

Blue Infrastructure Final Project Report and Deliverables

Prepared in Partial Fulfillment for the Project Titled “Blue Infrastructure Criteria and Map”

Marcia Berman, Carl Hershner, and Dan Schatt
Center for Coastal Resources Management
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

in conjunction with the
Blue Infrastructure Workgroup

submitted to

Virginia Coastal Resources Management Program
Department of Environmental Quality
Richmond, Virginia

This project was funded by the Virginia Coastal Program at the Department of Environmental Quality, Grant Number NA03NOS4190104 of the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act of 1972, as amended.

October, 2004



Introduction

Blue Infrastructure begins the development of a regional planning tool for organizations and governments with planning interests in the coastal zone. This phase of Blue Infrastructure called for the generation of several products.

Product 1) Defining Parameters: Work with a steering committee (Table 1) to develop a list of critically important aquatic resources in Virginia's Coastal Zone (Table 2). These are economically and ecologically important resources aquatic resources, not just those from which data are available. More details pertaining to the availability of these data sets can be found in the Needs Assessment document under product 2.

Table 1. Blue Infrastructure Steering Committee

Marcia Berman	VIMS
Julie Bixby	DEQ/VCP
Royce Bridger	VMRC
Steve Carter-Lovejoy	DCR/DNH
Anamarija Frankic	VIMS
Greg Garmen	VCU
Carl Hershner	VIMS
Paula Jasinski	NOAA/CBP
Laura McKay	DEQ/VCP
Shep Moon	DEQ/VCP
Dave Morton	DGIF
Chip Neikirk	VMRC
Karen Reay	VIMS
Eric Walberg	HRPDC
Tony Watkinson	VMRC

Table 2. Blue Infrastructure Parameters

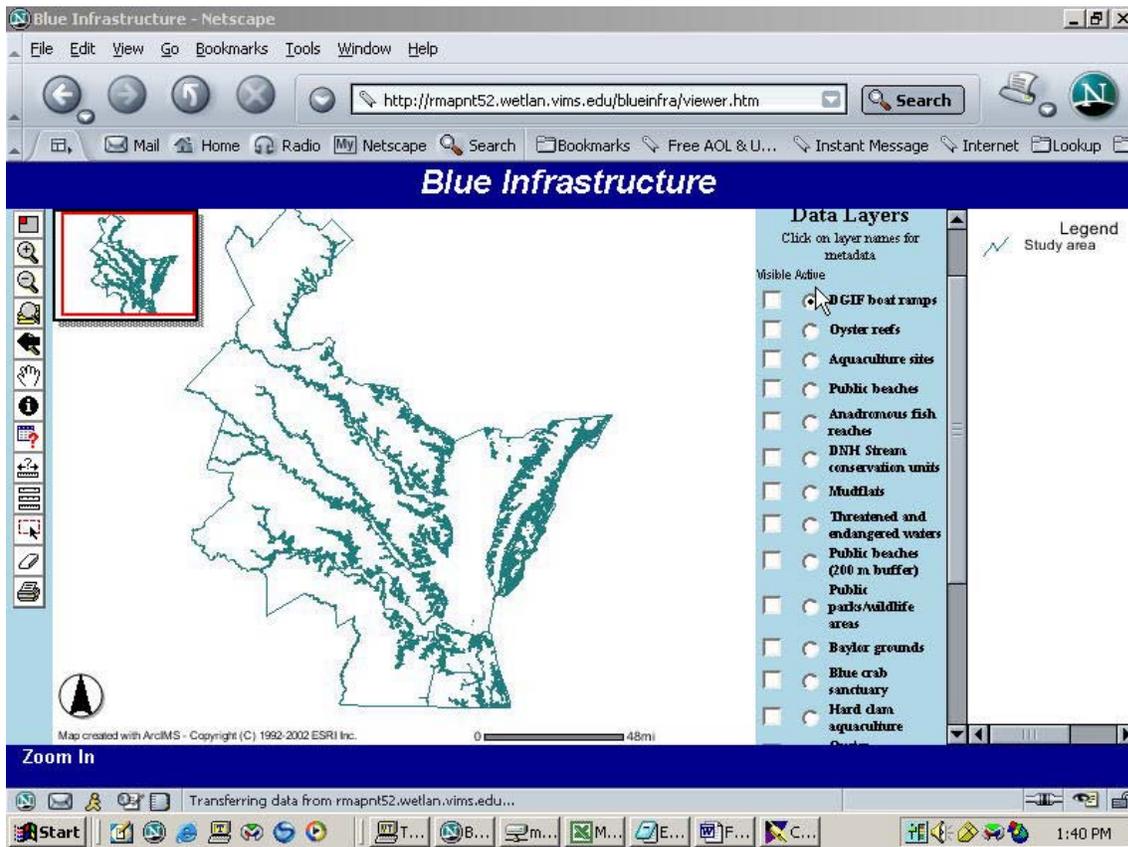
Anadromous fish streams (DGIF)	Oyster reefs
Aquaculture sites	Public Access (DGIF)
Baylor Grounds	Public beaches (with buffers)
Bottom Type	Private Leases
Blue crab sanctuary (Virginia)	Red drum sanctuaries
Channel, navigation markers	SAV beds
Clam sanctuaries – permanent	SAV restoration goal (185,000 acres)
Clam sanctuaries – seasonal	Shellfish management areas
Essential fish habitat	Striped bass sanctuaries
Hampton roads blue crab sanctuaries	Tidal mudflats
Interactive Stream Assessment Resouce	Threatened and endangered waters
James River Oyster seed Beds	Water Trails
Nearshore coastal parks or natural area preserves	

