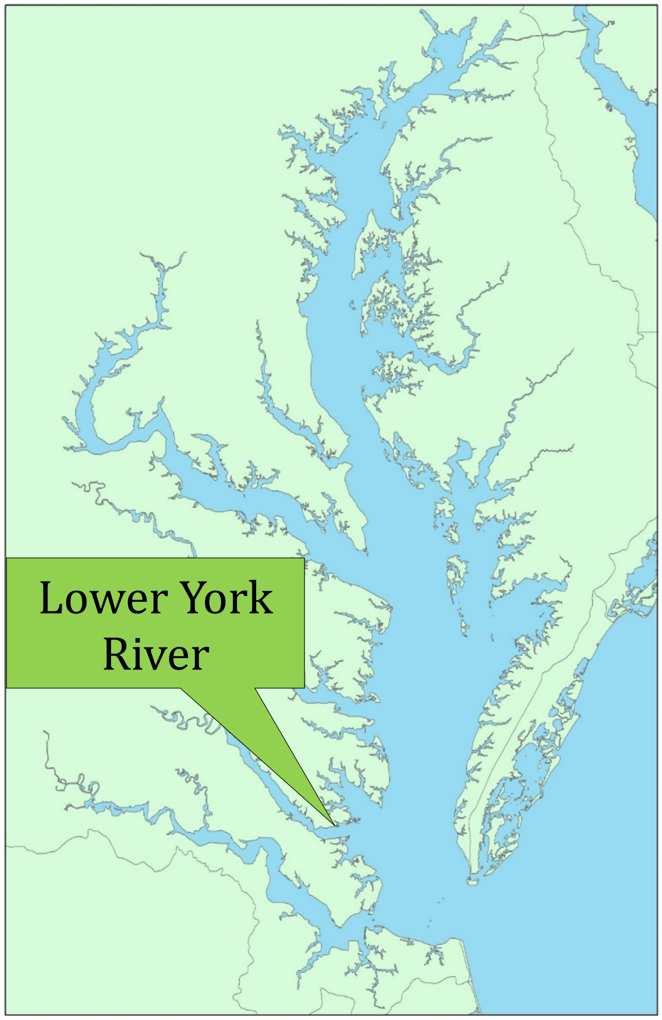
Lower York River Oyster Restoration Tributary Plan:

A Blueprint for Restoring Oyster Populations per the 2014 Chesapeake Bay Watershed Agreement

December 2019



Drafted by the Western Shore Oyster Restoration Workgroup under the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team

The Western Shore Oyster Restoration Workgroup includes representatives from: National Oceanic Atmospheric Administration (NOAA, cochair), U.S. Army Corps of Engineers' Norfolk District (USACE, cochair), The Nature Conservancy (TNC), Chesapeake Bay Foundation (CBF), Christopher Newport University (CNU), Virginia Institute of Marine Science (VIMS), Virginia Marine Resources Commission (VMRC), Virginia Commonwealth University (VCU), and U.S. Navy.

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Throughout this document, some units are metric and some are English. This was done to best reflect consensus on particular parameters (ex: water depth, buffers around aids to navigation). Converting entirely to metric or English would provide unit consistency, but would also produce non-round numbers that could distract from the overall clarity of the document.

Executive Summary

The 2014 Chesapeake Bay Watershed Agreement[1] is the guiding directive for the work of the federal-state Chesapeake Bay Program. The Agreement established a goal to "restore native oyster habitat and populations in 10 Bay tributaries by 2025, and ensure their protection." Responsibility for achieving this goal rests with the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team (GIT). For Virginia, the Sustainable Fisheries GIT convened workgroups to plan, implement, and track progress toward this goal. The Western Shore Oyster Restoration Workgroup (hereafter, the Workgroup) developed this document to explain how the lower York River's restoration goal was established and to describe plans to achieve it.

Consistent with the Chesapeake Bay Oyster Metrics[2] success criteria, the Workgroup developed a restoration goal of 200 acres for the River. VMRC and CBF have already constructed 34.82 acres of reefs, leaving an additional 165.18 acres that still need to be restored in the river. (Table 1).

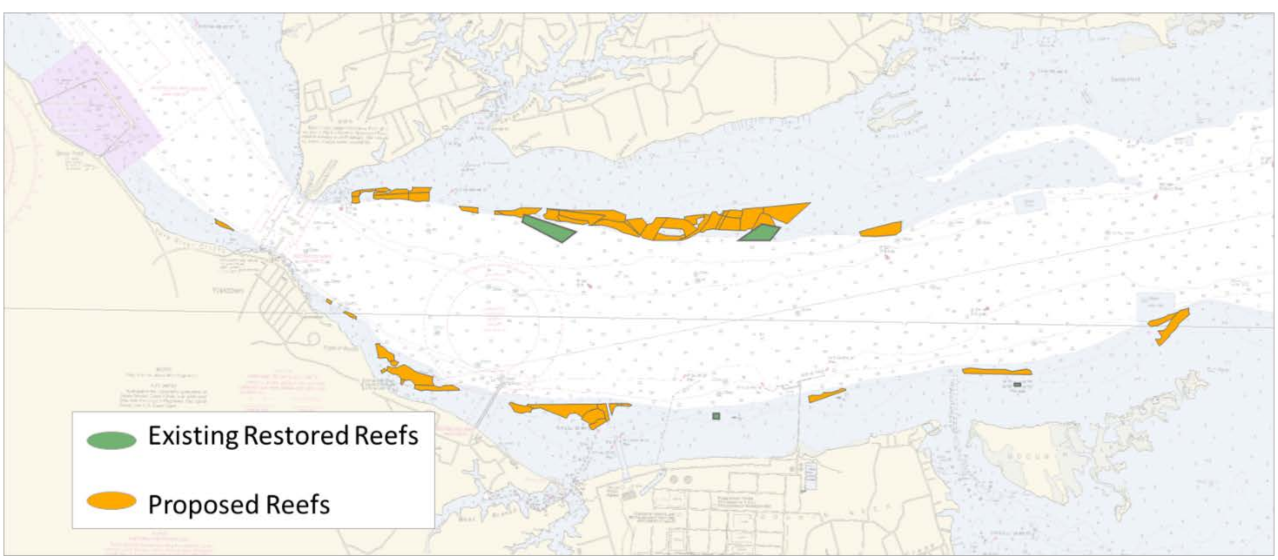
The cost estimate for completing the remaining acreage is $7.88 million, depending on variables including construction techniques, pre-restoration river bottom conditions at the reef site, construction materials, and other factors. (See Section V: Cost Estimate).

The Workgroup partners intend to work collaboratively to secure funding for and complete the restoration of the remaining 165.18 acres of oyster reefs by the 2025 deadline described in the 2014 Chesapeake Bay Watershed Agreement. Monitoring will extend beyond the 2025 implementation deadline.

Table 1: Lower York River oyster restoration target, existing restored area, and cost estimate

Restoration target for the lower York River	200 acres
Already restored *(existing restoration projects)*	34.82 acres
Remaining area to be restored	165.18 acres
Cost estimate to restore remaining area	$7.88 million (*approximate*)

Figure 1: Map of existing oyster reefs and proposed restoration areas on the lower York River.



Section 1: Policy Drivers, Chesapeake Bay Oyster Metrics, and Western Shore Oyster Restoration Workgroup Organizational Framework

1.1 Policy Drivers

Executive Order 13508 on Chesapeake Bay Protection and Restoration[3] directs federal agencies to protect and restore oysters in the Bay. The 2014 Chesapeake Bay Watershed Agreement[1] calls for state and federal partners to "restore native oyster habitat and populations in 10 Bay tributaries by 2025, and ensure their protection." Responsibility for achieving this '10 tributaries' oyster goal rests with the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team (GIT). For Virginia, the Sustainable Fisheries GIT convened two workgroups to plan, implement, and track progress toward this goal. Members of these workgroups include federal, state, and local agencies, universities, private business, and nonprofit organizations. The Western Shore workgroup, which coordinates work in the Piankatank, lower York, and Great Wicomico rivers, developed this document.

1.2 Chesapeake Bay Oyster Metrics

The Sustainable Fisheries GIT convened an Oyster Metrics panel to develop a science-based, common definition of a successfully restored tributary for the purpose of tracking progress toward the '10 tributaries' oyster goal. The panel was composed of representatives from the state and federal agencies involved in Chesapeake Bay oyster restoration, as well as oyster scientists from academic institutions. The panel produced "Restoration Goals, Quantitative Metrics and Assessment Protocols for Evaluating Success on Restored Oyster Reef Sanctuaries[2]," a report detailing these recommended success metrics (hereafter referred to as the Oyster Metrics report).

The following criteria were among those set forth in the Oyster Metrics report[2]:

1) A successfully restored reef should have:

- A minimum threshold of 15 oysters and 15 grams dry weight/square meter (m^2) covering at least 30% of the target restoration area at six years post restoration;
- Ideally, a higher, target of 50 oysters and 50 grams dry weight/square meter (m^2) covering at least 30% of the target restoration area at six years post restoration;
- Two or more oyster year classes present;
- A positive or neutral shell budget; and
- A positive or neutral postconstruction reef height and footprint.

2) A successfully restored tributary is one where:

- 50-100% of the "currently restorable oyster habitat" has oyster reefs that meet the reef-level metrics above.
- 8-16% of its historic oyster bottom has oyster reefs that meet the reef-level metrics above.

These Oyster Metrics[2] success criteria are being applied to tributary-scale oyster restoration work planned and implemented under the 2014 Chesapeake Bay Watershed Agreement '10 tributaries' oyster goal.

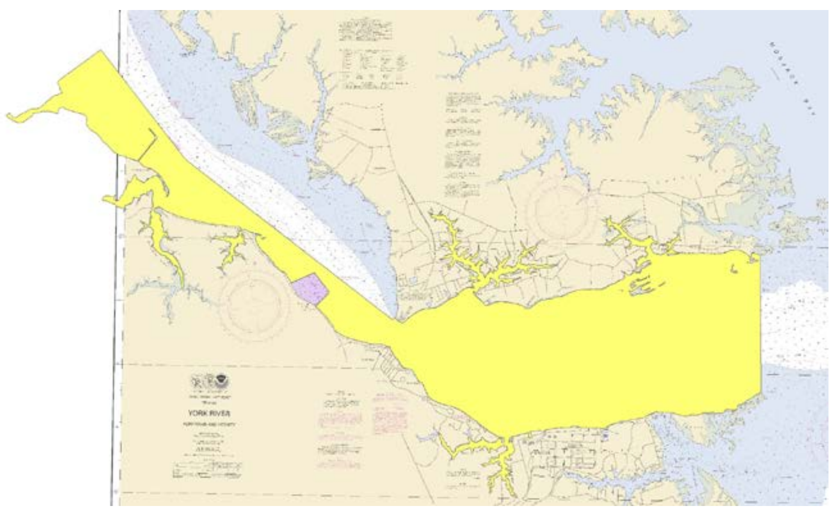
1.3 Selection of the Lower York River as Tributary for Large-Scale Oyster Restoration under the Chesapeake Bay Watershed Agreement Oyster Outcome, and Definition of the River Sub-Segment

Several factors led to the selection of the lower York River for large-scale oyster restoration under the Chesapeake Bay Watershed Agreement.

