Broad Creek Management Plan

January 2002

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Broad Creek Management Plan

A Comprehensive Plan for the Protection of Broad Creek, Hilton Head Island, SC

January 2002

Prepared by the Hilton Head Island Planning Department
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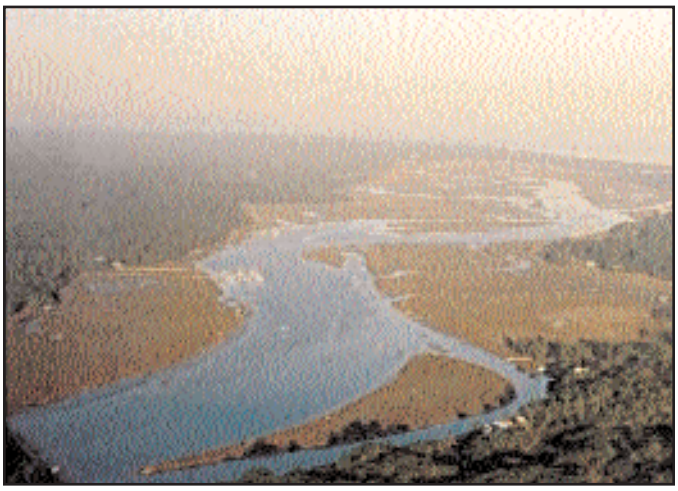
EXECUTIVE SUMMARY

The Broad Creek Management Plan was created to fulfill a recommendation of the 1999 Town of Hilton Head Island Comprehensive Plan, that a management plan be created for the creek to identify ways to protect this “most significant and most vulnerable natural resource” on the island. Its primary purpose was to gather and analyze baseline data for land use, water quality, wildlife, and recreation. The data were used to determine the level of current impacts that have occurred and estimate future impacts that could occur as a result of man’s activities in, on, and along the creek, and within the watershed of the creek (which encompasses 54% of the upland area of the Town).

This plan addresses water quality and other issues in a comprehensive manner. Land use, water quality, wildlife, and recreation are inter-connected and implementation strategies must be considered to address all aspects. For example, changing the land use of a parcel from undeveloped to developed impacts the quantity and quality of the stormwater runoff leaving the site. That stormwater entering the creek ecosystem in turn impacts the wildlife habitat and thus the wildlife in and along the creek. Recreational use of the creek is in turn affected, with reduced fisheries and fewer wildlife sightings. By examining all of these elements together, the recommendations made in this plan are more realistic in terms of addressing the overall needs of the Broad Creek ecosystem.



CHAPTER 1
INTRODUCTION

As what is one of the most important resources on Hilton Head Island, Broad Creek is vital to the welfare of the community. It has been largely ignored in previous planning efforts, and this Plan represents a progressive step for the creek and the Town.

The Planning Process

The Town of Hilton Head Island is located in Beaufort County in the southeastern corner of South Carolina, just off the coast in the Atlantic Ocean (see Figure 1-1). Connected to the mainland by a bridge, the island has undergone tremendous development during the last four decades.

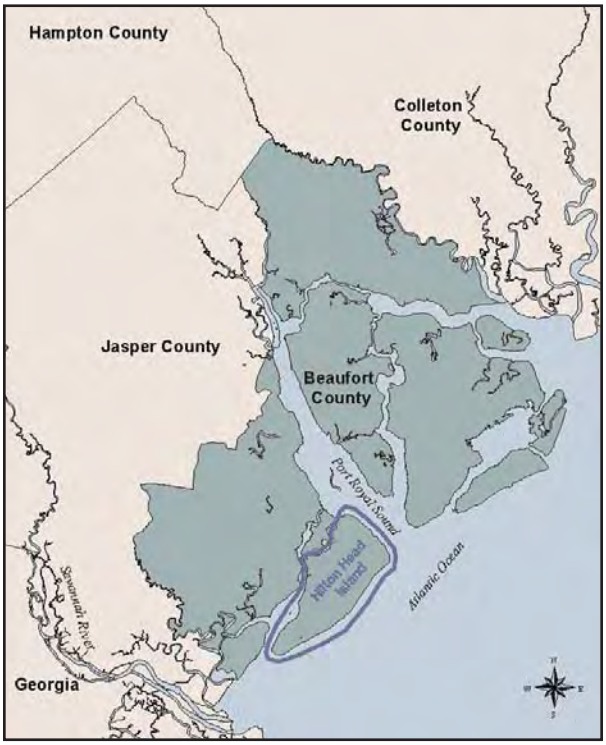


FIGURE 1-1: VICINITY MAP

The growth of the tourism industry and population of the Lowcountry and the island have put considerable strain on the natural environment. As with many places of beauty across the country, this growth has become so great as to threaten the very environment that many residents moved here to enjoy.

In 1995, 500 acres of shellfish beds were closed to harvesting due to high fecal coliform levels. This served as a wake-up call to a number of residents of Beaufort County, who organized a "Clean Water Task Force". This organization has two main objectives – to encourage the clean-up of polluted waters, and to identify steps to prevent additional pollution in county waters. As a result of their work, more attention has been paid to these issues in Beaufort County by local governments as well as state agencies.

The 1999 Comprehensive Plan recognized the creek's importance to the island as a "blueway" (a corridor of water, such as a creek or river, and its shoreline). It stated that the Town must "commit to protecting Broad Creek because it is the most significant and most vulnerable natural resource on Hilton Head Island." That plan recommended that a separate management plan be created for the creek, to identify ways to protect it from further degradation.

In 1999 Beaufort County was investigating the use of the Special Area Management Plan (SAMP) program to address water quality concerns throughout the county. The focus of the SAMP program in Beaufort County is the protection of water quality. Five areas of concentration were identified: stormwater management, wastewater management, water quality monitoring and enforcement, boating management, and public involvement and education. The Town of Hilton Head Island received a grant for research on Broad

Creek and became part of the Beaufort County SAMP.

This Broad Creek Management Plan goes beyond the focus of the SAMP to address other issues such as the impact of development on the scenic beauty of the creek, and wildlife and wildlife habitat on the creek. It is a comprehensive plan for Broad Creek, covering all aspects of the environment and man's impact on it.

Everything in this Management Plan is interrelated. The land uses affect the quality and quantity of stormwater runoff, which in turn impacts the water quality of Broad Creek, which impacts the wildlife habitat both in the water and along the shoreline. The impacts on the wildlife in turn impact the enjoyment of the creek by people recreating or fishing on the creek.

One goal of this planning effort is to establish on-going educational programs to keep the general public informed about the creek and man's impact on it. A recommendation made in the 1999 Comprehensive Plan should be implemented as a follow-up to this Plan. That recommendation (quoted from the Comprehensive Plan) is to "establish a management committee of business leaders, marina operators, boat owners, fishing and shellfishing interests, ecotour operators, and environmentalists to develop a long range protection and water use plan for Broad Creek."

This Broad Creek Management Plan is the first step in an overall management strategy for Broad Creek. It provides baseline data, an analysis of the findings, and recommendations on ways to reduce or mitigate impacts on the creek. A committee such as suggested by the 1999 Comprehensive Plan could be the cornerstone to continued efforts on the part of the entire community to improve the conditions in, on, and around Broad Creek.

Broad Creek Fundamentals

Broad Creek is a major tidal river system on Hilton Head Island. It lies in a northeasterly direction and nearly cuts the island in half (Figure 1-2). Both the watershed and corridor were examined.

FIGURE 1-2: LOCATION OF BROAD CREEK

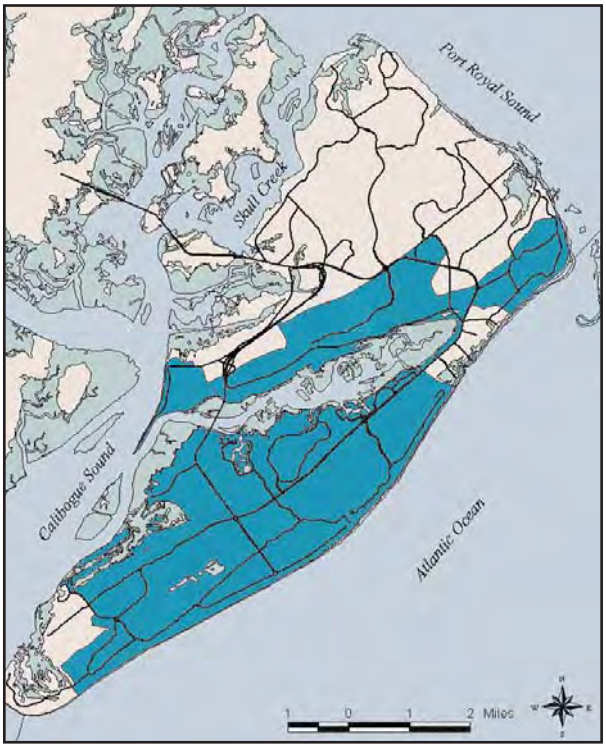


FIGURE 1-3: BROAD CREEK WATERSHED

The watershed of Broad Creek is shown in Figure 1-3. At 11,916 acres, it comprises 54% of the uplands on the island. All of the rain that falls within this area eventually enters Broad Creek, along with pollutants from roadways and parking areas. Since this non-point source pollution is a major factor in the degraded water quality of the creek, this study includes many discussions based on the watershed.

A corridor was defined to address the visual impact of development on the creek, and the impact of development close to the creek on wildlife and water quality. This corridor includes those areas that have the greatest impact on the creek based on their proximity to the water and marshes. This corridor can be seen in

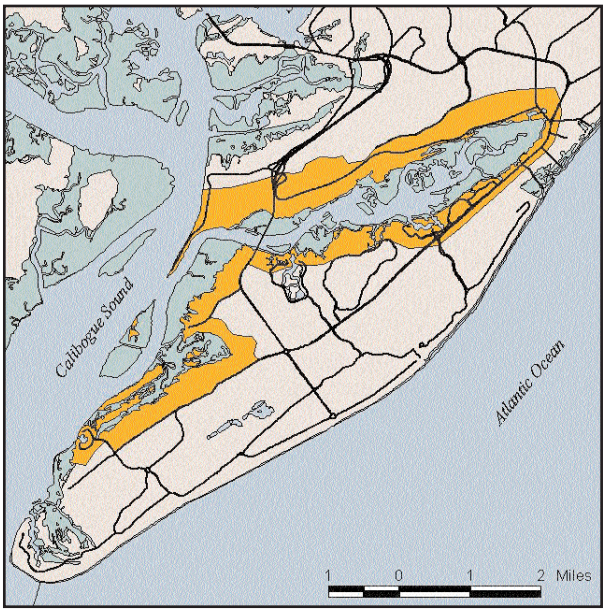


FIGURE 1-4: BROAD CREEK CORRIDOR

Figure 1-4. At 3,436 acres, it comprises approximately 16% of the island, and roughly 29% of the watershed. It should be noted that there are a few areas (totaling 285 acres) within the corridor that are not within the watershed. They include Harbour Town in the south, two small residential areas along the north boundary, one small area in the Mathews Drive area, and a narrow strip on the east side of William Hilton Parkway in the headwaters area. These areas are included in the corridor because they either already have a visual impact on the creek or they have the potential to have such an impact.

To aid in the discussions in the chapters that follow, the creek is divided into three sectors based on environmental zones. These are the mouth of the creek, the middle section, and the headwaters areas. Figure 1-5 shows these three zones.

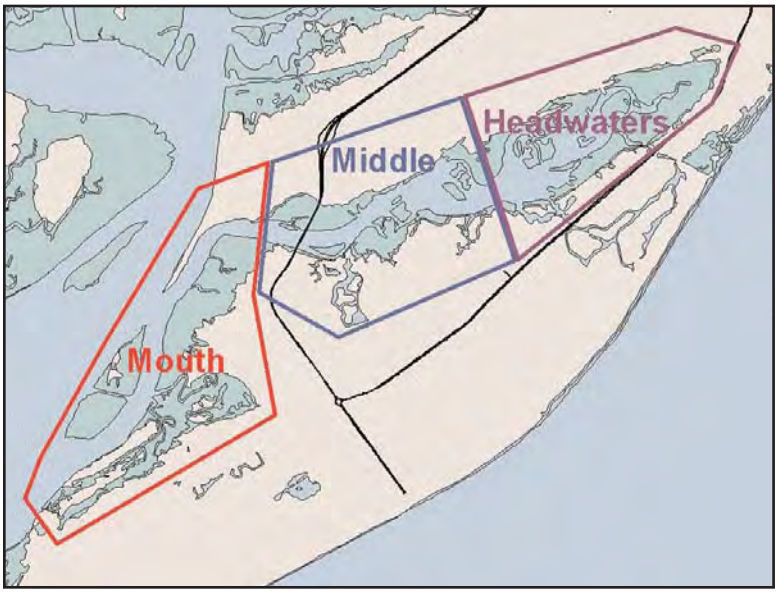


FIGURE 1-5: BROAD CREEK SECTORS

Much of Hilton Head Island is divided into ten gated communities or Planned Unit Developments (PUDs). Eight are wholly or partially within the watershed of Broad Creek (Figure 1-6). In total, the PUDs comprise 71% of the island. The portions of the PUDs that lie within the Broad Creek watershed comprise 76% of it. Similarly, the PUDs make up 71% of the corridor area. Each PUD has significant amounts of open space (including golf courses) and extensive stormwater management systems (canals and lagoons).

Description of Chapters

Chapter 2 focuses on land use and zoning and their effects on the creek. Since water quality, wildlife, and recreation are directly impacted by land use, it is discussed first in this Plan. A map of existing land uses is provided for the watershed and the corridor. Projections for future land uses within the watershed and corridor are discussed. Aesthetic issues are also included in this chapter.

Chapter 3 deals with water quality, one of the primary concerns of this Plan. It is subdivided into three sections. The first section on stormwater management discusses both the quantity and quality aspects of stormwater. The second section on wastewater system management discusses onsite sewage disposal systems and the public sewer systems in the watershed and corridor. The third section is a description of two Town

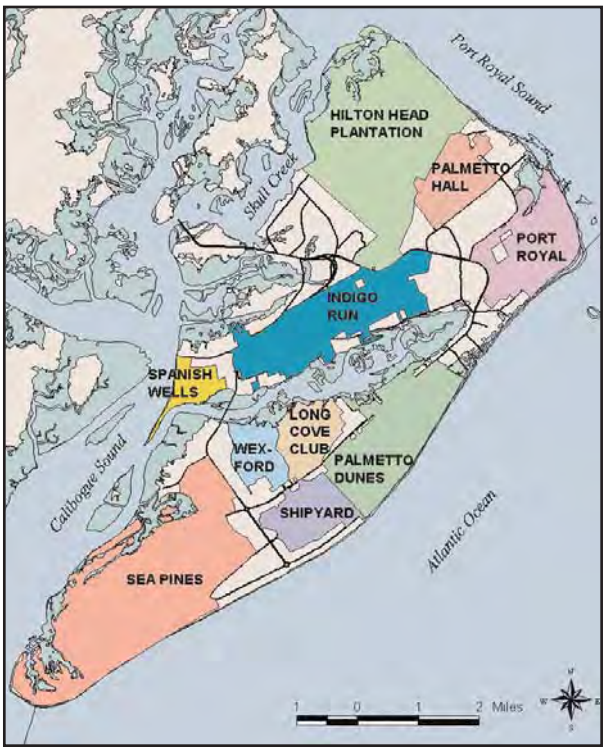


FIGURE 1-6: PLANNED UNIT DEVELOPMENTS

drainage projects (the Jarvis and Ashmore projects) which can be used as models for other sites.

Chapter 4 covers environmental issues, and includes information on data collected on wildlife usage of Broad Creek over a one year period. It also includes descriptions of the environmental zones of the creek and what activities are threatening and/or damaging the environment.

Chapter 5 discusses the recreational use of the creek and describes the results of the data collected on boating over a one year period.

Chapter 6 combines the public education recommendations made in each chapter, and provides ideas on how to meet the needs of the public through various educational outreach programs.

Finally, chapter 7 reiterates the goals from each chapter of the plan and combines all of the recommendations. The implementation strategies are grouped by task. These include amendments to the Town's Land Management Ordinance, other regulatory efforts, monitoring and enforcement activities, financial and other assistance, Town owned property, and other efforts involving citizen participation. Chapter 7 suggests other projects that should be done to complement this Plan and to further the work started in this study.

CHAPTER 2
LAND USE

Land use is an important element in the overall environment. It impacts how people interact with each other, the built environment, and the natural environment. To a large degree, land use determines whether a natural resource remains viable and whether it remains beautiful.

Introduction

One of the most important elements affecting water quality in any body of water is man's use of the land surrounding it. Even seemingly low impact uses such as recreation can have a detrimental impact on water quality, particularly as measured against an uninhabited, untouched watershed. Hilton Head Island has been inhabited for hundreds of years, and during the last 50 years the impact of human activities has had an impact on the water quality of Broad Creek and other area waterways. This is evidenced in the decline of the oyster industry in the area, as well as in water quality data from several studies done over the years (see Chapter 3).

As development increased on the island in the 1970s, many of the residents began to realize that they could lose the quality of life they had moved here to enjoy. Land use controls in place at the time were not particularly restrictive and projects were being constructed that did not fit in with the established character of the island. As a result, the Town of Hilton Head Island was incorporated in 1983, and new land use controls were adopted in 1987.

These land use controls have been used nationwide as models for site design, growth management, and environmental protection. They include standards for land use, density, open space, pervious surfaces, tree and vegetation protection, buffers, setbacks, drainage, and wetland protection. These controls and their affect on the creek will be discussed both in this chapter and in the following chapter on water quality.

This chapter will examine the existing land uses within the watershed and corridor of Broad Creek, and will forecast what the future holds for these areas. A description and maps of current zoning in the Broad Creek watershed and corridor can be found in Appendix A.

Existing Land Use

Map 2-1 shows the existing land use within the watershed of Broad Creek. It shows that the commercial land uses are concentrated along William Hilton Parkway and the Palmetto Bay Road/Pope Avenue corridor. There is a significant amount of multi-family development along the Atlantic Ocean and in pockets elsewhere. Golf courses occupy a considerable amount of the land area, and residential uses (mostly single family) are prevalent along the creek. Figure 2-1 shows the relative amount of the various land uses in

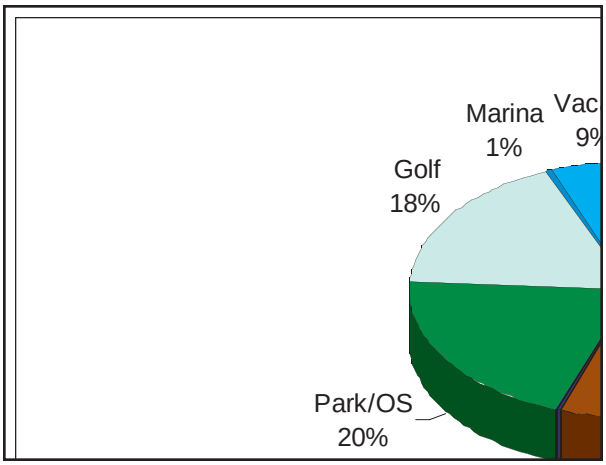


FIGURE 2-1: EXISTING LAND USE IN THE WATERSHED

the watershed. Parks and open space, golf courses, single family parcels and vacant land comprise 70% of the land area in the watershed. Commercial, marina, multi-family, and right-of-way uses comprise 30% of the watershed.

Map 2-2 shows the existing land use within the corridor of Broad Creek. This area has the greatest impact on the creek. This map shows that single family residential is the most predominant use in the corridor. Figure 2-2 shows that single family residential use occupies 28% of the land area in the corridor. Parks and open space rank second, with 18% of the land within the corridor. Golf courses, vacant land, and right-of-way each occupy 12 to 13 percent of the corridor.

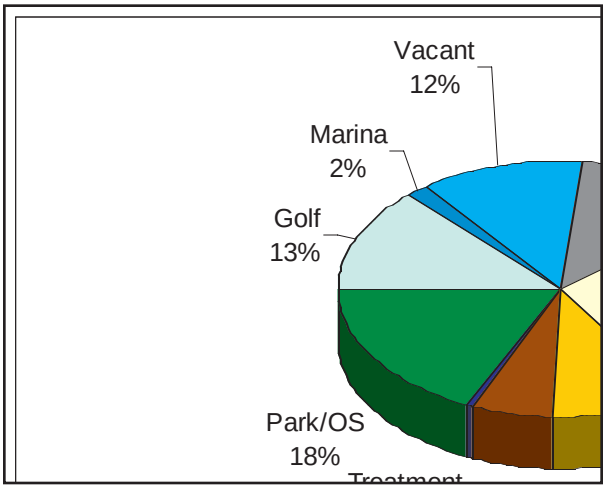


FIGURE 2-2: EXISTING LAND USE IN THE CORRIDOR

While marinas and wastewater treatment plants are small uses in terms of the amount of land they occupy, they have potential for a great impact on the creek. Marinas impact the creek in several ways including visually, the water quality, and the use of the creek by boats. Wastewater treatment plants have the potential of causing pollution in the creek.

There are five marinas on Broad Creek, which are described in Chapter 5 and Appendix Q. Potential impacts to the water quality from marinas include spills of petroleum products, spills of waste, and excess use of detergents from washing boats. Marinas are a ubiquitous part of the visual landscape on many waterbodies, and Broad Creek is no exception. Boat traffic on the creek is heavily influenced by the location of the marinas.

There are four treatment plants (Map 2-2) in the Broad Creek watershed. The South Island Public Service District (PSD) has a treatment plant located in the forest preserve area of Sea Pines. Wexford has a small treatment facility. The Broad Creek PSD treatment facility is located near Yacht Cove. The Hilton Head Number 1 PSD treatment facility is located off Mathews Drive near the headwaters of the creek.

The amount of impervious surface on the land is related to the type of land use. The amount of non-point source pollution is related to the amount of impervious surface. An analysis of existing land use was made to estimate the amount of impervious surface for each land use category. The results indicated that about 25% of the Broad Creek watershed is covered by impervious surfaces, and 27% of the corridor is covered. A discussion of this can be found in Appendix B.

	Existing	*Future*	*Increase*	*% Increase*
Commercial (square feet)	5,435,997	6,767,951	1,331,955	25
Single Family (units)	7,877	9,942	2,066	26
Multi-Family (units)	12,577	13,253	676	5

FIGURE 2-3: LAND USE PROJECTIONS FOR THE WATERSHED

	Existing	*Future*	*Increase*	*% Increase*
Commercial (square feet)	1,205,761	1,586,208	380,447	32
Single Family (units)	1,953	2,711	758	39
Multi-Family (units)	2,152	2,550	398	19

FIGURE 2-4: LAND USE PROJECTIONS FOR THE CORRIDOR

Land Use Projections

Land use projections based on zoning were developed by the Planning Department in the Spring of 2001. Those projections show that there is the potential for over 6.5 million square feet of commercial space in the Broad Creek watershed, an increase of over 1.3 million square feet (25%). There are 9,942 single family residential units projected in the watershed, an increase of 2,066 (26%). There are 13,253 multi-family residential units projected, an increase of only 676, or 5% (see Figure 2-3).

Figure 2-4 shows the land use projections for the corridor. Commercial uses will increase 32%, single family residential will increase 39%, and multi-family residential will increase 19%. A review of the data in Figures 2-3 and 2-4 show there will be a higher growth rate in all three categories in the corridor than is projected for the watershed.

This increased development, particularly in the corridor, will add to the pollutant loadings on Broad Creek unless steps are taken to require more aggressive water quality measures in the stormwater management systems constructed for the developments. Chapter 3 discusses and makes recommendations on this topic.

Aesthetics

Broad Creek is often described as a place of natural beauty. Although the shoreline of the creek is highly developed, the preservation of trees and salt marshes has resulted in the retention of the natural beauty of the creek. The development along the creek does not overwhelmingly detract from the beauty of the environment.

Buffers play a major role in preserving the beauty of the creek. Buffers serve a number of purposes: they soften the visual

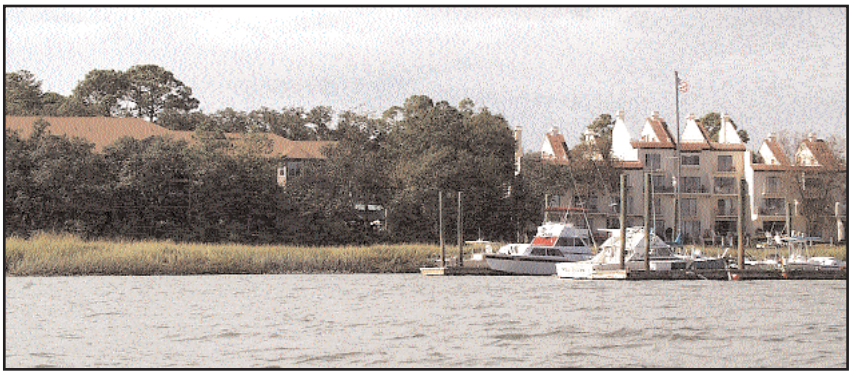


FIGURE 2-5: NEWER AND OLDER MULTI-FAMILY RESIDENTIAL BUILDINGS

appearance of buildings and other site development (such as parking lots), they help filter runoff before the water enters the creek, and they provide wildlife habitat. Public education about buffers is important. If the people understand the benefits of buffers, they will be more likely to create and maintain them. The use of buffers for improving water quality will be discussed in Chapter 3, and their use by wildlife is discussed in Chapter 4.

The Town's Land Management Ordinance (LMO) currently requires a 35 foot average buffer for multi-family residential and non-residential development along all salt water wetlands, which includes the entire length of Broad Creek. In addition, there is a 40 foot average setback for such structures, and a 50 foot average setback for impervious surfaces (such as parking lots) for such developments. The LMO requires a 20 foot buffer for all single family residential uses.

The current buffer regulations in the LMO prohibit the cutting of any vegetation within the wetland buffers, regardless of the type of development (single family, multi-family, etc.). This, while perhaps beneficial to the wildlife and water quality aspects of buffers, can prevent views from homes along the creek. The Town should review these regulations to determine if there is a more practical and workable regulation that would provide environmental protection while allowing the landowner views and enjoyment of the creek.

Prior to adoption of the LMO in 1987, the land use regulations permitted construction of buildings which, whether intentional or not, were imposing structures on the shoreline of Broad Creek. The 1987 LMO included regulations on the appearance of non-residential and multi-family residential structures within the Corridor Overlay District, which includes the shoreline of Broad Creek. This, combined with stricter buffer and setback regulations than existed before, has resulted in new commercial and multi-family residential structures along the creek having a less prominent impact on the view from or across the creek. Figure 2-5 illustrates this well, a newer multi-family building is on the left and an older multi-family building is on the right (behind a marina).

Single family dwellings, which make up a large percentage of the structures along the creek shoreline, are generally following the opposite trend. The older homes were smaller and lower to the ground than

new homes, and many are well buffered with trees and other natural vegetation. The newer homes, partly due to flood regulations which result in the house having to be built higher, and partly due to general housing market trends, are frequently larger and more prominent in the view. The preservation of trees and other vegetation between the house and the creek helps to soften the visual impact, but often the house is so large that the trees cannot be preserved.

Most of the homes along Broad Creek are within PUDs, where the Property Owner's Association (POA) has input on the appearance of homes and other structures. Educating those people who have a direct impact on the visual impact of the creek - including landowners, architects, developers, and the architectural review boards who oversee the appearance of structures in PUDs - on the importance of softening the visual impact of homes on the shoreline may help to protect the visual quality of the creek. Education efforts should include the benefits of re-establishing buffers where they have been cut.

The overall appearance of the Broad Creek corridor will change over the coming years. Out of the 450 single family lots along the shoreline of the creek, 100 are vacant. The vast majority of those 100 vacant lots are in the middle sector of the creek, and most are smaller than the lots in older subdivisions along the creek. As those remaining lots are developed, the character of this area will change from what is now a relatively pristine scene. The presence of salt marshes in some areas will help to moderate this effect, but since the homes will be built close together the aesthetic impact will be unmistakable.

While the Broad Creek Management Plan project has been progressing, another planning effort has been focusing on the redevelopment of the neighborhood called "Chaplin". Part of this neighborhood wraps around the headwaters of Broad Creek, along Marshland Road, Mathews Drive, and William Hilton Parkway. The Chaplin Plan recommends more intensive development along the Broad Creek shore than exists today. The future land uses will be mixed use (residential, commercial and office) at a moderate density. Site design will be an important factor; the Chaplin Plan recommends the buffers along the creek be preserved, the buildings be sited to take advantage of the views out to the creek, and the roofs of buildings be below the tree line.

Town Owned Land

The Town of Hilton Head Island owns over 1,000 acres of property. Figure 2-6 shows the Town owned properties which have frontage on Broad Creek. The Town should develop some of these properties for recreation and some should be left undeveloped, as open space and wildlife habitat. Future development of parks on these Town owned properties should include significant horizontal buffering (more than is required in the Town's Land Management Ordinance) but preserve the

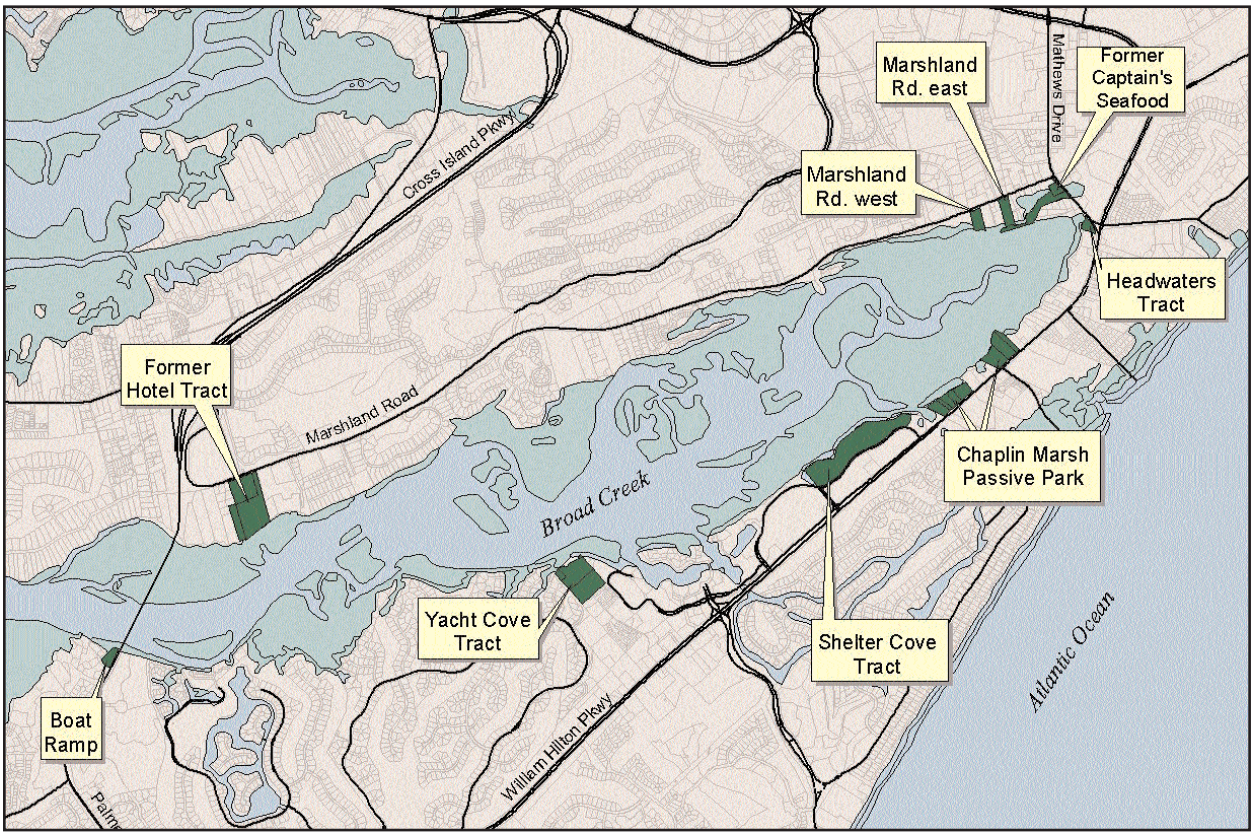


FIGURE 2-6: TOWN OWNED LAND ALONG THE SHORE OF BROAD CREEK

scenic view of the creek by selective thinning of the vertical buffer. Any landscaping needs should be filled using native plants. These properties should be designed, built, and operated as state-of-the-art demonstration projects, and should set an example of the best way to protect the creek while utilizing the land. More information on Town owned property can be found in Appendices C and D.

Implications

Human activities along the shores and within the watershed of any body of water have a profound impact on that environment. In shifting from a pristine, natural environment to an urbanized environment designed to serve the needs of people, society must make decisions on how much change is acceptable.

The watershed and corridor of Broad Creek are currently developed primarily for relatively low impact uses – single family residential, parks and open space, and golf courses top the list of existing land uses. There will be increases in the number of homes, multi-family developments, and commercial development in the watershed and corridor of Broad Creek. These will all contribute to an increase in impervious surfaces, and therefore stormwater runoff and non-point source pollution. As

development continues on the shoreline of the creek, the Town needs to examine the buffer regulations to establish regulations that are designed to protect the natural beauty of the creek while balancing the rights of the property owners to have a view of the creek.

Goals

1. *Land uses should be managed to protect the water quality of Broad Creek.* Development which typically has a high percentage of impervious surfaces should be encouraged or required to have pervious parking to reduce the amount of stormwater runoff. Drainage systems should be designed to reduce pollutants, including fecal coliform bacteria, from the stormwater before it is discharged off the site.

2. *Land uses should be managed to protect the natural beauty of the shoreline of Broad Creek.* As development continues, the visual appearance of the creek will change, but with the appropriate application of existing regulations, Broad Creek will remain a place of natural beauty.

3. *The Town should educate the public about the importance of buffers along Broad Creek.* Landowners and others involved in the design and construction industries should be educated as to the importance of buffers, not only for water quality and wildlife habitat, but for the preservation of the aesthetic beauty of the creek as well.

Implementation Strategies

To implement these goals, the following strategies are recommended:

1. *CONSIDER AMENDING THE LMO TO REQUIRE MORE STRINGENT STORMWATER MANAGEMENT TECHNIQUES TO REDUCE NON-POINT SOURCE POLLUTION FROM ENTERING BROAD CREEK.* This can include reducing impervious parking and alternative methods of designing and building stormwater structures. More on this subject is provided in Chapter 3.

2. *ENCOURAGE PROPERTY OWNERS AND DEVELOPERS TO USE A VARIETY OF BEST MANAGEMENT PRACTICES TO ACHIEVE THEIR DEVELOPMENT GOALS WHILE COMPLYING WITH THE ENVIRONMENTAL REGULATIONS THEY MUST MEET.*

3. *IDENTIFY PARCELS ALONG BROAD CREEK FOR POTENTIAL PURCHASE BY THE TOWN.* These should include properties which are subject to high density development and properties which have valuable qualities for their visual beauty and/or wildlife habitat.

4. *EXAMINE ANY FUTURE REZONINGS TO DETERMINE THEIR IMPACT ON BROAD CREEK.* Low impact land uses and creative site design should be strongly encouraged to preserve the creek's water quality and wildlife.

5. *WORK WITH THE ARCHITECTURAL REVIEW BOARDS OF THE PUDS AND THE*

INDIVIDUAL LANDOWNERS ALONG THE CREEK TO HELP THEM UNDERSTAND THE IMPORTANCE OF BUFFERS AND BUILDING DESIGN CONSIDERATIONS THAT IMPACT THE VISUAL QUALITY OF BROAD CREEK.

