YARMOUTH CREEK WATERSHED PLAN

Prepared for:
James City County, Virginia

Prepared by:
Center for Watershed Protection
8391 Main Street
Ellicott City, MD 21043
www.cwp.org

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Foreword

The Yarmouth Creek Watershed Plan is the culmination of a two year process led by the Center for Watershed Protection that began in the summer of 2001 with initial mapping and existing data collection. That work was followed in the fall by fieldwork that included a stream assessment, a conservation area assessment and a brief stormwater survey. The *Baseline Assessment* was completed in January 2002, followed by a stakeholder meeting coordinated with the James River Association and James City County on the initial findings in early February. The *Conservation Area Report for Yarmouth Creek* was completed in June 2002 and the *Technical Memo on the Reduced Freshwater Flow in Yarmouth Creek* was produced in July 2002. A second stakeholder meeting occurred in September in which stakeholders helped craft goals for the overall plan. This initial draft for the final watershed plan was completed in January 2003 and finalized after the final stakeholder meeting in June 2003.

Critical to the success of the plan was the input of local stakeholders, who helped identify vital issues and set goals for the watershed. This well attended stakeholder process was led by the James River Association and James City County who both facilitated an open process and supported the creation of the plan.

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EXECUTIVE SUMMARY

This watershed management plan provides a summary of the stakeholder process conducted by the Center for Watershed Protection (CWP), James River Association (JRA) and James City County (JCC) and the reports produced over the past year and a half as part of the Yarmouth Creek planning process. The reports included; the Yarmouth Creek *Baseline Assessment*, *Conservation Area Report for Yarmouth Creek*, and a *Technical Memo on the Reduced Freshwater Flow in Yarmouth Creek*. A watershed management plan and associated maps have been drafted for the nine subwatersheds in Yarmouth Creek based on the eight tools of watershed protection (CWP, 1998). These subwatershed management plans and associated maps serve as blueprints for the protection and restoration of Yarmouth Creek. They may also be used as planning maps for the implementation of the watershed management plan and as an important tool during the development review process.

The sixteen square mile Yarmouth Creek watershed is truly a state treasure. A recent natural areas inventory, conducted by the Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR), classified portions of the watershed as highly significant to biodiversity in the state (Clampitt, 1991). Along the remarkably undisturbed shoreline of mainstem Yarmouth Creek are extensive complexes of forested uplands, bald cypress swamps, and rare types of tidal freshwater marsh. These tidal wetlands are considered by VDCR to be one of the two largest relatively undisturbed wetlands on the lower peninsula of Virginia. Yarmouth Creek and its 1523 acres of wetlands provide habitat for a diversity of fish, waterfowl, and wildlife, which collectively contribute to the area's exceptional recreational value for hunting, fishing, bird watching and nature enjoyment. Additionally, these areas are home to at least one known heron rookery, a number of historic bald eagle nesting sites, and several globally rare or threatened plant species including the sensitive joint vetch, and narrow-leaved spatterdock.

Presently, the Yarmouth Creek watershed is lightly developed, but it is coming under greater development pressures, particularly in its northern headwaters. The majority of the watershed is zoned agricultural-forestal, but pressure to re-zone for residential development has become a recent issue. Developments within the upper portion of the watershed rely on public sewer, while most of the existing developments in the lower watershed rely on septic systems for wastewater disposal. The upper watershed is a mix of agricultural, residential and commercial land-uses. The lower watershed, dominated by tracts of forest, provides for forest related activities such as timber harvesting and organized hunting. The Yarmouth Creek Watershed Plan represents an excellent opportunity to protect and preserve the unique environmental resources, while allowing for development that does not destroy the natural conditions of the Creek.

Rapid development without adequate protection will most likely lead to a degradation of pristine natural resources in the watershed. The amount of impervious cover is often a good indicator of the extent land development. Research from around the country has

shown that stream and wetland quality begins to decline when the amount of impervious cover in a watershed exceeds approximately 10% (Schueler, 1994).

The principal effects of impervious cover in Yarmouth Creek include:

- Changes in the hydrology of streams, wetlands and floodplains
- Increased pollutant loads delivered in urban stormwater (bacteria, sediment, nutrients)
- Channel erosion in headwater streams
- Water level fluctuations that degrade wetlands
- Favors the establishment of invasive plant species
- Fragmentation of contiguous forests
- Increased flooding
- Reduction of baseflow of streams

Based on the Center's stream impervious cover model, all nine subwatersheds were classified as sensitive (CWP, 1998). If we consider future growth, four of these subwatersheds are expected to move into the impacted category. However, future growth in the watershed remains uncertain as areas can be re-zoned.

Watershed residents and other stakeholders including representatives from local businesses, developers and agencies played a vital role in the creation of this watershed management plan. Stakeholder involvement is a key ingredient in a watershed plan as stakeholders must live with the decisions that are made. They also bring issues to the table that are important to them and participation gives them a stake in the outcome and helps to ensure plan implementation. It was their insight into the problems within the watershed that led to two additional studies: a field assessment of the Little Creek reservoir subwatershed and a memo investigating the increase in salinity in the Yarmouth Creek watershed. The stakeholder process involvement in the Yarmouth Creek plan consisted of three public meetings; the first covered the baseline assessment and fieldwork performed by the Center; and the second engaged participants in the process of setting goals and the third will cover the recommendations in the final plan. The six overall watershed protection and restoration goals identified for the plan by the stakeholders are:

1. Prevent further degradation of water quality in Yarmouth Creek and maintain the outstanding quality of tidal and nontidal mainstem wetlands.
2. Respect the rights of landowners in the watershed plan recommendations and ensure that the cost of conservation is shared by the entire community, not just individual landowners.
3. Develop in a manner that is consistent with the protection of the high quality natural resources in Yarmouth Creek.
4. Work toward the formation of a citizen group to facilitate future participation and protection of Yarmouth Creek. Suggestions included:
    - Educate people about watershed awareness including litter and boat wakes). Promote active stewardship among residents, community associations, businesses, and seasonal visitors.
    - Work with neighbors to develop a vision for individual properties
    - Work with the county on shared goals

5. Minimize the local practices that increase salinity concentrations in the freshwater ecosystem of Yarmouth Creek and further investigate a minimum flow rate for Little Creek Reservoir.
6. Enhance stewardship of Yarmouth Creek by specifically addressing the litter issue and shoreline erosion due to boat wakes.

Process

The 16 square mile Yarmouth Creek watershed was divided into nine subwatersheds ranging from one to four square miles in area to create individual planning units (Figure E-1). Land use and impervious cover were analyzed for each subwatershed to provide preliminary expectations for current and future water quality and habitat conditions. Field conditions and conservation areas were evaluated to check expectations developed in the land use and impervious cover analysis. Together with the results of our conservation area work and the stream habitat assessment, draft goals were created for subwatersheds based on scientific assessment and existing and potential future land use. It was determined that Yarmouth Creek includes a mix of relatively high quality subwatersheds with considerable biodiversity and a number of subwatersheds that exhibit localized degradation of stream conditions especially in the upper portion of the watershed near Richmond Road. (Rt. 60).

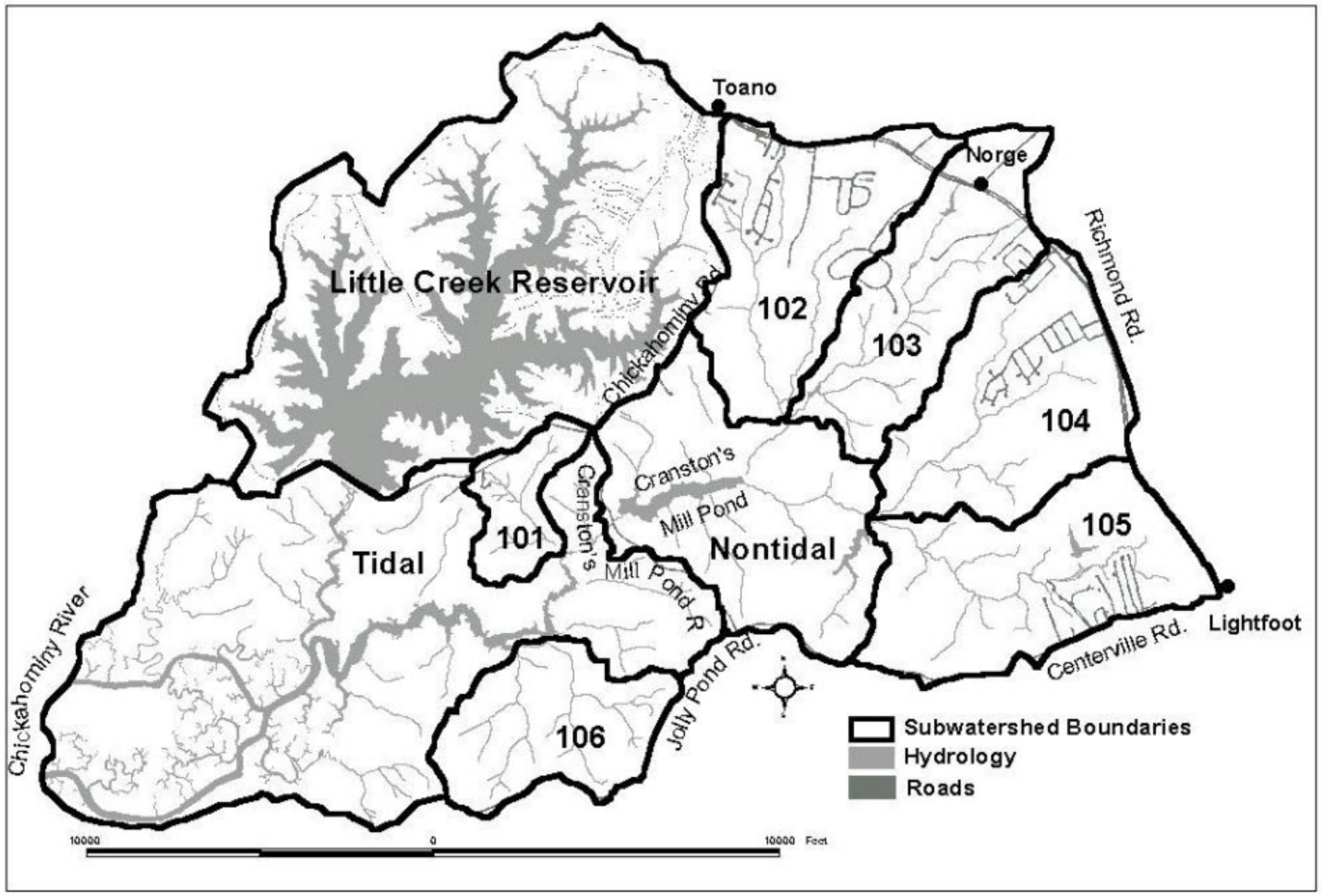


Figure E-1. Yarmouth Creek Subwatershed Map

Table E-1. provides a summary of the subwatershed goals as well as both the current and future impervious cover for each subwatershed based on the current zoning. These goals represent some of the responses that were echoed at the stakeholder meetings about how to manage individual subwatersheds. General agreement was reached for responsible development in the upper watershed and perhaps more conservation and protection in the lower tidal portion of the watershed. However, it was also clear that imposing conservation on individual property owners was not a favorable approach for the landowners. At the same time, there was a goal of preventing further degradation in the entire watershed by using stormwater retrofits, effective stormwater management, stream restoration and watershed education programs.

Table E-1. Subwatershed Goals

Subwatersheds	Current/ Future Status	Watershed Goals	Tools
101, Mainstem tidal, Mainstem non-tidal, 106, Little Creek Reservoir	Sensitive / Sensitive *less than 10% impervious cover*	Preserve the important mainstem tidal portion of the creek (conservation areas, sensitive streams and contiguous forest) without impeding private property rights	➢ Voluntary conservation and acquisition programs ➢ Close work with the Landowner watershed group ➢ Protect open space, when development does occur and attempt to minimize the impacts
102, 103, 104, 105	Sensitive / Impacted *10 -25% impervious cover*	Restore degraded streams and protect streams from further degradation	➢ Implement watershed education and stewardship programs ➢ Stormwater retrofits ➢ Stormwater practices ➢ Stream restoration

Recommendations

Prioritized implementation recommendations for the Yarmouth Creek watershed are summarized in Table E-2. These recommendations are prioritized based on how well they achieve stakeholder watershed goals and their importance to successful watershed management as gauged by CWP and JCC technical staff. Preliminary cost estimates and potential responsible parties have been identified so that financial resources can be allocated and staff roles can be defined. Real watershed protection requires a multi-faceted approach that combines land use and preservation decisions with on-the-ground implementation, education and protection of watershed functions. This approach strives for permanent protection, and attempts to minimize long-term costs by implementing proactive, preventative solutions. An estimated $160,000 a year over four years is our planning level estimate of the funding needed to implement the recommendations. This

number would increase considerably with a larger purchase of development rights program or conservation easement program that would need to be funded at one million dollars a year for at least four years to be relatively successful. Long-term protection of water quality, fisheries, forest and biodiversity have quantifiable community benefits including increased property values and enhanced quality of life, which compound over time. More details on the economic benefits of watershed protection can be found in Appendix A. Detail for each of the priorities in Table E-2 can be found in Section 3 Watershed Recommendations.