- In 2012, USACE completed the Native Oyster Restoration Master Plan[3], which evaluated 63 tributaries of the Chesapeake Bay watershed. The document prioritized rivers based on historical, physical, and biological attributes to support self-sustaining oyster populations in large-scale oyster restoration efforts. In this document, the York River was designated as a Tier One tributary, indicating it was an appropriate location for oyster restoration.
- The lower York River has historically exhibited strong oyster recruitment (natural spat set).[3]
- There are large areas of hard river bottom available for restoration and extensive existing oyster reefs in the River.
- USACE- Norfolk District and VMRC are supportive of cost sharing for oyster restoration efforts in this tributary.
- Virginia Institute of Marine Science is on the lower York River.
- The Virginia Interagency Oyster Team endorsed the selection of the lower York as a targeted tributary.

By agreement from the Sustainable Fisheries GIT in December 2017, the lower York River was selected for large-scale oyster restoration in Virginia under the 2014 Chesapeake Bay Watershed Agreement.

Figure 2: Sub segment (yellow area) of the lower York River selected for large-scale oyster restoration under the '10 tributaries' oyster restoration goal. Purple polygon is the restricted access area around the naval facilities.



For the purposes of restoring the lower York River under the '10 tributaries' goal, the Workgroup, by consensus, defined a sub segment of the River for restoration. In this document, the term "lower York River" refers to this sub segment of the River (Figure 2). This sub segment was selected because:

- The downstream boundary is the natural lower end of the river.
- The upstream boundary:
    - Includes the two Navy installations on the River, Naval Weapons Station Yorktown and the Cheatham Annex. Qualitative surveys in this area show good oyster recruitment. Oyster habitat restoration on federal lands (U.S. Navy installations) or within Navy restricted waters could protect the restoration investment and physically protect reefs from poaching due to security-related vessel access restrictions.
    -
    - Includes existing CBF restoration work near Felgates Creek.

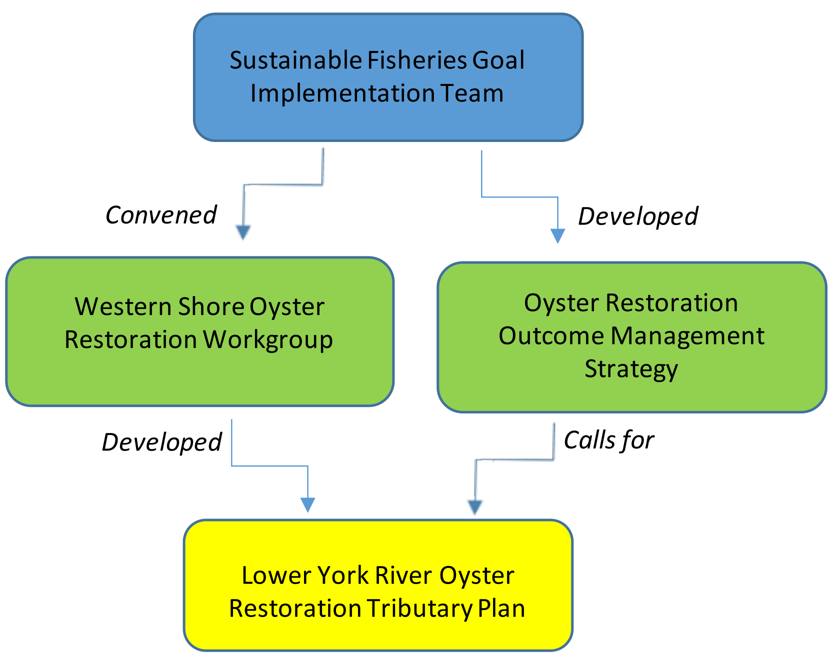
- Includes areas on the south side of the River above the Route 17 bridge, which are feasible for restoration. Restoring these areas will likely provide larval spillover for harvest reefs on the north side as well as downstream restoration reefs, per VIMS hydrodynamic modeling (Rom Lipscious, personal communication).

- Excludes the rotational harvest areas in the River. This was done in recognition of the fact that there is no intention to change the current management regime in the rotational harvest areas, and that these are not under consideration for ecological restoration. The workgroup recognizes, however, that a unique opportunity for us to implement a synergistic sanctuary-harvest network whereby larvae from protected sanctuaries on the south shore and downriver not only self replenish their natal reefs but concurrently subsidize recruitment to harvest grounds.

- Splits the portion of the river above the Coleman Bridge (Route 17) lengthwise, but maintains a geographically distinct, contiguous sub-segment of the river for restoration.

1.4 Organizational Framework

Figure 3: Organizational Framework for Large-Scale Oyster Restoration in Lower York River under the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team.



Responsibility for achieving the Chesapeake Bay Watershed Agreement oyster restoration goal rests with the Sustainable Fisheries GIT. The Sustainable Fisheries GIT convened workgroups in Maryland and Virginia to plan and coordinate large-scale oyster restoration. Virginia's groups are the Western Shore Workgroup (working in the Piankatank, Great Wicomico, and lower York rivers) and the Hampton Roads Workgroup (working in the Lafayette and Lynnhaven rivers). The Western Shore Workgroup (hereafter, "Workgroup") developed this plan. Like all Goal Implementation Teams under the Chesapeake Bay Program, the Sustainable Fisheries GIT crafted "management strategies" describing the steps necessary to achieve each Chesapeake Bay Watershed Agreement outcome. The strategies provide broad, overarching direction and are further supported by two-year work plans summarizing the specific commitments, short-term actions, and resources required for success. The Oyster Restoration Outcome Management Strategy[5] calls for the Virginia workgroups to develop tributary-specific plans to restore oysters in each tributary, consistent with the Oyster Metrics success criteria. (Figure 3).

The Western Shore Workgroup developed this document. It is meant as a guide to(submerged lands) oyster restoration for project partners. The Workgroup recognizes that its members may also have organization-specific oyster restoration plans and goals. This document is not meant to replace existing plans; rather, it is meant to be inclusive of those plans and provide the overarching strategy to achieve restoration of oyster populations of the lower York River.

Section 2: Current Status of Lower York River Oyster Resource

The lower York River is a polyhaline subestuary of the Chesapeake Bay, located in Virginia's western shore. The river bottom (submerged land) is managed by VMRC as a combination of public and private oyster grounds, and sanctuary (nonharvest areas).

The Workgroup cataloged existing oyster restoration projects on the River (Table 2). Restoration projects, built by VMRC and CBF between 1994 and 2018, total 34.82 acres.

Subtracting the 34.82 aces of existing restoration projects from the restoration target of 200 acres leaves a balance of 165.18 acres remaining to be restored. (Table 3). This Plan documents where the remaining 165.18 acres may be constructed, and the estimated cost.

It is possible that additional acres- beyond those actively restored by VMRC and CBF- could meet the Oyster Metrics density and biomass success criteria through natural oyster recruitment. In past oyster restoration plans under the '10 tribs' oyster goal, these were deemed 'premet' reefs. In the lower York River, there is a lack of data to determine which, if any, reefs should be considered 'premet'. The Workgroup, therefore, is making a conservative assumption throughout this Plan that all 165.8 acres will need to be restored through reef construction. Prior to reef construction on any shell habitat, oyster population data will be collected to ensure it does not have high densities of existing oysters. If a shell-habitat area is found to have sufficient oyster density and biomass to be considered successful per the Oyster Metrics[2] criteria (ie, 'premet'), the area will be counted toward the total 200-acre restoration target.

Table 2: Existing lower York River oyster restoration projects. These projects were present in the River prior to development of this document. They are color coded in green in Figure 1 (lower York map)

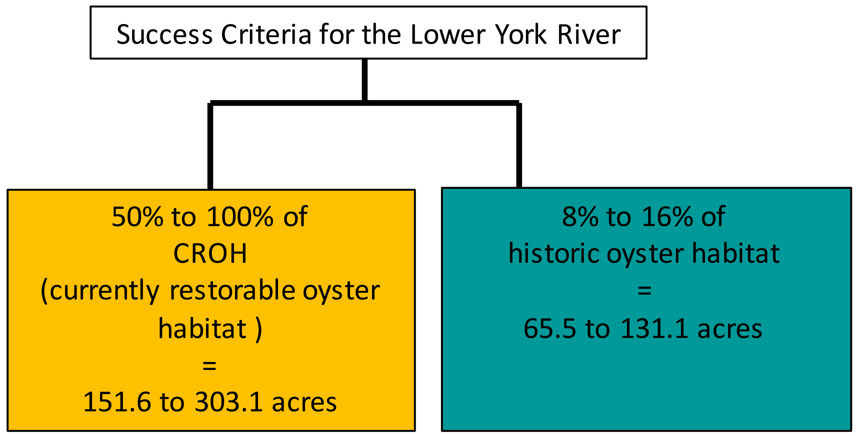
Geodatabase reef site ID	Reef Name	Acres	Year Constructed	Project Lead
YORK_01	Goodwin Island Reef	0.50	1994	VMRC
YORK_02	HRSD Oyster Reef	1.12	9999	VMRC-HRSD
YORK_03	Sarah's Creek 1	13.46	2019	VMRC
YORK_04	Sarah's Creek 2	19.37	2019	VMRC
YORK_58	Felgates Creek Reef	0.37	1999	VMRC-CBF
Total completed acres (existing restored reefs)		**34.82**		

Information on past restoration projects, leased areas, and other features is available in the Lower York River oyster restoration GIS geodatabase, www.habitat.noaa.gov/chesapeakebay/gis/Oyster_Restoration_Geodatabases/. This geodatabase is maintained by NOAA using information provided by the Workgroup.

Section 3: Oyster Restoration Target Setting

The Oyster Metrics[2] report recommends a two-pronged test to determine if a river is successfully restored (Figure 4). To meet Prong One, 50% to 100% of the 'currently restorable oyster habitat' (CROH) in the river must be covered with reefs functioning consistent with Oyster Metrics[2] reef-level success criteria. CROH is defined as *evidence-based oyster habitat*[6] within the restoration constraints determined by the Workgroup. Per the revised definition adopted by the Sustainable Fisheries GIT in December 2017[5], CROH is river bottom with evidence of existing or historic oyster reefs, within certain parameters determined by the Workgroup. Evidence of reefs is typically derived primarily from current-day sonar observations detecting shell river bottom, but could also include historical information, local knowledge, or other sources.