6. *RESEARCH WAYS TO AMEND THE BUFFER REGULATIONS IN THE LMO TO PERMIT SELECTIVE PRUNING OF VEGETATION TO OPEN UP VIEW WINDOWS.* This will enable creek front property owners to enjoy the scenic beauty of the creek without undermining the environmental benefits of the buffer.

7. *DESIGN AND INSTALL INTERPRETIVE SIGNS ON HOW HUMAN ACTIVITIES IMPACT THE CREEK.* These signs should be installed on public property where many people would benefit from the information. These signs should cover topics such as the impact of development on water quality through stormwater, the visual impact of development along the creek, and ways to mitigate those impacts.

8. *A BROCHURE ON USING RIPARIAN BUFFERS HAS BEEN PRODUCED AS PART OF THE SAMP GRANT.* This brochure addresses the various benefits of buffers, including water quality and aesthetics.

CHAPTER 3
WATER QUALITY AND STORMWATER MANAGEMENT

The quality of the water in Broad Creek is perhaps the most important component of a healthy ecosystem. Impairment of the water quality threatens the wildlife habitat, recreation, and aesthetic beauty provided by the creek. Many elements contribute to the quality of Broad Creek's water, including stormwater inputs, wastewater systems, and boat usage.

Stormwater Management

Fundamentals of Stormwater Management

Perhaps the single most important factor affecting the water quality of Broad Creek is stormwater. It is the only allowable discharge into Broad Creek.

Figure 3-1 is a depiction of the earth's water cycle. When precipitation occurs it either soaks into the ground or runs off as surface flow. The quantity and quality of runoff is affected by various meteorological and physical characteristics. Meteorological factors affecting runoff include such things as rainfall intensity, amount, duration, and area; soil moisture; and air temperature, wind, and relative humidity. Physical characteristics affecting runoff include land use, vegetation, soil type, drainage area, basin shape, topography, and the drainage network patterns. Appendix E is a more detailed discussion on the soil characteristics that affect runoff.

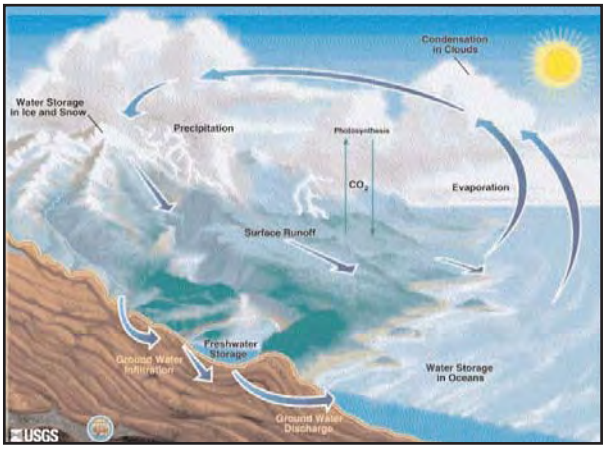


FIGURE 3-1: THE WATER CYCLE

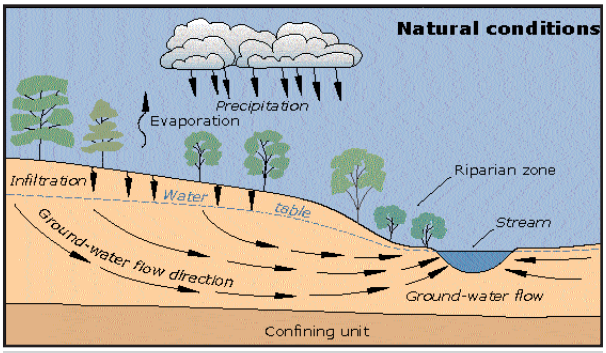


FIGURE 3-2: DIAGRAM OF GROUNDWATER FLOW

Water that infiltrates the soil can eventually become groundwater, and possibly surface water as well (Figure 3-2). It can also be absorbed by plant roots and recycled back into the atmosphere by evapotranspiration.

As an area becomes more developed, stormwater management becomes an important issue. When humans alter the land it impacts the natural hydrologic processes. Consider the results of clearing and paving a forested lot. After development the volume of stormwater traveling downstream is increased because the stormwater that previously was absorbed into the soil now runs off. The rate at which the stormwater is leaving the site is greater than before development because the ground surface has been altered. The area downstream may flood because of increases to both the volume and rate of stormwater flow leaving the site. Contaminants and any material that may have accumulated on the pavement surface are also swept downstream by the stormwater, impacting the environment downstream.

Stormwater Management Considerations

Hilton Head Island receives on average 51.4 inches of rainfall per year, with 50% falling between June and September. Since the island is flat with a low elevation, flooding can occur from tidal surges, significant rainfall or a combination of both (Figure 3-3).

FIGURE 3-3: A FLOODED STREET

Figure 3-4 is a relief map which shows that the island has a relatively uniform terrain with gentle slopes and dune fields running parallel to the ocean.

Water enters Broad Creek either as rainfall, groundwater seepage, or stormwater runoff. For the purpose of stormwater management, Hilton Head Island has been divided into 33 watersheds which drain to 13 different water bodies. Approximately half of the island's land mass drains into Broad Creek. Figure 3-5 shows the watersheds of the stormwater management system on Hilton Head Island. It should be noted that it does not exactly match the watershed as shown in Figure 1-3, due to the placement of stormwater outfalls.

Current Stormwater Regulations

When the island was relatively undeveloped, stormwater control was of little concern. As people started to inhabit a greater portion of the island, comprehensive stormwater management was needed. To deal with the potential for flooding, stormwater regulations have been in existence for the past 20 years.

The Town of Hilton Head Island and SC Department of Health and Environmental Control (DHEC) administer stormwater regulations for new developments. All development disturbing more than 5,000 square feet of land is required to meet the

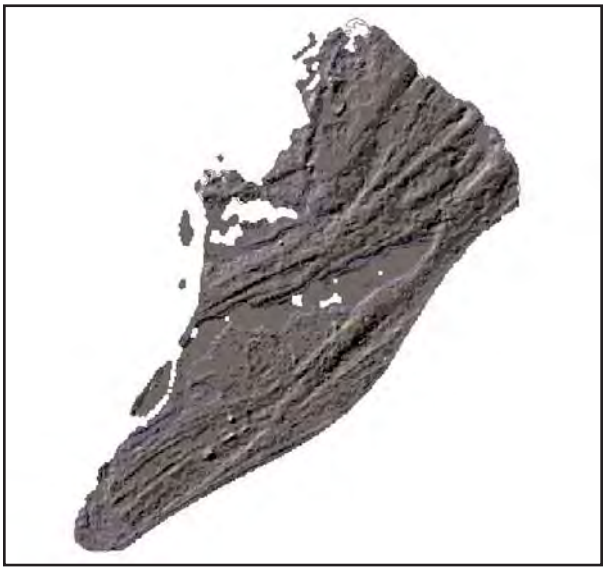


FIGURE 3-4: HILTON HEAD ISLAND IN RELIEF

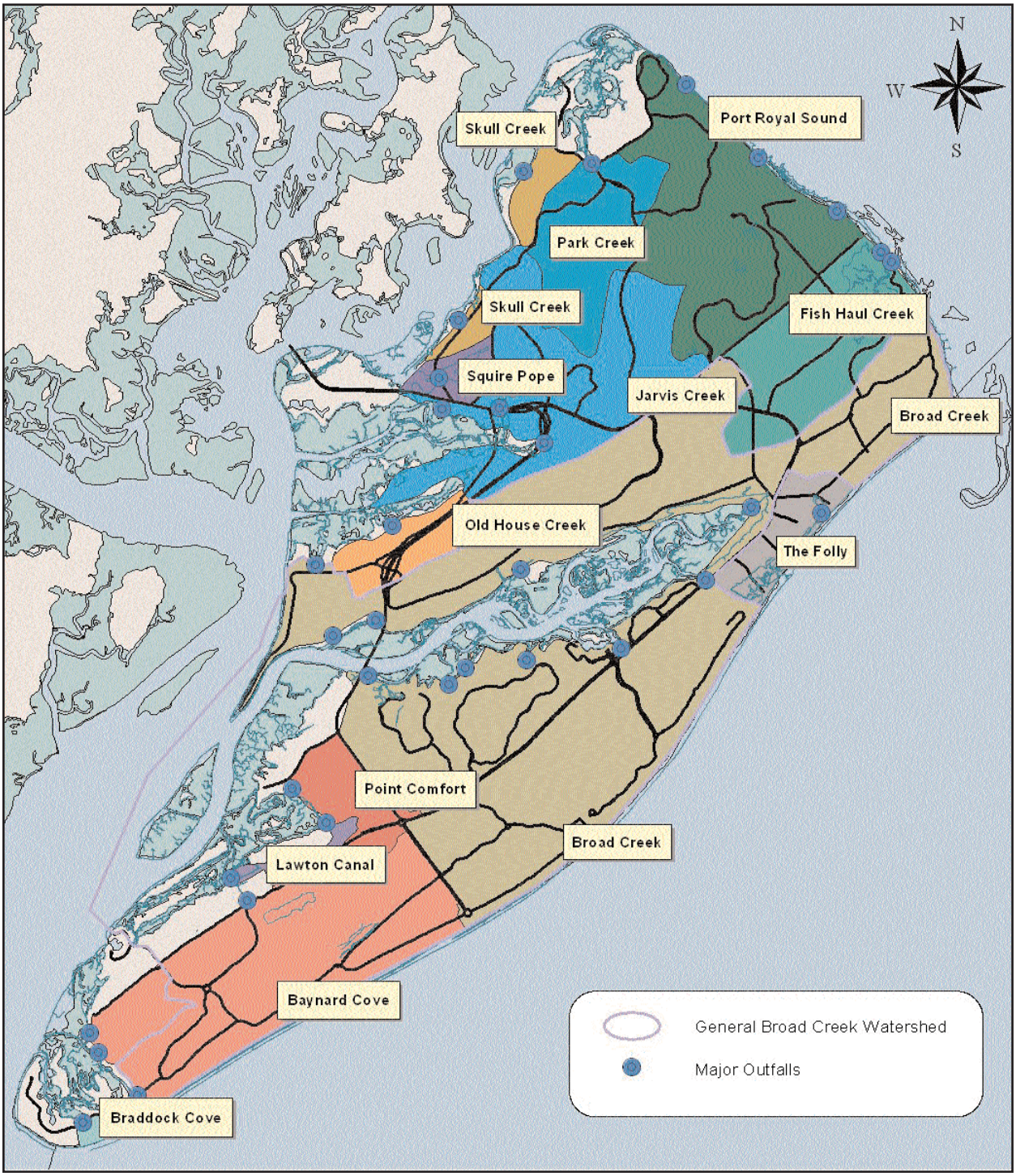


FIGURE 3-5: WATERSHEDS OF DRAINAGE SYSTEMS ON HILTON HEAD ISLAND

Town of Hilton Head Island stormwater regulations. Activities disturbing more than 2 acres or within one-half mile of a receiving water body must obtain a stormwater management permit from SC DHEC in addition to the required Town approval.

To reduce the flooding from the increased rate of water leaving a site, Hilton Head Island requires that the maximum rate of runoff after development not exceed the maximum rate of runoff from the site when it was in a natural state. This type of control is called stormwater detention. Most often this requirement is met by constructing a detention pond to which all of the site-generated runoff is routed and over time, discharged.

The first flush of rainfall is commonly regarded as carrying the most pollutants, and should be captured and filtered before leaving the site to control impacts on water quality. The Town of Hilton Head Island requires indefinite retention of the runoff produced by the first 1.0 inch of rainfall over the impervious surface area of the site. Again, this is most often accomplished with a pond or lagoon.

Regulating the use of existing wetlands is important in stormwater management. The wetlands provide an area for storage of runoff and filtering of pollutants and serve as habitat for a variety of flora and fauna. Recognizing the importance of wetland preservation in 1995, the Town adopted a "no net loss" wetland regulation along with requiring buffers and setbacks from the wetlands. All buildings and impervious and pervious paved surfaces must be set back from the edge of wetlands in accordance with the standards shown in Figure 3-6.

Use	*Required Buffer From*	
	Tidal Wetland	*Freshwater Wetland*
MF Residential or Non-Residential Impervious Surfaces	50' average 25' minimum	40' average 20' minimum
MF Residential or Non-Residential Pervious Paved Surfaces	35' average 15' minimum	35' average 10' minimum
MF Residential or Non-Residential Structures	40' average 20' minimum	35' average 20' minimum
Single Family Dwelling	20' minimum	none

FIGURE 3-6: WETLAND SETBACK REQUIREMENTS

Removal or disturbance of the soil, placement of fill, the use of grassed lawns, gardens, fences or structures, and the destruction or addition of plant life are all prohibited in the wetland buffer.

Current Management

The majority of development on the island is within the ten planned unit developments (PUDs) shown in Figure 1-6. Stormwater management was designed for each PUD with interconnected lagoons. The areas outside of the PUDs were developed without any comprehensive stormwater plan. Many of the developments within these areas have on-site drainage controls, a haphazard drainage system, or no defined drainage system at all. Additionally, many of the stormwater management systems in the areas outside

FIG. 3-7: OVERGROWN DITCH

of the PUDs have not been maintained since they were installed, resulting in heavily silted culverts, clogged inlets and overgrown channels. Figures 3-7 and 3-8 show examples of overgrown and cleared ditches.

FIG 3-8: CLEARED DITCH

In September of 1995, Thomas and Hutton Engineering Co., Inc. completed an Island Wide Drainage Study. It identified 17 major public drainage projects which would improve the stormwater management system in order to adequately handle the 25 year, 24-hour storm. The projects were prioritized using cost benefit criteria.

Project	*Discharge Creek*	*Water Quality Measure*
Jarvis Creek- Completed 2000	Jarvis Creek	pump station to 10-acre lake and wetland filtration
South Forest Beach- Completed 2001	Broad Creek	Utilizes the Sea Pines Forest Preserve allowing the run off from the South Forest Beach area to flood the wetlands for extra filtration.
Pineland Station- Completed 2001	Broad Creek	Discharges into wetlands owned by the Town of Hilton Head Island for additional filtration
Ashmore Tract – Scheduled Completion 2002	Broad Creek	Construction of treatment wetlands, and biofiltration pond
North Forest Beach- Scheduled Completion 2003	Broad Creek	Utilizes the lagoon systems in Shipyard and Wexford for settling of pollutants
Gum Tree - Completed 2001	Skull Creek	Construction of detention pond
Palmetto Hall/ Fish Haul Mitcheville- Completed 1998	Port Royal Sound	Discharges into wetlands for additional filtration

FIGURE 3-9: TOWN DRAINAGE PROJECTS

The major projects recommended in that report are expected to be complete by 2005. Water quality measures are being incorporated with flood control measures. Figure 3-9 shows the drainage projects, ultimate water body discharge and water quality measures.

While the study analyzed all the island's drainage systems, the projects primarily address the main line conveyance deficiencies. Once complete, the drainage system will be able to adequately carry the 25 year, 24 hour frequency storm, which is 8 inches of rain in a 24-hour period. This is the same design storm that new developments are required to meet. In addition, water quality should improve through the use of innovative techniques on most of these projects.

The Town of Hilton Head Island participates in the National Flood Insurance Program (NFIP) Community Rating System (CRS). A low CRS score entitles property owners to reduced flood insurance rates. As part of the CRS program, teams of Town staff inspect the water-carrying channels twice a year for any problems which might cause local flooding. Their recommendations result in a list of maintenance projects that are needed to reduce flooding. To reinforce the need to protect our drainage network, the Town of Hilton Head Island Municipal Ordinance 17-6-111 prohibits the alteration of the drainage system by the dumping of refuse or debris.

Future Stormwater Management on Hilton Head Island

In the fall of 2001, Beaufort County implemented a fee on all development to fund a stormwater utility. The first task of the utility will be to administer a comprehensive drainage study of the county, including updating the 1995 Hilton Head Island drainage study. A part of the 1995 drainage study was to map the existing systems; this map is now out of date. New software advances make it possible to model the drainage system in a Geographic Information System (GIS) environment, so the new map should be in digital format. This software allows changes to the drainage system to be modeled before construction, ensuring that the system continues to function properly. As-built drawings of new drainage elements should be entered into the system as soon as possible after construction to keep the map up to date.

An agreement between the Town of Hilton Head Island and Beaufort County stipulates that the Town will receive a portion of the revenue generated from the stormwater utility fee. The funds will be used to construct the aforementioned drainage projects and to maintain the facilities once constructed. The lack of maintenance of stormwater systems on the island has been problematic. Stagnant overgrown ditches and silted lagoons are a common sight. A centralized maintenance entity will ensure that the systems are operating as designed.

Appendix F provides a thorough discussion of the National Pollution Discharge Elimination System (NPDES) as it affects Hilton Head Island and the Beaufort County Stormwater Utility. This new regulation is an expansion of the existing federal storm water program which will require municipalities serving under 100,000 people to take measures to curb polluted runoff.

Water Quality

The elected officials and the citizens of Hilton Head Island value clean water and strive to understand the current status of the Town's waterways and ways to protect the resource. The Town has always been progressive in its protection of the environment and water quality is no exception.

Historic Water Quality Studies

Many water quality investigations are being or have been performed on Broad Creek and its watershed. Three of the most illustrative efforts are detailed below.

The South Carolina Department of Health and Environmental Control (DHEC) Bureau of Water, conducts routine monthly sampling at one location on Broad Creek. This data is used to assign water quality classifications as part of the Watershed Water Quality Assessment. The most recent assessment for the Savannah Salkehatchie River Basin (of which Broad Creek is a part) was released in 1997. This study showed Broad Creek as only partially supporting its use for shellfish harvesting because of low dissolved oxygen levels. Broad Creek was shown to meet all of the criteria for human recreation (SC DHEC, 1997).

In September 1997 ENSR Consulting compiled and analyzed the DHEC monitoring data from 1966 - 1996. They concluded that while the background levels of fecal coliform bacteria did not rise significantly during this time period, nonpoint source pollution associated with development has impaired the water quality of Broad Creek (ENSR, 1997).

In addition, DHEC's Bureau of Water, Shellfish Sanitation Section has conducted routine monitoring in Broad Creek since the early 1970s. This monitoring is intended to classify the water for purposes of shellfish harvest. Currently the Shellfish Sanitation Section monitors 25 sites in Broad Creek on a monthly basis. Water column samples are tested for fecal coliform bacteria, water temperature and salinity. The water quality results are used by DHEC to determine the areas of Broad Creek that may be used for shellfish harvesting. This testing is used to determine the safety of shellfish consumption, and is not intended to be an indicator of ecosystem health.

In the spring of 2000, A Baseline of Environmental and Biological Conditions in Broad Creek and the Okatee River, Beaufort County, SC was published. This study, a joint effort of NOAA, DHEC, and the South Carolina Department of Natural Resources (DNR), was intended to pro-

vide an idea of the health of these two tidal creek systems. The study examined water quality, sediment quality, and biological resources. In August 1997, water quality samples were taken at 15 sites each on Broad Creek and in the Okatee River. The study was designed to enable comparisons between open water sites, intertidal mud flats, and tidal creeks, as well as comparisons between Broad Creek and the Okatee River. Because samples were taken only once, this study provides a snapshot of conditions on the particular day sampled.

The report summarized the water quality of Broad Creek as impaired, with seven of the fifteen sites scoring as poor based on the rating system used. Fecal coliform bacteria levels exceeded the shellfish harvesting standard at all sites. Bacterial typing showed that seven sites had *E. coli* bacteria which exhibited resistance to antibiotics, indicating potential human sources of pollution.

While Broad Creek was shown to be impaired, the results were better than many researchers had expected. This is likely due to the land use controls in place in the Town for many years. Density standards, wetland buffer requirements, impervious surface maximums, and stormwater control regulations have all contributed to Broad Creek remaining remarkably healthy for a creek in an urban watershed.

Comparisons between Broad Creek and the Okatee River were intended to illustrate the differences between a highly developed watershed and an undeveloped one. Water quality results for the Okatee River were much better, with only one site out of fifteen classified as poor. The comparison may be flawed, however, since the Okatee samples were taken after a relatively dry period, and the night before the Broad Creek sampling Hilton Head Island received 1.3 inches of rainfall. That rainfall most likely flushed additional pollutants into Broad Creek (SC DHEC, 2000).

Town of Hilton Head Island Monitoring

Previous collection of water quality data for Broad Creek has either been focused on shellfish, or was collected at too few sites. None of the data were appropriate or of sufficient duration to draw conclusions about the stormwater entering Broad Creek. For this reason it was decided that routine water quality sampling was vital to the completion of a management plan for the creek.

Methodology

To accomplish the goal of consistent data collection, a water quality monitoring program was initiated. The program consists of bi-weekly water column sampling at six designated stormwater discharge sites on Broad Creek (Figure 3-10). At each site the following water quality parameters are sampled: temperature, pH, dissolved oxygen, turbidity, nitrate, fecal coliform bacteria, salinity, ammonia, total nitrogen, and total phosphorous. In addition, tide stage is recorded for each sampling event. The

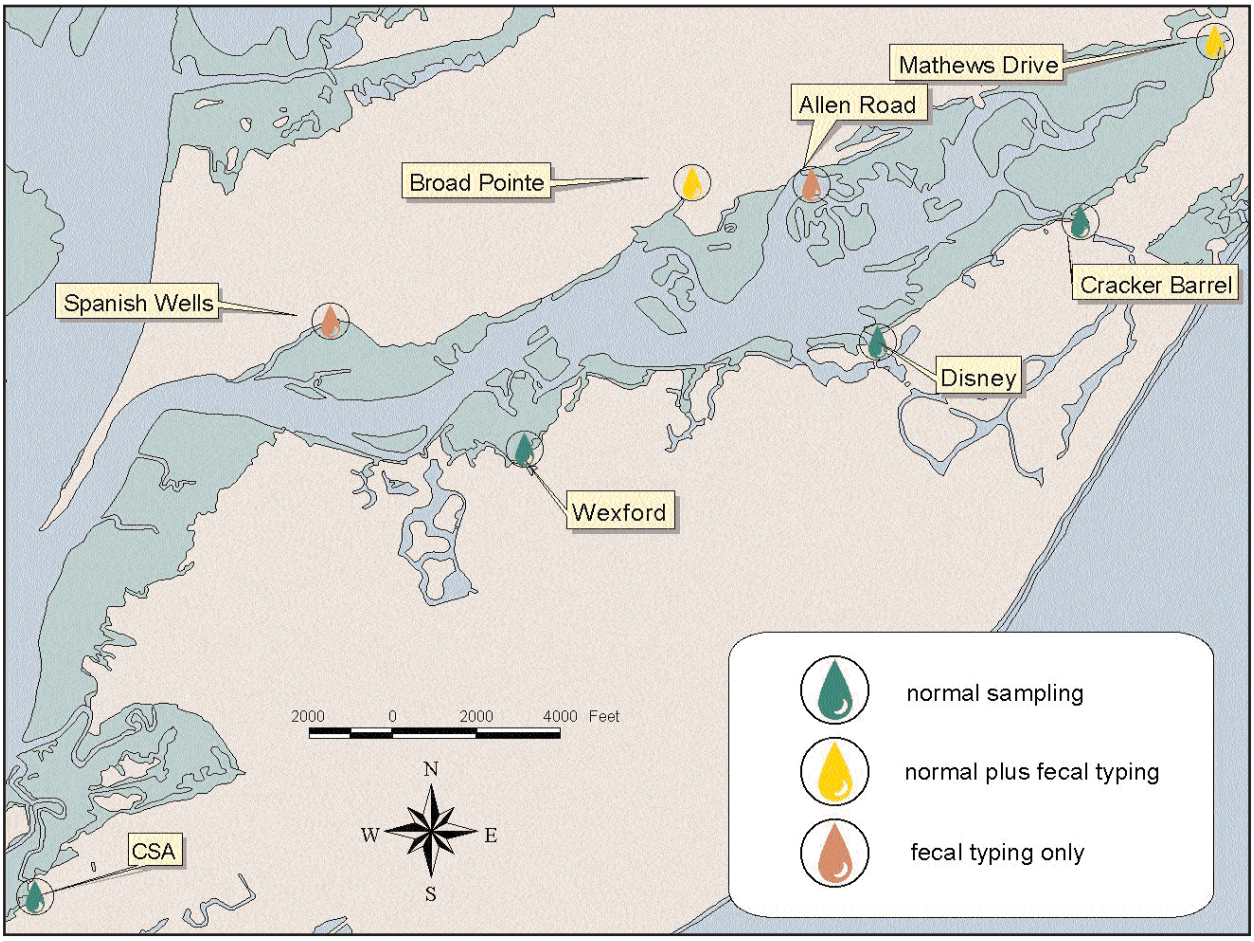


FIGURE 3-10: WATER QUALITY SAMPLING SITES

Town has contracted with General Engineering Laboratories of Charleston to collect and analyze the samples. All samples are analyzed using DHEC approved procedures.

Stormwater discharge sites were chosen as the sample locations with the knowledge that stormwater has a higher concentration of pollutants than would be found in Broad Creek as a whole. Measuring stormwater allows analysis of the direct inputs to the creek, but also returns much higher pollutant results than could be expected if samples were collected in the main channel.

In some instances water quality results are correlated to weather data. The weather data were collected using a Davis weather station installed on Town property approximately 20 feet from Broad Creek. For dates before July 7, 2000 when the weather station was installed, weather data from Broad Creek Public Service District were used.

Results

All water quality sampling results discussed are based on samples taken between September 30, 1999 and April 24, 2001. A total of 41 samples were collected and analyzed.

Several of the parameters tested are not illustrative on their own, but serve as important information for drawing correlations with the other data. These parameters, including temperature, pH, and turbidity are not discussed in detail. The remaining water quality parameters will be explained further below and in the appendices referenced in each section.

Salinity

Salinity is an important parameter in the health of tidal creeks such as Broad Creek. Salinity varies daily and seasonally, and salt marsh plants and animals are adapted to this fluctuation. Because stormwater drains upland areas, it is not saline, and its discharge into a tidal creek can change the natural salinity levels. The effects of this change are difficult to measure and no attempt has been made in this study to analyze the impacts of freshwater into the Broad Creek ecosystem.

The most important aspect of salinity is the level of daily fluctuation. Large daily fluctuations of salinity are stressful for aquatic species. The Town's water quality monitoring does not allow examination of daily fluctuations since the samples were only collected once per monitoring event.

Fecal Coliform Bacteria

Fecal coliform are bacteria that are naturally occurring in the digestive tracts of humans and other warm-blooded animals. Fecal coliform itself does not cause disease, but it may indicate the presence of other bacteria that may be harmful. Fecal coliform is routinely tested because it is a safe, inexpensive way to determine if other bacteria are present. If fecal coliform counts are high, it is likely that other organisms are present. It is these co-occurring organisms that have been linked to typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections.

Fecal coliform bacteria are often the most widely discussed water quality parameter because of their use as a standard for closing shellfish beds. For that reason, this monitoring effort focused on fecal coliform extensively. The results of the fecal coliform testing are described in detail in Appendix H.

None of the stormwater discharge sites on Broad Creek meet the state standard for fecal coliform levels for shellfish harvesting waters. DHEC's standards for tidal saltwaters suitable for primary and secondary contact recreation are less strict. The CSA, Wexford, Disney, and Cracker Barrel monitoring sites all meet this more relaxed standard. This means that the stormwater runoff entering Broad Creek from these discharge points would be considered safe for swimming, crabbing, fishing, and suitable for the survival of aquatic plants and animals.

As a result of high levels of fecal coliform bacteria at all of the sample locations, it was decided that more testing was necessary. As discussed previously, fecal coliform bacteria are present in the digestive tract of all warm-blooded animals. It is believed, however, that the harmful bacteria that often occur together with fecal coliform are more likely to be present in human contamination rather than animal. It is now possible, through the use of a procedure called multiple antibiotic resistance typing, to decipher if fecal coliform bacteria present in a given sample are of human or animal origin. The results of this typing can be used to determine if human sewage contamination may be to blame, or if the bacteria are the result of animal waste, either normal background levels from wildlife or from household pets (USEPA, 2001).

Three sites were sampled for fecal typing, but the only site to indicate a human source of bacteria was the Broad Pointe site. Further investigation indicated that septic systems upstream were failing and releasing waste into Broad Creek through the stormwater system. Subsequent tests by DHEC confirmed this, and the suspect septic tanks were repaired. It appears as if the fecal coliform concentrations are going down at the Broad Pointe site, but the levels still vary widely.

In many studies, pet waste has been found to be a large contributor to fecal coliform contamination (EPA, 2001). It appears that this may be the case in the Broad Creek watershed as well. Although wildlife can be a contributor, many of the areas upstream of the monitoring sites are developed areas with a significant number of single family homes and lawns. Pet waste runoff is a likely source for fecal coliform contamination in Broad Creek.

Total Phosphates

Phosphates occur naturally in low concentrations, but can be added to the environment through human and animal wastes, fertilizers, soaps, and land disturbance. Phosphate is one of the elements required by plants for growth. Because it is naturally limited in the environment, phosphate limits plant growth. An artificial increase in phosphate can cause rapid plant growth, leading to an algae bloom in the waterbody. This can increase the water temperature and lead to lower oxygen in the water, harming aquatic organisms.

As with fecal coliform, the individual results of phosphate concentrations vary widely over the study period. The table in Appendix J summarizes the results for the six sampling sites. None of the sites on Broad Creek demonstrate good total phosphate results when compared with statewide data.

Nitrogen

Nitrogen is another element that is needed by all plants and animals to grow and reproduce. It is very common, and is found in many forms in the environment. Nitrogen is most abundant in its elemental form, which makes up 79 percent of the air

we breathe. Elemental nitrogen is useless to most plants and animals, because it is not in a form that can readily used. Bacteria and blue-green algae convert elemental nitrogen into other compounds such as nitrates which can be used by plants to grow. Animals get the nitrogen they need by eating plants that have assimilated nitrogen. When plants and animals die, cell proteins are broken down by bacteria, forming ammonia. Ammonia is further broken down to form nitrite, and again to form nitrate. Both ammonia and nitrite are toxic to animals.

Overall, both the total nitrogen and ammonia being released through the stormwater system is not alarming. In all cases, the average over the study period is near or below other salt water bodies in the state (see Appendix K).

Dissolved Oxygen

Dissolved oxygen is a measurement of the amount of oxygen available in the water column for aquatic organisms. If dissolved oxygen (DO) levels fall too low, aquatic organisms may die. DO levels vary daily and seasonally. Levels tend to be lower in the morning, as well as lower in the warm summer months. Because DO availability is reduced by a surge in productivity, it can be used as an indicator of pollution. High nutrient levels from nitrogen and phosphorous can boost aquatic productivity, and lower the DO levels in the water column.

While some sites exhibited low DO levels occasionally, on average all sites met the minimum standard during the study period. The lowest recorded result was at the Wexford site with a DO of 0.71 which can be considered severe oxygen depletion and would likely result in aquatic organism mortality (see Appendix L). This sample seems suspect since it is such a deviation from the other samples.

Composite Water Quality

By looking at how each site ranked on the five water quality parameters discussed, an estimate can be made of the overall water quality at the site (see Figure 3-11). Italicized text in the table represents moderate water quality and bold text indicates poor water quality. Please refer to Figure 3-12 for a visual representation of the composite water quality score at each site.

Site	Fecal	Total P	Total N	Ammonia	Dissolved Oxygen
CSA	moderate	poor	moderate	good	moderate
Wexford	moderate	poor	moderate	good	moderate
Disney	moderate	poor	good	moderate	good
Cracker Barrel	moderate	moderate	good	moderate	moderate
Mathews	poor	poor	moderate	moderate	good
Broad Pointe	poor	moderate	good	moderate	moderate

FIGURE 3-11: COMPOSITE WATER QUALITY RESULTS

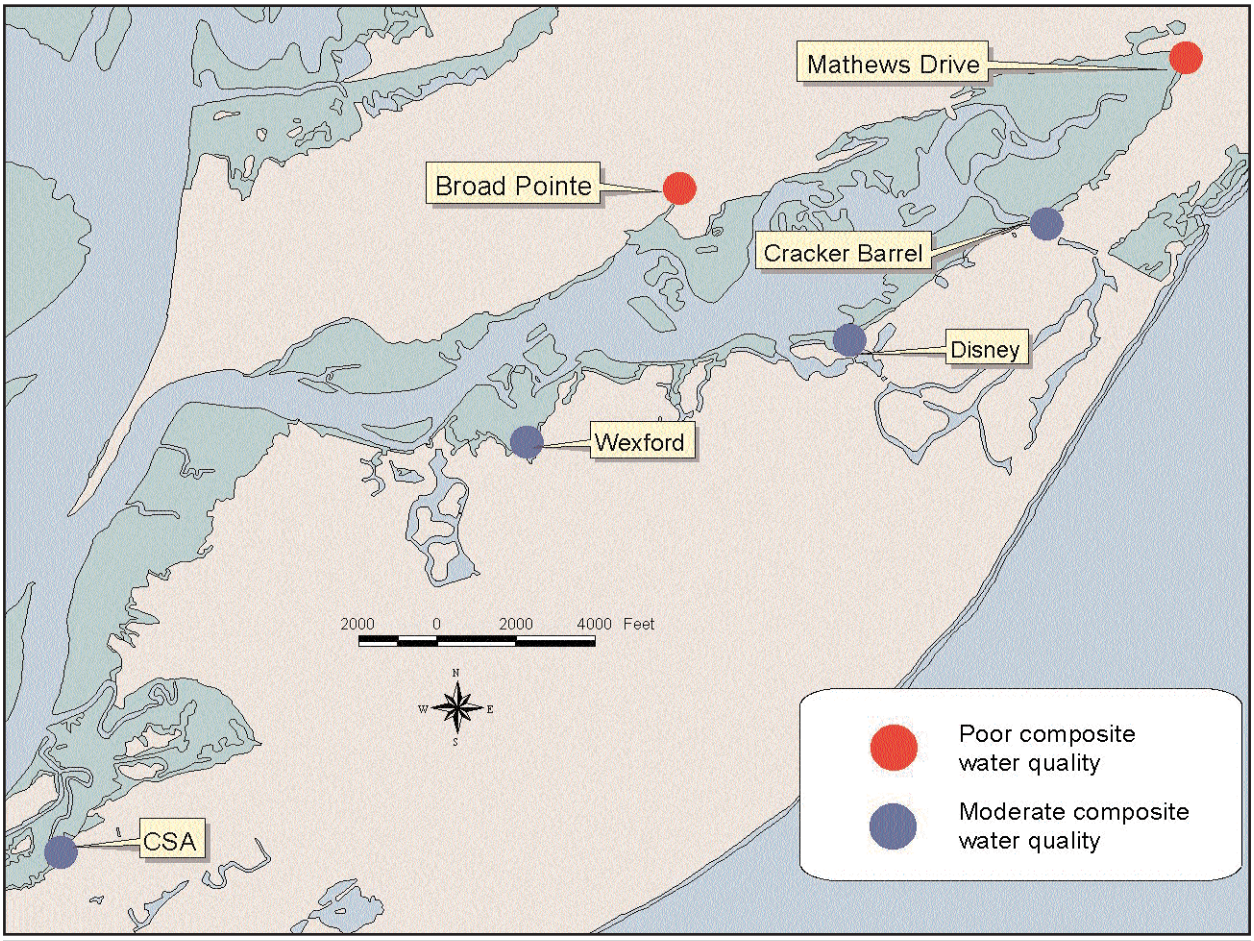


FIGURE 3-12: COMPOSITE WATER QUALITY SCORE

None of the stormwater discharge sites tested can be considered to have good water quality. Two sites, Mathews and Broad Pointe exhibit poor water quality, primarily due to high levels of fecal coliform and total phosphorous. It is anticipated that the Broad Pointe site will improve with respect to fecal coliform levels due to attempts to correct failing septic systems.