Product 2) Needs Assessment Document: Based on resources identified in Product 1, the availability of each of these elements in GIS format would be researched by VIMS. This was accomplished by inventorying data available within the VIMS archive, within archives of other agencies on the steering committee, and from the broader environmental programs at state and federal levels. A Needs Assessment Report was produced (see below) that discusses each resource. A justification for inclusion in Blue Infrastructure is presented, and/or an explanation regarding data availability is discussed. The Needs Assessment also includes a basic cost estimate and discussion of funds needed to collect data that are not currently available.

Product 3) Coastal Zone Wide Map and Digital Data Distribution: An online interactive map was developed using ArcIMS. The ArcIMS application for Blue Infrastructure is accessed via the project homepage which is currently accessible under “Mapping Tools” at VIMS’ Center for Coastal Resources Management website: <http://ccrm.vims.edu/mappingtools.html>. Subsequent links to these data may be provided by the Virginia Coastal Program.

The interface developed for the project uses all available GIS layers defined in the Needs Assessment Report (see below). The default layer is the study boundary which is defined by the geographic limits of Tidewater Virginia (figure 1)

Figure 1. Blue Infrastructure ArcIMS Interface with default layer Tidewater Virginia.



The user can select from the list of data layers on the right, display and compose maps, and query available attribute information. A series of built in tools on the left provides capabilities to zoom, pan, measure, and compute simple calculations. By clicking any data layer on the list, available metadata for that layer will appear.

Figure 2 demonstrates how one can zoom into an area (e.g. the lower York River and Mobjack Bay), and view selected layers like SAV and oyster reef distribution. The location of anadromous fish stream reaches is also illustrated in this example.

Figure 3 demonstrates the expanded capabilities of bringing attribute information to the desktop. This type of query allows users access to the same attribute information available from the host servers. Here the query reveals attribute information regarding one of the coastal parks.

