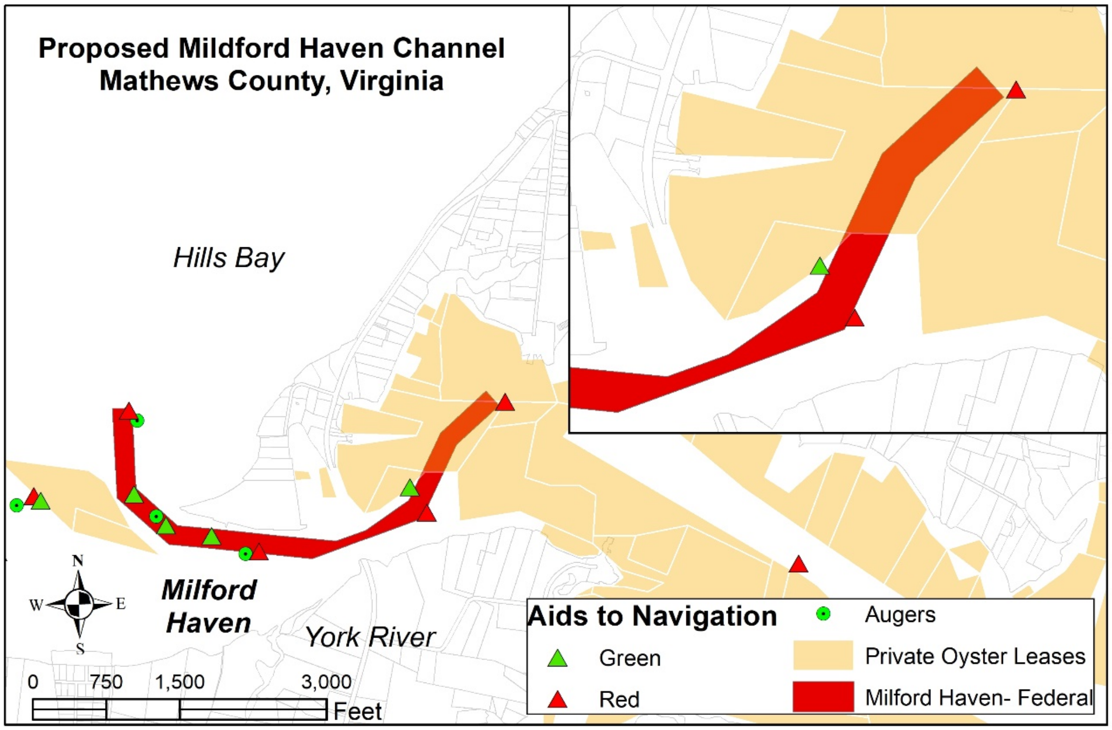

Proposed Mill Creek Channel
Mathews County, Virginia
NO SAV
East River
Mill Creek
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Mill Creek - Non-Federal

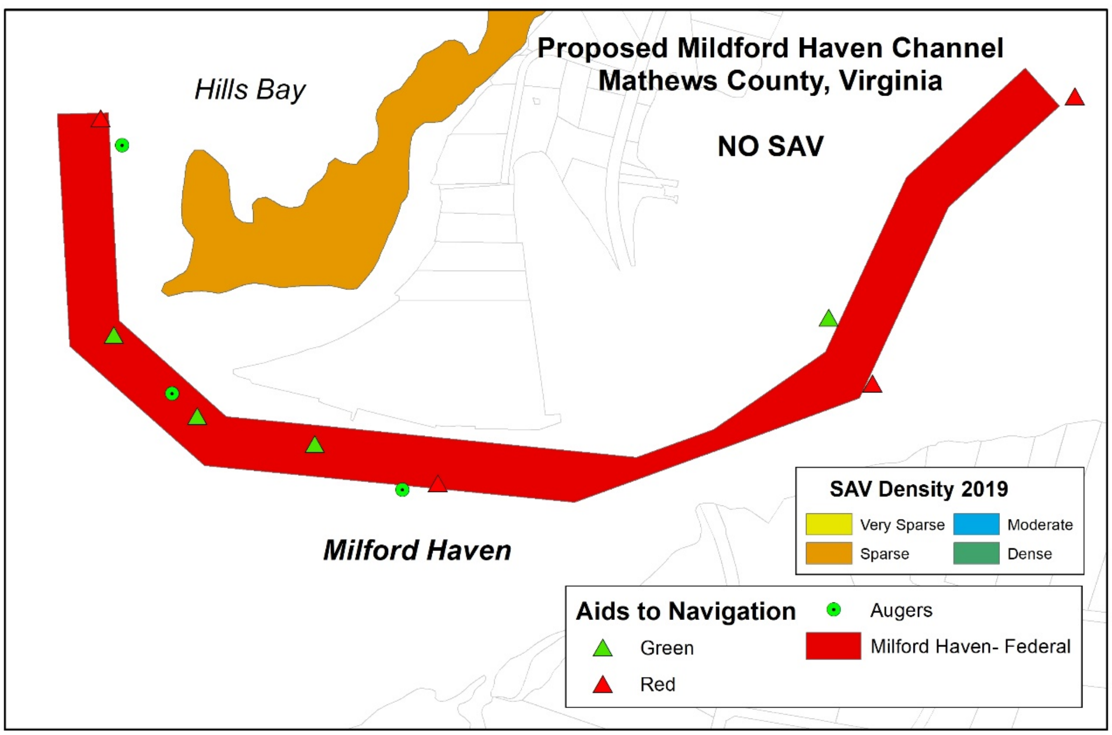
Mill Creek 2 Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Mill Creek 2	37.4009	-76.3528	B1-1	2.3	3.3		**SW**	Medium dense sand with trace silt	Olive gray
Mill Creek 2	37.4009	-76.3528	B1-2	2.3	4.3		**SW**	Medium dense sand with trace silt	Olive gray
Mill Creek 2	37.4006	-76.3529	B2-1	5.3	6.3		**ML**	Soft silt with trace sand	Olive gray
Mill Creek 2	37.4006	-76.3529	B2-2	5.3	7.3		**ML**	Soft silt with trace sand	Olive gray
Mill Creek 2	37.4005	-76.3522	B3-1	3.8	4.8		**SW**	Medium dense sand with trace silt and trace shell	Olive gray
Mill Creek 2	37.4005	-76.3522	B3-2	3.8	5.8		**SW**	Medium dense sand with trace silt and trace shell	Olive gray

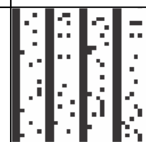
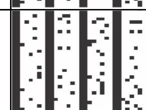
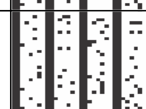
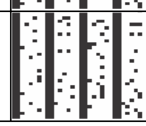
Milford Haven Bathymetry



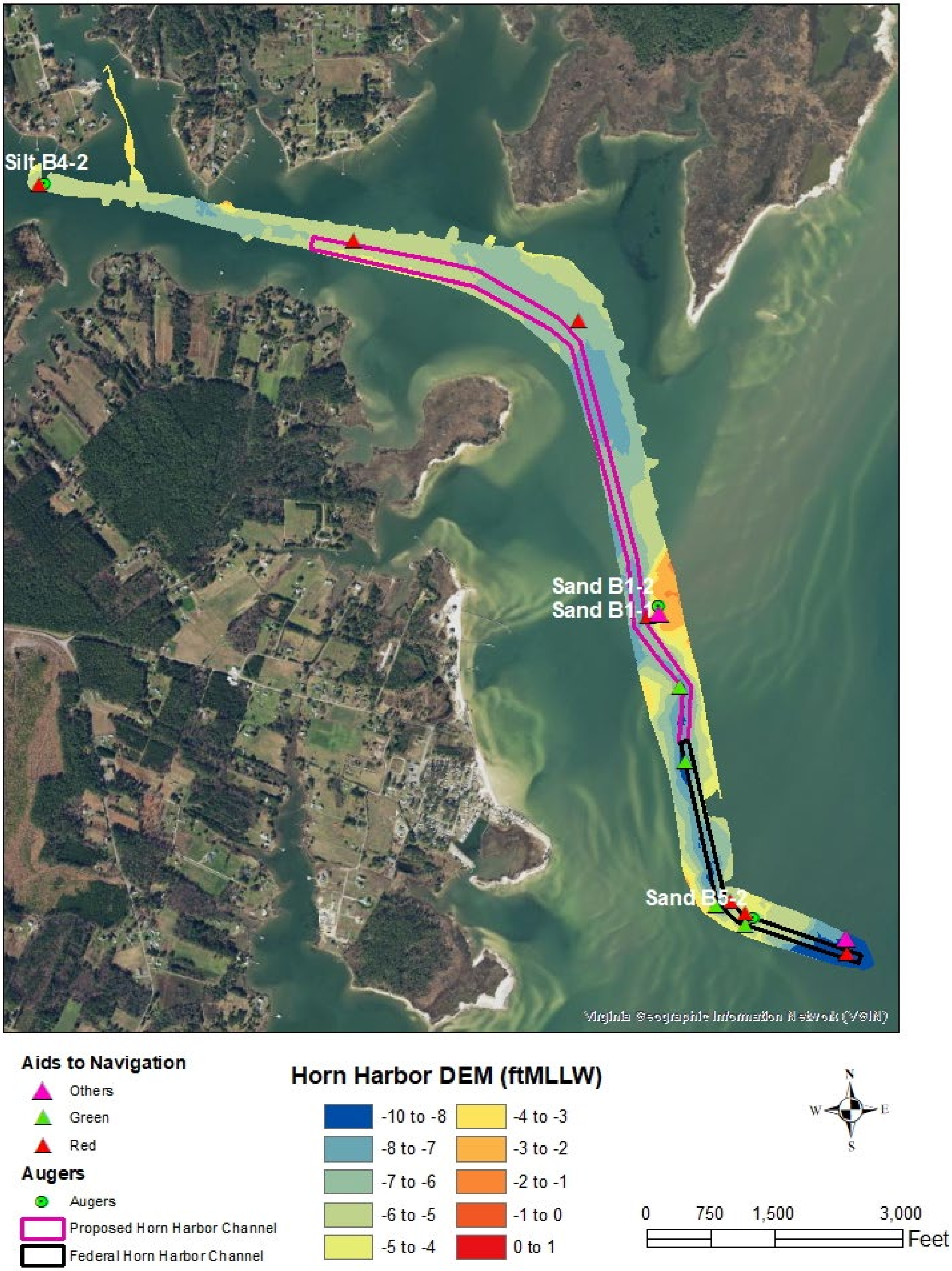

Proposed Mildford Haven Channel
Mathews County, Virginia
Hills Bay
Milford Haven
York River
N
W
E
S
0
750
1,500
3,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Milford Haven- Federal

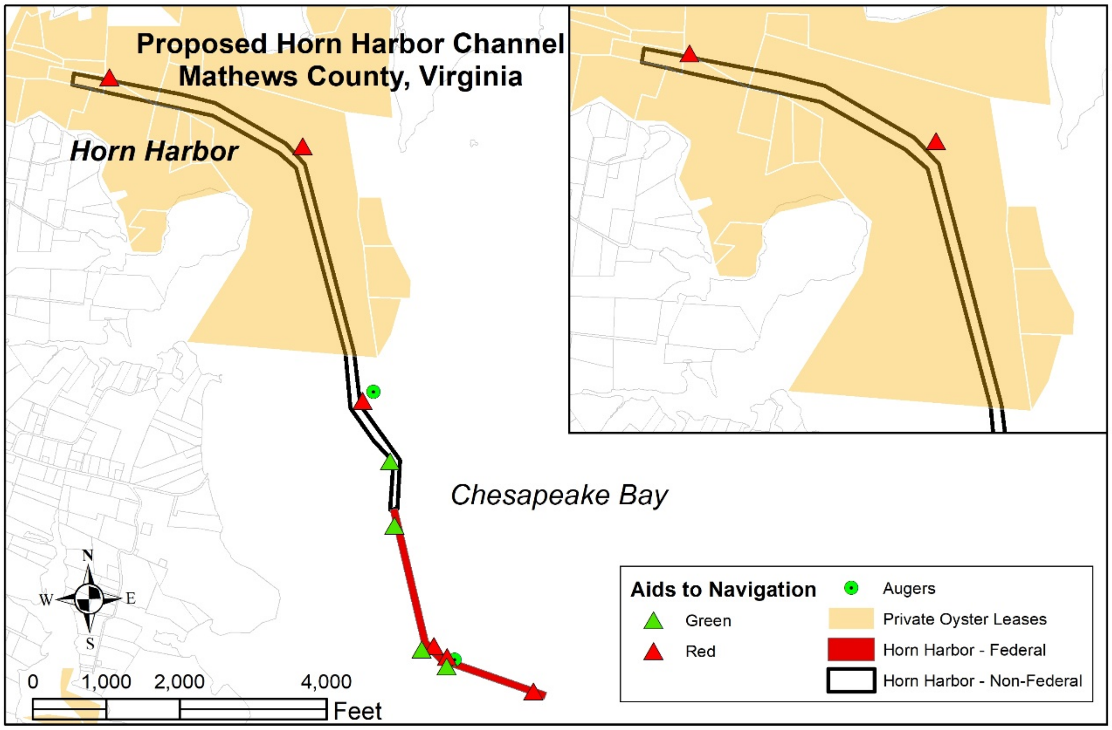

Proposed Mildford Haven Channel
Mathews County, Virginia
NO SAV
Hills Bay
Milford Haven
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Red
Milford Haven- Federal

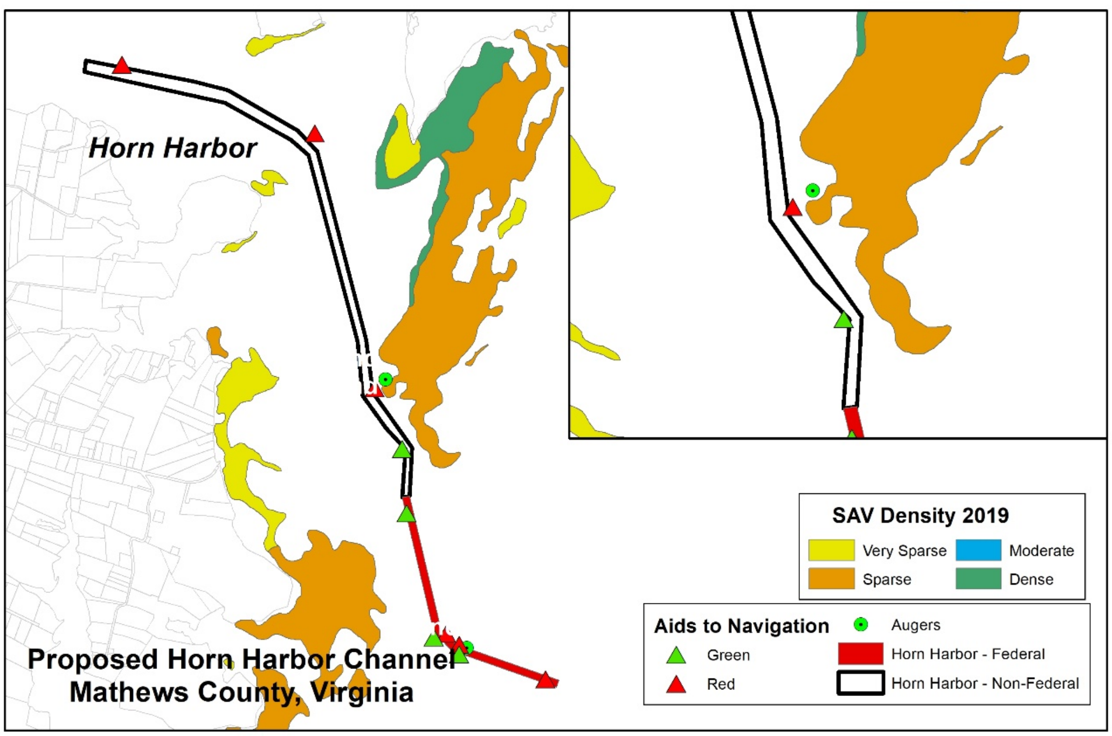
Milford Haven Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Milford Haven	37.4882	-76.3138	B1-1	4.4	5.4		**SM**	Medium dense sand with some silt	Dark gray
Milford Haven	37.4882	-76.3138	B1-2	4.4	6.4		**SP**	Medium dense sand	Olive gray
Milford Haven	37.4893	-76.3169	B2-1	2.4	3.4		**SM**	Medium dense sand with little silt	Dark gray
Milford Haven	37.4893	-76.3169	B2-2	2.4	4.4		**SM**	Medium dense sand with trace silt	Olive gray
Milford Haven	37.4920	-76.3175	B3-1	1.4	2.4		**SM**	Medium dense sand with trace silt	Olive gray
Milford Haven	37.4920	-76.3175	B3-2	1.4	3.4		**SM**	Medium dense sand with trace silt	Olive gray

Horn Harbor Bathymetry



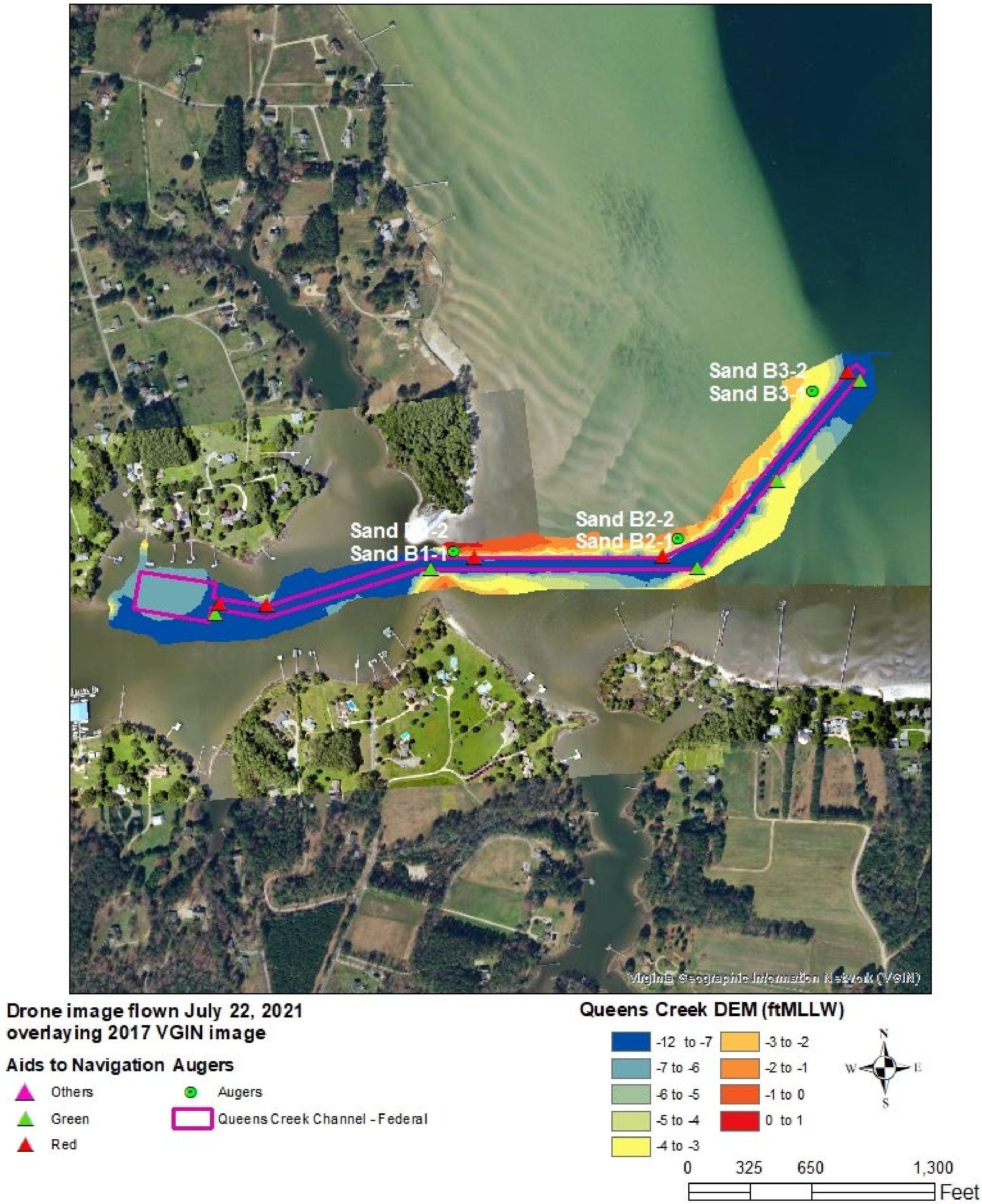

Proposed Horn Harbor Channel
Mathews County, Virginia
Horn Harbor
Chesapeake Bay
N
W
E
S
0
1,000
2,000
4,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Horn Harbor - Federal
Horn Harbor - Non-Federal