Figure 4: Schematic of Oyster Metrics[2] two-prong test for a successfully restored tributary, as applied to the lower York River. Adapted from Appendix A.



To determine CROH in the Lower York River, the Workgroup, by consensus, used the following parameters (see Appendix A for more detail):

- River extent: The portion of the lower York River defined in Figure 2 above.
- Depth interval: The Bay-wide Bathymetry Grid developed by the Chesapeake Bay Program and a NOAA sonar survey from 1960 were interpolated to define restoration depths. Depths between 4 feet and 16 feet were considered restorable. The 16-foot maximum depth was set due to concerns about potential hypoxia at greater depths, the fact that VMRC has not identified live oysters deeper than 20 feet in this river, and to be consistent with maximum depth limits set in the oyster restoration blueprint developed for the Piankatank River (which is ecologically similar to the lower York River). The shallow depth limit was set based on the practical limit of the vessels used for reef construction and monitoring, the limits of the acoustic surveys used to create the restorable bottom analysis, and Workgroup consensus that Lower York River reefs should be constructed sub tidally to avoid oyster mortality that occurs when intertidal reefs are exposed to freezing air temperatures.
- Benthic habitat (river bottom) type: NOAA sonar survey and ground truthing data (2018 & 2019) were classified using the Coastal and Marine Ecological Classification Standards[6]. River bottom classes used to determine suitable oyster restoration areas were: anthropogenic oyster rubble; sand with shell; biogenic oyster rubble; and muddy sand with shell.
- Water quality: In the USACE Native Oyster Restoration Master Plan[3], all Chesapeake tributaries (including the lower York) were evaluated using these criteria combined: a) summertime bottom dissolved oxygen levels from 2001-2006 (incorporating both wet and dry hydrologic years) greater than 5 mg/L; b) depth criteria of less than 20 feet; c) bottom and surface salinity greater than 5 parts per thousand. Areas that met all of these criteria

were considered suitable for oyster restoration. Most of the lower York was considered suitable for oyster restoration per these parameters (see Appendix A for details). There are eight Chesapeake Bay Program water-quality monitoring stations in or near the lower York River segment. Data from these stations were interpolated to the entire river segment. Beyond the data available from these stations, the approach in this Blueprint is to use depth as proxy for potentially hypoxic areas. The USACE Plan[3], which included water-quality analysis, ranked the lower York as a 'Tier 1' tributary for oyster restoration.

Using the above criteria, 303.1 acres were classified as CROH (Figure 4 and Appendix A). Therefore, to meet Prong One of the Oyster Metrics[2] definition of a restored tributary, between 151.6 and 303.1 acres will need to be restored.

Prong Two of the Oyster Metrics[2] restored tributary test calls for restoring at least 8-16% (Figure 4) of the river's historic acreage of oyster reefs. In the lower York River, consistent with the USACE Native Oyster Restoration Master Plan, 8% to 16% of historic reef acreage within the lower York River segment is 65.5 to 131.1 acres.

Since the low end of Prong Two is less than the low end of Prong One (Figure 4), restoring the acreage range defined in Prong One will also meet Prong Two. The goal range on the River therefore is defined by Prong One: between 151.6 and 303.1 acres.

From there, the Workgroup set a target of restoring 200 acres in the lower York River, which is 66% of CROH. This target was set by Workgroup consensus. It was developed by considering the Prong 1 goal range (151.6 to 303.1 acres), and by considering which areas in the River are the most feasible for reef construction and the least likely to create use group conflicts.

Areas considered feasible for oyster restoration met all of the following criteria:

- In 6-16 feet of water depth
- Not on mud river bottom
- Not on SAV beds, per VIMS SAV coverage maps from 1971-2017 per composite of 2007-2016 VIMS survey SAV boundaries
- On hard base sediments identified by sonar
- Not within 30 meters of oyster leases
- Not within 50 meters of VMRC oyster sampling areas (VOSARA reefs)
- Not overlapping with existing restoration sites
- Not within 150 feet of maintained navigation channels
- Not within 250 feet of navigational aids
- Not within 250 feet of private docks
- Not within 30 meters of clamming zones
- Not overlapping with utility crossings
- Outside of US Navy restricted zones
- Outside of shellfish prohibited zones
- Outside of registered archeological sites
- At least 1 acre in size

From among the feasible areas, the Workgroup determined that the areas with the least potential for user group conflict were those on those with shell river bottom (120.8 acres), and those with non-shell bottom outside of Baylor Grounds

(83.3 acres). This particularly avoids potential conflict with commercial wild oyster harvesting. Adding the two areas together equates to slightly more than 200 acres; the Workgroup rounded to a 200-acre target.

See Appendix A for full description of the feasibility analysis, maps showing the shell bottom outside of Baylor Grounds and the non-shell bottom, and geo-processing methods and assumptions.

There are 34.82 acres of existing restoration projects on the River built by VMRC and CBF (Table 2; Table 4). Subtracting the 34.82 aces of existing restoration projects from the target of 200 acres leaves a balance of 165.18 acres remaining to be restored. (Table 3). This Plan documents where the remaining 165.18 acres may be constructed, and the estimated cost.

Table 3: Accounting of area (acres) that remains to be restored as of the drafting of this plan (end of calendar year 2019).

Restoration target	200 acres
Existing restored areas	34.82 acres
Remaining areas the need to be restored *(as of end calendar 2019)*	165.18 acres

Section 4: Planned Oyster Restoration in the Lower York River

4.1 Proposed Oyster Reef Construction

The Workgroup used the above-mentioned feasibility analysis to determine the most suitable locations on the river to plan construction of the remaining 165.18 acres of reefs.

Figure 5 shows completed restoration projects (green), and areas proposed for potential reef construction (purple, sky blue, and dark blue areas). The proposed areas represent approximately 308 acres, far more than the 165.18 acres that need to be constructed. Partners plan to construct reefs on a 165.18-acre subset of the proposed areas. This allows for some of the proposed polygons to be eliminated due to permitting concerns, future input from local citizens, adaptive management, etc., while still achieving the restoration target. Given that the workgroup foresees the least amount of user-group conflict on the shell areas, and on the non-shell areas outside of the Baylor Grounds, the intent is to focus restoration work primarily in these locations.

The shell areas within Baylor Grounds are likely suitable areas to apply less intensive restoration techniques such as enhancement with shell or other smaller sized substrates. The non-shell areas are likely more suitable for larger substrates or more substantial restoration techniques. A plan that incorporates a diversity of restoration techniques and areas will provide all partners in restoration the flexibility needed to reach the restoration goal through the completion of projects of differing costs and scale. It will allow for continued restoration progress in the event that user-conflicts, funding, or other factors preclude certain areas or restoration methods .

The predominate restoration technique for the proposed reefs will likely be placing shell, stone, or other substrate onto the proposed site in either a striped configuration or covering the entire site. Natural oyster recruitment is generally high in the river, and the Workgroup expects reef substrate to self-seed with juvenile oysters, although some spat-on-shell may be planted onto some reefs.

It is noteworthy that the USACE's Comprehensive Water Resources and Restoration Plan identified the York sub-watershed as a priority area for ecological restoration work, including oyster habitat. . Any oyster restoration projects constructed for that purpose would be contribute toward the restoration goals.

Figure 5: Map of completed restoration projects and proposed restoration areas.

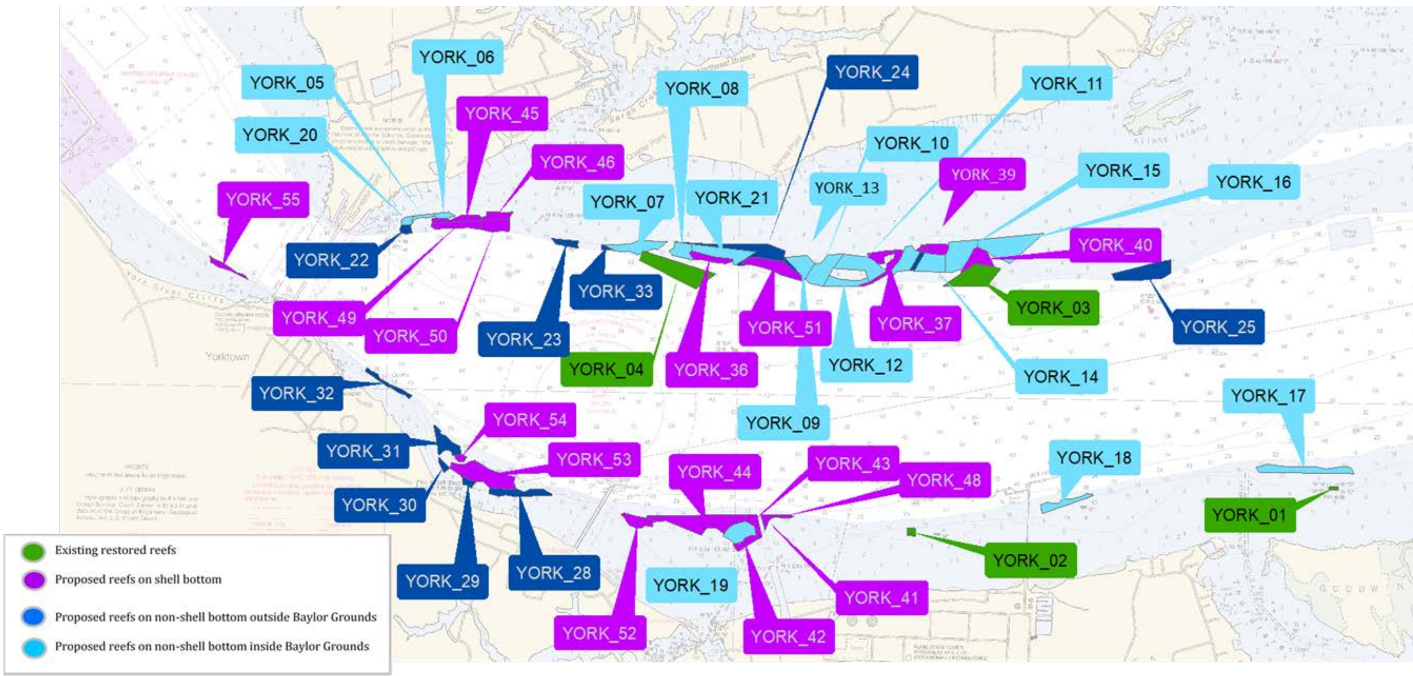


Table 4: Existing and proposed oyster restoration reefs on the lower York River.

