Great Wicomico River Oyster Restoration Tributary Plan

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

December 2020

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 (e.g., 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 Chesapeake Bay Program partnership, which includes federal, state, and local government, nongovernmental organizations, academic institutions, and other groups. 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 (Sustainable Fisheries 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 Great Wicomico 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 122.25 acres of reefs on the river. Ninety-nine acres of reefs already meet the Oyster Metrics success criteria. These are a combination of past restoration efforts by the U.S. Army Corps of Engineers (USACE), and reefs managed by the Virginia Marine Resources Commission (VMRC). This leaves an additional 22.5 acres that still need to be restored in the river (Table 1).

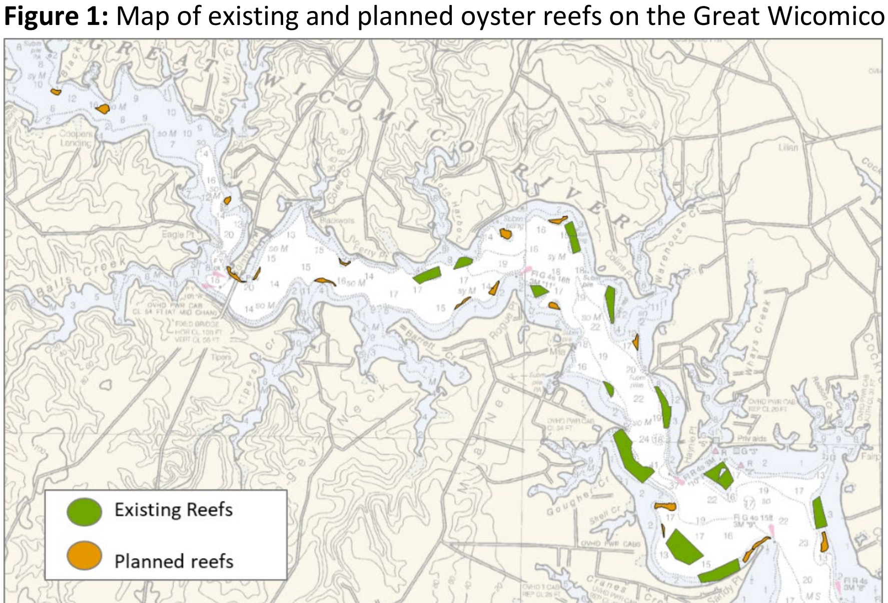
The cost estimate for completing the remaining acreage is $1 million, depending on variables including construction techniques, construction materials, prerestoration river bottom conditions at each reef site, and other factors. (See Section V: Cost Estimate.)

The Workgroup partners intend to work collaboratively to secure funding for and complete the restoration of the remaining 22.5 acres of oyster reefs by the 2025 deadline described in the 2014 Chesapeake Bay Watershed Agreement. Monitoring may need to extend beyond the 2025 implementation deadline.

Table 1: Great Wicomico River oyster restoration target, existing restored area, and cost estimate.

Restoration goal for the Great Wicomico River	122.25 acres
Already restored *(existing premet restoration projects)*	99.75 acres
Remaining area to be restored	22.5 acres
Cost estimate to restore remaining area	$1 million (*rounded*)

Figure 1: Map of existing and planned oyster reefs on the Great Wicomico 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 Oyster Restoration Workgroup, which coordinates work in the Piankatank, lower York, and Great Wicomico rivers, developed this document. (The second Virginia workgroup is the Hampton Roads Oyster Restoration Workgroup, which coordinates work in the Lafayette and Lynnhaven rivers).

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:
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 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 Great Wicomico River as Tributary for Large-Scale Oyster Restoration under the Chesapeake Bay Watershed Agreement Oyster Outcome, and Definition of the River Subsegment

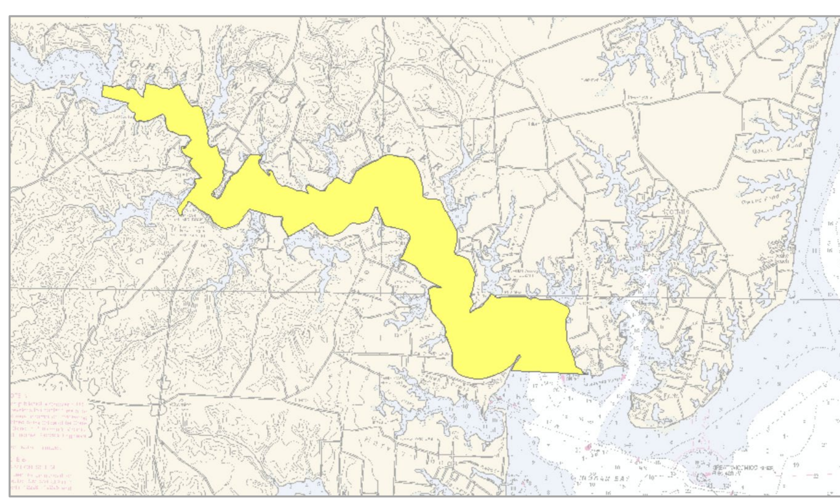
Several factors led to the selection of the Great Wicomico River for large-scale oyster restoration under the Chesapeake Bay Watershed Agreement.

- In 2012, USACE completed the Native Oyster Restoration Master Plan,[4] which evaluated 63 tributaries of the Chesapeake Bay watershed. The document prioritized rivers based on historical, physical, and biological attributes to support selfsustaining oyster populations in large-scale oyster restoration efforts. In this document, the Great Wicomico River was designated as a Tier One tributary, indicating it was an appropriate location for oyster restoration.
- The Great Wicomico River has historically exhibited strong oyster recruitment (natural spat set).[4]
- There are large areas of hard river bottom available for restoration and extensive existing oyster reefs, including oyster leases, in the river.
- Extensive restoration work has already been undertaken on the river. This includes work by USACE and VMRC under the first USACE plan[5] recommending large-scale sanctuary reef restoration and selecting the Great Wicomico River as a priority site. Most of these reefs have exceeded the Oyster Metrics success criteria for oyster density and biomass.
- USACE and VMRC support cost sharing for oyster restoration efforts in this tributary.
- The Virginia Interagency Oyster Team endorsed the selection of the Great Wicomico as a targeted tributary.

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

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

Figure 2: Subsegment (yellow area) of the Great Wicomico River selected for large-scale oyster restoration under the '10 tributaries' oyster restoration goal.

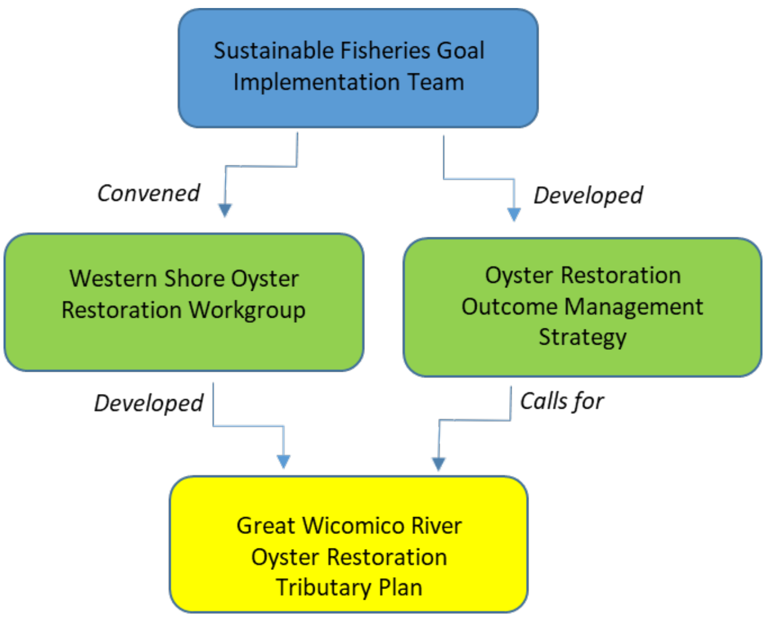


- The entire river segment is within a single HUC-12 (hydrolic unit code) boundary.
- The downstream boundary:
  - Aligns closely with the HUC-12 boundary;
  - Is a natural downriver end of the river;
  - Encompasses all existing restoration work; and
  - Excludes the harvest reefs downstream of the line.
- The upstream boundary:
  - Roughly aligns with the upstream extent of suitable oyster salinity, based on a published habitat suitability index;[6]
  - Excludes upstream areas with the low spat settlement and little influx of oyster larvae, based on a published habitat suitability index;[6]
  - Represents the upstream-most extent of oyster leases and known oyster reefs; and

- Is the upstream extent of NOAA's benthic habitat survey.

1.4 Organizational Framework

Figure 3: Organizational Framework for Large-Scale Oyster Restoration in Great Wicomico 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 Oyster Restoration Workgroup (working in the Piankatank, Great Wicomico, and lower York rivers) and the Hampton Roads Oyster Restoration Workgroup (working in the Lafayette and Lynnhaven rivers). The Western Shore Oyster Restoration 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[7] 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 Oyster Restoration Workgroup developed this document. It is meant as a guide to 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 Great Wicomico River.

Section 2: Current Status of Great Wicomico River Oyster Resources

The Great Wicomico 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 oyster grounds (including seed areas), private oyster grounds, and sanctuary (nonharvest areas).

The Workgroup cataloged reefs in the river that already meet Oyster Metrics success criteria (Table 2; also see Appendix A for analysis of reef meeting Oyster Metrics success criteria). These areas total 99.75 acres, and consist of oyster restoration projects built by USACE and managed by VMRC on an ongoing basis.

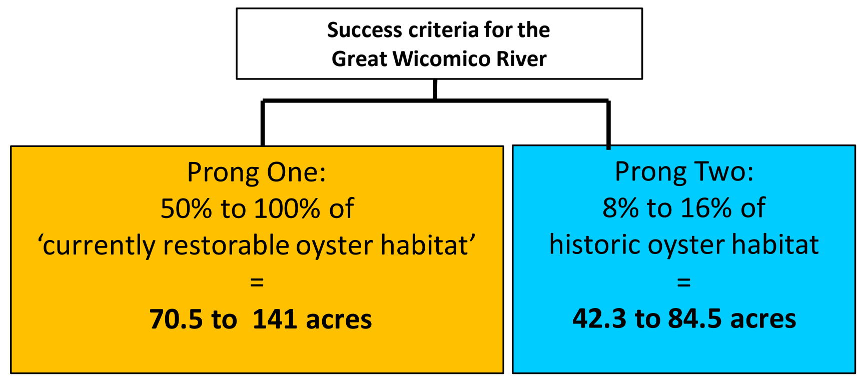
Table 2: Existing Great Wicomico River oyster restoration projects. These projects were present in the river prior to development of this document, and are considered premet, meaning they met the Oyster Metrics density success criteria prior to the drafting of this Blueprint. They are colored green in Figure 1.