Figure 2. Zoom View of Lower York River and Mobjack Bay

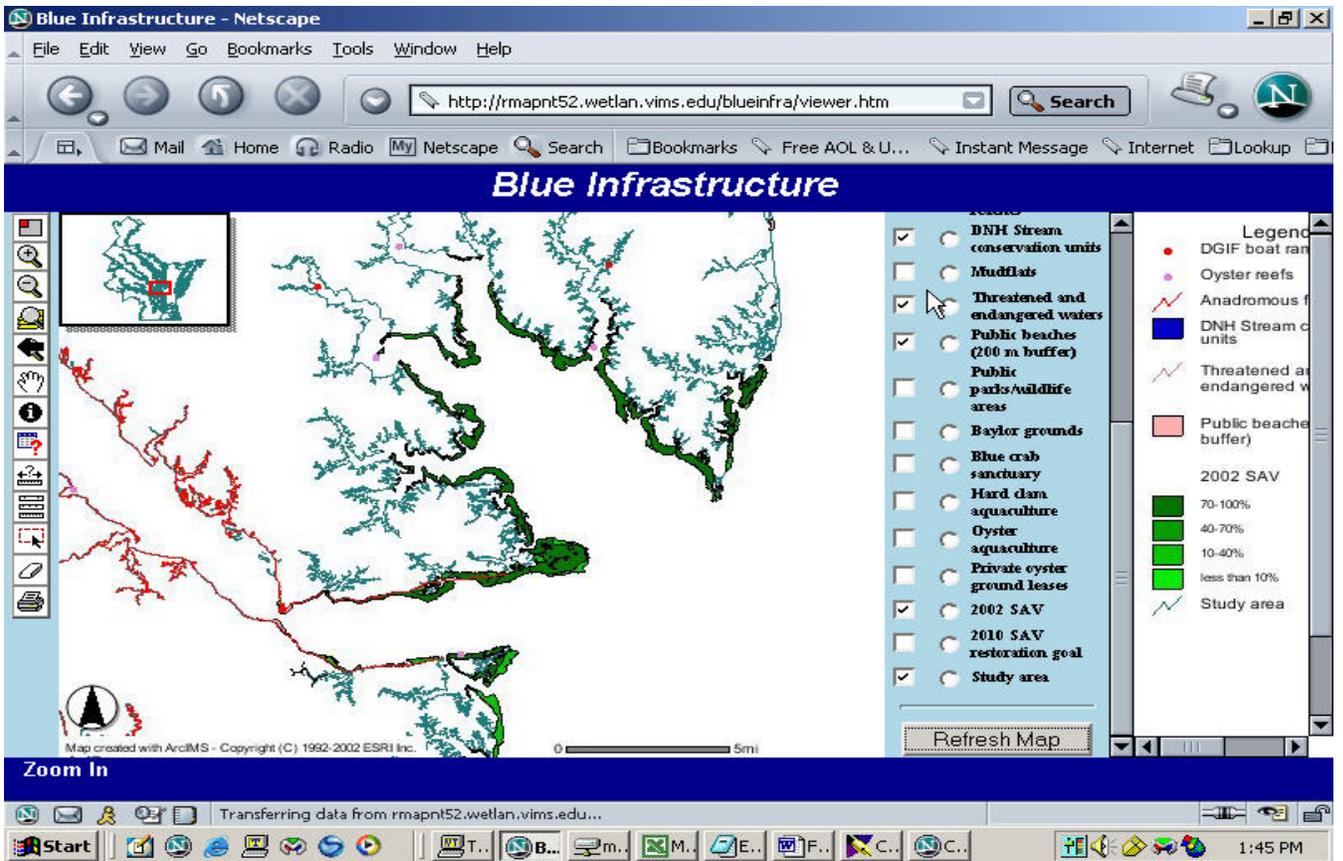
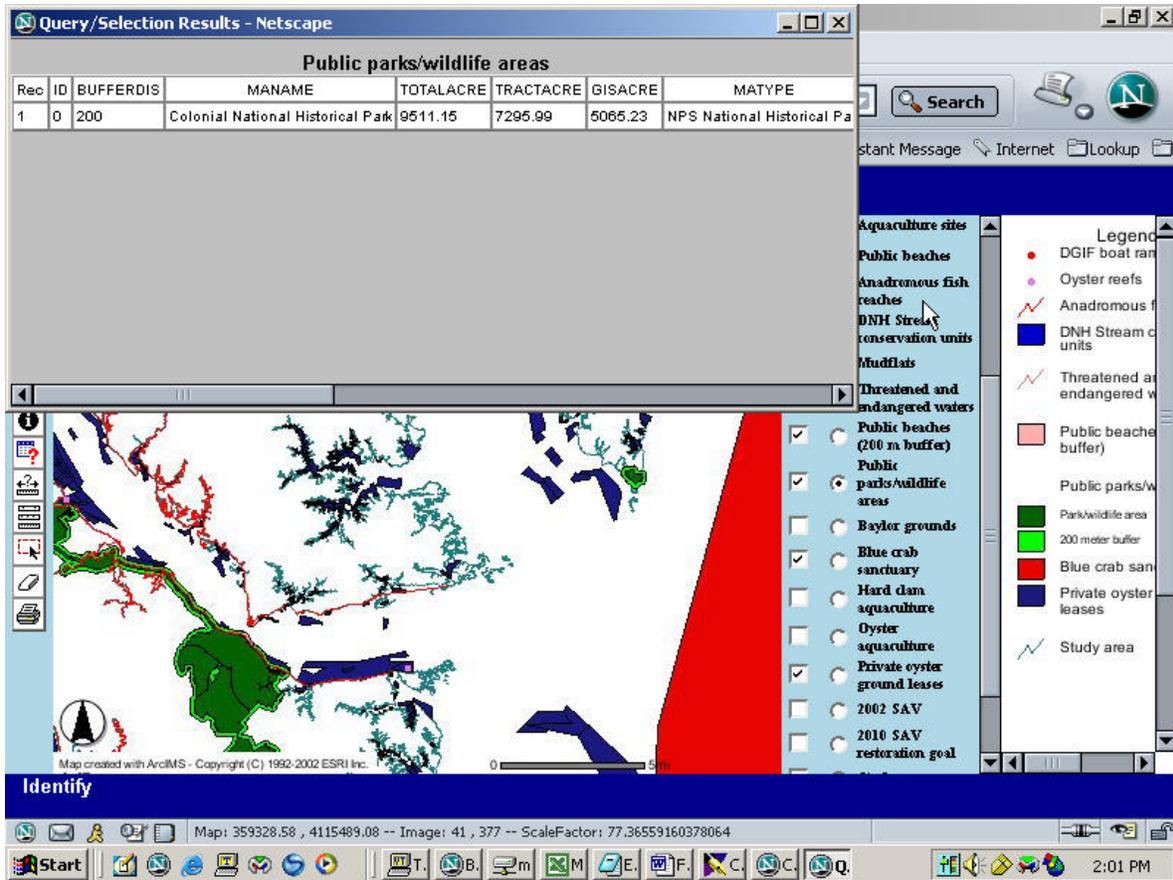