Table E-2. Priorities and Costs for Watershed Protection and Restoration in Yarmouth Creek

Priority	Goals Achieved	Protection Tool or Evaluation Measure	Where	Costs to JCC and Action	Responsibility
1	1,3,6	Use of subwatershed maps to ensure local staff and stakeholder awareness of existing locations for restoration and potential conservation areas	Watershed wide	Small	JCC Planning, Development Management, Environmental Division
2	1,2,4	Foster development of a watershed group for Yarmouth Creek led by the landowners/ stakeholders in the Creek	Watershed wide	Small Consider initial seed money	Stakeholders, JCC Planning, Development Management, Environmental Division
3	1,2,3,5	Adopt Special Stormwater Criteria (SSC) in the Watershed to increase groundwater recharge in the development process	Sub-watersheds in PSA and re-zonings watershed wide	Small Criteria should be the same as Powhatan	Environmental Division
4	1,5	Establish a working group to address salinity issues and consider min flow from Little Creek	Tidal Yarmouth Creek	Small 0.1 FTE	Stakeholders, Development Management, Environmental Division
5	1,2	Work with stakeholder watershed group to conserve land through purchase development rights/ easements in sensitive areas	Watershed wide	Expensive 1million a year for 4 years	PDR Program, Development Management

Table E-2. Priorities and Costs for Watershed Protection and Restoration in Yarmouth Creek					
Priority	**Goals Achieved**	**Protection Tool or Evaluation Measure**	**Where**	**Costs to JCC and Action**	**Responsibility**
6	1,2	Perform 4 stormwater retrofits	Sub-watersheds 102, 103, 104, 105	Expensive $50k a year for 4 years	Environmental Division, Development Management
7	1,2	Perform stream restoration and channel stabilization projects	Sub-watersheds 103, 104	Expensive $100k** a year for 4 years	Environmental Division, Development Management
8	1,2,3	Maintain priority of Purchase of Development Rights (PDR) program for special resource areas including buffers and conservation areas	Watershed wide	Small	PDR Program, Development Management
9	1,6	Meaningfully address trash issues in the watershed Arrange cleanups and work with stakeholder group to change behavior	Watershed wide	Small 0.1 FTE $500 year for roll off dumpster rental	Environmental Division, Solid Waste Division
10	1,2,3,4	Encourage Better Site Design across the watershed and the county by improving code language and having a roundtable – a series of meetings with developers, VDOT, JCC staff and other stakeholders	Watershed wide	Moderate 0.5 FTE for a planner	Stakeholders, Developers, JCC Planning, Development Management, Environmental Division
11	1,4,5	Monitor salinity in Yarmouth Creek in cooperation with the stakeholder watershed group	Tidal Yarmouth Creek	Small $100 in equipment	Stakeholder watershed group

Table E-2. Priorities and Costs for Watershed Protection and Restoration in Yarmouth Creek					
Priority	**Goals Achieved**	**Protection Tool or Evaluation Measure**	**Where**	**Costs to JCC and Action**	**Responsibility**
12	1,4,6	Signage and educational materials to begin to address boat wake issues	Tidal Yarmouth and Chick boat ramps	Small $1-2k over two years	Stakeholder watershed group, Environmental Division, Development Management
13	4,6	Monitor restoration efforts on stream channels and biota	Watershed wide	Small to Moderate 0.2 FTE or $5k a year sub to W&M	Environmental Division, Development Management
14	1,2	Continue to strengthen enforcement of existing RPA laws on new development and as stated in the law protect all perennial streams and connected wetlands	Watershed wide	Small	Development Management, Environmental Division
Total	$160k a year over 4 years + additiona1 1 million a year for an expanded PDR program and .75 FTE				
FTE- Full-time employee JCC- James City County PDR- Purchase of Development Rights VIMS- Virginia Institute of Marine Science					
Costs Small – Less than 5k Moderate -- $5-40k Expensive >40k ** Bioengineering costs based on (City of Asheville, 1998) costs of $25-$55 linear ft					

Another key component of this watershed plan is measuring and monitoring the success of the plan. In Yarmouth Creek, this consists of monitoring the effects of management measures on stream channel stability, water quality, RTE species and impervious cover. This will enable county staff to learn from the successes and challenges of plan implementation and craft better strategies in the future.

SECTION 1. INTRODUCTION

The entire Yarmouth Creek watershed including Little Creek Reservoir is located within James City County, Virginia. The creek drains to the Chickahominy River, which in turn discharges to the lower portion of the James River. The Yarmouth Creek watershed is located north of Powhatan Creek watershed, where the Center recently completed a watershed planning process. Unlike the Powhatan Creek watershed, the Yarmouth Creek watershed has steeper slopes surrounding the mainstem and its tributaries, and there is less development in the Yarmouth Creek watershed.

For the purposes of this study, the 16 square mile Yarmouth Creek watershed was divided into nine major subwatersheds, consisting of six headwater subwatersheds, the Little Creek Reservoir subwatershed and the tidal and non-tidal subwatersheds (Figure 1). The non-tidal portion of the mainstem of Yarmouth Creek is located upstream of Cranston Mill Pond Road. This area comprises some 1.7 square miles, and contains floodplains, wetlands, and a few small tributary streams. The tidal portion of Yarmouth Creek extends from its confluence with the Chickahominy River upstream to just below Cranston's Pond. This portion comprises 4.6 square miles of quality wetlands including the rare freshwater tidal marsh.

Yarmouth Creek watershed is approximately 64% forested, and less than one-third of the watershed is developed. Power and sewer lines run across the upper portion of the watershed, while the lower portion is primarily undeveloped. Only one road, Cranston Mill Pond Road crosses Yarmouth Creek. Steep ravines exist along the riparian corridors and some of these areas contain ancient shell deposits and unique plant communities. The tidal portion of the watershed contains freshwater tidal marsh as well as three rare, threatened or endangered (RTE) species.

The upper portion of the Yarmouth Creek watershed (subwatersheds 102,103,104,105, Little Creek reservoir) is lightly developed, while the lower portion (subwatersheds 101,106, and the tidal and nontidal mainstem) is mostly forested and/or wetlands. A recent natural areas inventory classified almost 50% of the watershed as zones of moderate to high significance in terms of biodiversity (Clampitt, 1991). Most of these identified conservation areas are located in the tidally-influenced portion of the watershed near the confluence with the Chickahominy River. The uplands of the watershed have mostly forested riparian slopes, and contain veins of fossil shell deposits that often have unique plant communities associated with them.

Yarmouth Creek watershed has extensive complexes of wooded swamp, freshwater wetland, and rare tidal freshwater marsh. These wetlands are home to several globally rare or state rare species including the sensitive joint vetch, bald eagle, narrow-leaved spatterdock, and small whorled pogonia. Also found in the watershed are the blue heron, Florida adder's-mouth, and shadow-witch. Yarmouth Creek's 1523 acres of wetlands provide habitat for a diversity of fish, waterfowl, and wildlife. These high quality natural resources make the Yarmouth Creek watershed one of James City County's premier locations for hunting, fishing, birdwatching and enjoying nature.

Presently, the Yarmouth Creek watershed is only lightly developed, but it is coming under greater development pressures, particularly in its northern headwaters. The upper part of the watershed relies on sewer, while most existing development in the lower watershed relies on septic systems for wastewater disposal. The upper watershed is dominated by agricultural, residential and commercial land uses. The lower watershed is dominated by large tracts of forested land. Timber harvesting and organized hunting clubs are the predominant activities on the land. The majority of the watershed is zoned for agricultural use, but pressure to re-zone for residential development has become a recent issue. The Yarmouth Creek Watershed Plan represents an excellent opportunity to protect and preserve the unique environmental resources, while allowing for sustainable development.

A number of special studies and efforts were conducted to gain a better scientific understanding of the stream system; these included a stream habitat and fish assessment, a conservation area study, a rapid stormwater retrofit survey, and an assessment of the increases in salinity in Yarmouth Creek. The stream assessment consisted of an instream habitat survey for the majority of the non-tidal watershed and a fish assessment at four locations in the upper watershed. The assessment reported on stream channel stability and habitat conditions in each of the subwatersheds. The Conservation Area Study identified the presence of Rare, Threatened or Endangered (RTE) species, contiguous forest, high quality wetlands, and identified potential threats and impacts to their existence. A stormwater retrofit inventory was performed to determine obvious potential retrofits and determine the necessity for the county to perform additional work in that arena. Salinity increases in Yarmouth Creek were assessed in response to valid citizen concerns and observations of salinity increases in Yarmouth Creek. Summary findings on these individual studies are presented below and more detail is provided in the Conservation Area Report for Yarmouth Creek, the Baseline Watershed Assessment for Yarmouth Creek and the Technical Memo on the Reduced Freshwater Flow in Yarmouth Creek which are available on James City County's website.

Stream Habitat and Fish Assessment

Stream habitat surveys show early and clear signs of stress in the most headwater streams primarily due to stormwater runoff from Richmond Rd (Rt. 60) corridor. However, streams quickly improve as you move downstream from the Rt. 60 corridor. The streams in the lower watershed show fewer sources of stress, though there was some degradation associated with trash dumping in Subwatershed 101. Stormwater impacts to the mainstem tidal creek were not detected and problems seem more related to salinity increases and the resulting decline in wetland plant species.

Fish were assessed in subwatersheds 102,103,104, and 105 by CWP staff and staff of Virginia Department of Game and Inland Fisheries (DGIF). More detailed information about the stream habitat and fish assessment can be found in the *Conservation Areas for Yarmouth Creek Report* (CWP, 2002a). A summary of the outcomes of the assessments are provided in the bullets and table below;

- identification of 5 subwatersheds with excellent habitat conditions
- identification of 4 subwatersheds with good habitat conditions
- identification of subwatersheds 104, 105, tidal Yarmouth Creek and Little Creek Reservoir to support excellent fisheries

Table 1-1 Impervious Cover and Stream Conditions in Yarmouth Creek Subwatersheds

Subwatershed	Area (Acres)	Current Impervious Cover	Future Impervious Cover	Habitat Conditions	Fish Conditions
101	220	2.2%	6.8%	Good	
102	870	7.3%	11.5%	Good	Good
103	744	5.1%	11.4%	Excellent	Good
104	860	9.0%	19.7%	Excellent	Excellent
105	931	5.5%	16.7%	Good	Excellent
106	548	0.4%	3.5%	Excellent	
Non-tidal	1072	1.1%	3.3%	Excellent	
Tidal	2912	0.3%	1.8%	Excellent	**
Little Creek Reservoir	2887	<2%*	<5%*	Good	**

* the impervious cover numbers for Little Creek are general estimates based on current and future land use

**Both the tidal portion of Yarmouth Creek and the Little Creek Reservoir are also reported by watershed stakeholders and Virginia Department of Game and Fisheries (per. comm.) to support excellent fisheries (though they were not monitored by CWP)

Salinity Issue

In recent years there has been a growing concern about rising salinity levels in the tidal portion of Yarmouth Creek. At the Yarmouth Creek watershed meeting in February 2002, stakeholders described changes in the marsh vegetation as well as an increase in saltwater species, including blue crabs, and fish species such as the croaker further up the Chickahominy River. Some residents fear that a gradual shift in the salinity may affect this marsh ecosystem. The change in the salinity regime and marsh ecosystem is a serious concern as Yarmouth Creek is considered one of the two largest relatively undisturbed tidal freshwater wetlands on the lower peninsula by Virginia Department of Conservation and Recreation (VDCR) (Clampitt, 1991).

A review of the available data supported the observation that increases in saltwater concentrations are occurring. Though the relative causes of salinity and vegetation changes that have occurred in the Yarmouth Creek watershed may be disputed, Sea Level Rise (SLR) and increases in salinity due to freshwater take for drinking water will likely continue in Yarmouth Creek, and there are limited local solutions available to address this issue. These include the following:

- Set salinity or freshwater flow thresholds in the Chickahominy that would trigger voluntary and mandatory conservation methods on the peninsula.
- Ensure groundwater recharge stormwater practices and site design are used in the Yarmouth Creek watershed to maintain baseflow conditions.
- Explore the possibility of beneficial releases from Diascund, Little Creek and/or reduced intake from the Chickahominy during drought conditions to combat salinity increases and associated impacts from SLR and water withdrawals.
- Explore the possibility of increased pumping from the Chickahominy during high flow conditions, (ie. > 25% of the highest flows). This would be a time where effects downstream are likely to be negligible, and this may also help to compensate for losses during beneficial releases or reduced intake during drought conditions.
- Consider high flow releases from Diascund and Little Creek during extended high flow events.

The last three potential solutions require further study to understand the full range of pros and cons that would result from implementation.

Retrofit Inventory

The Rapid Retrofit Inventory in Yarmouth Creek focused primarily on existing dry and wet ponds in the upper watershed. Although this was a very limited survey, we were able to make some conclusion and recommendations regarding opportunities within upper watershed where the majority of development has occurred (subwatersheds 102 through 105). Key findings of the retrofit survey include:

- The majority of the facilities investigated could benefit from fairly simple, low cost enhancements, such as addition of a forebay in wet ponds, or orifice conversion for existing dry facilities to incorporate a permanent pool and improve channel protection where necessary.
- One dry facility (105-R2) had severe embankment failure, and needs attention.
- Maintenance issues were observed at a few facilities primarily resulting from clogging and trash.
- Overall, creation of additional facilities to treat the uncontrolled runoff from residential land may not be beneficial, due to limited downstream impacts and possible wetland and forest impacts when constructing practices.
- Stream assessment suggests that the upper reaches of streams within Subwatershed 104 are showing some signs of degradation, and this area may warrant more detailed retrofit investigations.

The inventory included investigation of 11 locations, primarily focusing on existing stormwater ponds. The inventory is summarized in Table 1-2 and on the appropriate Subwatershed maps located in Section 5. Retrofits have been grouped into one of three categories, low, moderate or high priority depending on the costs and benefits to be gained by performing each individual retrofit.