Site_ID	Reef_Name	Reef_Material	Construction_ Year	Project_Lead	US_Acres	Status
GW_01	GW CORP AREA 1 AND 2	Oyster Shell	2004	USACE/VMRC	5.96	Premet
GW_02	#3 GW CORP	Oyster Shell	2004 & 2015	USACE/VMRC	3.41	Premet
GW_03	#4 GW CORP	Oyster Shell	2004	USACE/VMRC	2.82	Premet
GW_04	#9 GW CORP	Oyster Shell	2004	USACE/VMRC	7.07	Premet
GW_05	GW CORP AREA 10 AND 11	Oyster Shell	2004	USACE/VMRC	19.57	Premet
GW_06	#8 GW CORP	Oyster Shell	2004	USACE/VMRC	1.89	Premet
GW_07	#13 GW CORP	Oyster Shell	2004	USACE/VMRC	5.03	Premet
GW_08	#16 GW CORP	Oyster Shell	2004	USACE/VMRC	7.25	Premet
GW_09	HARCUM FLATS	Oyster Shell	<Null>	USACE/VMRC	5.98	Premet
GW_10	HAYNIE BAR	Oyster Shell	<Null>	USACE/VMRC	4.74	Premet
GW_11	HILLY WASH	Oyster Shell	<Null>	USACE/VMRC	3.24	Premet
GW_12	ROGUE POINT	Oyster Shell	<Null>	USACE/VMRC	3.35	Premet
GW_13	SANDY POINT	Oyster Shell	<Null>	USACE/VMRC	11.75	Premet
GW_14	SHELL BAR	Oyster Shell	<Null>	USACE/VMRC	17.69	Premet
					99.76	

Information on past restoration projects, leased areas, and other features is available in the Great Wicomico 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

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



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*[7] within the restoration constraints determined by the Workgroup. Per the revised definition adopted by the Sustainable Fisheries GIT in December 2017,[8] 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.

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

- River extent: The portion of the Great Wicomico 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 14 feet were considered restorable. The 14-foot maximum depth was set due to concerns about potential hypoxia at greater depths. This is slightly shallower than the 16-foot deep-water limit set in the Piankatank River, as Workgroup consensus is that there could be issues with low dissolved oxygen. 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 Great Wicomico River reefs should be constructed subtidally to avoid oyster mortality that occurs when intertidal reefs are exposed to freezing air temperatures. This shallow-depth limit is the same as that used in the Piankatank River, which is ecologically similar.
- Benthic habitat (river bottom) type: NOAA sonar survey and ground-truthing data (2018 & 2019) were classified using the Coastal and Marine Ecological Classification Standards.[9] 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,[4] all Chesapeake tributaries (including the Great Wicomico) 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; and 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 Great Wicomico was considered suitable for oyster restoration per these parameters (see Appendix A for details). Data from Chesapeake Bay Program water-quality monitoring sites stations in or near the Great Wicomico River segment stations were interpolated to the entire river segment (see Appendix A). Beyond the data available from these stations, the approach in this Blueprint is to use depth as proxy for potentially

hypoxic areas. The USACE Master Plan,[4] which included water-quality analysis, ranked the Great Wicomico as a ‘Tier 1’ tributary for oyster restoration.

- Correction factor for inflated CROH in the Great Wicomico River:
  - Issue: Unlike the other nine tributaries identified for large-scale restoration under the 2014 Chesapeake Bay Watershed Agreement oyster outcome, the Great Wicomico River has had huge amounts of shell additions over many decades. This is due to two main factors. First, large portions of the river bottom have been privately leased over many decades. Leaseholders typically enhance their leases by adding shell. Second, there have been several major oyster restoration efforts in the river, also going back many decades. The initial effort was undertaken in the 1960s by VMRC’s predecessor agencies (Commission of Fisheries and Bureau of Commercial Fisheries). Through this, millions of bushels of shells were planted on Baylor bottom in an attempt to develop seed areas that were resistant to the oyster disease MSX, which was decimating the industry at the time. The next wave of restoration started in 2004, in partnership with USACE. Again, millions of bushels of shell were planted on areas of the Baylor bottom. It is likely that these past efforts are the reason that such a large portion of the river bottom meets the current oyster metrics. However, it also makes determining CROH using the current methods problematic because the shell additions artificially inflate CROH.
  - Resolution: Given that applying the methods used to determine CROH on past tributaries would artificially inflate the number of CROH acres in the Great Wicomico River (hereafter referred to as ‘inflated CROH’), the Workgroup developed a correction factor. The Workgroup recognizes it is difficult to develop a perfect correction factor, given that it is not possible to determine which shell, or how much, has been added over the decades. Anthropogenic and natural shell are often indistinguishable. In the absence of a perfect correction factor, the Workgroup applied a correction factor of .4 to the inflated CROH value. The .4 correction factor is a consensus number agreed to by the Workgroup. It is based on the correction factor used in the USACE Master Plan. USACE adopted a goal of restoring from 20% to 40% of assumed acreage, in keeping with Marine Protected Area size recommendations from the literature as cited in the Master Plan.[4] See Appendix A for details on how the correction factor was applied to inflated CROH values. There is precedent for correcting goal-setting methods under the ‘10 tributaries’ initiative when the standard methodology is not appropriate to apply in a particular tributary. For example, this was done in the Piankatank River Blueprint[10] for the analysis of the historic reef area (the equivalent of ‘Prong Two’ in Figure 4), as it was deemed inaccurate to apply the standard methodology.

Using the above parameters, 141 acres were classified as CROH (Figure 4 and Appendix A). Therefore, to meet Prong One of the Oyster Metrics definition of a restored tributary, between 70.5 and 141 acres of reefs will need to be restored. Prong Two of the Oyster Metrics[2] restored tributary test calls for restoring at least 8% to 16% (Figure 4) of the river’s historic acreage of oyster reefs. In the Great Wicomico River, consistent with the USACE Native Oyster Restoration Master Plan, 8% to 16% of historic reef acreage within the Great Wicomico River segment is 42.3 to 84.5 acres. Because 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 70.5 and 141 acres.

From there, the Workgroup set a target of restoring 122.25 acres in the Great Wicomico River, which is approximately 87% of CROH. This target was set by Workgroup consensus. It was developed by considering:

- The Prong 1 goal range (70.5 to 141 acres),
- The fact that 99.75 acres within the river already meet the Oyster Metrics definition of a restored reefs (these are a combination of existing restoration projects constructed by USACE and reefs managed continuously by VMRC), and
- The fact that 22.5 acres in the river are feasible for reef construction. To be considered feasible for reef construction, a site was required to meet the following conditions (see Appendix A for details):

- In 6-14 feet of water depth;
- Outside of oyster leases, navigation channels, VOSARA sites, VMRC Shellfish Condemnation Zones, and SAV boundaries (per composite VIMS 2007-2016 SAV footprint);
- On appropriate river bottom type (either on shell dominant bottom, or on hard, non-shell bottom);
- Not within 30 meter buffer around oyster leases;
- Not within 250 foot buffer around navigation aids or private docks;
- Not within 50 meter buffer around VOSARA sites;
- Not within 30 meter buffer around VMRC clamming zones; and
- On a contiguous polygon greater or equal to 0.5 acres.

Table 3: Accounting of area (acres) that remains to be restored as of the drafting of this plan (late in calendar year 2020)

Restoration target	122.25 acres
Existing restored areas	99.75 acres
Remaining areas the need to be restored *(as of fall 2020)*	22.5 acres

Section 4: Planned Oyster Restoration in the Great Wicomico River

4.1 Proposed Oyster Reef Construction

The predominant 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. Reefs will likely be constructed using varying amounts of substrate, depending on existing river bottom type. Where suitable shell bottom already exists, lesser amounts of substrate can be used for reef construction. Conversely, in areas with hard river bottom but little or no shell substrate, more substrate (piled higher) will be required. See Section 5: Cost Estimate for acreage breakdown among treatment types and descriptions. It may be possible on some reefs to also deploy larger material, such as very large stone (boulders) or prefabricated concrete structures. These may provide additional reef structure while potentially serving as a poaching deterrent. Deploying such structures may increase the cost of reef construction. For example, a USACE oyster reef restoration project in the Great Wicomico River was substantially reconstructed to bring some low-relief reefs (a few inches in height) to high-relief in height (at least one foot) to improve their performance, and to counteract possible poaching and sedimentation (David Schulte, pers. comm.). Costs associated with this were approximately $2.77 million.[11]

Figure 5 shows the 99.75 acres of reefs that already meet the Oyster Metrics success criteria (in green). It also identifies the 22.5 acres planned for restoration work (in orange and red). These proposed restoration areas were determined using the reef construction feasibility criteria listed in Section 3. Additionally, Figure 5 shows two polygons (GW_31 and GW_32) near Glebe Point that are potential sites for reef construction by USACE. These were added because historically they had some of the highest natural oyster recruitment in the River[12]. These sites are close to VIMS and VMRC annual dredge surveys, so any reef construction will be done in coordination with VIMS and VMRC to avoid conflict.

Figure 5: Map of completed restoration projects and proposed restoration areas. Reef numbers can be cross-referenced with Table 4.