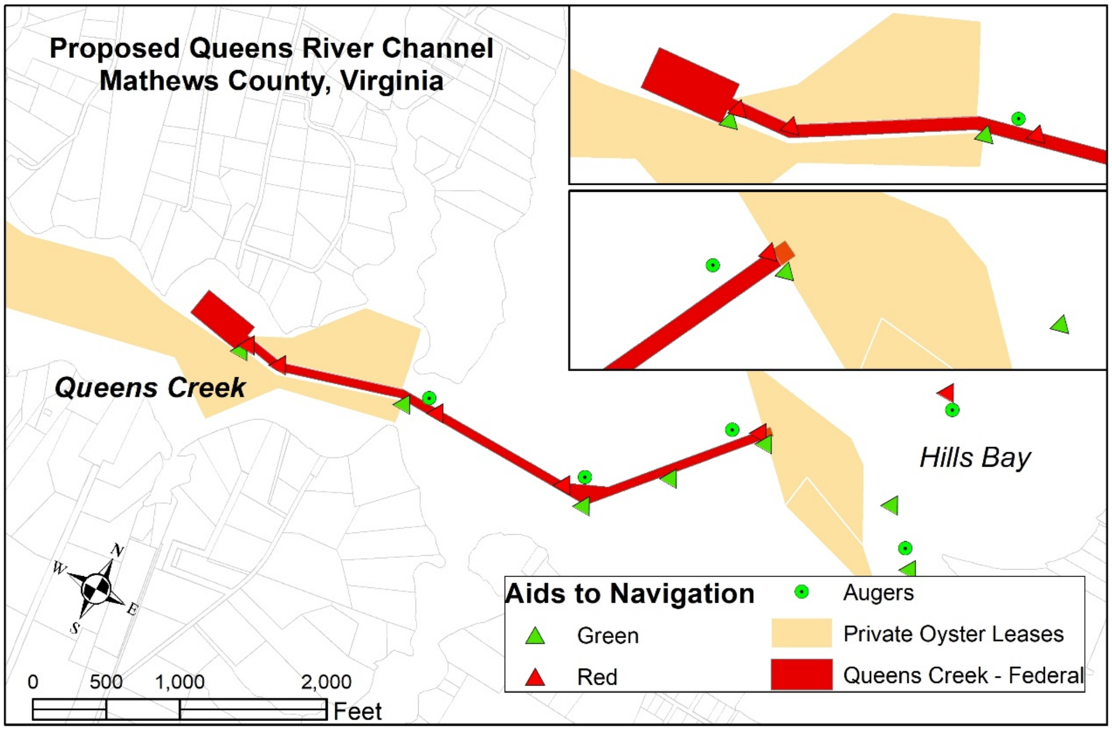

Horn Harbor
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Horn Harbor - Federal
Red
Horn Harbor - Non-Federal
Proposed Horn Harbor Channel
Mathews County, Virginia

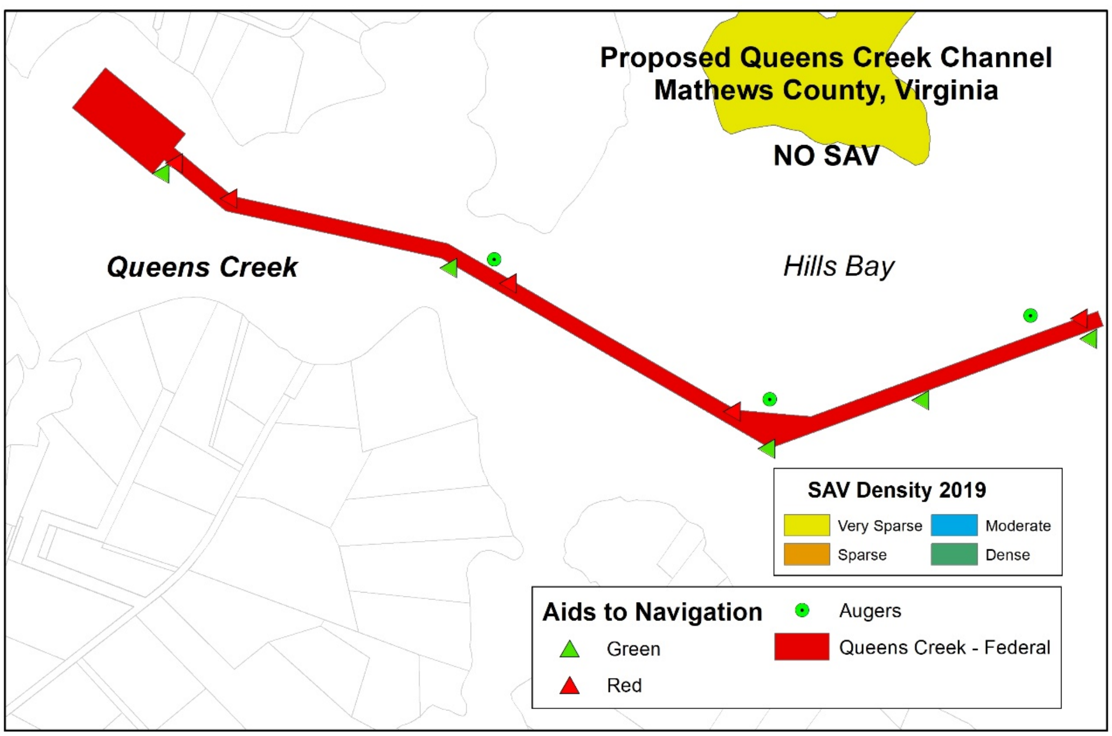
Horn Harbor Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Horn Harbor	37.3485	-76.2665	B1-1	2.5	3.5		**SP**	Medium dense sand	Olive gray
Horn Harbor	37.3485	-76.2665	B1-2	2.5	4.5		**SP**	Medium dense sand	Olive gray
Horn Harbor	37.3682	-76.3016	B2-1	4.4	5.4		**ML**	Soft silty clay with trace shell	Olive gray
Horn Harbor	37.3682	-76.3016	B2-2	4.4	6.4		**ML**	Soft silty clay with trace shell	Olive gray
Horn Harbor	37.3637	-76.2979	B3-1	4.8	5.8		**ML**	Soft silty clay	Olive gray
Horn Harbor	37.3637	-76.2979	B3-2	4.8	6.8		**ML**	Soft silty clay	Olive gray
Horn Harbor	37.3626	-76.2909	B4-2	4.8	6.8		**ML**	Soft silty clay	Olive gray
Horn Harbor	37.3384	-76.2630	B5-2	4.8	6.8		**SM**	Medium dense sand with trace silt	Olive gray

Queens Creek Bathymetry



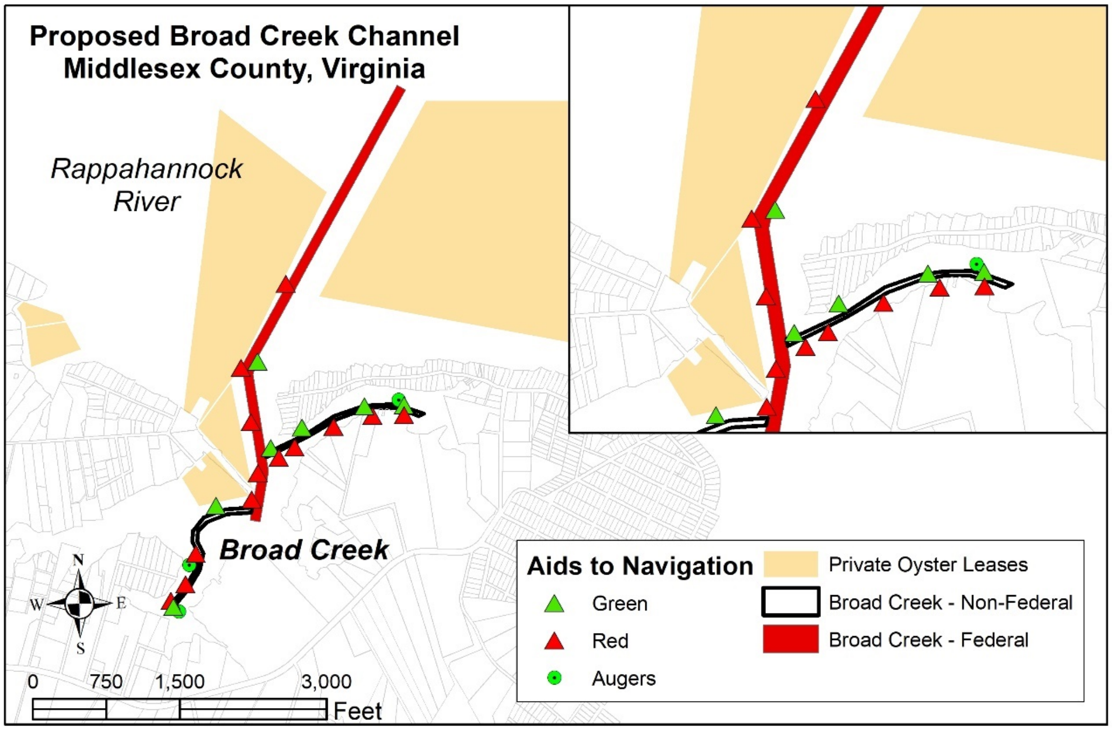

Proposed Queens River Channel
Mathews County, Virginia
Queens Creek
Hills Bay
N
W
E
S
0
500
1,000
2,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Queens Creek - Federal

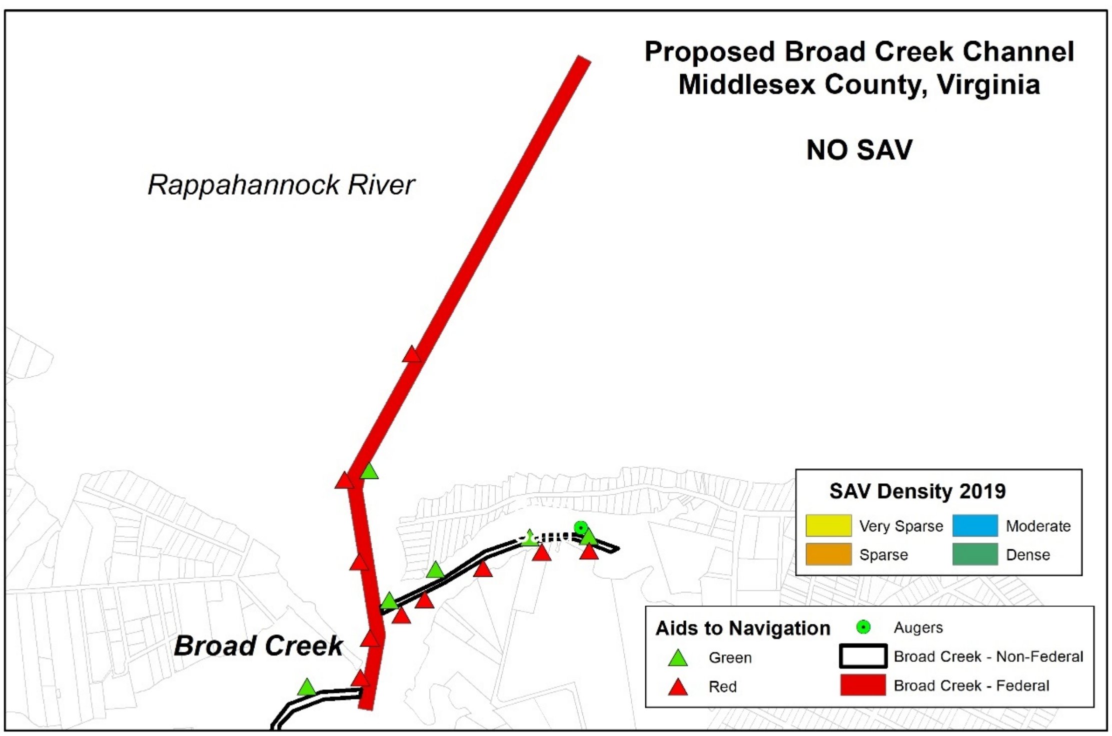

Proposed Queens Creek Channel
Mathews County, Virginia
NO SAV
Queens Creek
Hills Bay
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Queens Creek - Federal
Red

Queens Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Queens Creek	37.4875	-76.3284	B1-1	1.5	2.5		**SM**	Medium dense sand with trace silt	Olive gray
Queens Creek	37.4875	-76.3284	B1-2	1.5	3.5		**SM**	Medium dense sand with trace silt	Olive gray
Queens Creek	37.4876	-76.3243	B2-1	2.8	3.8		**SP**	Medium dense sand	Olive gray
Queens Creek	37.4876	-76.3243	B2-2	2.8	4.8		**SP**	Medium dense sand	Olive gray
Queens Creek	37.4897	-76.3218	B3-1	3.0	4.0		**SP**	Medium dense sand	Olive gray
Queens Creek	37.4897	-76.3218	B3-2	3.0	5.0		**SP**	Medium dense sand	Olive gray

Broad Creek Bathymetry

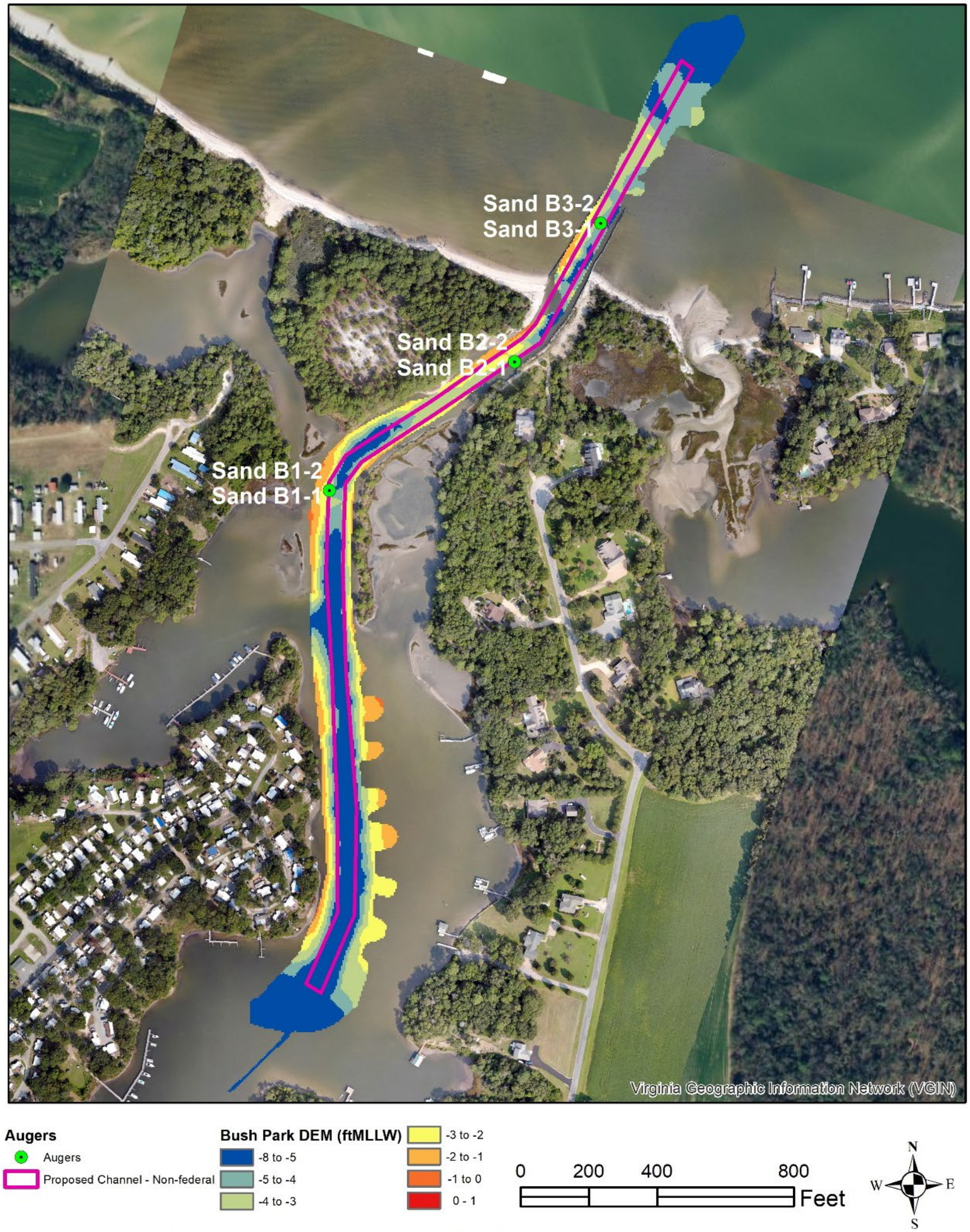

Proposed Broad Creek Channel
Middlesex County, Virginia
Rappahannock River
Broad Creek
N
W
E
S
0
750
1,500
3,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Broad Creek - Non-Federal
Broad Creek - Federal


Proposed Broad Creek Channel
Middlesex County, Virginia
NO SAV
Rappahannock River
Broad Creek
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Red
Broad Creek - Non-Federal
Broad Creek - Federal