Additional Investigations

Routine monitoring efforts indicated that levels of common pollutants are higher than state standards at the stormwater discharge points. This result is expected as stormwater carries concentrated runoff from developed areas. It was suspected that the high levels seen at the discharge point would be diluted fairly rapidly in Broad Creek.

To evaluate the level of dilution expected after stormwater enters Broad Creek, two comparative sampling events were conducted. Two sites were chosen on Broad Creek, one near the mouth of the creek, and one in the headwaters (see Maps 3-1

and 3-2). At each stormwater discharge point routine monitoring data was collected. Three additional samples were collected by boat at regular intervals in the Creek. Both sites were sampled on a falling high tide, with 0.31 inches of rain in the previous 72 hours.

As expected, pollutant levels are reduced with increased distance into the creek at both sites, but not always enough to meet state water quality standards (see Appendix M for the full results).

FIGURE 3-13: JARVIS CREEK PROJECT

Model for Water Quality Program

The Town of Hilton Head Island has been progressive in its treatment of stormwater management. In response to flooding and water quality concerns several large drainage projects have been undertaken in the last few years. This section will discuss two of those projects, and detail how the lessons learned can be applied to other areas of the Broad Creek watershed, and the island as a whole.

The Jarvis Creek Project

The Jarvis Creek Project is a combined drainage improvement project and community park at the Town of Hilton Head Island's Jarvis Creek Tract (see Map 3-3 and Figure 3-13). The tract is approximately 50 acres, of which roughly half are wooded. The remainder was cleared for pasture as part of the antebellum Honey Horn Plantation. This project is not within the Broad Creek watershed.

This project is unique in the sense that it was a creative solution to a difficult problem. The 1995 Island Wide Drainage recommended upgrading the stormwater outfall under US 278 and enlarging the natural freshwater creek upstream of tidal Jarvis Creek, reducing problematic flooding in the Main Street, Hilton Head Plantation and William Hilton Parkway areas. During large storm events the Main Street commercial areas and the Hilton Head Plantation residential areas experience extreme flooding.

The original drainage plan included widening the natural freshwater creek adjacent to the Jarvis Creek Tract (at that time privately owned) to a bottom width of 35 feet and a depth of approximately 6 feet. The sloping bank would create a 100 foot wide canal. Enlarging the freshwater creek would destroy a large and unique area of upland habitat and over 4 acres of freshwater wetlands.

Work began in fiscal year 1996/7 on the

conceptual design and topographic survey of the Jarvis Creek Ditch Project. Significant wetlands and trees were found within the proposed project location. The Town therefore began to pursue an option that minimized the wetland impact by rerouting the ditch. Rerouting also meant lengthening the ditch, which in turn increased the amount of excavation and loss of trees and wildlife habitat. Costs increased from $1.6 million to $3.0 million.

It was also during the summer of 1996 that the Town was negotiating the purchase of the Jarvis Creek Tract adjacent to the existing Jarvis Creek ditch. The tract was purchased by the Town and Town staff began to explore additional design options to solve the drainage issues. A 13 acre lake capable of storing and conveying the necessary stormwater was envisioned. A pump station was needed in order to move the water from the ditch to the lake (see Figure 3-14). From the lake, water would flow through a vegetated spillway that discharges into the headwaters of Jarvis Creek.

FIGURE 3-14: JARVIS PUMP STATION

This alternative plan was chosen, resulting in the protection of 3.5 acres of valuable freshwater wetlands, and the reduction in upland habitat and tree loss.

The change from a 100 foot wide canal to a stormwater retention lake with wetland filter is intended to have profound impacts on water quality. The stormwater is designed to flow into the lake, through the vegetated wetland mitigation site, into an existing bottomland hardwood wetland, and then into the freshwater creek. The detention time in the lake, and the filtering effect of the wetlands, is designed to improve the quality of water flowing into Jarvis Creek (see Figure 3-15).

FIGURE 3-15: DRAGONFLIES AT CREATED WETLAND

The innovative nature of this project makes it ideal as a model for future stormwater projects. Treatment wetlands are one method of improving water quality before it is discharged into a receiving water body. To determine if the wetland at Jarvis Creek is indeed providing this function, bi-weekly water quality monitoring

has been conducted at the pump station site near William Hilton Parkway, and at the freshwater creek behind the outfall since the start of the project. This monitoring checks for 10 different water quality parameters including nitrogen, phosphorous and fecal coliform bacteria. The intention was to develop a good baseline of data before the pump station was operational to use as a comparison for after the stormwater is actively pumped through the system. This monitoring has been going on since September 1999, and will continue indefinitely. The Town intends to use the data collected and the lessons learned on other stormwater improvement projects in the Town.

This project is one of the most innovative in the Town's Capital Improvements Program. In fact, its unique design has been recognized as outstanding by the Association of State Floodplain Managers, and was awarded the DNR Flood Mitigation Assistant Grant two years in a row, the South Carolina Municipal Association Award, and the 2000 SC DNR Stewardship Development Award. These grants, worth over $500,000, represented all the money available in South Carolina for this program during those two years.

Ashmore Tract Drainage Project

The Ashmore tract is a 74.3 acre parcel of land directly upstream from the headwaters of Broad Creek (see Map 3-4). The Town purchased this land in 1996 to eliminate a potential commercial development, and to use as part of a drainage and open space project. There is currently an open stormwater channel through the site that drains part of Port Royal Plantation, the Hilton Head Number 1 Public Service District (PSD) wastewater treatment facility and a church. This channel drains directly into the headwaters of Broad Creek. Based on the 1995 Island Wide Drainage Study, this channel was scheduled to be upgraded in an attempt to alleviate flooding in Port Royal Plantation. Because of the water quality impairments in the headwaters area of Broad Creek, proper management of the Ashmore tract is critical. It was recognized that any improvements to the stormwater system must include not only volume considerations, but water quality considerations as well.

In 2001, the Town contracted with WK Dickson to evaluate the stormwater needs on the site, and to address water quality concerns. As part of WK Dickson's analysis, the Town agreed to conduct water quality monitoring at several sites within the Ashmore tract (see Map 3-4 for all of the monitoring sites). Previous monitoring efforts had shown that nutrient and bacteria levels were low at the upstream edge of the site, and much higher at the downstream edge. The challenge was to determine why these levels were rising, and to devise methods to reverse this result.

Additional monitoring failed to pinpoint the cause of the increased pollutants, but narrowed the source down to the area beginning at the PSD tributary. In particular, fecal coliform concentrations rise at the

confluence of the main channel and the PSD tributary, and remain elevated throughout the remainder of the main channel. WK Dickson's final recommendations included cleaning of the stormwater ditch and several innovative stormwater management techniques to improve water quality. All of the recommendations will be implemented in the coming year.

The first recommendation was to construct a bio-retention facility to treat the stormwater runoff from Fire Station 3. A bio-retention area is a depressional area with a sand substrate, planted with wetland vegetation (see Figure 3-16). Stormwater runoff is conveyed as sheet flow to the treatment area which consists of a grass buffer strip, sand bed, ponding area, mulch layer, and wetland plants. The water passes over the sand bed, which slows its velocity, and distributes it along the length of the ponding area. The water ponds and filters into the soil. Pollutants are removed by adhering to the soil particles, and by uptake by plants and microorganisms in the soil.

The bioretention area planned for the fire station is unlikely to provide a large reduction in pollutants on the Ashmore tract, but it will treat any inputs from the fire station itself, and will be used as a demonstration project for other development.

Another treatment method that should improve water quality significantly is the construction of a stormwater wetland on the Ashmore tract. Stormwater wetlands retain stormwater for long periods, which allows settling of pollutants and reduces the impact on the receiving water body. If large areas are allowed to dry out periodically, increased pollutant and bacteria removal will result because the bacteria cannot survive for long in dry conditions.

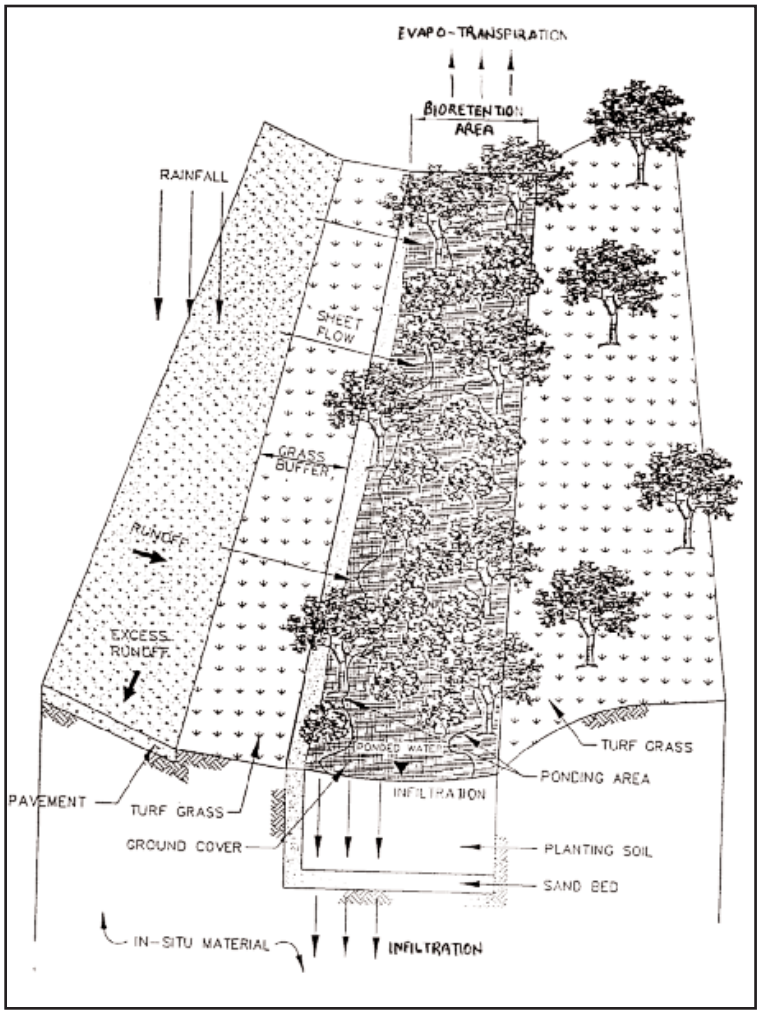


FIGURE 3-16: BIO-RETENTION AREA

Map 3-5 shows the area that is proposed to be excavated to create a new wetland system. Water will be diverted from the PSD tributary through a by-pass ditch into a large existing wetland. Another by-pass ditch will connect the existing wetland to a created treatment wetland. The water will meander through the treatment wetland and eventually be released back into the main channel. This diversion of flow should improve the water quality and reduce fecal coliform concentrations. In addition to the improvement of water quality, the treatment wetland will provide valuable wildlife habitat. The area planned for the wetland is in the Santee Cooper power line easement, which is already cleared of trees. The only tree removal required would be what is necessary for the by-pass ditches.

One additional water quality BMP is proposed for the Ashmore tract. In 1998 a mitigation wetland was created adjacent to the Ashmore ditch as part of the widening of Mathews Drive (see Map 3-4, "created wetland"). This area is fulfilling the mitigation requirements, but is hydrologically separate from the Ashmore drainage ditch, and is therefore providing no water quality benefit for Broad Creek. As part of the water quality improvement efforts on the Ashmore tract, this mitigation area will be re-graded and connected to the main channel, allowing stormwater to flow into the mitigation area and be filtered of pollutants.

Additional water quality improvement should be observed with the redevelopment of the PSD site, which includes a retention/detention basin to collect stormwater rather than allow it to discharge directly into the ditch.

Routine water quality monitoring will be conducted during the construction of these projects, and afterwards to determine whether water quality is improving.

Both the Ashmore and Jarvis Creek projects are examples of innovative stormwater management projects being conducted by the Town. The lessons learned on these projects will help the Town make sound stormwater management decisions in other areas of the Island. Innovative stormwater strategies are vital to protecting and improving water quality. These methods should be adapted to stormwater projects Island wide.

Sewage Disposal and its Impacts on Water Quality

Development History

As part of the Beaufort County SAMP, the National Small Flows Clearinghouse has prepared a report dealing with onsite sewage disposal systems throughout the county. While their efforts concentrated on the unincorporated parts of the county, they did include Hilton Head Island in their work. To that end, this discussion is limited to the watershed of Broad Creek, and does not cover the existing regulations or alternative onsite sewage disposal system designs, as that material is covered in the Small Flows report.

Along with human occupation comes the need to dispose of human wastes. In the years before modern development on Hilton Head Island, people relied upon privies or septic systems for their sewage disposal. This was adequate for the amount of development at that time.

As modern development began in earnest in the 1960's, it became clear that if the island was to support a large number of homes and businesses, a centralized approach to sewage disposal would be needed. The 1970 population on the island was estimated at 3,000, and by 1975 it had risen to 6,511. The 2000 Census reported the population of the Town was 33,900. The population density of the island in 1960 was 18.5 people per square mile, and had soared to 628 in 2000.

The majority of development on the island from the 1960s through the 1990s took place within private communities – the Planned Unit Developments (PUDs). As these PUDs were planned, sewer systems were designed by the developers to provide sewage disposal. Sea Pines, the first PUD to be planned and begin development, originally relied upon onsite sewage disposal systems. Once the PUD reached a certain level of development, the developer constructed a centralized sewage treatment facility and the associated sewer lines. Further development was then connected to the sewer system.

Spanish Wells was designed in the 1960s as a subdivision around a nine hole golf course. At that time there were no centralized sewage treatment facilities on the island, and each home had its own onsite sewage disposal system. This PUD consists of 185 single family lots, each at least one acre in size, the nine hole golf course, two tennis courts, and a small club house. This area remains dependent upon onsite sewage disposal systems. All of the remaining PUDs have centralized sewage disposal facilities, although Port Royal Plantation initially relied upon onsite systems.

Large sections of those areas outside of the PUDs, or 29% of the island, are occupied by small rural neighborhoods which are dependent upon onsite sewage disposal systems. Part of this area lies within the watershed and corridor of Broad Creek.

Onsite sewage disposal systems, when designed properly for the specific soil and site conditions, and maintained properly, are a reliable method to dispose of human waste. They typically consist of a septic tank where the solids settle out and decompose, and an absorption field (also referred to as leach field) where the liquids, or effluent, are disposed of through the soil. As the effluent passes through the soil, some of the harmful substances are absorbed by the soil particles, some are taken up as nutrients by plant roots, and some are broken down by micro-organisms in the soil. When an onsite sewage disposal system fails, these harmful substances can reach the groundwater and surface water bodies, causing pollution.

A failed onsite sewage disposal system is one which is no longer providing adequate treatment of the wastes. Symptoms include a smell of sewage near the absorption field, sewage backing up into the house, or sewage breaking out to the surface of the ground. Fecal coliform bacteria can enter the environment through the groundwater before symptoms appear.

Soil Conditions

The majority of the Town of Hilton Head Island has soils which are not well suited for disposal of effluents, particularly for onsite sewage disposal systems. The reasons for this originate with the geology of the area and the morphology of the soils.

The Soil Conservation Service (SCS), who published soil maps for Beaufort County in 1980, also developed suitability ratings for septic tank absorption fields. Appendix N contains a thorough discussion of the soils and their suitability for onsite sewage disposal systems. Most of the soils in areas where onsite sewage disposal systems exist in the watershed and corridor are not well suited for them. This increases the potential for human waste to pollute Broad Creek from failed septic systems.

In all, there are 1,099 known onsite sewage disposal systems within the watershed of Broad Creek, and 724 in the corridor. Some of these may have been abandoned, as the sewer systems have been expanded into some neighborhoods which originally depended on onsite sewage disposal systems.

In 1998 SC DHEC surveyed all the systems on the island, and found that of the 1,099 systems in the watershed of Broad Creek, 29 were failing or were in questionable condition and 1,070, or 97%, were in working order. Within the corridor, of the 724 onsite sewage disposal systems, 26 were failing or were in questionable condition, so 698, or 96%, were working properly. That is a good rate considering the limitations of the soils for onsite sewage disposal systems.

Nonetheless, several of those reported as having failed were located in the headwaters area of Broad Creek, which is cause for concern given the importance of the headwaters ecosystem to the overall health of the creek. Since the survey was completed, there have probably been additional septic system absorption field failures. While SC DHEC does its best to inspect onsite sewage disposal systems and require repairs in a timely fashion, it is likely that there are times when E-coli bacteria reaches Broad Creek from failed onsite sewage disposal systems.

As was described in the earler discussions of water quality, high fecal coliform bacteria levels were continuously detected at one of the regular monitoring points (Broad Pointe). Multiple Antibiotic Resistance (MAR) testing of samples from this site determined that the fecal coliform bacteria were of human origin. This was traced to a residential area, where several failed systems were found. These systems have since been repaired.

A total of 28% of the onsite sewage disposal systems in the watershed are located in soils which are rated as having slight limitations for septic system absorption fields, meaning onsite sewage disposal systems should function properly. Conversely, 787 (72%), are located in soils that are rated "severe" for septic system absorption fields.

However, 692 of those 787 systems are in soils which can be modified to overcome the limitations that give them the "severe" rating. Only 95 systems (or 9% of the 1,099) are located in soils which would be difficult if not impossible to overcome the limitations, and one system is located in a soil which is completely unsuitable for septic systems. It is these last two categories which pose the greatest hazard to water quality, due to the greater possibility of failure of the septic system absorption fields.

It is assumed that failures of those systems close to the creek (within the Broad Creek corridor) have a higher potential for causing high fecal coliform contamination than systems that, while within the watershed of the creek, are further away. It can also be assumed that those onsite sewage disposal systems that are located in soils rated "severe" would have a higher potential for failure and thus a higher potential for causing pollution than systems located in soils rated "slight".

Map 3-6 provides a clear picture of the vulnerability of the creek from those systems located close to the creek and in poor soils. There are 446 onsite sewage disposal systems in this group which should be closely monitored. The 81 indicated with a red dot are those located in the poorest soils and for which alternative methods of sewage disposal should be pursued first.

The high density of onsite sewage disposal systems in an area can be another contributing factor to failures. For the areas with onsite sewage disposal systems within the corridor of Broad Creek, the density of systems ranges from 0.5 systems per acre in Spanish Wells to 5.8 systems per acre in Roller's Trailer Park, with an average of 2.1. The area outlined in red on Map 3-6 should have a high priority for sewer connection due to the high density of septic systems there. This area is on the south side of Marshland Road between Crosswinds and the Owners Club, both developments are within the Indigo Run PUD.

There are three private wastewater utilities, also known as Public Service Districts (PSD) located on the island. These utilities provide sewer systems and wastewater treatment facilities. Their boundaries are shown in Figure 3-17. South Island PSD is currently working to complete construction of their sewer system, three neighborhoods remain without sewer but will be connected within five years.

Hilton Head No. 1 PSD (HH #1 PSD) on the north end of the island has a large number of customers in need of sewer. Not only are the areas discussed here in need of public sewer, but the areas along

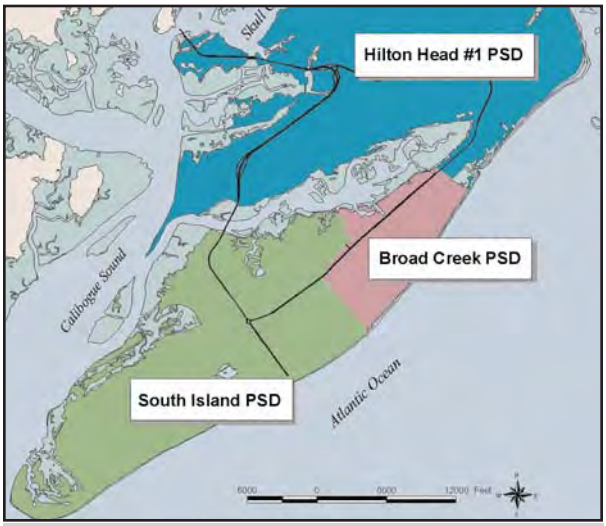


FIGURE 3-17: PUBLIC SERVICE DISTRICTS

Old House Creek, Jarvis Creek, and Skull Creek currently lack sewer service. HH #1 PSD is working with the Town to develop a master plan for the eventual expansion of the sewer system to the remainder of the island. Construction of this system will be a massive undertaking and is expected to take many years. Their sewage treatment facility has been upgraded to handle the projected volume for build-out of the island.

Centralized sewage treatment plants are not immune from problems of their own. In 1991, upon completion of HH #1 PSD's new treatment facility, a construction error resulted in approximately 5.25 million gallons of untreated wastewater being discharged into Broad Creek. This was an isolated incident which was a direct result from the construction, and spills like this are not likely to occur again. A study was done to determine the impact of the spill to the shellfish resources in the headwaters of Broad Creek. That study concluded that due to the flushing action of the tides (even though limited in the headwaters) there would be no long term impact to the shellfish resources from the wastewater spill.

Map 3-7 shows the high risk onsite sewage disposal systems (from Map 3-6) in conjunction with the existing sewer lines (mains and collection pipes) in the area. From this it can be seen that in some cases, connection to the sewer system should not be difficult or prohibitively expensive. However, in all areas a system of gravity fed collection pipes must be installed in order to provide sewer service to individual homes or businesses.

In 2000 the Town recieved a Community Development Block Grant (CDBG) to provide sewer to the Muddy Creek area. This project will provide sewer to 48 low to moderate income homes, and will be designed to provide for extension only to a portion of the Spanish Wells Road area. The Spanish Wells PUD will not be able to connect to sewer using this sewer main, it will require a second main to be constructed. As the map shows, there are a number of systems in Spanish Wells (37) which are listed as having the highest priority for finding an alternative means of sewage disposal – of which connection to the public sewer is the preferred and planned for method.

Many of the onsite sewage disposal systems are old, undersized, and/or inadequately designed. Maintenance of onsite sewage disposal systems is an ongoing

problem, as many residents who depend on them have little or no knowledge of how they work – in some cases residents don't even know they exist. Since the vast majority of onsite sewage disposal systems in the Broad Creek watershed are constructed in soils which are unsuitable for septic system absorption fields, it is not surprising that problems exist.

The Public Service Districts on the island dispose of their treated wastewater through land application, primarily at golf courses which use the wastewater for irrigation. They have special distribution systems for this treated wastewater, which is sprayed on the land at times when people are least likely to be there. This does not pose any health threat, since the wastewater has received tertiary treatment (the highest level available) and is tested before it enters the system. No fecal coliform exists in this treated wastewater.

Currently there are 15 golf courses within the Broad Creek watershed utilizing treated wastewater for irrigation. In addition, South Island PSD's irrigation system includes some commercial and residential areas. During extremely wet seasons, HH #1 PSD discharges some of this treated wastewater into the wetlands in two conservation areas in Hilton Head Plantation and a third in Palmetto Hall Plantation, all of which are outside of the Broad Creek watershed. Broad Creek PSD occasionally sprays treated effluent on a parcel of Town owned property, and on rare occasions discharges into the irrigation pond for the Long Cove Club golf courses.

Implications

The water quality monitoring done for this project demonstrates what has been perceived for some time; that the water quality of Broad Creek is impaired in many ways. The fact that none of the monitoring sites meet all, or even most, state standards (where standards exist) is of concern. While it is known that standards are unlikely to be achieved at the discharge point, the distance sampling shows that if pollutant levels are high, even a fair amount of dilution does not always improve water quality enough to meet standards. A concerted effort must be made to improve the quality of water leaving the stormwater pipes. While the Town can and should take measures to reduce pollutants at the discharge point, the most effective way to reduce pollution is at the source. Educating citizens about their role in stormwater management is critical.

One positive finding of this study is that for the level of development in the watershed, Broad Creek is still fairly healthy. Shellfish harvesting is still permitted in some areas, and the water is safe for all types of recreation. While improvements need to be made, past Town policies regarding land use and buffers have clearly paid off.

An additional positive finding is that efforts to reduce nutrient loadings upstream can make a significant improvement in the water quality in Broad Creek. The distance sampling study showed that a lower level of nutrients and bacteria entering the Creek makes the dilution more effective.

An additional lesson learned from the water quality monitoring effort is that the Town must focus reduction efforts on fecal coliform bacteria and phosphate to make the biggest improvement in water quality. These are the two pollutants which had the highest levels in the monitoring study, and which have the greatest margin for improvement. A reduction in phosphate should also lead to reductions in nitrogen and ammonia inputs.

While the majority of the watershed is serviced with centralized sewage collection and treatment facilities, there are a substantial number of onsite sewage disposal systems still in use, particularly on the north side of the creek. The potential for failure of many of these systems is high due to the soil conditions in the watershed. The public service districts are striving to expand their centralized systems to those areas not currently served, but it will be a number of years before it will be done.

Goals

The study of the quality of stormwater entering Broad Creek makes it clear that steps need to be taken to preserve the resource. The water quality of Broad Creek needs to be protected because it is vital to the continued health of the creek ecosystem in many ways. The following goals strive for the continued protection of the resource.

1. *The top priority of the Town of Hilton Head Island's stormwater program should be to protect and improve the water quality in Broad Creek.* As the Town continues to develop, it will be important to maintain water quality at the present level to ensure there is no need for increased shellfish bed closures (due to high fecal coliform concentrations), and no increased risks to public health. Significant effort will be required to improve water quality, but it can be achieved, bringing Broad Creek back to a measure of its previous health.

2. *The Town should strive to exceed the requirements to the maximum extent possible for the NPDES permit.* The Town of Hilton Head Island already fulfills many of the requirements of the NPDES permit, and should continue to work with Beaufort County to examine and address all of the required elements of the NPDES program.

3. *The Town of Hilton Head Island should take a role in educating the public about stormwater issues and their effects on Broad Creek*. As the source of much of the pollutants in stormwater, the citizens of the Town as well as visitors are the first line of defense in ensuring the long term health of Broad Creek. An informed public is more likely to become involved in protecting and improving natural resources. The Town cannot eliminate pollutants at the discharge points; pollutants must be reduced at the source.

4. *The Town must strive to reduce and eventually eliminate to the extent possible the threat of human waste contributing to the pollution of Broad Creek*. Improperly treated human waste is a significant health hazard, and reducing this threat should be

a high priority. Pollution from failed onsite sewage disposal systems is harmful to wildlife and humans alike. High levels of fecal coliform bacteria can cause disease in mammals (including humans), and the closure of oyster beds.

Implementation Strategies

The goals listed above explain the need to protect the water quality of Broad Creek. The following implementation strategies lay out ways these goals can be achieved. In many instances the implementation strategy addresses more than one goal.

Use of Vegetated Buffers

Vegetated buffers adjacent to Broad Creek and other water bodies, including stormwater conveyance systems, are vital in improving the quality of water in the creek. Vegetation slows the velocity of water, allows time for infiltration into the soil, and provides a means for nutrient uptake through plants. Following are some ways to increase the use of buffers for water quality.

1. *ENFORCE EXISTING BUFFER STANDARDS AND EVALUATE WAYS TO AMEND THE WETLAND BUFFER REGULATIONS IN THE LMO TO PERMIT SELECTIVE PRUNING OF VEGETATION FOR VIEW WINDOWS.* The Town currently requires that all development, including single family homes, along tidal wetlands maintain a minimum 20 foot vegetated buffer. Disturbance of the native vegetation in this buffer is prohibited. Recent studies have shown that a larger buffer is needed to further protect riverine ecosystems. While this is likely true, much of the property along Broad Creek is already developed, and wider buffers are not feasible. Enforcing the existing buffer standards to the extent possible will go a long way to protect Broad Creek.

Many people feel that thick vegetated buffers will eliminate their view. The Natural Resources Division supports limited pruning of buffer vegetation to create view "windows" of the creek. Currently this involves a site visit to determine proper pruning techniques. The LMO does not address pruning for view, and language should be adopted addressing this.

Education is vital to this effort. The Town should involve property owners, architectural review boards and garden clubs in spreading knowledge about the importance of buffers.

2. *ENCOURAGE PROPERTY OWNERS TO PROVIDE VEGETATED BUFFERS ON ALL RECEIVING WATER BODIES.* This is particularly important for stormwater detention ponds and lagoons. The purpose is to allow for improvement of water quality before it reaches the stormwater system and is discharged into Broad Creek. Educating property owners about the importance of vegetation for water quality improvement, and showing examples of how buffers can be beautiful as well as functional will be important in this effort.

3. *ACQUIRE VACANT PARCELS IN THE BROAD CREEK WATERSHED AND MANAGE THEM AS OPEN SPACE FOR STORMWATER FILTRATION.*

Use of Stormwater Best Management Practices

Many practices exist which are designed to improve stormwater before it enters the receiving water body. The Town should encourage the use of grassed swales, treatment wetlands, wetland plants, biofiltration, and engineered filters. Best management practices (BMP) should be chosen which target the removal of fecal coliform bacteria and phosphorous, the two main pollutants in Broad Creek.

1. *THE TOWN SHOULD CONTINUE TO IMPROVE WATER QUALITY AS PART OF THE CAPITAL IMPROVEMENTS PROGRAM (CIP).* The Town has the opportunity and responsibility to use the CIP as a model for progressive stormwater management. Town projects should continue to make use of the latest in treatment options and encourage their use by others. The Town has been very progressive in the use of alternative stormwater methods and has made a commitment to improving water quality in the stormwater drainage system. See Model for Water Quality Program section for a detailed description of current Town efforts.

2. *THE TOWN SHOULD AMEND THE LAND MANAGEMENT ORDINANCE TO ENCOURAGE OR REQUIRE DEVELOPMENT TO USE INNOVATIVE BMP'S IN PLACE OF CONVENTIONAL STORMWATER MANAGEMENT.* Either through requirements or incentives, developers should be encouraged to use cluster developments, grassed swales in place of curb and gutter, reduced impervious surfaces, and other management practices. Changes to the stormwater and land use sections of the LMO should be examined.

Reduce Dependance on Onsite Sewage Disposal Systems

1. *CONTINUE TO WORK WITH PSD#1 TO DEVELOP A MASTER PLAN FOR EXTENDING SEWER SERVICE TO ALL AREAS CURRENTLY DEPENDENT UPON ONSITE SEWAGE DISPOSAL SYSTEMS.* Those areas identified in this chapter which are at the highest risk for failure and pollution of Broad Creek should be incorporated into that master plan's priority listing.

2. *RESEARCH AND APPLY FOR GRANTS WHICH COULD BE USED TO CONNECT SOME OF THOSE HIGHEST PRIORITY AREAS IDENTIFIED IN THIS CHAPTER TO PUBLIC SEWER.*

3. *WORK WITH SC DHEC TO REVIEW THE DENSITIES OF DWELLING UNITS WHERE ONSITE SEWAGE DISPOSAL SYSTEMS ARE THE ONLY MEANS OF SEWAGE DISPOSAL.* If appropriate, consider amending the Town's Land Management Ordinance to restrict the number of onsite sewage disposal systems that can be installed in those areas by reducing the permitted density (except when development is connected to the public sewer).

Currently the LMO permits up to 4 units per acre without sewer, which, as the information presented earlier as well as in Appendix N, is too high to adequately protect the creek.

4. *WORK WITH SC DHEC TO IDENTIFY AREAS WHICH SHOULD BE CLOSELY MONITORED FOR ONSITE SEWAGE DISPOSAL SYSTEM FAILURES.* Promptly notify SC DHEC when failed systems are found.

5. *ENCOURAGE ALL RESIDENTS WHO HAVE PUBLIC SEWER AVAILABLE BUT HAVE NOT YET CONNECTED TO ABANDON THEIR ONSITE SEWAGE DISPOSAL SYSTEMS AND CONNECT TO THE SEWER SERVICE.*

6. *THE TOWN SHOULD SUPPORT ANY APPLICABLE RECOMMENDATIONS MADE IN THE SMALL FLOWS REPORT.* That report, another portion of the Beaufort County SAMP program, covers onsite sewage disposal systems. It may include recommendations to change the regulations or approval process, or on alternative onsite sewage disposal system designs that function better in coastal soils.

Water Quality Monitoring and Enforcement

1. *THE TOWN SHOULD CONTINUE TO MONITOR WATER TO ADD TO THE BODY OF KNOWLEDGE.* The Town should continue to use the water quality monitoring results to evaluate potential problems and report irregularities to the proper regulatory authority.

Public Education

Only through education can citizens and visitors become aware of the tremendous resource of Broad Creek, and of their role in protecting it. The citizens of the Town of Hilton Head Island value clean water, but often do not realize that their actions have a direct impact. The Town and other groups should take the responsibility to educate people and increase their opportunities for learning about protecting the water quality of Broad Creek.

1. *THE TOWN SHOULD CONSIDER HOLDING SEMINARS TO EDUCATE BUILDERS AND DEVELOPERS ABOUT INNOVATIVE STORMWATER TECHNIQUES AND ENCOURAGE IMPLEMENTATION IN THEIR DEVELOPMENTS.* Providing information, including potential cost savings, is important in convincing builders of the values of proper stormwater management.

2. *EDUCATE THE PUBLIC ABOUT THE USE OF RIPARIAN BUFFERS TO PROTECT WATER QUALITY.* As part of this SAMP grant, a brochure has been produced on why buffers are important, what regulations exist regarding buffers, and how to design a riparian buffer.

3. *EDUCATE THE PUBLIC ABOUT ONSITE SEWAGE DISPOSAL SYSTEMS. A* brochure has been written as part of this SAMP grant providing an overview of how an onsite sewage disposal system functions and what property owners and residents can do to help prevent failures. This brochure should be mailed

to addresses known to have onsite sewage disposal. It should also be translated into Spanish and distributed to Spanish speaking residents in areas with onsite sewage disposal systems.

4. *THE TOWN SHOULD MAKE FULL USE OF ITS WEB PAGE TO INFORM CITIZENS ABOUT PROPER STORMWATER MANAGEMENT.* This should include copies of any brochure produced and links to other stormwater management sites.

CHAPTER 4
ENVIRONMENTAL ZONES AND WILDLIFE

Broad Creek is a thriving ecosystem in the center of a rapidly changing urban environment. The ecology and wildlife of Broad Creek have not been intensively studied in recent years. As part of this management plan, the Town of Hilton Head Island has undertaken a year-long survey to identify and inventory the wildlife of Broad Creek.

Environmental Zones

For the purposes of this study, Broad Creek was divided into three ecological zones. These zones, as depicted in Figure 1-5 in Chapter 1, are primarily based on the differing hydrologic conditions in the Creek. Broad Creek experiences semidiurnal tides, consisting of two high and two low tides each lunar day. Mean tidal range is normally 7.0 feet, and up to 8.9 feet during spring tides. The hydrology drives subtle differences in the plant species that are present, in the wildlife usage of the creek, and in the physical and chemical components of the system. Each of these topics will be examined more closely.

The zone at the mouth is that section of Broad Creek from the confluence of Calibogue Sound to Spanish Wells. The middle zone of the creek stretches from Spanish Wells to near Shelter Cove Harbor. The headwaters zone of Broad Creek consists of the area from Shelter Cove Harbor up to Mathews Drive. See Maps 4-1, 4-2, and 4-3 for the latest aerial photo of each zone.

The Mouth of Broad Creek

The area around the mouth of Broad Creek is characterized by wide stream channels and a relatively stable hydrologic regime. Its proximity to Calibogue Sound has a modifying effect on the tidal and nutrient fluctuations of the creek. The area is well flushed by the daily tides. The topography in this zone is relatively flat, with gently sloping marsh islands and mud flats. Some of the banks are experiencing erosion, possibly due to boat wakes. Water depths range as high as 25 feet.