Site_ID	Reef_Name	Acres	Status	Year Built	Lead	Bottom_Type	Baylor_
YORK_02	HRSD Oyster Reef	1.12	Complete	1999	VMRC-HRSD	Anthropogenic Reef	Outside Baylor
YORK_01	Goodwin Island Reef	0.50	Complete	1994	VMRC	Anthropogenic Reef	Outside Baylor
YORK_03	Sarah's Creek 1	13.46	Complete	2019	VMRC	SHELL	Inside Baylor
YORK_04	Sarah's Creek 2	19.37	Complete	2019	VMRC	SHELL	Inside Baylor
YORK_58	Felgates Creek Reef	0.37	Complete	1999	VMRC-CBF	Anthropogenic Reef	Outside Baylor
Total exisiting restoration projects		**34.82**					
YORK_05	<Null>	1.23	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_06	<Null>	1.66	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_07	<Null>	8.09	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_08	<Null>	4.75	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_09	<Null>	6.35	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_10	<Null>	10.26	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_11	<Null>	11.81	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_12	<Null>	5.19	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_13	<Null>	7.13	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_14	<Null>	8.23	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_15	<Null>	12.65	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_16	<Null>	17.93	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_17	<Null>	10.65	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_18	<Null>	5.28	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_19	<Null>	7.98	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_20	<Null>	1.45	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_21	<Null>	10.37	proposed	<Null>	<Null>	NO SHELL	Inside Baylor
YORK_22	<Null>	1.74	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_23	<Null>	2.70	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_24	<Null>	11.99	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_25	<Null>	13.31	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_26	<Null>	4.98	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_27	<Null>	12.49	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_28	<Null>	6.96	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_29	<Null>	1.42	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_30	<Null>	1.36	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_31	<Null>	6.49	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_32	<Null>	3.47	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_33	<Null>	0.69	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_34	<Null>	1.02	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_35	<Null>	1.65	proposed	<Null>	<Null>	NO SHELL	Outside Baylor
YORK_36	<Null>	4.38	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_37	<Null>	4.48	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_38	<Null>	3.61	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_39	<Null>	3.66	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_40	<Null>	6.55	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_41	<Null>	1.67	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_42	<Null>	3.00	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_43	<Null>	3.28	proposed	<Null>	<Null>	SHELL	Inside Baylor
YORK_44	<Null>	19.25	proposed	<Null>	<Null>	SHELL	Inside Baylor
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YORK_49	<Null>	5.75	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_50	<Null>	5.93	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_51	<Null>	10.12	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_52	<Null>	4.93	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_53	<Null>	17.14	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_54	<Null>	1.20	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_55	<Null>	2.50	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_56	<Null>	0.67	proposed	<Null>	<Null>	SHELL	Outside Baylor
YORK_57	<Null>	0.27	proposed	<Null>	<Null>	SHELL	Outside Baylor
Total area feasible for restoration		**308.54**					

4.2 Implementation and Progress Tracking

Implementation of this Plan depends primarily on funding availability, as well as permitting and reef-building material availability. Workgroup partners will continue to pursue state, federal, and private funding to ensure the lower York River is restored consistent with Chesapeake Bay Watershed Agreement '10 tributaries' oyster outcome. Workgroup partners will continue to coordinate on reef construction, progress tracking, and Plan implementation.

Data relating to Plan implementation will be logged in the lower York GIS geodatabase maintained by NOAA at www.habitat.noaa.gov/chesapeakebay/gis/Oyster_Restoration_Geodatabases/

Since 2016, the Workgroup, along with the Hampton Roads Oyster Restoration Workgroup (coordinating restoration on the Lafayette and Lynnhaven rivers) has produced annual update documents describing Virginia progress toward the '10 tributaries' outcome. The Workgroup will continue to produce these documents annually. The 2017 version of the annual document is here: https://chesapeakebay.noaa.gov/images/stories/pdf/2017virginiaoysterrestorationupdate.pdf

Section 5: Cost Estimate

Restoration partners may use a variety of substrates and techniques to construct oyster reefs in the lower York River. Reef construction costs will vary due to factors such as:

- Type, size, and availability of reef substrate materials used;
- Environmental compliance and permitting costs;
- Existing river bottom composition (remnant shell reef, hard sand, hard mud, etc.) at the reef construction site;
- Hydrodynamics at the reef construction site;
- Number of acres constructed at once, which can affect costs for mobilization/demobilization and bulk material purchasing; and
- Physical design, including material spacing and height of the constructed reefs.

To develop a cost estimate for constructing the planned 165.18 acres of reefs, the Workgroup made these assumptions:

- Each restored reef will be constructed from shell, stone, crushed concrete, or material similar in cost, or a combination of such materials;
- Reefs will primarily seed with oysters via natural oyster recruitment, so no seeding costs are included in the cost estimate;
- Reefs to be constructed on non-shell river bottom will require treatment costing approximately $80,000 per acre. This was derived from the per-acre cost of a 25-acre reef constructed on the nearby Piankatank River in 2018. This reef was built on hard sand bottom, meaning it had to be entirely reconstructed and therefore required more substrate than the less-expensive projects. It was also built in an area with high wave and tidal energy, so it had to be constructed from larger material. The reef was built 12-18 inches high, with stone substrate placed in stripes across the reef area (30 feet wide) and spaced 45 feet apart[7]. This per-acre cost estimate has not been adjusted for inflation or other cost increases from 2018.
- Of the reefs to be constructed on shell river bottom, half will have suitable existing shell substrate, and will therefore require only a light shell or stone layer treatment (ex: 2-6 inches of shell or stone). These will cost approximately $13,500 per acre. This cost was derived from two sources: 2019 VMRC shelling costs in the lower

York River (Andrew Button, VMRC- personal communication) , and the low-end per-acre cost estimate developed in the Piankatank Blueprint[7].

- The remaining half of the reefs to be constructed on shell river bottom will cost an average of $46,740 per acre. This is the mean between the $80,000 per acre for the non-shell areas, and the $13,500 for the lightly-treated shell bottom areas.
- Given that construction on shell river bottom may be less costly than constructing on non- shell areas, the Workgroup assumed that the priority would be to restore the shell areas. There are 107 acres of remaining shell areas feasible for reef construction in the lower York River. The Workgroup assumed that half of these (53.5 acres) would need more intensive treatment, and half could be restored with less intensive treatment. If all 107 acres of shell river bottom are restored, that would leave 58.18 acres remaining in to reach the 165.18 acre target. These 58.18 areas would require the $80,000 per acre treatment.

Using these assumptions yields a rounded cost estimate of $7.88 million to complete the remaining planned oyster reef construction on the lower York River (Table 5).

Table 5: Calculations for the cost estimate for completing oyster restoration in the lower York River.

	Acres projected to need this treatment	**Estimated cost per acre**	**Cost for this treatment type**
Non-shell areas	58.18	$80,000	$4,654,400
Shell areas- more intensive restoration treatment	53.5	$46,750	$2,501,125
Shell areas- less intensive restoration treatment	53.5	$13,500	722250
Total acres needing treatment	**165.18**		
Total estimated cost			**$7,877,775**

Section 6: Public Outreach

The Western Shore Oyster Restoration Workgroup, the author of this Plan, comprises representatives from watershed groups, the scientific community, and personnel from state and federal agencies. The group represents an array of viewpoints and stakeholders, and those viewpoints were incorporated into this plan. USACE also did extensive public outreach during its Environmental Assessment process for the project Chesapeake Bay Oyster Recovery, Lower York River, Virginia, available at https://usace.contentdm.oclc.org/digital/collection/p16021coll7/id/2815/

A National Environmental Policy Act (NEPA) Scoping meeting was conducted on Thursday, January 10, 2019 at the Great Neck Library in Virginia Beach, Virginia for the implementation of the Chesapeake Bay Native Oyster Recovery Program in the Commonwealth of Virginia. The format of the meeting was an informal open-house, where the public could review presentation boards and ask questions from USACE staff and provide scoping comments on the program. USACE Norfolk is preparing an Environmental Impact Statement on the Chesapeake Bay Native Oyster Recovery Program in Virginia.

Section 7: Monitoring

7.1 Monitoring relative to Oyster Metrics Success Criteria

The main objective of monitoring efforts in the lower York River is to determine whether the restored reefs can be considered successful per the Oyster Metrics[2] standards. There are examples of appropriate sampling and analysis methodology in the Oyster Metrics[2] report itself, and in the Maryland monitoring reports[8,9,10]. According to the Oyster Metrics[2] report, biological parameters (oyster density, oyster biomass, and presence of multiple year classes), and structural parameters (reef height, reef areal extent), should be monitored three years, and again six years, postrestoration to determine reef-level success. (Table 6). The Workgroup stresses the need for consistent monitoring following protocols referenced in the Oyster Metrics[2] report to measure reef-level success, so success can be compared across all reefs under the '10 tributaries' goal.

Table 6: Reef-level success criteria for oyster restoration projects (adapted from the Oyster Metrics[2] report, and *2016 Oyster Reef Monitoring Report Analysis of Data from Large-Scale Sanctuary Oyster Restoration Projects in Maryland*[8])

Biological Metrics	Oyster density	Minimum threshold = 15 oysters per m^2 over 30% of the reef area; Target = 50 oysters per m^2 over 30% of the reef area
	Oyster biomass	Minimum threshold = 15 grams dry weight per m^2 over 30% of the reef area; Target = 50 grams dry weight per m^2 over 30% of the reef area
	Multiple year classes	Presence of at least two year-classes of oysters on the reef
	Shell budget	Stable or increasing shell budget on the reef
Structural Metrics	Reef footprint	Stable or increasing reef footprint compared to premet
	Reef height	Stable or increasing reef height compared to premet

In keeping with the Oyster Metrics[2] report, and assuming funding can be secured, these parameters (Table 6) will be monitored on the lower York River restored reefs, likely in partnership with scientists, nongovernmental organizations, private contractors, and government agencies. Results will be used to determine reef success and to implement adaptive management actions as necessary.

7.2 Diagnostic Monitoring

In addition to monitoring to evaluate restored reefs per the Oyster Metrics[2] criteria, it is wise to include further monitoring that will help determine the causes of oyster restoration success or failure. These are deemed "diagnostic" monitoring parameters, and include water quality and oyster disease. Understanding these parameters alongside metrics of restoration success will allow practitioners to understand not only whether or not the project succeeded, but why. Water quality will be monitored using existing Chesapeake Bay Program stations on the lower York River. Oyster disease information will be obtained where available from VMRC and various academic and research programs.

References

1. Chesapeake Executive Council, 2014. The Chesapeake Bay Watershed Agreement. http://www.chesapeakebay.net/documents/FINAL_Ches_Bay_Watershed_Agreement. withsignatures-HIres.pdf.

2. Oyster Metrics Panel, 2011. "Restoration Goals, Quantitative Metrics and Assessment Protocols for Evaluating Success on Restored Oyster Reef Sanctuaries." Report to the Sustainable Fisheries Goal Implementation Team of the Chesapeake Bay Program. http://www.chesapeakebay.net/channel_files/17932/oyster_restoration_success_metrics_final.pdf

3. U.S. Army Corps of Engineers, Baltimore and Norfolk Districts, 2012. "Chesapeake Bay Oyster Recovery: Native Oyster Restoration Master Plan, Maryland and Virginia."