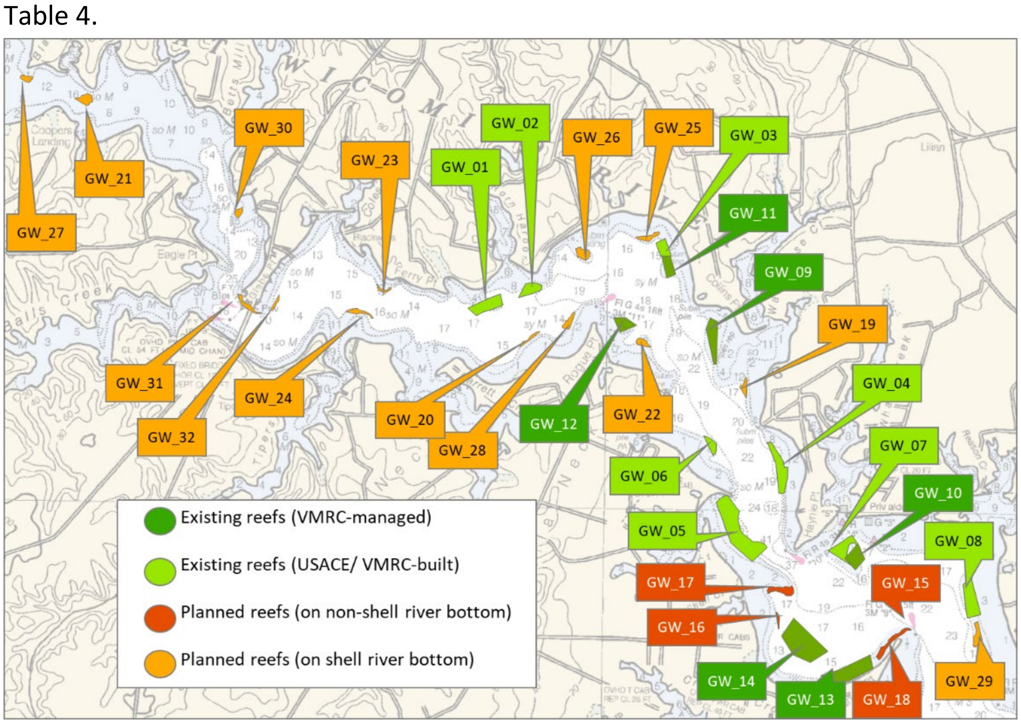


Table 4: Existing and proposed oyster reefs on the Great Wicomico River.

Site_ID	Reef_Name	Status	Project_Lead	BottomType	US_Acres
GW_01	GW CORP AREA 1 AND 2	Premet	USACE/VMRC	N/A	5.96
GW_02	#3 GW CORP	Premet	USACE/VMRC	N/A	3.41
GW_03	#4 GW CORP	Premet	USACE/VMRC	N/A	2.82
GW_04	#9 GW CORP	Premet	USACE/VMRC	N/A	7.07
GW_05	GW CORP AREA 10 AND 11	Premet	USACE/VMRC	N/A	19.57
GW_06	#8 GW CORP	Premet	USACE/VMRC	N/A	1.89
GW_07	#13 GW CORP	Premet	USACE/VMRC	N/A	5.03
GW_08	#16 GW CORP	Premet	USACE/VMRC	N/A	7.25
GW_09	HARCUM FLATS	Premet	USACE/VMRC	N/A	5.98
GW_10	HAYNIE BAR	Premet	USACE/VMRC	N/A	4.74
GW_11	HILLY WASH	Premet	USACE/VMRC	N/A	3.24
GW_12	ROGUE POINT	Premet	USACE/VMRC	N/A	3.35
GW_13	SANDY POINT	Premet	USACE/VMRC	N/A	11.75
GW_14	SHELL BAR	Premet	USACE/VMRC	N/A	17.69
GW_15	Un-named	Proposed	Unknown	Non-shell bottom	1.46
GW_16	Un-named	Proposed	Unknown	Non-shell bottom	0.49
GW_17	Un-named	Proposed	Unknown	Non-shell bottom	2.69
GW_18	Un-named	Proposed	Unknown	Non-shell bottom	1.41
GW_19	Un-named	Proposed	Unknown	Shell bottom	1.15
GW_20	Un-named	Proposed	Unknown	Shell bottom	0.83
GW_21	Un-named	Proposed	Unknown	Shell bottom	2.01
GW_22	Un-named	Proposed	Unknown	Shell bottom	1.23
GW_23	Un-named	Proposed	Unknown	Shell bottom	0.58
GW_24	Un-named	Proposed	Unknown	Shell bottom	1.32
GW_25	Un-named	Proposed	Unknown	Shell bottom	1.55
GW_26	Un-named	Proposed	Unknown	Shell bottom	2.09
GW_27	Un-named	Proposed	Unknown	Shell bottom	1.00
GW_28	Un-named	Proposed	Unknown	Shell bottom	1.46
GW_29	Un-named	Proposed	Unknown	Shell bottom	2.31
GW_30	Un-named	Proposed	Unknown	Shell bottom	0.92
GW_31	Un-named	Proposed	Unknown	Shell bottom	1.61
GW_32	Un-named	Proposed	Unknown	Shell bottom	0.63

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 Great Wicomico River is restored consistent with the 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 Great Wicomico 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. These documents are available at https://www.chesapeakebay.net/who/publications-archive/maryland_and_virginia_oyster_restoration_interagency_teams.

Section 5: Cost Estimate

Restoration partners may use a variety of substrates and techniques to construct oyster reefs in the Great Wicomico 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 22.5 acres of reefs still required on the river, 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 will be constructed to varying heights, depending on existing river-bottom substrate type.
  - Non-shell river bottom (most intensive restoration treatment; 6 acres). 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 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.[10] This per-acre cost estimate has not been adjusted for inflation or other cost increases from 2018.
  - Shell river bottom (16.5 acres). Of the reefs to be constructed on shell river bottom, half (8.25 acres) will have suitable existing shell substrate, and will therefore require the least-intensive restoration treatment, such as 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 Great Wicomico River (Andrew Button, VMRC, pers. comm.), and the low-end per-acre cost estimate developed in the Piankatank Blueprint.[10] The remaining half of the reefs (8.25 acres) to be constructed on shell river bottom will have less shell substrate and therefore require moderately intensive restoration treatment. These 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 least-intensively treated reef sites.

Using these assumptions yields a rounded cost estimate of just under $1 million to complete the remaining planned oyster reef construction on the Great Wicomico River (Table 5).

Table 5: Calculations for the cost estimate for completing oyster restoration in the Great Wicomico River.

Restoration Treatment Level	Acres projected to need this treatment	Estimated cost per acre	Cost for this treatment type
Non-shell areas: most intensive restoration treatment	6	$80,000	$480,000
Shell areas: moderately intensive restoration treatment	8.25	$46,750	$385,688
Shell areas: least intensive restoration treatment	8.25	$13,500	$111,375
Total acres needing treatment	22.5		
Total estimated cost			**$977,063**

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 did extensive public outreach during its Environmental Assessment process for the project Chesapeake Bay Oyster Recovery, Great Wicomico River, Virginia, https://www.nao.usace.army.mil/About/Projects/Oyster-Restoration. Further public outreach was done in the course of conducting the required permit process for reefs constructed prior to this plan. Input received through these processes was incorporated into this Blueprint document. In the future, additional public input will also be collected through the permit process required for constructing the reefs described in this Blueprint. The Blueprint will be adapted as needed based on this input.

To keep interest parties informed, partners will continue to produce annual update documents describing progress made in Virginia toward the '10 tributaries' oyster restoration goal. These updates will be available at https://www.chesapeakebay.net/who/publications-archive/maryland_and_virginia_oyster_restoration_interagency_teams.

Section 7: Monitoring

7.1 Monitoring Relative to Oyster Metrics Success Criteria

The main objective of monitoring efforts in the Great Wicomico River is to determine whether the restored reefs can be considered successful per the Oyster Metrics standards. There are examples of appropriate sampling and analysis methodology in the Oyster Metrics report itself, USACE/VIMS monitoring of the USACE-built reefs in the Great Wicomico River,[14,15] and in the Maryland monitoring reports.[15,16,17] According to the Oyster Metrics 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 report)

Biological Metrics	Oyster density	Minimum threshold = 15 oysters per m^2 over 30% of the reef area; Target = 50 oysters per m2 over 30% of the reef area
	Oyster biomass	Minimum threshold = 15 grams dry weight per m2 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 baseline
	Reef height	Stable or increasing reef height compared to baseline

In keeping with the Oyster Metrics report, and assuming funding can be secured, these parameters (Table 6) will be monitored on the Great Wicomico 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 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 Great Wicomico River. Oyster disease information will be obtained where available from VMRC and various academic and research programs.

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Appendix A:

Great Wicomico River Oyster Restoration

Restorable Bottom Assessment

NOAA Chesapeake Bay Office

07/06/2020

Background

This document identifies the location and area suitable for oyster restoration in the Great Wicomico River based on existing spatial data.

Among the items contained here are:

1) An inventory of available restoration-relevant spatial data
2) An estimate of "evidence-based" restoration target of Currently Restorable Oyster Habitat (CROH) derived from 2009 and 2019 habitat survey data
3) An estimate of Historic Oyster Habitat (HOH)
4) An assessment of baseline oyster density on VOSARA sites
5) An estimate of area and location feasible for high and low relief reef construction based on existing survey and exclusionary data layers
    a. High-relief reef restoration: large substrate material placed on non-shell river bottom at heights of 1 ft or greater, deployed with a crane and clamshell bucket
    b. Low-relief restoration: small substrate material distributed in thin layers on shell bottom, deployed with a water cannon
6) First draft of the Restoration Blueprint. This is a GIS layer that identifies location and area of completed and planned restoration sites

GIS layers were geoprocessed using decision thresholds similar to those used in the Piankatank and York rivers and other Virginia and Maryland restoration projects.

Summary 1: Great Wicomico Restoration Area Target Estimates (Inflated and Corrected CROH) 05/15/2020

Currently Restorable Oyster Habitat (CROH) target (depth = 4.0-14.0 Ft MLLW)	**352 acres[a]**
INFLATED 50% of CROH target	**176 acres**
CORRECTED Currently Restorable Oyster Habitat (CROH) target (depth = 4.0-14.0 Ft MLLW)	**141[a]**
CORRECTED 50% of CROH target	**70**
Area meeting the restoration success density metric (50 live oysters/m^2 over 30% of site - 2012-2017)	**99 acres**
Estimated area suitable (Feasible) for High Relief Reef Restoration	**7[b]**
Estimated area suitable (Feasible) for Low Relief Reef Restoration	**17[b]**
Sum area: meets Target + suitable for High & Low Relief Reef Restoration	**124[b]**
Percent of CROH that meets Target+ High & Low Relief Reef Restoration	**35%**
Percent of CORRECTED CROH that meets Target+ High & Low Relief Reef Restoration	**88%**

Notes:

[a] Corrected CROH (141 ac.) was calculated as 40% of original CROH (352 ac.). See page 12 for CROH target estimation methods.

[b] Feasible restoration area values presented here (sum = 124 ac) come from raw geo-processed polygons. Boundaries of these restoration sites in the blueprint GIS layer (Blueprint v. 06022020/Geodatabase v. 06012020) were simplified to reduce the number of vertices. This resulted in a loss of 4 acres (sum = 120 acres; see page 18). The 120 blueprint acres represent 85% of Corrected CROH.