Figure 3. This query reveals the number of acres within this region of the Colonial National Historical Park



ArcIMS will facilitate easy expansion of the project in the future. Digital data is also being delivered to the Coastal Resources Management Program. Shape files of all layers are provided on the Blue Infrastructure homepage. Explicit distribution, disclaimers, and data limitations imposed by data originators apply in all cases. Users should review metadata associated with each layer and contact appropriate agencies with questions. Contacts and websites are provided in Appendix 2 of the Needs Assessment Report.

Product 2: Blue Infrastructure -GIS Data Needs Assessment

Introduction

Blue Infrastructure includes the ecologically and economically significant aquatic resources (marine and freshwater) found within the coastal zone of Virginia. The intent of this project was to make a preliminary determination of which coastal resources should be included as blue infrastructure and to assess the status of data available for each identified resource. The following data inventory for Blue Infrastructure is an outgrowth of discussions among the Blue Infrastructure Advisory Committee assembled for this project (see membership list in Appendix 1). The inventory is preliminary and may evolve over time. Ultimately, data assembled on these resources will be combined with data on land-based “green infrastructure”, as well as certain “contextual data” about coastal resources as part of the Virginia Coastal Program’s Blue-Green Integration Strategy. The intent is to make the data readily available over the internet to all parties involved in, or affected by, individual coastal resource management decisions.

In theory, the audience who will benefit most from Blue Infrastructure products are managers within local and regional governments, as well as those within citizen groups who play an important role in lobbying for environmental initiatives and building awareness within communities. In many ways these individuals have the greatest opportunity for determining the character and quality of the waterway. Blue infrastructure must recognize that community development at the waterfront contributes to the overall condition achievable for the aquatic ecosystem. Seemingly, land use choices may conflict with desires to support the highest levels of aquatic health. Blue Infrastructure is not intended as a tool to help mediate use conflicts. It will incorporate community structure and its choices, and attempt to highlight where land use decisions may be in conflict with sensitive and important aquatic resources.

Data Inventory - Parameters for Inclusion in Blue Infrastructure

The following resources have been identified by the Steering Committee for inclusion in Blue Infrastructure:

1) Anadromous Fish Streams: This dataset was developed by the Virginia Department of Game and Inland Fisheries. It identifies stream reaches that are confirmed or potential migration pathways, spawning grounds, or nursery areas for anadromous fish. Certain time-of-year restrictions apply to areas used by anadromous fish. As stocks of anadromous fish have declined, time of year restrictions have been imposed to conserve and restore these species. This dataset is intended as a tool to assist in those efforts and in land use planning.