FIGURE 4-1: MOUTH OF BROAD CREEK

There are several small tidal creeks entering Broad Creek in this zone, including Point Comfort Creek and Lawton Creek. These tidal creeks are characterized by sinuous shallow channels that are difficult to navigate during low tide.

The vegetation in this zone of the creek is predominantly smooth cordgrass (Spartina alterniflora). Smooth cordgrass is an erect perennial grass that grows 1-8 feet tall with hollow round stems and smooth elongated leaves. It is an important part of the producer side of the food chain. From early June to late October smooth cordgrass is a brilliant green color. In the winter months it dries to a soft brown. The renewal of the cordgrass in late spring is one of the most beautiful sights on the marsh.

FIGURE 4-2: SMOOTH CORDGRASS

Occurring in less abundance in this area of the creek is black needlerush (Juncus roemerianus). Black needlerush grows landward of smooth cordgrass in clumps up to 6.5 feet tall. It is an evergreen grasslike plant with stiff sharply pointed leaves which appear black at the tip.

There are few oyster beds around the mouth of Broad Creek. The small amount of oyster resource is primarily in narrow linear bands adjacent to the marsh islands.

The Middle of Broad Creek

The area between Spanish Wells and Shelter Cove Harbor is characterized by relatively wide stream channels, with areas of marsh islands. It is the most developed section of Broad Creek and has the most boat traffic (see Chapter 5). The area is well flushed by the daily tides. The topography in this zone is similar to the mouth zone of the creek, with the exception of the marsh islands, which in this zone are taller with more steeply sloped shorelines. Water depth ranges from 7 feet to 21 feet in the channel of this zone, with shallow depths adjacent to the marsh islands.

As in the mouth zone, the vegetation in the middle zone of the creek is predominantly smooth cordgrass and black needlerush. Oyster beds are more abundant in this section of the Creek, adjacent to marsh areas, with some beds exhibiting densely clustered oysters.

FIGURE 4-3: MIDDLE ZONE

The Headwaters of Broad Creek

Unlike the mouth and middle zones of Broad Creek, the headwaters zone is not characterized by a wide, open channel. This zone consists of narrow sinuous channels that are difficult to navigate at low tide. There are many small inlets and oxbows in this zone. The headwaters is not well flushed by the daily tides, and water (and pollutants) tend to have long

FIGURE 4-4: HEADWATERS ZONE

residence times in this area. Smooth cordgrass dominates this ecosystem, in large marsh areas that often block navigation. Water depths in the main channel of this zone only range from about 6 feet to less than 1 foot.

Oysters are abundant in this area, with large and dense oyster beds adjacent to the marshes. Also present in this zone are mud flats, areas without oysters or vegetation that are exposed at low tide.

Because of the narrow channels and inefficient flushing of this zone, there are unique challenges to the management of this area.

Wildlife in Broad Creek

Wildlife surveys of Broad Creek were conducted for one full year beginning in May 2000. The purpose of this wildlife survey was to gather information on the species and abundance of wildlife present on Broad Creek. This data is useful in determining the health of the Creek, and can be used as a baseline for comparison with any future surveys.

Methodology

As discussed earlier, Broad Creek was divided into three environmental zones. Two wildlife monitoring stations were located in each zone, for a total of six monitoring sites (see Map 4-4). Each monitoring site was visited four times to capture the range of tides and times of day. In addition, each zone of the creek was inventoried in its entirety once each season. In total, 36 wildlife monitoring events were conducted.

Wildlife monitoring was conducted by boat, with the site trips consisting of anchoring for two hours at the designated site. All wildlife observed was recorded including species, number, and behavior. The seasonal trips were conducted by motoring slowly up and down the designated zone of Broad Creek and recording species, number, and behavior.

Results

In total, 73 different species were observed on Broad Creek. By far, birds were the most common wildlife on the Creek. In addition to the 67 species of birds, 2 fish species, 1 reptile species, and 3 mammal species were noted. Because neither water column nor bottom sampling

was routinely conducted, the full range of aquatic species is not represented in this sample. The aquatic species noted were found only coincidentally, and cannot be judged to be an adequate representation of Broad Creek. While oyster beds are abundant in Broad Creek, no attempt was made here to quantify their numbers, and they will be discussed separately. The chart on the following page identifies all of the species noted in the wildlife sampling.

Some species were noted with much more frequency than others. The ten most commonly observed species are shown in Figure 4-5. Not surprisingly, most of these commonly observed species are birds that are not considered threatened or endangered, and are found in great numbers throughout the region. The exception to this is the brown pelican.

Figure 4-6 shows the species that were observed only once on Broad Creek. Three of these species, the bald eagle, the West-Indian manatee, and the loggerhead sea turtle are endangered species and are discussed in further detail in Appendix O.

Species Observed	Number of Observations
Boat-tailed grackle	474
Red-winged blackbird	373
Cormorant	330
Great egret	316
Laughing gull	283
Snowy egret	229
Bufflehead	177
Dunlin	154
Brown pelican	143

FIGURE 4-5: MOST COMMONLY OBSERVED SPECIES

Species Observed
American bittern
Royal tern
Loggerhead sea turtle
West Indian manatee
Red-tailed hawk
Swamp sparrow
Bald eagle
Virginia rail

FIGURE 4-6: LEAST COMMONLY OBSERVED SPECIES

One, the Virginia rail, was heard quite often, but rarely seen.

Patterns of Wildlife Usage of Broad Creek

In addition to identifying which species use Broad Creek, one of the purposes of this study was to identify peak wildlife usage of Broad Creek. Relationships of wildlife usage to site location, time of day, tide stage, and season were examined.

Wildlife usage and site location

The abundance of wildlife on Broad Creek was very much site dependent, although the number of individual species was not as disparate. As shown in Map 4-4, sites 1 and 2 were located near the mouth of Broad Creek and the confluence with Calibogue Sound. Sites 3 and 4 were located in the high traffic middle section of the creek, and sites 5 and 6 were located in the relatively sheltered headwaters area of the creek.

Figure 4-7 shows the patterns of usage at

Wildlife Species Observed on Broad Creek

American bittern
American coot
American oystercatcher
American widgeon
bald eagle
barn swallow
belted kingfisher
black skimmer
black vulture
boat tailed grackle
bottlenose dolphin
brown pelican
bufflehead
cattle egret
chimney swift
clapper rail
common grackle
common loon
common merganser
common tern
cormorant
crow
dunlin
European starling
file fish
Forster's tern
great blue heron
great egret
greater yellowlegs
green heron
gull - unidentified
gull billed tern
herring gull
hooded merganser
laughing gull
least sandpiper
least tern
lesser yellowlegs
little blue heron
loggerhead sea turtle
marsh wren
mink
mourning dove
osprey
pied-billed grebe
piping plover
red breasted merganser
red-tailed hawk
red-winged blackbird
ring billed gull
royal tern
ruddy turnstone
sanderling
sandpiper - unidentified
sandwich tern
seaside sparrow
semi-palmated plover
snowy egret
sparrow
sting ray
swamp sparrow
tern - unidentified
tree swallow
tri-colored heron
turkey vulture
Virginia rail
West-Indian manatee
whimbrel
white ibis
willet
wood stork
yellow crowned night heron

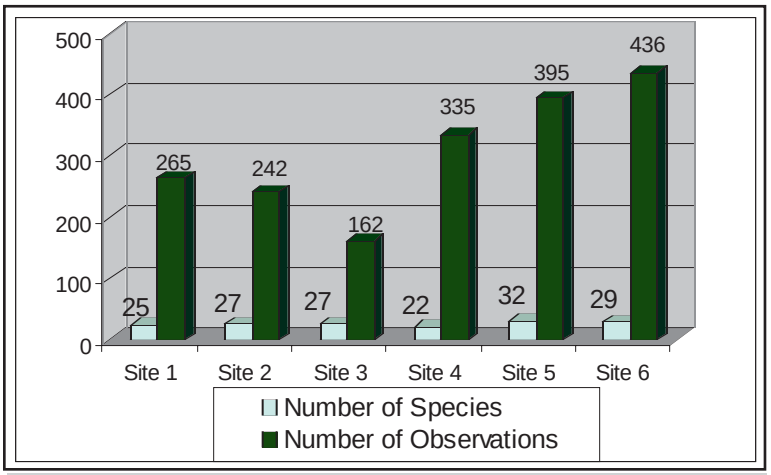


FIGURE 4-7: WILDLIFE USAGE AND SITE LOCATION (REGULAR TRIPS)

each permanent monitoring site (sites monitored regularly at different tides, times, and seasons). Sites in the headwaters of the Creek (sites 5 and 6) have the most wildlife observations, while sites near the mouth (sites 1 and 2) have the fewest observations. In terms of the number of species, sites in the headwaters again seem the most productive, but the difference between sites is not as great.

The four seasonal trips, the results of which are shown in Figure 4-8, produced the opposite result. The mouth of Broad Creek had the highest wildlife abundance, and the headwaters had the lowest abundance. This result is likely due to the observation of large flocks of birds on several of the seasonal trips. The large numbers of birds in a flock seen in one trip skew the results.

Most species were sighted at least once in each zone of the creek. Three species were never observed near the mouth of Broad Creek: the ruddy turnstone, piping plover, and clapper rail. Two species, the gull-billed tern and the mink were never observed in the headwaters area of the creek.

Wildlife usage and time of day

Time of day also appears to influence patterns of wildlife usage. Figure 4-10 shows the number of wildlife observations recorded at each time of day. Morning (from 2 hours after sunrise until noon) appears to be the most active time. Afternoon (from noon to sundown) follows. Dusk appears to be the least active period. This pattern is logical given that many of the bird species observed roost in other areas and travel to Broad Creek to feed. Birds are less abundant in the late evening and early morning

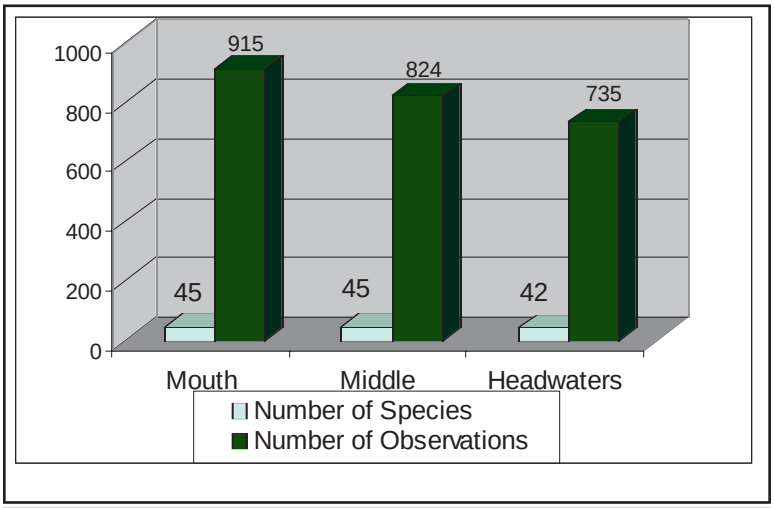


FIGURE 4-8: WILDLIFE USAGE AND SITE LOCATION (SEASONAL TRIPS)

FIGURE 4-9: DAWN ON BROAD CREEK

because they are likely traveling to and from their roosting sites.

Only two species were observed exclusively in the morning, the common tern (17 individuals seen over two occasions), and the sanderling (10 individuals seen on two occasions). Two species were observed during both dawn and morning hours, the chimney swift (18 individuals observed over many occasions), and the yellow-crowned night heron (20 individuals seen over four occasions). There were no species observed only at dusk. The American coot was only observed at dawn and dusk. The following three species were seen only during the afternoon and dusk hours: the bald eagle (2 individuals observed on two occasions), the hooded merganser (76 individuals observed on three occasions), and the ruddy turnstone (15 individuals observed on three occasions). Two species, the common loon (26 individuals observed on a number of occasions), and the pied-billed grebe (6 individuals observed on 4 occasions), were seen only during the morning and afternoon hours, but not at dawn or dusk. The Forster's tern was seen at dawn, dusk, and morning, but never during the afternoon hours.

Time of day	Number of trips	Total Number of Observations	Average Number of Observations
Dawn	12	1455	121
Morning	6	1122	187
Afternoon	7	1253	139
Dusk	7	523	75

FIGURE 4-10: WILDLIFE USAGE AND TIME OF DAY

Wildlife Usage and Tide Stage

The patterns of wildlife usage were examined in relationship with tide stage to determine if management recommendations needed to be tailored to tide. The results shown in Figure 4-11 were surprising. Based on casual observation, it was hypothesized that low tide would be the most active time for wildlife on Broad Creek. The results indicate that slack tides, both low and high, are actually the least active time. Falling tide appears to be a time of increased wildlife activity, followed by rising tide. This may be due to the fact that food items are more available when the water is moving.

Many of the species observed in this study utilized Broad Creek at

Tide	Number of trips	Total Number of Observations	Average Number of Observations
Low	9	994	110
Rising	7	994	142
Falling	5	1253	207
High	13	1328	102

FIGURE 4-11: WILDLIFE USAGE AND TIDE STAGE

all tide levels. Figure 4-12 on the next page lists the species that appeared to favor one or more tide stages.

Wildlife usage and season

Because of the migratory nature of many of the bird species present on Broad Creek, patterns of wildlife usage by season are important. Monitoring trips were evenly distributed throughout the year to accurately record seasonal variation. Figure 4-13 shows the number of species recorded, and the total observations in each season. While the number of individual species observed does not vary greatly, fall appears to be the most active in terms of total observations.

Many of the species observed using Broad Creek were seen at all times of the year; however, some species exhibited seasonal preferences. Several species were observed only in the winter and early spring months, including the common loon, which was seen 26 times, the hooded merganser which was observed 76 times, and the American widgeon, seen 6 times. The American coot was observed four times, all during the fall season. Two species, the American bittern, seen only once, and the chimney swift, observed 18 times, were observed only in the summer months. Green herons, observed 26 times, and gull billed terns, seen 29 times, were observed in the spring, summer and fall, but not at all in the winter months. The ring-billed gull was observed 28 times, in the summer, fall and winter. The ruddy turnstone was seen 15 times, in the fall and winter.

Related to both season and time of day is temperature. Very few observations were recorded at extreme temperatures, either below 50 degrees F or above 90 degrees F (see Figure 4-14). The most wildlife, 247 observations, was observed when the temperature was between 50 and 70

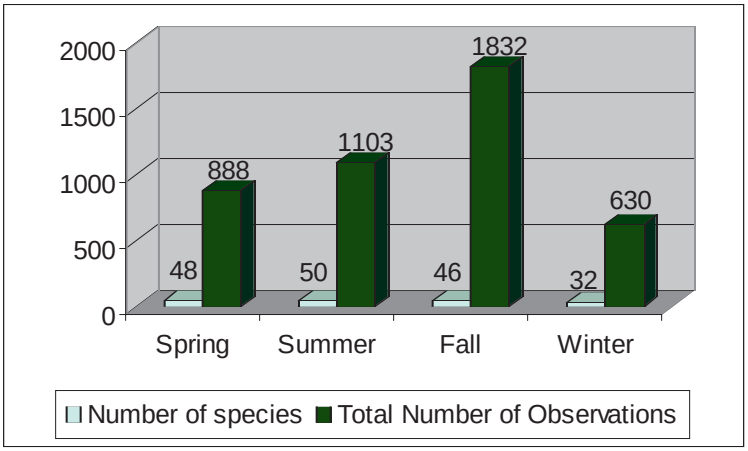


FIGURE 4-13: WILDLIFE USAGE AND SEASON

Species	High tide	Falling tide	Rising Tide	Low Tide
American coot	X			
American oystercatcher	X	X	X	
Bald eagle		X		X
Barn swallow	X	X		X
Chimney swift	X		X	X
Clapper rail	X		X	X
Common grackle	X		X	X
Common tern			X	X
Dunlin	X			
Forster's tern	X			X
Hooded merganser		X	X	X
Least sandpiper			X	X
Lesser yellowlegs		X		X
Pied-billed grebe	X		X	X
Piping plover	X			X
Ruddy turnstone		X	X	
Sandwich tern	X			X
Semi-palmated plover		X	X	X
Whimbrel			X	X
Yellow-crowned night heron	X	X		X

FIGURE 4-12: WILDLIFE SPECIES - TIDE PREFERENCES

degrees, but this was only one monitoring event, a winter afternoon. Ten monitoring trips were conducted when the temperature was between 61 and 70 degrees, with an average of 156 observations per trip. None of these trips occurred in the summer months.

Thirteen trips were conducted when the temperature was between 71 and 80 degrees. These trips, averaging 105 sightings per trip, were conducted on summer evenings and mornings, and fall afternoons. Nine trips were conducted when the temperature was between 81 and 90 degrees. These trips occurred from May through September and had an average of 109 observations.

From these results, it appears as if wildlife are active during moderate temperatures, between 50 and 80 degrees, regardless of the season or time of day.

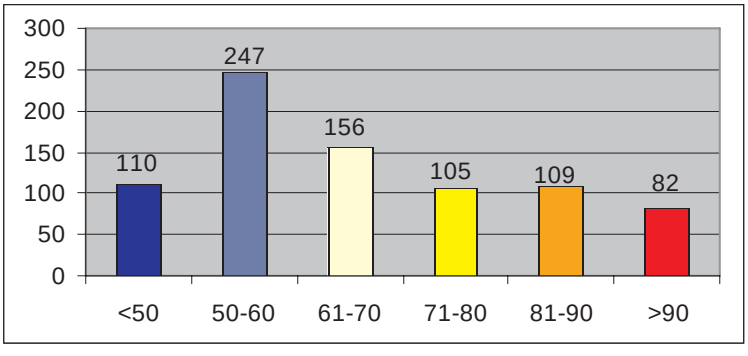


FIGURE 4-14: AVERAGE WILDLIFE OBSERVATIONS BY TEMPERATURE

Shellfish Habitat in Broad Creek

The health of Broad Creek's shellfish resource has been an important issue to Island residents for many years. Recent closures of shellfish harvesting grounds were the impetus for further investigation of Broad Creek's overall health. This management plan attempts to investigate the shellfish resource, threats to its continued vitality, and measures to reduce harvesting restrictions.

Shellfish Resources

In Broad Creek, the predominant shellfish resource is the oyster (*Crassostrea virginica*). As in the rest of South Carolina, oysters in Broad Creek are found in the intertidal zone, the area between high and low tide. Oysters spawn between May and November of each year. The larval oysters float freely until they reach an adequate substrate, preferably live oyster shells, and attach to the site. The juvenile oysters, now called spat, stay in one place and continue to grow and produce a shell. Oysters are sexually mature in less than one year, and are of harvestable size in 2 to 3 years. The life span of an oyster is up to 15 years.

Oysters feed by sucking in water and filtering out food particles. It is this "filter feeding" which makes oysters vulnerable to pollution. Bacteria and other pollutants can accumulate in oyster tissue over time. This feeding mechanism also makes oysters ideal for improving water quality. When pollutants are suspended in the water column, they are readily available and cause harm to many aquatic organisms. After passing through oysters, pollutants are either accumulated in the oyster tissue, or are passed as psuedo feces. This psuedo feces settles to the bottom, and effectively removes the pollutants from the water column (the pollutants are not gone, they are now in the silt or mud). It has been estimated that one adult oyster can filter approximately 2.5 gallons of water per hour. Multiply that by the hundreds of thousands of oysters in Broad Creek, and it is clear that oysters have a positive impact on the water quality of Broad Creek.

In addition to water quality benefits, oyster reefs provide valuable habitat areas. Reefs are habitat for blue crabs, larval and juvenile fish, white and brown shrimp, grass shrimp, snapper, flounder and sheepshead. Many bird species also use oyster reefs as feeding grounds.

FIGURE 4-15: OYSTER BED

Oyster reefs are beneficial as natural breakwaters. They protect the salt marsh, reduce bank erosion, trap silt, and reduce wave energy. However, too much wave action from boat wakes can kill oysters and result in large accumulations of dead shell, characterized by white mounds of bleached shell. In Broad Creek this is evidenced by the distinct change in oyster beds near wake zones. At the Long Cove dock in particular, the area adjacent to the wake zone is almost exclusively washed shell, whereas the area in the no wake zone has a large oyster population.

Historic Use

Oysters have been harvested and used as a food source for over 2000 years. Shell mounds from ancient cultures are found near many salt marshes on Hilton Head Island as a reminder of the importance of oysters to these civilizations.

Modern oyster harvesting dates back several hundred years. As far back as 1890, intertidal oyster beds have been mapped. The first oyster leases began in 1891. In 1893, South Carolina's first oyster cannery was opened on Daufuskie Island. Canneries operated by using iron grabs to collect oysters, which were then transported to the cannery where they were steamed and shucked. The empty shells were then usually deposited back onto the intertidal banks to serve as substrate for new oysters.

Oyster cannery production peaked in South Carolina in the 1920s and 1930s. In 1986 the last cannery in Beaufort County closed, concurrent with a large-scale oyster die off. Since that time, oyster harvesting in Broad Creek has been done primarily by hand, and in small quantities. There is currently one leaseholder with rights to harvest Broad Creek oysters. Other areas are open for public recreational oyster harvesting.

Oyster resources have been declining in South Carolina for many years. Reasons for this decline include loss of steam canneries which produced shells for regenerating reefs, declining water quality due to coastal development, and an increase in boat traffic which increases wave action, destroying oyster beds.

South Carolina DHEC estimates current commercial oyster harvest in Beaufort County is approximately 90,000 bushels each year. Estimates of recreational harvest are approximately 25-30,000 bushels per year.

As part of this management plan, the volume of live oysters in Broad Creek was estimated. All intertidal oyster beds were surveyed by the SC Department of Natural Resources (DNR) in 1981 (see Map 4-5). The methodology they used consisted of walking the oyster beds, measuring them with a meter stick, and drawing polygons on a quad map. The hand drawn maps were later digitized into GIS. The method, which used the best technology of the time, was inexact, and tended to over-estimate the size of the oyster beds.

It was apparent that the size and extent of the oyster beds in Broad Creek was much different than shown in the 1981 maps. The inaccuracies and loss of beds over time made any volume calculations from the existing maps irrelevant. To measure the change, a pilot study to re-map the oyster beds of a small portion of Broad Creek was conducted.

Three days were spent mapping the oyster beds in a small area of Broad Creek. A global positioning system was used to map the beds with great spatial accuracy.

The volume of oysters present per acre was recorded for each distinct oyster bed (based on previous DNR studies of oyster bed densities). This attribute, called strata, allows the calculation of an approximate volume of oysters in the study area. Map 4-6 shows each oyster bed by strata.

This pilot study was an attempt to determine how great the change in the oyster beds has been since 1981, and to provide an estimate of the resources required to entirely re-map Broad Creek's shellfish resources.

The differences between the locations of the oyster beds mapped in 1981 and 2001 are shown in Map 4-7.

Because of the inaccuracies of the original map, it is difficult to quantify how much of the difference in the data is due to changes in the oyster population over time, and how much is due to spatial differences from the mapping techniques. The 1981 map shows 2.38 acres of intertidal oyster beds in the study area. The 2001 data show only 0.68 acres, a reduction of 1.7 acres. Even assuming an overestimation in 1981, the apparent loss of oyster beds in the study area is large.

FIGURE 4-16: MAPPING OYSTER BEDS

In order to enable proper monitoring of the oyster population it is necessary to map the oyster beds along the entire length of Broad Creek. Updated mapping would establish how much the resource has been impacted since the early 1980's, when the island had about two thirds of today's existing development. Analyzing the differences between the 1981 data and new data along with land use change information might provide clues as to why the oyster resource has declined in Broad Creek. Based on the time required to map the study area, it is estimated that it would take at least 6 months of daily field work to map the oysters in the entire creek.

The comparison of bushels of live oysters is even more illustrative. In 1981 the study area was estimated to contain 12,187 bushels of live oysters. In the 2001 mapping effort, the pilot study area contains approximately 1,648 bushels of live oysters in eight different strata. See Map 4-6 for a visual representation of the density of oysters in this area, and photos of some of the strata types.

Aerial photography was also used to identify and classify oyster beds in Broad Creek. With the resolution of the aerial photography available, this method did not prove to be adequate and was dismissed. There is currently a multi-agency effort to remap all of the shellfish areas in the state. Aerial photography and other remote sensing techniques are being explored as methods for doing the mapping, and Broad Creek is one of three potential pilot areas for this effort. This is due in part to the work that has been done on Broad Creek as part of this Plan.

Current Shellfish Management

DHEC's Shellfish Sanitation Program regulates the shellfish resource in Broad Creek. Based on monthly water quality sampling at 10 sites in Broad Creek, DHEC determines whether harvesting of shellfish will be permitted. Results of the testing for the previous three years is used to determine the harvesting classifications. DHEC has established four shellfish harvesting classifications.

Approved classification is given when fecal coliform concentrations in the water column do not exceed 14 colonies per 100 milliliters, and not more than ten percent of the samples exceed 43 colonies per 100 milliliters (see Chapter 3 for a thorough explanation of fecal coliform bacteria).

Conditionally Approved classification is given when the area is subject to temporary, but predictable, conditions of pollution. In this instance harvesting is allowed under certain conditions. In Broad Creek, this means that harvesting is allowed unless rainfall exceeds 1.50 inches in a 24 hour period.

Restricted classification is given when the area is subject to increased pollution levels which may pose a health hazard. Harvest from restricted areas is allowed only for the purposes of relay to approved areas, and only under certain conditions. Relaying oysters is the practice of harvesting oysters from a restricted area and re-depositing them in approved areas for a period of time to cleanse them.

Prohibited classification is given to shellfish growing areas if there is no current monitoring data, or monitoring data shows unsafe levels of fecal coliform bacteria. All areas near marinas and dock facilities are administratively classified as prohibited.

The 2000 Shellfish Management Area 20 Annual Update lists six areas in Broad Creek which are administratively classified as Prohibited (see Map 4-8). The headwaters area of Broad Creek is restricted. The large area in the middle section of the

Creek is classified as conditionally approved (with the exception of the administrative closures). There are no shellfish areas listed as approved in Broad Creek.

Discharge of marine sewage may also have an impact on oyster beds due to the increase in fecal coliform concentrations. Currently Broad Creek is designated as a marine waste no-discharge zone which prohibits the dumping of marine waste anywhere in the creek. If this designation is removed there is a potential for increased closure of oyster harvesting areas.

Future Trends

Based on water quality results from July 2000 to the present, improvement has been made in the water quality of the area from Palmetto Bay Marina to Brams Point. In the 2001 Annual Update this area will be classified as conditionally approved, an improvement over its current restricted classification. Because fecal coliform concentrations are higher after rainfall events, this apparent improvement is likely due to the on-going drought in our area. If rainfall patterns return to normal these results could change, changing the areas available for oyster harvest.

Oyster Restoration

There is currently an initiative in Beaufort County for community oyster habitat restoration and enhancement. This program, called SCORE is jointly sponsored by the South Carolina Department of Natural Resources, NOAA Office of Habitat Restoration, NOAA Coastal Services Center, 5 Star Restoration Program, South Carolina Sea Grant Consortium, Hilton Head Foundation, Charleston Math and Science Hub, South Carolina Coastal Conservation League, and the South Carolina Aquarium. The program aims to improve the quality of the oyster resource by planting recycled oyster shells at suitable sites and allowing for natural regeneration. The program seeks to get donations of oyster shell from restaurants and resorts to put in mesh bags that can be planted at appropriate intertidal sites.

Sites will be chosen based on characteristics such as historical shellfish use, a firm bottom, 20-30 parts per thousand of salinity, easy accessibility, and low boat traffic. Planted reefs will be monitored to determine success.

This program hopes to not only improve the oyster population, but create wildlife habitat, reduce shoreline erosion, and protect adjacent salt marshes.

Implications

Monitoring efforts have provided a great deal of insight into the management requirements of Broad Creek. Broad Creek is used by a large variety of species, some in great numbers. Many species, including some that are endangered, rely on Broad Creek's ecosystem. This is a resource that needs and deserves protection. To encourage contin-

ued wildlife use, habitat must be protected and water quality must be ensured. An emphasis on the health and extent of oyster resources is necessary.

Tidal creeks and salt marshes are critical to many of South Carolina's fisheries of commercial and recreational importance. The creeks and adjacent marshes provide abundant food supply and refuge areas for juvenile fish, shrimp, and crabs. Some species that rely on estuaries such as Broad Creek include: red drum, spot, spotted sea trout, white shrimp, brown shrimp, croaker, and blue crab. These, and the juvenile fish found in oyster bed areas, provide food for birds.

Goals

The preceding sections of this chapter outline the findings of the extensive data collection efforts of this project. Study of the wildlife of Broad Creek makes it abundantly clear that Broad Creek is a thriving ecosystem and efforts to ensure its continued vitality are necessary. Protection of the wildlife is a vital link in the interconnected ecosystem; as a link to the past and to the future. The most important result of this effort is to develop goals for the continued protection of the resource.

1. *The Town should strive to increase protection of important habitat.* The protection of habitat important to the wildlife species observed on Broad Creek is critical to protecting these species. In most cases, species decline is most strongly linked to destruction of habitat. In Broad Creek there are many different habitats worth protecting: the water, the marsh, the oyster beds, and the surrounding uplands. Many of the bird species observed rely on the water column for food, spartina grass margins of the creek for food and shelter, the forested edges for food and cover, and the mud flats and oyster beds for food. These areas must be protected if we are to maintain our current wildlife abundance.

2. *The Town should strive to restore degraded systems.* Merely protecting the remaining habitat areas on Broad Creek is not sufficient to ensure the long-term ecological integrity of this system. Impacts have occurred from past development practices, but with continued diligence, future development can be less impactive. In many instances, the restoration of degraded systems can have a multitude of positive effects. Oyster bed health in particular needs to be addressed, as improving it can improve water quality, wildlife habitat, fisheries, and oyster harvest.

3. *The Town should make education of the public a priority.* In all of the Town's efforts to preserve and maintain Broad Creek as a center of wildlife activity, education of the public is key. This education effort must be targeted to creek front homeowners, island residents, daily off-island visitors, and tourists from around the country and around the world. Individuals in each of these groups make decisions every day that can potentially impact Broad Creek. The opportunity must be taken to involve them and teach them practices that can protect this vital resource.

Implementation Strategies

The goals listed above explain the need to protect the wildlife of Broad Creek. The following implementation strategies lay out the ways to achieve those goals. In many instances the implementation strategy addresses more than one goal.

Protection of Critical Habitat

To protect important habitat, the Town should continue to encourage the preservation of native plant species. It is these native plants that the wildlife population has come to rely on. The plant and wildlife species evolved together, and are in many instances dependent on one another for survival. Riverine ecosystems such as Broad Creek are interconnected; so much so that is often difficult to identify any one factor for the decline of the ecosystem. For that reason it is vital to encourage the use of species that are native to the system, and discourage the use of exotic or ornamental species. The Town has been proactive in this regard, but further action should be considered. Following are several ways to encourage the use of native vegetation for the protection of habitat:

1. *EDUCATE THE PUBLIC ABOUT, AND ENFORCE THE TOWN'S EXISTING TIDAL WETLAND BUFFER REGULATIONS.* As was discussed in Chapter 2, the Town currently requires that all development adjacent to tidal wetlands, including single family homes, maintain a vegetated buffer along the wetland. This includes all property along Broad Creek. Enforcing the existing buffer standards to the extent possible, including requiring the replanting of buffers where they have been completely removed, will go a long way to protect Broad Creek.

The Natural Resources Division has been working with Code Enforcement to identify ways to monitor buffer violations and to educate homeowners to prevent violations from occurring. A brochure on riparian buffers has been produced as part of this SAMP grant. The Town should involve property owners, architectural review boards in the various communities with creek frontage, people in the design and construction industries, and garden clubs in spreading knowledge about the importance of buffers.

2. *RESEARCH WAYS TO AMEND THE TOWN'S LMO TO PERMIT SELECTIVE PRUNING OF THE BUFFER VEGETATION TO OPEN UP VIEW WINDOWS.* Currently the Town's regulations prohibit disturbance of the native vegetation in the wetland buffer. This creates conflicts with property owners along the creek who wish to enjoy the views of the creek. Permitting limited pruning of the vegetation within the buffer will enable residents to have their views without undermining the environmental benefits of the buffer.

It should be noted that recent studies have shown that a larger buffer (up to 100 feet or more) is needed to protect riverine ecosystems. While this is likely true, much of the property along

Broad Creek is already developed, and increasing the depth of buffers is not feasible and is not recommended. In some cases there may be other methods to help increase the cleanliness of the water before it reaches the creek.

3. *ENCOURAGE THE USE OF NATIVE PLANT SPECIES IN LANDSCAPING PROJECTS.* Development projects in the Broad Creek watershed should be encouraged to use native plants in their landscape and minimize the use of ornamentals. The Design Review Board can play a role in this through their review of site plans in the early planning stages for development other than single family residences. The Design Review Board should require developers to leave the native trees and understory in the back and side buffers, and not allow detention ponds in these buffer areas. Any Town projects occurring in the Broad Creek watershed should be used as demonstration areas, and utilize all native plants. These projects should stand out as models to others.

4. *REQUIRE PRESERVATION OF LARGE TREES ON SINGLE FAMILY LOTS.* Mature trees are vital to the continued existence of many wildlife species that use Broad Creek. Currently, the Town's tree protection ordinance regulates trees on common property and open space in single family subdivisions, and on all multi-family and non-residential projects. The Town should consider amending the LMO to require preservation of specimen trees on single family lots. This would ensure that large trees are saved, or are mitigated, on all property within the Town. The LMO amendment would require a specific definition of the species and size requirements for specimen trees.

5. *THE TOWN SHOULD ENCOURAGE PROPERTY OWNERS TO PRESERVE LARGE, MATURE TREES ON SINGLE FAMILY LOTS TO PROVIDE IMPORTANT HABITAT.* Trees not only provide food and cover for wildlife, but they add aesthetic beauty and increase property values. Involvement of the Natural Resources Division during the building permit process might improve communication and foster a cooperative environment with builders. Brochures outlining tree protection measures during construction are available and should be distributed to every building permit applicant. It is also important that the property owner associations be educated about the value of large trees, and be encouraged to require that these trees remain. The POAs are often the only body reviewing tree removals, and they can play an important role in preserving significant trees.

6. *RESEARCH VACANT PARCELS FOR POSSIBLE ACQUISITION FOR OPEN SPACE.* These efforts should focus on the Broad Creek corridor, but all vacant, undeveloped properties within the watershed as well as the remainder of the Town have wildlife habitat value. Any properties purchased for open space should

be managed for wildlife habitat. Priority should be given to parcels which can be part of a wildlife corridor system as discussed in the next section. The Natural Resources Element of the Comprehensive Plan supports this recommendation.

Creation of Wildlife Corridors

The Town should encourage the creation of wildlife corridors. One of the most devastating effects of development is the parceling up of land, and the fragmentation of wildlife habitat. Many wildlife species depend on more that one habitat type for their survival. Movement from one area to another is vital. As lands are fragmented, wildlife movement is severely limited. This not only increases wildlife mortality, but it increases human/wildlife interaction, sometimes resulting in conflicts such as traffic accidents and pest situations. Creating vegetated corridors that wildlife can safely use to travel from one area to another is critical. There are several ways the Town can encourage the creation of wildlife corridors:

1. *MANAGE TOWN OWNED LAND ALONG BROAD CREEK TO PROVIDE WILDLIFE CORRIDORS.* These properties are perhaps the most important first step and must be managed so that they provide linkages between parcels. The use of native vegetation to provide cover, and limiting fencing and other barriers on Town property is critical for wildlife movement. Current Town projects are being designed with this consideration.