Summary 2: Processing Table: Area Feasible for High-Relief Reef Construction (Restoration of Non-Shell Bottom with Large Substrate), 6-14 ft. Depths

This table documents the steps used to determine area feasible for high relief substrate reef construction. Similar methods were used in other VA and MD restoration projects			
	Layer	**Area (acres)**	**Data Source**
	NEW Draft Project Extent	2305	**NOAA CBO**
	NEW CMECS Extent (source area data)	1790	**NOAA CBO**
Feasible High-Relief Substrate Reef Area Geoprocessing			
Step	**Geoprocessing Action**	**Area Remaining After Geoprocessing (acres)**	**Data Source**
1	Remove depths less than 6 ft. and greater than 14 ft.	620	**NOAA Survey Soundings**
2	Remove shell dominant, sandy mud and mud bottoms (keep sand & muddy sand, with and without shell)	100	**NOAA CBO**
3	Remove intersection with 30 m buffers around oyster leases	17	**VMRC**
4	Remove intersection with composite 2007-2016 SAV footprint	17	**VIMS**
5	Remove intersection with 250ft buffer around navigation aids	16	**2016 USCG Light List**
6	Remove intersection with 250ft buffer around private docks	13	**VIMS**
7	Remove intersection with maintained navigation channels	13	**USACOE**
8	Remove intersection with 50m buffers around VOSARA sites	10	**VMRC**
9	Remove intersection with 30 buffers around VMRC Clamming Zones	10	**VMRC**
10	Remove intersection with VMRC Shellfish Condemnation Zones	10	**VMRC**
11 FINAL	Remove polygons (slivers) less than 0.50 acres => 4 sites, 0.54-3.1 acres, sum area = 6.5 acres.	6.5	

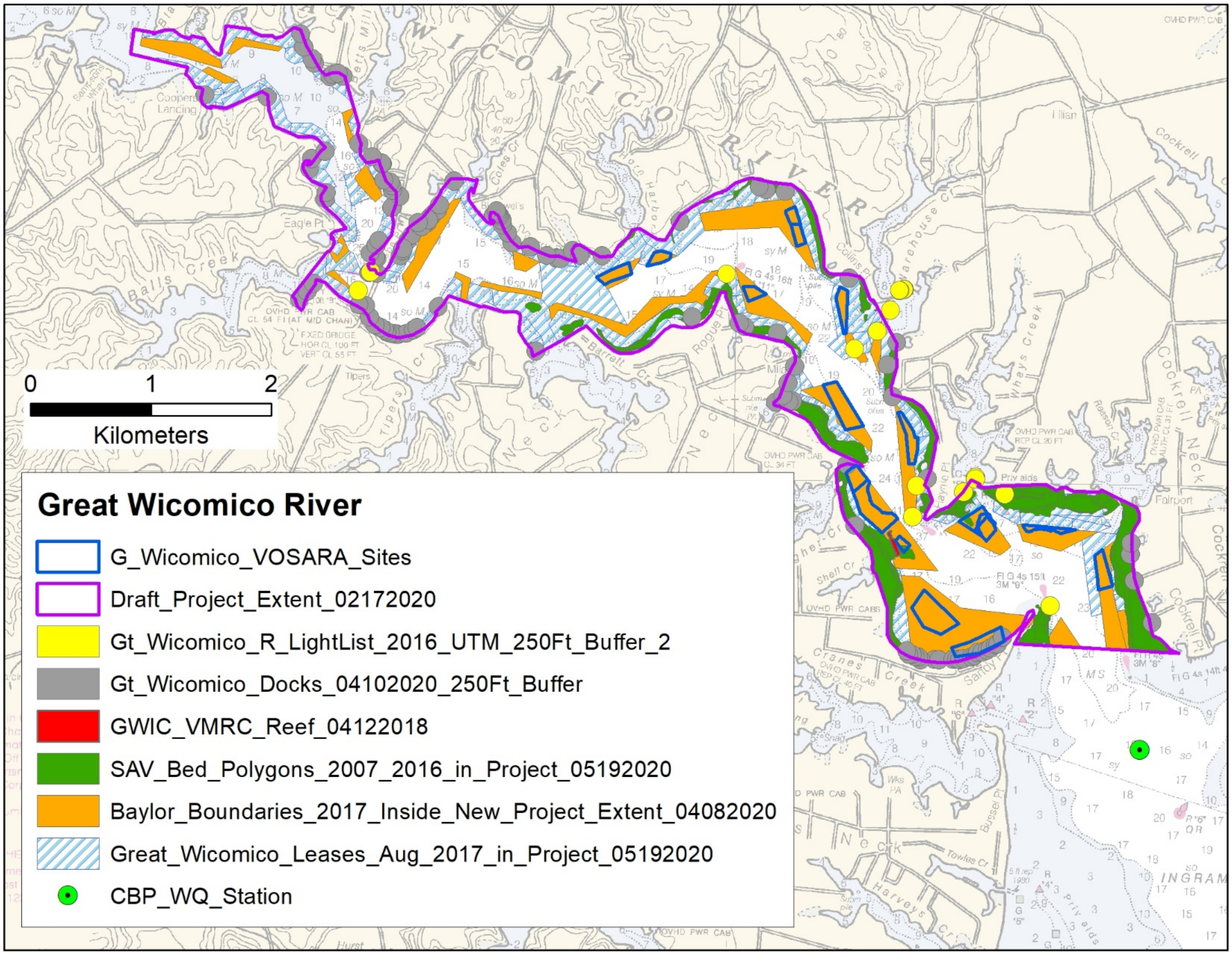
Summary 3B: Processing Table: Area Feasible for Low-Relief Reef Construction (Restoration of Shell Bottom with Small Substrate) 6-14 ft. Depths

This table documents the steps used to determine area feasible for low relief substrate reef construction. Similar methods were used in other VA and MD restoration projects			
	Layer	**Area (acres)**	**Data Source**
	Draft Project Extent	2305	**NOAA CBO**
	2009 Bottom Survey Extent (source area data)	1789	**NOAA CBO**
Feasible Low-Relief Substrate Reef Area Geoprocessing			
Step	**Geoprocessing Action**	**Area Remaining After Geoprocessing (acres)**	**Data Source**
1	Remove non-shell bottom	404	**NOAA CBO**
2	Remove sonar footprint of USACE restoration sites	307	**NOAA CBO**
3	Remove intersection with 30 m buffers around oyster leases	112	**VMRC**
4	Remove depths less than 6 ft. and greater than 14 ft.	50	**NOAA Survey Soundings**
5	Remove intersection with composite 2007-2016 SAV footprint	50	**VIMS**
6	Remove intersection with 250ft buffer around navigation aids	50	**2016 USCG Light List**
7	Remove intersection with 250ft buffer around private docks	45	**VIMS**
8	Remove intersection with maintained navigation channels	45	**USACOE**
9	Remove intersection with 50m buffers around VOSARA sites	20	**VMRC**
10	Remove intersection with 30 buffers around VMRC Clamming Zones	20	**VMRC**
11	Remove intersection with VMRC Shellfish Condemnation Zones	20	**VMRC**
12 Final	Remove polygons (slivers) less than 0.5 acres => 12 Sites, 0.6-2.3 acres, sum area = 16.7 cres	17	

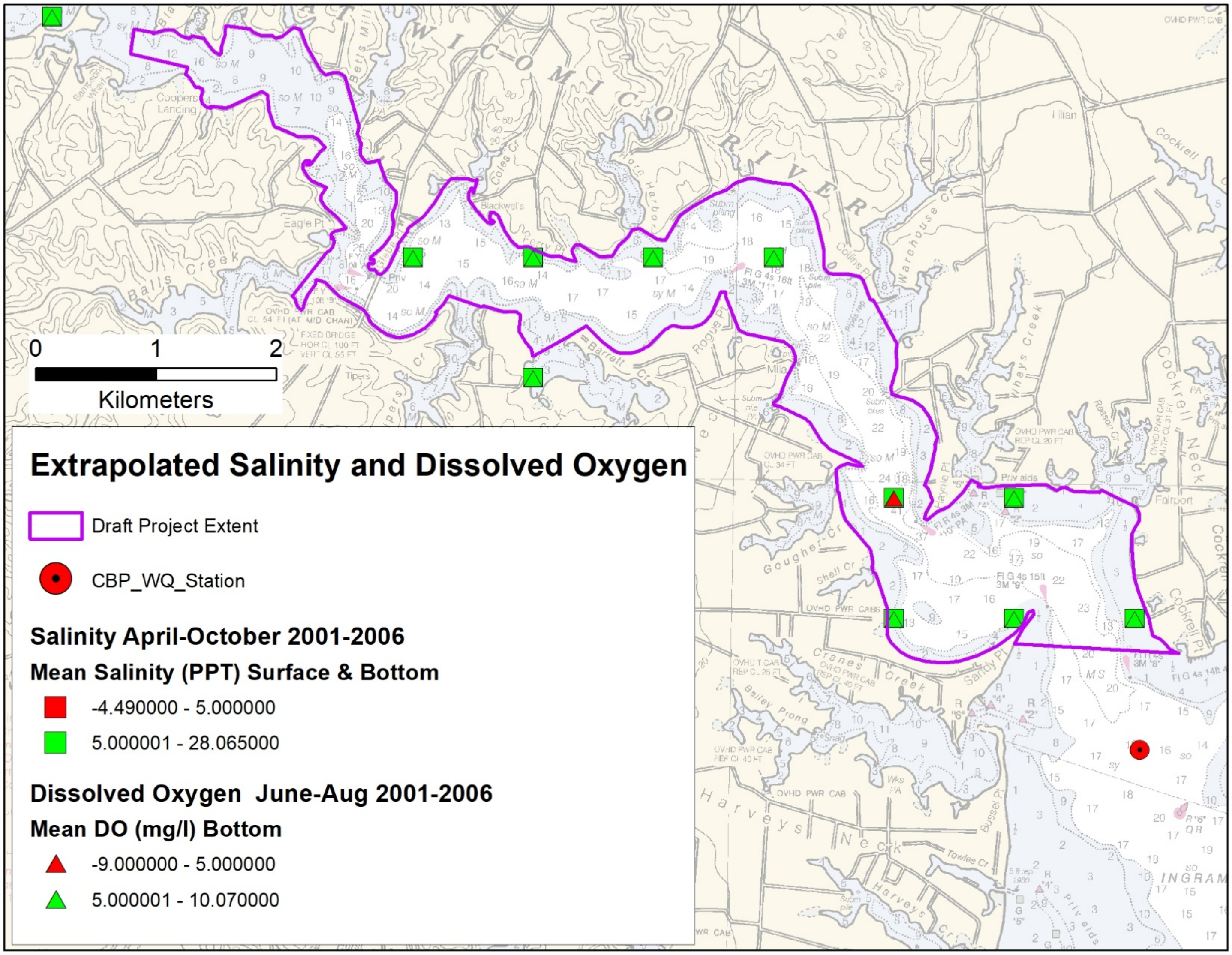
Spatial Data Inventory

Category	Number of features	Acres
Project Boundary (May 2020)	1	2,305.8
Benthic Habitat Characterization Footprint	204	1,789.7
Baylor Grounds	27	527.9
Aquaculture Leases	123	843.9
Aquaculture Leases 30m Buffer	123	1465
VOSARA Sites	17	116.9
VOSARA Sites 50m Buffer	17	294.8
VMRC 3D Reef	1	1.8
VMRC Clamming Zones	0	0
VMRC Shellfish Condemnation Zones	6	25.6
Depth 6-14 ft.	1	647.9
SAV Footprint 2007-2016	23	282.9
Docks 2014 250 Ft Buffer	129	581.5
Maintained Navigation Channels	0	0
Aids to Navigation in Sanctuary 250 Ft Buffer	17	76.6
CBP Water Quality Sampling Sites in Sanctuary	1	N/A