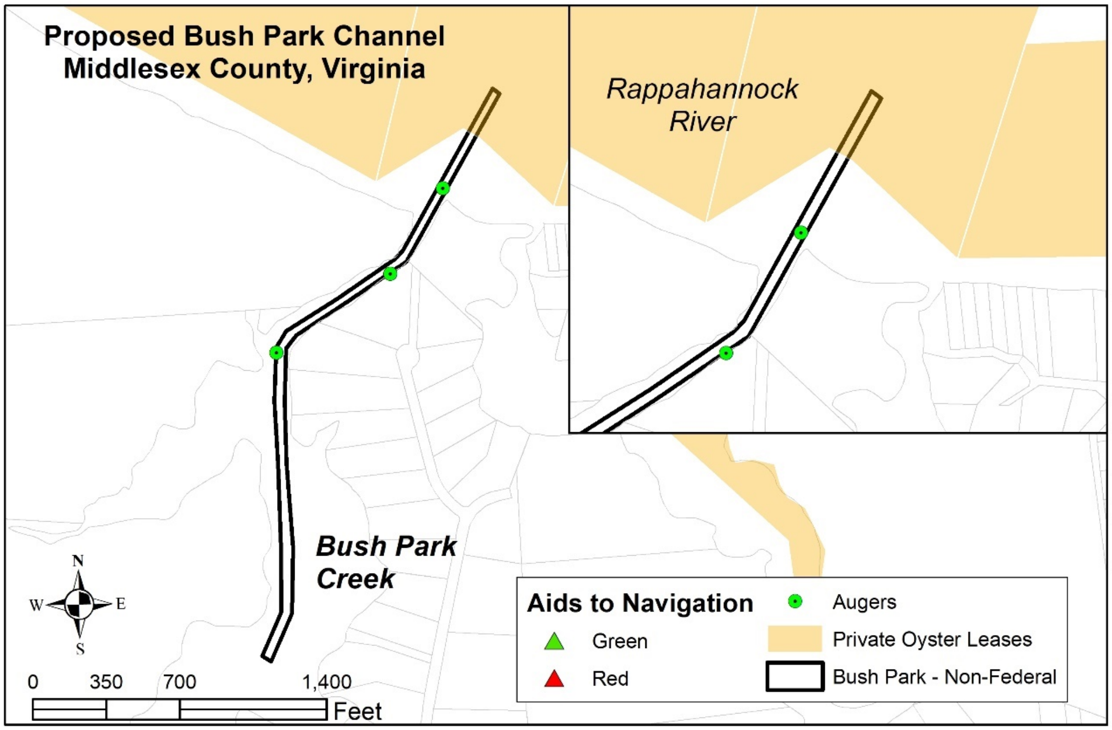
Broad Creek Sediment Analysis

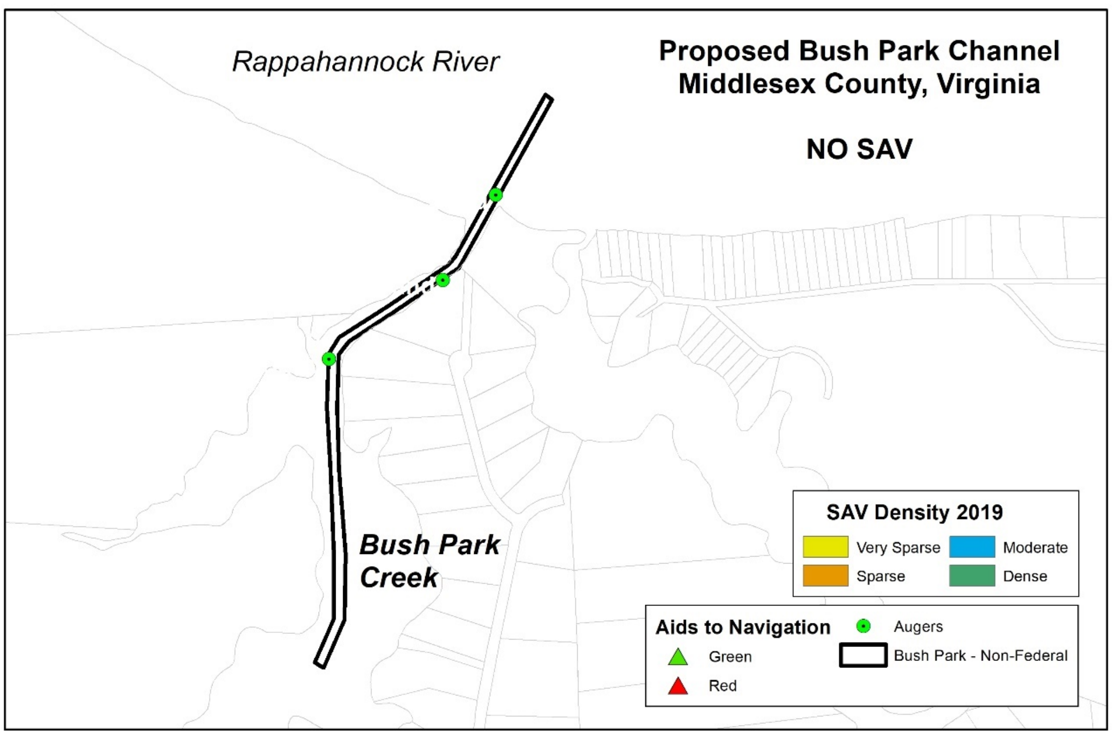
Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Broad Creek	37.5621	-76.3088	B1-1	2.0	3.0		**SP**	Medium dense sand	Olive gray
Broad Creek	37.5621	-76.3088	B1-2	2.0	4.0		**SP**	Medium dense sand	Olive gray
Broad Creek	37.5563	-76.3167	B2-1	4.6	5.6		**ML**	Soft silty clay	Dark gray
Broad Creek	37.5563	-76.3167	B2-2	4.6	6.6		**ML**	Very soft silt	Olive gray
Broad Creek	37.5576	-76.3163	B3-1	0.8	1.8		**SP**	Medium dense sand with trace silt	Olive gray
Broad Creek	37.5576	-76.3163	B3-2	0.8	2.8		**SP**	Medium dense sand with trace silt	Olive gray

Bush Park Creek Bathymetry



Drone Image Date: September 12, 2021 overlaying VGIN 2017

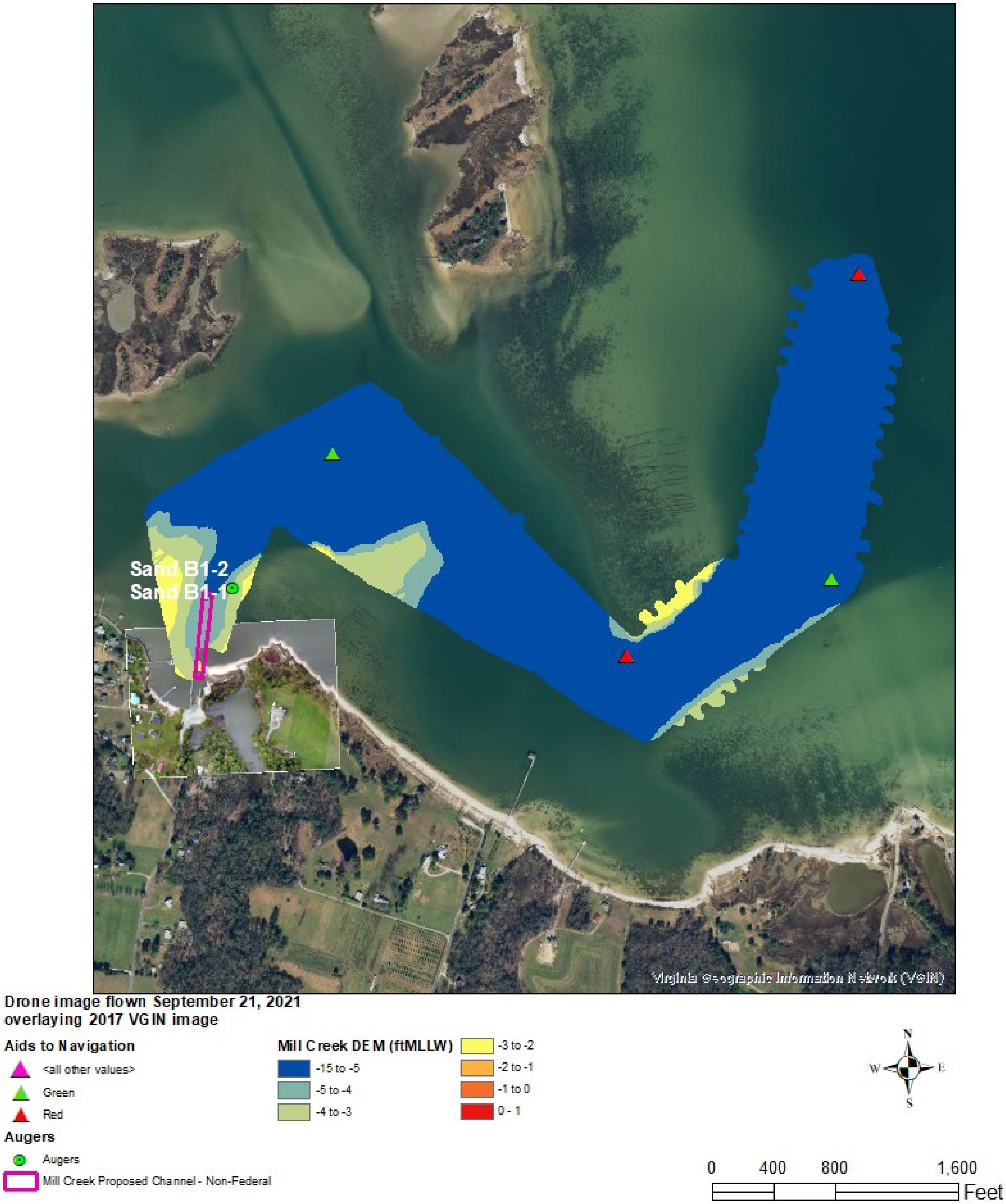

Proposed Bush Park Channel
Middlesex County, Virginia
Rappahannock
River
Bush Park
Creek
N
W
E
S
0
350
700
1,400
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Bush Park - Non-Federal

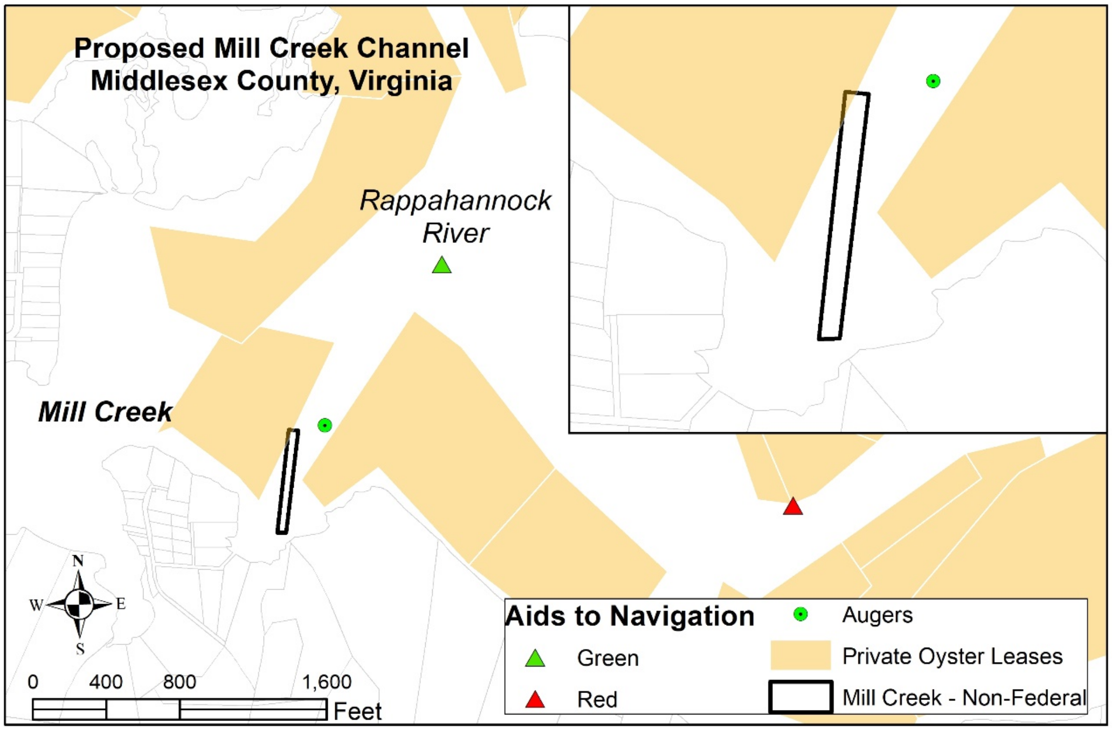

Rappahannock River
Proposed Bush Park Channel
Middlesex County, Virginia
NO SAV
Bush Park
Creek
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Bush Park - Non-Federal
Red

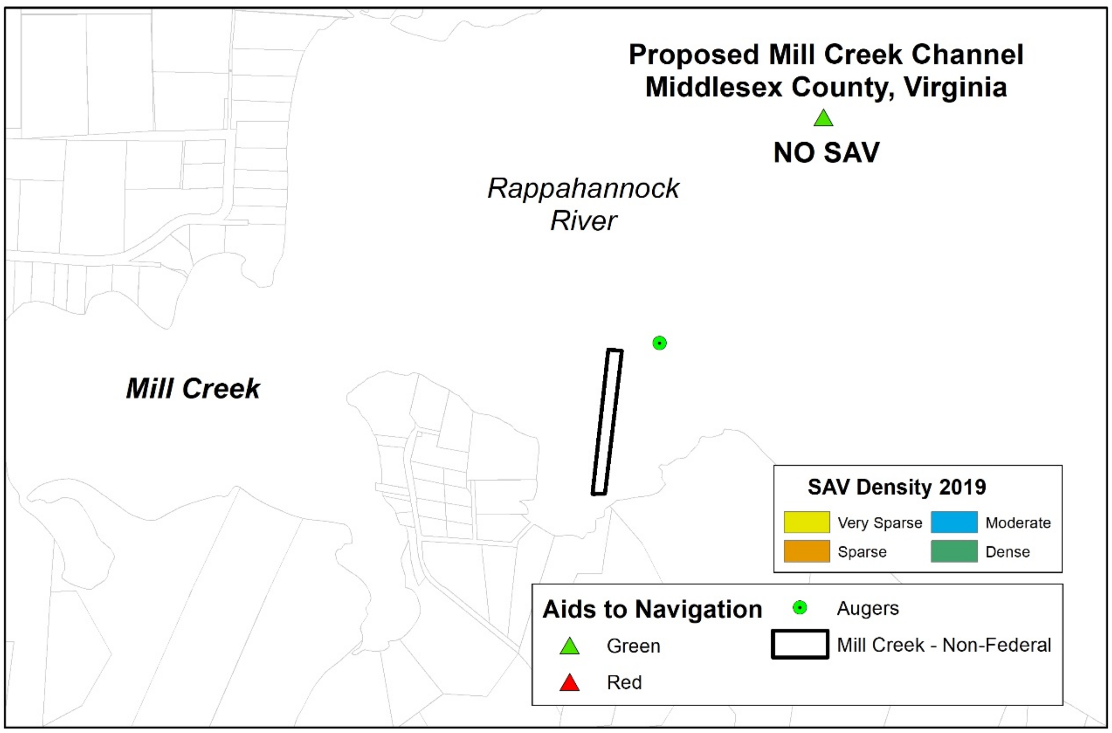
Bush Park Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Bush Park Creek	37.5717	-76.3874	B1-1	3.7	4.7		**SM**	Medium dense sand with trace shell	Olive gray
Bush Park Creek	37.5717	-76.3874	B1-2	3.7	5.7		**SM**	Medium dense sand	Olive gray
Bush Park Creek	37.5727	-76.3855	B2-1	2.7	3.7		**SP**	Medium dense sand	Olive gray
Bush Park Creek	37.5727	-76.3855	B2-2	2.7	4.7		**SP**	Medium dense sand	Olive gray
Bush Park Creek	37.5738	-76.3846	B3-1	2.7	3.7		**SM**	Medium dense sand	Olive gray
Bush Park Creek	37.5738	-76.3846	B3-2	2.7	4.7		**SM**	Medium dense sand	Olive gray

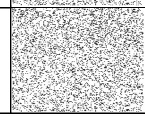
Mill Creek Bathymetry



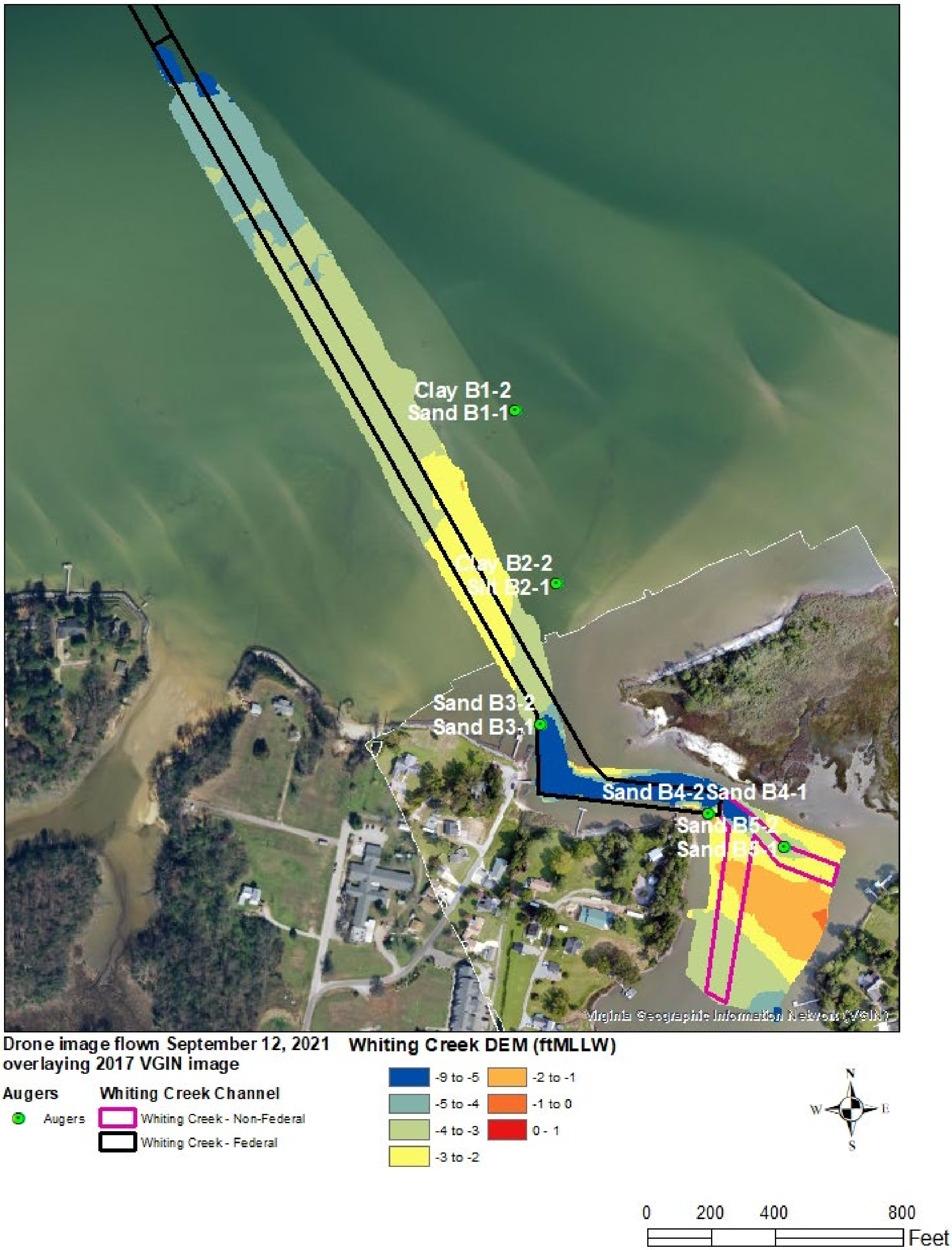

Proposed Mill Creek Channel
Middlesex County, Virginia
Rappahannock River
Mill Creek
N
W
E
S
0
400
800
1,600
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Mill Creek - Non-Federal

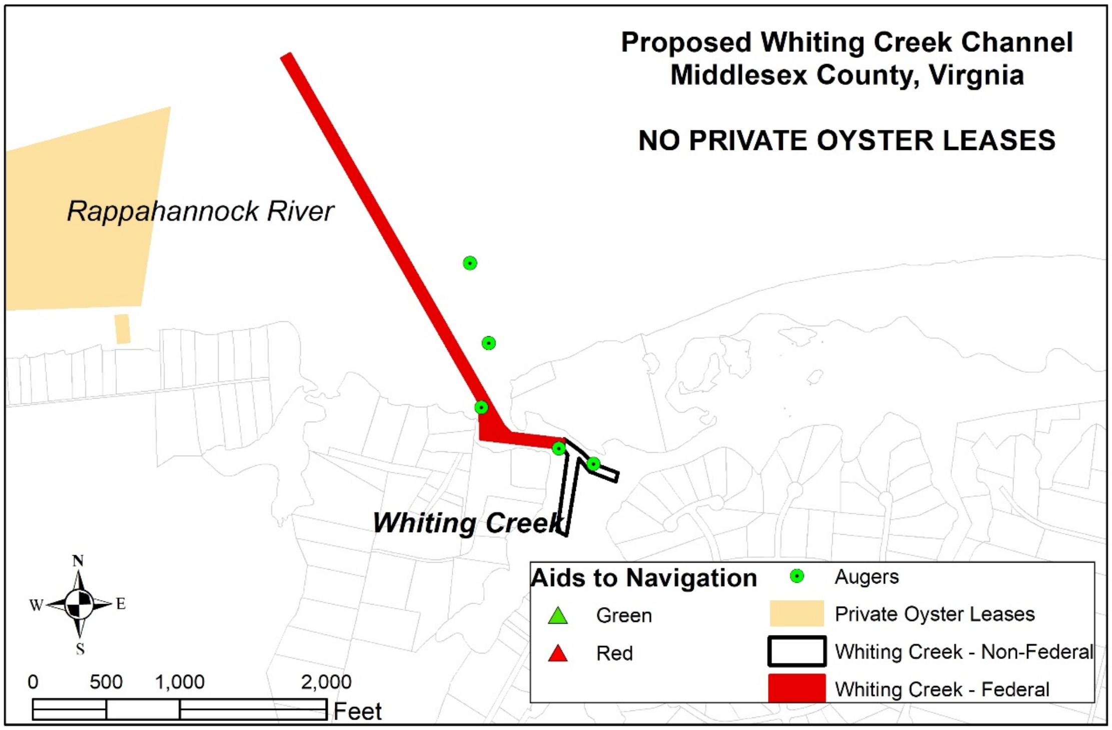

Proposed Mill Creek Channel
Middlesex County, Virginia
NO SAV
Rappahannock River
Mill Creek
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Augers
Green
Mill Creek - Non-Federal
Red