2. *ENCOURAGE CREEK FRONT PROPERTY OWNERS TO MANAGE THEIR PROPERTY IN SUCH A WAY AS TO PROVIDE A CONTINUOUS WILDLIFE CORRIDOR.* The land along Broad Creek is a natural wildlife corridor, and is vital to the continued health of our wildlife populations. While the Town must set an example, most of the creek front property is privately owned. The Town should encourage these property owners to manage their property to provide wildlife access. This will involve educating property owners about the importance of wildlife corridors, and providing them with information on how to make best use of their property. Limiting fences and docks are important aspects of providing connectivity. The development of a backyard wildlife program would be an excellent way to encourage participation. Articles in neighborhood newsletters are another good way to reach homeowners.

3. *THE TOWN SHOULD CONTINUE TO WORK WITH UTILITY COMPANIES TO ENCOURAGE THE MANAGEMENT OF THEIR RIGHTS OF WAY AS WILDLIFE HABITAT.* The utility rights of way that criss-cross the island are perfect areas to provide wildlife corridors. These areas provide links from one end of the island to the other, but must be managed properly to provide the needed habitat. Santee Cooper has initiated a program of herbicide management that allows herbaceous cover to thrive under their transmission lines, while controlling woody species. This program allows Santee Cooper to

maintain the clearance they need to safely provide power to island residents while protecting the habitat for wildlife use. This type of program needs to be expanded to include all of the utility providers.

Oyster Restoration

The Town should encourage oyster restoration efforts in Broad Creek. Oysters are a very important feature of Broad Creek, and are at risk of further declines unless action is taken. The habitat provided by oysters is vital to many of the species observed using Broad Creek, and should be protected and restored where necessary. Birds, shrimp, and juvenile fish rely on oyster beds for habitat. These areas need to be protected. Following are some ways the Town can improve oyster resources in Broad Creek:

1. *THE TOWN SHOULD BECOME AN ACTIVE PARTICIPANT IN THE OYSTER RESTORATION EFFORTS OF SCORE.* The Town can provide assistance by providing areas for shell storage, volunteers for shell bagging, and help with determination of proper reef building sites.

2. *THE TOWN SHOULD WORK WITH SC DNR AND THE BEAUFORT COUNTY SHERIFF'S OFFICE TO IMPROVE ENFORCEMENT AND PERHAPS EXPAND NO-WAKE ZONES*. Currently there are only two areas of Broad Creek that are not designated as no-wake zones. In both of these areas the destruction of oyster reefs is apparent. Large wakes can damage reefs and kill the oysters. The establishment of the original no-wake zone designation has likely led to the improvement of oyster reefs in those areas.

The Town should examine the possibility of extending the no-wake area, particularly the small section of Broad Creek adjacent to the Long Cove dock. Perhaps more important than an increase in the no-wake areas is the enforcement of existing no-wake zones. These areas are often ignored, and boats regularly produce damaging wakes all along the creek. Local fishing and boating clubs may be willing to monitor and report wake violations to the SC DNR and/or the Sheriff's Office.

3. *THE TOWN SHOULD CONTINUE EFFORTS TO IMPROVE THE QUALITY OF WATER BEING DISCHARGED INTO BROAD CREEK THROUGH THE STORMWATER SYSTEM.* Improvement of water quality is extremely important to the health of the oyster population. See Chapter 3 for specific recommendations for water quality improvement. The Town should also ensure that water quality does not decline and further limit the areas available for harvest. In addition, the Town should examine how to provide areas where the water is cleaner for relay of oysters to increase harvest.

4. *THE TOWN SHOULD ENSURE THAT BROAD CREEK REMAINS A FEDERALLY DESIGNATED NO-DISCHARGE ZONE FOR MARINE SEWAGE.* The Town worked hard to get

Broad Creek approved as a no-discharge area, a designation which is crucial to ensuring that the quality of Broad Creek's water is not compromised. The Town's Municipal Code should be amended to include the no-discharge designation.

5. *THE TOWN SHOULD PURSUE MAPPING THE OYSTER RESOURCES ALONG THE ENTIRE LENGTH OF BROAD CREEK.* The Town should search for grant money to fund the effort. The pilot study indicated that two people would be needed for at least 6 months to complete the mapping. The Town should share all data with SC DNR, and perhaps investigate partnering with them to complete the mapping. The project should also investigate other methods of mapping oysters, including remote sensing alternatives. The results of mapping the oyster beds in the entire creek would be helpful in evaluating the long-term change in oyster resources, as well as serve as a way of being alerted to any future declines, and serving as a way to identify and monitor oyster restoration sites.

Public Education

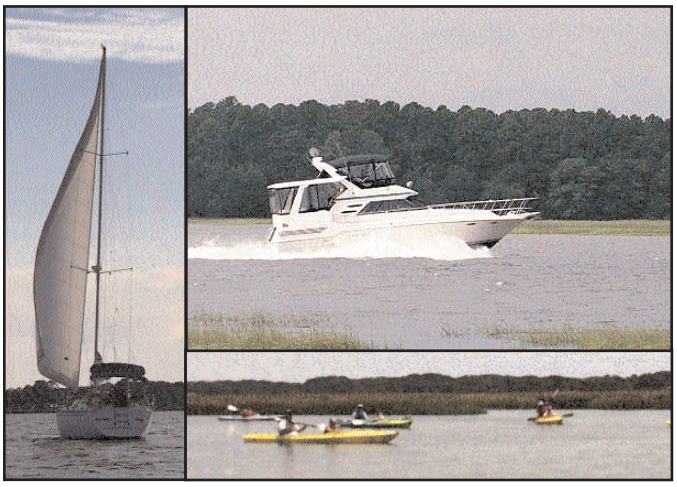
The Town should increase educational opportunities relating to Broad Creek**.** No effort by a governmental body can produce optimal results without the cooperation of the community. Only through education can citizens and visitors become aware of this tremendous resource, and of their role in protecting it. The Town should take the responsibility to educate people and increase the opportunity of citizens and visitors to learn about the wildlife on Broad Creek.

1. *EDUCATE THE PUBLIC ABOUT WILDLIFE AND SHELLFISH RESOURCES ON BROAD CREEK.* As part of this SAMP grant, brochures were produced on protecting the wildlife on Broad Creek, preserving the shellfish resources on Broad Creek, and the importance of obeying the no-wake zones and no-discharge designation of Broad Creek. These and other brochures will provide a needed link between the Town and our community.

2. *THE TOWN SHOULD CONTINUE TO LOOK FOR WAYS TO INCREASE PUBLIC ACCESS TO BROAD CREEK.* One of the best ways to educate the public about a resource is to get the public to the resource. Access to Broad Creek should be provided in a variety of ways. The Town should ensure that public property along the Creek is available for wildlife viewing and interpretation. Current Town projects are being designed with this in mind. See Chapter 5 for a more thorough discussion.

3. *THE TOWN SHOULD PROVIDE EDUCATIONAL OPPORTUNITIES FOR SCHOOL CHILDREN TO DISCOVER THE WILDLIFE OF BROAD CREEK.* Hilton Head Island is blessed with knowledgeable and interested residents. This interest extends to the children of the island, who are eager to learn about their environment.

The Town must make every effort to involve children of all ages in learning about Broad Creek. Field trips and classroom exercises are great ways to encourage exploration and empower the next generation to care for our resources.



CHAPTER 5
RECREATION AND BOATING MANAGEMENT

Broad Creek is a beautiful resource which should be available for all to enjoy. The majority of recreation on the creek is boating, partly because there are few public properties where people can enjoy the creek, so the only way to enjoy it is to get in a boat and get out on it. Some of the Town land along Broad Creek should be developed for additional recreational uses.

Recreational use of Broad Creek is very important to the residents of Hilton Head Island and its many visitors. This chapter discusses access to the creek, which is provided by marinas, landings and docks. There is also be a discussion about the no-wake and no-discharge zones on Broad Creek. The effects of powerboats and personal watercraft (PWC) on the environment is reviewed and includes a discussion on the pros and cons of PWC use on the creek. Various boating safety courses that are available in South Carolina were researched, a listing and description of these courses is provided. A series of water and land based surveys were conducted to determine recreational use of the creek. The results of these surveys is provided in this chapter. The chapter concludes with the goals and implementation strategies that have been developed as a result of the information collected on the recreational use of Broad Creek.

Access To The Creek

Broad Creek runs 8.1 miles through the heart of Hilton Head Island. Public access to the creek is extremely limited, with the majority of the shoreline being in private ownership. There are several marinas that provide access to the creek to those who dock their boats at them for a fee as well as to visitors who pay to go on tours of the creek. Currently there is only one free public access point on the creek, the Beaufort County boat landing on Marshland Road. This section describes these access opportunities.

Marinas and Docks

Currently there are three public and two private marinas that provide access to the creek. The public marinas are Shelter Cove Marina, Broad Creek Marina, and Palmetto Bay Marina. The private marinas are the community docks at Long Cove Club and the marina and private docks in Wexford Harbour. The services provided by each marina and the number of slips that are available for docking is described in Appendix P.

FIG. 5-1: MOORED BOATS

In addition to the five marinas, there are also some moorings located to the west of Palmetto Bay marina near the southern shore of the creek (see Figure 5-1) which provide an approved area for transient boaters to drop anchor.

Access to the creek is also provided to some residents through the many private docks that line the shores of Broad Creek. Currently there are over 500 docks located on the creek. The following paragraphs will describe the current situation on docks and evaluate the impact of docks on wildlife and on the recreational use of the creek. Appendix Q provides additional

detailed information on the mapping of the docks.

Dock construction is permitted by the Office of Ocean and Coastal Resource Management (OCRM), a section of SC DHEC. The regulations pertaining to docks are general and most docks applied for are permitted. There are no regulations on materials used, but there are regulations on the size of the structures and the construction of roofs. There are also regulations on storage facilities built or placed on docks. The Town has no jurisdiction on the construction of docks.

In order to fully understand the impact of docks on Broad Creek, an up-to-date map and database were created showing every dock on the creek. This database includes the location of the dock structure, the number of slips and boatlifts, and the time period the dock was built. The result is a very accurate picture of what the dock situation is on Broad Creek. The number of slips is important for estimating the maximum number of boats that can be docked on the creek at any given time. The map gives an accurate picture of dock location and length, allowing assessment of their impact on the wildlife and on recreation.

Altogether there are 522 docks on Broad Creek, including 220 in Wexford Harbour. Of those 522, 73% (383 docks) were built prior to 1995. Figure 5-2 shows a typical older dock. Of the total 522 docks, 108, or 21%, were built between 1995 and 1998. Only 3 docks were constructed in 1999, 17 in 2000, and 11 in 2001 (through July). Many of the docks in the "pre-1995" category are estimated to be 30 to 40 years old. Some are in such a state of disrepair that they do not appear to be safe.

FIGURE 5-2: TYPICAL OLDER DOCK

There are over 1,000 slips included in the 522 docks on the creek. While a number of these are in the marinas, many are not. Most docks (43%) have 2 slips, while 33% have only 1 slip. There are 25 docks that do not have slips, they are likely used for fishing or just sitting on to enjoy the water. A total of 60 docks have either 3 or 4 slips. The remaining 38 docks have 5 or more slips. Most of these are in the five marinas.

Only 48 docks (9%) on Broad Creek have a boat lift (see Figure 5-3). Of those, 7 have two lifts at the dock. Conversely, 91% of the docks on the creek do not have a lift. Boat lifts are used to elevate the boat above the water, which, if suspended correctly, can help reduce the amount of maintenance needed on the boat. Another reason people use boat lifts is to eliminate the damaging effects of wave action on a boat tied to a dock.

FIG. 5-3: BOAT LIFT

Map 5-1 shows the docks on the entire length of Broad Creek. Not including the marinas, there are only 9 docks in the headwaters, 178 in the middle sector of the creek, and 146 in the mouth sector. Of the 178 in the middle sector, 136 of those are private docks at individual home sites in Wexford Harbour, and 42 are docks out on the main channel of the creek. There are 210 docks altogether in the five marinas (including the docks at the Wexford marina). More detailed maps of the docks on the creek are in Appendix R.

The problems encountered when there are a large number of docks in a small area include damage to boats from passing boat wakes, alteration of the wildlife patterns from the presence of the docks (both in the water and along the shore) and changes in the aquatic environment. While one might think that the chemical compounds used to treat wooden piles would have a detrimental impact on the water quality, a study has shown there is essentially no impact on marine life (Wendt, 1995).

The presence of docks, particularly in areas where there are many lining the shore, can hamper the movement of animals (Figure 5-4). Dolphins, for example, must swim further out in the channel where they are more likely to encounter boats. Dolphins are also impacted by the elimination of these shorelines from their feeding grounds – one way which they feed is called “strand feeding”, where they chase fish up into the shallow water right at the shoreline. This is not possible along

FIGURE 5-4: DOCKS IN SEA PINES

shorelines with many docks. Deer who are grazing along the shoreline cannot do so as easily in areas where there are many docks.

Docks may have beneficial effects for wildlife, many birds perch on docks and railings to rest or look for food in the water below. Docks provide shelter for aquatic animals, including the manatee. In some coastal areas, shellfish restoration programs utilize private docks for growing new oysters, since they are easily accessible and the dock owner can keep a close watch on the growing oysters (The Washington Post Metro, in an article on Chesapeake Bay oyster restoration).

The visual experience along the creek will continue to change as the vacant lots along the shoreline are developed. Most of these are single family lots, and many of them will probably build a dock along with a house. One method to limit the number of docks is to allow one community dock for new subdivisions and not permit individual docks at each single family lot. This was done in the Broad Pointe subdivision. New docks should be discouraged in areas where there is a large salt marsh between the lot and the creek, since long

docks crossing the marsh have a negative impact on it during construction, primarily due to destruction of the marsh itself.

The material which docks are made from was examined. Most docks on Broad Creek are wooden, and blend in well with the natural environment from a distance. There have recently been several docks built of metal, which do not blend in with nature. While the majority of docks were in good repair and kept clean, there were some which were in disrepair and/or were cluttered with belongings. These conditions contribute to the degradation of the visual experience on the creek, and may be in violation of SC DHEC regulations (Section 30-12), which limit the amount of storage and specifies that storage be in a bench like locker.

An additional factor in the aesthetic issue of docks is their size. Most docks on Broad Creek are modest in size, built just to provide access to the creek. Some docks, however, are quite large, with sitting areas out over the water, some with roofs. It appears that the more recent docks are larger than the older docks. These large docks detract from the beauty of the natural environment. They can also disturb the natural vegetation on the bank of the creek, which could lead to increased erosion.

It can be seen from the preceding that a few areas of Broad Creek have a significant number of docks, and that has an impact on the natural environment, the wildlife, and on the recreational use of the creek. Steps should be taken to limit the number of new docks to be built as well as their size in other areas of the creek, especially where significant impact to the environment would result from long marsh crossings (such as the headwaters). The natural beauty of the creek will continue to be impacted as the number of docks continues to rise, especially if more are constructed from metal materials rather than wood.

Public Landings

Public landings on the creek are important because they provide a place to launch boats. They also can be used by residents and visitors for fishing. There is currently one public boat landing on Broad Creek. It is the Beaufort County landing on Marshland Road, to the east of the Old Oyster Factory in the headwaters of the creek. See Figure 5-5. Since it is located in the headwaters, this landing is of limited use during low tide because the water is shallow (approximately 2 feet deep in the

FIGURE 5-5: BEAUFORT COUNTY BOAT LANDING

deepest part of the channel during low tide).

This landing and the condition of the ramp are not ideal for powerboat launching. The ramp has a sudden drop-off at the end which trailers are subject to falling off of while launching at lower tide levels. It is very difficult to launch power boats from this ramp at low tide, most boaters don't try to do so unless the tide is at least mid level. In addition, only small boats are launched here due to the shallow water in the oxbow channel. Vehicles have been observed stuck in the mud at this ramp during low tide. Occasionally the *Cool Stuff* tour bus/boat, which is an amphibious vehicle, enters the creek here (Figure 5-6).

FIG 5-6: COOL STUFF TOUR VEHICLE

Due to the location of this landing and the condition of the ramp, the primary activity here is kayak launching – several local eco-tour businesses launch from this location. These tours run throughout the day and into the evening, daily through the summer months and quite often during the rest of the year as well. Tide level is not an issue for them, as the boats are simply carried to the water's edge for launching. The kayaks are transported to and from the landing on trailers, and are stored in off site locations.

The headwaters are currently heavily used by kayakers, partly because the only place for most of them to launch is at this County landing. The guided trips are typically 1 to 2 hours long, and most kayakers cannot go very far in that time span. If other kayak launch sites were available along the creek, more of it could be utilized by these tours as well as by individuals. Such launching facilities could be simply a trail or short boardwalk to the water's edge, and would not necessarily have to be accessible at all tides.

Visitors and residents of the Island also use this landing for cast netting and crabbing. People have been observed swimming at this location, although swimming in Broad Creek is rare.

As was discussed in Chapter 4, there are some areas of Broad Creek that are now open to the public for oyster harvesting during certain conditions. The SC DHEC monitors the conditions and makes decisions periodically on whether the beds are open or closed. This information needs to be available to the public. One good way to do that would be to install an information kiosk, or covered sign, at this landing to provide a place for posting of public notices regarding the status of shellfish bed openings and closings. Other information useful to the general public could also be posted. Interpretive signage on the ecosystem and wildlife on the creek should also be installed here.

The landing is maintained by the Beaufort County Public Works Department, and is kept clean with the help of Southern Exposure Adventure Kayaking, who has adopted the landing in SC DNR's "adopt a landing" program. This program is designed to have various organizations clean litter from public boat landings all over the State several times a year, similar to the "adopt a highway" program. There are no picnic tables or benches available at the landing, although picnicking is a permitted activity at the site. There are also no bathroom facilities at this landing.

While it is not located on Broad Creek, many boaters in this area use the Pinckney Island boat landing for access to the area waterways, including Broad Creek. This landing has better facilities for launching larger boats. If Broad Creek had better public launching facilities, boaters headed for the creek would not have to make the 4½ mile trip from the Pinckney boat landing to Broad Creek just south of Brams Point in Spanish Wells.

The County is currently obtaining permits to construct a new public boat landing just to the west of and underneath the Cross Island bridge. This landing will have paved access and gravel parking, with space for 12 cars and 46 vehicles with trailers. The ramp will be 300 feet long including the approach, and will be useable at all tide levels. This boat landing is expected to be heavily used, as it will not have the limitations of the Marshland Road landing, and it will result in a shorter trip for boats going out to the Sound or the Atlantic Ocean for the day. A drawing of this boat ramp is shown in Figure 5-7.

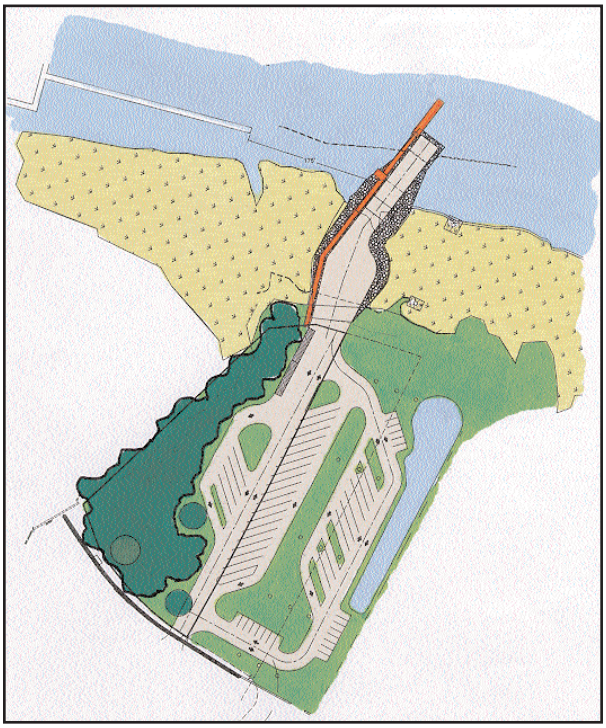


FIGURE 5-7: NEW COUNTY BOAT LANDING

The Impact of Recreation on the Environment

No Wake Zones on Broad Creek

Prior to development on Hilton Head Island, Broad Creek and all of the other waterways in the area were open to boating of any type and at any speed. It was up to the good sense of the pilot of the boat to slow down when appropriate. As development increased along the shore and boating increased on the creek, problems began to arise from boat wakes. The following paragraphs discuss the impact of boat wakes and the no-wake zone that

was established on Broad Creek. A more detailed discussion of how the no-wake zone was created is in Appendix R.

A study of Bohicket Creek near the Edisto River in South Carolina concluded that wakes can have a devastating effect on fragile marine creatures and plants (The Island Packet, 1998). When concentrated, sediments churned up by swift-moving boats can clog the gills of young fish, retard egg development, smother oysters and reduce the production of organic substances such as plankton. Shrimp and shellfish larvae are particularly sensitive to sediment levels. Sediment contains the grease, oil, cleaners, gasoline and waste discharged by boats that settle to the bottom of a creek. Healthy plants and animals living on creek bottoms are essential to the estuarine food chain. The productivity of fish and crab populations is directly related to the health of these organisms. In addition, heavy wakes cause erosion of salt marshes and shorefront properties, and also cause floating docks to bounce which can damage the boats tied to them.

Wakes cause marsh and upland erosion and can affect docks. The degree of erosion depends on the size of the boats creating the wakes. Another study done on Bohicket Creek over a 17 day period of heavy boating found that one foot of salt marsh was eroded from two study sites between a recreational marina and the ocean. A site just upstream from the marina that has little boat traffic experienced no erosion during the same 17 days.

Most South Carolina tidal creeks are susceptible to wake damage when large boats travel within 600' of the shoreline. The width of Broad Creek is between 500' and 800' in most areas, and is 1200' wide in only one short stretch in the mouth. Wakes from smaller boats (16-18' long) may do little damage compared with wakes from large boats. Research shows that 1' to 2' breakers rarely occur along the edges of tidal creeks under natural conditions, yet such waves are constant in areas of high boat traffic.

Although smaller boats cause less of a wake than larger boats going the same speed, the amount of damage caused by the wakes depends on the width of the channel. In a wider channel, the waves created by wakes have a greater distance to dissipate before they reach the shoreline. In a narrow channel, the waves often crash directly into the shoreline, causing erosion (see Figure 5-8).

As a result of this information, the Town passed a resolution in 1996 to make all Island waters no-wake zones, and on May

FIGURE 5-8: BANK EROSION

14, 1998, the SC House passed a bill establishing the no-wake zone on Broad Creek. The details of the process the Town went through to accomplish this is provided in Appendix R. The rationale in creating the no-wake zone was to protect the environment within and along the creek.

The Town originally wanted the entire creek designated no-wake, but reached a compromise with area fisherman and water sport business owners who believed the no-wake designation for the entire Creek would hurt their businesses. Thus, the entire creek except for a two mile stretch from the Cross Island Bridge to the number 19 green navigational marker (ATON), which is at the entrance to Shelter Cove Marina, was designated a no-wake zone. However, SC boating regulations require boats to travel at idle speeds when passing within 50' of docks, so the areas adjacent to the docks at Long Cove Club, River Club, Otter Hole and the Broad Creek Marina are also designated no-wake zones. These no-wake zones are shown in greater detail on Map 5-2.

The no-wake zones are posted with signs (Figure 5-9) and buoys by the SC Department of Natural Resources (DNR) and are enforced by the DNR and the Beaufort County Sheriff's Office. The Town funded the purchase of two boats for the Sheriff's Office for the primary purpose of enforcing these zones.

FIGURE 5-9: SIGN

Nonetheless, many boats violate the no-wake zones. The public needs to be made aware of the damage that wakes cause to docks, other boats, the shoreline, and oyster beds. Only increased enforcement and education will stop boaters from violating the designated no-wake zones.

Damage Caused by Boats and Personal Watercraft

Boating in inappropriate areas can harm plants and wildlife. Vessels often injure plant structures either when the boat hull strikes the sediment bed and destroys the root system or when the propeller slashes through leaf blades. These activities can cause significant damage to aquatic vegetation environments.

Recreational boating can impact marine fish and invertebrate species during the critical life stages of these species, which typically occur during peak boating seasons. Outboard motors generate engine wash that can damage eggs and larvae while the rotational forces of passing vessels churn up sediment that smothers or destroys organisms. Marine engine emissions are also a factor in egg mortality and larval settlement rates (Newcombe, 1991). These emissions are toxic and can cause cell mutations and a disruption in bodily functions such as growth and reproduction. In recent years, researchers have been conducting studies to examine the ecological impacts of recre-

ational boating on marine fish species. They are investigating whether or not boating traffic and noise disrupts foraging, migrating and schooling behavior or if it alters the predator/prey relationship.

A personal watercraft (PWC) is a small one or two-person vessel that uses a jet propulsion system instead of the spinning propeller that is found on most boat engines. As small, quick boats, PWCs are designed to be fast and agile. They are marketed as fun recreational vehicles to be used in relatively small areas as opposed to boats which are meant to travel greater distances. Most of the PWC users observed on Broad Creek were young and obviously looking for a fast, exciting ride. See Figure 5-10.

The design of PWCs gives them easy access at high speeds to shallow waters where wildlife is nesting. There is also evidence that marine mammals may be at risk around PWCs. These mammals are subject to collisions with personal watercraft because the sound waves emitted from the PWC lack the low-frequency components necessary to carry them through the water. Marine mammals use sound waves as an indicator to swim to another location. The operation of a PWC is often unpredictable and prolonged, constantly leaving and reentering the water, which prevents marine mammals from finding safe escape routes or breathing spots. The use of PWCs has also been proven to interfere with the feeding and migratory habits of various cetaceans, including bottlenose dolphins, which frequent Broad Creek.

FIGURE 5-10: A PWC IN USE

The use of PWCs on Broad Creek is a controversial subject within the Town. The marinas and those that use them are in favor of the continued use on the creek. Many people concerned with the noise and pollution caused by these vessels would prefer to see them banned. Personal watercraft-related noises are often intensified by the repetitive smacking of the hull against the water and the tendency of personal watercraft operators to circle about the same area continuously.

Personal watercraft also have several characteristics that make them more difficult to control than other vessels, particularly for young or inexperienced riders. Personal watercraft can accelerate very quickly (up to 65 mph). They also have the ability to turn rapidly and weave through congested areas. Changing direction on a PWC is only possible if the engine is receiving sufficient power. However, PWCs do not have brakes and clutches

which allow them to slow down or reverse their direction. The only way that an operator can stop a personal watercraft is to let up the throttle and coast to slow down.

Generally, PWC operators going at high speeds have less time to react to obstacles such as boats, people or other PWCs. Likewise, other boaters may not have sufficient reaction time when approached by a PWC travelling at high speed. They are less stable than other vessels and often capsize if the rider falls off. The three factors given for the majority of personal watercraft accidents are: inattention, inexperience and inappropriate speed (NTSB, 1998). These factors generally result from a lack of operator training and experience. As of 1998, personal watercraft accounted for 40% of the accidents on South Carolina waterways while comprising only 25% of the boats on the water (NTSB, 1998).

Most boaters use the creek as a "road" to get to the Sound. By tabulating the number of slips at Shelter Cove, Long Cove, Broad Creek and Wexford Marinas as well as those at individual docks along the headwaters and middle sections of the creek, it is possible that up to 736 boats may pass through the area between Broad Creek Marina and the Cross Island Bridge in a single day. This area is not designated as a no-wake zone and therefore boats traveling through this section of the creek are often moving at high speed.

This area is also where PWCs from Broad Creek Marina are used. They were frequently observed jumping the wakes of passing vessels. Although jumping wakes is not prohibited by State Code, it is illegal to jump the wake of a vessel that is very close to the PWC. Boaters often blew their horns at the PWC drivers as a warning to keep a safe distance between the two vessels. People who rent PWCs are given a short lesson on how to power and steer the watercraft and then are sent out to play. This lack of training combined with the unsafe behaviors observed indicate that stricter training should be required for PWC renters and guides. In addition, increased enforcement of boating regulations should help to ensure the safety of the boating public.

No Discharge Designation

Prior to May of 2000, it was illegal to discharge untreated sewage from vessels within Broad Creek, but treated sewage could be discharged into the creek. While some recreational boats have on-board restroom facilities, those that do not are required to have an approved marine sanitation device (MSD). There are two types of MSD: a holding tank designed to be pumped out but which can be discharged directly into the water, or a smaller tank that chemically treats the waste before discharging it to the water.

Studies by the Environmental Protection Agency (EPA) indicate that poorly flushing tidal creeks that host substantial boating activity, like Broad Creek, are particularly sensitive to the cumulative effect of boats releasing untreated, or poorly treated,

human waste into the water. The untreated discharge from one boat on one weekend puts the same amount of bacterial pollution into the water as does the sewage from 10,000 people whose waste has passed through a wastewater treatment system.

Nutrients, microorganisms, and chemicals contained in human waste discharged from boats have an adverse impact on aquatic species, particularly in areas not naturally flushed by tide or current. The headwaters of Broad Creek do not flush well; a 1999 study indicated it took more than two days to flush all the water in the headwaters.

As a result of those studies, the Town began the process to have Broad Creek designated a no discharge zone (NDZ) in March of 1997. On May 26, 2000 the EPA officially designated Broad Creek a no discharge zone. This means that it is illegal to release any boat waste to the creek, treated or otherwise.

Boaters can dispose of sewage at pump-out stations available at all of the marinas on Broad Creek with the exception of Broad Creek Marina. Pump-out stations take waste from holding tanks on boats and pump it into the public sewer system or store it until it can be taken to a sewage treatment plant. These facilities must be adequate to handle all wastewater generated on boats at the marina. A standardized sign has been designed by SC DNR to help boaters recognize which marinas are equipped with a pump-out station.

The marina operators of Shelter Cove, Long Cove, Wexford Harbor and Palmetto Bay Marinas all reported an increase in the use of these pump-out stations after the creek was designated a no discharge zone. Each said that public education is the best way to ensure that all boat owners comply with the no discharge regulations.

Boating and Personal Watercraft Regulations In South Carolina

South Carolina, which ranks 9th in the number of registered boats in the United States, developed its boating regulations to ensure that travel on the state's waterways is safe. These rules and regulations were adopted as part of the Boating Safety Act of 1996 and are enforced by the SC Department of Natural Resources (SC DNR). Section 50-21-870(6) of the State Code states that vessels may not be operated in excess of idle speed within 50 feet of an anchored vessel, wharf, pier, dock or a person in the water.

All vessels are required to have the following equipment on board: personal flotation devices (PFDs) for each person on board or being towed, a fire extinguisher, navigation lights, flares, and an efficient sound producing device such as a bell or a whistle. All motorized boats must be registered and have a validation decal affixed to both sides of the boat. No vessel shall be operated in a reckless or negligent manner. Examples of this type of operation include but are not limited to the following: excessive speed in congested areas, operation

of a personal watercraft which endangers life or property, and operating under the influence of drugs or alcohol.

In South Carolina the regulations for personal watercraft are also enforced by DNR. Each person on a personal watercraft must wear a U.S. Coast Guard approved personal flotation device. All PWCs must be equipped with either a self-circling or lanyard-type engine cutoff switch. A personal watercraft may not be operated between sunset and sunrise.

State Code Section 50-21-870 (9) also states that "no person may operate while upon the waters of the State a personal watercraft, specialty propcraft, or vessel in a manner which unreasonably or unnecessarily endangers life, limb, or property including, but not limited to, weaving through congested vessel traffic, jumping the wake of another vessel unreasonably or unnecessarily close to the other vessel or when visibility around the other vessel is obstructed, and swerving at the last possible moment to avoid collision."

In 1996, the Town proposed stricter regulations on PWCs due to environmental, safety and aesthetic factors. The proposal would have limited engine size, and required idle speed within 200 feet of the shore, another boat, a dock or a person. Only licensed drivers would have been allowed to operate a PWC. The state denied the proposal since state law addresses most of these provisions.

A number of boater safety courses and programs are offered throughout South Carolina by the following organizations: SC DNR, United States Power Squadrons (USPS) and the local United States Coast Guard Auxiliary. Appendix S provides more information about the courses and programs offered by these groups.

There are numerous opportunities for both residents and visitors to learn more about boating safety. A brochure on boating safety and specific issues for boaters to be aware of in Broad Creek has been prepared as part of the SAMP grant. This brochure includes information on the availability of the courses discussed above. It should be made available to all individual boat owners on Hilton Head Island, and displayed at all public marinas and landings.

Since many boaters on Broad Creek are transient, information on boating safely in Broad Creek should be made available on the internet. This should include regulations, a description of the creek including some landmarks, and information on oyster beds. A map showing the location of the main channel, with depths noted in several locations should be provided, as well as information on areas to avoid due to shallow water.

Recreational Survey

A year long recreational survey of Broad Creek was done starting in April of 2000 in order to determine how the creek is used by residents and visitors. Data was collected during 34 trips at different times of

Power Boats	*Sail Boats*	*Self Propelled Boats*	*Commercial Boats*
Small (< 20') Large (≥ 20') Single PWC Double PWC	Large Small	Single Kayak Double Kayak Skull or Shell Canoe	Fishing/Crabbing Ferry Tour Boat

FIGURE 5-11: TABLE OF VESSELS FOR RECREATIONAL SURVEY

day during all four seasons. The survey was designed to collect data on boating including the type of vessel, the tide, weather, and the particular type of day (i.e. holiday, weekday, weekend). The types of vessels were categorized as shown in Figure 5-11. Other types of recreational activity, such as fishing from the shore, was also recorded.

Surveys were conducted on both land (5 days) and water (29 days). During the land-based surveys, one surveyor would collect data from the Town-owned parcel at Yacht Cove while the other would collect data from a dock at Palmetto Bay Marina. The water-based surveys were conducted by boat and included the entire Creek.

A total of 1,603 boats were observed during the survey. Small powerboats were the types of vessel observed most often and kayaks were the second most frequently observed vessel. Figure 5-12 illustrates the frequency with which each vessel was observed.

Most recreational traffic was seen from July through September. The winter months, as expected, were the slowest on the Creek. Figure 5-13 shows the seasonal use of the creek.

Not surprisingly, July 3, 2000, in the middle of a long holiday weekend, had the most boating activity, with 136 boats observed. The weather may have had something to do with the high level of activity, it was clear, calm, and in the mid-80's. On the opposite end of the spectrum, only 3 boats were observed on May 5, 2000, another day of good weather.