Table 1-2 Retrofit Opportunities in Yarmouth Creek Watershed

ID (County ID)	Facility Type	Description	Comments	Priority
102-R1 (YC-020)	Existing Dry Pond	Enhancements including addition of a sediment forebay, and expansion of the wet pool area to incorporate greater water quality. Also, remove debris from clogged outlet.	Some trash at outlet. Simple retrofit.	Moderate
102-R2 (YC-019)	Existing Dry Pond	Enhancements including addition of a sediment forebay, and expansion of the wet pool area to incorporate greater water quality.	Some trash at outlet. Simple retrofit.	Moderate
102-R4 (YC-013)	Existing Wet Pond	Possible addition of a forebay.	Simple retrofit. Otherwise nice facility.	Moderate
103-R1 (YC-006)	Existing Wet Pond	Possible addition of a forebay.	Simple retrofit. Otherwise nice facility.	Moderate
103-R2	Infiltration Basin/Dry Pond	Infiltration basin which may be acting more like a dry pond Possible orifice retrofit to provide downstream channel protection	Simple retrofit	Moderate/ High
103-R3	No existing facility	Location where road runoff from Rt. 60 is entering the stream untreated possible linear bioretention facility in the median or on the side of the road	Would require design and coordination of with VDOT	Moderate
104-R1 (YC-002)	Infiltration Basin	Consider adding bioretention elements to enhance the facility. Mulch the base of the facility, and incorporate a variety of plants.	This facility is currently recorded as a dry pond.	Low
105-R1	Unmanaged Runoff	Add a stilling basin at the outfall. Small drainage area estimated at 7,500 square feet. Could incorporate wet storage for water quality.	Sewer line and wetlands present potential conflicts.	Low
105-R2 (YC-015)	Existing Dry Pond	Catastrophic failure. Undermining of the barrel has resulted in severe erosion, resulting in a roughly 20' deep canyon at the outfall, and trash in the facility. This problem should be repaired, and wet storage could possibly be incorporated as well during this enhancement.	This is a potentially high cost retrofit. JCC Development Management has been working to secure funding and landowner permission for this repair.	High
105-R3	Unmanaged Existing Development	Create a small wet pond to provide water quality and channel protection volumes.	Would result in loss of at least three large trees, but can help to control runoff from dense development	Moderate
105-R4 (YC-014)	Existing Dry Pond	Convert from a dry to wet storage to improve water quality treatment.	Facility also has an unlocked cover on the manhole, which can pose a safety hazard.	Moderate: Water Quality High: Unlocked manhole cover

Stream Restoration

Six candidate sites for stream restoration were located during the field assessment portion of the watershed study. Five of the six sites are located in the upper watershed where impacts from the Rt. 60 commercial corridor are apparent. For this project, a distinction

has been made between stream restoration and channel stabilization. The goals of stream restoration projects are to reduce sediment transport from eroding streambanks and to improve habitat for both fish and the aquatic insects that begin the food chain. Consequently stream restoration occurs solely on perennial streams that flow year round and support complex biological systems. Channel stabilization can occur on perennial or intermittent streams and focuses on restoring stability to an eroding channel or headcut area that may or may not serve as habitat for biota.

The descriptions of the proposed sites as well as the type of restoration effort that would be required are provided in Table 1-3. Only one site 104-S1 would be considered stream restoration as it would combine stormwater retrofitting with stream restoration approach and focus primarily on recreating habitat lost as a result of uncontrolled stormwater. The locations for the stream restoration sites are identified on the subwatershed maps in Section 5.

Table 1-3. Potential stream restoration / channel stabilization sites in Yarmouth Creek

Site	Description	Type of Effort	Priority
103-S1	Small eroding channel in 103 primarily located on the Candle Factory Property	Channel stabilization - A good bioengineering project –	High
104-S1	Reach of stream adjacent to the west side of the Kristansand neighborhood in Subwatershed 104	Stream restoration -Should be combined with a retrofit, habitat and stability should be restoration goals.	Medium
104-S2	Two reaches on the south side of Kristansand neighborhood experiencing streambank erosion and headcutting	Channel stabilization	Medium
104-S3	Two small headwater channels with active headcuts in subwatershed 104 downstream of the proposed US Homes development	Channel stabilization	Medium
105-S1	Upper reaches of Subwatershed 105 experiencing headcutting and erosion (Several thousand feet of channel is affected)	Channel stabilization	Medium
NT1-S1	Roadside ditch adjacent to Cranston Mill Pond Rd eroding soil into Yarmouth Creek	Channel stabilization	Medium

Conservation Areas

The *Conservation Area Report for Yarmouth Creek* was prepared by assessing orthophoto maps, reviewing rare, threatened, endangered species (RTE) information provided by the Virginia Department of Natural Heritage and performing field surveys of natural resource areas in the watershed. The locations were then ranked based on their level of importance for resource protection. The eight conservation sites of greatest quality were determined based on environmental significance, development pressure, and ease of protection among other factors. General site descriptions and management

recommendations for these conservation areas are outlined in Table 1-4 and provided on the subwatershed maps in Section 5. In addition to the area associated with a mainstem buffer, the total area of the recommended eight priority conservation areas is approximately 3710 acres or roughly 45% of the watershed. However, much of that area is already protected by the Chesapeake Bay Act Resource Protection Area (RPA), or through steep slope, wetland, and floodplain provisions. Accounting for these undevelopable lands, a total area of approximately 2160 acres or 26% of the watershed, was identified for priority upland conservation.

The Conservation Area Report provided an inventory of existing natural areas in the Yarmouth Creek watershed and served as an important baseline tool for this watershed management plan. Existing tracts of contiguous forest in the watershed are represented as polygons with green hash marks in Figure1-1 and in the subwatershed management maps located in Section 5. These areas are designated to provide land managers scientifically-based information on the location and extent of contiguous forests in the watershed. Any attempt to manage or conserve these areas should be conducted with the landowner's full participation in the planning and implementation process. The costs of conservation and protection should be borne by the entire county and not just specific landowners.

Table 1-4 Yarmouth Creek Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
1	C2	480	320	Tidal mainstem; best mature contiguous forest in the watershed. Potential RTE habitat on steep slopes	63	Continued landowner stewardship; potential conservation easements & restrictions on timber harvesting
2	C1	890	80	Mouth of Yarmouth Creek & Chickahominy River. Contains tidal wetlands, 3 known RTE species	58	Majority of wetlands within RPA; recommend target upland areas for conservation easements or acquisition
3	C4	740	570	Non-tidal mainstem, Boy Scout property. Contiguous forest, potential heron rookery above Cranston Mill Pond; globally rare plant identified (1993) at Camp Chickahominy	57	High development potential; recommend conservation easement, RPA extension, BSD to protect streams are clustering for larger buffers
4	C3	170	100	Upper portion of tidal mainstem; Heron rookery and bald cypress stand	54	Partially protected by RPA, however uplands unprotected; consider acquisition/easement of surrounding area
5	C5	190	140	Subwatershed 104; sensitive stream, contiguous forest, shell-marl	54	Targeted for development; RPA protection for all first order streams, BSD
6	C6	260	190	Subwatershed 105; sensitive stream, contiguous forest, shell-marl, good fish	52	Targeted for development; RPA protection for all first order streams, BSD, stringent stormwater treatment
7	C7	830	610	Tidal mainstem and subwatershed 106; young	48	Acquisition/easement, to maintain contiguous forest; Conservation

Table 1-4 Yarmouth Creek Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
				contiguous forest and potential RTE habitat		easement to maintain hunting and selective logging
8	C8	150	150	Mature forest in Little Creek Subwatershed; contiguous tract connecting Yarmouth with neighboring watershed		Work with utility to maintain existing forest buffer to protect water supply and maintain contiguous forest; Develop long range forest management plan
Total % Watershed		3710 45%	2160 26%			

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

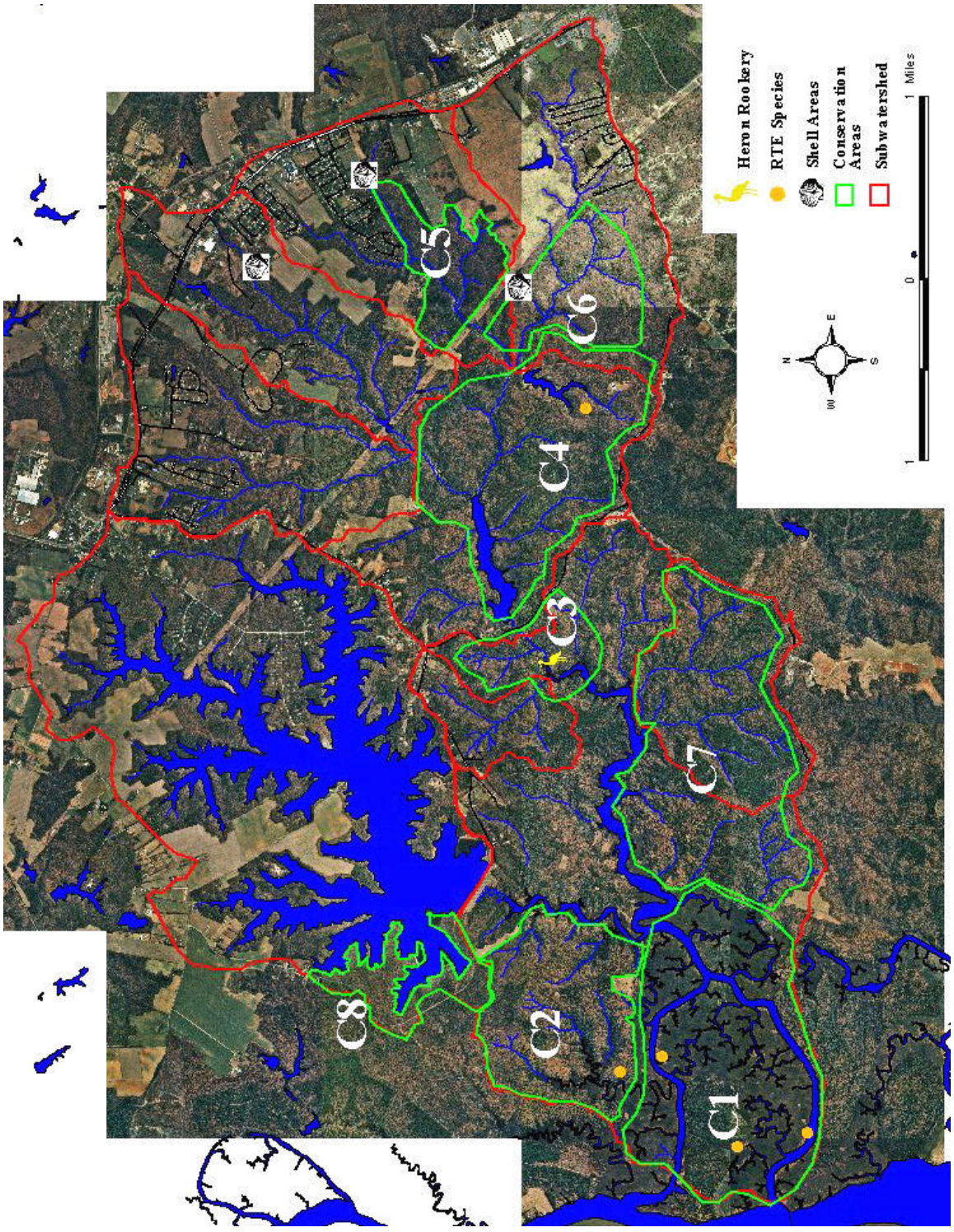


Figure 1-1. Conservation Areas in Yarmouth Creek

SECTION 2: WATERSHED GOALS

The public and other stakeholders including members of the business community and local government staff play a vital role in the creation and implementation of a watershed management plan. It is important to involve the citizens, businesses, and other interested parties in the development of the watershed plan, since they will have to live with the decisions that are made. Stakeholders also bring to the table the issues that are important to them. Their participation gives them a stake in the outcome and helps to ensure the implementation of the plan. Two meetings were held with watershed stakeholders; the first introduced the baseline assessment and fieldwork that was performed by the Center, the second engaged participants in the process of setting goals for the watershed. After receiving input from residents and other watershed stakeholders on what goals were deemed important to the community at large, the following set of principles were drafted to guide recommendations of the Yarmouth Creek Watershed Management Plan:

1. Prevent further degradation of water quality in Yarmouth Creek and maintain the outstanding quality of tidal and nontidal mainstem wetlands.

This goal reflects the importance of the tidal Yarmouth Creek for the watershed stakeholders and the importance of maintaining the outstanding quality of the resource. The resource is used by stakeholders for fishing, hunting, birdwatching, and specific concerns include high speed boat wakes causing shoreline erosion, the increase in salinity concentrations in Yarmouth Creek, and minimizing the impacts of future development on the tidal ecosystem.

2. Respect the rights of landowners in the watershed plan recommendations and ensure that the cost of conservation is shared by the entire community, not just individual landowners.

There was a strong message from the stakeholders that respecting private property rights and ensuring the burden and costs of protecting Yarmouth Creek are not unduly placed on individual landowners in the watershed. While landowners have an interest in protection of the creek, they do not wish to assume the cost of reduced rights to their land, those costs should be assumed by the community as a whole.

3. Develop in a manner that is consistent with the protection of the high quality natural resources in Yarmouth Creek.

Stakeholders expressed the need for future development to be consistent with the protection of the unique resources of Yarmouth Creek. They also expressed the importance of the enforcement of existing laws when it comes to development -- including on county property. Stakeholders also expressed the need for consistent guidelines and rules for development across the county.

4. Work toward the formation of a citizen's group to aid in the protection and participation of residents in the future of Yarmouth Creek.

The stakeholders specifically discussed the possible formation of a citizen's watershed group. Some of the specific activities the group mentioned that it may engage in include working with other landowners to develop a future vision of individual properties, working to improve watershed awareness and active stewardship in response to key issues including litter and boat wakes, and working directly with their neighbors and the county on common goals.

5. Minimize the local practices that increase salinity concentrations in the freshwater ecosystem of Yarmouth Creek and further investigate a minimum flow rate for Little Creek Reservoir.

Increasing the minimum flow rate from Little Creek and allowing additional flushing was an important issue raised by stakeholders to at least improve conditions locally in Little Creek. There was a concern about both the lack of flushing of saltwater and the deposition of sediments in Little Creek below the dam which then cannot be flushed out as would have occurred prior to the dam being in place. Stakeholders were also very concerned about the changes in marsh vegetation and biota that are occurring in Yarmouth Creek.