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5. Lazar, Jay. 2017. Adaptive Management: Oyster Restoration Framework Update. Chesapeake Bay Program Sustainable Fisheries GIT Meeting December 18, 2017. https://www.chesapeakebay.net/channel_files/25674/6_adaptive_management-oyster_restoration_framework_update_12-18-2017.pdf

6. Federal Geographic Data Committee, Marine and Coastal Data Subcommittee. 2012. Coastal and Marine Ecological Classification Standard. FGDC-STD-018-2012. Washington, D.C. 353 pp.

7. Piankatank River Oyster Restoration Tributary Plan: A Blueprint for Restoring Oyster Populations per the Chesapeake Bay Watershed Agreement. Western Shore Oyster Restoration Workgroup under the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team. 2019.

8. NOAA. 2016. Analysis of Monitoring Data from Harris Creek Sanctuary Oyster Reefs Data on the First 102 Acres/12 Reefs Restored. https://chesapeakebay.noaa.gov/images/stories/habitats/hc3ydcheckinjuly2016.pdf

9. NOAA. 2017. 2016 Oyster Reef Monitoring Report Analysis of Data from Large-Scale Sanctuary Oyster Restoration Projects in Maryland https://chesapeakebay.noaa.gov/images/stories/pdf/2016oysterreefmonitoringreport.pdf

10. NOAA. 2018. 2017 Oyster Reef Monitoring Report Analysis of Data from Large-Scale Sanctuary Oyster Restoration Projects in Maryland file:///C:/Users/Stephanie.westby/Downloads/2017%20Monitoring%20Report%20DRAFT%2011.2.18.pdf

Appendix A:
York River Restorable Bottom Assessment

09/06/2019

Background

This document estimates oyster restoration targets and locations suitable for restoration in the Lower York River, VA. GIS layers were geo-processed using decision thresholds similar to those used for the other VA restoration projects. The final products in this draft are 1) and inventory of available restoration-relevant spatial data, 2) an estimate of "evidence based" restoration target of Currently Restorable Oyster Habitat (CROH) based on sidescan sonar and ground truth survey data, 3) a draft estimate of Historic Oyster Habitat (HOH), 4) an estimate of the total area that could be restored with substrate reef construction and cultch augmentation methods given a series of spatial constraints, and 5) an estimate of the total area that could be restored with substrate reef construction and cultch augmentation methods given a series of spatial constraints.

Index

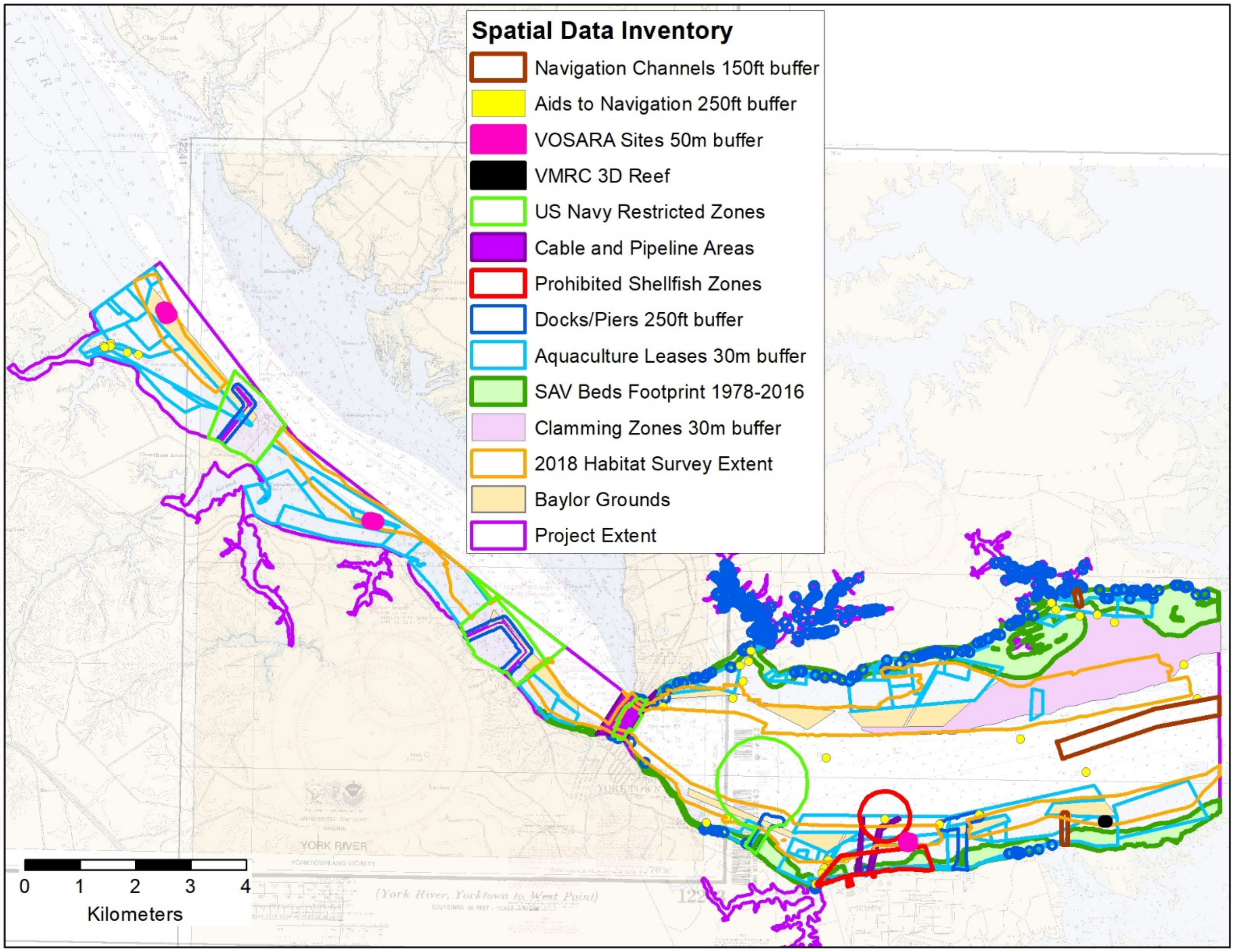
Summary: Area Targets and Restorable Bottom Estimates 2019

Currently Restorable Oyster Habitat (CROH) target	**303.1 acres**
50% of CROH target	**151.6 acres**
Area meeting the restoration success density target (50 live oysters/m^2)	**0.7 acres**
Estimated area feasible for restoration (min. depth = 6.0 ft)[1]	**347.7 acres**
Sum area: meets target + feasible for restoration	**348.4 acres**
1 – Includes feasible restoration on shell (cultch replenishment) and non-shell bottom (alternative substrate reef construction), inside and outside Baylor boundaries	

Above table suggests that the restoration target area should range from 151.6 to 303.1 acres. Breakdown of feasible restoration acreage is on page 9.

Spatial Data Inventory

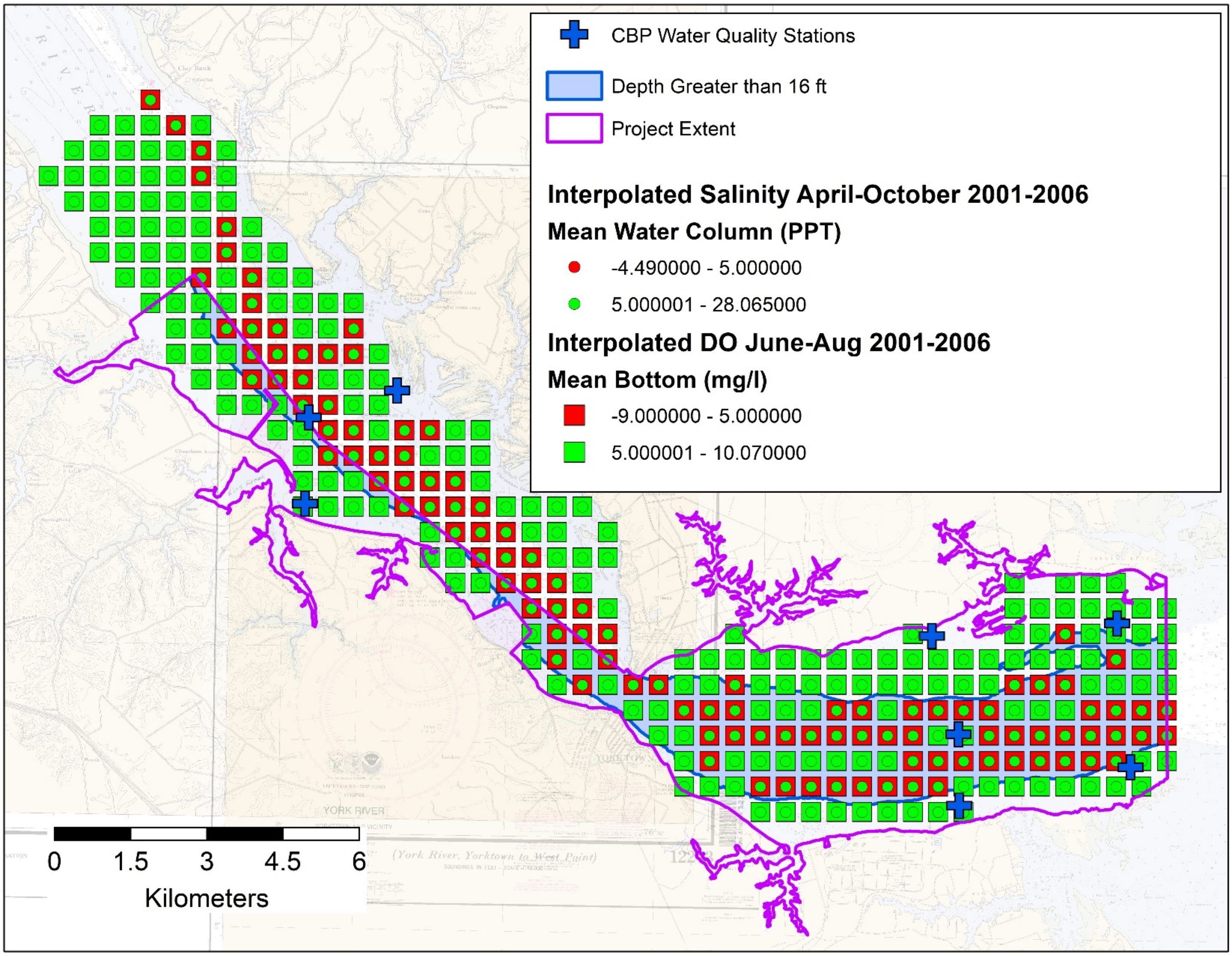
Category	Number of polygons	Acres
Project extent	1	14334
Benthic habitat characterization footprint	92	3577
Baylor 2017 boundaries	11	819
Aquaculture leases 30m buffers footprint	14	4540
Depth 6 to 16ft (see p. 8)	5	2612
SAV footprint 2007-2016	21	1469
Docks 250ft buffer	410	1848
Maintained navigation channel 150ft buffer	3	261
VOSARA sites 50m buffer	3	21
Cable crossings and pipelines	3	140
US Navy restricted zones	5	1311
Aids to navigation 250ft buffers	40	172
VMRC 3D reef	1	0.5
Clam Fishery Zones 30m buffer	1	1366
Prohibited Shellfish Zones	2	335