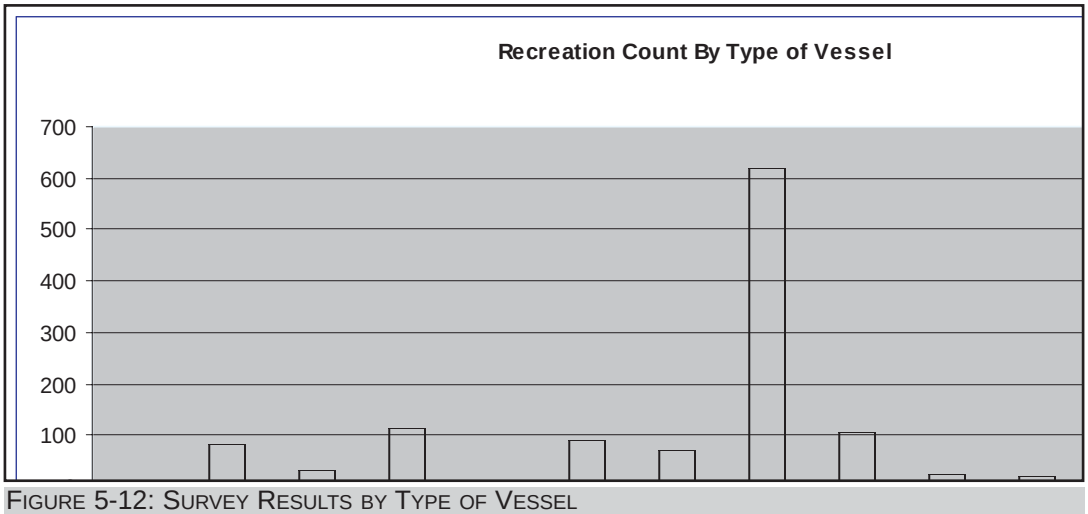


FIGURE 5-12: SURVEY RESULTS BY TYPE OF VESSEL

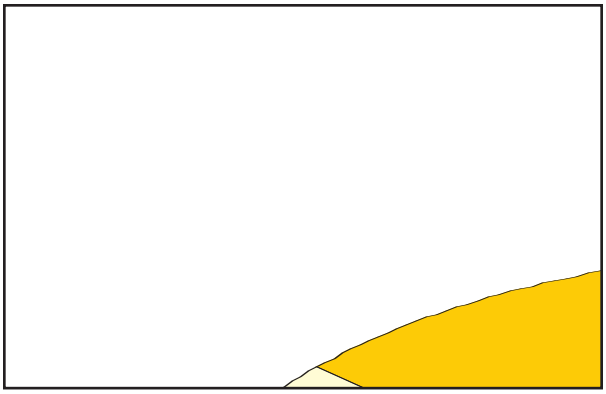


FIGURE 5-13: RESULTS BY SEASON

Surveys were conducted during all types of weather. Although most of the days were clear and calm, quite a bit of recreational traffic was observed on days that were windy, rainy and cloudy. See Figure 5-14 for a more specific breakdown of this weather data.

Motorized boats typically use the creek as a "road" to Calibogue Sound while kayaks and skulls tend to stay in the headwaters and middle areas of the creek. A total of 1,154 motorized vessels and 404 non-motorized vessels were observed on the creek during the 34 trips of the survey.

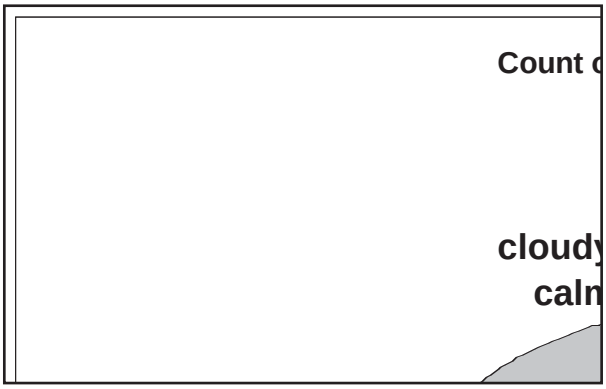


FIGURE 5-14: RESULTS BY WEATHER

Many of these were the same boats which were observed on multiple trips (such as the Haig Point ferry). Map 5-3 shows the primary recreational uses of the various areas of Broad Creek.

A description of and other pertinent information on each type of vessel observed during the course of the survey, appears in Appendix T.

Implications

As stated at the outset of this chapter, use of Broad Creek for recreation both on and near the water is very important. Currently, access to the creek for recreation – either active or passive – is quite limited, but the Town and County are working towards improving access in various ways. Boat traffic on the creek is busier during the warmer seasons, and with the possible exception of the busiest summer weekends, does not appear to be a problem.

Boating safety would improve for all creek users and damage to the environment would be reduced with increased enforcement of the no-wake zones on the creek. Water quality in the creek should be improving now with the designation of the creek as a no discharge zone for boat sewage. Finally, the recreational survey provides a baseline by which future recreation can be measured to help determine whether recreational demand on the creek is increasing and whether additional access points are needed.

Goals

The preceding sections of this chapter illustrate the recreational opportunities and use of Broad Creek. It is clear that additional recreational resources should be developed to increase public access to the creek. The following goals have been developed to ensure that Broad Creek meets the recreational needs of both residents and visitors to the island.

1. *The Town should strive to increase public access to Broad Creek.* Access is currently provided through private docks, a public landing and several marinas. Residents and visitors to the island cannot fully enjoy all of the recreational opportunities that the creek has to offer without adequate access. It is evident that the existing public boat landing is not sufficient to meet the needs of the boating public.

2. *The Town should consider ways to limit the number of docks on Broad Creek as well as ways to mitigate their appearance.* With over 200 docks along the main channel of Broad Creek, docks are an important part of the landscape and can impact the use and enjoyment of the creek by both humans and wildlife.

3. *The Town should strive to improve safety for boaters on Broad Creek.* Recreational users of Broad Creek should be safe whether they are aboard some type of vessel or not. It is very important for the boating public to understand the safety regulations to prevent accidents on the creek. With many visitors using Broad Creek who may be unfamiliar with the particulars of the creek, the potential for accidents is higher than it would be if everyone were knowledgeable about the creek. Boater safety should be a priority.

4. *The Town should strive to educate the public on recreational issues.* These include boating safety, complying with no-wake and no-discharge designations, and recreational opportunities available on the creek. This effort should be targeted to both Island residents and visitors, both of whom have an impact on the creek. Education will become more important as additional access points and parks for passive recreation along the shore become available. The public needs to know where and how they can benefit from this resource as well as how they can help to protect it.

Implementation Strategies

The goals listed above suggest improvements that are needed to enhance boating management and public access to Broad Creek. The following implementation strategies are ways that we can achieve these goals.

Access to Broad Creek

1. *IDENTIFY AND EVALUATE ADDITIONAL ACCESS POINTS FOR BOATS.* The new public landing by the Cross Island Bridge will provide much needed deep-water boat access at the south end of the island. However, more accesses may be needed. In particular, boat

launches for non-motorized vessels should be considered because they generally cause less environmental disturbance. If necessary, the Town should consider purchasing additional land for public access.

2. *THE TOWN SHOULD CONSIDER WORKING WITH BEAUFORT COUNTY TO MAKE IMPROVEMENTS TO THE PUBLIC LANDING ON MARSHLAND ROAD.* Examples include the addition of picnic tables, benches, and a restroom facility (either a permanent structure or a portable toilet). The ramp should also be improved to make it easier to launch at lower tide levels.

3. *THE TOWN SHOULD CONSIDER DEVELOPING ITS PUBLICLY OWNED LAND IN SUCH A MANNER AS TO PROVIDE PUBLIC ENJOYMENT OF THE CREEK.* This could be in the form of trails along the creek, picnic areas and benches along certain parts of the creek, boardwalks out to the creek and deep-water access points for boat launching. The Town could also consider working with non-profit rowing and kayak clubs in a public/private partnership to facilitate construction of a facility for the launching and storage of kayaks and rowing vessels.

4. *THE TOWN SHOULD CONSIDER WORKING WITH OCRM TO REVIEW THE DOCK REGULATIONS.* It may be appropriate to add specific regulations to address the concerns in tidal creeks in heavily developed areas such as Broad Creek. This could include limitations on the number of new docks, their size and material.

5. *THE TOWN SHOULD WORK WITH DEVELOPERS ALONG THE CREEK TO LIMIT THE NUMBER, SIZE, AND APPEARANCE OF DOCKS IN THEIR SUBDIVISIONS.*

6. *ENCOURAGE WATERFRONT OWNERS TO CONSTRUCT DOCKS AND BULKHEADS FROM WOOD RATHER THAN LESS NATURE BLENDING MATERIALS SUCH AS METAL, OR TO COVER METAL DOCKS WITH WOOD.* Dock owners should also be encouraged to paint or stain handrails and other parts of the dock a nature blending color.

Safety on Broad Creek

1. *ENCOURAGE BOATERS TO TAKE A SC DNR APPROVED BOATING SAFETY CLASS.* Boat operators who have taken such classes are more likely to be able to avoid accidents and they have a better understanding of how other boats are likely to react in various situations. Regulations of SC DNR require that children under age 16 who intend to operate a boat with a greater than 15 hp engine take a boating safety class. All users of PWCs should be encouraged to pass a safety course. They can then be issued a certificate or laminated photo permit that indicates that they have passed the course. These courses are available throughout the country as well as over the internet. The Town should also consider requiring PWC guides to have passed the SC DNR approved boating safety class, the US Coast Guard Auxiliary class on PWCs, and a first aid/CPR class.

2. *THE TOWN SHOULD CONSIDER WORKING WITH SC DNR TO ESTABLISHING STRICTER REGULATIONS FOR PWC USE IN BROAD CREEK TO IMPROVE SAFETY FOR ALL BOATERS.* Personal watercraft are generally used on the creek only in the area between Broad Creek Marina and the Cross Island Bridge. Groups of PWCs go out together, often with young and inexperienced operators. The riders spend most of the time driving at the maximum speed, jumping the wakes of passing vessels and making sharp turns close to other PWC riders. These actions can lead to dangerous situations for other vessels and PWC riders.

3. *THE TOWN SHOULD WORK WITH THE BEAUFORT COUNTY SHERIFF'S OFFICE AND SC DNR TO IMPROVE ENFORCEMENT OF THE NO-WAKE ZONES AND GENERAL SAFETY REGULATIONS.* The areas around Shelter Cove Marina, east of the Cross Island Bridge, and Brams Point should be specifically targeted because those are the sections where boaters were observed violating safety regulations most often. Offenders could be given a brochure explaining the importance of obeying the no-wake zones.

4. *THE TOWN SHOULD REVIEW THE PWC LOAN PROGRAM TO DETERMINE IF PARTICIPATION WOULD BENEFIT THE TOWN.* This program is run by the Personal Watercraft Industry Association (PWIA) which loans PWCs to rescue and law enforcement agencies. If appropriate, the Town should consider participating in this program to allow both the Beaufort County's Sheriff's Office and the island's Fire & Rescue Department to have more flexibility when responding to emergencies on the creek. The program could also benefit the lifeguard services on the ocean.

Public Education

1. EDUCATE THE BOATING PUBLIC ON THE HISTORY BEHIND THE NO-WAKE ZONES ON BROAD CREEK AND THE REASONS THAT IT IS IMPORTANT TO OBEY THESE DESIGNATIONS. The majority of the creek was designated as a no-wake zone to protect the environment and waterfront property. A brochure that discusses the importance of observing the no-wake zones has been produced as part of the SAMP grant.

2. *THE TOWN SHOULD CONSIDER WORKING WITH THE MARINAS AND INDIVIDUAL BOAT OWNERS ON THE ISLAND TO STRESS THE IMPORTANCE OF KEEPING THE CREEK AS FREE OF HUMAN WASTE AS POSSIBLE.* The entire creek was designated as a no-discharge zone in 2001 by the EPA to protect wildlife and plant life on the creek. Acres of shellfish beds on the creek have been closed due to high fecal coliform levels. A section of one of the brochures produced for the SAMP grant covers the no-discharge section. It informs boaters that the discharge of untreated or treated sewage is prohibited in Broad Creek. A listing of all marinas that provide pump-out stations is included. The Town should work with

marina operators to ensure that they have a SC DNR approved pump out station sign posted at an obvious location near their pump out station. The Town should also choose several locations on the creek where "No-Discharge Zone" signs can be placed, and work with SC DNR to install them.

3. *EDUCATE THE PUBLIC ABOUT RECREATIONAL OPPORTUNITIES AVAILABLE ON BROAD CREEK*. As part of the SAMP grant, the Town has developed a brochure that lists the recreational opportunities available now. These include both passive and active recreational activities, both on and off the water.

4. *EDUCATE THE PUBLIC ABOUT BOATING SAFETY AND SPECIFIC ISSUES FOR BOATERS TO BE AWARE OF IN BROAD CREEK.* A brochure on this has been prepared as part of the SAMP grant. This brochure includes information on the safety courses described in this chapter as well as information specific to Broad Creek.

5. *A BROCHURE ON PADDLING IN THE HEADWATERS SHOULD BE PRODUCED.* This should provide a map of the navigable inlets (including at what stages of the tide they are accessible) and information pertinent to safe paddling and wildlife viewing.

6. *THE TOWN SHOULD INSTALL AN INFORMATION KIOSK AT THE PUBLIC LANDING.* This kiosk would have a plexiglass enclosed bulletin board so postings of public notices regarding the status of shellfish bed openings and closings could be changed as needed. Other information useful to the general public could also be posted. Interpretive signage on the ecosystem and wildlife on the creek should also be installed here. A kiosk could be designed with a bench facing the creek and the posting area on the parking lot side of the kiosk.

7. *INFORMATION ON BOATING SAFELY IN BROAD CREEK SHOULD BE MADE AVAILABLE ON THE INTERNET.* This should include not only regulations, but a description of the creek, some landmarks, and information on oyster beds. The location of the main channel, with depths noted in several locations (in map form) should be provided, as well as advice about areas to stay out of due to shallow water. This information could be included in the Town's web site, or perhaps on existing boating related sites. A map showing the location of the main channel, with depths noted in several locations should be provided, as well as information on areas to avoid due to shallow water.

8. *THE TOWN SHOULD HELP TO EDUCATE THE PUBLIC ABOUT THE OPERATION COAST WATCH PROGRAM RUN BY SC DNR.* This program allows citizens to report marine violations to a central office at DNR, which then investigates the complaint and apprehends violators if appropriate. The program covers saltwater fishing and environmental laws.

Additional Studies

1. *THE TOWN SHOULD CONSIDER UPDATING THE DOCK MAP ON AN ANNUAL BASIS AND EXPAND THIS MAP TO INCLUDE ALL OF THE DOCKS ON THE ISLAND'S NAVIGABLE WATERWAYS.*

2. *THE TOWN SHOULD CONSIDER CONDUCTING AN ABBREVIATED RECREATIONAL SURVEY EVERY FIVE YEARS.* The data collected would be compared with the results of the survey done for this study. These surveys would allow the Town to determine changes in use of the Creek, and assess whether the implementation strategies in this Plan have been successful in meeting the goals.

CHAPTER 6
PUBLIC EDUCATION PROGRAM

An informed public is critical to any effort to protect the Broad Creek ecosystem. Public education is vital to the success of implementing the recommendations made in this Plan.

One of the most important things the Town can do to improve conditions in and on Broad Creek is to educate the public on the various issues involved. Only through education can citizens and visitors become aware of the tremendous resource that Broad Creek is, and of their role in protecting it. As discussed in each of the preceding chapters, there are various ways to accomplish this, and a number of audiences that need to be reached.

Brochures are an inexpensive, effective way of reaching a large audience. Those being produced as part of our SAMP grant include the following:

1. septic systems & the environment
2. wildlife preservation & management
3. shellfish preservation & management
4. using buffers to protect water quality
5. recreational activities available on Broad Creek
6. boating safety & tips pertaining to Broad Creek
7. no-wake zones and no-discharge designation

Other brochures will be produced as follow-up projects to this grant, and may include topics such as kayaking the headwaters of Broad Creek, proper use of fertilizers and pesticides, proper handling of pet waste, and stormwater discharge guidelines – one for the general public and another for development design professionals and contractors.

Dissemination of these brochures will depend on the topic. All brochures will be added to the public information center at Town Hall. Brochures on wildlife, shellfish, and recreation will be broadly disseminated by exhibiting them in public locations such as the Coastal Discovery Museum, local tourist information centers, marinas, and boat landings.

The brochure on septic systems will be mailed to all applicable property owners. It should also be translated into Spanish and distributed to Spanish speaking residents in areas with onsite sewage disposal systems. The brochure on vegetated buffers may be mailed to the property owners along the shoreline. The brochure on boating safety and regulations will be available at the local marinas and perhaps at boating supply stores in the area.

In addition to brochures, another way to reach the public is to hold seminars on specific subjects to target audiences. For example, a half-day seminar could be offered on how to landscape your yard with native vegetation and how to design it to reduce the impact on waterways. This could include water quality issues such as reducing the amount of chemicals used on lawns as well as wildlife habitat issues such as how to encourage wildlife to use and travel through shoreline properties. While this seminar would be open to the general public, it would be geared toward those property owners who live on or very close to the shoreline of Broad Creek as well as other creeks on Hilton Head Island.

An additional seminar topic is on drainage design issues, which would be geared toward those in the construction industry. This seminar would compliment the brochure mentioned above, and would provide ideas for alternative designs of drainage systems that would not only meet existing regulations, but would provide better filtering of the runoff. The best management practices discussed in this Plan will be described, and open discussion will be encouraged to get input from those responsible for designing building sites for development. Providing information, including potential cost savings, is important in convincing builders of the values of proper stormwater management.

Since computers are in such widespread use today, another way to provide public education is to create a CD-ROM with a self running slide show highlighting the findings of the study. This slide show would include many of the photographs taken over the course of the project, and provide short text descriptions where appropriate. This CD-ROM could be distributed free of charge, or for a nominal fee, to schools, museums, civic organizations, and other agencies or groups. The CD-ROM would be stand-alone, no additional software would be required.

The internet is another excellent method to disseminate information to the public. This will be particularly useful to the boating public, especially those who travel by boat from other parts of the country to visit Hilton Head Island. If they have access to the information in the boating safety and regulations brochure before they arrive, they will be better prepared to have a safe and successful visit while here.

Information to provide on one central web site devoted to boating on Hilton Head Island would include topics such as the no wake zones, the no discharge zones, the location of the main channel of Broad Creek, areas to avoid due to shallow water, the location, general services and phone numbers of the marinas on Broad Creek (including links to their web sites if they have them), information on tides on Broad Creek (including either a tide schedule specific to the creek or a link to a web site where it is available), and information on fishing, shellfish, and wildlife on Broad Creek.

Other information can be included on the Town's existing web site. This could include a summary of the Broad Creek plan, the information in the various brochures, and other information as applicable. Since work will continue to improve conditions on the creek, the internet can be used as one tool to make information available to the public regarding upcoming events, meetings, and projects involving the creek and the issues discussed in this plan.

Another use of the internet for public education would be to connect the Town's Broad Creek weather station to the internet. Automatic downloads of the weather data collected by the station could be made every 15 minutes, with automatic uploads to the internet. There could also

be a viewing station at the site for people to see what the current weather conditions are. This information would be useful to anyone who uses the creek, including SC DHEC shellfish managers who must monitor the rainfall to determine when shellfish beds must be closed.

One of the best ways to educate the public about a resource is to get the public to the resource. Access to Broad Creek must be provided in a variety of ways, including use of public property for wildlife viewing and interpretation as well as recreation. Information kiosks can be erected at the public boat landings, with enclosed bulletin boards where public agencies can post information on the creek and its resources. Boxes for brochures could be included in these kiosks. Also, interpretive signs can be erected at public properties to provide information on wildlife, the creek ecosystem, and how our activities impact the creek.

Another excellent educational resource available to the Town is the local schools. Educational opportunities for school children to discover the wildlife of Broad Creek should be offered to all schools. Field trips and classroom exercises are great ways to encourage exploration and empower the next generation to care for our resources. As an added benefit, many children teach their parents about interesting things they have learned at school.

The following is a summary of the public education recommendations made in the preceding chapters of this Plan.

Produce and Distribute Brochures on:

1. the use of riparian buffers to protect water quality and the scenic beauty of Broad Creek,

2. shellfish resources and management on Broad Creek,

3. wildlife on Broad Creek and endangered species awareness,

4. an overview of how an onsite sewage disposal system functions and what property owners and residents can do to prevent failures,

5. the importance of respecting no-wake and no-discharge zones on Broad Creek,

6. boating safety and specific issues for boaters to be aware of in Broad Creek,

7. recreational opportunities available on Broad Creek,

8. proper use of fertilizers and pesticides,

9. the importance of curbing pet waste,

10. the importance of not dumping harmful substances into storm drains, and

11. kayak trails in the headwaters of the creek.

Seven brochures have been produced as part of the SAMP grant, and are available at Town Hall and other locations as appropriate for the material they cover. Some will be distributed to specific audiences through direct mailings or other techniques. The last four brochures in the list above should be produced in the near future to further the education of the public on these important issues.

Interpretive and Other Signage

1. Design and install interpretive signs on how human activities impact the creek.

2. Design and install information kiosks at the public boat landings to display current information on oyster harvesting areas and conditions along with information on the creek's ecosystem.

3. Ensure that all marinas with pump-out stations have the SC DNR approved "pump-out station" sign posted at an obvious location near the station.

4. Post No-Discharge Zone signs at appropriate locations on the creek.

5. Ensure that No-Wake Zone signs are posted in all applicable areas on the creek.

Computer Programs and the Internet

1. Produce a self running CD-ROM with a slide show on the Plan.

2. Include information on the Town's web site about proper stormwater management. This should include copies of any brochure produced and links to other stormwater management sites.

3. Information on boating safely in Broad Creek should be made available on the internet.

Seminars

1. Hold seminars to educate waterfront property owners about riparian buffers.

2. Hold seminars to educate builders and developers about innovative stormwater management techniques and encourage them to implement them in their developments.

Other

1. Work with the architectural review boards from the PUDs along Broad Creek to help them understand the importance of buffering and building design considerations that impact the water quality and visual quality of the creek.

2. Encourage residents who have public sewer available but who have not yet connected to abandoned their onsite sewage disposal systems and connect to the sewer service.

3. The Town should consider working with marinas and individual boat own-

ers to help educate the public, especially boat owners, about the importance of not discharging waste into Broad Creek.

4. Increase public access to Broad Creek to encourage use and understanding of the creek and its resources.

5. Provide educational opportunities for school children to visit and learn about the creek through talks, boat trips, and science projects.

6. The Town should help to educate the public about the Operation Coast Watch program run by SC DNR. This program allows citizens to report marine violations to DNR and could help with enforcement of saltwater fishing and environmental laws on the creek and elsewhere.

CHAPTER 7
SUMMARY AND RECOMMENDATIONS

The goal of this Plan is to improve the environment and ecosystem of Broad Creek for all living creatures. This Plan should form the foundation for the improvement of the water quality, wildlife habitat and environment, and public access to Broad Creek. Much work remains to be done to implement the recommendations made in this Plan. With the cooperation of many individuals, agencies, and organizations, Broad Creek will continue to be enjoyed for generations to come.

Goals of the Broad Creek Management Plan

The 1999 Hilton Head Island Comprehensive Plan calls for Broad Creek to become a blueway. In order to implement that general goal, this Management Plan addressed the following: sustain or improve the water quality of Broad Creek; preserve the environmental quality of the creek and its wildlife; protect the aesthetic beauty of the creek, and provide better recreational opportunities and public access to the creek.

The overall goal of the Broad Creek Management Plan is to improve the environment of the creek and its ecosystem for all living creatures. To ensure the long-term ecological integrity of this system, negative impacts from past development practices should be mitigated, and new practices should be instituted which will not have such detrimental effects on the creek's ecosystem. The following goals were identified in the preceding chapters, and are summarized here.

1. Improve water quality in Broad Creek:

Manage land uses to protect the water quality of Broad Creek.

Reduce current pollutant loads entering Broad Creek through the stormwater system to improve the water quality in the creek.

Reduce and eventually eliminate to the extent possible pollution of Broad Creek from onsite sewage disposal systems.

Meet and exceed requirements for the NPDES permit. The Town of Hilton Head Island and Beaufort County should comply with all of the required elements of the NPDES program.

2. Improve the natural resources available for wildlife in and along Broad Creek:

Protect important habitat including the water, the marsh, the oyster beds, and the surrounding uplands.

Restore degraded systems. Merely protecting the remaining habitat areas on Broad Creek is not sufficient.

3. Maintain the natural beauty of the creek.

Manage land uses to preserve the natural beauty of Broad Creek and its shoreline.

Investigate ways to limit the number of docks on Broad Creek as well as ways to mitigate their appearance.

4. Improve conditions for recreational use of the creek.

Improve the accessibility of the creek to the public by creating additional access points along the creek

for recreational purposes, both boating and passive recreation on the shore.

Investigate ways to improve safety for boaters and others on the creek.

5. Educate the public about these issues.

An informed public is more likely to become involved in protecting and improving this outstanding resource.

Implementation Strategies

To implement these goals, the following recommendations have been made in this Plan. These recommendations are organized by task, and many of them address more than one of the goals listed above. Details on these implementation strageties can be found in the preceding chapters.

Regulatory – Amend the Town's Land Management Ordinance to:

1. Require more stringent stormwater management techniques to reduce non-point source pollution entering Broad Creek. This could include reducing allowable levels of impervious parking as well as stormwater system designs.

2. Encourage or require the use of innovative BMPs in place of conventional stormwater management to aid in improving the water quality of the stormwater runoff before it enters the creek. The use of more than one BMP can help to achieve a property owners development goals while complying with the environmental regulations.

3. Investigate ways to amend the wetland buffer regulations to permit selective pruning to create view windows for property owners along the shoreline.

4. Work with SC DHEC to review the densities of dwelling units in areas where onsite sewage disposal systems are the only means of sewage disposal. If appropriate, reduce the density of dwelling units in those areas to prevent pollution from system failures.

5. Require preservation of specimen trees on single family lots. Mature trees are vital to the continued existence of many wildlife species that use Broad Creek.

6. Evaluate any future rezoning proposals to determine their impact on Broad Creek.

Other Regulatory Efforts:

1. The Municipal Code of the Town of Hilton Head Island should be amended to include the no-discharge designation of Broad Creek.

2. Consider expanding no-wake zones to include the main channel

of the creek between the Long Cove community docks and Broad Creek Marina.

3. Consider requiring PWC guides to have passed the SC DNR approved boating safety class, the US Coast Guard Auxiliary class on PWCs, and a first aid/CPR class.

Improve Monitoring And Enforcement Efforts:

1. Enforce the Town's existing tidal wetland buffer regulations. Vegetated buffers adjacent to Broad Creek and other water bodies, including stormwater conveyance systems, are vital in improving the quality of water in the creek.

2. Continue to monitor the water quality of Broad Creek. The results should be used to evaluate potential problems and the success of water quality improvement efforts. Irregularities found should be reported to the appropriate authorities.

3. Work with SC DHEC to identify areas which should be closely monitored for onsite sewage disposal system failures, and provide prompt notification to them when failed systems are found.

4. Work with the Beaufort County Sheriff's Office and SC DNR to improve enforcement of the no-wake zones. Offenders should be given a copy of the No-Wake Zone brochure which explains the importance of obeying these zones.

5. Work with SC DNR and the Beaufort County Sheriff's Office to improve enforcement of general boating regulations on the creek.

Financial and Other Assistance:

1. Continue to work with HH #1 PSD to develop a master plan for extending sewer service to areas currently dependent upon onsite sewage disposal systems. Provide any assistance needed to South Island PSD in their work to complete their public sewer system.

2. Investigate and apply for grants which could be used to expand the public sewer system. Expansion of the sewer system will eliminate the use of onsite sewage disposal systems, which will prevent potential pollution from failed systems.

3. Become an active participant in the oyster restoration efforts of SCORE. The Town can provide areas for shell storage, volunteers for shell bagging, and help with determination of proper reef building sites.

4. Work with Beaufort County to make improvements to the public landing on Marshland Road, such

as adding picnic tables and a restroom facility, and improving the existing ramp.

5. Consider working with SC OCRM to review the current dock and bulkhead regulations. It may be appropriate to add specific regulations to address the concerns in tidal creeks in heavily developed areas such as Broad Creek.

Town Owned Property:

1. Design capital improvement projects as models for progressive stormwater management, making use of the latest in treatment options, and encourage their use by others.

2. Landscape Town projects in the Broad Creek watershed with native plants. These projects should be demonstration projects, serving as models to others.

3. Manage Town owned land to provide wildlife corridors. The use of native vegetation to provide cover, and limiting fencing and other barriers on Town property is critical to allow wildlife movement.

4. Research parcels for potential purchase that could benefit the Town for recreation or open space. Any properties purchased along the shoreline or within the Broad Creek watershed should be managed as parks and/or open space. This will protect wildlife habitat, increase public access to the creek, and prevent additional development which could be detrimental to the creek. An added benefit could be the reduction in dwelling units and traffic if a parcel is zoned to permit high density development.

5. Develop publicly owned land to permit wildlife viewing and interpretation as well as recreational access to the creek. Trails along the creek, picnic areas and benches, boardwalks out to the creek, and deep-water access points for boat launching are examples of how this can be accomplished. The Town could also consider working with non-profit rowing and kayak clubs in a public/private partnership to create better access to the creek for non-motorized boats.

Other Efforts Involving Citizen Participation:

1. Encourage residents who have public sewer available but have not yet connected to consider abandoning their onsite sewage disposal systems and connecting to the sewer service. This includes those residents in Sea Pines Plantation.

2. Encourage property owners to provide vegetated buffers along all receiving water bodies, particularly stormwater detention ponds, to

improve water quality before it is discharged into Broad Creek.

3. Encourage the preservation of native plant species, which our wildlife population relies on for their survival.

4. Encourage creek front property owners to manage their property to provide a continuous wildlife corridor. The land along Broad Creek is a natural wildlife corridor, and is vital to the continued health of our wildlife populations.

5. Encourage the proper management of utility company right of ways to serve as wildlife corridors.

6. Encourage the preservation of large, mature trees on single family lots to provide important wildlife habitat and soften the visual impact of buildings.

7. Encourage developers of new neighborhoods on the creek to build a community dock rather than allowing each homeowner to have an individual dock. This will help maintain the current level of visual impact as well as the impact on wildlife movement along the shore.

8. Encourage waterfront owners to construct docks and bulkheads so they will blend in as much as possible with the environment, to help preserve the beauty of the creek.

9. Encourage all boaters to take a SC DNR approved class on boating safety to improve safety conditions on the creek.

Additional Studies and Efforts:

1. Map the oyster resources along the entire length of Broad Creek. This map would provide the necessary information to evaluate the long term change in oyster resources in the creek, including any future declines. It would also help in the identification of potential oyster restoration sites.

2. Consider working with SC DNR to establish stricter regulations for PWC use on Broad Creek to improve safety for all boaters.

3. Update the dock map on an annual basis and expand the database to include docks on all the island's navigable waterways.

4. Conduct an abbreviated recreational survey every five years. This will allow the Town to determine if the recreational use of the Creek has changed, and assess whether the implementation strategies have been successful in meeting the goals.

5. Review the Personal Watercraft Industry Association (PWIA) program which loans PWCs to rescue and law enforcement agencies to

determine if participation would benefit the Town. This would allow both the Beaufort County's Sheriff's Office and the Town's Fire & Rescue Department to have more flexibility when responding to emergencies on the creek.

6. The Town should support any applicable recommendations made regarding onsite sewage disposal systems in the Small Flows report that would lead to improvement of the water quality of Broad Creek.

APPENDIX

A: Zoning
B: Impervious vs. Pervious
C: Town Owned Land Along Broad Creek
D: Other Town Owned Land
E: Stormwater Management Considerations
F: National Pollution Discharge Elimination System (NPDES)
G: Water Quality Results
H: Fecal Coliform Results
I: Correlation Matrices
J: Phosphate Results
K: Nitrogen Results
L: Dissolved Oxygen Results
M: Distance Series Results
N: Soil Suitability for Septic Systems
O: Endangered Species
P: Marinas on Broad Creek
Q: Docks on Broad Creek
R: Establishment of No-Wake Zones
S: Boating Safety Courses
T: Recreational Survey Results: Vessel Descriptions
U: References

Hilton Head Island has an Official Zoning Map with 20 zoning districts, portions of 15 of these districts are within the Broad Creek watershed.

The Island also has ten Planned Unit Developments (PUDs), eight of which are located within the Broad Creek watershed. The PD-1 zoning district consists of these PUDs. Each of these PUDs is governed by an approved master plan which identifies the specific land uses that are allowed for each parcel within each PUD.

The PUD master plan land use designations were combined with the base zoning districts. Those were combined into categories that best describe the permitted land uses in the Broad Creek watershed and corridor. For the purpose of clarity, these categories will be referred to as zoning; even though the PUD master plans do not refer to their land use designations as zoning, that is essentially what they are.

Maps A-1 and A-2 show the current zoning for the watershed and the corridor, respectively. These maps clearly illustrate the distribution of the various categories in these areas. Following is a description of each category.

Low Density Residential includes the RS-3/4/5 (Residential Detached Single Family) and the RM-4 (Low to Moderate Density Residential) zoning districts. It is the intent of the RS districts to allow, preserve, and protect the character of low density, single family areas and neighborhoods at densities ranging from two to five units per net acre (note that on Hilton Head, “net acre” is the acreage of all land areas excluding salt water wetlands). Other uses allowed by right in the RS districts include parks and short term rental units (single family structures only).

Densities in the RM-4 zoning district range from four to eight units per net acre, depending on availability of public water and sewer. The majority of these areas are not presently serviced with public sewer, and the existing development is generally low density (4 or fewer units per acre).

The *Moderate Density Residential* category includes the RM-8 zoning district, which allows the development of up to eight dwelling units per net acre. The intent is to provide a variety of residential opportunities including single family (attached and detached), multi-family residential, and manufactured housing parks.

The *High Density Residential* category is primarily within the PUDs. The highest concentration of this use within the watershed is within Palmetto Dunes. This category also includes the RM-12 (Moderate to High Density Residential) zoning district. This district allows up to twelve dwelling units per net acre. The RM-12 district in the watershed

encompasses two apartment complexes, neither of which are within the corridor area.

The *Mixed Use* category within the Broad Creek watershed consists primarily of the Community Mixed Use (CMU) zoning district located near the headwaters as well as some small areas within Sea Pines. The intent of the CMU district is to encourage flexible development in areas that are in transition. This district is primarily residential in nature; any commercial uses are designed to provide goods and services to the residents of that area. Uses allowed in this district in addition to single and multi family residential include the following either as a conditional use or by special exception: day care, parks, restaurants, offices, banks, and some retail commercial uses including supermarkets.

The *Waterfront Mixed Use* (WMU) categories are found primarily outside of the PUDs with the exception of the Harbour Town marina area, which is located inside Sea Pines. The WMU zoning districts include Shelter Cove Marina, Broad Creek Marina and adjacent properties, Palmetto Bay Marina and adjacent residential and commercial developments, and Edgewater. The intent of the WMU district is to recognize those sites in the Town that are oriented toward water and as such are conducive to water oriented commercial and residential uses. This district is designed to serve the residents of these areas as well as transient boaters and tourists. Permitted uses in this district include residential, parks, real estate offices, restaurants, a number of retail commercial uses, and resort accommodations (by condition or special exception).

The *Resort* category includes two areas within the watershed: the Pope Avenue/South Forest Beach area, and the Bradley Beach area. These are located outside of the PUDs and are comprised of the Central Forest Beach (CFB) and Resort Development (RD) zoning districts. The purpose of the CFB district is to provide for the continued development of this moderate intensity resort oriented neighborhood and infill with other compatible visitor oriented development. Multi family residential, hotels, timeshares and similar residential development designed for short-term occupancy as well as moderate commercial development is encouraged in this district. The intent of the RD zoning district is to provide for tourist resort development through the use of timeshare and multi family units as well as the limited development of motels and resort hotels. All commercial development in this district is intended to serve the transient island visitor staying in the residential resort area.

The majority of the parcels in the *Commercial* category are interspersed among different zoning districts across the island, but are concentrated along the William Hilton Parkway, Pope Avenue and Palmetto Bay Road corridors. There is a significant area of commercial zoning located along the headwaters area of the Creek. This includes both the

Commercial Center (CC) and Light Commercial (CL) zoning districts. The latter is intended to allow clusters of retail businesses that serve the daily needs of nearby residential areas. The CC district allows moderate to high intensity commercial development. This district encourages office and general retail development as well as traffic and pedestrian interconnections.

The *Office/Institutional* category is found along the William Hilton Parkway corridor. Those areas outside of the PUDs are composed of the Office and Institutional (OL and OM) zoning districts. These districts have been established between major commercial areas of the Island and are designed to limit the types of nonresidential uses permitted. The only uses permitted are office and institutional in an effort to minimize travel impacts, provide a balance among land use types in major corridors and improve the visual appearance along these major corridors. Uses allowed by right or special exception include general office uses, assisted living facilities, churches and banks.