6. Enhance stewardship of Yarmouth Creek by specifically addressing the litter issue and shoreline erosion due to boat wakes.

Litter and trash dumping was also an important issue to the stakeholders in Yarmouth Creek. Specific areas noted included Cranston Mill Pond Rd. Suggestions for addressing the problem include signage and reducing or eliminating the tipping fees at the local landfill – so that residents responsible for the dumping will have more incentive to use the landfill.

SECTION 3. WATERSHED RECOMMENDATIONS

This section presents subwatershed-based recommendations for Yarmouth Creek in the context of six of the eight tools of watershed protection as outlined by the Center in the Rapid Watershed Planning Handbook in 1998. Specific recommendations are made for land use planning, better site design, aquatic buffers, stormwater management, conservation areas, and stewardship. The other tools, erosion and sediment control (ESC) and non-stormwater discharges (NSD) are addressed by the county in its ESC ordinance and NSD does not apply particularly to this watershed as there are only a small number of homes on septic systems. Each tool is introduced below and is linked with specific recommendations for Yarmouth Creek subwatersheds. As a consequence, the overall watershed priorities are presented as they relate to the eight tools and do not necessarily appear in numerical order.

A. Land Use Planning

Land use planning tools are needed to assist in the conservation of lands that are important to safeguarding the long-term protection of water quality, pristine streams, wildlife corridors, contiguous forest and the unique biodiversity of the Yarmouth Creek watershed. The preservation of conservation areas will also serve as recharge sites to filter groundwater and to help maintain freshwater baseflow in the streams that form Yarmouth Creek. Planning must also encompass the creation of a blueprint for the restoration of existing streams and locations that have been degraded by stormwater and litter. Our recommendation in this area is for the use of subwatershed management maps by county staff and stakeholders in reviewing site plans and managing Yarmouth Creek.

Overall Priority #1. Use of subwatershed maps to ensure local staff and stakeholder awareness of existing need for restoration and locations of potential conservation areas.

The creation and use of subwatershed maps are a critical component of a watershed plan because they serve as the blueprints for restoration and protection of the creek. Subwatershed maps illustrate the locations of potential improvements for stormwater treatment, the restoration of streams, the cleanup of trash dumps, as well as the locations of important conservation areas. The knowledge of these areas allows county staff and watershed stakeholders to work toward the protection and restoration of identified locations. The information should also be shared with developers as development proposals are received so they can incorporate restoration or protection into their projects. In some cases proffers for protection of conservation areas or for the construction of restoration projects can be requested during the development process. In other cases, restoration efforts can be conducted by county staff or volunteers with existing county resources or through state or federal grants.

Maps for each subwatershed as well as explanations for the information portrayed on the maps are located in Section 5. It is important that subwatershed maps and text are distributed to personnel in the JCC environmental division, planning division, PDR program and the development management division as well as the stakeholder group.

B. Better Site Design

Better site design (BSD) is a critical tool for watershed protection and can be effectively implemented in future development of the Yarmouth Creek watershed. BSD techniques incorporate a combination of 22 model development principles that are designed to reduce impervious cover, minimize clearing and grading during construction, and maintain native vegetation on-site. BSD is a tool for allowing flexibility and creativity in designing residential and commercial areas scheduled to be developed. Better site design is not an issue of zoning or future land use, rather it is a means of producing the most environmentally sensitive development possible. One of the primary benefits of BSD is the reduction of impervious cover in future development and the resulting decrease in stormwater impact on the future water quality of Yarmouth Creek.

In reviewing its development codes and standards, JCC received a relatively high score on the codes and ordinance worksheet (COW) assessment (Appendix B). The COW assesses the extent to which local codes and ordinances allow or prevent the model development principles from being implemented by developers. James City County development standards appear to allow usage of many of these principles such as open space requirements, cluster development, and buffer requirements. The County scored 75 out of 100 points–indicating that opportunities exist to improve the county's development codes. In the self assessment, JCC identified three major areas in its codes that may limit environmentally-friendly development. These included: parking requirements, setbacks, frontages and street standards.

Overall Priority #10. Encourage Better Site Design (BSD) across the watershed by improving code language and having a specific meeting or series of meetings with local developers and VDOT. Consider holding a site planning roundtable in James City County.

The importance of a structured dialog and an educational program for developers, county staff and VDOT reviewers cannot be overstated. Better Site Design can actually decrease infrastructure costs for developers and reduce maintenance and stormwater costs while better protecting streams and rivers. Generally, once these shared benefits of BSD are understood even environmentalists and the most ardent developers can agree that changes are needed. Special Stormwater Criteria SSC (Priority #4) represents a means to encourage and structure the use of BSD by promoting natural recharge by infiltrating water back into the soil.

Most of the better site design tools are available to developers in the field as is evidenced by the relatively high score (75 out of 100) JCC received on CWP's assessment of the county codes and ordinances. Though it appeared that in much of the new development in JCC, a number of important BSD aspects were not being utilized. Regulatory, economic, and educational barriers to BSD implementation must be identified and addressed if the Yarmouth Creek watershed is to benefit from this protection tool. Recommendations for encouraging better site design techniques include code revision, increased education of developers and planning staff, good coordination with VDOT in

the use of minimum road standards, "shoulder and ditch standards" (though a poor term because we advocate the use of wider swales that are easier for homeowners to maintain and do not result in the erosion of traditional ditches), the provision of incentives for developers to use them, and the targeted use of BSD criteria in sensitive watersheds. Specific recommendations and barriers to Better Site Design are located in Appendix B.

Due to the subjective nature of Better Site Design, several benchmarks are recommended for its increased use in Yarmouth Creek and JCC.

1. Measurable changes in the type of development that occurs in James City County
    - reduced average road widths on residential streets
    - reduced use of cul-du-sacs or the incorporation of vegetated islands
    - reduced average setbacks and frontages
2. Use of innovative stormwater treatment and better site design practices to promote recharge of groundwater
    - digitized soil survey within three years or require a soil survey prior to the plan review process to determine locations for infiltration based practices including open swales and bioretention
    - five projects that utilize bioretention, sandfilters or open swales over the next three years
3. Expedited review or by-right acceptance of BSD criteria
    - By-right use of BSD or expedited review
    - 0.5 position for a planner to advocate for and review BSD proposals
    - Stormwater credits for BSD and implementation of SSC in sensitive subwatersheds
4. Completion of site planning training with good participation from the development community

C. Aquatic Buffers

Aquatic buffers are an important element in a comprehensive watershed protection strategy. A well established and unbroken buffer network provides many benefits to overall watershed health. In addition to serving as a refuge and travel corridor for wildlife, buffers protect streamside wetlands and floodplain areas and serve as a stream "right of way" allowing for lateral movement, protecting private property from flooding and helping to reduce watershed imperviousness.

Priority # 14. Continue to strengthen existing RPA (Resource Protection Area) laws are enforced on new development and as stated in the law protect all perennial streams and connected wetlands.

In James City County aquatic buffers are protected by the County's Chesapeake Bay Preservation Ordinance. The 100ft RPA protects perennial streams, tidal areas and connected wetlands. Enforcement of the RPA regulations on new development is important to protect the long-term water quality of Yarmouth Creek. Determination of buffers in the development process should be scientifically based to ensure fairness and conformity.

D. Stormwater Treatment Practices

Key stormwater-related threats to the natural environment of the Yarmouth Creek watershed include changes in hydrology in streams, wetlands, and floodplains; increased pollutant loads delivered in urban storms (bacteria, sediments, nutrients); and water level fluctuations that degrade wetlands. Headwater streams have shown the greatest degradation, with accelerated channel erosion reported in upper tributaries that creates sediment deposition within floodplains and associated wetlands. By performing stormwater retrofits in a few locations where there is stream degradation and by implementing special stormwater criteria (SSC) and Better Site Design (summarized in the previous section) so additional future impacts to Yarmouth Creek can be minimized.

Priority #3. Adopt Special Stormwater Criteria (SSC) in the Watershed to increase groundwater recharge in the development process.

Special Stormwater Criteria (SSC) for new development: In the Yarmouth Creek watershed, the high quality of the streams, low watershed imperviousness and the presence of hydrologically sensitive conservation areas warrant stormwater management above and beyond the current County standards. The goal of SSC is to attempt to preserve pre-development hydrology as much as possible and to reduce impacts to high quality streams. The volume of recharge that occurs on a site depends on slope, soil type, vegetative cover, precipitation, and evapotranspiration. Sites with natural ground cover, such as forest and meadow, have higher recharge rates, less runoff, and greater transpiration losses under most conditions. This helps to preserve existing water table elevations thereby maintaining the hydrology of streams and wetlands during dry weather. Because development increases impervious surfaces, a net decrease in recharge rates is inevitable.

The criteria require that additional points (above JCC's 10 point system) for stormwater management are gained by disconnecting impervious cover, preserving open space, and or reforestation. More information on the SSC can be found in Appendix C though the details of SSC may change as the county is putting together a committee or task group composed of local engineering firms, developers, HOAs representatives and a local landscape architect to help craft the criteria.
Specific examples of elements of SSC include:

- designs that convey runoff from roads, driveways and rooftops to pervious areas to increase infiltration

- community designs that preserve natural or managed open space – more points being gained for open space left in forest or meadows
- projects that replant trees lost to clearing, and projects that plant additional trees beyond what was lost to clearing

Overall Priority #6. Perform 4 stormwater retrofits

Over ten locations were surveyed for potential retrofits and rated as high, moderate or low priority for restoration. Our recommendation is to perform four stormwater retrofits over the next four years. The majority of development in the watershed includes stormwater practices designed under the County's prior stormwater criteria or with no stormwater management. Many of these facilities were not designed to provide adequate water quality or channel protection. Where appropriate, facilities built under the old criteria (>2 yr control) could have the outflow orifices modified to control the 1 year storm and provide for more extended detention. This represents a cost-effective way to reduce channel erosion and improve water quality. Several of the Yarmouth tributaries are still adjusting to the altered hydrology. The stormwater retrofit inventory portion of this study examined potential locations for stormwater retrofits. The priorities are located in Table 1-2 and the locations of the retrofits are depicted on the subwatershed maps in Section 5.

E. Conservation Areas

Priority #5. Work with the stakeholder group to conserve land through purchase of development rights and easements, and continued landowner stewardship in conservation areas.

Landowners in Yarmouth Creek were committed to the long-term protection of the creek and an important component of that is land conservation in the Yarmouth Creek watershed.

An important component of a PDR program for Yarmouth Creek would be the cooperation and direct consultation with the stakeholder group. Stakeholders have often owned land for many years and have formal long-term relationships with other landowners. Without significant buy-in from this important constituent group, land conservation efforts are bound to be unsuccessful. These community ties are critical for the implementation of land conservation efforts in a watershed. A partnership is needed between the county and the stakeholder group to work strategically to protect conservation areas important to the long-term protection of Yarmouth Creek. At the same time, a partnership with the stakeholder group should ensure property rights of existing landowners are respected. Specific elements of such a partnership could include:

- Informing and engaging other land preservation groups on conservation goals in Yarmouth Creek; these include the James River Association, Williamsburg Land Trust, Nature Conservancy and Virginia Outdoors Federation.

- Creation of a slideshow which could be used to inform others about the resources in need of protection in Yarmouth Creek
- Quarterly meetings to discuss progress (to include the groups named above as well as members of the PDR program from the county)
- Neighbor to neighbor discussions of their long term intentions of the use of their land

Priority #8. Maintain the priority in the PDR program for special resource and conservation areas.

Currently much of the focus in the PDR program is for preserving agricultural land in James City County. The pristine and unique nature of the lower Yarmouth Creek watershed resulted in it being rated as one of the two most important freshwater tidal marsh systems on the lower Peninsula of Virginia (Clampitt, 1991). The preservation of open space that includes natural resources that do not exist elsewhere or exist infrequently such as heron rookeries, mature bald cypress stands and streams with high biological diversity, are of equal or greater ecological value than farmland especially in terms of water quality, recreation and resource protection. Conservation areas identified in the Yarmouth plan should receive high importance in the PDR program. Areas for special consideration also include contiguous forest tracts because of their importance to declining forest interior songbirds and aquatic buffers within the first 300ft of high tide on the tidal mainstem of Yarmouth Creek because of their importance to wildlife including bald eagles, osprey, and marsh birds seeking refuge during high tides.

F. Watershed Education and Stewardship Programs

Stewardship by both the county agencies and the stakeholder groups is critical to provide structure for important elements of the watershed plan which includes education of residents, land conservation efforts, coordination of litter cleanups, monitoring of water quality conditions and restoration efforts.

Specific recommendations for James City County to achieve in the stewardship of the Creek include:

- support the formation of a watershed group in Yarmouth Creek
- target some watershed education efforts to new residents through existing PRIDE and Turf Love efforts
- support local efforts to clean up trash from Yarmouth Creek
- support volunteer monitoring efforts
- facilitate study of the salinity issue and vegetation/ biota changes in Yarmouth Creek
- initiate stream restoration and monitoring projects
- foster or encourage the preservation of conservation areas in Yarmouth Creek

Overall Priority #2. Foster development of a watershed group for Yarmouth Creek led by the landowners/stakeholders in the Creek.

Stakeholders have expressed interest in the formation of a watershed group to represent landowner interests in the preservation of Yarmouth Creek. The presence of a local watershed group to represent both the stakeholders interest and the long term interest of the creek is fundamental to the long term protection of Yarmouth Creek. Specific concerns and potential roles for the stakeholders include those in Table 3-1.