Spatial Data Inventory
Navigation Channels 150ft buffer
Aids to Navigation 250ft buffer
VOSARA Sites 50m buffer
VMRC 3D Reef
US Navy Restricted Zones
Cable and Pipeline Areas
Prohibited Shellfish Zones
Docks/Piers 250ft buffer
Aquaculture Leases 30m buffer
SAV Beds Footprint 1978-2016
Clamming Zones 30m buffer
2018 Habitat Survey Extent
Baylor Grounds
Project Extent
0 1 2 3 4
Kilometers

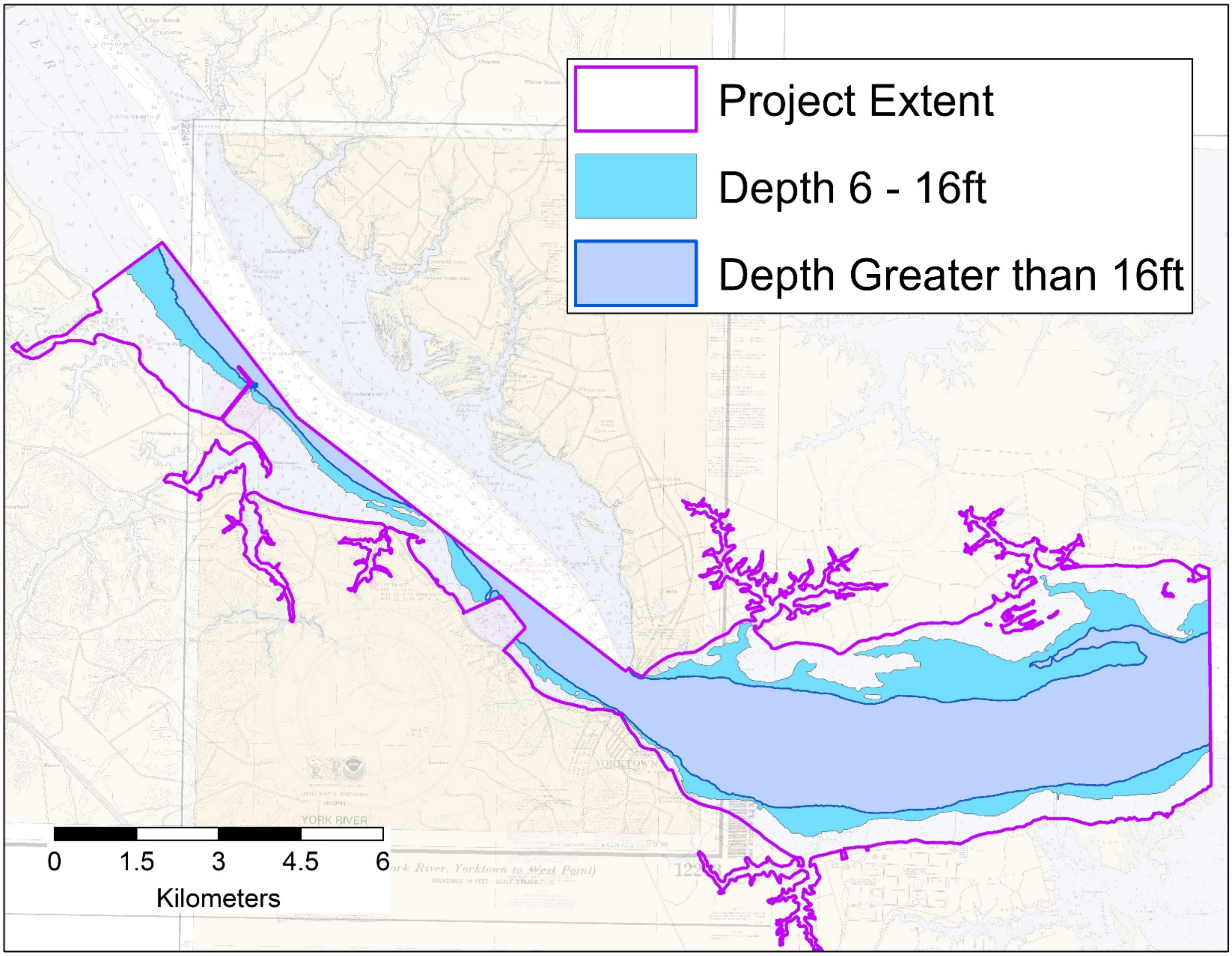
Interpolated Salinity and DO

USACE Master Plan Criteria



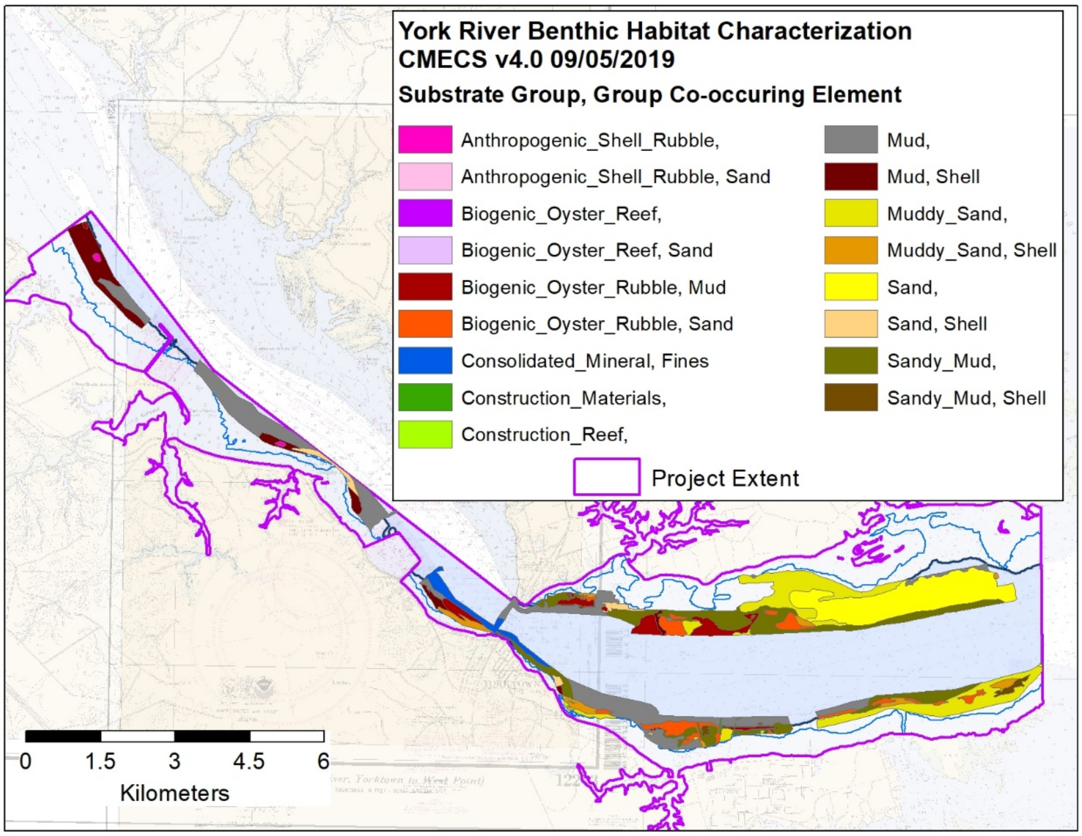
Interpolated water quality data are based on field samples collected at the Chesapeake Bay Program monitoring sites 2001-2006 and were derived with the Chesapeake Bay Interpolator. The US Army Corps Engineers Oyster Restoration Master Plan identifies tributary restorability absolute criteria for salinity as a mean of 5.0 ppt for bottom and surface for the interval of April to October 2001-2006. The absolute criteria for DO is a mean bottom value of 5.0 mg/l for the interval June-August 2001-2006. Data presented here suggest that salinity levels are adequate relative to Master Plan (green circles) and that DO levels may be critical (red squares) in the deeper areas of the central river channel.

Depth Contours



The USACE Master Plan absolute criteria for maximum depth is 20 feet MLLW. The York River oyster restoration workgroup suggested a 16ft maximum depth and a 6ft minimum depth (light blue) for substrate reef construction.

Bottom Type 2019



The distribution of benthic habitats and materials was surveyed with sonar and sediment grabs in 2018. Survey data was classified with the Coastal and Marine Ecosystem Classification Standard (CMECS).

Area Summary: Existing Benthic Habitat Based on Survey Data

Bottom Type Group	Group Co-Occurring Element	Number Polygons	Sum Acres	Percent
Construction_Reef		1	1.3	0.0
Construction_Materials		3	4.0	0.1
Anthropogenic_Shell_Rubble		2	9.0	0.3

Sandy_Mud	Shell	8	40.3	1.1
Sand	Shell	5	62.4	1.7
Muddy_Sand	Shell	9	84.4	2.4
Consolidated_Mineral	Fines	1	98.1	2.7
Biogenic_Oyster_Rubble	Mud	8	165.6	4.6
Biogenic_Oyster_Rubble	Sand	15	215.7	6.0
Mud	Shell	7	243.9	6.8
Sandy_Mud		12	586.0	16.4
Muddy_Sand		8	599.0	16.7
Sand		2	613.1	17.1
Mud		11	854.4	23.9
	Sum =	92	3577.1	100.0

Restoration Target Area 2019

Method 1: Currently Restorable Oyster Habitat (CROH) based on distribution of shell bottom from recent survey data at depths between 4 and 16 ft. Actual restoration would range from 50-100% of CROH.

Area Summary: Setting the "Evidence based" Restoration Target of Currently Restorable Oyster Habitat (CROH) at Depths Between 4 and 16 ft.