2) Aquaculture sites: The location of existing commercial and non-commercial aquaculture are included in Blue Infrastructure because they represent potentially important economic and water quality improvement areas in the shallow water habitat. The database used here includes oyster and hard clam aquaculture. Aquaculture sites may be at risk if certain types of development or activity occurs within the vicinity. Since they are traditionally restricted to shallow water,

aquaculture operations can conflict with other potential uses of the shallow water zone. This includes preservation of bottom for SAV restoration. The project also includes modeled output for potential future sites for clam and oyster aquaculture. These are distinguished from actual sites in the Blue Infrastructure ArcIMS project. Refer to the metadata for more details on how these areas were modeled.

3) Baylor Grounds: Baylor Grounds are public oyster grounds mapped between 1892-1895 by what is now the Virginia Marine Resource Commission (VMRC).. The surveys were conducted throughout state tidal waters to locate and map the naturally productive oyster beds, rocks, and shoals. According to the VMRC website, these areas are reserved for public shellfish harvesting and cannot be leased or used for other purposes. They are included in Blue Infrastructure because they represent a state-owned aquatic resource with designated use restrictions that should be noted by local and regional governments.

4) Bottom Type Mapping: Bottom type mapping refers to the act of surveying subaqueous bottom to spatially delineate composition and structure. Since these characteristics are critical for identifying essential fish habitat within the Bay they are an important component of Blue Infrastructure. This dataset is not currently available in GIS (see next section regarding parameters not currently in GIS).

5) Channel/Navigation Markers: Channel and navigational markers represent areas that have potentially high boat traffic and where encroachment is prohibited. These areas would be regulated from development, but are included in Blue Infrastructure because they represent areas where access to waterways for recreation and commercial activity is possible. This dataset is not currently available in GIS (see next section regarding parameters not currently in GIS).

6) Essential Fish Habitat: The National Marine Fisheries Service of NOAA writes the following regarding essential fish habitat, "Congress defined Essential Fish Habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). The EFH guidelines under 50 CFR 600.10 further interpret the EFH definition as follows: Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle." This dataset is not currently available in GIS (see next section regarding parameters not currently in GIS).

7) Fishery Management Areas: Fishery management areas are designated by the VMRC. These areas are noteworthy because they support a high level of one or more particular species or lifestage of a particular species within the Bay. These were, among others, submitted to NOAA for inclusion in their Marine Protected Areas Inventory for Virginia. A discussion related to data availability is below. Fishery management areas identified for this project include: Blue crab sanctuary (Virginia), Hampton Roads Crab Sanctuary, Clam Sanctuaries (permanent and seasonal), James River Oyster Seed Beds, Red Drum Sanctuaries, Shellfish Management Areas,

Striped Bass Sanctuaries. These datasets are not currently available in GIS (see next section regarding parameters not currently in GIS)

8) Instar (Interactive Stream Assessment Resource) - Instar is a product under development by Virginia Commonwealth University. Among other things, Instar has generated more than 600 habitat assessments pertaining to fish populations. Ultimately, virtual models can be constructed through an interactive map site. This project is nearing completion and components will be added to Blue Infrastructure in the near future.

9) Near Shore Areas Adjacent to Coastal Parks and Wildlife Refuges: This listing includes state and federal parks or wildlife areas located along tidal shoreline. While the boundaries of these protected areas end at the shoreline, in many cases the recreational and wildlife use of these areas extends into the waterway. Activities on the upland in the vicinity of these designated areas should be made aware that sensitive, aquatic dependent resources or activities may be present.

10) Oyster Reefs: Efforts throughout Virginia waters to construct and restore oyster reefs is widespread. These structures are built on public Baylor Grounds (see above). Oyster reefs are a valuable economic and ecological resource in Virginia and due to their preferred habitat (shallow coastal waters adjacent to upland environments), they are particularly vulnerable to activities on the land.

11) Public Boat Landings (DGIF): Public access areas refer to public property owned and operated by the Department of Game and Inland Fisheries that provides a landing and launch site for recreational boats to the water. Technically these are upland facilities which usually include a parking area, pier, and boat ramp. However, this is an aquatic dependent use which may be influenced by development on the upland. In the vicinity of these areas, recreational boating traffic can be expected.