Map of Project Extent and Selected Spatial Data



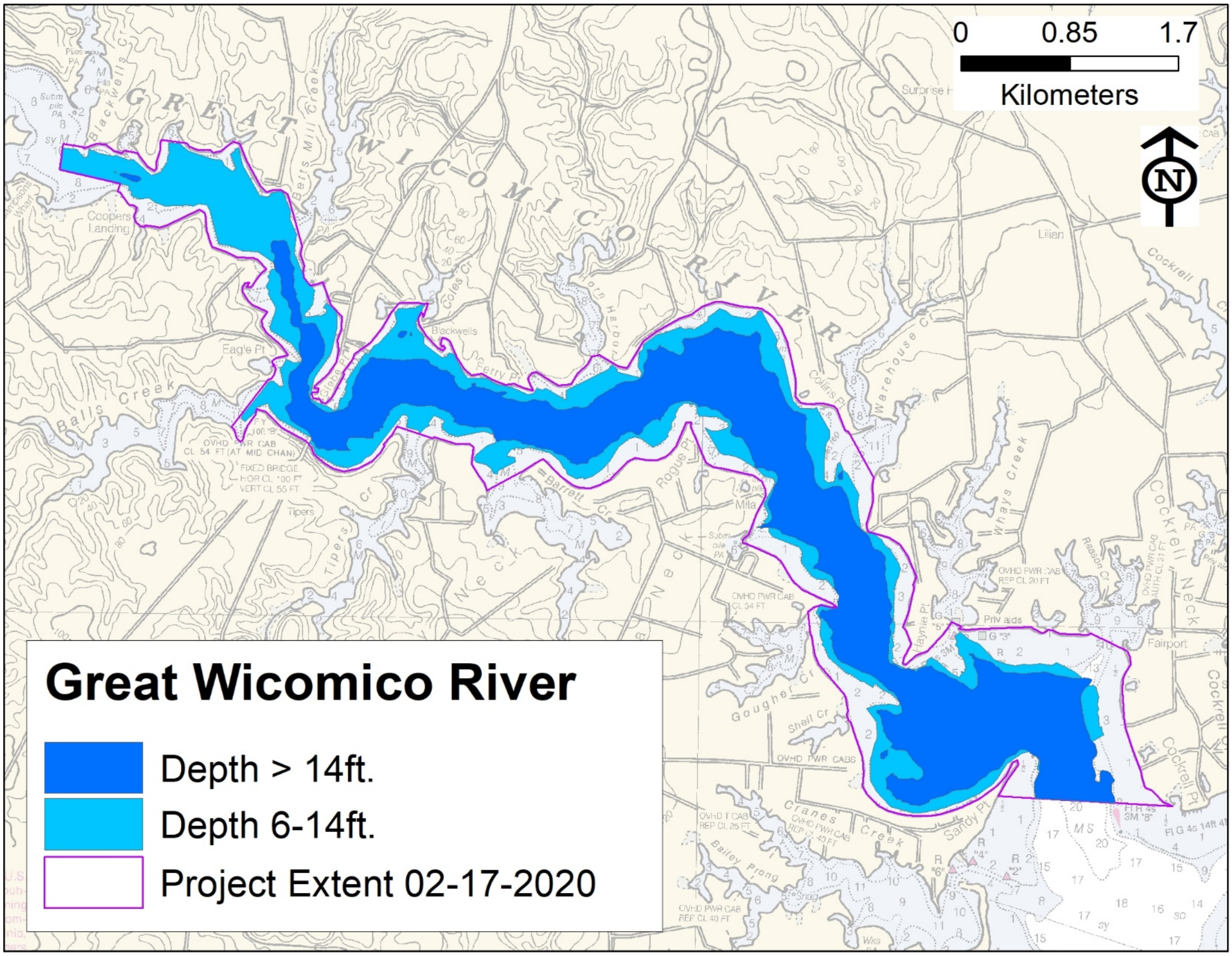
Extrapolated Salinity and Dissolved Oxygen, USACE Master Plan Criteria



The USACE 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 to August 2001-2006.

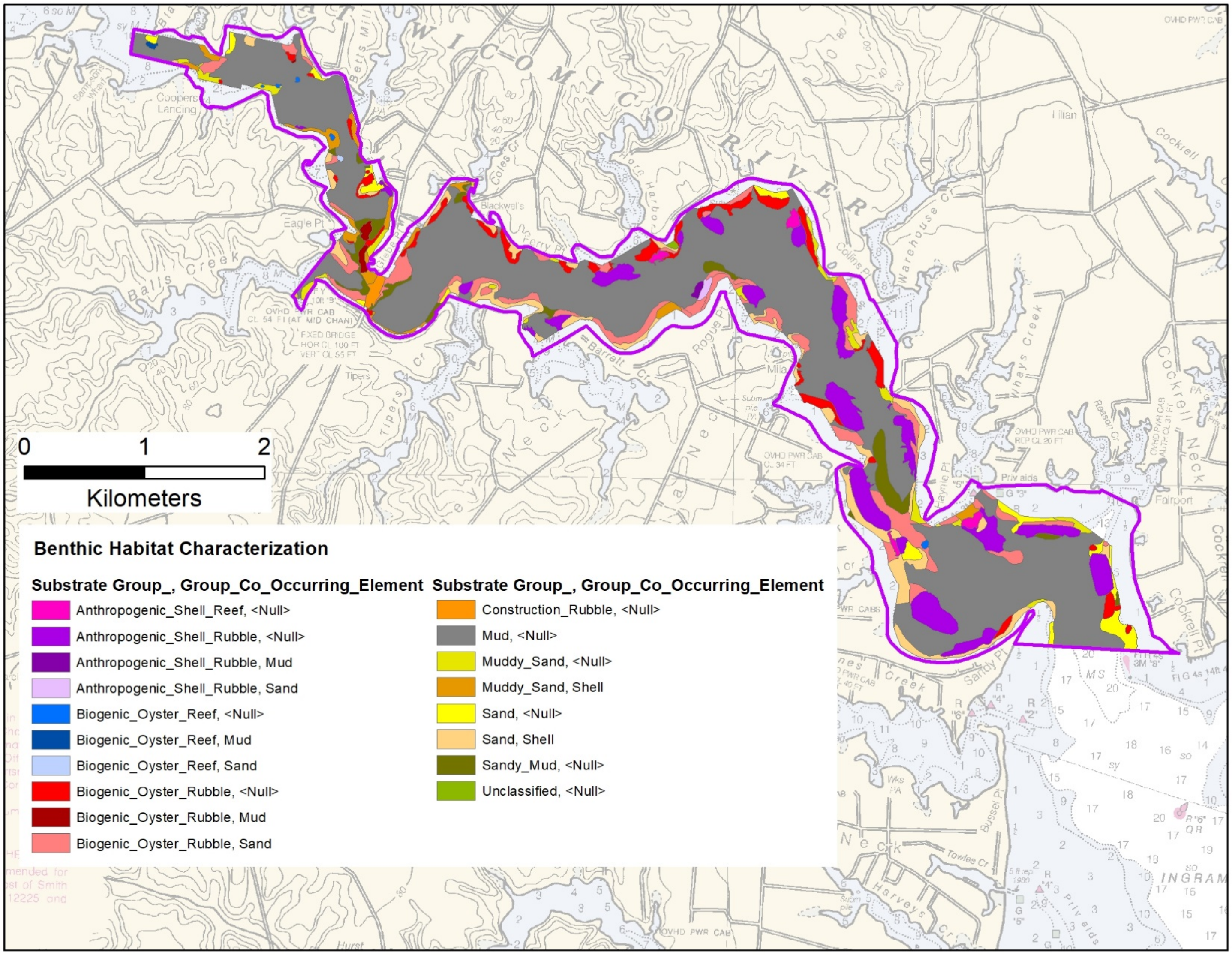
In above map, extrapolated water quality data are based on field samples collected at Chesapeake Bay Program (CBP) monitoring sites 2001-2006 and were derived with the Chesapeake Bay Interpolator. Data presented here suggest that salinity levels are adequate relative to Master Plan (green squares) and that DO levels may be critical (red triangle) on the bottom in the deeper areas of the central river channel.

Depth and Restoration



The USACE Oyster Restoration Master Plan absolute criteria for maximum depth is 20 feet MLLW. The targeted depths for substrate reef construction used in this assessment are 6-14ft. These values were adopted from standards set by the Western Shore Oyster Restoration Workgroup.

Bottom Habitat Characterization 09/16/2019



Above map identifies the distribution of bottom materials identified by the 2009 and 2019 NOAA Chesapeake Bay Office habitat surveys. An area summary is in table below.