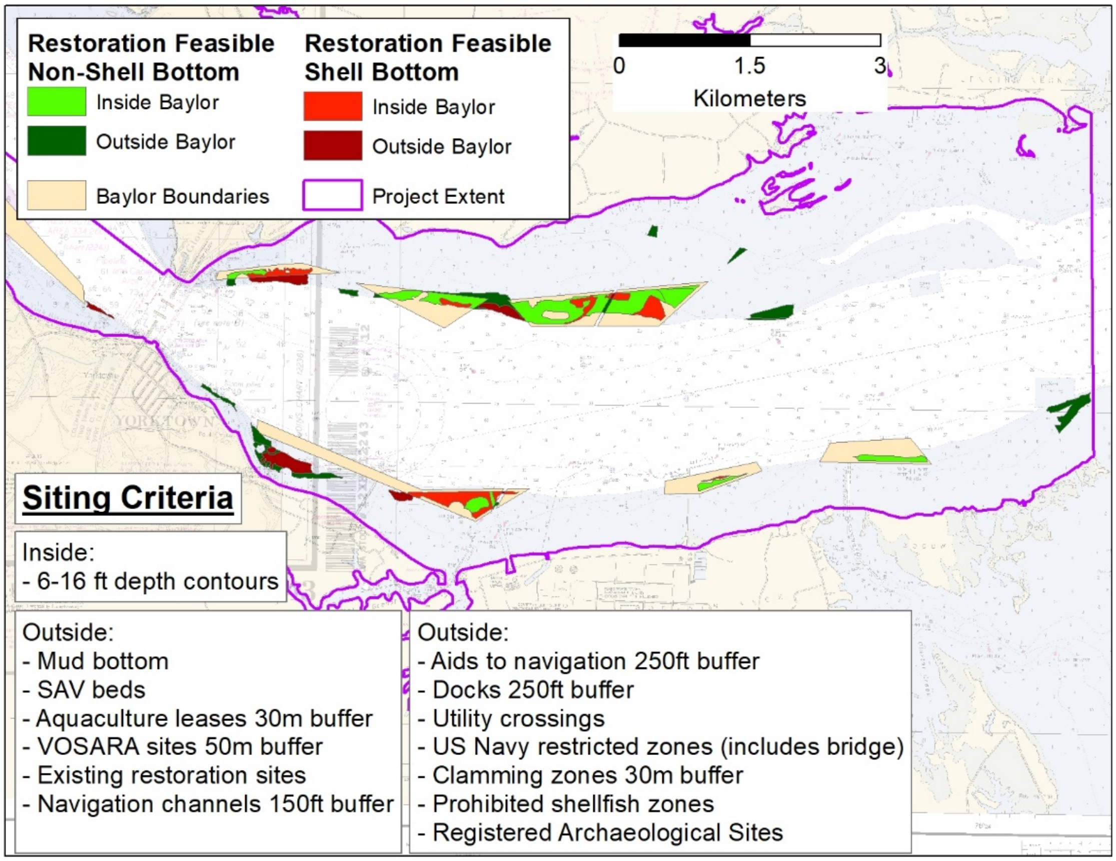
Bottom Type Group	Group Co-Occurring Element	Sum Acres
Anthropogenic_Shell_Rubble		9.0
Sand	Shell	52.9
Muddy_Sand	Shell	55.3
Biogenic_Oyster_Rubble	Mud	64.6
Biogenic_Oyster_Rubble	Sand	121.3
	Sum(CROH)=	303.1
	50%(CROH)=	151.6

Method 2: Historic Oyster Habitat (HOH) based on the Baylor bars. Consistent with the US Army Corps of Engineers (USACE) Native Oyster Restoration Master Plan, the actual restoration target would range from 8-16% of HOH.

Area Summary: Setting the Restoration Target of Historic Oyster Habitat (HOH) Based on Area of Baylor Bars in Project Extent

Name	Identifier	Acres
York Baylor Bars	073.027.0600	34.8
York Baylor Bars	073.028.0600	75.0
York Baylor Bars	073.029.0600	85.6
York Baylor Bars	073.929.0600	93.9
York Baylor Bars	199.001.0600	182.9
York Baylor Bars	199.002.0600	18.3
York Baylor Bars	199.003.0600	86.5
York Baylor Bars	199.004.0600	71.4
York Baylor Bars	199.005.0600	48.8
York Baylor Bars	199.006.0600	115.0
York Baylor Bars	199.906.0600	7.0
	Sum Acres (HOH)	819.2
	16% HOH	131.1
	8% HOH	65.5

Restoration Target Area Continued

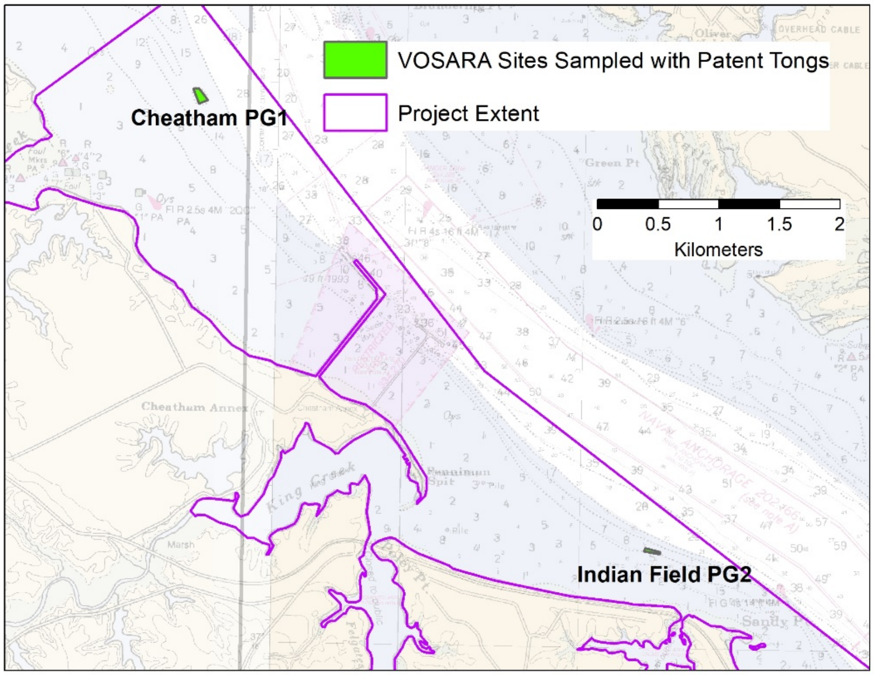


Above map shows locations feasible for restoration as determined by siting criteria. Feasible non-shell bottom identifies area suitable for substrate reef construction. Feasible shell bottom identifies area suitable for replenishment with cultch. There is an additional 39 acres of sediment and shell (sand/muddy sand/sandy mud with shell) that are not accounted for in the map or table below. It is assumed that none of the area of shell bottom supports oyster densities that meet the restoration success target for density or biomass (50/m^2). Patent tong survey monitoring could provide information on live oyster abundance and potentially change the feasible restoration area values for shell bottom.

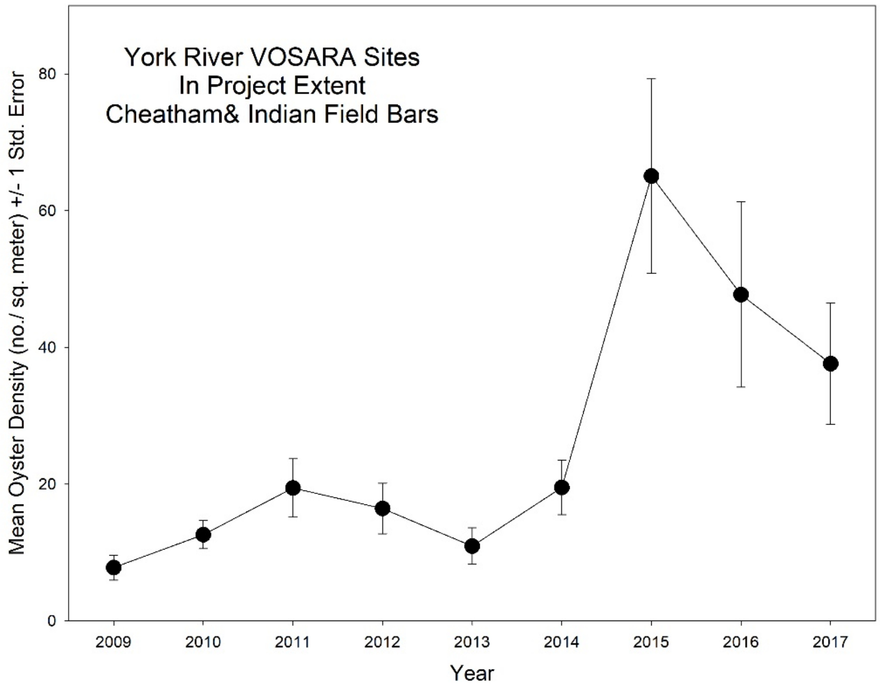
Restoration	Bottom Type	Baylor Boundaries	Acres
Feasible	Shell Dominant	Inside	69.5
Feasible	Shell Dominant	Outside	51.3
Feasible	Shell Dominant	Total	120.8
Feasible	Non-Shell	Inside	143.6
Feasible	Non-Shell	Outside	83.3
Feasible	Non-Shell	Total	226.9
Feasible	Shell Dominant + Non-Shell	Inside	213.1
Feasible	Shell Dominant + Non-Shell	Outside	134.6

Feasible	Shell Dominant + Non-Shell	Total	347.7

Oyster Abundance 2009-2017 VOSARA Surveys



Cheatham (1.9 acres) and Indian Field (0.7 acres) are the only VOSARA sites sampled annually with patent tongs within the project extent.



Oyster density values 2015-2017 are relatively similar and this time interval was used to estimate composite oyster abundance at the two VOSARA sites.