12) Public Beaches: Public beaches are another example where the upland use of the resource extends into the aquatic habitat. Public beaches are included in Blue Infrastructure because safety and water quality must be maintained in order for these areas to support their intended use.

Public beaches represent an important economic value to communities.

13) Private Leases: There are currently 90,000 acres of subaqueous bottom leased for private shellfish cultivation in Virginia. Individuals pay an annual "rent" to the VMRC for use of the bottom. The agency surveys and maintains all lease information. The GIS file for private leases was developed by CCI with survey data provided by VMRC in 2001. While private lease boundaries can shift, the purpose for incorporating these data into Blue Infrastructure is not for jurisdictional delineations or regulation. The purpose is to identify that an area noted for supporting important aquatic resources (e.g. shellfish grounds) may be present. This remains true even if boundary and lease information has changed.

14) Submerged Aquatic Vegetation Beds (SAV): SAV mapped from 2002 aerial photography are delineated following protocols established by Orth et.al., 2003. These surveys are repeated

periodically and should be updated whenever possible for Blue Infrastructure. SAV constitute important aquatic habitat that must be preserved and protected whenever possible. SAV can be eradicated quickly from an area. The introduction of very high sediment loads sometimes associated with upland runoff in developing watersheds can be a cause. Therefore development along the waterfront should be advised if SAV beds are present.

15) SAV Restoration Goal: Within the Chesapeake Bay there is a regional effort to restore SAV grasses. Restoration goals are somewhat based on historic abundance and delineations. The spatial depiction of the current SAV Restoration Goal suggests the shallow water environment has supported or is suitable for SAV.

16) Tidal Mudflats: Tidal mudflats are extracted from the National Wetlands Inventory database. Tidal mudflats are rich ecosystems and support important members of the food chain. In addition to supporting a productive and diverse benthic infaunal and epifaunal community, tidal mudflats are important foraging grounds for shore birds and grazers.

17) Threatened and Endangered Streams: These data, designated and maintained by DGIF, delineate stream reaches which are noted to support state or federally listed threatened or endangered species.

18) Water Trails: Water Trails, usually conveyed to the public in maps, are an important resource for tourism and recreational use. This dataset is not currently available in GIS (see next section regarding parameters not currently in GIS).

Needs Assessment - Resources Currently Not Available in GIS

GIS has been selected as the mechanism to archive, manipulate and display Blue Infrastructure. This section of the Needs Assessment is focused on data (identified in Table 1) that are not currently in GIS format. As anticipated, these data are available in a variety of other formats including hardcopy. Table 1 summarizes data sets targeted for acquisition and development under future Blue Infrastructure efforts.

1) Bottom Type Mapping: Bottom type mapping refers to the delineation of bottom substrate throughout the study region. Information pertaining to subaqueous bottom is critical for evaluating potential habitat for commercial and recreation fisheries, benthic organisms, aquaculture, and SAV.

Bottom mapping is a large-scale project which will require significant financial commitment for completion. Mapping bottom composition and structure within relatively large areas has been accomplished using remote side scan sonar devices. The approach has been used to cover large river systems equivalent to any of the tidal tributaries within the VA-CRMP region. The resources necessary to accomplish the entire study are estimated in the millions and over several years.

To serve the needs of Blue Infrastructure, the recommendation put forth here suggests a focused assessment of shallow water subaqueous bottom (less than 3 meters). This would include the tributaries of the James, York, Rappahannock, and Potomac Rivers, and the bayside of the Eastern Shore. It is estimated that approximately 5 years, 3 fte's, and \$275,000 annually would be required.

The project should ultimately be expanded beyond this geographic region and include the sea side of the Eastern Shore of Virginia, and Back Bay in Virginia Beach. Cost estimates for these areas should be made at a later date.

2) Essential Fish Habitat - There are certainly elements that make-up essential fish habitat (EFH) which are currently available (e.g. SAV distribution). However, there are other elements that are clearly not available in a format to support a GIS based atlas. Included in this would be bottom type, mentioned above. A list of parameters that comprise EFH must be derived before efforts can begin to incorporate such parameters into Blue Infrastructure.