Bottom Type Area Summary

Location	Substrate Group	Group Co-Occurring Element	Number Habitat Polygons	Sum Acres	Percent
Great Wicomico	Biogenic_Oyster_Reef	Sand	1	0.5	0.0
Great Wicomico	Biogenic_Oyster_Reef	Mud	1	1.0	0.1
Great Wicomico	Unclassified		1	1.1	0.1
Great Wicomico	Anthropogenic_Shell_Rubble	Mud	1	2.0	0.1
Great Wicomico	Biogenic_Oyster_Reef		5	2.1	0.1
Great Wicomico	Anthropogenic_Shell_Rubble	Sand	1	2.6	0.1
Great Wicomico	Biogenic_Oyster_Rubble	Mud	3	6.0	0.3
Great Wicomico	Construction_Rubble		1	6.0	0.3
Great Wicomico	Anthropogenic_Shell_Reef		4	10.8	0.6
Great Wicomico	Muddy_Sand		18	33.0	1.8
Great Wicomico	Muddy_Sand	Shell	12	34.4	1.9
Great Wicomico	Sand		14	41.0	2.3
Great Wicomico	Sandy_Mud		14	49.9	2.8
Great Wicomico	Biogenic_Oyster_Rubble		33	73.9	4.1
Great Wicomico	Sand	Shell	31	100.2	5.6
Great Wicomico	Biogenic_Oyster_Rubble	Sand	43	137.4	7.7
Great Wicomico	Anthropogenic_Shell_Rubble		21	167.1	9.3
Great Wicomico	Mud		11	1120.6	62.6
		Sum=	215	1789.7	100.0

Restorable Bottom Target Estimates (CROH & HOH) 05/18/2020

Method 1: Currently Restorable Oyster Habitat (CROH) based on distribution of shell bottom from recent habitat characterization (page 9) with a minimum depth of 4 ft. and a maximum depth of 14 ft. The actual restoration target would range from 50-100% of CROH.

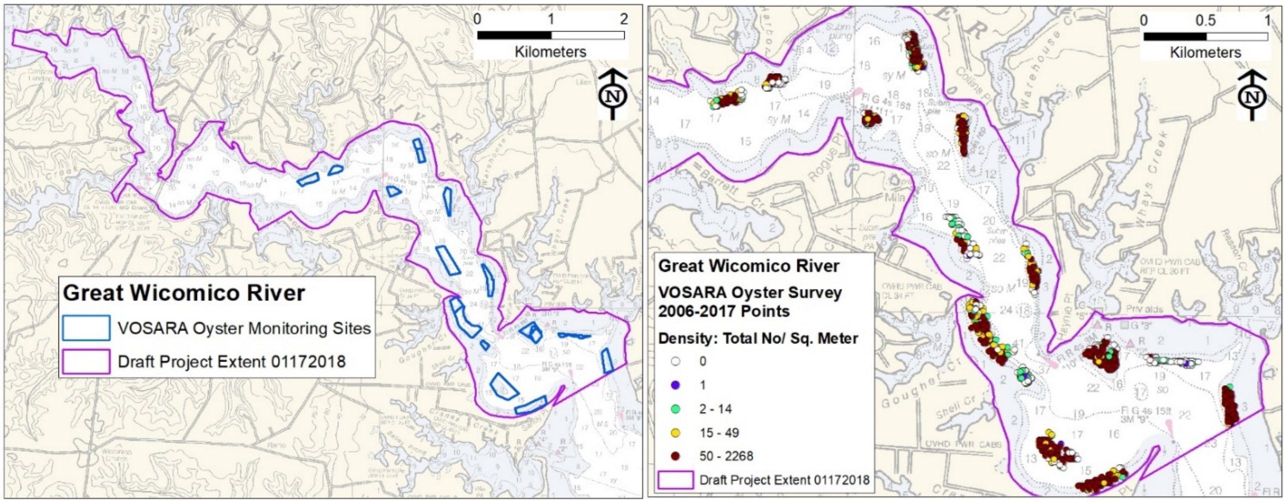
Area Summary: Setting the "Evidence Based" Restoration Target of Currently Restorable Oyster Habitat (CROH) at Depths Between 4 and 14 Ft

Location	Substrate Group	Group Co-Occurring Element	Number Polygons	Sum Acres	Percent
Gt. Wicomico	Biogenic_Oyster_Reef	Sand	1	0.2	0.0
Gt. Wicomico	Biogenic_Oyster_Rubble	Mud	2	0.7	0.1
Gt. Wicomico	Biogenic_Oyster_Reef	Mud	1	1.0	0.1
Gt. Wicomico	Biogenic_Oyster_Reef	<Null>	4	1.1	0.2
Gt. Wicomico	Anthropogenic_Shell_Rubble	Mud	1	1.6	0.2
Gt. Wicomico	Anthropogenic_Shell_Rubble	Sand	1	2.5	0.4
Gt. Wicomico	Anthropogenic_Shell_Reef	<Null>	4	7.0	1.0
Gt. Wicomico	Muddy_Sand	Shell	12	21.8	3.1
Gt. Wicomico	Biogenic_Oyster_Rubble	<Null>	31	64.0	9.1
Gt. Wicomico	Sand	Shell	31	76.5	10.9
Gt. Wicomico	Anthropogenic_Shell_Rubble	<Null>	20	84.9	12.1
Gt. Wicomico	Biogenic_Oyster_Rubble	Sand	42	90.4	12.9
		Sum =	150	351.8	50.2
			CROH =	351.8	
			50% CROH =	175.9	
			Corrected CROH (CROH*0.4)=	140.7	
			50% Corrected CROH =	70.4	

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

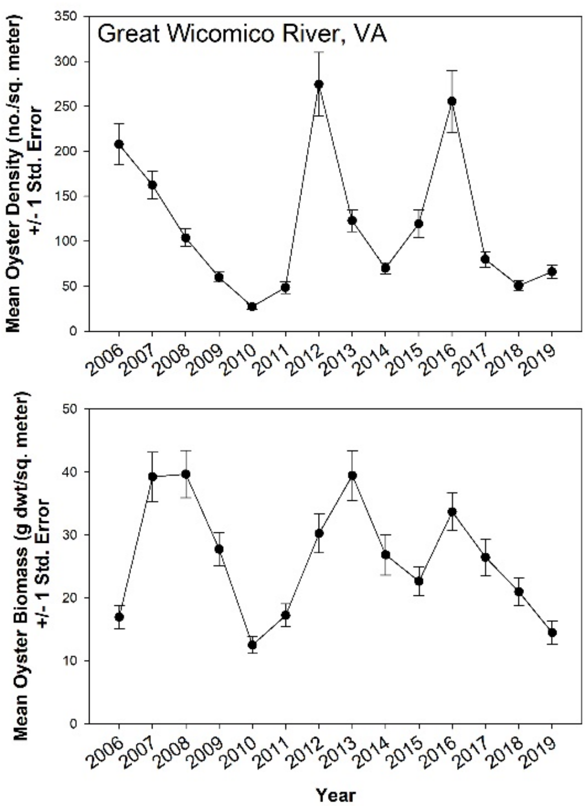
Location	Component	Sum Acres
Gt. Wicomico	Baylor Grounds	527.9
	100% of HOH	527.9
	16% of HOH	84.5
	8% of HOH	42.2

Location of VOSARA Oyster Monitoring Sites



Above figures show the location of VOSARA sites and oyster density points for samples collected in the 2006-2017 patent tong survey.

VOSARA surveys: temporal variability in oyster density and biomass 2006-2019



Based on above plots, 2012-2019 survey data were used to assess baseline density and biomass at the 17 VOSARA sites.

Baseline Oyster Density 2012-2017

Table identifying the Great Wicomico River VOSARA sites that meet the oyster restoration success metrics for density.

VOSARA Site ID	Site Acres	Site Sq. Meters	Total Area of Interpolated Grid Sq. Meters	No. Grid Cells with Density Value >= 15	No. Grid Cells with Density Value >= 50	% Grid Cells with Density Value >= 15 **(THRESHOLD)**	% Grid Cells with Density Value >= 50 **(TARGET)**
#1+2 GW CORP	6.0	24109.7	24114	19088	14996	79.2	62.2
#10 GW CORP	5.1	20818.7	20705	15464	6518	74.7	31.5
#11 GW CORP	14.4	58373.6	58249	50263	42724	86.3	73.3
#12 GW CORP	1.8	7393.4	7397	2067	469	27.9	6.3
#13 GW CORP	5.6	22755.2	26796	24897	22922	92.9	85.5
#15 GW CORP	3.0	12252.4	12249	840	605	6.9	4.9
#16 GW CORP	7.3	29350.6	29341	29115	28335	99.2	96.6
#3 GW CORP	3.4	13791.3	13794	9704	7456	70.3	54.1
#4 GW CORP	2.8	11413.1	11441	8299	5949	72.5	52.0
#8 GW CORP	13.5	54795.7	54789	16934	12672	30.9	23.1
#9 GW CORP	7.1	28630.5	28640	24366	18703	85.1	65.3
HARCUM FLAT	6.0	24211.2	24214	22964	21371	94.8	88.3
HAYNIE BAR	4.7	19171.7	19172	18111	17129	94.5	89.3
HILLY WASH	3.3	13123.8	13116	13070	12374	99.6	94.3
ROGUE POINT	3.4	13561.8	13557	12727	11566	93.9	85.3
SANDY POINT	11.8	47540.8	47528	46391	38693	97.6	81.4
SHELL BAR	17.7	71599.0	71597	62852	53815	87.8	75.2
Sum Acres=	116.9						

Meets Density Metric (>=30% coverage): [green]

Fails Density Metric (< 30% coverage): [red]

Total area that meets the restoration success density target (density >= 50 oysters/m2) over > = 30% if the site = 98.6 acres

		Acres
Total Area of Sites Sampled with Patent Tongs		116.9
Total area of sites that do NOT meet the density target (interpolated densities >= 50/m2 over < 30% of site)	Area of Site #12 GW CORP	-1.8
	Area of Site #15 GW CORP	-3.0
	Area of Site #8 GW CORP	-13.5
Total area of sites meeting the density target (interpolated densities >= 50/m2 over >= 30% of site)		98.6

Baseline Oyster Biomass 2012-2017

Table identifying the Great Wicomico River VOSARA sites that meet the oyster restoration success metrics for biomass.