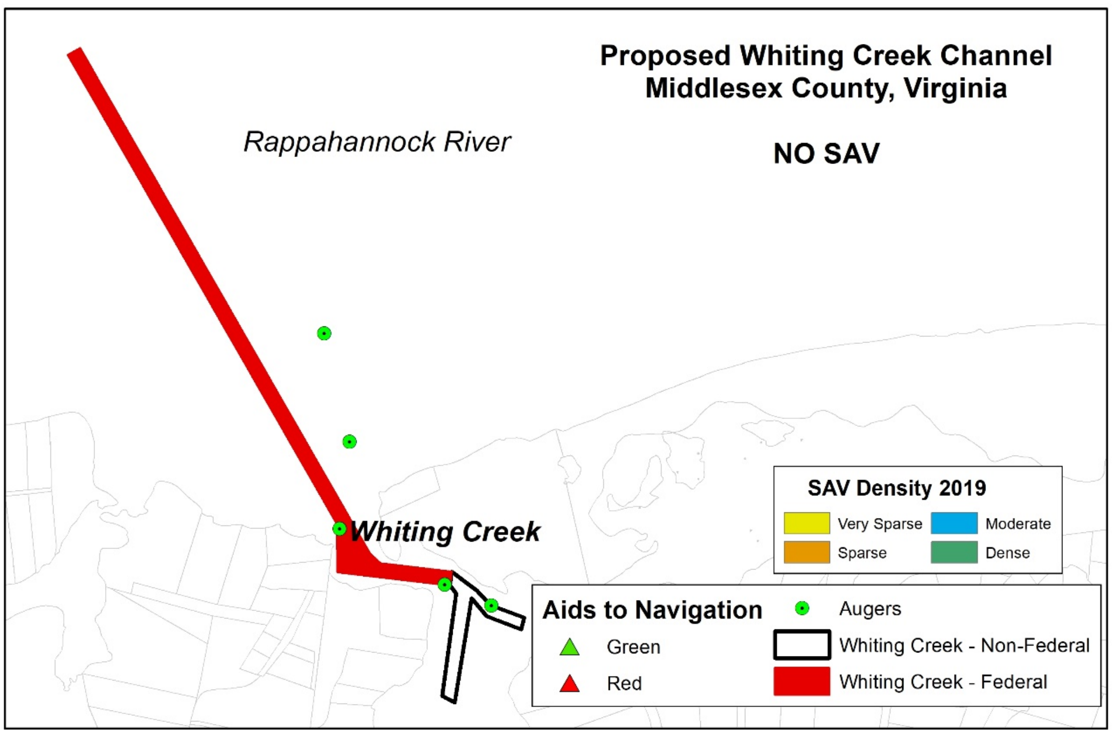
Mill Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Mill Creek	37.5861	-76.4236	B1-1	4.2	5.2		**SP**	Medium dense sand with trace silt	Olive gray
Mill Creek	37.5681	-76.4236	B1-2	4.2	6.2		**SP**	Medium dense sand with trace silt	Olive gray

Whiting Creek Bathymetry



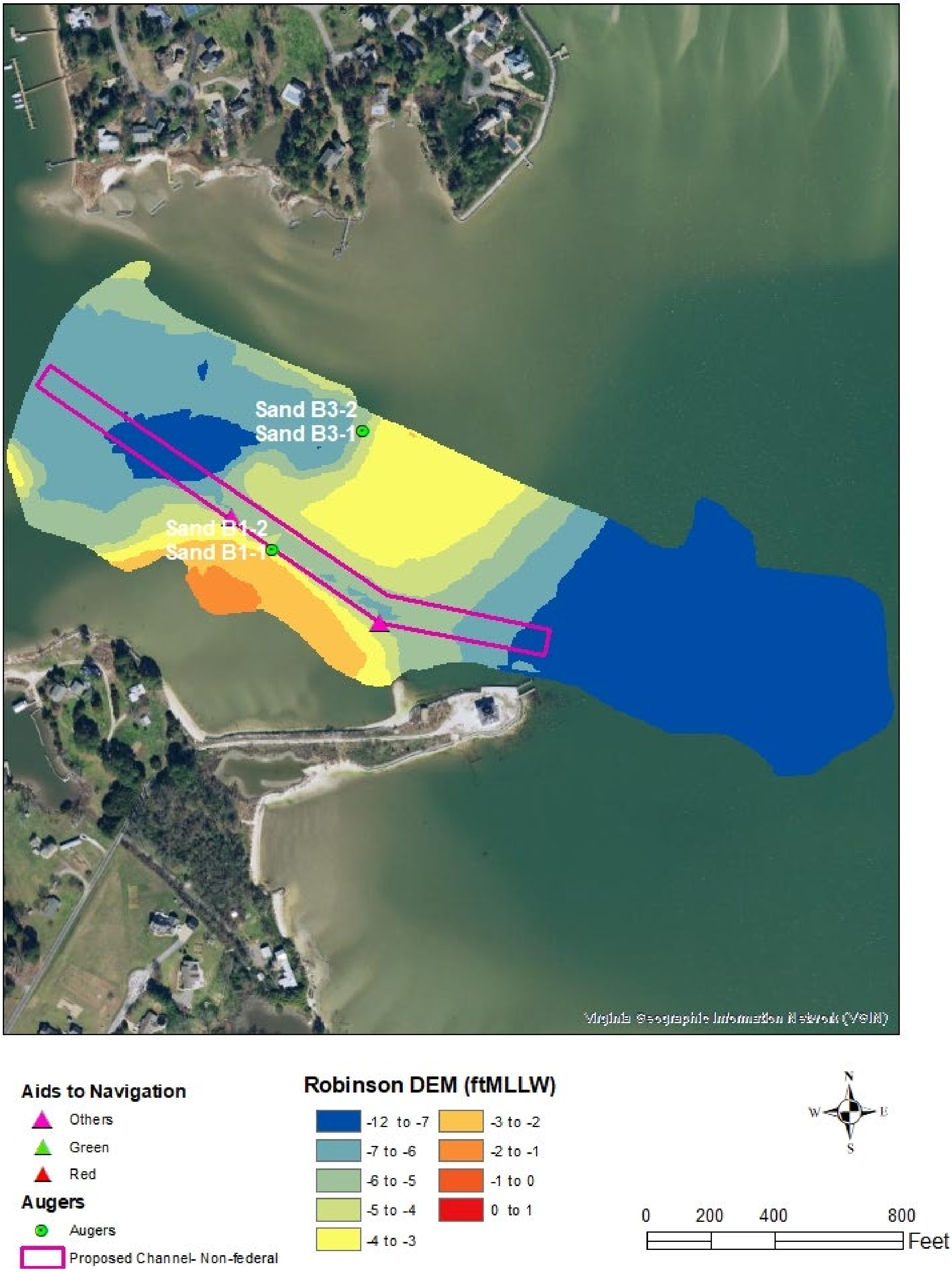

Proposed Whiting Creek Channel
Middlesex County, Virgnia
NO PRIVATE OYSTER LEASES
Rappahannock River
Whiting Creek
N
W
E
S
0
500
1,000
2,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Whiting Creek - Non-Federal
Whiting Creek - Federal

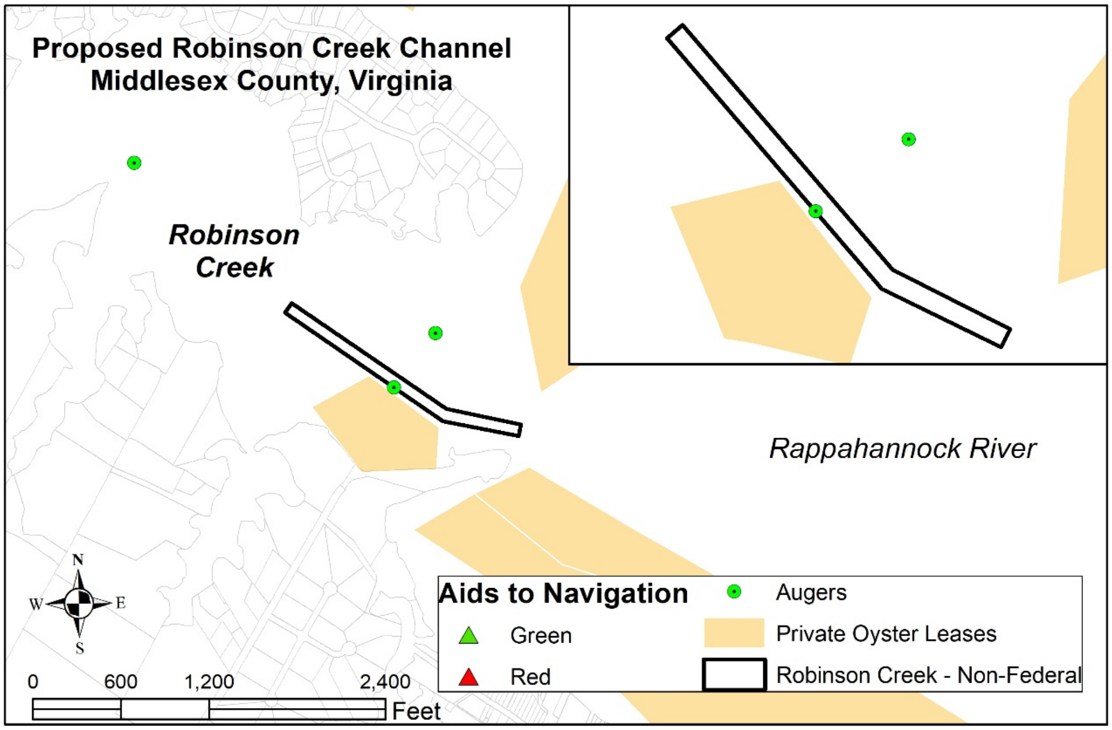

Proposed Whiting Creek Channel
Middlesex County, Virginia
NO SAV
Rappahannock River
Whiting Creek
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Whiting Creek - Non-Federal
Whiting Creek - Federal

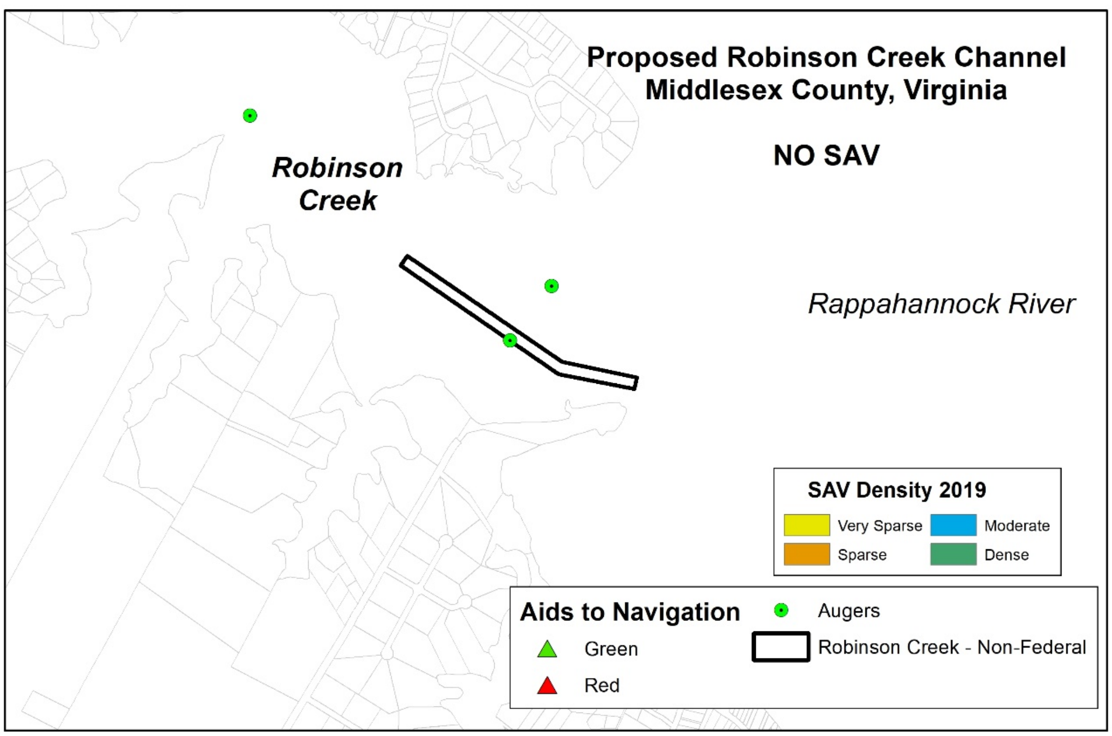
Whiting Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Whiting Creek	37.6132	-76.5061	B1-1	2.9	3.9		**SM**	Medium dense sand with little silt	Olive gray
Whiting Creek	37.6132	-76.5061	B1-2	2.9	4.9		**CL**	Stiff clay with trace sand	Olive gray
Whiting Creek	37.6117	-76.5057	B2-1	2.9	3.9		**ML**	Soft silt and shell	Olive gray
Whiting Creek	37.6117	-76.5057	B2-2	2.9	4.9		**CL**	Soft clay with trace sand and trace broken shell	Olive gray
Whiting Creek	37.6105	-76.5059	B3-1	4.5	5.5		**SM**	Loose sand with trace silt	Olive gray
Whiting Creek	37.6105	-76.5059	B3-2	4.5	6.5		**SW**	Loose sand with trace shell	Yellowish orange
Whiting Creek	37.6097	-76.5041	B4-1	3.0	4.0		**SW**	Loose sand with trace shell	Yellowish orange
Whiting Creek	37.6097	-76.5041	B4-2	3.0	5.0		**SW**	Loose sand with trace shell	Yellowish orange
Whiting Creek	37.6094	-76.5033	B5-1	4.0	5.0		**SM**	Medium dense sand	Olive gray
Whiting Creek	37.6094	-76.5033	B5-2	4.0	6.0		**SM**	Medium dense sand with trace shell	Olive gray

Robinson Creek Bathymetry



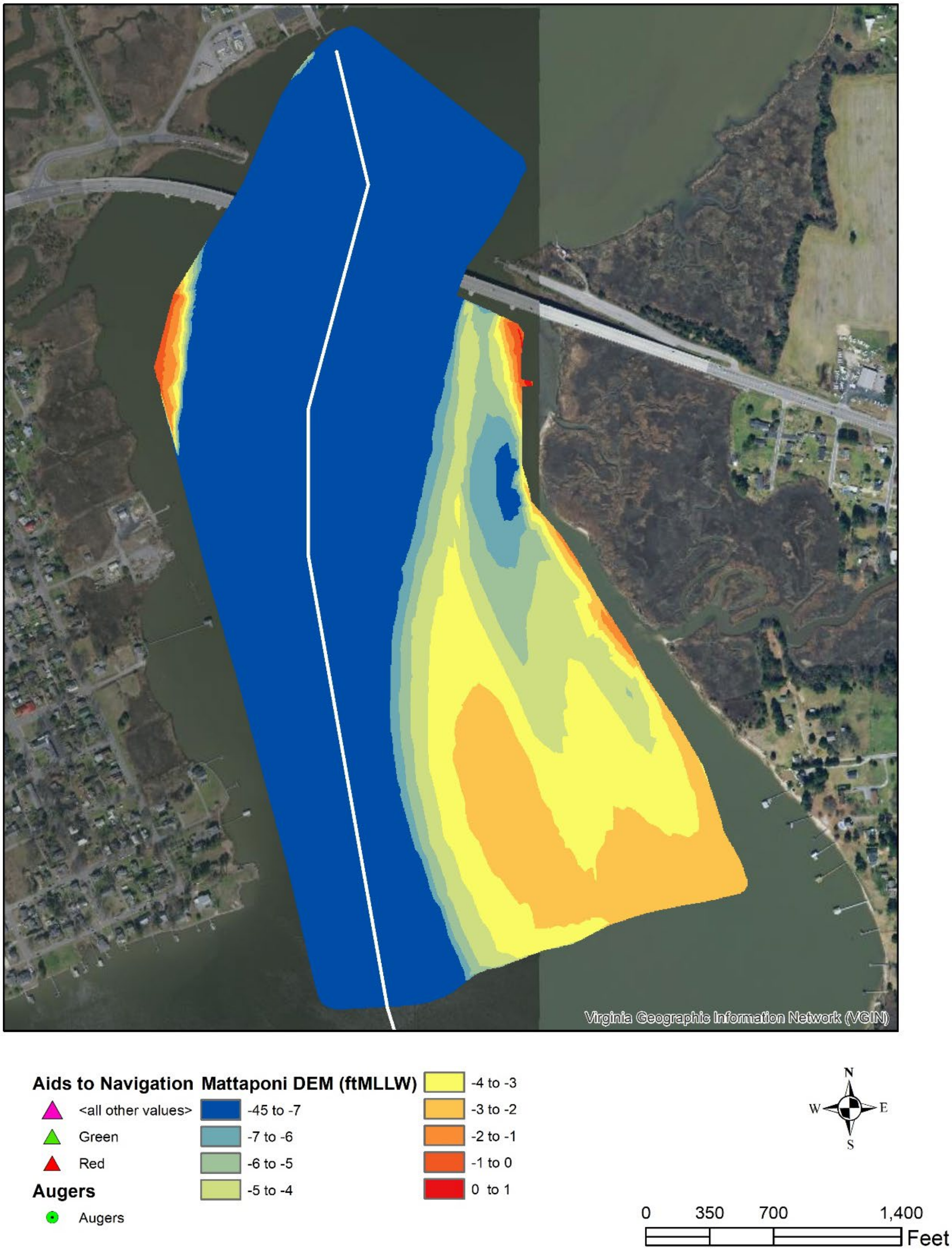

Proposed Robinson Creek Channel
Middlesex County, Virginia
Robinson Creek
Rappahannock River
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Robinson Creek - Non-Federal
N
W
E
S
0
600
1,200
2,400
Feet