3) Channel/Navigation Markers - Efforts to acquire these data in digital form have been unsuccessful. In a recent meeting with VMRC, however, it became apparent that the survey division of this agency does map the congressionally maintained channels. These data are in AutoCad and can be converted to GIS. Conditions for this conversion are analogous to those discussed below for Fisheries Management Areas.

4) Fisheries Management Areas - The truly aquatic Marine Managed Areas considered at this stage in Blue Infrastructure are largely comprised of areas designated by the Virginia Marine Resources Commission (VMRC).

Presently the boundaries of these areas are surveyed by VMRC as dictated in the code of Virginia. VMRC uses the AutoCad mapping system to maintain and archive the boundaries. This system does not allow direct export of files to a GIS. An upgrade to the existing AutoCad software does provide for this integration. VMRC is now integrating this newer version into their program. They estimate roughly a 6 month training period followed by efforts directed toward moving all their existing survey programs to this new system. It is understood that this conversion will take time and significant personnel resources.

Since the intended uses of Blue Infrastructure calls for these data, VMRC was asked to submit an estimate for time and personnel costs to complete this conversion and elevate these designations as a high agency priority for conversion. There are approximately seven (7) areas to address. The agency estimates approximately \$18,000 and 3 months of effort to be spread over a 12 month period to complete the tasks.

4) Instar (Interactive Stream Assessment Resource - Being developed by Virginia Commonwealth University (VCU), Instar is nearing completion. This will be a web-based product. Datasets that have been integrated into Instar will become available to Blue Infrastructure in the near future.

5) Water Trails - Water trails, usually conveyed to the public in maps, are an important resource for tourism and recreational uses. In the near future existing water trails for the Eastern Shore and other sections of the Virginia Chesapeake Bay will be added.

References

Orth, R. Wilcox, D., Nagey, L., Owens, A., Whiting, J., and A. Serio, 2003. 2002 Distribution of Submerged Aquatic Vegetation in Chesapeake Bay and Coastal Bays, Special Scientific Report Number 139, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia.

Table 1. Blue Infrastructure Data Layer Availability

Data Layer	Hardcopy Only	Digital (GIS)	Not Available
Anadromous fish streams (DGIF)		X	
Aquaculture sites		X	
Baylor Grounds		X	
Bottom Type			X
Blue crab sanctuary (Virginia)		X	
Channel, navigation markers (COE)			X
Clam sanctuaries – permanent (VMRC)			X
Clam sanctuaries – seasonal (VMRC)			X
Essential fish habitat			X
Hampton roads blue crab sanctuaries (VMRC)			X
Interactive Stream Assessment Resouce (VCU- in prep)		X	
James River Oyster seed Beds (VMRC)			X
Nearshore coastal parks or natural area preserves		X	
Oyster reefs		X	
Public Access (DGIF)		X	
Public beaches (with buffers)			X
Private Leases		X	
Red drum sanctuaries (VMRC)			X
SAV beds		X	
SAV restoration goal (185,000 acres)		X	
Shellfish management areas (VMRC)			X
Stream Conservation Units (DCR)		X	
Striped bass sanctuaries (VMRC)			X
Tidal mudflats		X	
Threatened and endangered waters		X	
Water Trails	X		

Appendix 1. Blue Infrastructure Steering Committee

Marcia Berman	VIMS
Julie Bixby	DEQ/VCP
Royce Bridger	VMRC
Steve Carter-Lovejoy	DCR/DNH
Anamarija Frankic	VIMS
Greg Garmen	VCU
Carl Hershner	VIMS
Paula Jasinski	NOAA/CBP
Laura McKay	DEQ/VCP
Shep Moon	DEQ/VCP
Dave Morton	DGIF
Chip Neikirk	VMRC
Karen Reay	VIMS
Eric Walberg	HRPDC
Tony Watkinson	VMRC