Table 3-1. Stakeholder concerns and potential roles of a watershed group

Concern	Potential Role
Increases in salinity seen in Yarmouth Creek	➢ Part of a work group to discuss and study the issue ➢ Volunteer salinity monitoring ➢ Work toward a long-term study of freshwater withdrawal and SLR (sea level rise) in Yarmouth Creek and corresponding changes in vegetation
Litter and trash	➢ Help to organize cleanups and possibly affect policy on landfill fees
Land preservation and stewardship	➢ Help to better educate the public on stewardship and work with the county to implement a land preservation program ➢ Provide greater knowledge and understanding of Yarmouth Creek through possible education program for children and/or adults (ie. two canoe trips a year with interpretation perhaps coordinate with James River Association)

Overall Priority #4. Establish a working group to address and perhaps further study the salinity changes occurring in Yarmouth Creek and perhaps the larger Chickahominy.

In the conclusion section of the *Technical Memo on the Reduced Freshwater Flow in Yarmouth Creek* (Appendix D), it was clear that salinity levels in the Yarmouth Creek are of both current and future concern. Increasing water demands on the peninsula and sea level rise (SLR) are placing increasing stress on the important freshwater tidal ecosystem in Yarmouth Creek. Further study on the possible effects of the salinity increases on the vegetation and biota of Yarmouth Creek and the potential strategies to offset or minimize the changes are warranted. The formation of a working group is recommended and could be composed of appropriate representatives from Virginia Institute of Marine Sciences (VIMS), JCC, Newport News Water Works (NNWW), Department of Game and Inland Fisheries, and a representative of the Yarmouth Creek stakeholder group. As a first step,

the group could be established and work toward a small conference to improve the understanding of sea level rise and effects of freshwater intake on downstream systems. Further academic research is recommended into both the causes and the effects of increased salinity as well as to determine additional strategies to reduce future salinity increases. JCC may be able to play a role by providing cost share for academic research. Specific tasks to work on include:

Implementation of local solutions (see Appendix D for more detail)

- Voluntary restrictions during drought conditions in the Chickahominy when flows are less than 15 cfs. This represents less than the lowest 10 percent of historical flows at the Providence Forge stream gage.
- Groundwater recharge criteria (Special Stormwater Criteria) referenced in the Powhatan Plan, whereby more stormwater runoff is directed back into the ground to reduce loss of groundwater input.
- Reduced intake of drinking water during drought conditions

Further Research

- Salinity monitoring
- Long term study of vegetation and biological community
- Predictions of future conditions

Overall Priority #7. Perform stream restoration and channel stabilization projects.

Six sites were identified for potential stream restoration projects and channel stabilization projects in Yarmouth Creek. For the sake of this project, a distinction is made between stream restoration and channel stabilization based on existing site hydrology and goals. The goals of stream restoration projects are to reduce sediment transport from eroding streambanks and to improve habitat for both fish and the aquatic insects that begin the food chain. Consequently stream restoration occurs solely on perennial streams that flow year round and support complex biological systems. Channel stabilization can occur on perennial or intermittent streams and focuses on restoring stability to an eroding channel or headcut area that may or may not serve as habitat for biota.

For stream restoration or channel stabilization to be successful, it is important to address the root of the problem. Two root problems that often need to be addressed prior to or during a stream restoration project include: stormwater runoff from impervious cover or land use change that creates channel instability and ineffective streambank protection due to the loss of the extensive root systems associated with mature streamside vegetation. For channel stabilization projects, the key elements are a design that will be rigorous enough to withstand the range of flow events that it will be exposed while not creating additional problems by increasing velocities and sheer stress downstream.

The conceptual designs for a restoration project and a stabililzation project both based on bioengineering approaches which use natural materials to stabilize streambanks and create habitat (in the case of 104-1). The concepts in Figures 3-1 and 3-2 highlight the design approach that is recommended for site103-S1 where the existing banks would be graded to a 2 to 1 or 3 to 1 slope, after stabilizing the toe of the slope with coconut fiber rolls (biologs). The slope would then be planted with native plant materials such as willows or red osier and silky dogwoods. The restoration of the second site 104-S1 would take place after the source of stormwater to the channel is determined and a retrofit is put in place. This concept is for a simple and relatively inexpensive placement of log vanes, staggered on alternating streambanks approximately 30 –50 feet apart (Figure 3-3) and placed (Figure3-4) in 10 to 15 locations in the channel to improve the habitat that has been severely degraded by stormwater runoff. The structures should be placed facing upstream in the channel at an approximately 20-30 degree angle. The objective is to tweak the natural system to improve habitat that has been degraded by stormwater.

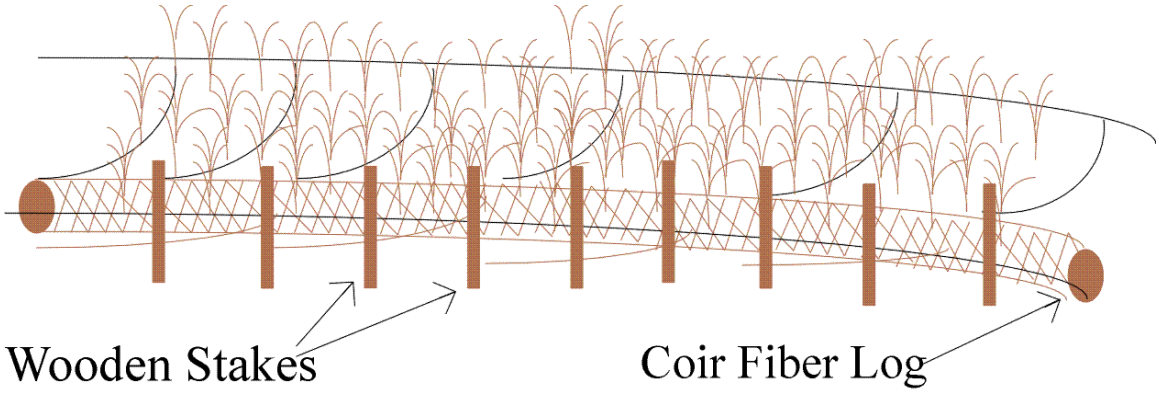


Figure 3-1. Schematic of the use of a coir fiber log for bank stabilization Concept for Site 103-S1 (Brown, 2000)

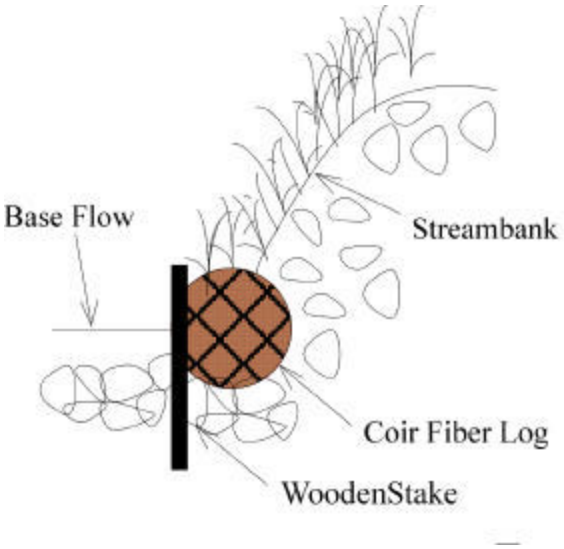


Figure 3-2. Cross section view for a coir fiber log practice concept 103-S1 (Brown, 2000)

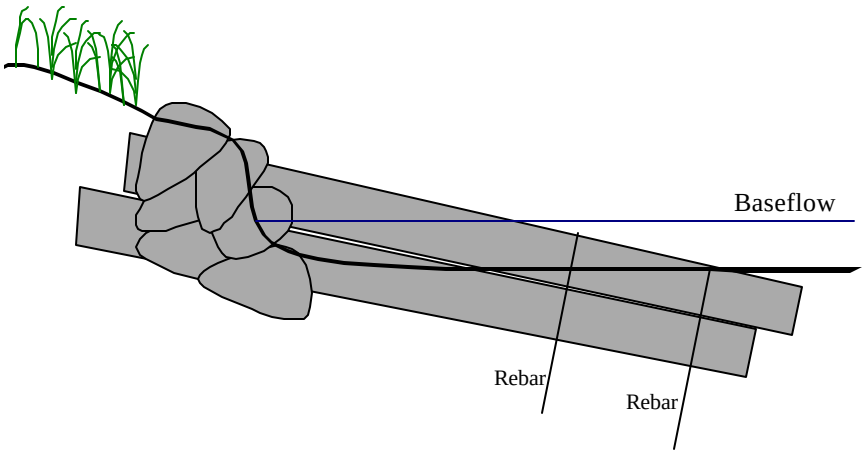


Figure 3-3. Log vein structure concept for site 104-S1 (Brown, 2000)

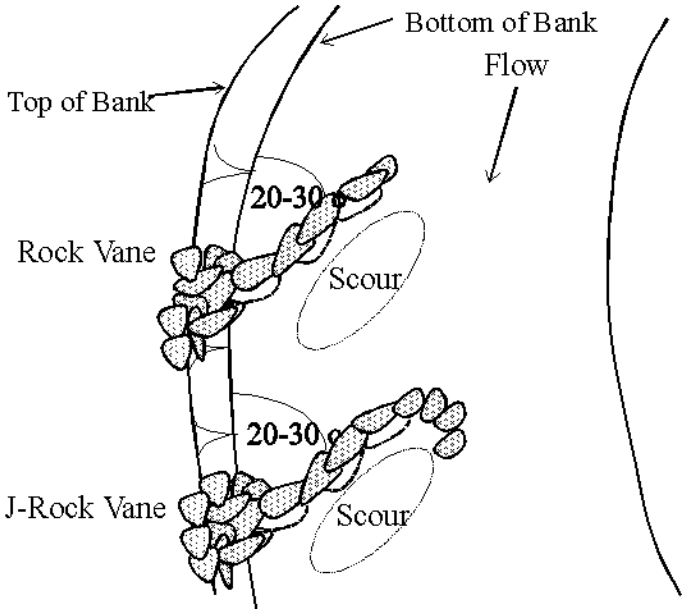


Figure 3-4. Plan view of rock vane and j-hook illustrating the technique for placement of a log vane

Overall Priority #9. Meaningfully address the trash issues in the watershed.

Trash dumping in the rural watershed is an issue that resonated among the majority of the stakeholders. Finding meaningful ways to address the dumping issue as well as cleaning up the existing trash dumps is an important part of this watershed plan and certainly adds to the quality of life of the watershed residents. Specifically, the county can take the lead in helping to arrange for cleanups with the watershed residents and potential watershed group. Stakeholders also voiced that it was important to investigate some of the factors that may contribute to illegal dumping such as tipping fees and consider alternative strategies to help reduce trash dumping.

Recommended benchmarks to address the trash and dumping issue include:

1. Arrange three cleanups over the next two years and coordinate with the existing JCC Spring Cleanup program
2. Implement an adopt-a-road, or the existing Adopt-a-Spot program on Cranston Mill Pond Rd and Rt. 60
3. Work with VDOT or post county signs that set fines for dumping and littering along Cranston Mill Pond Rd and Rt. 60 and ensure adequate legal authority is present.
4. Review possibility of reducing tipping fees to encourage proper disposal of waste

Overall Priority #11. Monitor salinity in Yarmouth Creek in cooperation with the stakeholder watershed group.

Since salinity is an important issue, it is logical that stakeholders should also be involved in monitoring salinity levels in Yarmouth Creek. Particularly, stakeholders who live along the Creek and who could easily access locations to monitor salinity. This would improve local knowledge of salinity conditions in Yarmouth Creek and help to reinforce the need for conservation efforts on the peninsula. Monitoring could take place on a weekly or biweekly basis with refractometers that measure salinity concentrations between 0 – 10 parts per thousand (ppt). Purchase of reliable and accurate instruments is relatively inexpensive (~$100 each).

Overall Priority #12. Signage and educational materials to begin to address boat wake issues

Shoreline erosion in tidal Yarmouth Creek is a phenomena that watershed stakeholders have noticed increasing in recent years. Stakeholders suspect that the recent proliferation in high speed boat traffic and resultant wakes being left by boaters is a major cause of the shoreline erosion. Locations of erosion include Wright's Island and along Shipyard point (shown in Figure 3-4). Recommended management options include:

- Posting no wake zones or boat speed limit signs along eroding shoreline areas
- Posting educational signs that discuss the loss of sediment from the shoreline and the resulting shoaling (shallowing of waters due to sediment) and loss of habitat for the species of fish many fisherman are pursuing. These signs could be posted at public boat ramps and locations where erosion is occurring.

Figure 3-5. Shoreline erosion along Wright's Island

Overall Priority #13. Monitor restoration efforts on stream channels and biota

There are two primary recommendations for restoration monitoring in Yarmouth Creek: James City County, the Department of Inland Game and Fisheries (DGIF) and the College of William and Mary are potential investigators for the monitoring efforts.

1. James City County should ensure monitoring of stream restoration projects is done in order to measure whether the efforts are successful. In particular stream cross sectional monitoring is important to determine if restoration efforts improve stream channel stability (Harrelson, 1994). At site 104-S1 it is important to begin sampling for fish in order to establish the pre-restoration fish community to see if the project is successful in improving habitat and the fish community.
2. Continue long term monitoring of fish and perhaps benthic macroinvertebrates at a minimum of five stations to measure long-term health of the watershed. The stations should be consistent with the stations monitored for the watershed plan perhaps with the addition of Yarmouth Creek at Cranston Mill Pond Rd.

SECTION 4: IMPLEMENTATION SCHEDULE

A draft implementation and cost schedule was created to provide planning level estimates for recommendations involved in the implementation of the watershed management plan. A five-year implementation time horizon was deemed reasonable. The first year of implementation would be the most labor intensive with a number of new programs and additional tasks for county staff. Subsequent years would focus primarily on continued stormwater retrofits, stream restoration, land conservation, better site design and watershed stewardship programs. Federal and state programs and grants are often available for the implementation of watershed restoration projects. Typically there is a cost-share requirement where salaries and capital dollars can be used as matching funds. [A few examples of such funds include EPA Section 319 of the Clean Water Act, Coastal Zone Management Funds, state Watershed Restoration Action Strategies funding and partnerships with the Army Corp of Engineers.] The implementation of this watershed plan fulfills many of the future requirements of EPA's Phase II National Pollutant Discharge Elimination System (NPDES).