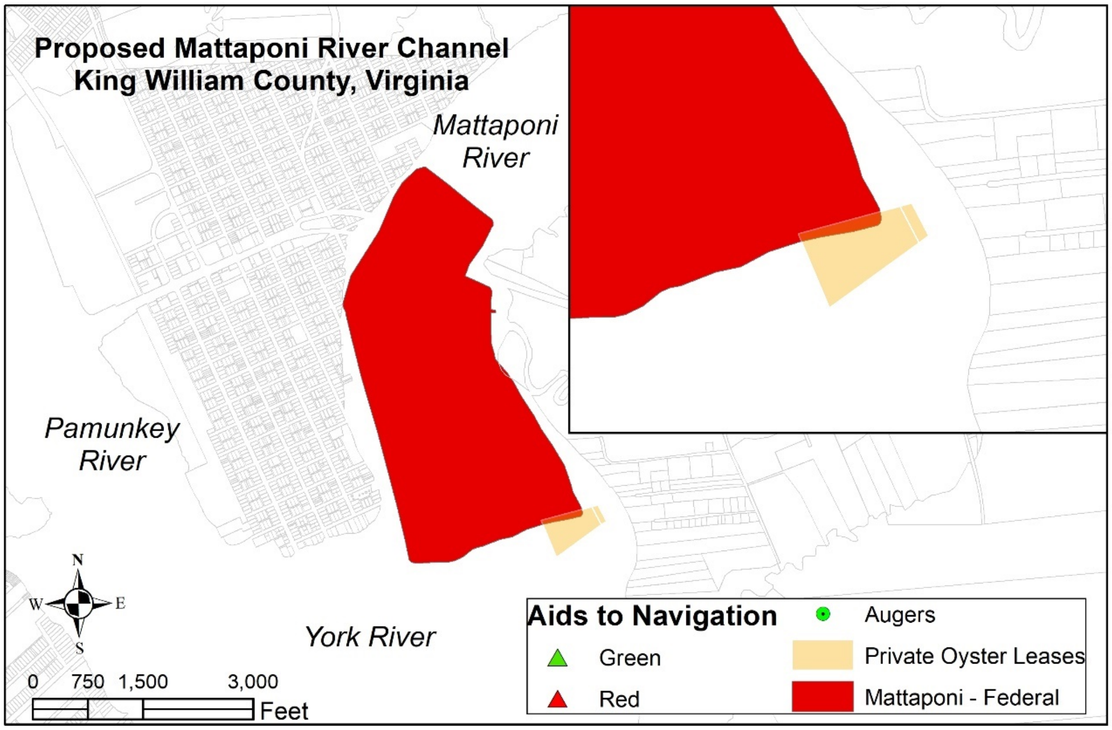

Proposed Robinson Creek Channel
Middlesex County, Virginia
NO SAV
Robinson Creek
Rappahannock River
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Robinson Creek - Non-Federal

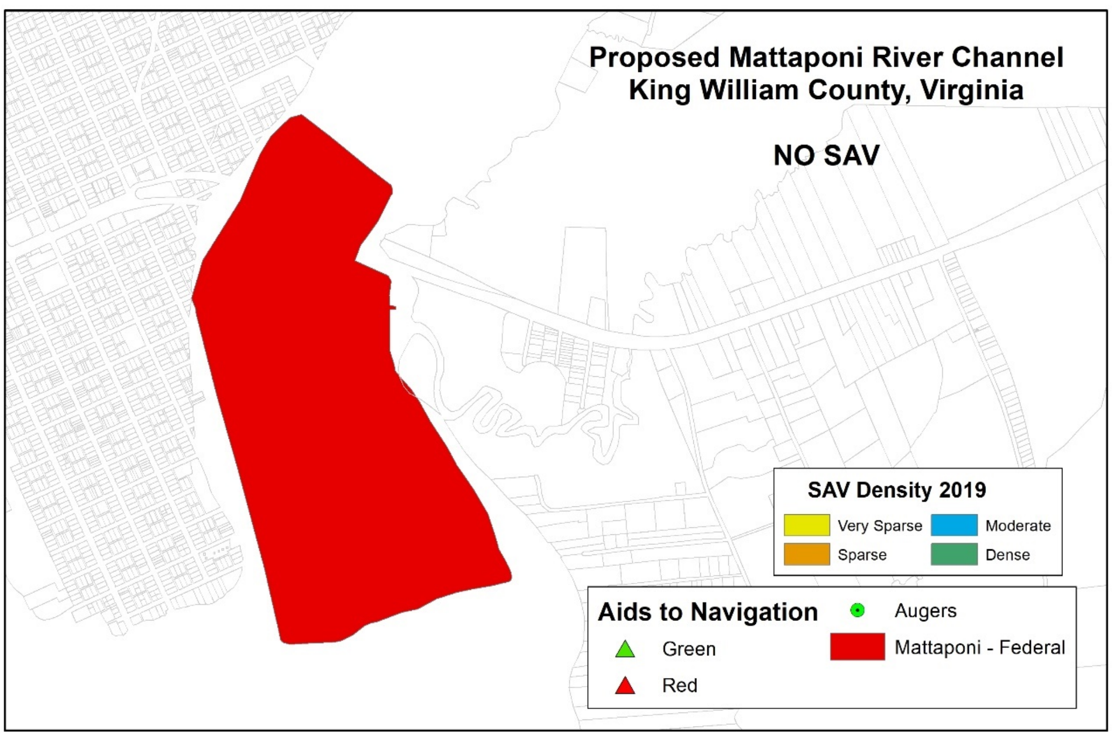
Robinson Creek Sediment Analysis

Location	Latitude	Longitude	Auger ID	Water Level MLLW (ft)	Auger Depth MLLW (ft)	Graphic	USCS Soil Type	Description	Color
Robinson Creek	37.6520	-76.5772	B1-1	3.6	4.6		**SP**	Medium dense sand with trace silt	Olive gray
Robinson Creek	37.6520	-76.5772	B1-2	3.6	5.6		**SP**	Medium dense sand with trace silt	Olive gray
Robinson Creek	37.6563	-76.5832	B2-1	3.1	4.1		**SP**	Medium dense sand with trace silt	Olive gray
Robinson Creek	37.6563	-76.5832	B2-2	3.1	5.1		**SP**	Medium dense sand with trace silt	Olive gray
Robinson Creek	37.6530	-76.5762	B3-1	4.4	5.4		**SM**	Dense sand with some silt and broken shell	Olive gray
Robinson Creek	37.6530	-76.5762	B3-2	4.4	6.4		**SM**	Dense sand with some silt and broken shell	Olive gray

Mattaponi River Bathymetry




Proposed Mattaponi River Channel
King William County, Virginia
Mattaponi River
Pamunkey River
York River
N
W
E
S
0 750 1,500 3,000
Feet
Aids to Navigation
Green
Red
Augers
Private Oyster Leases
Mattaponi - Federal

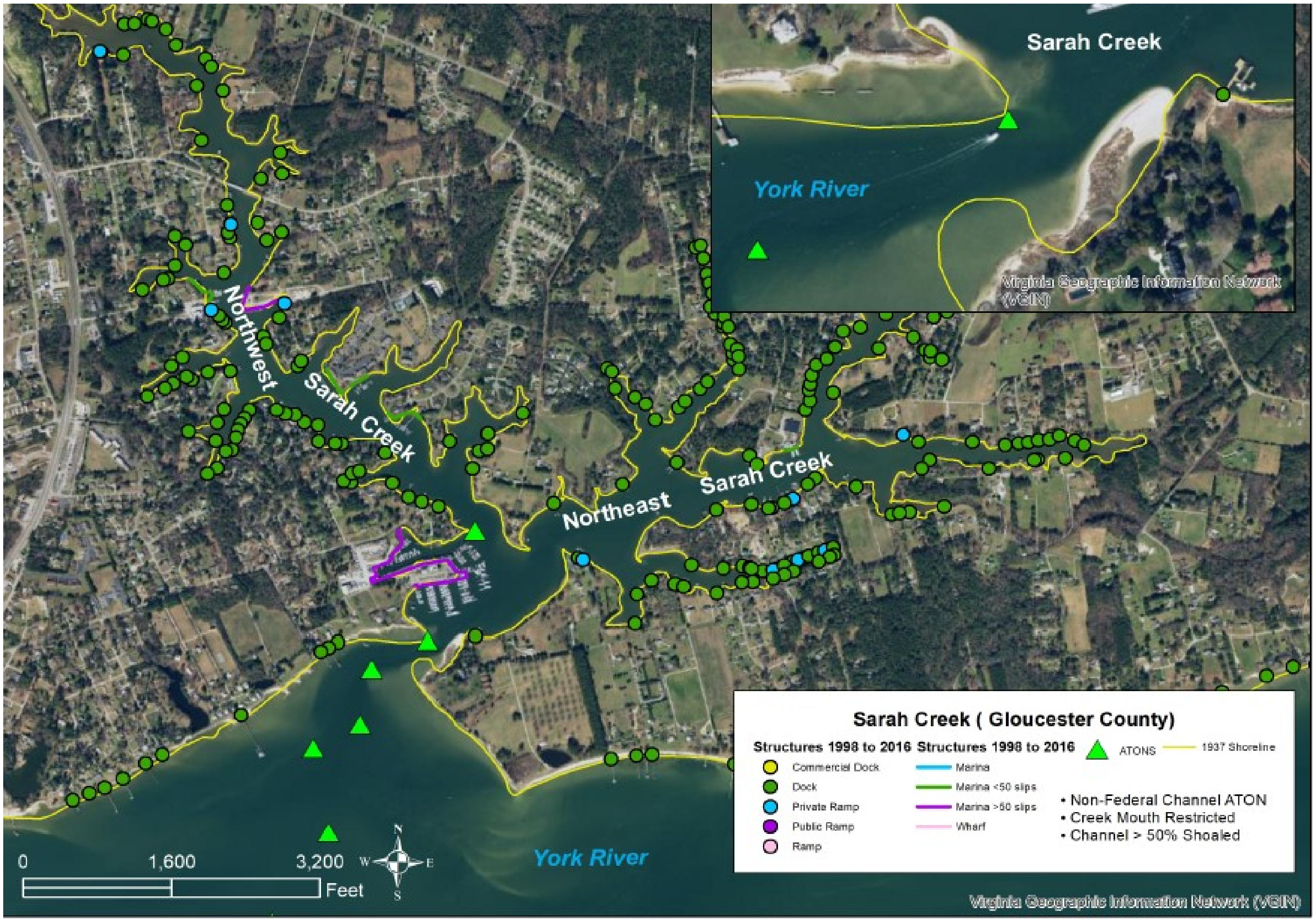

Proposed Mattaponi River Channel
King William County, Virginia
NO SAV
SAV Density 2019
Very Sparse
Moderate
Sparse
Dense
Aids to Navigation
Green
Red
Augers
Mattaponi - Federal

Appendix B

Structures in each Creek

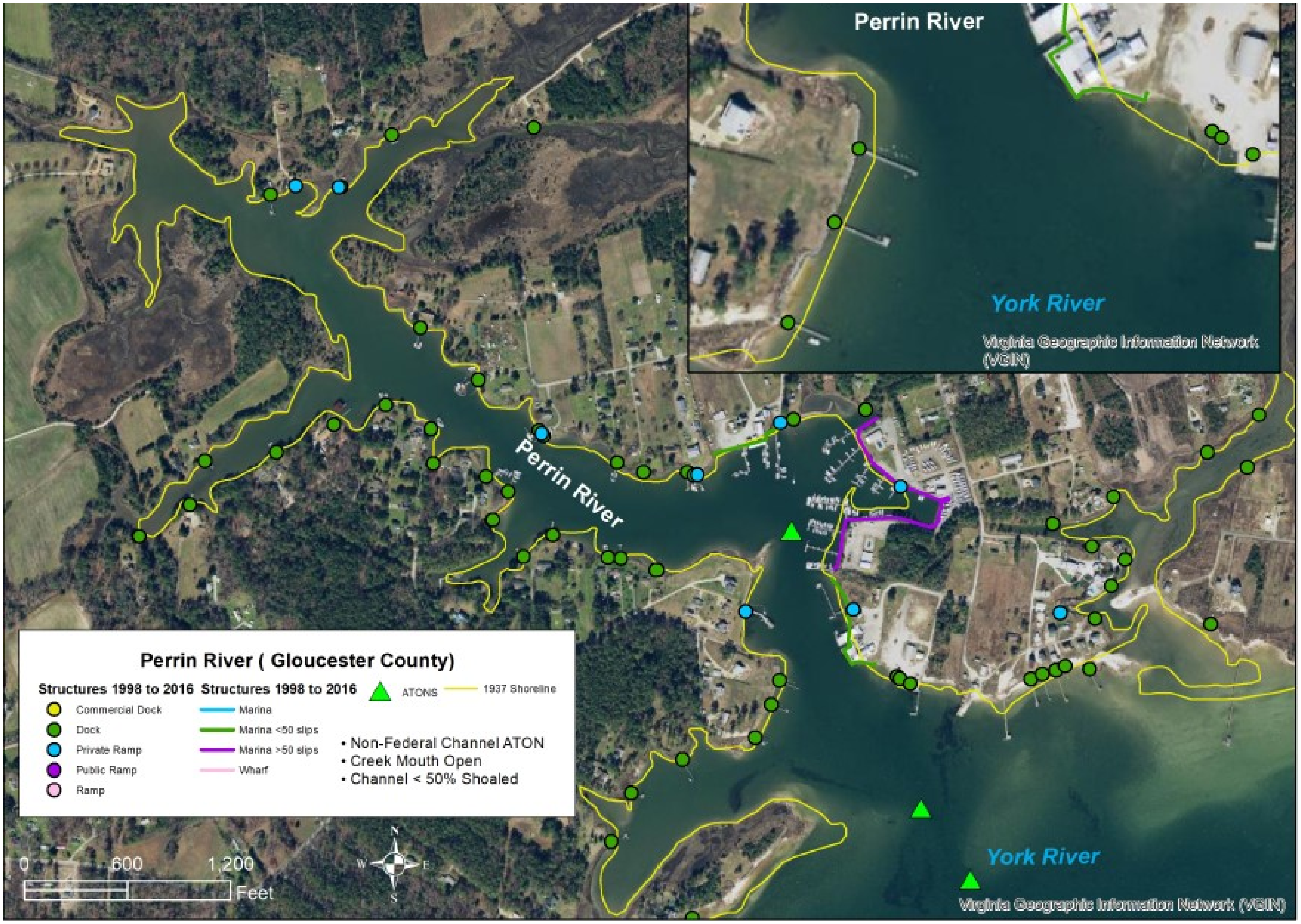
From Milligan et al. (2021)

Sarah Creek

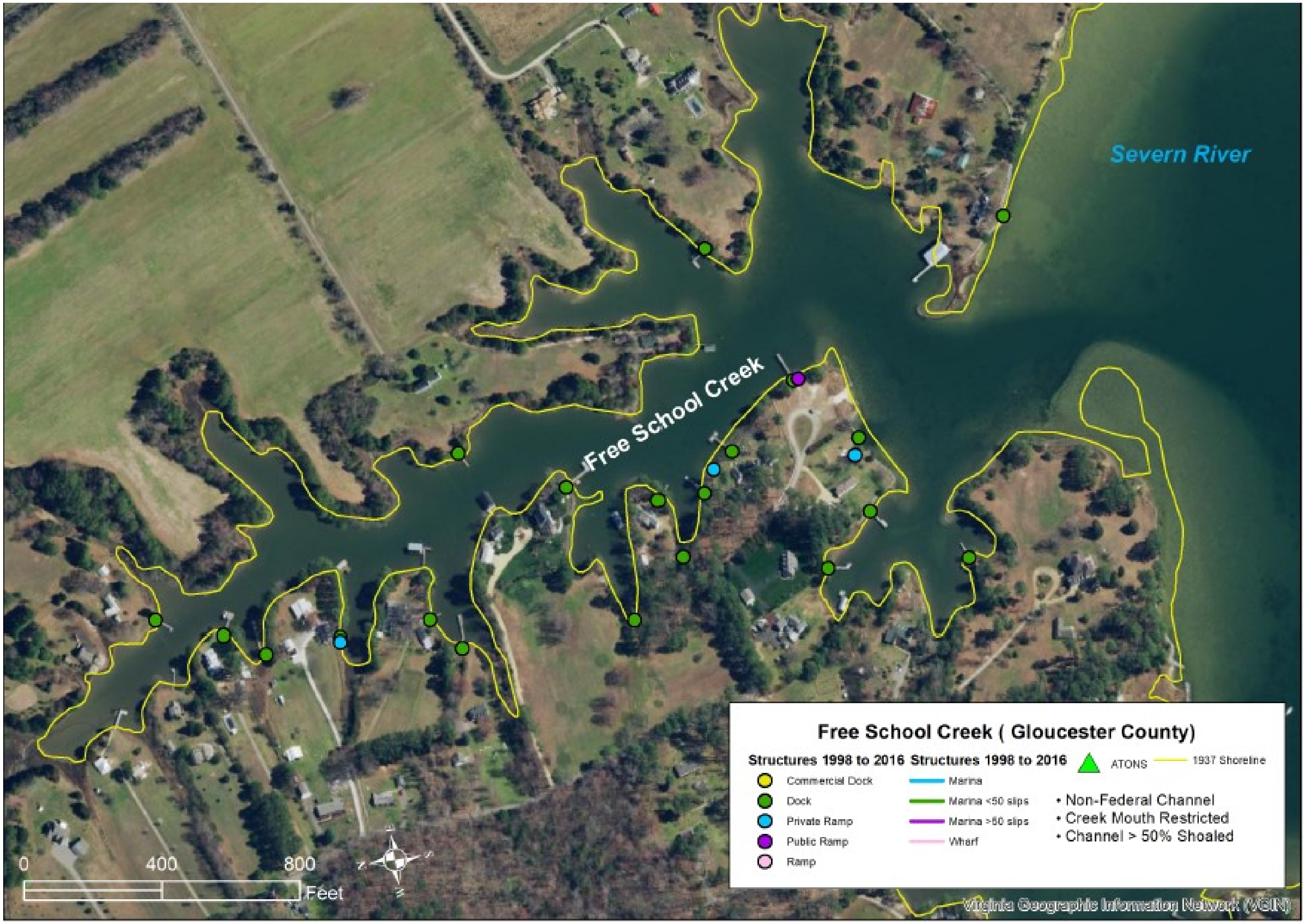


Sarah Creek
York River
Virginia Geographic Information Network (VGIN)
Northwest Sarah Creek
Northeast Sarah Creek
York River
0
1,600
3,200
Feet
N
W
E
S
Sarah Creek (Gloucester County)
Structures 1998 to 2016
Structures 1998 to 2016
ATONS
1937 Shoreline
Commercial Dock
Dock
Private Ramp
Public Ramp
Ramp
Marina
Marina <50 slips
Marina >50 slips
Wharf
• Non-Federal Channel ATON
• Creek Mouth Restricted
• Channel > 50% Shoaled
Virginia Geographic Information Network (VGIN)