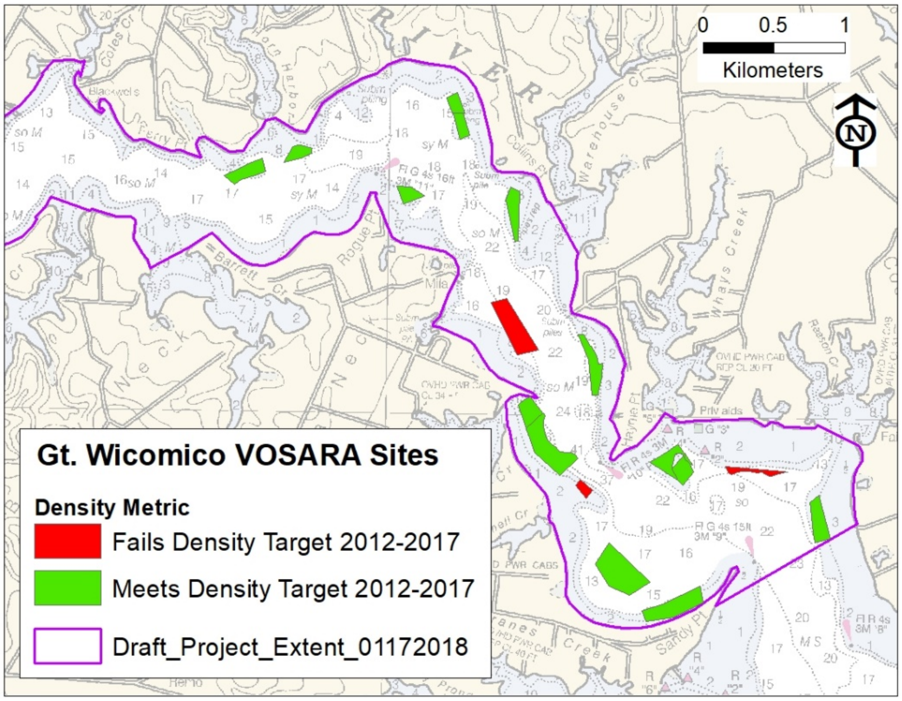
VOSARA Site ID	Site Acres	Site Sq. Meters	Total Area of Interpolated Grid Sq. Meters	No. Grid Cells with Biomass Value >= 15	No. Grid Cells with Biomass Value >= 50	% Grid Cells with Biomass Value >= 15 **(THRESHOLD)**	% Grid Cells with Biomass Value >= 50 **(TARGET)**
#1+2 GW CORP	6.0	24109.7	24114	13056	5027	54.1	20.8
#10 GW CORP	5.1	20818.7	20744	6691	746	32.3	3.6
#11 GW CORP	14.4	58373.6	58251	43610	10254	74.9	17.6
#12 GW CORP	1.8	7393.4	7397	164	16	2.2	0.2
#13 GW CORP	5.6	22755.2	26796	22855	5894	85.3	22.0
#15 GW CORP	3.0	12252.4	12249	542	154	4.4	1.3
#16 GW CORP	7.3	29350.6	29341	28788	17237	98.1	58.7
#3 GW CORP	3.4	13791.3	13794	6008	863	43.6	6.3
#4 GW CORP	2.8	11413.1	11405	5757	1305	50.5	11.4
#8 GW CORP	13.5	54795.7	54789	7642	0	13.9	0.0
#9 GW CORP	7.1	28630.5	28640	18864	2642	65.9	9.2
HARCUM FLAT	6.0	24211.2	24214	19292	2144	79.7	8.9
HAYNIE BAR	4.7	19171.7	19172	16828	8927	87.8	46.6
HILLY WASH	3.3	13123.8	13116	12295	7587	93.7	57.8
ROGUE POINT	3.4	13561.8	13557	11015	1987	81.2	14.7
SANDY POINT	11.8	47540.8	47528	41280	4686	86.9	9.9
SHELL BAR	17.7	71599.0	71597	50505	13240	70.5	18.5
Sum acres=	116.9						

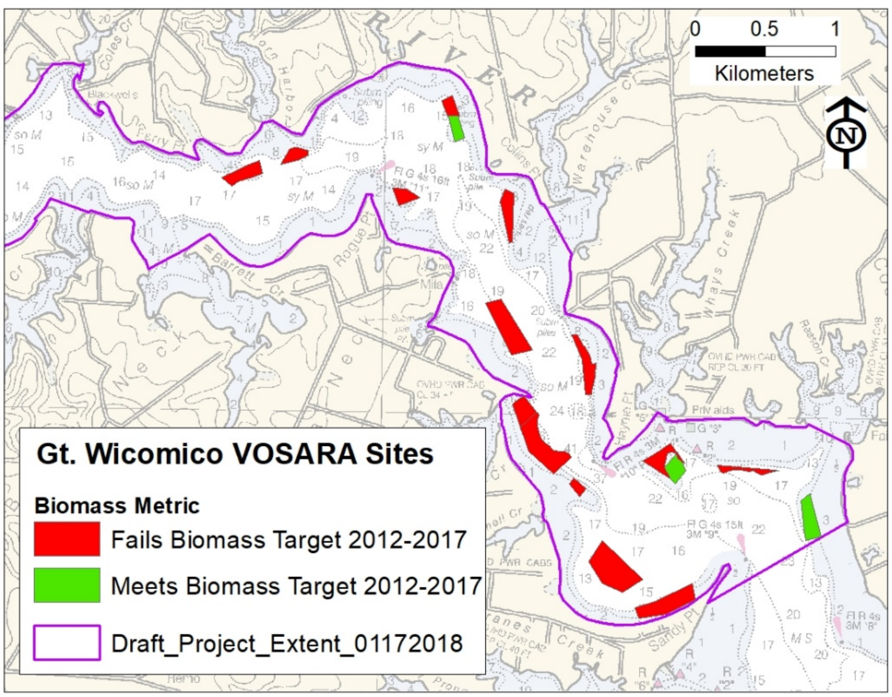
Meets Biomass Metric (>=30% coverage):

Fails Biomass Metric (< 30% coverage):

Total acres that meet Biomass Target (sum of #16 GW CORP+ HAYNIE BAR+ HILLY WASH)= 15.3

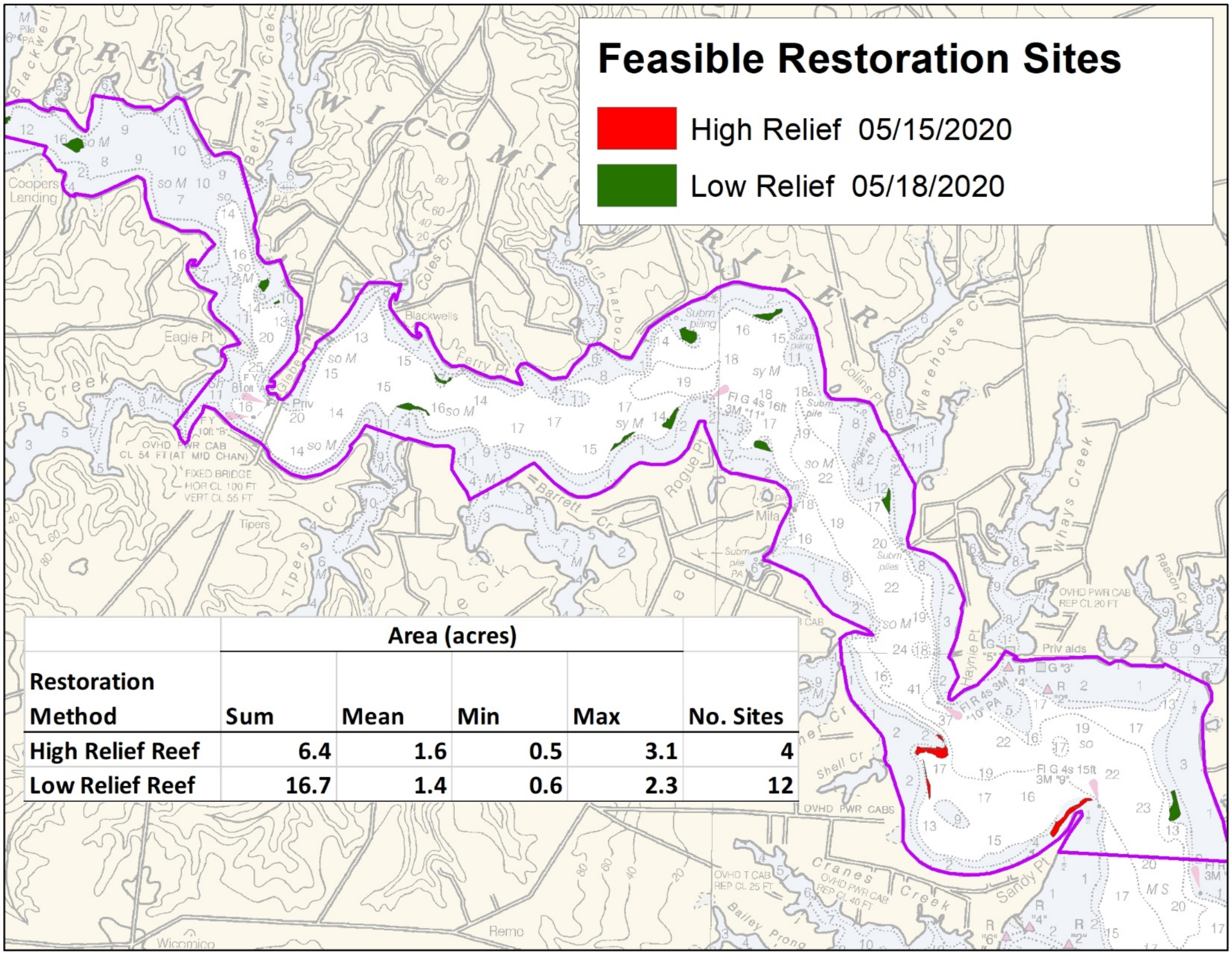
Baseline Oyster Density and Biomass Maps





Above maps identify the VOSARA sites that meet oyster restoration success metrics for density and biomass based on interpolated patent tong data from the 2012-2017 surveys. The restoration threshold metrics are greater or equal to 15 live oysters/m^2 or 15g dry weight/m^2 over 30% of the site. The target metrics are greater or equal to 50 live oysters/m^2 or 15g dry weight/m^2 over 30% of the site. Detail on interpolation methods are in the section "Baseline Oyster Density Assessment: Identify Area Meeting Restoration Success Metrics at VOSARA sites" below.