Survey Data Summary: Summary Statistics of Oyster Density and Biomass 2015-2017 Cheatham and Indian Field VOSARA Sites

Oyster Density (#/sq. meter) Summary Stats
York River VOSARA Patent Tong Survey 2015-2017 Pooled

Obs	Reef_Name	_TYPE_	_FREQ_	mean_density	stdev	stderr	min	max	n
1	Cheatham PG 1	0	21	35.380952381	29.17100648	6.3656354901	0	143	21
2	Indian Field PG 2	0	19	69.736842105	55.906511353	12.82583333	0	199	19

Oyster Biomass (g dwt/sq. meter) Summary Stats
York River VOSARA Patent Tong Survey 2015-2017 Pooled

Obs	Reef_Name	_TYPE_	_FREQ_	mean_biomass	stdev	stderr	min	max	n
1	Cheatham PG 1	0	21	20.847142857	13.978060002	3.0502627633	0	63.78	21
2	Indian Field PG 2	0	19	29.996842105	25.573604676	5.8669872845	0	88.44	19

Survey Data Summary: Frequency Distributions of Oyster Density and Biomass 2015-2017 Cheatham and Indian Field VOSARA Sites

Frequency Distribution of Oyster Density (#/sq. meter)
York River VOSARA Patent Tong Survey 2015-2017 Pooled

The FREQ Procedure

Reef_Name=Cheatham PG 1

bin_code_D	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A_Density=0	1	4.76	1	4.76
B_Density=1-14	3	14.29	4	19.05
C_Density=15_49	15	71.43	19	90.48
D_Density>50	2	9.52	21	100.00

Frequency Distribution of Oyster Density (#/sq. meter)
York River VOSARA Patent Tong Survey 2015-2017 Pooled

The FREQ Procedure

Reef_Name=Indian Field PG 2

bin_code_D	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A_Density=0	3	15.00	3	15.00
B_Density=1-14	2	10.00	5	25.00
C_Density=15_49	4	20.00	9	45.00
D_Density>50	11	55.00	20	100.00

Frequency Distribution of Oyster Biomass (g dwt/sq. meter)
York River VOSARA Patent Tong Survey 2015-2017 Pooled

The FREQ Procedure

Reef_Name=Indian Field PG 2

bin_code_B	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A_Biomass=0	3	15.00	3	15.00
B_Biomass=1-14	5	25.00	8	40.00
C_Biomass=15_49	7	35.00	15	75.00
D_Biomass>50	5	25.00	20	100.00

Frequency Distribution of Oyster Biomass (g dwt/sq. meter)
York River VOSARA Patent Tong Survey 2015-2017 Pooled

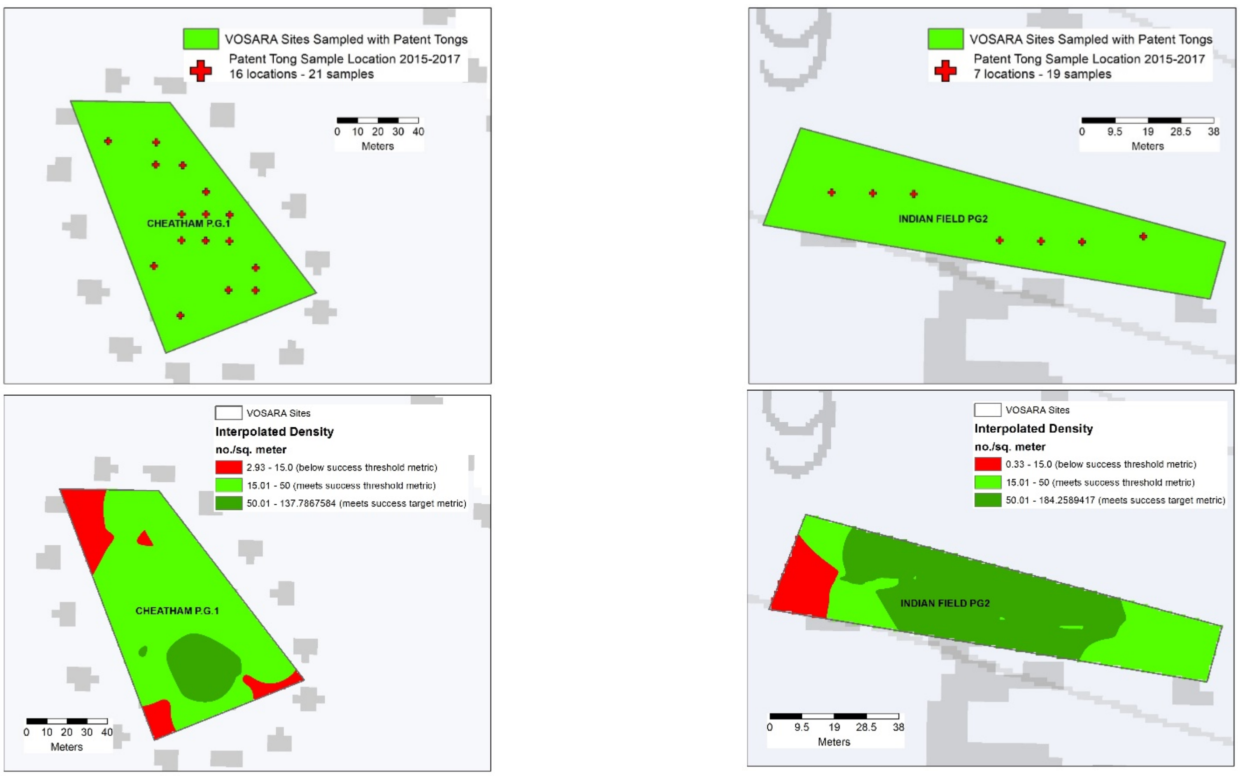
The FREQ Procedure

Reef_Name=Cheatham PG 1

bin_code_B	Frequency	Percent	Cumulative Frequency	Cumulative Percent
A_Biomass=0	1	4.76	1	4.76
B_Biomass=1-14	6	28.57	7	33.33
C_Biomass=15_49	13	61.90	20	95.24
D_Biomass>50	1	4.76	21	100.00

Interpolated Oyster Abundance 2015-2017

Cheatham and Indian Field VOSARA Sites



Oyster abundance data is used to determine the area of bottom that meets restoration success metrics and therefore does not need to be restored. The density success metric is 50 oysters/meter^2 over 30% of the oyster bar and the biomass metric is 50 grams dry weight/meter^2 over 30% of the oyster bar. Patent tong samples (top images, above) are interpolated (bottom images above) to determine the percent area meeting the metrics. In tables below, column on far right identifies proportion of area at each oyster bar that meets the density and biomass success metric.

Location	Area acres	Area sq. meters	Parameter	Tot. area from grid	Sum area < 15/sq. m	Sum area >= 15/sq. m	Sum area > 50/sq. m	% < 15/sq. m	% >= 15/sq. m	% >=50/s m
Cheatham	1.87	7589.5	Number/sq. m	7590	1029	6561	934	13.6	86.4	12.3
Indian Field	0.74	2985.2	Number/sq. m	2984	293	2691	1724	9.8	90.2	57.8

Location	Area acres	Area sq. meters	Parameter	Tot. area from grid	Sum area < 15/sq. m	Sum area >= 15/sq. m	Sum area > 50/sq. m	% < 15/sq. m	% >= 15/sq. m	% >=50/s m
Cheatham	1.87	7589.5	BIOMASS/sq. m	7590	2808	4782	59	37.0	63.0	0.8
Indian Field	0.74	2985.2	BIOMASS/sq. m	2984	1109	1875	252	37.2	62.8	8.4

Appendix

Geoprocessing Methods & Log Used to Identify Area and Locations Feasible for Substrate Reef Construction on Non-Shell Bottom and Cultch Addition to Shell Bottom

Source ArcMap Project: York_River_RBA_MAP_09_09_2019

Source Geodatabase:

York_River_Oyster_Restoration_BluePrint_GeoDatabase_04_01_2019_1.gdb

Starting Polygon:

York_CMECS_Benthic_Habitat_Characterization_Project_09052019

Area = 3577.1 acres.

Steps:

1) Clip with (keep inside)depth 6-16ft

(Depth_Polygon_6ft_16FT_in_project) E**nsures area within 6-16 ft contour**

Output polygons =Feasible_Step_1. Area = 1926.3 acres. **DONE**

2) Remove mud and mud & shell bottom polygons

Ensures area is on shell, sand, sand & shell, muddy sand, muddy sand & shell, sandy mud, and sandy

mud & shell.

Output polygons = Feasible_Step_2. Area = 1455.9 acres. **DONE**

3) Erase (keep outside) 30m lease bottom buffer (Lower_York_Leases_2017_in_Project_30m_Buffer)

Ensures area not on leases

Output polygons = Feasible_Step_3 (no intersection w/leases). Area = 807.9 acres. **DONE**

4) Erase (keep outside)250 ft navigation aid buffer (York_River_LightList_2016_UTM_250FT_Buffer)

Ensures area not adjacent to navigation aids

Output polygons = Feasible_Area_Step_4. Area = 799.9 acres. **DONE**

5) Erase (keep outside) 250ft Private Dock buffers (Docks_2014_Piers_Bridge_250ft_Buffer).

Ensures area not adjacent to private docks

Output polygons = Feasible_Area_Step_5. Area = 796.5 acres. **DONE**

6) Erase (keep outside) US Navy Restricted Zones (includes bridge).

Ensures area not on Restricted Zones

Output polygons = Feasible_Area_Step_6. Area = 796.5 acres. **DONE**

7) Erase (keep outside) Cable and Pipeline Crossings.

Ensures area not on utility crossings

Output polygons = Feasible_Area_Step_7. Area =795.3 acres. **DONE**

8) Erase (keep outside) Maintained Navigation Channel 150 ft Buffers.

Ensures area not on navigation channels

Output polygons = Feasible_Area_Step_8. Area = 795.2 **DONE**

9) Erase (keep outside) 2007-2016 SAV Beds.

Ensures area not on SAV bed location

Output polygons = Feasible_Area_Step_9. Area = 795.2 **DONE**

10) Erase (keep outside) VOSARA Sites 50 M buffer.

Ensures area not on VOSARA Sites

Output polygons = Feasible_Area_Step_10. Area =789.8 **DONE**

11) Erase (keep outside) VMRC 3D Reef.

Ensures area not on VMRC 3D Reef

Output polygons = Feasible_Area_Step_11. Area = 789.8 **DONE**

12) Erase (keep outside) VMRC Prohibited Shellfish Zones

Ensures area not on VMRC Prohibited Shellfish Zones

Output polygons = Feasible_Area_Step_12. Area = 789.8 **DONE**

13) Erase (keep outside) VMRC Clamming Zones 30m Buffer

Ensures area not on VMRC Clamming Zones

Output polygons = Feasible_Area_Step_13. Area = 413.2 **DONE**

14) Delete polygons < = 1 acre
Output polygons = Feasible_Area_Step_14. Area = 403.3 **DONE**

15) Export Shell Dominant Bottom polygons (Shell bottom area feasible for cultch addition)

A) Output polygons = Feasible_Shell_Bottom_Area_Step_15. Area = 124.9 **DONE**

B) Remove 250 ft buffer around registered archaeological sites
Output polygons = Feasible_Shell_Bottom_Area_Step_15_NO_ArcheoSites. Area = 120.8 **DONE**

16) Export Shell Sub-Dominant Bottom polygons (sediment with shell: includes sand&shell, muddy-sand&shell, and sandy-mud&shell)

A) Output polygons = Feasible_SedimentShell_Bottom_Area_Step_16. Area = 40.6 **DONE**
B) Remove 250 ft buffer around registered archaeological sites

Output polygons = Feasible_SedimentShell_Bottom_Area_Step_16_NO_ArcheoSites. Area = 39.4 **DONE**

17) Export NON Shell Bottom polygons (Non-shell bottom area feasible for substrate reef construction)

A) Output polygons = Feasible_NONShell_Bottom_Area_Step_17. Area = 237.7
B) Remove 250 ft buffer around registered archaeological sites

Output polygons = Feasible_NONShell_Bottom_Area_Step_17_NO_ArcheoSites. Area = 226.9 **DONE**