The *Industrial* category includes few areas within either the watershed or corridor of Broad Creek. The Light Industrial (IL) zoning district makes up the bulk of this area. The purpose of this district is to provide for light industrial and service-related land uses with large buildings or outside storage requirements. Permitted uses in this district include major and minor utilities, funeral homes, furniture stores, landscape nurseries, vehicles sales and services, warehouses and manufacturing facilities. Treatment plants are allowed as a special exception in the IL zoning district.

The *Parks And Open Space* category includes golf courses, open space areas within the PUDs, and the Parks and Recreation (PR) zoning district. The intent of the PR district is to manage the types of land uses permitted on publicly held land through the establishment of areas for active or passive recreation as well as the preservation of land in its natural state for public enjoyment. Development in this district should be designed to have a minimal impact on both the environment and the community. Every golf course on the Island is located within a PUD. Over 2,100 acres are dedicated to golf course use and over 1,700 acres within the eight PUDs alone are dedicated to other forms of recreation or open space.

The distribution of these zoning categories for the Broad Creek watershed is illustrated in Figure A-1. This shows that Parks/Open Space and Low Density Residential are by far the most prevalent zoning districts in the watershed, with 35% and 30% respectively. Road right-of-ways, which technically are not a zoning district, but on which no other use can be put, comprise 11% of the watershed, a substantial number when compared to the rest of the permitted uses.

High Density Residential and Commercial districts each comprise 6% of the watershed. Following that is Moderate Density Residential, Resort, and Office/Institutional districts, with 3% each. Finally, Mixed Use, Waterfront Mixed Use, and Industrial districts each comprise 1% of the watershed.

Similarly, the distribution of zoning districts in the corridor of Broad Creek is illustrated in Figure A-2. Again, Low Density Residential and Parks/Open Space are the two largest categories, at 38% and 27% respectively. It is interesting to note that in both the watershed and the corridor, these two districts together contain 65% of the total land area.

The remaining zoning districts follow a similar pattern to that found in the watershed, with a few shifts. Table A-1 lists the details for this data.

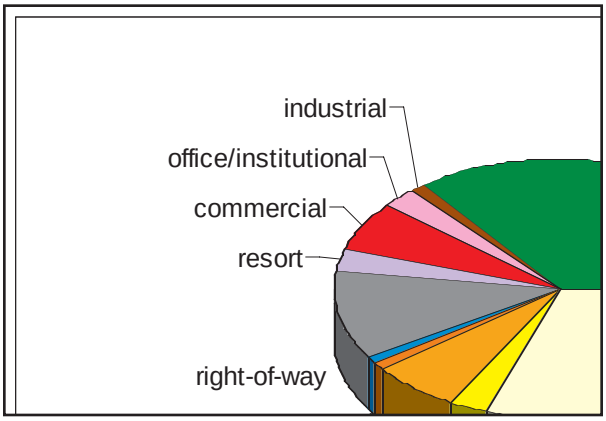


FIGURE A-1: ZONING IN THE WATERSHED

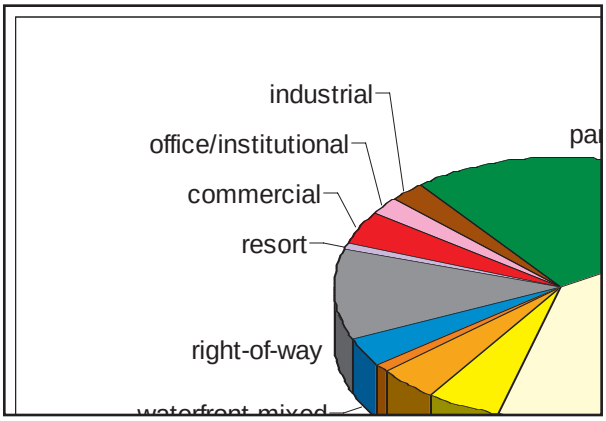


FIGURE A-2: ZONING IN THE CORRIDOR

	WATERSHED		CORRIDOR	
Permitted Use	*Acres*	*% of Total*	*Acres*	*% of Total*
Low Density Residential	3,660	30.1	1,335	37.7
Moderate Density Residential	342	2.8	192	5.4
High Density Residential	779	6.4	145	4.1
Mixed Use	93	0.8	35	1.0
Waterfront Mixed Use	119	1.0	136	3.8
Resort	356	2.9	24	0.7
Commercial	732	6.0	149	4.2
Office/Institutional	309	2.5	80	2.2
Industrial	142	1.2	85	2.4
Park/Open Space	4,278	35.2	966	27.3
Right-of-way	1,331	11.0	393	11.1
Total	**12,142**	**100.0**	**3,540**	**100.0**

FIGURE A-3: RESULTS OF ZONING ANALYSIS

When land is developed, buildings, driveways, parking areas, and sidewalks are typically part of the development. These items are usually made from impervious materials, which do not let water pass through to the underlying ground. Examples include buildings, asphalt or concrete pavement, and swimming pools. When rainfall hits these surfaces, it collects pollutants (oil, grease, etc.) and transports them into the drainage system and eventually to the creek. Pervious surfaces include landscaped areas, natural areas, and gravel or open concrete block paver driving and parking areas. When rainfall hits these surfaces, it percolates into the soil. If the soil is already saturated from heavy rain or flooding, the excess water runs off.

Research has shown that the greater percent of impervious surfaces in the watershed, the greater the impact will be on a water body from non-point source pollution. Not only do pollutants enter a water body from oil, gas, and other vehicle related materials, but also from fertilizers, pesticides, and even compounds leaching out of roofing materials. Wherever development takes place and stormwater is not properly managed, non-point source pollution tends to increase. As Hilton Head has developed over the past half century, the amount of impervious surface has increased, and impacts on the water quality have resulted.

To estimate the ratio of pervious to impervious surface in the Broad Creek watershed, the maximum permitted amount of impervious surface from the LMO for each zoning district was used. For each category in this study (each of which consists of several zoning districts), those maximums were averaged to give a single figure. Those were then applied to the land use acreage.

Some developments will exceed this impervious coverage percentage while others will not. This results in a conservative analysis, meaning that the results will be higher than what should really be there. Given the goal of improving water quality in Broad Creek, this is not unreasonable. The results are shown in Figures B-1 and B-2. The graph shows the amounts of impervious and pervious surfaces for each land use category in the watershed.

It is estimated that in all, 25% of the watershed is covered with impervious surfaces. This is a significant amount of land – 3,097 acres covered with impervious materials in all of the land use categories.

While commercial development occupies one of the smaller amounts of land within the watershed, it contributes a significant amount of the impervious surface, at 60% of its total acreage, or 530 acres. This amounts to 17% of the impervious coverage in the entire watershed.

Both single and multi family residential uses contribute a significant portion of the impervious surface area within the watershed. Single family uses, which average about 40% impervious coverage, contribute 1,110 acres, or 36% of all the impervious surfaces in the watershed. Multi family uses contribute 581 acres, or 19% of the total impervious coverage. Roadways (with an average of 50% impervious cover within the right-of-way) also contribute a large amount of impervious surface, at 677 acres, or 22% of the total in the watershed.

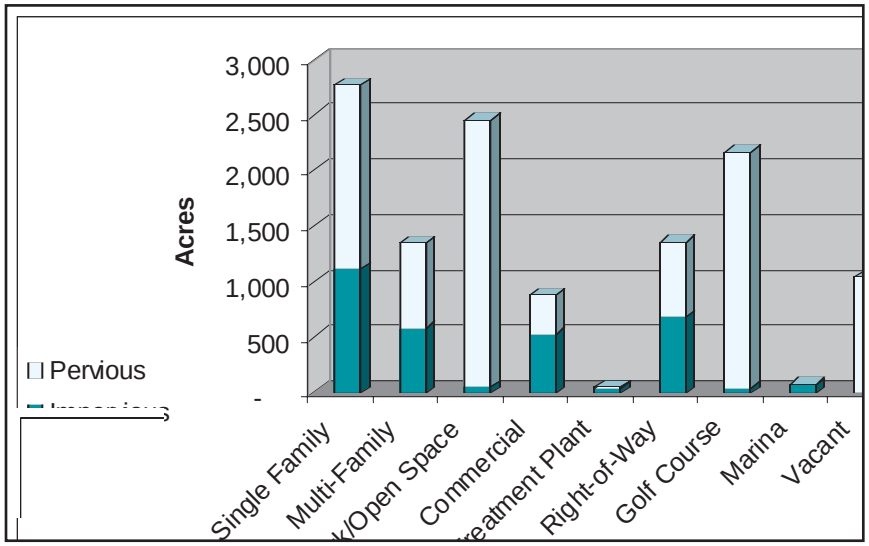


FIGURE B-1: IMPERVIOUS VS. PERVIOUS: WATERSHED

	watershed			
	acres	avg. % imperv. Coverage	acres imperv.	% imperv of total imperv.
Single Family	2,774	40%	1,110	36%
Multi-Family	1,350	43%	581	19%
Park/Open Space	2,455	2%	49	2%
Commercial	884	60%	530	17%
Treatment Plant	55	75%	41	1%
Right-of-Way	1,353	50%	677	22%
Golf Course	2,165	2%	43	1%
Marina	78	85%	66	2%
Vacant	1,037	0%	-	0%
Total	**12,151**		**3,097**	100%

FIGURE B-2: IMPERVIOUS SURFACE DATA: WATERSHED

There is approximately 27% impervious coverage in the corridor. Figures B-3 and B-4 show the amounts of impervious and pervious surfaces in each land use category within the corridor. The graph shows similar trends as those seen for the watershed, the most notable difference being the higher percentage overall of vacant land in the corridor than there is in the watershed.

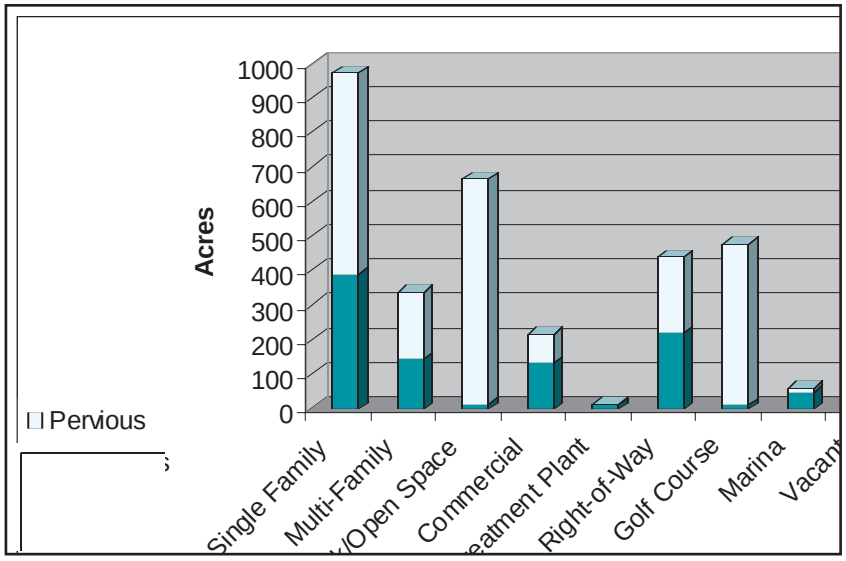


FIGURE B-3: IMPERVIOUS VS. PERVIOUS: CORRIDOR

	corridor			
	acres	avg. % imperv. Coverage	acres imperv.	% imperv of total imperv.
Single Family	974	40%	390	40%
Multi-Family	337	43%	145	15%
Park/Open Space	665	2%	13	1%
Commercial	217	60%	130	13%
Treatment Plant	13	75%	10	1%
Right-of-Way	441	50%	221	23%
Golf Course	476	2%	10	1%
Marina	59	85%	50	5%
Vacant	422	0%	-	0%
Total	**3,604**		**968**	100%

FIGURE B-4: IMPERVIOUS SURFACE DATA: CORRIDOR

The “Hotel Tract”, 17.4 acres, has access from Marshland Road near the Cross Island Parkway. A power line easement runs along one edge of the northern portion and through the southern portion. This power line crosses Broad Creek at this point. This tract is heavily forested, and has the possibility of small boat access during mid to high tide to Broad Creek via a small tidal creek which comes near the shore at the south-western corner of the property. The majority of the creek frontage has marsh 800’ out to the main channel of the creek. Nearby existing land uses include single family, multi-family, and a marina.

Potential future uses of this tract include a neighborhood park, a small boat ramp, and a crabbing dock. It is recommended that most park uses (playgrounds, fields, etc.) be located in the northern portion of the tract away from the creek, in order to preserve the existing forested buffer. It would be acceptable to do some limited pruning (while maintaining the required 20 foot buffer) in a few select locations to permit views out across Broad Creek. A pathway could wind through the property with benches to enjoy the view from. It is also recommended that interpretative signs be installed along the path to teach people about the marsh, the buffer, and the creek. Finally, it may be possible to use about a half acre of this site near the power station for shell recycling and storage activities associated with oyster bed restoration in the creek.

The properties labeled “Marshland Road West” and “Marshland Road East” in Figure 2-6 on page 13 are part of a recent purchase by the Town. They are located on Marshland Road in the headwaters area of the creek, and consist of 1.6 acres each. Both parcels are forested, and neither has any existing buildings or other development. Nearby land uses include residential, commercial, and industrial uses.

The future use of these parcels includes a neighborhood park, which will not have water access to Broad Creek due to the large distance from the shore to the channel of the creek. It is recommended that both of these parcels be used for parks or permanent open space. Either or both could have drainage facilities included as water features to help improve the quality of the runoff into Broad Creek as the surrounding area continues to develop with higher intensity uses than currently exist.

It is also recommended that the design of the parks on these parcels not only keep the existing vegetated buffer intact, but that it be substantially larger then the 20’ required by the Town’s Land Management Ordinance. These parks should include pathways which wind down toward the creek, some educational signage, and benches. Some thinning of the buffer in select locations to provide views across the creek would be appropriate. More intense uses for the park should be on the portions closer to Marshland Road, but a good buffer should be left there as well – for both safety and aesthetic reasons.

The parcel labeled “Captain’s Seafood” is a .8 acre parcel on Mathews Drive which was occupied by a seafood business and restaurant, which burned down several years ago. More than one third of this site is covered with concrete, but there are some trees and a very narrow strip of buffer between the concrete pad and the marsh. There is no access to the channel of Broad Creek from this site. The Town also owns a 5.4 acre parcel adjacent to this site which is almost entirely tidal marsh. Recommended future use of the Captain’s Seafood site is to remove the concrete and restore the wetlands which once occupied a substantial portion of it. This is scheduled to be completed within a year as required wetland mitigation for the construction of the new County boat landing to be built under the Cross Island Bridge.

The “Headwaters Tract” is located at the corner of William Hilton Parkway and Mathews Drive at the Folly Field Road intersection. It consists of 1.4 acres, most of which is forested. Due to the right turn lane from Mathews Drive onto William Hilton Parkway, there is no good vehicular access into this parcel. There are no existing curb cuts into this site. Nearby uses include residential (across the intersection), commercial (across the parkway), open space and a cemetery (adjacent to the south). There is no water access to Broad Creek. It is recommended that this parcel remain undeveloped as open space.

The parcels labeled “Chaplin Marsh Passive Park” in Figure 2-6 include 12.8 acres total although about half of the northern area is tidal marsh. These areas are between William Hilton Parkway and Broad Creek, and are all vacant at this time. Nearby uses include residential and commercial. These properties have no water access to the creek, but offer excellent scenic views of the headwaters area and the abundant wildlife. The recommended future use of these parcels is passive park, with pathways, benches, a few picnic tables, and some garden areas. This park area should be part of a linear park extending from Shelter Cove. There should also be connection across the highway to the new community recreation park which is currently under construction.

The “Shelter Cove Tract” is 24 acres, and has frontage along Shelter Cove Lane. Scenic views across the marsh would be excellent along the entire length of the parcel. The majority of the property is wooded, although there are a few short dirt roads and some cleared areas. Nearby uses include commercial development and the dredge spoil site for the Shelter Cove Marina. A power easement runs through a portion of this property.

One of the land uses for this tract is a festival center consisting of mostly open grassed areas for tents, parking areas, and electrical connections. This festival area is on the southern portion of the tract, across from the shopping center. The remainder of the tract should be left as permanent open space with the exception that a pathway should be constructed to connect to the linear park on the Chaplin properties. A portion of the site

already cleared at the northern end of this tract could be used for oyster shell recycling and other activities associated with oyster bed restoration in the creek, although this is not the ideal site since there is inadequate access to the water.

The “Yacht Cove Tract” is 13.2 acres and has access to William Hilton Parkway via Yacht Cove Drive, a residential street serving a moderate sized residential community. Most of the tract is forested, with a dirt road looping through the site. The site is currently gated to prevent vehicle access, but is used by local people for walks. Nearby uses include residential and resort. Water access to the creek is limited, with a small tidal creek being full enough at high tide for kayaks. There is approximately 350’ of marsh between the upland and the main channel of the creek. While this is a significant area to cross with a dock structure, it may be the only place on Town owned land on the creek where the Town could construct access to the water for non-motorized boats.

It is recommended that this tract be used for a low impact park – one with picnic areas, a playground, a crabbing dock, trails, and perhaps a kayak launch area. It is advisable to construct a small restroom facility at this site, to prevent additional and unnecessary pollution of the creek from people using the park. In order to minimize impact on the neighborhood, this park should be closed from dusk to dawn. It is possible that this site could be used for oyster shell recycling and activities associated with oyster bed restoration on the creek.

Benches should be installed along the shore, with limited pruning if necessary to allow views of the creek. This site is home to the town’s weather station, which is mounted on a pole in an open area near the shore. This station is solar powered and contains a cellular modem for twice daily downloading of the weather data to a computer at Town Hall. Educational signage should be included in this park to discuss the weather station, the creek, wildlife, buffers, and drainage issues. If a restroom facility is constructed and electrical power brought into the site, the weather station could be hardwired and a small observation station could be set up at the site for people to see what the weather station is collecting at that moment. In addition, the weather data could then be posted on the internet with frequent updates.

Finally, the property labeled “Boat Ramp” in Figure 2-6 is 1.9 acres off Helmsman Way on the south side of Broad Creek next to the Cross Island bridge. The site is currently forested, but will soon be developed into a Beaufort County boat ramp, providing much needed public boat access to this area of the creek. Nearby uses include residential, commercial, and a marina. There is roughly 200 feet of marsh between the shoreline and the creek channel.

Map D-1 shows the Town owned land in the watershed of Broad Creek. The Town has three beach parks along the Atlantic Ocean that are within the Broad Creek watershed. The largest of these is the Islander's Beach Park, a facility reserved for Hilton Head property owners, located on the north end of the island near Port Royal Plantation. Other than the beach parks, most of the land designated for parks/open space remain vacant and undeveloped at this time. The most notable exception to this is the Crossings Park, which is a community recreational facility with 3 baseball fields, a soccer field, a playground, an open area used for a variety of activities, a roller skating rink/basketball court, and a skateboard park. This facility is located off Palmetto Bay Road on the southern end of the Cross Island Parkway bridge over Broad Creek.

While it is not within the Broad Creek watershed, there is another community recreational facility currently under construction near the headwaters of Broad Creek. It will have several multi-purpose ball fields, basketball courts, tennis courts, and a playground. It is located on the east side of William Hilton Parkway between Burkes Beach Road and Singleton Beach Road, and extends from the highway to the ocean. There is a small special purpose beach park designated for the beach front portion of this property.

Activity at this recreational facility should not impact the water quality of Broad Creek, since the runoff does not flow into the creek. However, the fields will be lighted, and there is the potential for some adverse impacts on the wildlife in and near the creek from the lights during the evening – especially during the spring and summer nesting seasons. It is believed this impact will be small, since the lights will be designed to shine downwards and to have minimal impact on neighboring properties.

The future use of a number of Town owned properties is as yet undetermined. Some of these may become open space, others may be used for parks, and others may be used for public facilities such as parking lots. One large parcel near the headwaters of Broad Creek (the Ashmore Tract) will likely have multiple uses, including a major drainage improvement project which will include water quality enhancement features. This will consist of refurbishing a constructed wetland on the southern portion of the site, constructing a bio-retention pond near the new fire station, and constructing a new wetland designed to reduce fecal coliform bacteria. See Chapter 3 for a detailed description of this project.

Other significant land holdings within the Broad Creek watershed include the Town Hall complex at the entrance to Wexford Plantation, Coligny Beach Park and parking area at Coligny Circle, Boggy Gut wetland on the south side of Pope Avenue, a large wetland area between Marshland Road and William Hilton Parkway, and a large tract of land between Beach City Road and Mathews Drive.

The Department of Agriculture Natural Resources Conservation Service (NRCS, previously named the Soil Conservation Service) developed a classification system dividing soils into four hydrologic groups (A-D) to estimate runoff from precipitation. Soils are classified based on their runoff producing characteristics. It provides a way to compare different soils for their ability to absorb water, thus the relative amount of runoff they will produce. The hydrologic soil groups for the Broad Creek watershed are shown in Map E-1, which includes a summary of the characteristics of each hydrologic group. Figure E-1 shows that most of the soils in the watershed have low infiltration rates, and high runoff potential. 23% of the soils are classified as Group A, 2% are Group B, less than 3% of the soils are Group C, and 34% of the soils are classified as Group D.

A joint classification, such as B/D or A/D, indicates that the soil is in the D classification because of a high water table that creates a drainage problem. If underdrain systems are installed, the soil is reclassified into the other group (B or A in this case). 35% of the soils in the watershed are classified as Group B/D soils, and 3% are classified as Group A/D soils. Adding these two classifications in with the Group D (34%) brings the total of Group D soils in the watershed to 72%.

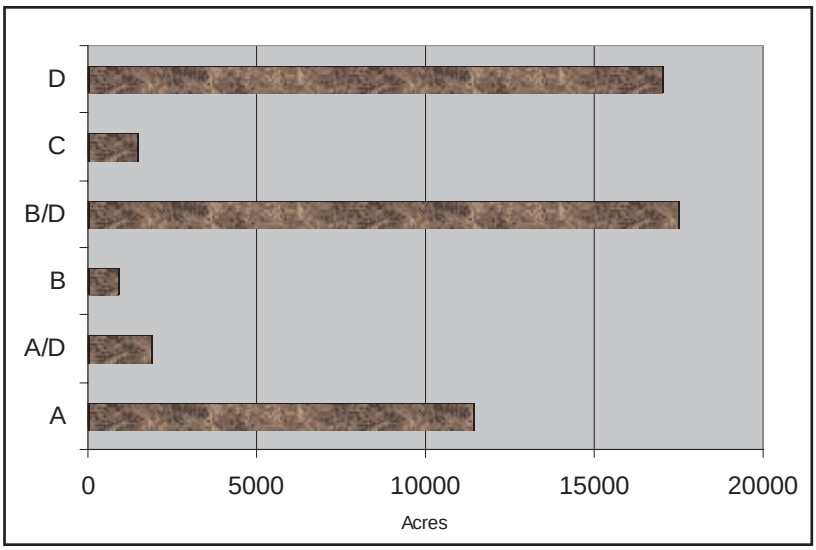


FIGURE E-1: DISTRIBUTION OF HYDROLOGIC GROUPS

National Pollution Discharge Elimination System (NPDES) Stormwater Phase II

The Clean Water Act of 1972 first introduced the National Pollution Discharge Elimination System (NPDES). The Clean Water Act prohibits anyone from discharging "pollutants" through a "point source" into a "water of the United States" unless they have an NPDES permit. The permit will contain limits on what can be discharged, monitoring and reporting requirements and other provisions to ensure that the discharge does not diminish water quality or threaten people's health. In essence, the permit translates general requirements of the Clean Water Act into specific provisions tailored to the operations of each site discharging pollutants.

The Environmental Protection Agency of the United States Federal Government has been charged with administration of the program to enforce environmental compliance. The first permits issued from 1973 to 1976 were for industrial sources of pollution. Over the past 30 years the program was expanded to include stormwater discharges. SC DHEC administers the permitting of such facilities in South Carolina, and will administer the stormwater Phase II Rule. SC DHEC has not released the final regulations for the Phase II Rule but will be required to follow the guidelines promulgated by the EPA.

The new Beaufort County Stormwater Utility will be responsible for obtaining a permit for the entire county, including the Town of Hilton Head Island. Beaufort County will be considered an operator of a Municipal Shared Storm Sewer System (MS4). An MS4 is the EPA designation for a conveyance or system of conveyances designed or used for collecting or conveying stormwater that is owned or operated by a public body.

The Phase II Final Rule was published in the *Federal Register* on December 8, 1999 (64 *FR* 68722). The NPDES permitting authority (SC DHEC) will issue general permits for Phase II-designated small MS4s and small construction activities by December 9, 2002. Operators of small MS4s by definition automatically fall within the Phase II Rule. They must obtain permit coverage within 90 days of issuance of the general permit. Operators of regulated small MS4s must fully implement their stormwater management programs by the end of the first permit term, typically a 5-year period.

Phase II Small MS4 Program Requirements**:** Operators of regulated small MS4s are required to design their programs to: reduce the discharge of pollutants to the "maximum extent practicable" (MEP); protect water quality; and satisfy the appropriate water quality requirements of the Clean Water Act. Implementation of the MEP standard will typically require the development and implementation of BMPs and the achievement of measurable goals to satisfy each of the six minimum control measures. The Phase II Rule defines a small MS4 stormwater management program as a program comprising

six elements that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving waterbodies. The six MS4 program elements, termed "minimum control measures," and suggested activities are outlined below.

1. Public Education and Outreach

Distribute educational materials and perform outreach to inform citizens about the impacts polluted stormwater runoff discharges can have on water quality. The following are suggested activities the Town and Stormwater Utility can do to comply:

Staff a public education task force with volunteer citizen educators;

Stencil storm drains with messages such as "Do Not Dump - Drains Directly to Creek;"

Provide economic incentives to citizens and businesses (e.g., rebates to homeowners purchasing mulching lawnmowers or biodegradable lawn products);

Prepare brochures or fact sheets for general public and specific audiences ;

Provide alternative information sources, such as web sites, bumper stickers, refrigerator magnets, and restaurant placemats;

Compile a library of educational materials for community and school groups;

Create tributary signage to increase public awareness of local water resources.

Provide stormwater hotlines for information and for citizens reporting polluters;

Participate in events such as home shows and community festivals with educational displays;

Prepare educational programs for school-age children;

Provide recreational guides to educate groups such as golfers, hikers, boaters, paddlers, climbers, fishermen, and campers.

2. Public Participation/Involvement

Provide opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representation on a stormwater management panel. The Town and Stormwater Utility should sponsor the following activities:

Public meetings/citizen panels which allow citizens to discuss various viewpoints and provide input concerning appropriate stormwater management policies and BMPs;

Water quality monitoring using volunteers gives citizens first-hand knowledge of the quality of local water bodies, and provides a cost-effective means of collecting water quality data;

Workshops conducted with volunteer educators and other speakers; encourage public participation in these workshops, and provide staff for them;

Community clean-ups along local waterways, beaches, and around storm drains; citizen watch groups can aid local enforcement authorities in the identification of polluters; and "Adopt A Storm Drain" programs encourage individuals or groups to keep storm drains free of debris and to monitor what is entering local waterways through storm drains.

3. Illicit Discharge Detection and Elimination

Develop and implement a plan to detect and eliminate illicit discharges to the storm sewer system. This would include developing a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste. Sources of illicit discharges include sanitary wastewater, effluent from septic tanks, car wash wastewater, improper oil disposal, radiator flushing disposal, laundry wastewater, spills from roadway accidents, and improper disposal of auto and household toxic materials. The exceptions to this include discharges from NPDES-permitted industrial sources and discharges from fire-fighting activities.

Currently neither the Town of Hilton Head Island or the Beaufort County Stormwater Utility have a formal program to address this issue. The following measures need to be implemented.

Create a storm sewer system map showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls. The storm sewer system map is meant to demonstrate a basic awareness of the intake and discharge areas of the system. It is needed to help determine the extent of discharged dry weather flows, the possible sources of the dry weather flows, and the particular waterbodies these flows may be affecting. The current inventory is outdated and is not in a useful format.

Prohibit non-stormwater discharges into the MS4 via an ordinance or other regulatory mechanism (to the extent allowable under State or local law); include appropriate enforcement procedures and actions;

Develop a plan to detect and address non-stormwater discharges, including illegal dumping, into the MS4;

Educate public employees, businesses, and the general public about the hazards associated with illegal discharges and improper disposal of waste.

4. Construction Site Runoff Control

Develop, implement, and enforce an erosion and sediment control program for construction activities that disturb one or more acres of land (controls could include silt fences and temporary stormwater detention ponds). The Town of Hilton Head Island stormwater regulations meet all the requirements listed below.

Develop an ordinance or other regulatory mechanism requiring the implementation of proper erosion and sediment controls, and controls for other wastes, on applicable construction sites;

Develop procedures for site plan review of construction plans that consider potential water quality impacts;

Develop procedures for site inspection and enforcement of control measures;

Develop sanctions to ensure compliance (established in the ordinance or other regulatory mechanism);

Establish procedures for the receipt and consideration of information submitted by the public;

Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure.

5. Post-Construction Runoff Control

Develop, implement, and enforce a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas (e.g., wetlands) or the use of structural BMPs such as grassed swales or porous pavement. The Town of Hilton Head Island is currently meeting the first two requirements listed below, but needs to implement a program with the Stormwater Utility to achieve the last two.

Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs);

Develop an ordinance or other regulatory mechanism requiring the implementation of post-construction runoff controls to the extent allowable under State or local law,

Ensure adequate long-term operation and maintenance of controls;

Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure.

6. Pollution Prevention/Good Housekeeping

Develop and implement a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning). Implementation of the Broad Creek Management plan will be a good first step towards achieving this goal.

Incorporate pollution prevention/good housekeeping techniques into municipal operations such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and stormwater system maintenance. To minimize duplication of effort and conserve resources, the MS4 operator can use training materials that are available from the EPA, appropriate State agencies, or other relevant organizations;

Determine the appropriate best management practices (BMPs) and measurable goals for this minimum control measure;

Develop maintenance activities, maintenance schedules, and long-term inspection procedures for structural and non-structural controls to reduce floatables and other pollutants discharged from separate storm sewers;

Establish controls for reducing or eliminating the discharge of pollutants from areas such as roads and parking lots, maintenance and storage yards and waste transfer stations. These controls could include programs that promote recycling (to reduce litter), minimize pesticide use, and ensure the proper disposal of animal waste and waste removed from separate storm sewer systems and areas listed in the bullet above, including dredge spoil, accumulated sediments, floatables, and other debris;

Find ways to ensure that new flood management projects assess the impacts on water quality and examine existing projects for incorporation of additional water quality protection devices or practices. The EPA encourages coordination with flood control managers for the purpose of identifying and addressing environmental impacts from such projects.