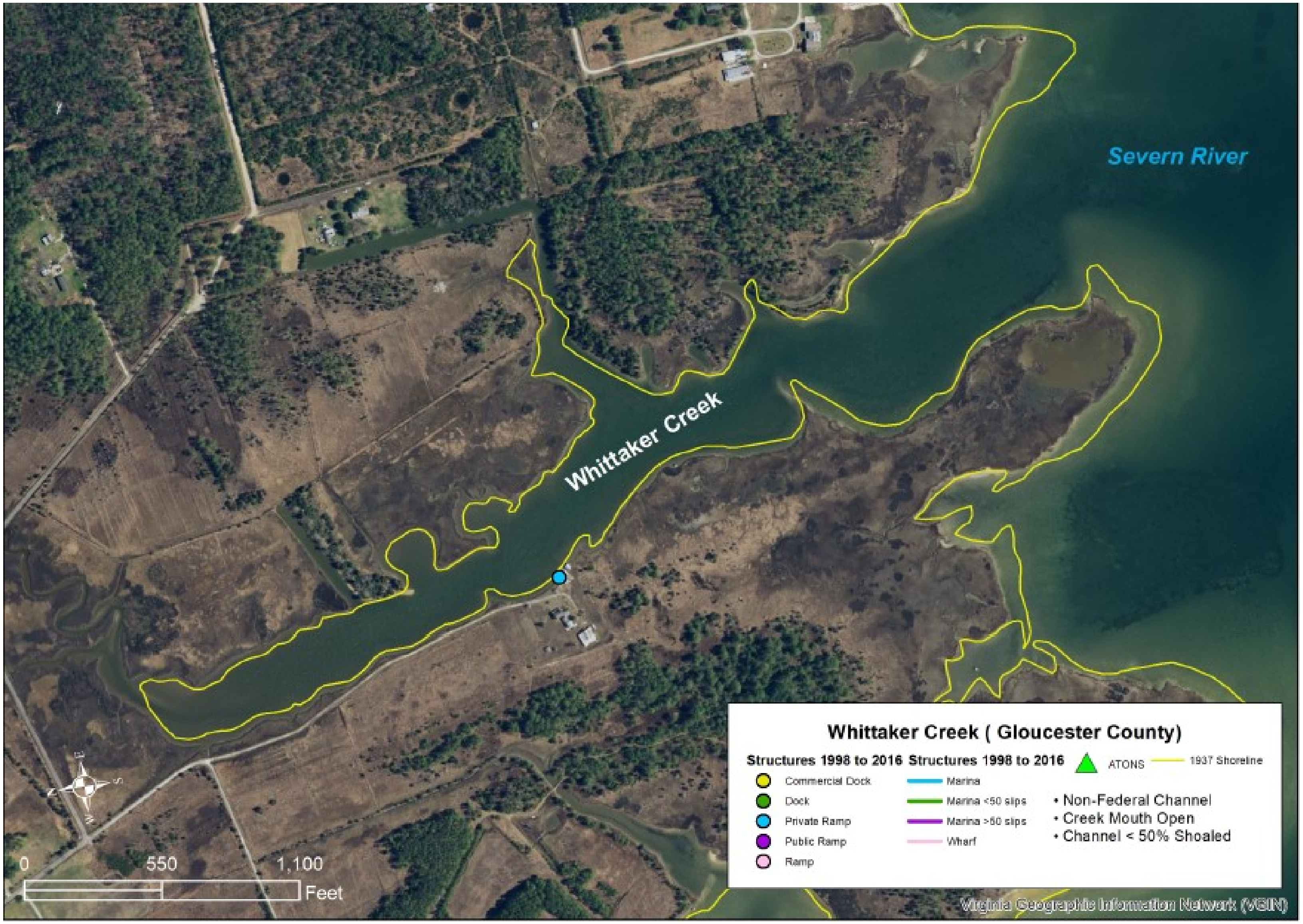
Perrin River



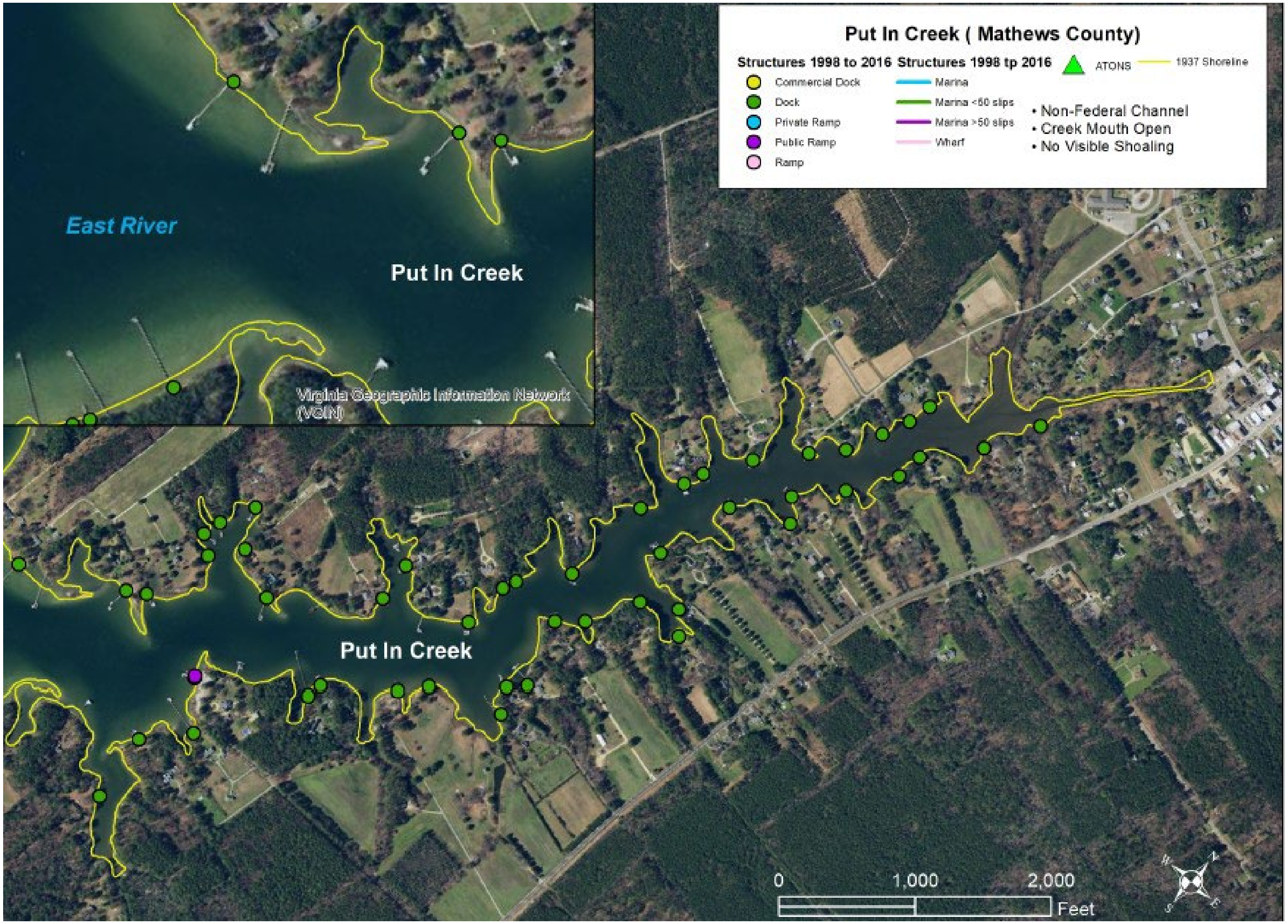
Free School Creek



Whittaker Creek



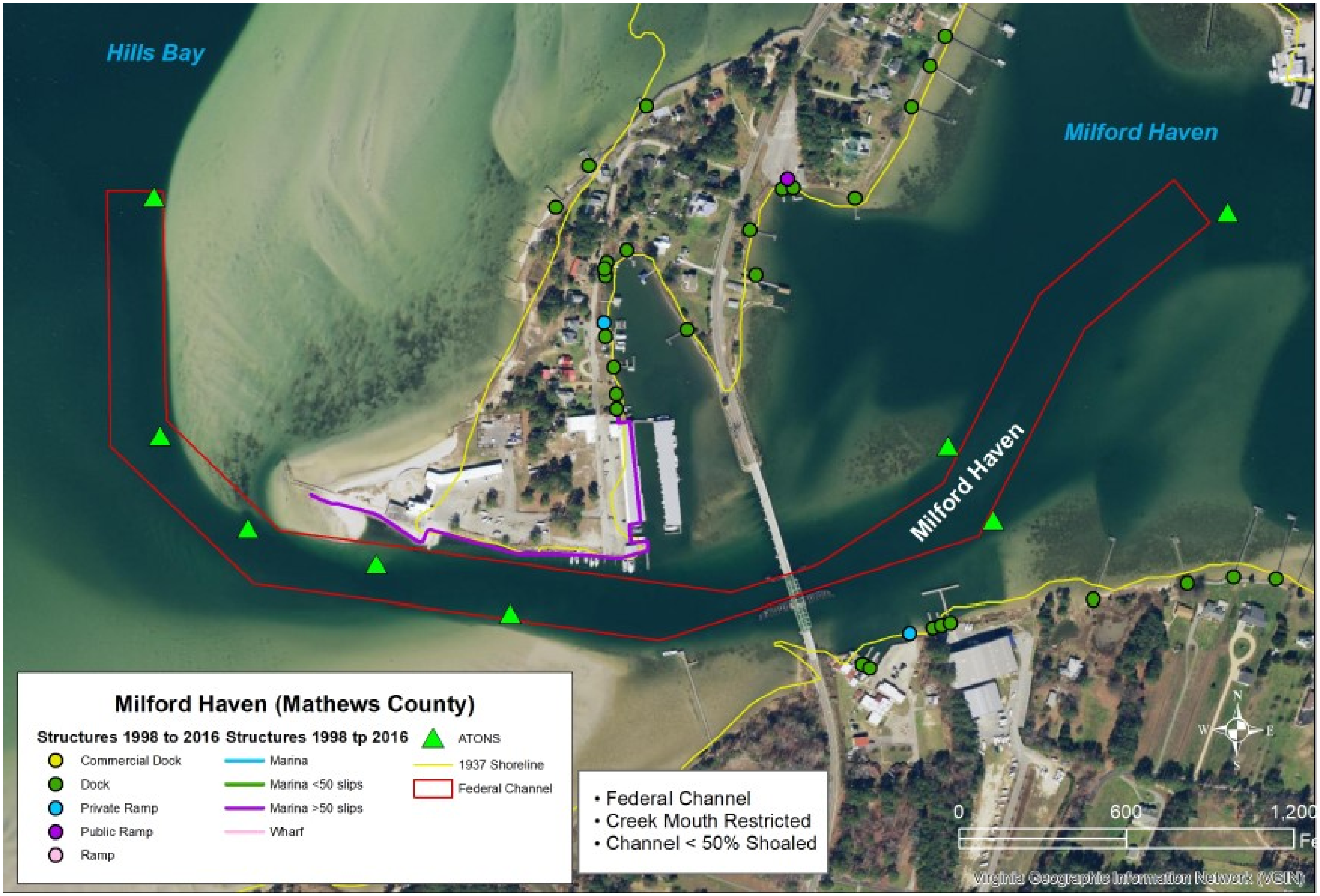
Put in Creek


Put In Creek (Mathews County)
Structures 1998 to 2016
Commercial Dock
Dock
Private Ramp
Public Ramp
Ramp
Structures 1998 tp 2016
Marina
Marina <50 slips
Marina >50 slips
Wharf
ATONS
1937 Shoreline
• Non-Federal Channel
• Creek Mouth Open
• No Visible Shoaling
East River
Put In Creek
Virginia Geographic Information Network (VGIN)
Put In Creek
0
1,000
2,000
Feet

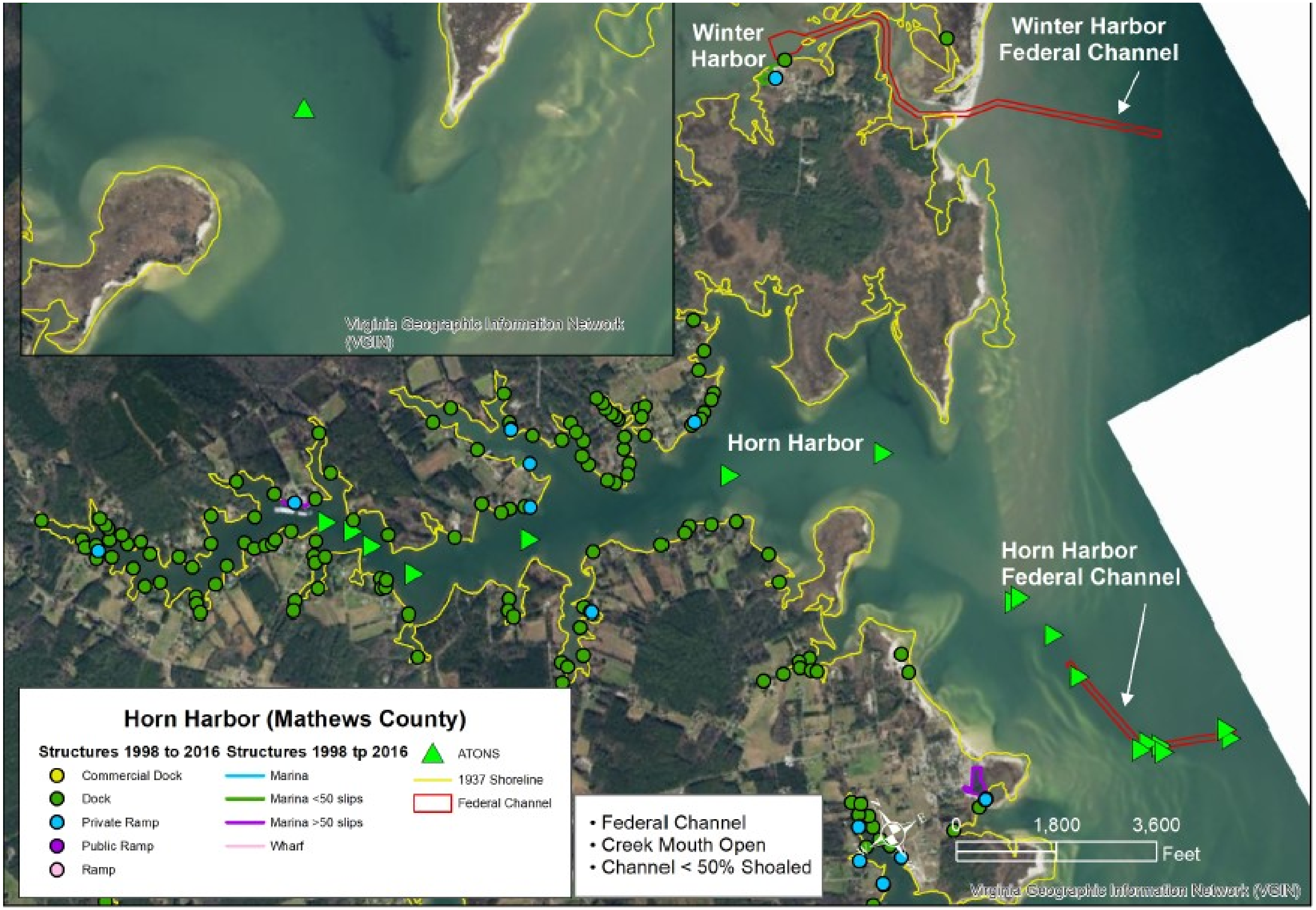
Mill Creek 2


Mill Creek
East River
Virginia Geographic Information Network (VGIN)
East River
Mill Creek
Mill Creek (Mathews County)
Structures 1998 to 2016
Structures 1998 tp 2016
ATONS
1937 Shoreline
Commercial Dock
Dock
Private Ramp
Public Ramp
Ramp
Marina
Marina <50 slips
Marina >50 slips
Wharf
• Non-Federal Channel
• Creek Mouth Inlet
• Channel < 50% Shoaled
N
W
E
S
0
300
600
Feet
Virginia Geographic Information Network (VGIN)

Milford Haven

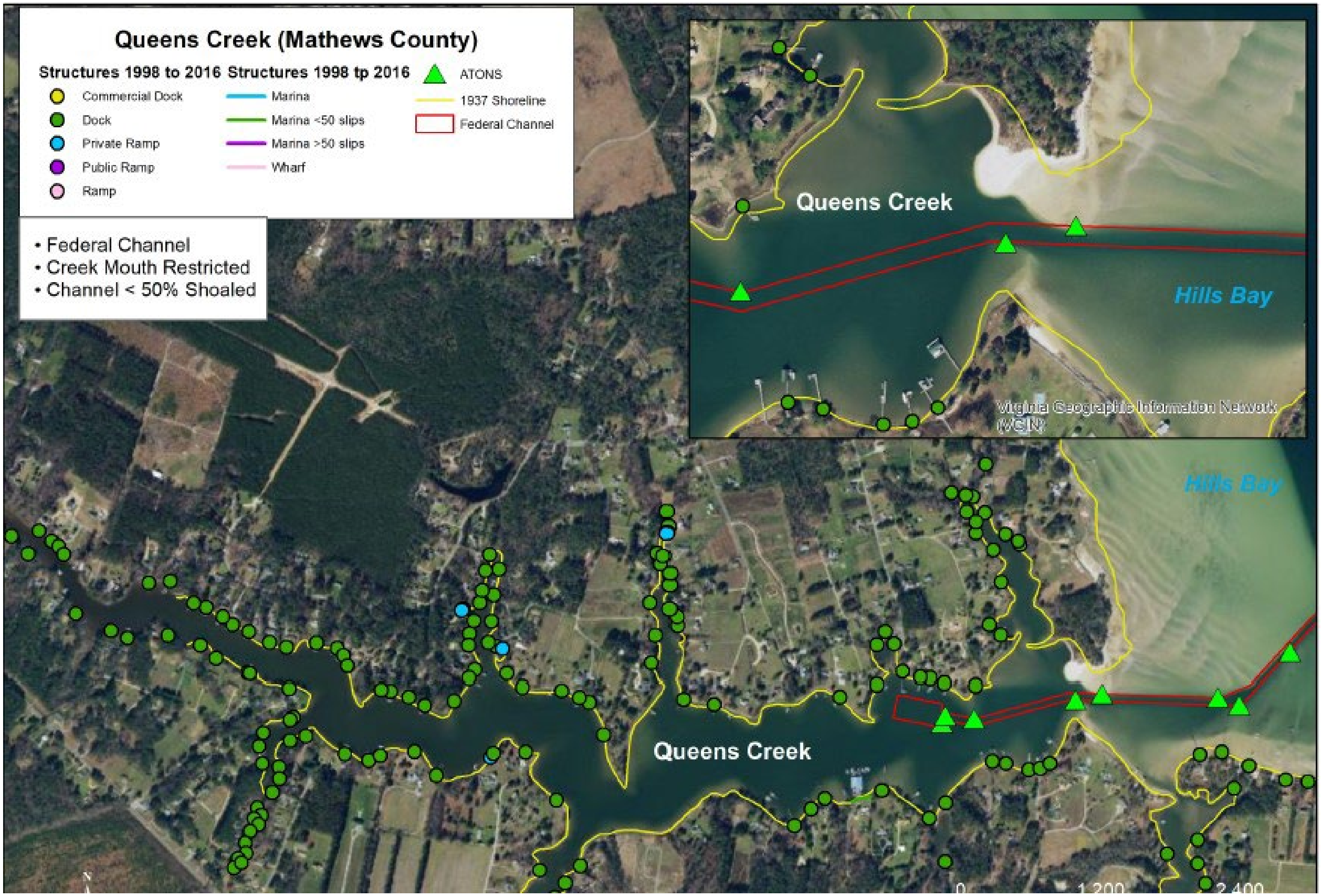


Horn Harbor

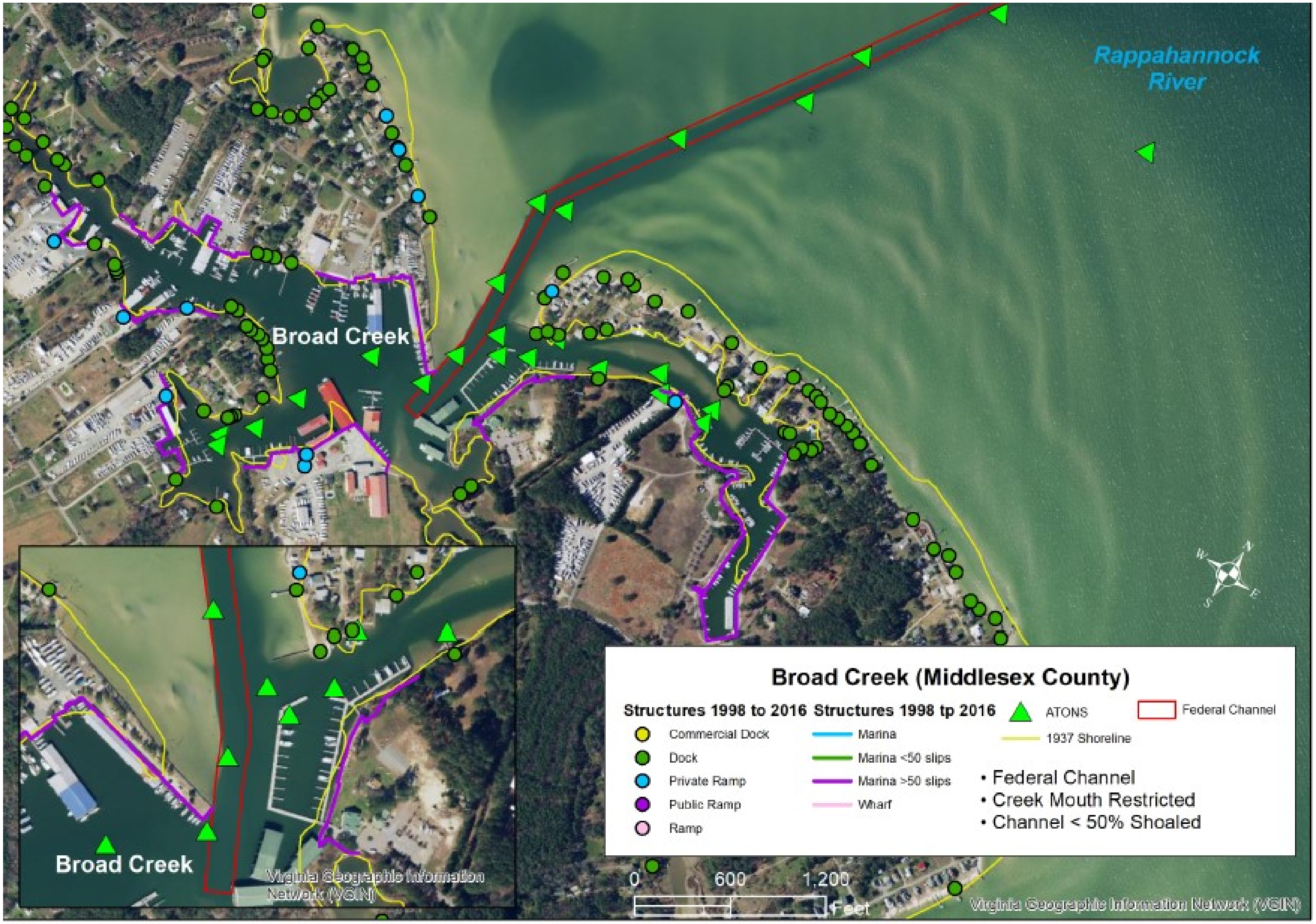


Winter Harbor
Winter Harbor Federal Channel
Horn Harbor
Horn Harbor Federal Channel
Horn Harbor (Mathews County)
Structures 1998 to 2016
Commercial Dock
Dock
Private Ramp
Public Ramp
Ramp
Structures 1998 tp 2016
Marina
Marina <50 slips
Marina >50 slips
Wharf
ATONS
1937 Shoreline
Federal Channel
• Federal Channel
• Creek Mouth Open
• Channel < 50% Shoaled
0 1,800 3,600 Feet
Virginia Geographic Information Network (VGIN)