Table 4-1. Implementation schedule for the Yarmouth Creek Watershed Plan

Protection Tool or Evaluation Measure	Costs to JCC and Action
Year 1	
1. Implement use of subwatershed maps by local staff and facilitate stakeholder awareness by posting on JCC website and in county libraries.	Small
2. Foster development of a watershed group for Yarmouth Creek led by the landowners/ stakeholders in the Creek	Small Consider initial seed money
3. Encourage Better Site Design across the watershed and the county by improving code language and having a specific meeting or series of meetings with developers and VDOT	Small
4. Adopt Special Stormwater Criteria (SSC) in the Watershed to increase groundwater recharge in the development process	Small
5. Establish a working group to address salinity issues and consider min flow from Little Creek	Small 0.1 FTE
6. Extend the priority of Purchase of Development Rights (PDR) to special resource and conservation areas	Small
7. Meaningfully address trash issues in the watershed Arrange 2 cleanups and work with stakeholder group to develop strategies to minimize dumping	Small $500 year 0.1 FTE
8. Begin monitoring salinity in Yarmouth Creek in cooperation with the stakeholder watershed group	Small $100 in equipment
9. Perform one stormwater retrofit	$50k
10. Begin planning for one stream restoration project	$5k

Table 4-1. Implementation schedule for the Yarmouth Creek Watershed Plan	
Protection Tool or Evaluation Measure	**Costs to JCC and Action**
11. Begin monitoring stream channels and biota at future restoration sites	0.2 FTE or $5k a year sub to W&M
Total	**$60k**
Year 2-5	
1. Encourage Better Site Design across the watershed and the county by improving code language and having a specific meeting or series of meetings with developers and VDOT	Small
2. Continue working group to address salinity issues and consider min flow from Little Creek	Small
3. Begin working with stakeholder watershed group to conserve land through purchase development rights/ easements in sensitive areas and increase funding to PDR program by 1 million dollars and target for Yarmouth Creek for 4 years	Expensive 1 million dollars a year for 4 years
4. Arrange two cleanups and continue to work with stakeholder group to develop strategies to minimize dumping	$500 year
5. Continue monitoring salinity in Yarmouth Creek in cooperation with the stakeholder watershed group	Small
6. Plan and construct one stormwater retrofit a year	$50k a year
7. Plan and construct one stream restoration project every year.	$100k a year
8. Signage and educational materials to begin to address boat wake issues	Small $1-2k over two years
9. Continue monitoring stream channels and biota at future restoration sites	0.2 FTE or $5k a year sub to W&M
Total	**$160k a year over 4 years + 1 million a year for the expanded PDR program**

SECTION 5: SUBWATERSHED MANAGEMENT PLANS

Conditions and watershed management concerns vary across each of the nine subwatersheds, including Little Creek reservoir, the mainstem non-tidal and tidal creek segments. This section contains a detailed profile for each of these areas, with respect to current and future impervious cover; estimated developable area; stream habitat conditions, locations of trash dumping, presence of wetlands, fossilized shell marl areas, contiguous forest, locations of rare, threatened and endangered species; priority stream restoration and retrofit sites.

Subwatershed maps have also been created to accompany the text and serve as a blueprint for the protection and restoration of the Yarmouth Creek watershed. They also can be used as a tool in which to review future development projects, negotiate proffers, or review re-zoning requests. The maps contain priority conservation areas such as contiguous forest tracts, sensitive streams and locations of rare, threatened or endangered species. The maps also contain locations for priority retrofit sites, stream restoration and trash cleanups. Zoning is also included on the maps according to the categories as follows.

A1 General Agricultural District
B1 General Business District
LB Limited Business District
M1 Limited Business/Industrial District
M2 General Industrial District
MU Mixed Use District
PUD-C Planned Unit Development District
R1 Limited Residential District
R2 General Residential District
R4 This district is intended to permit development, in accordance with a master plan, of large, cluster-type communities
R5 Multifamily Residential District
R6 Low-Density Residential District
R8 Rural Residential District
RT Research and Technology District

The watersheds are organized into the Upper and Lower Subwatersheds because of their physical proximity to each other and the ability to combine maps for the Lower watershed. The Upper subwatersheds include Subwatersheds 102,103,104, 105 and Little Creek Reservoir. The Lower subwatersheds include Subwatersheds 101, 102, Non-tidal Mainstem and Tidal Mainstem.

Richmond Rd.

Chickahominy Rd.

102-R4
YC-013

102-R2
YC-019

102-R1
YC-021

Yarmouth Creek Watershed

Subwatershed 102

Watershed
Subwatershed
Hydrology
Roads
Parcels
Buildings
NWI Wetlands

Potential Channal Stabilization/Restoration
Potential Conservation Areas
Priority Retrofits
Trash/Debris
Sensitive Fish
PSA

Developable Parcels (1997 Zoning)
A1
B1
LB
M1
M2
MU
R1
R2
R8

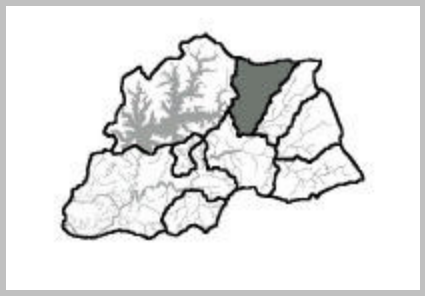
N

4000 0 4000 8000 12000 Feet

UPPER SUBWATERSHEDS

Subwatershed 102

Overall Characterization



This subwatershed currently has 7.3% impervious cover, and it is projected to have a buildout imperviousness of 11.5%, which would shift its classification from SENSITIVE to IMPACTED. The subwatershed is moderately developed with residential areas and some commercial areas in the upper portion. There are some good quality forest areas and mature forested stream buffers. The upper stream reaches are somewhat degraded (scored fair on RBP), with trash in the stream; however, conditions improve as one moves downstream. Six fish species were found at a sampling site in the upper tributary and streams in the lower portion of the watershed received excellent habitat scores. Two dry pond retrofit sites were identified that needed maintenance and could be unclogged or retrofit to provide wet storage and better channel protection downstream.

General Characteristics

Drainage Area	870 acres
Length of Mapped Streams	4.14 miles

Current Land Use and Stream Classification in Subwatershed 102

1996 Impervious Cover	7.3%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in Subwatershed 102

Buildout Impervious Cover	11.5%
Projected Stream Classification	Impacted
Developable Area	445.7 acres
Developable Area %	51%

Conservation Areas in Subwatershed 102

Existing RPA wetland area	2.8 acres
Existing RPA wetland %	< 1%

Presence of RTE species: The shell-marl ravine forest is likely to be found in the upper section although no shell deposits were observed in the field.

Wetlands (from NWI): 43.5 acres of wetlands (5% of subwatershed), mostly riparian. High quality wetlands associated with the floodplain occur along with beaver dams in the lower portions of the subwatershed.

Other Conservation Areas: none identified

General Stream Conditions in Subwatershed 102

Habitat Assessment: The upper stream reaches are somewhat degraded (scored fair on RBP), with trash in the stream; however, conditions improve as one moves downstream. Only six fish species were found at a sampling site in the upper tributary reflecting the somewhat degraded conditions found there. Streams in the lower portion of the watershed had higher habitat scores and were in good condition.

Stormwater Management in Subwatershed 102

There is a school and some residential development in this upper subwatershed. A quick survey of stormwater facilities revealed two facilities that are subject to clogging and could receive a retrofit to improve water quality protection. The remaining facility would benefit from the addition of a forebay. Descriptions of these facilities are provided below.

Table 102-1. Retrofit Opportunities in Subwatershed 102

ID	Facility Type	Description	Comments	Priority
102-R1	Existing Dry Pond	Enhancements including addition of a sediment forebay, and creation of a wet pool area to incorporate greater water quality. Also, remove debris from clogged outlet.	Some trash at outlet. Simple retrofit.	Moderate
102-R2	Existing Dry Pond	Enhancements including addition of a sediment forebay, and creation of a wet pool area to incorporate greater water quality.	Some trash at outlet. Simple retrofit.	Moderate
102-R4	Existing Wet Pond	Possible addition of a forebay.	Simple retrofit. Otherwise nice facility.	Moderate

Richmond Rd.

103-R3

103-R1

YC-006

103-R2

YC-023

103-S1

Yarmouth Creek Watershed

Subwatershed 103

Watershed
Subwatershed
Hydrology
Roads
Parcels
Buildings
NWI Wetlands

Potential Channal Stabilization/Restoration
Potential Conservation Areas
Priority Retrofits
Trash/Debris
Shell Deposits
PSA

Developable Parcels (1997 Zoning)
A1
B1
LB
M1
M2
MU
R1
R2
RS

N

900 0 900 1800 Feet

Subwatershed 103

Overall Characterization

Subwatershed 103 currently has an impervious cover percentage of 5.1% and is classified as SENSITIVE. The subwatershed is projected to have a buildout imperviousness of 11.4%, which would shift its classification to IMPACTED. This subwatershed is lightly developed in the upper western portion and moderately developed in the upper eastern section with agricultural, residential and commercial areas. The upper eastern tributary is characterized by degraded stream conditions due to trash dumping issues and the invasive plant species Nepal microstegium. The upper western tributary is in good condition and the subwatershed contains good quality forested areas with shell-marl ravine forest. Stream conditions also tend to improve considerably as you progress downstream.

General Characteristics

Drainage Area	744 acres
Length of Mapped Streams	4.94 miles

Current Land Use and Stream Classification in Subwatershed 103

1996 Impervious Cover	5.1%
Initial Stream Classification	Sensitive
Current Stream Condition	Fair to Good

Future Land Use and Stream Classification in Subwatershed 103

Buildout Impervious Cover	11.4%
Projected Stream Classification	Impacted
Developable Area	502.2 acres
Developable Area %	68%

Conservation Areas in Subwatershed 103

Existing RPA wetland area	27.2 acres
Existing RPA wetland %	4%

Presence of RTE species: Shell deposits indicative of the shell-marl ravine forest are located in the upper watershed, though conditions in the eastern tributary are affected by the invasive carpet-like Nepal microstegium which out-competes native plant species limiting the likelihood of rare species.

Wetlands (from NWI): 40.4 acres of wetland (5% of subwatershed), mostly riparian. High quality wetlands associated with the floodplain occur along with beaver dams in the lower portions of the subwatershed.

Other Conservation Areas: None identified.

General Stream Conditions in Subwatershed 103

Habitat Assessment: The upper stream reaches are somewhat degraded (scored fair on the habitat assessment), with trash in the stream; however, conditions improve as one moves downstream. Six fish species were found at a sampling site in the upper tributary, most of which were relatively pollution tolerant and reflect the somewhat degraded conditions found there. Streams in the lower portion of the watershed had higher habitat scores and were in good condition.

Stormwater Management in Subwatershed 103

Several possible retrofits exist and are associated with commercial and highway runoff from the Rt. 60 corridor.

Table 103-1. Retrofit Opportunities in Subwatershed 103

ID	Facility Type	Description	Comments	Priority
103-R1	Existing Wet Pond	Possible addition of a forebay.	Simple retrofit. Otherwise nice facility.	Moderate
103-R2	Infiltration Basin/Dry Pond	Infiltration basin which may be acting more like a dry pond Possible orifice retrofit to provide downstream channel protection	Simple retrofit	Moderate /High
103-R3	No existing facility	Location where road runoff from Rt. 60 is entering the stream untreated possible linear bioretention facility in the median or on the side of the road	Would require design and coordination with VDOT	Moderate

Channel Stabilization in Subwatershed 103

A small drainage channel is experiencing considerable erosion likely due in part to stormwater runoff. A stabilization concept can be found in Section 3 Watershed Recommendations.

Table 103-2. Potential channel stabilization site in Subwatershed 103

Site	Description	Comments	Priority
103-S1	Small eroding stream in 103 primarily located on the Candle Factory Property	A good bioengineering project	High

Yarmouth Creek Watershed

Subwatershed 104

Watershed
Subwatershed
Hydrology
Roads
Parcels
Buildings
NWI Wetlands

Potential Channel Stabilization/Restoration
Potential Conservation Areas
Priority Retrofits
Trash/Debris
Sensitive Fish
Shell Deposits
RTE Plant
Bald Eagle
Heron Rookery

Developable Parcels (1997 Zoning)
A1
B1
LB
M1
M2
MU
R1
R2
R8
PSA
US Homes

James City County

CENTER FOR WATERSHED PROTECTION

600 0 600 1200 Feet

N

104-R1
104-R2

Richmond Rd.

104-S1
104-S2
104-S3

C5

Subwatershed 104

Overall Characterization

Subwatershed 104 is currently in the SENSITIVE category at 9.0% impervious cover and under the current zoning was projected to have a buildout imperviousness of 11.6%, which would shift its classification to IMPACTED. Recently, a significant portion of the subwatershed was rezoned from agricultural to residential, which shifted the future impervious cover projection to 19.3%. Currently, the subwatershed is moderately developed with residential and commercial areas in the upper portion. The upper western tributary has been impacted by uncontrolled stormwater from an older residential development, and the stream appears to be straightening as well as carrying a an excess sediment load. The eastern and lower portions of the subwatershed have excellent stream conditions. A fish survey below the confluence of the two upper tributaries showed eight fish species including the sensitive brook lamprey. Good quality floodplain forest exists here as well as the shell-marl ravine forest, though the shell areas have been affected by the spread of invasive Nepal microstegium associated with the sewer line. Upland areas may provide habitat for the rare small whorled pogonia, which was recently located in this subwatershed by Williamsburg Environmental Group. This area contains relatively mature contiguous forest.