Appendix 2. Blue Infrastructure Data Layers

Data Layer	Agency	Contact	Description
Anadromous Fish Streams	DGIF	Dave Morton	Stream reaches that have confirmed or potential use by anadromous fish
Aquaculture Sites	VMRC	Chip Neikirk	Private and commercial permits issued for clam and oyster aquaculture
Baylor Grounds	VMRC	Ben Stagg	Public oyster bottom
Bottom type	n/a	n/a	Will describe bottom sediment characteristics and structure
Blue Crab Sanctuary	VMRC	Ben Stagg	Crabbing is closed from June 1 through September 15 to protect females during their spawning migration
Channel, navigation markers	COE, NOS	n/a	
Clam sanctuaries – permanent	VMRC	Ben Stagg	Areas designated for placement of clams to enhance productivity
Clam sanctuaries – seasonal	VMRC	Ben Stagg	n/a
Essential fish habitat	n/a	n/a	Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity
Hampton roads blue crab sanctuaries	VMRC	Ben Stagg	The Sanctuary is closed to commercial and recreational crabbing from June 1 through September 15 to protect female crabs during their spawning migration
Interactive Stream Assessment Resouce	VCU	Greg Garmen	Stream health assessment tool
James River Oyster seed Beds	VMRC	Ben Stagg	Designated area in the James for the harvest of seed oysters
Nearshore coastal parks or natural area preserves	various	David Boyd	Waters adjacent to state and federal parks and wildlife areas
Oyster reefs	VMRC	Jim Wesson	Reef restoration sites
Public Access-DGIF Boat Landings	DGIF	Dave Morton	Public launch sites
Public beaches (with buffers)	VIMS	Marcia Berman	Official and unofficially designated sandy areas
Private Leases	VMRC	Ben Stagg	Private oyster leases issued by VMRC
Red drum sanctuaries	VMRC	Ben Stagg	n/a
SAV beds	VIMS	David Wilcox	Submerged aquatic vegetation
SAV restoration goal (185,000 acres)	CBAY	Howard Weinberg	Proposed SAV restoration goal
Shellfish management areas	VMRC	Ben Stagg	To protect and promote the hard clam resource within designated areas of the York, Poquoson, Back and James Rivers
Stream Conservation Units	DCR	David Boyd	Identify stream reaches that contain aquatic natural heritage resources
Striped bass sanctuaries	VMRC	Ben Stagg	
Tidal mudflats	NWI	n/a	Extracted from the NWI database for areas designated as unvegetated bottom
Threatened and endangered waters	DGIF	Dave Morton	Stream reaches which contain state or federal threatened or endangered species
Water Trails	n/a	n/a	Information on river sites and access points

Appendix 2. Blue Infrastructure Data Layers (con't)

Data Layer	Limitations	GIS Availability	GIS Originator	Website
Anadromous Fish Streams	none reported	yes	DGIF	http://www.dgif.state.va.us/gis/datadownload.html
Aquaculture Sites	not updated regularly	yes	VIMS/CCI	
Baylor Grounds	survey boundaries can change	yes	VIMS/CCI	
Bottom type	not established yet	no		
Blue Crab Sanctuary	n/a	no		
Channel, navigation markers	n/a	n/a		
Clam sanctuaries – permanent	n/a	n/a		
Clam sanctuaries – seasonal	n/a	n/a		
Essential fish habitat	not established yet	n/a		
Hampton roads blue crab sanctuaries	n/a	n/a		
Interactive Stream Assessment Resouce	restricted to freshwater	yes	VCU	http://gaia.vcu.edu/
James River Oyster seed Beds	n/a	n/a		
Nearshore coastal parks or natural area preserves	as currently delienated	yes	misc	
Oyster reefs	as currently delienated	yes	VIMS	http://www.deq.virginia.gov/oysters/buildb.html http://www.dgif.state.va.us/boating/pba/index.asp , http://www.dgif.state.va.us/gis/datadownload.html
Public Access	as currently delienated	yes	DGIF	
Public beaches (with buffers)	could be incomplete	yes	VIMS	
Private Leases	survey boundaries can change.	yes	VIMS	
Red drum sanctuaries	n/a	no		
SAV beds	updated annually by originator	yes	VIMS	http://www.vims.edu/bio/sav/savdata.html
SAV restoration goal (185,000 acres)	n/a	yes	CBAY	
Shellfish management areas	n/a	no		
Stream Conservation Units	designations can change	yes	DCR	http://www.dcr.virginia.gov/dnh/infoservices.htm
Striped bass sanctuaries	n/a	no		
Tidal mudflats	n/a	yes	FWS/NWI	http://www.nwi.fws.gov/downloads.htm
Threatened and endangered waters	designations can change	yes	DGIF	http://www.dgif.state.va.us/gis/datadownload.html
Water Trails	n/a	no		