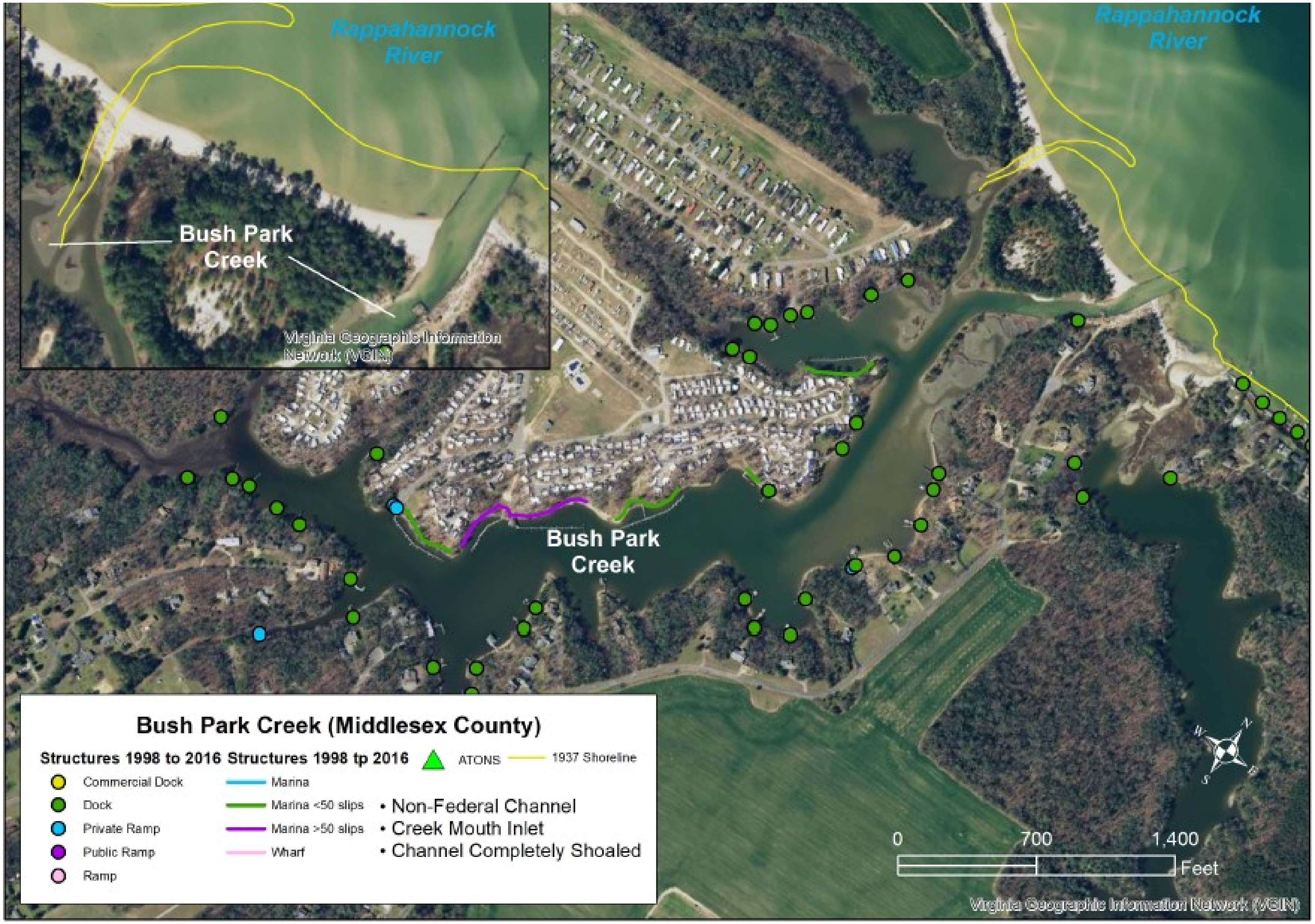
Queens Creek



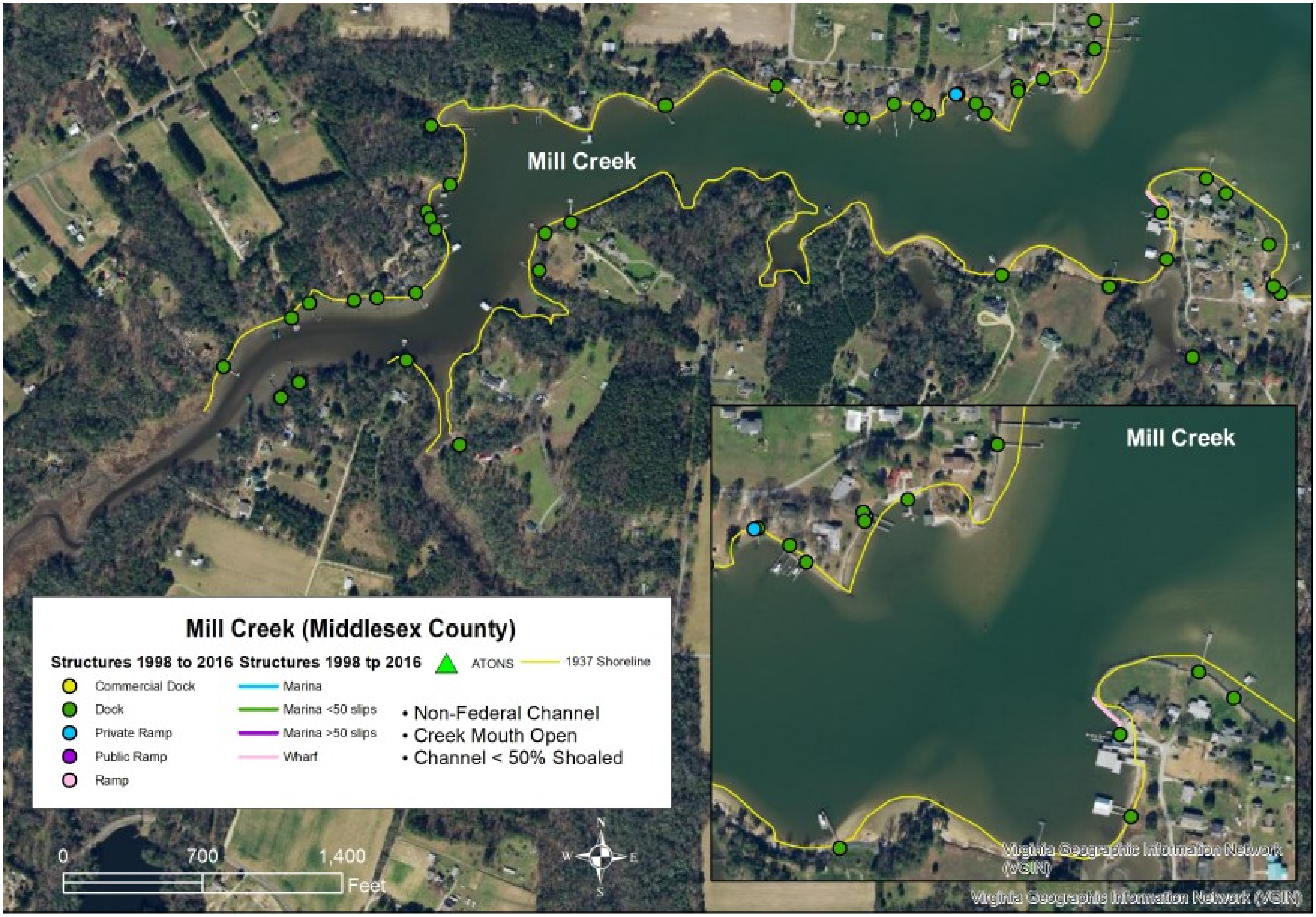
Broad Creek


Rappahannock
River
Broad Creek
Broad Creek
Virginia Geographic Information Network (VGIN)
Broad Creek (Middlesex County)
Structures 1998 to 2016
Commercial Dock
Dock
Private Ramp
Public Ramp
Ramp
Structures 1998 tp 2016
Marina
Marina <50 slips
Marina >50 slips
Wharf
ATONS
1937 Shoreline
Federal Channel
• Federal Channel
• Creek Mouth Restricted
• Channel < 50% Shoaled
0
600
1,200
Feet
Virginia Geographic Information Network (VGIN)

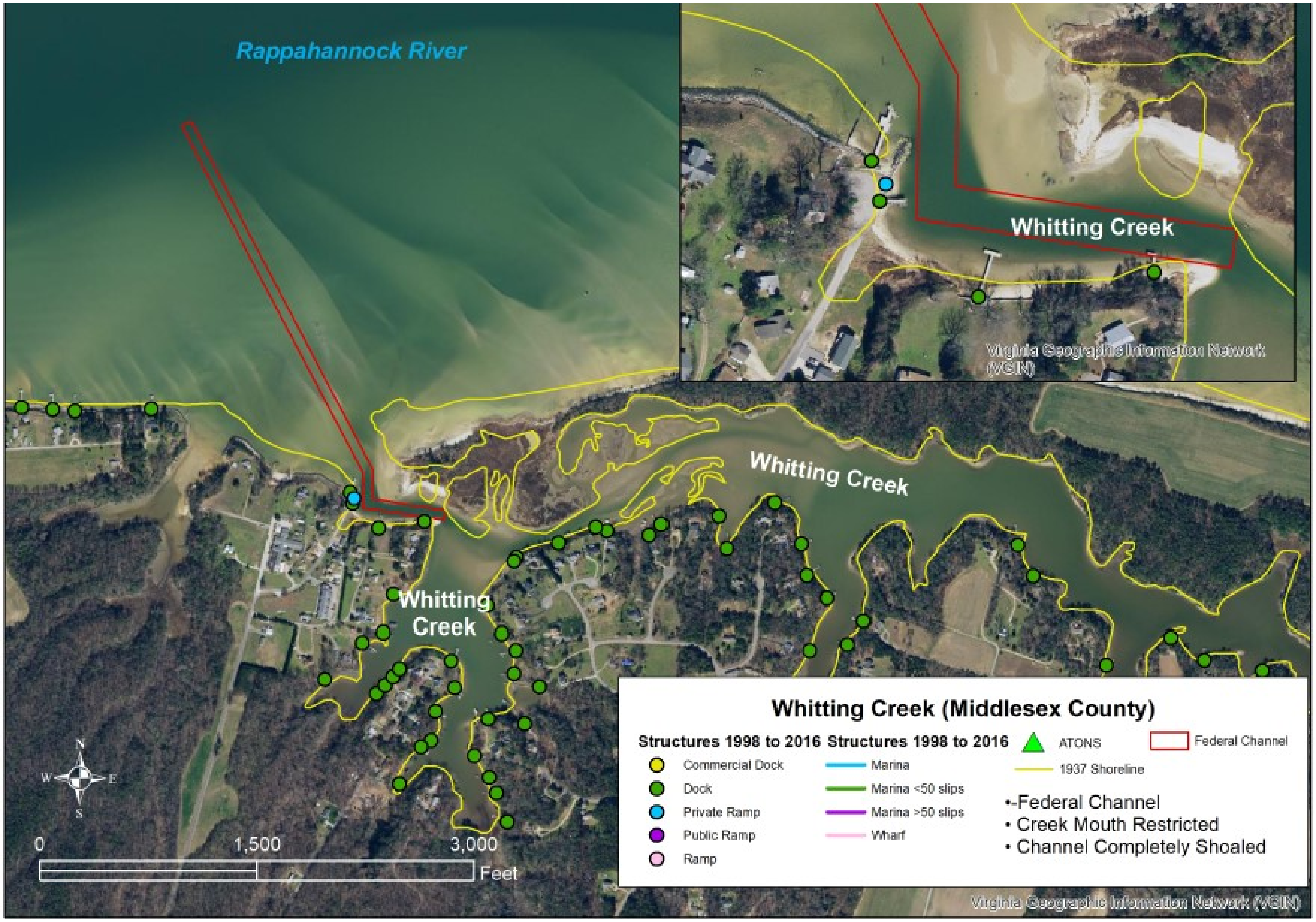
Bush Park Creek



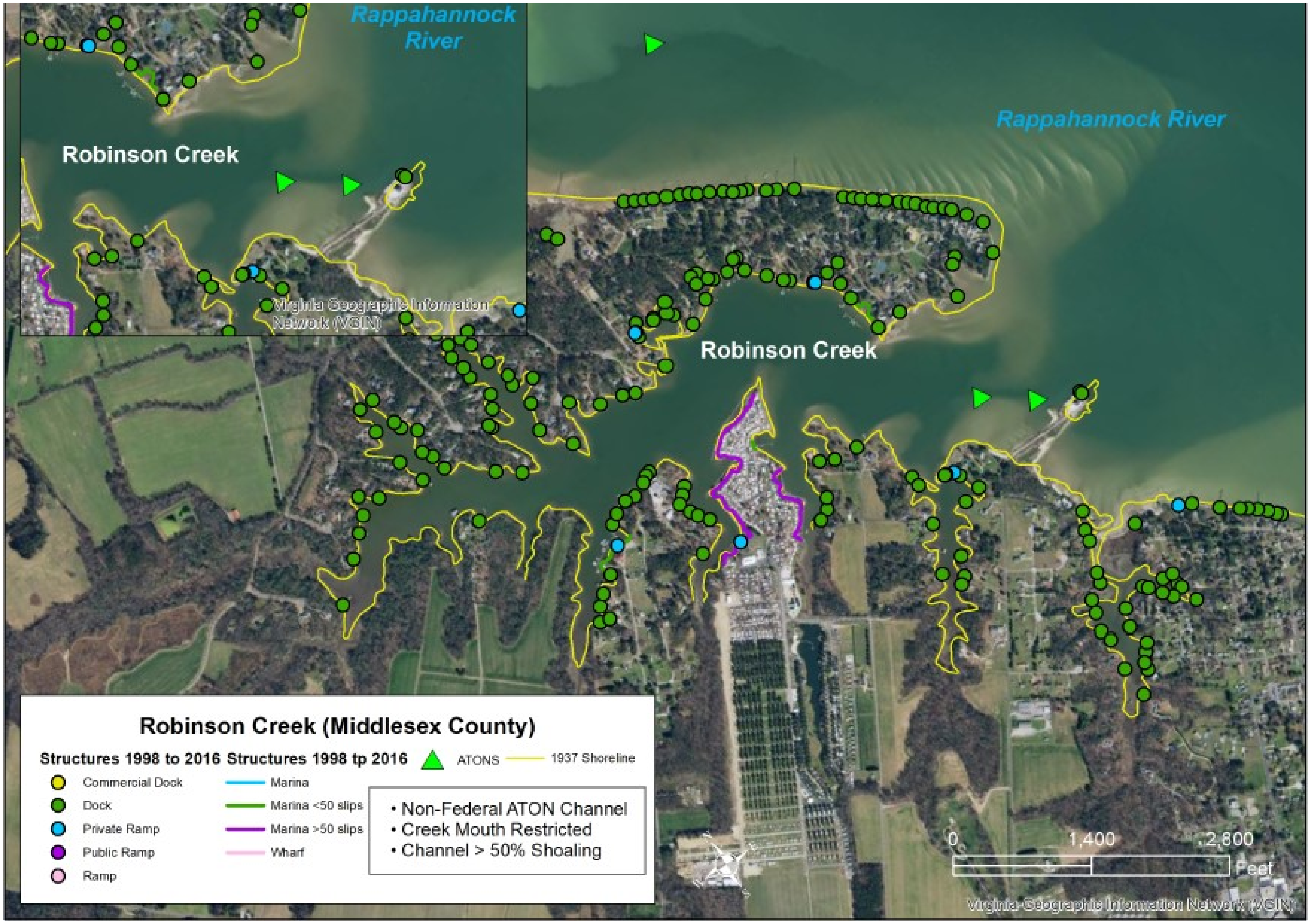
Mill Creek


Mill Creek
Mill Creek (Middlesex County)
Structures 1998 to 2016
Structures 1998 tp 2016
ATONS
1937 Shoreline
Commercial Dock
Dock
Private Ramp
Public Ramp
Ramp
Marina
Marina <50 slips
Marina >50 slips
Wharf
• Non-Federal Channel
• Creek Mouth Open
• Channel < 50% Shoaled
0
700
1,400
Feet
N
S
E
W
Mill Creek
Virginia Geographic Information Network (VGIN)
Virginia Geographic Information Network (VGIN)