General Characteristics

Drainage Area	860 acres
Length of Mapped Streams	3.78 miles

Current Land Use and Stream Classification in Subwatershed 104

1996 Impervious Cover	9.0%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in Subwatershed 104

Buildout Impervious Cover	19.3%
Projected Stream Classification	Impacted
Developable Area	573.6 acres
Developable Area %	67%

Conservation Areas in Subwatershed 104

Existing RPA wetland area	24 acres
Existing RPA wetland %	3%

Contiguous Forest Yes, 200 acre forested plot

Presence of RTE species: A small whorled pogonia population is located in the uplands and there are shell deposits indicative of the shell-marl ravine forest located in the upper watershed. Conditions in the eastern tributary are affected by the invasive Nepal microstegium.

Wetlands (from NWI): 42.7 acres of wetlands (5% of subwatershed), mostly riparian. High quality wetlands associated with the floodplain occur along with beaver dams in the lower portions of the subwatershed.

Other Conservation Areas: None found

Table 104-1. Priority Conservation Areas in Subwatershed 104

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
5 out of 8	C5	190	140	Subwatershed 104; sensitive stream, contiguous forest, shell-marl	54	Targeted for development; RPA protection for all first order streams, BSD

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

General Stream Conditions in Subwatershed 104

Habitat Assessment: The upper western tributary has been impacted by uncontrolled stormwater from residential development, and the stream appears to be straightening as well as carrying a large sediment load. The eastern and lower portions of the subwatershed have good stream conditions. A fish survey below the confluence of the two upper tributaries showed eight fish species including the sensitive brook lamprey.

Stormwater Management in Subwatershed 104

There is an opportunity to retrofit the development on the western tributary to provide channel protection and limit downstream impacts of stormwater runoff. Another opportunity for stormwater retrofitting may be to expand the capacity of an infiltration basin to provide more storage.

Table 104-2. Retrofit Opportunities in Subwatershed 104

ID	Facility Type	Description	Comments	Priority
104-R1	Infiltration Basin	Consider adding bioretention elements to enhance the facility. Mulch the base of the facility, and incorporate a variety of plants.	This facility is currently recorded as a dry pond.	Low

Stream Restoration/ Channel Stabilization in Subwatershed 104

There is the potential for several stream stabilization and one potential stream restoration project in Subwatershed 104. The stream restoration project is associated with the degraded western tributary. However the source of the stormwater that is degrading the channel is undetermined. Treatment of the stormwater prior to restoration should be a prerequisite for this project. The bioengineering concept for the restoration project is located in Section 3 Watershed Recommendations. Descriptions of the potential channel stabilization projects are located in Table 104-3.

Table 104-3. Stream Restoration/ Channel Stabilization Opportunities in Subwatershed 104

Site	Description	Type of Effort	Priority
104-S1	Reach of stream adjacent to the west side of the Kristansand neighborhood in Subwatershed 104	Stream restoration -Should be combined with a retrofit, habitat and stability should be restoration goals.	Medium
104-S2	Two reaches on the south side of Kristansand neighborhood experiencing streambank erosion and headcutting	Channel stabilization	Medium
104-S3	Two small headwater channels with active headcuts in subwatershed 104 downstream of the proposed US Homes development	Channel stabilization	Medium

C5

C4

C6

105-R4
YC-014

105-R2
YC-015

105-S1

105-R1

105-R3

Richmond Rd

Centerville R

900 0 900 1800 2700 Feet

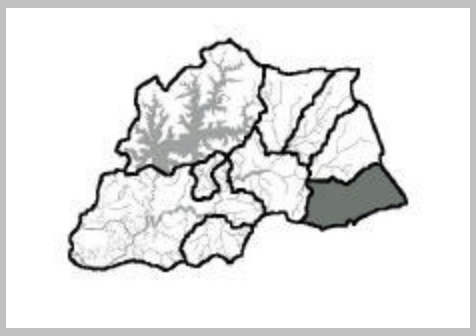
Yarmouth Creek Watershed
Subwatershed 105

- Watershed
- Subwatershed
- Hydrology
- Roads
- Parcels
- Buildings
- NWI Wetlands
- Potential Channel Stabilization/Restoration
- Potential Conservation Areas
- Priority Retrofits
- Trash/Debris
- Sensitive Fish
- PSA
- US Homes

Developable Parcels (1997 Zoning)
- A1
- B1
- LB
- M1
- M2
- MU
- R1
- R2
- R8

Subwatershed 105

Overall Characterization



Subwatershed 105 is currently in the SENSITIVE category with 5.5% impervious cover. Under the current zoning this subwatershed was projected to have a buildout imperviousness of 8.3%, which means it would remain in the SENSITIVE category. Recently, a significant portion of the subwatershed was rezoned and the new development will shift the classification to IMPACTED and the future impervious cover to 16.7%. Currently the subwatershed is moderately developed with most of the development located in the upper portion including commercial and residential areas. Power lines and uncontrolled stormwater runoff from a commercial development may also have impacted stream quality here. The lower reaches of the watershed are in excellent condition with good diversity of habitat. The shell-marl ravine forest is found here as well as potential habitat for the small whorled pogonia. A 264 acre forested area has been identified as a potential contiguous forest conservation area.

General Characteristics

Drainage Area	931 acres
Length of Mapped Streams	5.4 miles

Current Land Use and Stream Classification in Subwatershed 105

1996 Impervious Cover	5.5%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in Subwatershed 105

Buildout Impervious Cover	16.7%
Projected Stream Classification	Impacted
Developable Area	609.7
Developable Area %	65%

Conservation Areas in Subwatershed 105

Existing RPA wetland area	39.1 acres
Existing RPA wetland %	4%

Contiguous Forest: Potential contiguous forest area, 264 acre plot

Wetlands (from NWI): 52.7 acres of wetland (6% of subwatershed), mostly riparian. Good quality wetlands associated with the floodplain and some beaver dams occur in the upper portion of the watershed.

Other Conservation Areas: none identified.

Table 105-1. Yarmouth Creek Subwatershed 105 Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
6 out of 8	C6	260	190	Subwatershed 105; sensitive stream, contiguous forest, shell-marl, good fish	52	Targeted for development; RPA protection for all first order streams, BSD, stringent stormwater treatment

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

General Stream Conditions in Subwatershed 105

Habitat Assessment: The upper stream reaches have been somewhat degraded by uncontrolled stormwater runoff. The upper tributary and its floodplains have also been impacted by power and sewer lines. The lower portion of the subwatershed has excellent stream conditions and contained sensitive fish species in our assessment.

Stormwater Management in Subwatershed 105

The upper stream reaches have been somewhat degraded by uncontrolled stormwater runoff. A catastrophic failure of a dry pond was also noted which caused severe erosion and a safety hazard in one tributary although it does not seem to have had major impacts downstream. Some erosion was also noted at the bottom of a concrete channel that serves as an outfall for runoff from a residential development.

Table 105-2. Retrofit Opportunities in Subwatershed 105

ID	Facility Type	Description	Comments	Priority
105-R1	Unmanaged Runoff	Add a stilling basin at the outfall. Small drainage area estimated at 7,500 square feet. Could incorporate wet storage for water quality.	Sewer line and wetlands present potential conflicts.	Low
105-R2	Existing Dry Pond	Catastrophic failure. Undermining of the barrel has resulted in severe erosion, resulting in a roughly 20' deep canyon at the outfall, and trash in the facility. This problem should be repaired, and wet storage could possibly be incorporated as well during this enhancement.	This is a potentially high cost retrofit, but the facility in its current state is a public safety hazard, and exports sediment as well. JCC Development Management has been working to secure funding for this repair.	High
105-R3	Unmanaged Existing Development	Create a small wet pond to provide water quality and channel protection volume.	Would result in loss of at least three large trees, but can help to control runoff	Moderate

Table 105-2. Retrofit Opportunities in Subwatershed 105				
ID	Facility Type	Description	Comments	Priority
			from dense development	
105-R4	Existing Dry Pond	Convert from dry to wet storage to improve water quality.	Facility also has an unlocked cover on the manhole, which can pose a safety hazard.	Moderate :Water Quality High: Unlocked manhole cover

Channel Stabilization in Subwatershed 105

One channel stabilization project was identified in Subwatershed 105. The channel stabilization project is located on two adjacent upper reaches of the subwatershed. A description of the potential channel stabilization project is located in Table 105-3 and the project location is provided in the Subwatershed 105 Map.

Table 105-3. Channel Stabilization Opportunities in Subwatershed 105			
Site	**Description**	**Type of Effort**	**Priority**
105-S1	Upper reaches of Subwatershed 105 experiencing headcutting and erosion (Several thousand feet of channel is affected)	Channel stabilization	Medium

Yarmouth Creek Watershed
Little Creek

Watershed
Subwatershed
Hydrology
Roads
Parcels
Buildings

NWI Wetlands
Potential Conservation Area
Trash/Debris
PSA

Developable Parcels
(1997 Zoning)
A1
B1
M1
R1
R2
R8

N

800 0 800 1600 Feet

Forge Rd.

Chickahominy Rd.

Little Creek Dam Rd.

Little Creek
Reservoir

C8

Little Creek Reservoir Subwatershed

Overall Characterization

This subwatershed is composed primarily of the 996 acre Little Creek reservoir. Currently this subwatershed has less than 2% impervious cover and is comprised mainly of agricultural and forested land with a small, lightly developed area. Only one perennial stream was located in the watershed as the original streams have been inundated with the creation of the reservoir. The key water quality issue for the reservoir itself is shoreline erosion that is due primarily to the impacts of wind and wave action and beaver activity on erodible soils. However, it remains unclear how the erosion affects downstream conditions in Yarmouth Creek, simply because the water which passes over the dam is not measured. Based on a preliminary estimate, the discharge appears to be small only 0.5 cubic feet/second (CFS) on average.

General Characteristics

Drainage Area	2887 acres
Length of Mapped Streams	1.7 miles
Wastewater Disposal	Sewer and septic systems
Number of Households (1996)	*331*

Current Land Use in Little Creek Subwatershed

Percent Forested Land (MRLC)	53%
Percent Agricultural Zoning	88%
Current Impervious Cover	<2%
Current Stream Classification	Sensitive
Developable Area	1039 acres
Developable Area %	36%

Conservation Areas in Little Creek Subwatershed

Existing RPA Wetland Area	886 acres
Existing RPA Wetland %	46%
RPA Buffer Area	454.8 acres
RPA Buffer %	16%

Presence of RTE Species: No RTE species were identified in this subwatershed

Wetlands (from NWI): 906.3 acres of wetlands, including the reservoir itself, some riparian areas and a few small pocket wetlands.

Conservation Area: yes, 150 acres of mature hardwood contiguous forest.

Other Conservation Areas: None identified.

Table LC-1 Little Creek Reservoir Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
8	C8	150	150	Mature forest in Little Creek Subwatershed; contiguous tract connecting Yarmouth with neighboring watershed		Work with utility to maintain existing forest buffer to protect water supply and maintain contiguous forest; Develop long range forest management plan

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

Stormwater Management in Little Creek Subwatershed

There is one existing stormwater treatment practice in this subwatershed, which is located in the Low Density Residential area.

Land Use in Little Creek Subwatershed

Land use in the Little Creek subwatershed is a mixture of forest land, low density residential and agricultural land. The low density residential land is located primarily in the north and east portions of the subwatershed. Agricultural land is located on the western portion of the subwatershed along Norge Road and bordering the reservoir.

General Stream Conditions in Little Creek Subwatershed

Habitat Assessment

One habitat assessment was performed in the one perennial stream that was identified in the watershed. The stream was determined to be stable and habitat conditions were rated as Good. The only habitat metrics that received low scores were pool variability and substrate, which normally score low on small 1st order streams such as this. The majority of the land draining to this stable stream was forested with a small area of low density residential development, and as a result of its good condition, no management actions were recommended for this stream.

Little Creek Reservoir Assessment

General Characteristics

The lake itself has a particularly good fishery that includes largemouth bass, striped bass and catfish, and the only major management issue was shoreline erosion. The erosion

generally was most severe on the east side of the dam, on north and west facing slopes with considerable fetch, and in areas associated with the powerlines and beaver activity. The reservoir has a surface area of 996 acres with an estimated 40 miles of shoreline. It is used by Newport News Water Works (NNWW) for water supply on portions of the Virginia peninsula. The average depth is 35 ft. and in most years the water elevation is lowered approximately 8-10 ft beginning in August. The minimum allowable discharge from the reservoir is based on the 10-year, 7- day low flow event, meaning discharge has to be greater than the average flow for the lowest flow week that occurs every ten years. That minimum is estimated at less than 0.25 cfs and NNWW estimates that an average of 0.5 cfs are lost due to leaks and flow through. This is compared to a yearly daily average flow of 4 cfs, prior to the dam, based on the size of the watershed.

Shoreline erosion was identified as an important issue in Little Creek Reservoir during the Yarmouth Creek stakeholder meeting in February 2002. Potential factors that contribute to erosion are shoreline construction, beaver activity, wind and wave action during storms, and soil composition. Boat wake is not believed to be an influencing factor because, with the exception of a patrol boat, gasoline-powered engines are not allowed on the reservoir. Typical vessels include kayaks, canoes, and fishing boats with electric engines, none of which produce sufficient wake to cause shoreline erosion.

Clearing and construction on the reservoir shoreline is fairly limited because private piers are not permitted on the reservoir. Based on field observations, the only areas that have been cleared to the water's edge include some park property, power line right-of-ways, beaver slides, and several single-family lots. Beaver are a major concern in the reservoir area due to their ability to clear land and alter stream channels through the creation of dams There are an estimated 20 beaver huts in the vicinity of the reservoir. Beaver activity (tree clearing, slides, and huts) can be found on almost all parts of the reservoir. Wind action is also a major contributor to shoreline erosion. The predominant wind is from the northeast and has an average speed of 10-15 knots. These wind speeds, when combined with the exposed, erodible clay soils found in some areas of the reservoir, can cause moderate erosion.