Sites Feasible for Substrate Reef Construction

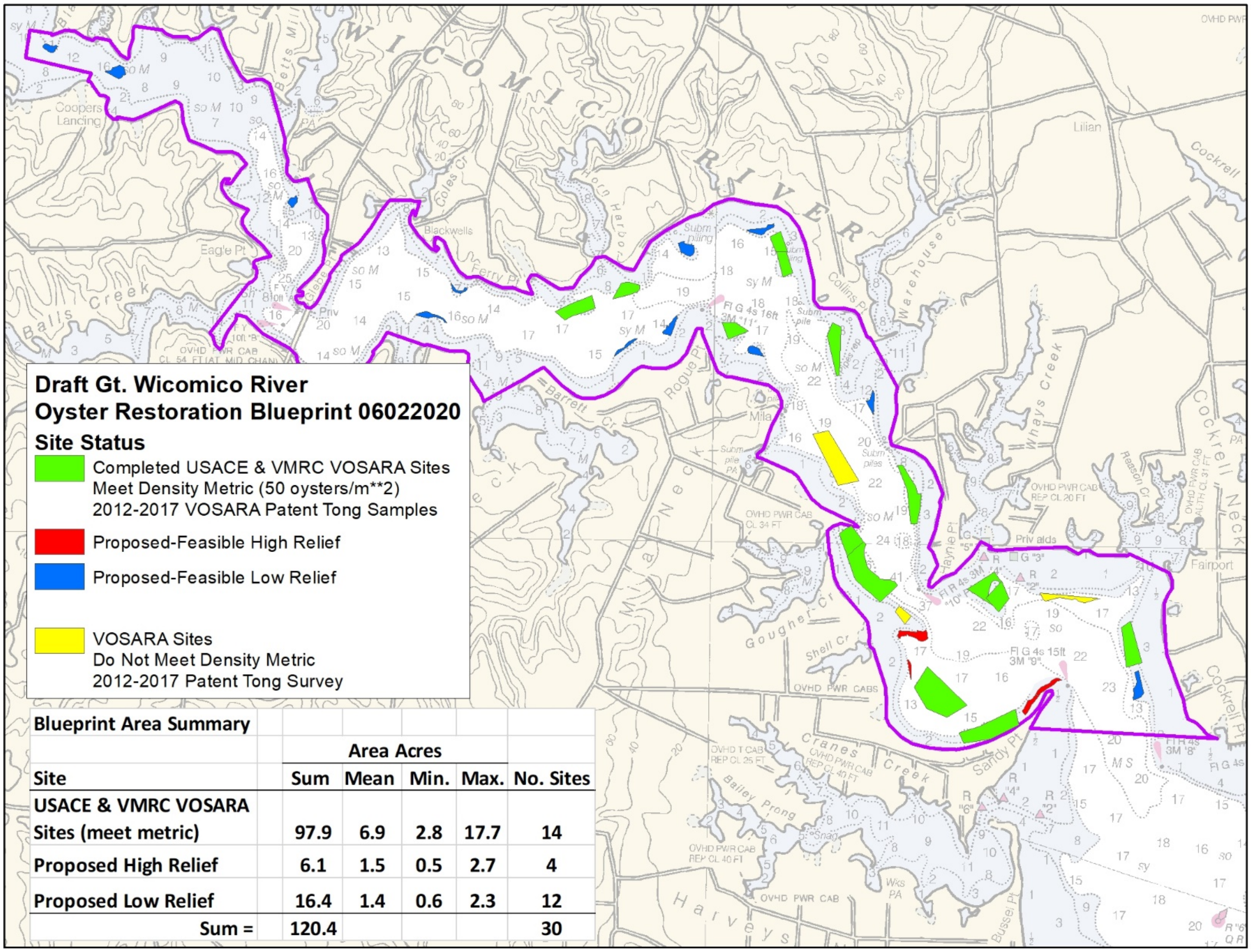


Restoration Method	Area (acres) Sum	Mean	Min	Max	No. Sites
High Relief Reef	6.4	1.6	0.5	3.1	4
Low Relief Reef	16.7	1.4	0.6	2.3	12

Above map identifies general location and acreage that can feasibly be restored with constructed substrate reefs based on criteria listed below.

Siting Criteria for Substrate Reef Restoration:

- High Relief: large sized substrate material on non-shell bottom (not on mud or sandy mud)
- Low Relief: small sized substrate material on shell dominant bottom
- Depth 6-14 ft.
- Outside oyster leases, navigation aids, navigation channels, docks, VOSARA sites & existing restoration sites, shellfish condemnation zones, and SAV boundaries
- Site area greater or equal to 0.5 acres



Blueprint Area Summary					
	Area Acres				
Site	Sum	Mean	Min.	Max.	No. Sites
USACE & VMRC VOSARA Sites (meet metric)	97.9	6.9	2.8	17.7	14
Proposed High Relief	6.1	1.5	0.5	2.7	4
Proposed Low Relief	16.4	1.4	0.6	2.3	12
Sum =	120.4				30

Baseline Oyster Density Assessment: Identify Area Meeting Restoration Success Metrics at VOSARA sites

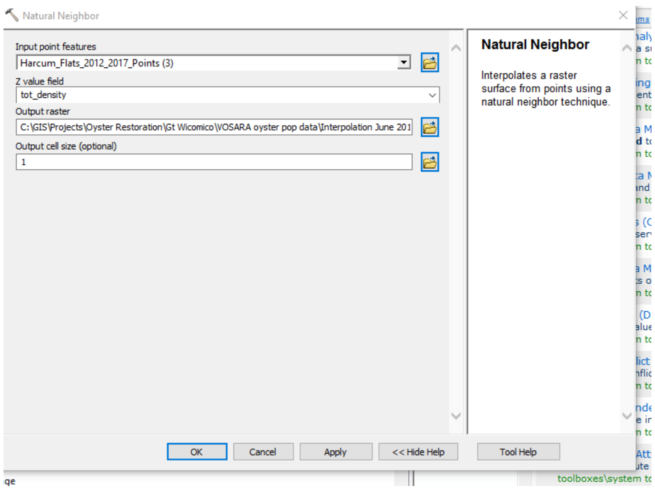
<u>Methods</u>

1) Based on time series plots of oyster density and biomass, patent tong sample data from the 2012-2017 surveys were used to determine baseline oyster density and biomass at the VOSARA sites.

2) 50 meter buffer polygons were created around each of the VOSARA site boundaries.

3) Generalized polygons were created from the 50m buffer using a 50m generalization distance.

4) Dummy points located at the vertices of the generalized polygons were added to the patent tong sampling data, and were assigned values of zero. This was done to ensure that the oyster density interpolations extended beyond the outermost patent tong sampling points and covered the entire site polygon.



5) Patent tong oyster density and biomass data were interpolated with the Natural Neighbor method (above). The output grid had 1x1 m cell dimensions.

6) Density and biomass grid cells were converted to points and clipped with the site boundary polygon.

7) Interpolated points from the 17 sites were merged and exported to flat files. Proportions of grid cell values (1 m^2) greater or equal to 15 and greater or equal to 50 were calculated for each site.
8) **<u>Threshold Metric:</u>** VOSARA sites that had 30 % or greater of the interpolated density (or biomass) grid cells equal to or greater than 15/m^2 were designated as meeting the restoration success threshold.
9) **<u>Target Metric:</u>** Sites that had 30 % or greater of the interpolated density (or biomass) grid cells equal to or greater than 50/m2 were designated as meeting the restoration success target.

Appendix B:
Additional Analysis on USACE Reefs to Determine Premet Status

In addition to the assessment described in Appendix A, partners agreed to develop additional analysis on Great Wicomico reefs previously restored by USACE to determine if these reefs were performing sufficiently to be considered 'premet'. ('Premet' is defined as reefs that met the Oyster Metrics density success criteria prior to the drafting of this Blueprint). Additional data were available on these reefs from VIMS, and were used to inform the analysis.

Methodology

For each USACE reef, VIMS (Rom Lipcius, pers. comm.) provided mean oyster density and biomass data from a 2019 survey, and USACE (David Schulte, pers. comm.) provided the adjusted areal extent (acreage) (Table App B 1). On some USACE reefs, these acreages differ somewhat from the original reef polygons used in the VOSARA survey. The VOSARA reef polygons are also used for tracking Great Wicomico restoration progress in NOAA's GIS geodatabase.

Because the oyster density success metric requires only ≥30% of the reef area to have a certain oyster density, then as long as the USACE polygon acreage is at least 30% of the VOSARA/NOAA polygon acreage for a given reef, and the reef (per USACE- Norfolk District polygons) had an average oyster density of ≥15 oysters per m^2, then the reef could be considered 'premet'. ('Premet' is defined as a reef that met the Oyster Metrics density criterion at the time this plan was drafted. These reefs are not targeted for additional restoration.) By consensus, Workgroup members agreed that for the purposes of determining the premet acreage in the Great Wicomico River, the VOSARA/NOAA acreages would be used. The USACE may in some cases use its adjusted acreages in technical publications.

Results of analysis

All of the USACE reefs listed in Table App 1 B, except reef GW_06 (red row), can be considered premet. Reef GW_6 has now been reduced to 1.88 acres in the NOAA geodatabase, to reflect the fact that only this portion of the reef is considered premet. These premet reefs total 53 acres (all green cells in Table App 1B, plus 1.88 acres of reef GW_6). This differs only slightly from the results using the methodology in Appendix A, which showed 51.1 acres of premet USACE reefs in the River. By consensus of the Workgroup, and because the analysis in Appendix B uses a preferred statistical method for determining oyster density, the results in this appendix (Appendix B; 53 acres) will be used as the acreage considered premet in the Blueprint document.

Table App B 1: Results of Analysis on USACE Reefs to Determine Premet Status

Site_ID	Reef_Name	Mean oyster density over the reef (m^2)	Mean oyster biomass over the reef (m2)	VOSARA/ NOAA geodatabase acreage	Corps of Engineers adjusted acreage	What percentage of the VOSARA/ NOAA polygon is occupied by the Corps adjusted polygon? (rounded)	Considered premet?
GW_01	GW CORP AREA 1 AND 2	195.9	210.5	5.96	2.03	34%	Yes
GW_02	#3 GW CORP	224.0	223.6	3.41	1.92	56%	Yes
GW_03	#4 GW CORP	127.3	122.7	2.82	2.64	94%	Yes
GW_06	#8 GW Corps	218.6	98.8	13.54 (reduced to 1.88 acres)	1.88	14%	No
GW_04	#9 GW CORP	70.9	36.0	7.07	7.07	100%	Yes
GW_05	GW CORP AREA 10 AND 11	56.8	35.4	19.57	19.59	100%	Yes
GW_07	#13 GW CORP	144.7	138.6	5.03	3.46	69%	Yes
GW_08	#16 GW CORP	335.1	157.5	7.25	7.25	100%	Yes
				53.0 acres			