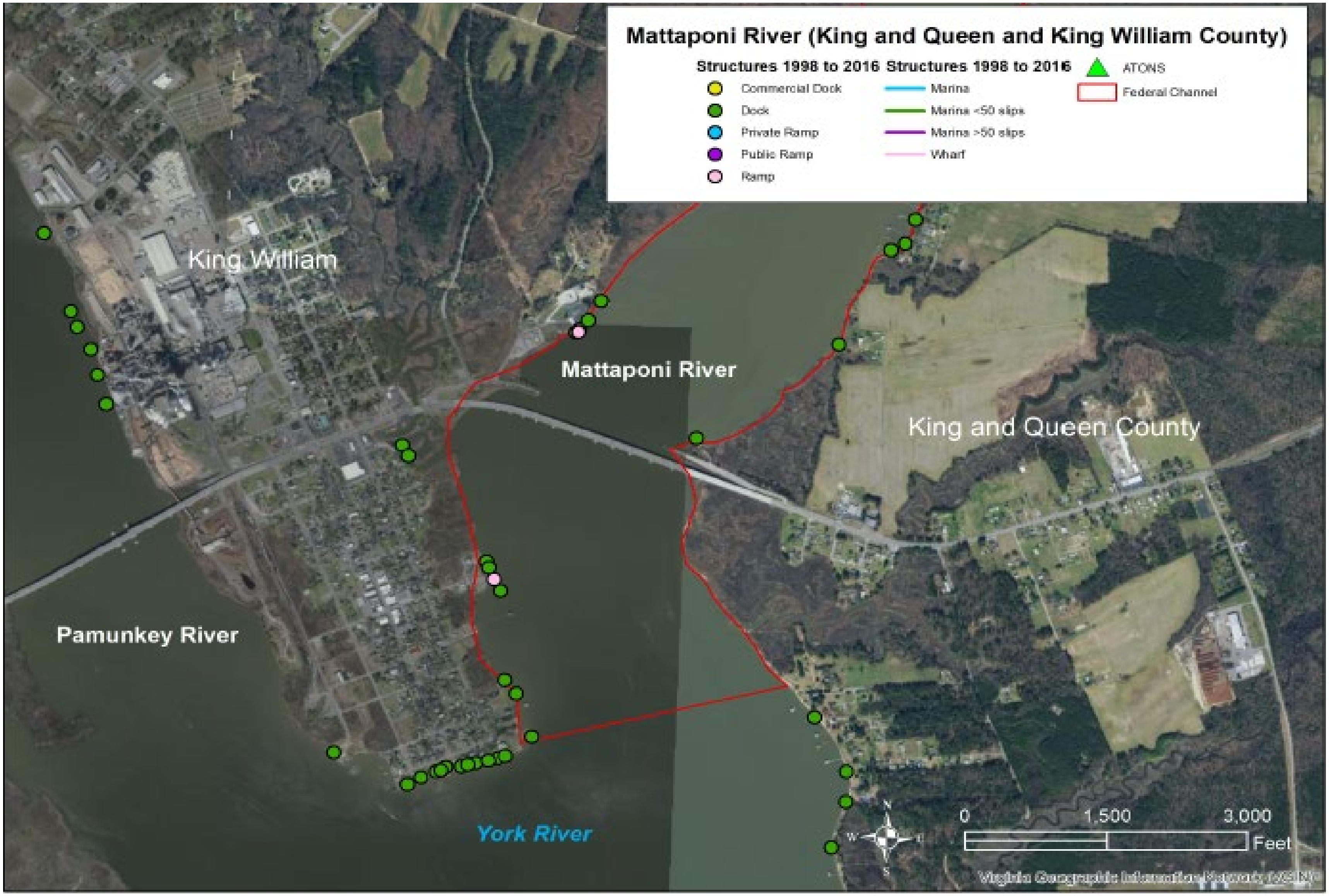
Whiting Creek



Robinson Creek



Mattaponi River



Appendix C

Creek Volume Calculation and Zones

Channel	Locality	Channel Type	Fed Defined Depth (ft MLLW)	Fed Defined Chan+OverD (ft MLLW)	Fed Defined Width (ft)
Broad Creek	Middlesex	Federal/Proposed	-7	-8	100
Horn Harbor	Mathews	Federal/Proposed	-7	-8	100
Milford Haven	Mathews	Federal	-10	-11	200
Queens Creek	Mathews	Federal	-6	-7	60
Whiting Creek	Middlesex	Federal/Proposed	-4	-5	70
		Deeper Dredge Depth	-6	-7	70

Channel	Locality	Channel Type	Estimated Vol Federal (cy)	Estimated Vol Proposed (cy)	Total Volume (cy)	Suggested Dredging Method	Preferred Disposal Method	Estimated Dredging Cycle
Broad Creek	Middlesex	Federal/Proposed	900	6,250	7,150	Hydraulic	Shore/Upland	5-10 years
Horn Harbor	Mathews	Federal/Proposed	14,700	67,570	82,270	Hydraulic	Shore/Upland	10-20 years
Milford Haven	Mathews	Federal	11,000		11,000	Either	Shore	10-20 years
Queens Creek	Mathews	Federal	1,000		1,000	Hydraulic	Shore	5-10 years
Whiting Creek	Middlesex	Federal/Proposed	9,170	4,540	13,710	Either	Shore/Upland	5-10 years
		Deeper Dredge Depth	22,580	9,070	31,650			
			*federally-defined	*proposed, possibly needs dredge				

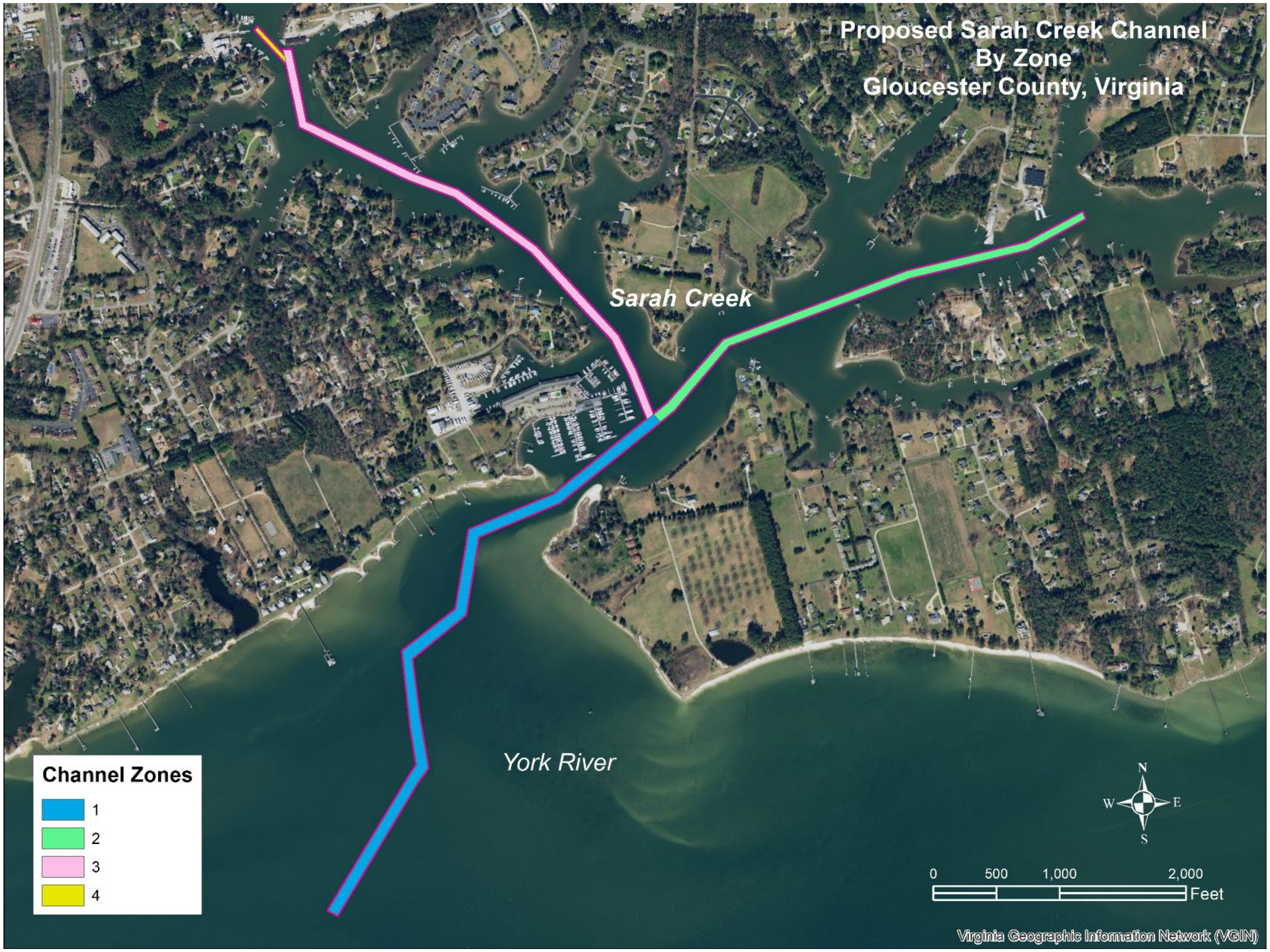
Channel	Locality	Channel Type	Proposed Depth (ft MLLW)	Proposed Chan+OverD (ft MLLW)	Proposed Width (ft)
Bush Park Creek	Middlesex	Non-Federal	-4	-5	40
Free School Creek	Gloucester	Non-Federal	-4	-5	60
Mattaponi River	King&Queen	Non-Federal	No Dredging		
Mill Creek	Middlesex	Non-Federal	-4	-5	
Mill Creek 2	Mathews	Non-Federal	-4	-5	40
Perrin River	Gloucester	Non-Federal	-6	-7	80/80/40/40
Put in Creek	Mathews	Non-Federal	-4	-5	20/12
			-2	-3	20/12
Robinson Creek	Middlesex	Non-Federal	-6	-7	80
Sarah Creek	Gloucester	Non-Federal	-6	-7	80/60/60/30
Whittaker Creek	Gloucester	Non-Federal	-2	-3	40
			-3	-4	40
			-4	-5	40

*Estimated dredging cycle may not be accurate because no data on fast these small, shallow channels will infill from adjacent marsh and upland

Channel	Locality	Channel Type	Estimated Vol Zone 1 (cy)	Estimated Vol Zone 2 (cy)	Estimated Vol Zone 3 (cy)	Estimated Vol Zone 4 (cy)	Total Volume (cy)	Suggested Dredging Method	Preferred Disposal Method	Estimated Dredging Cycle
Bush Park Creek	Middlesex	Non-Federal	2,570				2,570	Mechanical	Shore	<5 years
Free School Creek	Gloucester	Non-Federal	220				220	Mechanical	Upland	10-20 years
Mattaponi River	King&Queen	Non-Federal								NA
Mill Creek	Middlesex	Non-Federal	480				480	Mechanical	Shore	10-20 years
Mill Creek 2	Mathews	Non-Federal	1,130				1,130	Mechanical	Shore/Upland	5-10 years
Perrin River	Gloucester	Non-Federal	2,460	8,640	1,250	2,250	14,600	Hydraulic	Shore/Upland	5-10 years
Put in Creek	Mathews	Non-Federal	5,370				5,370	Mechanical	Upland	5-10 years*
			1,780				1,780	Mechanical	Upland	
Robinson Creek	Middlesex	Non-Federal	4,400				4,400	Mechanical	Upland	5-10 years
Sarah Creek	Gloucester	Non-Federal	1,010	3,660	4,830	50	9,550	Mechanical	Shore/Upland	5-10 years
Whittaker Creek	Gloucester	Non-Federal	3,020				3,020	Mechanical	Upland	5-10 years*
			5,330				5,330			
			8,950				8,950			

*Estimated dredging cycle may not be accurate because no data on fast these small, shallow channels will infill from adjacent marsh and upland

Sarah Creek Zone Channel Map

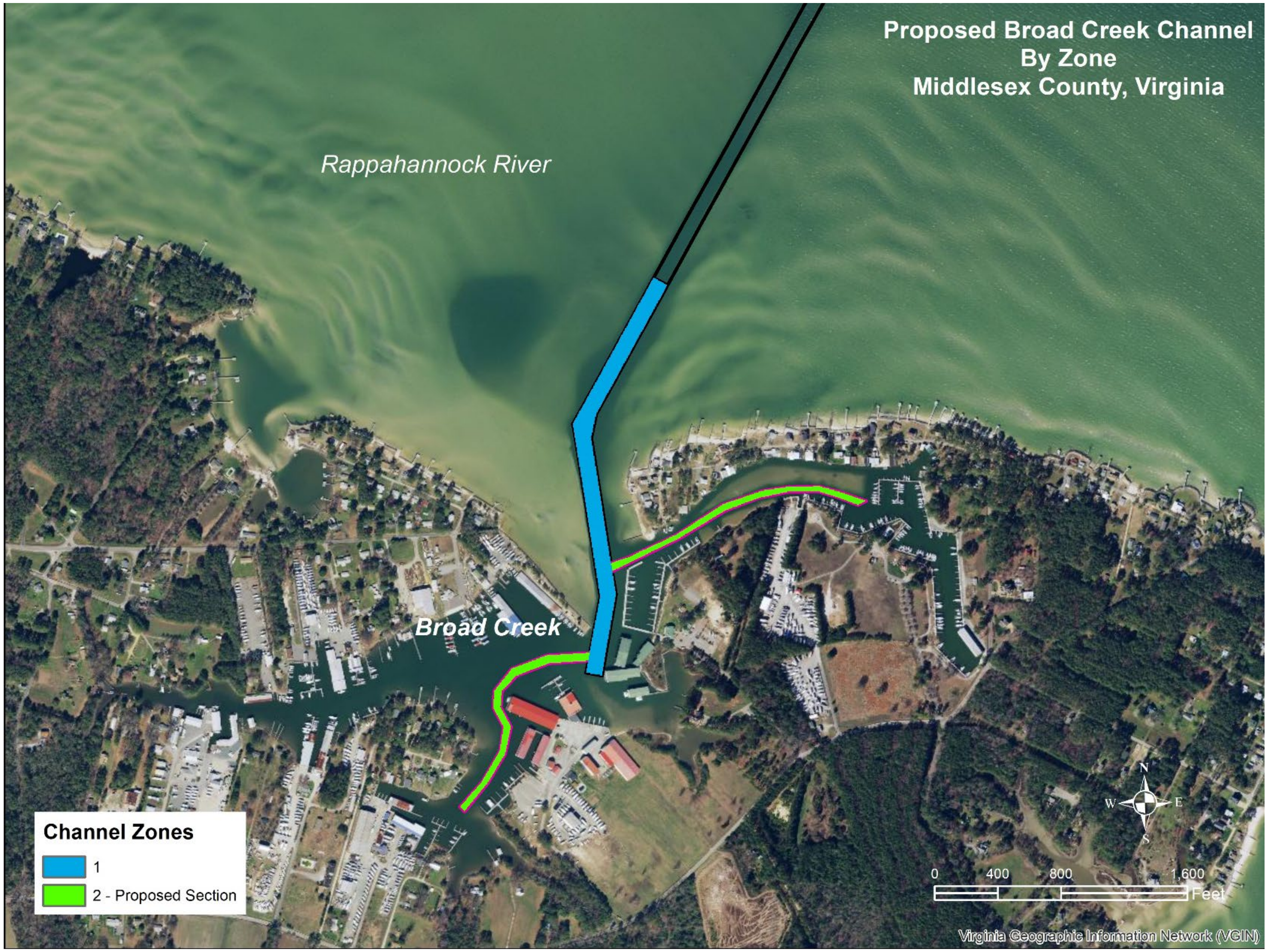


Perrin River Zone Channel Map

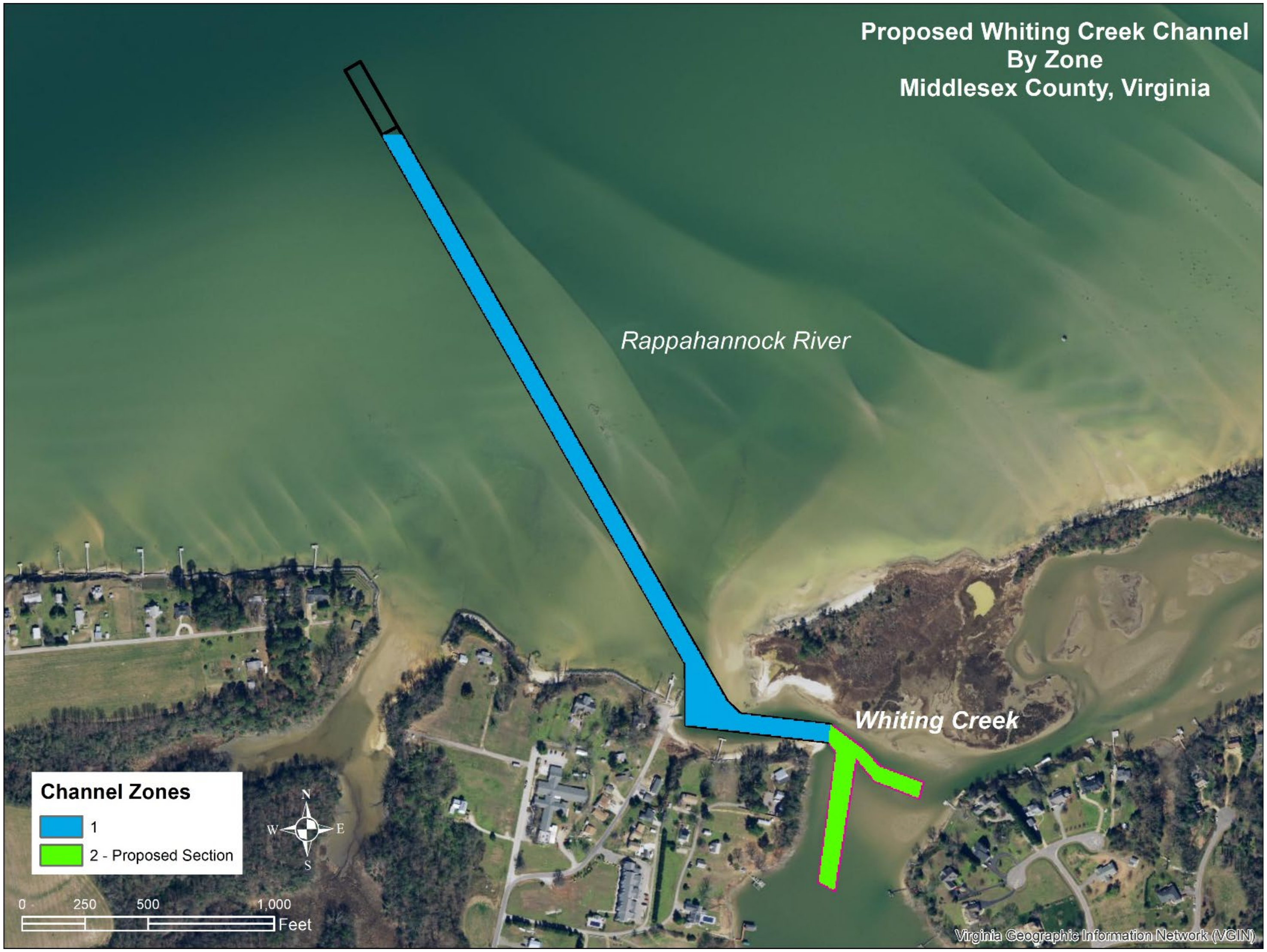
Put in Creek Zone Channel Map

Horn Harbor Zone Channel Map

Broad Creek Zone Channel Map



Whiting Creek Zone Channel Map



Appendix D

Project Equipment for Bathymetric Survey

The following equipment was used by CBNERR-VA staff for the collection of scoping level bathymetry data for the 15 creeks and rivers in the Middle Peninsula Study:

Depth Sounding Equipment

Garmin GPSMAP 1042XSV	Garmin Dual Beam Transducer set at 200 KHZ
Clear Screen and Bright: 10.1″ diagonal 1024 x 600-pixel	This dual beam transducer replaces the one included with the echo series and mounts on a 0 to 70-degree transom
Keypad Control: The unit uses keypad navigation along with a multifunction control knob to manage settings and options	Frequency (77/200 kHz)
Built-in GPS: 10hz GPS receiver	Power (500 W)
Network Capabilities: Easily share sonar data, Panoptix sonar, user data, waypoints, routes, radar, and IP Cameras	Beam width (45°/15°)

Water Level Recorders

The Aqua TROLL 200 instrument is an all-in-one instrument that measures and records water level, pressure, conductivity and temperature. It is available in vented and non-vented configurations, features a unique conductivity cell design that allows for a wide accurate-measurement range in a narrow diameter instrument. Titanium construction resists corrosion and sub-1-inch design fits narrow-diameter wells, making the Aqua TROLL 200 Data Logger ideal for coastal, remediation and mine-water monitoring projects.

The instrument contains a pressure sensor. A pressure transducer senses changes in pressure, measured in force per square unit of surface area, exerted by water or other fluid on an internal media-isolated strain gauge. Common measurement units are pounds per square inch (psi) or newtons per square meter (pascals). A non-vented or “absolute” pressure sensor measures all pressure forces exerted on the strain gauge, including atmospheric pressure. Its units are psia (pounds per square inch “absolute”), measured with respect to zero pressure.

Aqua TROLL 200 Data logger
Pressure in psi or kPa
Depth in feet or meters
Water Level with a reference (an “offset”) – set to zero
Accuracy: ±0.05%FS or better
Resolution: ±0.01%FS or better

GPS Equipment

Trimble R8 GNSS Model 2 Base Kit
Trimble R-Track technology
Advanced Trimble Maxwell 6 Custom Survey GNSS chip with 220 channels
High precision multiple correlator for GNSS pseudorange measurements
Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
Signal-to-Noise ratios reported in dB-Hz
Proven Trimble low elevation tracking technology
Satellite signals tracked simultaneously