Field Findings

In April of 2002, CWP staff surveyed the shoreline of the Little Creek reservoir. Field findings indicated that shoreline erosion caused by wind and wave action, lack of shoreline buffers and highly erodible soils are the greatest factors influencing shoreline erosion in the Little Creek reservoir. The two areas of most severe erosion are located near the dam. One area, immediately east of the dam, experiences severe rill erosion likely due to very erodible clays that may be remnants from the original construction of the dam. This area also appears to affect water quality at least locally in the reservoir as the clays become suspended even on days with only minor wave action. The other erosion hotspots are isolated parcels of land facing the dam and areas where there is sufficient fetch for wave action to develop.

Yarmouth Creek Watershed
Tidal and Non-Tidal Mainstem
Subwatersheds 101 and 106

Little Creek Reservoir

Cranstons Mill Pond

Cranstons Mill Pond Rd.

Centerville Rd.

Jolly Pond Rd.

Chickahominy River

Subwatershed 101

Subwatershed 106

Tidal Mainstem

Non-Tidal Mainstem

C1

C2

C3

C4

C7

BW-1

BW-2

BW-3

BW-4

NTM-S1

N

2000 0 2000 4000 Feet

Watershed
Subwatershed
Hydrology
Roads
Parcels
Buildings
NWI Wetlands

Boat Wake Erosion
Potential Channel Stabilization/Restoration
Potential Conservation Areas
Trash/Debris
Sensitive Fish
RTE Plant

Bald Eagle
Heron Rookery

Developable Parcels (1997 Zoning)
A1
B1
LB
M1
M2
MU
R1
R2
RS
PSA

LOWER SUBWATERSHEDS

Subwatershed 101

Overall Characterization

Currently, this subwatershed is classified as SENSITIVE with 2.2% impervious cover. Based on the zoning the subwatershed is projected to remain in the SENSITIVE category at 6.8% impervious cover provided the zoning does not change. This subwatershed has little development, and is primarily hunting land and rural residential. Much of the uplands have been logged except for the steep slopes along stream channels, where the remaining buffers are in good condition. The upper part of the subwatershed contains a few trash dumping locations and degraded stream channels and consequently scored the lowest habitat score in the entire watershed. The lower portion of the subwatershed contains a bald cypress swamp that supports a heron rookery.

General Characteristics

Drainage Area	220 acres
Length of Mapped Streams	1.98 miles

Current Land Use and Stream Classification in Subwatershed 101

1996 Impervious Cover	2.2%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in Subwatershed 101

Buildout Impervious Cover	6.8%
Projected Stream Classification	Sensitive
Developable Area	149.9 acres
Developable Area %	68%

Conservation Areas in Subwatershed 101

Existing RPA wetland area	6.5 acres
Existing RPA wetland %	3%

Presence of RTE species: None identified

Wetlands (from NWI): 11.2 acres of wetland (5% of subwatershed), mainly riparian

Other Conservation Areas: Habitat for a heron rookery and a small contiguous forest.

General Stream Conditions in 101

Habitat Assessment: The habitat assessment revealed one location with poor habitat scores and several trash dumps present in the upper portion of the watershed. The lower stream reaches however were in good condition and generally had good floodplain connection. Stream buffers generally have not been logged in this subwatershed because of steep slopes.

Stormwater Management in Subwatershed 101

Due to the limited amount of development in subwatershed 101, there are no identified opportunities for the use of stormwater management.

Subwatershed 106

Overall Characterization

Subwatershed 106 is currently in the SENSITIVE category with 0.4% impervious cover. Under the current zoning, the subwatershed is projected to have a buildout imperviousness of 3.5%, meaning the subwatershed would remain in the SENSITIVE category. This subwatershed is very lightly developed with good areas of fairly young forest and good stream conditions. Instream habitat diversity is somewhat limited by the lack of woody debris due to the young age of forest. Impervious cover is not likely to increase significantly here, and there is the potential for preserving tracts of contiguous forest.

General Characteristics

Drainage Area	548 acres
Length of Mapped Streams	4.69 miles

Current Land Use and Stream Classification in Subwatershed 106

1996 Impervious Cover	0.4%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in Subwatershed 106

Buildout Impervious Cover	3.5%
Projected Stream Classification	Sensitive
Developable Area	422 acres
Developable Area %	77%

Conservation Areas in Subwatershed 106

Existing RPA wetland area	16.6 acres
Existing RPA wetland %	3%

Contiguous Forest: Forest is young but contiguous, potential for preservation, the majority of the subwatershed is forested

Wetlands (from NWI): 39.8 acres of wetland (7% of subwatershed), mostly riparian. Most of the wetlands are associated with the floodplain.

Other Conservation Areas: None identified

Table 106-1. Yarmouth Creek Subwatershed 106 Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
7 out of 8	C7	830	610	Tidal mainstem and subwatershed 106; young contiguous forest and potential RTE habitat	48	Acquisition/easement, to maintain contiguous forest; Conservation easement to maintain hunting and selective logging

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

General Stream Conditions in Subwatershed 106

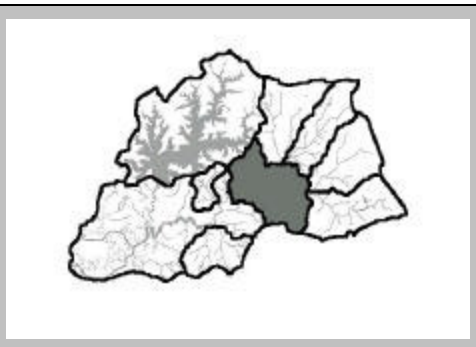
Habitat Assessment: The upper stream reaches were in good condition as were the lower reaches. Habitat quality was only limited by the lack of large woody debris in the watershed due to the young surrounding forest. Fish were not monitored in this watershed.

Stormwater Management in Subwatershed 106

No opportunities exist because of the limited development.

NON-TIDAL MAINSTEM OF YARMOUTH CREEK

Overall Characterization



The non-tidal mainstem is currently in the SENSITIVE category with 1.1% impervious cover. Under the current zoning it is projected to have a buildout imperviousness of 3.3% and would remain in the SENSITIVE category. The non-tidal mainstem portion of Yarmouth Creek is very lightly developed and includes areas of direct drainage to Yarmouth Creek to just below Cranston's Pond. Cranston's Pond takes up a large portion of this area and the dam may be a barrier to fish migration. The extensive forested areas consist of mixed pines and dry-site hardwoods and the forest, as well as the streams, are in good to excellent condition. The shell-marl ravine forest is likely to exist here, and is potential habitat for rare or disjunct plant species. According to Virginia Division of Natural Heritage, a small population of a globally rare plant is located below Deer Lake though it was not located during our assessment. One conservation area of 740 acres was identified above Cranston's Pond. This conservation area contains some contiguous forest as well as bald cypress stands, which are a potential location for a heron rookery.

General Characteristics

Drainage Area	1072 acres
Length of Mapped Streams	5.22 miles

Current Land Use and Stream Classification in the Non-Tidal Mainstem Portion

1996 Impervious Cover	1.1%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in the Non-Tidal Mainstem Portion

Buildout Impervious Cover	3.3%
Projected Stream Classification	Sensitive
Developable Area	835.7 acres
Developable Area %	78%

Conservation Areas in the Non-Tidal Mainstem Portion

Existing RPA wetland area	88.3 acres
Existing RPA wetland %	8%

Contiguous Forest: Yes, some contiguous forest in the conservation area above Cranston's Pond, includes bald cypress stand.

Presence of RTE Species: According to Virginia Division of Natural Heritage, a globally-rare plant species exists below Deer Lake (Clampitt, 1991). There is also good potential for areas of shell-marl ravine forest which is potential habitat for rare or disjunct species.

Wetlands (from NWI): 120.9 acres of wetlands (11% of subwatershed), mostly riparian. Good quality wetlands associated with the stream floodplain.

Other Conservation Areas: Potential for heron rookery

Table NT-1. Yarmouth Creek Non-Tidal Mainstem Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
3 out of 8	C4	740	570	Non-tidal mainstem, Boy Scout property. Contiguous forest, potential heron rookery above Cranston Mill Pond; globally rare plant identified (1993) at Camp Chickahominy	57	High development potential; recommend conservation easement, RPA extension, BSD to protect streams are clustering for larger buffers

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

General Stream Conditions in the Non-Tidal Mainstem Portion

Habitat Assessment: The habitat assessment showed upland streams in good condition and good habitat was found in larger streams flowing into Cranston's Pond. The dam which forms Cranston's Pond is a possible barrier to fish migration. The fish survey found 16 species of fish, including the least brook lamprey and the tadpole madtom, which are relatively sensitive in this area.

Stormwater Management in the Non-Tidal Mainstem Portion

No stormwater management opportunities exist in this subwatershed because very little development has occurred.

Channel Stabilization in the Non-Tidal Mainstem

There is one channel stabilization project that was identified in the non-tidal mainstem. The channel stabilization project is associated with a drainage channel along Cranston Mill Pond Rd. A description of the potential project is located in Table NT-2.

Table NT-2. Channel Stabilization Opportunities in Subwatershed NT-2

Site	Description	Type of Effort	Priority
NT-2	Drainage channel along Cranston Mill Pond Rd. experiencing erosion and headcutting.	Channel stabilization	Medium

TIDAL SEGMENT OF YARMOUTH CREEK

Overall Characterization

The non-tidal mainstem is currently in the SENSITIVE category with 0.3% impervious cover. Under the current zoning it is projected to have a buildout imperviousness of 1.8% and would remain in the SENSITIVE category. The tidal section of Yarmouth Creek watershed has almost no development and much of the land here is privately owned and leased for hunting. This area contains extensive freshwater tidal marsh dominated by wild rice, pickerelweed and a variety of other herbaceous species as well as areas of bald cypress swamp. The uplands are forested with a mix of pines and hardwoods. A natural areas inventory identified much of the tidal portion as having high significance for biodiversity because of the existence of three RTE species. The tidal section provides a good breeding ground for fish, and contains high habitat diversity, quality streams, wetlands and forest, as well as numerous sloughs and inlets. Four potential conservation areas have been identified: 480 acres of mature contiguous forest, 890 acres of tidal marsh, 170 acres that contains a bald cypress swamp and heron rookery, and a 300 ft buffer that serves as important habitat for ospreys, eagles and animal species using the marsh.

General Characteristics

Drainage Area	2912 acres
Length of Mapped Streams	11.76 miles

Current Land Use and Stream Classification in the Tidal Mainstem Portion

1996 Impervious Cover	0.3%
Initial Stream Classification	Sensitive
Current Stream Condition	Good

Future Land Use and Stream Classification in the Tidal Mainstem Portion

Buildout Impervious Cover	1.8%
Projected Stream Classification	Sensitive
Developable Area	1382.6 acres
Developable Area %	47%

Conservation Areas in the Tidal Mainstem Portion

Existing RPA wetland area	1244.7 acres
Existing RPA wetland %	43%

Contiguous Forest: Yes, 480 acres of mature forest are located within 3 parcels.

Presence of RTE Species: Three rare, threatened or endangered species have been confirmed by Virginia Natural Heritage for the tidal section of Yarmouth Creek: the bald eagle, sensitive joint-vetch, and narrow-leaved spatterdock. Some potential exists for RTE species in heath-bald areas where drought tolerant plants are found. In general, the forest is composed of young trees because of past and present timber management.

Wetlands (from NWI): 1171.8 acres of wetlands including tidal freshwater marsh, and cypress swamps (40% of subwatershed).

Other Conservation Areas: A heron rookery also exists in the upper portion of the tidal section close to where the creek becomes non-tidal, and a pristine freshwater tidal marsh comprises approximately 890 acres of the tidal mainstem portion of the watershed. A 300 ft buffer has also been placed on the map that represents an important area for wildlife habitat and a goal in the voluntary PDR program in JCC.

Table T-1. Tidal Yarmouth Creek Priority Conservation Areas

Rank	ID	Approx. Area* (acres)		Description	Score	Management Recommendations
		Total	Developable			
1 out of 8	C2	480	320	Tidal mainstem; best mature contiguous forest in the watershed. Potential RTE habitat on steep slopes	63	Continued landowner stewardship; potential conservation easements & restrictions on timber harvesting
2 out of 8	C1	890	80	Mouth of Yarmouth Creek & Chickahominy River. Contains tidal wetlands, 3 known RTE species	58	Majority of wetlands within RPA; recommend target upland areas for conservation easements or acquisition
4 out of 8	C3	170	100	Upper portion of tidal mainstem; Heron rookery and bald cypress stand	54	Partially protected by RPA, however uplands unprotected; consider acquisition/easement of surrounding area

*These are approximate areas calculated using GIS and rounded to the nearest tenth. Total area represents the total acreage within the conservation area boundary. The developable area within those conservation areas was calculated by subtracting unbuildable land and built-out land from the total area. Unbuildable land included the NWI wetlands, open water, the existing RPAs (not including RPA buffer), stream valleys (a 100-foot buffer on either side of all streams), and slopes greater than 25% (derived from 5-foot contour lines). Because this estimate was based on limited data and certain assumptions were made about how to estimate this area, it should only be used as a planning tool only and not as an actual guide for development.

General Stream Conditions in the Tidal Mainstem Portion

Initial habitat Assessment: The habitat in the tidal mainstem is reported to be high quality wetlands and tidal sloughs that serve as an important breeding ground for tidal fish species.

Stormwater Management in the Tidal Mainstem Portion

No stormwater management opportunities exist in this subwatershed because very little development has occurred here.

Boat Wake Erosion in the Tidal Mainstem Portion

Boat wake erosion is a significant issue in the lower tidal mainstem portion of Yarmouth Creek. Locations where the problem was particularly pervasive are included in the Tidal subwatershed map. The recommendation is, at a minimum to post information at local boat ramps that explains the susceptibility of small tidal creeks to erosion and post no wake areas where there are significant problems. Worth mentioning is the fact that the shoreline erosion can result in loss of habitat and spawning grounds for gamefish and contribute to reducing water depth in the tidal creeks.

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