Water Quality Results at CSA Site

Averages	20.68	7.15	4.96	9.58	0.13	191.39	20.38	0.11	0.6
09/30/1999	24.3	6.09	3.87	7.84	0.073	1600			1.1
10/13/1999	23.9	7.37	3.2	6.08	0.05	900			1.1
10/27/1999	17.4	7.23	4.37	7.03	0.05	80			0.9
11/10/1999	20.1	7.14	1.93	7.25	0.05	350			0.7
11/24/1999	20.2	7.17	6.65	2.99	0.05	240			0.6
12/08/1999	12.4	7.24	7.07	4.34	0.05	300	6.1	0.85	0.7
12/22/1999	13	7.4	6.38	3.54	0.278	500	9.5	0.57	0.9
01/05/2000	10.1	6.45	8.43	4.02	0.3	9	9.6	0.28	1.4
01/19/2000	10.3	7.16	7.86	4.27	0.516	500	7.1	0.05	1.5
02/02/2000	5.9	7.17	9.59	3.5	0.755	900	3.1	0.05	1.3
02/16/2000	13.11	7.67	7.73	7.6	0.05	280	6.3	0.11	1.3
03/01/2000	16.35	7	4.36		0.05	500	4.2	0.11	1.4
03/14/2000	16.8	7.15	4.46	4.7	0.05	90	6.4	0.11	1.
03/29/2000	18.5	6.93	4.19	4.55	0.05	34	3.8	0.13	1.2
04/12/2000	21.52	7.38	7.11	6.42	0.05	80	16.4	0.06	0.9
04/26/2000	19.51	7.09	4.36	2.2	0.05	1600	12.1	0.06	0.7
05/10/2000	27.17	7.32	5	6.62	0.05	900	25.3	0.05	0.5
05/24/2000	27.62	7.32	4.92	10.4	0.05	14	29.1	0.05	0.6
06/07/2000	27.48	7.51	3.58	13.4	0.05	50	28.8	0.05	0.5
06/21/2000	29.71	7.23	1.77	8.9	0.05	50	1	0.05	0.3
07/05/2000	29.69	7.77	2.95	15.6	0.05	22	32.8	0.05	0.
07/19/2000	30.7	7.66	1.91	22.5	0.05	17	34	0.05	0.2
08/02/2000	30.75	7.42	3.6	9	0.05	1600	25.2	0.05	0.7
08/16/2000	28.26	7.22	4.22	4.9	0.05	30	15.7	0.05	0.
08/30/2000	28.41	6.92	1.9	15.8	0.05	170	14.6	0.13	0.6
09/13/2000	26.87	7.31	4.4	19.6	0.05	170	28.6	0.05	0.1
09/27/2000	23.51	7.19	4.01	13.3	0.05	140	29.4	0.05	0.1
10/11/2000	18.68	7.14	4.92	10.2	0.05	50	31.6	0.14	0.1
10/25/2000	20.69	7.44	5.42	28.8	0.05	110	33	0.05	0.1
11/08/2000	21.82	6.95	4.27	14.9	0.05	79	30.3	0.05	0.3
11/17/2000	16.69	7.04	5.13	21.6	0.05	350	29.1	0.05	0.2
12/06/2000	9.69	7.24	5.74	9.9	0.1	240	23.9	0.05	0.4
12/20/2000	7.38	7.06	5.67	21.5	0.129	1600	19.4	0.05	0.6
01/03/2001	3.41	6.8	8.27	8.4	1.32	540	11.4	0.05	1.0
01/17/2001	11.98	7.76	7.99	22.3	0.05	130	20.2	0.05	0.4
02/01/2001	12.65	6.9	5.09	7	0.37	110	12	0.05	0.7
02/14/2001	12.68	6.95	6.51	4.2	0.209	170	18.4	0.05	0.6
02/28/2001	18.32	6.79	4.29	6.2	0.133	920	20.1	0.05	0.6
03/13/2001	16.77	6.8	4.68	12.8	0.109	280	21.9	0.1	0.3
03/28/2001	13.97	6.98	5.21	10.8	0.161	33	14.1	0.05	0.6

Water Quality Results at Wexford Site

Averages	21.56	7.30	5.40	9.70	0.10	10.26	107.96	0.16	0.63
09/30/1999	26	5.89	3.55	5.89	0.149		1600		1.31
10/13/1999	24.6	7.2	4.34	3.89	0.097		140		0.98
10/27/1999	18.2	7.5	5.63	9.29	0.05		22		0.19
11/10/1999	19.8	7.59	8.16	4.58	0.05		170		0.5
11/24/1999	21.1	7.17	4.77	1.8	0.132		50		0.36
12/08/1999	13.6	7.29	5.24	2.64	0.1	6.1	130	1.01	0.53
12/22/1999	14.2	7.5	6.54	2.62	0.083	4.2	900	0.86	0.5
01/05/2000	13.4	6.62	7.08	3.51	0.05	10	80	0.27	0.31
01/19/2000	12.9	6.94	7.51	2.58	0.05	10.3	1600	0.5	0.29
02/02/2000	8.8	7.13	10	5.78	0.129	5.3	500	0.17	0.34
02/16/2000	13.99	7.85	10.1	11.9	0.096	4.3	500	0.06	0.35
03/01/2000	18	7.44	7.65		0.05	5.7	50	0.07	0.29
03/14/2000	20.91	7.53	5.1	13.4	0.05	9.6	80	0.16	0.42
03/29/2000	19.95	7.25	7.49	8.77	0.05	3.3	130	0.05	0.52
04/12/2000	21	7.74	8.08	6.44	0.05	4.4	23	0.05	0.85
04/26/2000	21.03	7.39	6.64	16.3	0.05	4.2	300	0.08	0.49
05/10/2000	26.28	7.6	6.42	5.77	0.05	5.7	50	0.05	0.71
05/24/2000	27.16	7.6	4.8	10.5	0.05	7.7	80	0.05	1.01
06/07/2000	27.37	7.49	4.75	9.7	0.05	10.5	50	0.05	1.12
06/21/2000	29.48	7.38	3.56	10.2	0.05	11.6	30	0.05	1.3
07/05/2000	27.4	7.23	2.46	15.4	0.05	17.7	23	0.15	0.69
07/19/2000	29.61	6.89	0.71	27.3	0.05	26.6	170	0.28	0.28
08/02/2000	30.62	7.73	4.11	5.9	0.05	12	4	0.05	0.77
08/16/2000	29.77	7.45	4.77	4.2	0.05	3.8	14	0.05	1.34
08/30/2000	27.93	7.13	4.54	12.9	0.117	1.9	900	0.05	1.11
09/13/2000	27.78	7.22	2.63	12.4	0.199	2	140	0.31	0.78
09/27/2000	23.61	7.49	3.5	8	0.167	2.3	110	0.19	0.81
10/11/2000	16.42	7.6	5.78	9	0.305	3	4	0.34	0.72
10/25/2000	21.39	7.49	4.92	49.2	0.139	21.5	350	0.07	0.22
11/08/2000	22.93	7.18	6.87	23	0.05	10.4	46	0.14	0.25
11/17/2000	16.62	7.14	5.59	16	0.117	11.3	1600	0.05	0.26
12/06/2000	10.43	7.68	6	8.7	0.198	6	280	0.05	0.43
12/20/2000	7.34	7.41	6.56	19.3	0.429	12.9	1600	0.21	0.31
01/03/2001	7.28	7.04	6.65	9.2	0.271	6.4	49	0.12	0.39
01/17/2001	12.13	7.21	7.23	20.1	0.05	9.9	920	0.07	0.2
02/01/2001	13.92	7.39	6.98	9.1	0.16	5.9	130	0.17	0.2
02/14/2001	13.3	7.26	7.86	5.1	0.125	5	170	0.05	0.32
02/28/2001	19.78	7.12	5.29	5.6	0.1	10.7	110	0.05	0.22
03/13/2001	19.2	7.21	6.81	17.8	0.146	7.8	140	0.05	0.28

Water Quality Results at Disney Site

Averages	21.56	7.36	5.65	8.31	0.05	106.15	26.22	0.12	0.37
09/30/1999	25.7	5.93	7.95	6.62	0.229	500			0.56
10/13/1999	24	7.32	3.86	3.9	0.05	240			0.43
10/27/1999	18.8	7.63	8.25	2.61	0.062	220			0.5
11/10/1999	20	7.46	7.01	4.49	0.05	900			0.38
11/24/1999	19.9	7.09	5.79	2.95	0.05	170			0.33
12/08/1999	13.4	7.14	6.21	2.48	0.05	33	24.3	1.14	0.34
12/22/1999	14.5	7.5	5.45	2.32	0.05	17	18	0.8	0.26
01/05/2000	11.9	6.29	8.73	1.93	0.05	34	24.9	0.32	0.18
01/19/2000	11.7	7.07	7.23	1.94	0.05	110	23.8	0.5	0.2
02/02/2000	8.3	7.51	7.64	6.71	0.05	80	24.2	0.05	0.25
02/16/2000	14.62	8.1	9.15	7.8	0.05	8	25.6	0.05	0.25
03/01/2000	17.83	7.52	6.87		0.05	240	24.8	0.05	0.2
03/14/2000	18.19	7.63	5.64	15.2	0.05	170	28.4	0.05	0.4
03/29/2000	19.79	7.28	5.79	3.85	0.05	30	24.4	0.05	0.24
04/12/2000	21.46	7.63	5.54	4.47	0.05	240	24.2	0.05	0.46
04/26/2000	20.42	7.57	5.69	2.3	0.05	300	22.6	0.05	0.45
05/10/2000	26.36	7.42	4.8	7.35	0.05	80	25.2	0.05	0.51
05/24/2000	26.61	7.63	4.2	4.89	0.05	280	27.6	0.05	0.6
06/07/2000	26.59	7.64	4.28	6.6	0.05	50	29.2	0.05	0.41
06/21/2000	29.79	7.33	2.46	13.1	0.05	900	32.9	0.05	0.23
07/05/2000	29.56	7.94	3.9	11.6	0.05	27	31.4	0.05	0.43
07/19/2000	30.97	7.34	2.03	19.6	0.05	50	33.4	0.05	0.25
08/02/2000	30.08	7.3	2.37	10.5	0.05	500	33.1	0.05	0.14
08/16/2000	29.85	7.17	2.68	7.8	0.05	13	31.2	0.05	0.14
08/30/2000	28.58	7.6	5.6	16.3	0.05	60	24.6	0.05	0.37
09/13/2000	28.96	7.77	7.94	4.4	0.05	130	17.3	0.41	1.34
09/27/2000	24.37	7.45	6.03	10.6	0.05	350	19.5	0.05	0.49
10/11/2000	18.3	7.21	5.69	6.3	0.05	70	21.1	0.09	0.63
10/25/2000	21.32	7.46	5.93	27.1	0.05	220	23.7	0.05	0.45
11/08/2000	22.23	7.18	6.47	25.6	0.05	130	26.7	0.05	0.69
11/17/2000	17.31	7.14	5.37	17.4	0.05	33	29.3	0.05	0.23
12/06/2000	12.02	7.34	5.53	11.1	0.05	79	29.6	0.05	0.34
12/20/2000	9.99	7.46	6.05	13	0.05	170	29	0.05	0.2
01/03/2001	4.65	6.95	8	6.6	0.05	170	23.2	0.05	0.25
01/17/2001	12.64	7.31	8.64	18.2	0.05	8	24.1	0.05	0.35
02/01/2001	13.46	7.2	6.83	4.7	0.05	46	24.1	0.05	0.14
02/14/2001	12.69	7.03	7.58	5.8	0.05	46	24.3	0.05	0.24
02/28/2001	18.32	7.12	7.19	4.7	0.05	79	28.2	0.05	0.07
03/13/2001	16.4	7.24	7.4	12.9	0.05	49	27.8	0.05	0.19

Water Quality Results at Cracker Barrel Site

Averages	21.14	7.32	5.13	19.72	0.13	25.85	32.62	0.17	0.13
09/30/1999	25.7	6.09	4.3	11.1	0.05	70			0.09
10/13/1999	23.8	7.31	3.57	10.4	0.05	30			0.11
10/27/1999	18.5	7.51	5.35	9.59	0.05	50			0.16
11/10/1999	19.8	7.6	5.32	4.46	0.05	23			0.09
11/24/1999	20.6	7.2	5.99	9.78	0.05	130			0.08
12/08/1999	14	7.33	6.84	3.45	0.05	4	31.9	0.88	0.12
12/22/1999	13.8	7.73	6.35	5.8	0.05	80	23.2	0.68	0.06
01/05/2000	13.1	6.46	7.45	10.9	0.196	80	31	0.25	0.12
01/19/2000	12.5	7.12	8.2	5.39	0.21	1600	31.8	0.05	0.06
02/02/2000	7.3	7.37	10.4	3.69	1.2	13	26.3	0.05	0.11
02/16/2000	15.62	8.2	8.97	14.2	0.691	4	29	0.05	0.12
03/01/2000	18.3	7.4	4.38		0.145	2	31.3	0.07	0.08
03/14/2000	17.75	7.65	5.79	11.8	0.359	7	32.2	0.13	0.12
03/29/2000	19.98	7.26	5.03	9.57	0.324	7	30	0.05	0.11
04/12/2000	22.16	7.59	5.38	17.6	0.138	4	32.2	0.06	0.17
04/26/2000	19.91	7.5	4.97	10.2	0.088	30	27.1	0.06	0.09
05/10/2000	26.76	7.38	4.5	9.66	0.103	30	31.3	0.05	0.2
05/24/2000	26.36	7.5	3.93	20.6	0.115	30	33	0.08	0.14
06/07/2000	25.33	7.32	4.49	19.3	0.391	8	32.1	0.05	0.24
06/21/2000	29.36	7.15	2.18	15.2	0.05	14	35	0.06	0.15
07/05/2000	28.54	7.42	3.05	16.1	0.05	50	34.9	0.05	0.15
07/19/2000	30.61	7.16	1.99	24.5	0.05	22	36.1	0.05	0.19
08/02/2000	30.31	7.32	3.7	13.3	0.05	17	33.6	0.05	0.11
08/16/2000	29.37	7.11	2.82	9.5	0.05	30	31.9	0.05	0.1
08/30/2000	27.59	7.3	3.8	22.2	0.05	23	30.5	0.05	0.09
09/13/2000	28.84	7.28	5.15	12.4	0.05	30	26.8	0.08	0.05
09/27/2000	23.39	7.3	4.45	10.9	0.064	170	29.7	0.07	0.08
10/11/2000	17.51	7.19	5.67	12	0.094	13	31.6	0.36	0.17
10/25/2000	21.09	7.31	5.03	55.2	0.05	22	33.6	0.05	0.14
11/08/2000	23.48	7.12	4.54	26.2	0.05	11	33.7	0.2	0.16
11/17/2000	16.2	7.24	5.62	34	0.05	46	35.3	0.05	0.05
12/06/2000	9.84	7.48	5.03	15.3	0.095	8	33.7	0.35	0.14
12/20/2000	4.38	7.45	6.2	72.7	0.45	49	28.4	0.27	0.16
01/03/2001	3.92	7.46	7.41	9.8	0.05	13	31.7	1.09	0.3
01/17/2001	11.83	7.48	5.58	174.2	0.05	79	32.4	1.28	0.32
02/01/2001	12.94	7.22	5.24	10.2	0.05	9	31	0.26	0.05
02/14/2001	12.64	7.23	6.66	5.9	0.075	33	32.3	0.05	0.05
02/28/2001	18.7	7.24	5.63	13.8	0.05	31	32.5	0.05	0.05
03/13/2001	16.92	7.29	5.84	15.9	0.05	26	31.5	0.05	0.06

Water Quality Results at Mathews Drive Site

Averages	21.15	7.07	5.77	18.03	0.47	838.25	9.21	0.17	0.23
09/30/1999	27.7	5.8	4.15	12.3	0.168	1600			0.21
10/13/1999	23.5	7.13	2.55	9.07	0.05	1600			0.11
10/27/1999	18.5	7.18	5.01	6.28	0.469	300			0.28
11/10/1999	19.4	7.45	6.35	81.6	0.493	300			0.35
11/24/1999	20.8	7.29	5.82	14	0.05	1600			0.12
12/08/1999	12.7	7.17	6.87	9.4	0.105	900	25.5	0.86	0.15
12/22/1999	13.6	7.43	6.43	12.8	0.43	900	14.9	0.94	0.13
01/05/2000	12.3	6.77	7.52	5.81	2.49	900	1.2	0.25	0.6
01/19/2000	11.7	7.07	8.98	7.03	3.13	220	4.8	1	0.55
02/02/2000	7.8	6.92	9.46	6	4.99	240	1	0.05	1.09
02/16/2000	15.63	7.89	9.62	11.7	1.3	500	1	0.05	0.37
03/01/2000	19.02	7.4	5.9		0.518	900	1	0.17	0.2
03/14/2000	19.39	7.51	6.59	19.39	0.236	1600	4.7	0.23	0.25
03/29/2000	20.12	7.55	6.59	9.03	0.303	280	1	0.13	0.23
04/12/2000	21.31	7.02	5.27	10.5	0.361	170	1	0.2	0.29
04/26/2000	18.89	6.82	5.13	13.1	0.283	500	1	0.22	0.19
05/10/2000	27.28	7.06	7.02	11.3	0.312	280	1.8	0.09	0.23
05/24/2000	26.69	7.31	6.25	26.6	0.365	1600	4.6	0.18	0.28
06/07/2000	23.76	7.09	4.75	39.7	0.187	1600	4.5	0.17	0.31
06/21/2000	28.2	7.1	3.92	22.6	0.104	1600	16.2	0.11	0.33
07/05/2000	28.62	7.17	2.76	21.1	0.135	500	23.9	0.08	0.33
07/19/2000	30.97	7.45	7.33	40.8	0.05	300	23.1	0.05	0.49
08/02/2000	30.05	7.12	2.08	26	0.146	1600	20	0.06	0.35
08/16/2000	28.96	6.94	2.6	17.3	0.145	350	18.9	0.31	0.31
08/30/2000	27.8	7.04	3.93	21.9	0.111	500	25.6	0.05	0.17
09/13/2000	26.87	6.55	4.78	2.8	0.378	280	1	0.09	0.08
09/27/2000	22.23	6.91	4.02	14.2	0.195	1600	19	0.05	0.05
10/11/2000	18.09	6.66	7.01	12.9	0.505	900	2.3	0.1	0.1
10/25/2000	20.79	7.33	13.6	78.7	0.44	1600	6.2	0.06	0.14
11/08/2000	24.64	7.13	5.73	21.7	0.05	1600	2.2	0.05	0.21
11/17/2000	15.64	6.81	5.61	33.5	0.05	540	27.9	0.05	0.05
12/06/2000	10.67	7.2	6.66	14.5	0.524	350	2.1	0.05	0.1
12/20/2000	6.97	7.65	6.99	13.3	0.492	540	1.1	0.05	0.05
01/03/2001	5.1	7.23	7.4	7.1	0.56	540	1.1	0.05	0.12
01/17/2001	12.04	7.33	8.27	25.9	0.05	1600	2.4	0.05	0.13
02/01/2001	12.98	6.97	6.62	9.5	0.427	920	1.1	0.05	0.05
02/14/2001	15.62	6.86	8.55	19.5	0.294	1600	11.1	0.05	0.13
02/28/2001	18.5	7.37	6.14	12.3	0.245	920	13.1	0.05	0.18
03/13/2001	18.69	6.87	6.45	24.5	0.227	1600	7.4	0.05	0.14

Water Quality Results at Broad Pointe Site

Averages	22.23	7.19	5.90	18.08	0.54	1033.99	11.97	0.14	0.28
09/30/1999	27.1	5.81	4.21	43.6	0.053	1600			0.19
10/13/1999	23.9	6.99	2.95	60.9	0.05	1600			0.12
10/27/1999	17.4	7.26	4.95	6.78	0.05	1600			0.15
11/10/1999	20.9	7.13	3.98	9.16	0.05	900			0.05
11/24/1999	21.3	7.07	5.79	7.75	0.05	1600			0.05
12/08/1999	13.5	7.06	6.87	18.6	0.05	1600	24.5	0.89	0.12
12/22/1999	13.8	7.38	6.7	6.35	0.05	1600	19	1.19	0.05
01/05/2000	11.7	6.62	7.04	4.08	0.05	1600	2.6	0.22	0.07
01/19/2000	11.2	6.88	7.32	4.61	0.05	50	23.4	0.8	0.07
02/02/2000	7.9	6.7	9.74	4.25	0.05	300	1.9	0.05	0.05
02/16/2000	14.69	7.88	8.61	12.2	0.05	900	13.8	0.1	0.07
03/01/2000	21.29	6.62	2.92		0.05	500	6.8	0.05	0.05
03/15/2000	21.53	7.29	5.67	12.2	0.05	130	18.7	0.12	0.06
03/29/2000	21.83	7.47	5.81	11	0.062	900	1	0.05	0.06
04/12/2000	23.67	7.06	4.21	14.5	0.05	1600	18.8	0.09	0.08
04/26/2000	21.51	7.2	6.94	3.6	0.05	900	1	0.05	0.05
05/10/2000	29.17	6.94	4.77	7	0.05	1600	21	0.05	0.12
05/24/2000	30.01	7	4.41	18.7	0.05	1600	17.4	0.05	0.3
06/07/2000	26.82	6.84	2.93	22.4	0.05	1600	25.2	0.05	0.13
06/21/2000	30.57	6.94	2.03	28.2	0.05	1600	6.8	0.11	0.58
07/05/2000	29.85	7.29	3.58	24.3	0.05	1600	30.3	0.05	0.16
07/19/2000	31.38	6.97	2.53	28	0.05	900	28.8	0.05	0.29
08/02/2000	30.54	7.2	3.4	15.6	0.05	1600	28.2	0.05	0.1
08/16/2000	32.85	6.91	4.39	37.4	0.05	1600	19.3	0.05	0.09
08/30/2000	26.98	6.89	4.39	18.1	0.05	1600	19.5	0.05	0.08
09/13/2000	30.06	7.14	7.61	3	0.526	900	1	0.05	0.05
09/27/2000		7.18		3.73	0.382	1600	2.3	0.05	0.1
10/11/2000	20.73	6.8	3.21	18.1	0.181	1600	10.6	0.09	0.09
10/25/2000	22.82	7.03	9.53	31.9	0.081	1600	20.8	0.09	0.06
11/08/2000	23.62	7.01	3.12	28.6	0.05	1600	12.3	0.05	0.08
11/17/2000	16.26	7.1	4.91	32.6	0.05	1600	24.8	0.05	0.05
12/06/2000	11.4	7.6	5.08	15.9	0.17	1600	3.5	0.1	0.05
12/20/2000	10.16	6.93	3.5	18.4	0.177	1600	2.2	0.21	0.05
01/03/2001	6.19	7.96	8.7	9.4	0.05	540	1	0.05	0.06
01/17/2001	11.26	8.54	10.39	17.2	2.39	1600	1	0.05	0.31
02/01/2001	11.8	7.95	10.14	7.1	3.49	1600	1	0.05	0.38
02/14/2001	13.65	7.68	9.95	4.4	3.54	920	1	0.05	1.34
02/28/2001	19.58	7.11	8.09	14.2	3.79	1600	1	0.13	2.1
03/13/2001	19.07	7.74	10.04	18.7	3.51	350	1	0.05	1.66

This Appendix contains more detailed information about fecal coliform bacteria and the results of the study.

State standards for Shellfish Harvesting Waters mandate that fecal coliform levels should not exceed a geometric mean of 14 colonies per 100 milliliters; nor shall more than 10% of the samples exceed 43 colonies per 100 ml. The standard for contact recreation is 200 colonies per 100 ml. These standards are intended as measurements of the water quality in the stream channel, and it is expected that fecal coliform in stormwater runoff will be higher. Concentrations decline as stormwater is diluted in the main water body. There is no fecal coliform standard for stormwater.

Testing has revealed that fecal coliform concentrations are widely variable over time, as can be demonstrated by Figure H-1, which shows the fecal coliform concentrations at the Wexford monitoring site. The graph shows a maximum fecal coliform concentration of 1600 colonies per 100 milliliters of water, which is the limit of our current testing method.

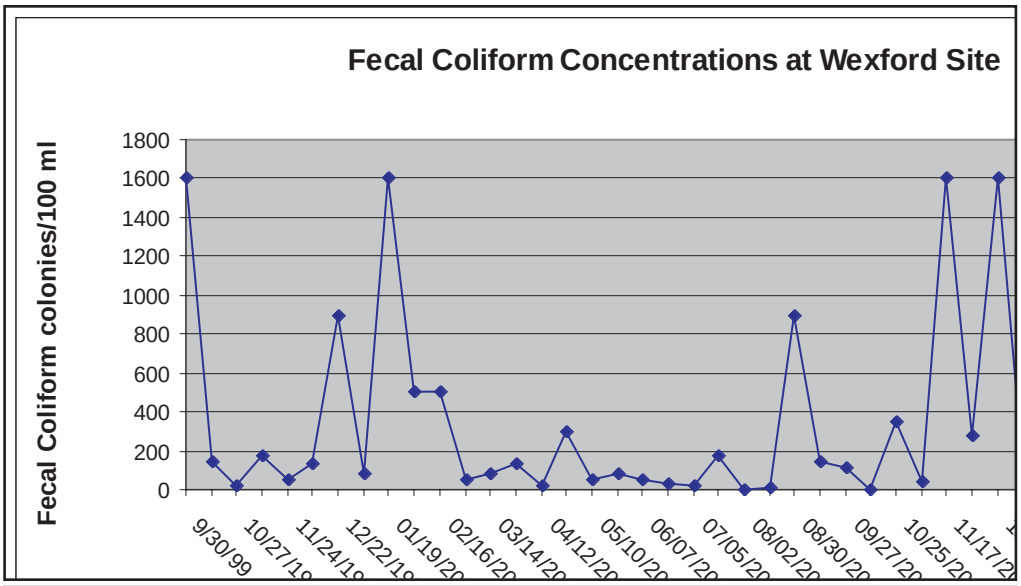


FIGURE H-1: FECAL COLIFORM RESULTS AT THE WEXFORD MONITORING SITE

The fecal coliform data for all five monitoring sites is analyzed and simplified in the table below. In this table **bold** text on the site name indicates poor quality, *italics* indicates moderate quality, and SMALL CAPS text indicates fair or good water quality. (Figure H-2).

To explain relationships in the data set, correlations were used. Correlation measures the degree to which two variables are associated. It is measured using a correlation

coefficient (derived mathematically) which ranges from -1 to 1, with a higher absolute correlation coefficient indicating a strong relationship between the variables. A negative correlation indicates a relationship where one variable increases as the other decreases.

There does not appear to be any consistent correlation between fecal coliform concentrations and any of the other parameters tested. The highest correlation coefficient with fecal coliform concentration was 0.345 with turbidity at the Broad Pointe site (turbidity is a measure of the suspended solid matter in the water column, or cloudiness). This means that in this data set it appears that fecal coliform concentrations and turbidity both increase at the same time. This relationship was not observed at any of the other sites. A full correlation matrix is included in Appendix I.

The correlation between fecal coliform concentration and rain was not consistent. At two sites fecal coliform was higher when there had been rain in the previous 72 hours (the expected result), but at the remaining 4 sites fecal coliform was lower. None of the correlation coefficients were significant, although the positive correlations were much higher. The results were equally inconsistent when measured with rainfall in the previous 24 hours. The reasons for this apparent anomaly are unknown, although it may be due to the low number of data points (43), or the fact that a large number of the fecal coliform observations were at the detection limit, thus making correlations difficult.

The wide variation in fecal coliform concentrations was examined as a function of both tide and rainfall events. At four of the six monitoring sites, the average fecal coliform concentration was greatest at high tides, both rising and falling. At two sites, Wexford and Cracker Barrel, the average fecal coliform concentration was highest at low tide.

Site	Highest result (1600 limit)	Lowest result	% of samples above 14/100	Geometric mean
CSA (Sea Pines)	1600	9	95	171
Wexford	1600	4	95	117
Disney	900	8	86	96
Cracker Barrel	1600	2	60	22
Mathews	1600	170	100	740
Broad Pointe	1600	50	100	1066

FIGURE H-2: FECAL COLIFORM RESULTS

Please see the fold out page for the correlation matricies of the various water quality measurements for the six testing sites.

Total phosphate is measured in milligrams of phosphate per liter of water. High concentrations of phosphate indicate poor water quality. South Carolina does not have a standard for total phosphate, but DHEC publishes a compilation of the results of all sites tested in the state between 1993 and 1997. Results of all tested sites are divided into percentiles, which can be used to compare with new data. The DHEC report provides three levels for comparison: the 50th percentile, 90th percentile, and 95th percentile. If new results are less than the number given for the 50th percentile that means the new result is at least as good as 50% of all tested sites. If the result is less than the 90th percentile, it is worse than 50% of all sites tested, but better than 10%. If the new result is higher than the 95th percentile, the result is worse than 95% of all sites tested in the state. This indicates extremely poor water quality.

The percentiles for phosphate concentration in saltwater in South Carolina are:
50^{th} percentile - 0.06 mg/l;
90^{th} percentile – 0.16 mg/l;
95^{th} percentile - 0.28mg/l.

Total Phosphate is positively correlated with nitrate and total nitrogen at all sites with the exception of the Broad Pointe site. The correlation with total nitrogen is strong (up to 0.709) at all sites. This means that as total nitrogen increases, total phosphates also increase. This indicates that these two nutrients are from similar sources (such as runoff from suburban lawns), and that reducing inputs from the source could reduce the levels of both nutrients in Broad Creek.

Site	Average of all samples	% of samples less than 50^{th} (good wq)	% of samples greater than 95^{th} (poor wq)
CSA (Sea Pines)	0.74	0	88
Wexford	0.56	0	88
Disney	0.36	0	62
Cracker Barrel	0.12	14	2
Mathews	0.24	10	26
Broad Pointe	0.30	24	26

FIGURE J-1: PHOSPHATE RESULTS

As with the fecal coliform data, correlations between phosphate and rainfall are inconclusive. Three of the six sites exhibit weak positive correlations with 72 hour rainfall (between 0.10 and 0.23), while the other 3 show negative correlations (between 0.035

and 0.13). The 24 hour rainfall correlations exhibit this inconsistency as well. An interesting result is that a site with a positive correlation at the 24 hour rain does not necessarily have a positive correlation with the 72 hour rain.

At four of the monitoring sites, the average total phosphate concentration was highest on a falling tide (both high and low). This could indicate that pollutants are being encountered when the water levels reach higher into the upland, and that they are being washed away as the tide falls.

The state uses the percentile system for both total nitrogen and ammonia. Both are measured in milligrams per liter of water, with higher numbers representing poorer water quality.

The percentiles for total nitrogen are:
50th percentile - 0.59mg/l;
90th percentile - 1.06 mg/l;
95th percentile -1.26 mg/l.

The percentiles for ammonia are:
50th percentile - 0.05 mg/l;
90th percentile - 0.11 mg/l;
95th percentile - 0.25 mg/l.

The results for nitrogen are analyzed and summarized in the tables below. The results for nitrate are not shown because they were not illustrative of overall water quality in the creek. The entire dataset can be found in the digital data document.

Total nitrogen was strongly correlated with total phosphate as discussed previously. It is also positively correlated with ammonia (0.574 at Cracker Barrel site). Since ammonia represents a portion of total nitrogen, this result is expected.

Site	Average of all samples	% of samples less than 50th	% of samples greater than 95th
CSA	0.66	49	10
Wexford	0.71	33	45
DISNEY	0.62	66	10
CRACKER BARREL	0.43	81	5
Mathews	0.75	43	14
BROAD POINTE	0.64	48	5

FIGURE K-1: TOTAL NITROGEN RESULTS

Correlation between total nitrogen and 24 hour rainfall follows a more consistent pattern than the other parameters, with 5 of the 6 sites exhibiting positive correlations (between 0.03 and 0.28). The opposite is true for the 72 hour rainfall, with 5 of the 6 sites showing negative correlations (-0.08 to -0.27). It is apparent from this and the other results that our attempt to understand nitrogen inputs to Broad Creek as a function of rainfall is not conclusive.

As with phosphates, the average total nitrogen concentration was highest on a falling tide (both high and low). Again, this indicates a loading from upland sources during tidal inundation, and a removal of the pollutant with the tide.

AMMONIA

Ammonia is negatively correlated with turbidity at all sites except for the Cracker Barrel site where it exhibits a strong positive correlation (0.49). At all sites ammonia appears to have a negative relationship with water temperature. As water temperature increases, ammonia concentrations are reduced.

Ammonia shows the most predictable association with rainfall of all the parameters examined. All six sites are positively correlated with the 24 hour rainfall, and with higher correlation coefficients than the other parameters (0.07 to 0.38). Correlation coefficients with the 72 hour rain are much lower (0.01 to 0.13), but 5 of the sites do exhibit a positive correlation.

Site	Average of all samples	% of samples less than 50th	% of samples greater than 95th
CSA (SEA PINES)	0.11	62	8
Wexford	0.17	43	16
DISNEY	0.13	86	11
Cracker Barrel	0.20	51	22
Mathews	0.17	41	8
Broad Pointe	0.15	62	8

FIGURE K-2: AMMONIA RESULTS

The surface dissolved oxygen standard for shellfish harvesting waters is a daily average not less than 5.0 mg/l, with a low of 4.0 mg./l.

As expected, DO concentrations are generally lower in the warmer months, with very few low concentrations occurring between November and March.

Dissolved oxygen does not appear to be correlated with any of the other parameters except for temperature, where the expected negative relationship is apparent. There is, however, a pattern with respect to tidal stage. Dissolved oxygen levels are at their highest during a low tide. This is likely due to the fact that the average water temperature is lowest during low tide, and lower water temperatures result in higher dissolved oxygen concentrations.

Dissolved oxygen was not correlated with either the 24 hour or 72 hour rainfall, with the highest correlation coefficient at 0.13.

Site	Lowest result	% of samples < 5.0 mg/l	% of samples < 4.0 mg/l	Average DO
CSA (Sea Pines)	1.77	56	24	5.02
Wexford	0.71	38	19	5.73
DISNEY	2.03	23.8	14	5.98
Cracker Barrel	1.99	40	21	5.28
MATHEWS	2.08	28.5	14	6.11
Broad Pointe	2.03	39	27	5.94

FIGURE L-1: DISSOLVED OXYGEN RESULTS

Two sites were chosen to test the hypothesis that pollutants entering Broad Creek through the stormwater system are diluted in the main channel. Please refer to Chapter 3 for maps showing the site locations.

The first site, Mathews Drive and the headwaters area, showed what the expected result (Figure M-1). At the discharge site the parameters had high values, but dilution occurred at points away from the discharge site. Dissolved oxygen levels increased at each interval away from the discharge site, while fecal coliform, total nitrogen and nitrate decreased at each interval. Ammonia and total phosphate trended downward, but not perfectly. It is important to note that while these water quality parameters are trending in the right direction with distance away from the stormwater discharge, none of the parameters meet the state standard or the 50th percentile. At further distances the water quality may improve enough to meet the standards, but this is still an unacceptable result. Water quality at the Mathews Drive and headwaters area needs to be improved dramatically.

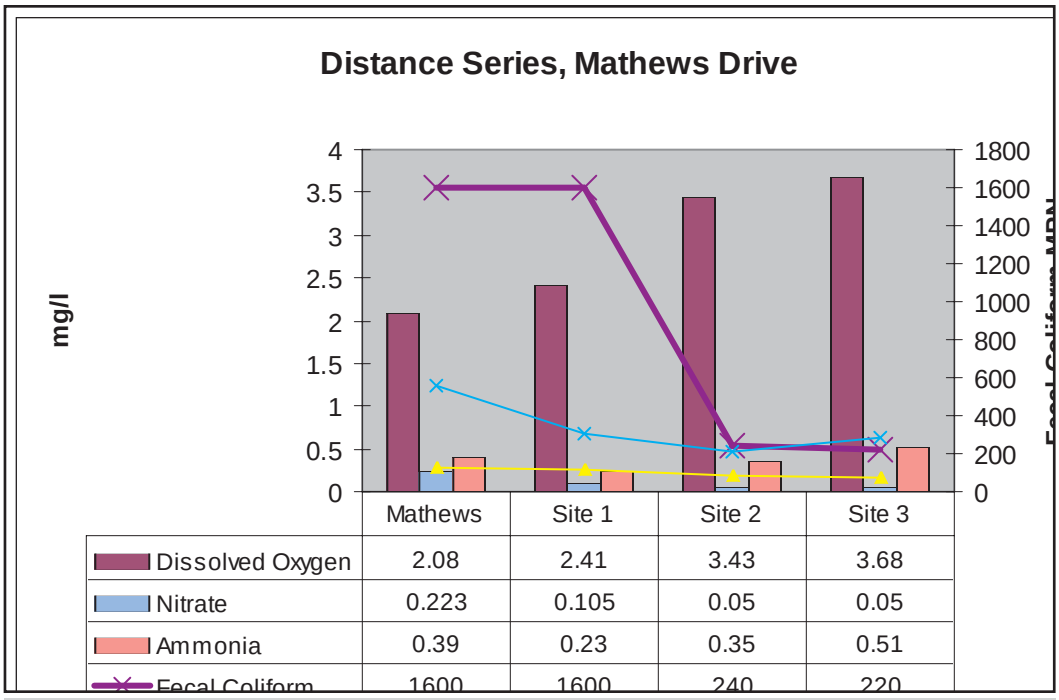
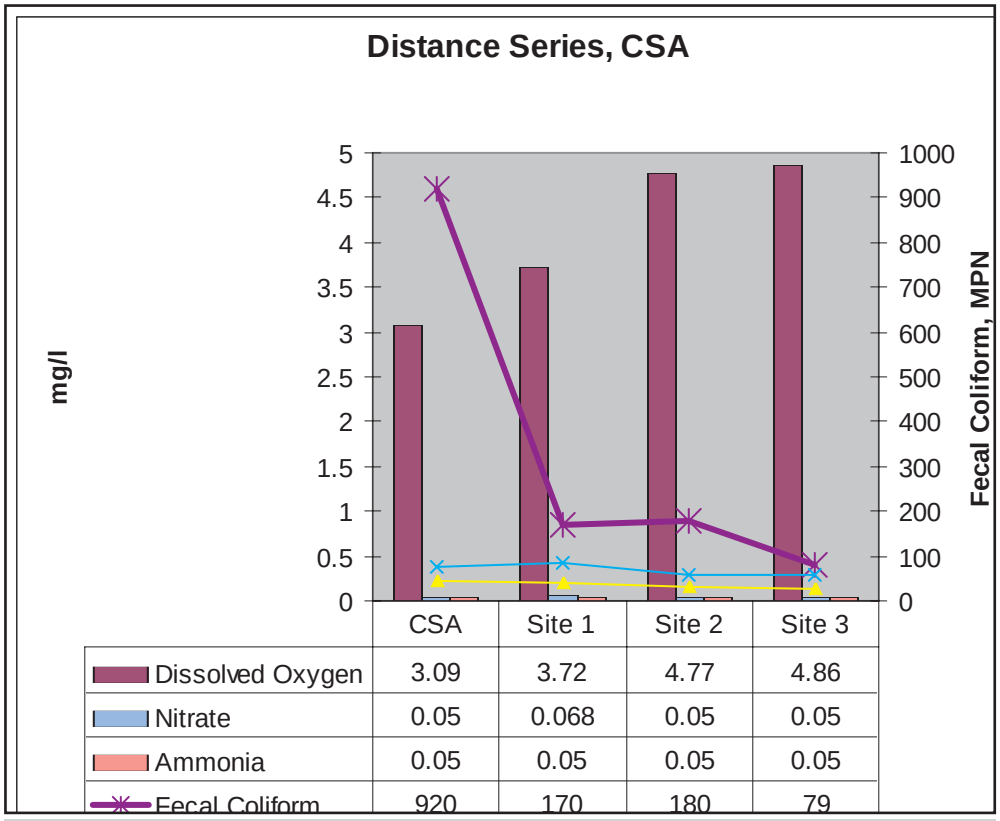


FIGURE M-1: RESULTS OF DISTANCE SERIES, MATHEWS DRIVE (HEADWATERS)

The results are much the same for the distance series beginning at the Sea Pines Community Services Association (CSA) stormwater outfall (Figure M-2). Levels of the stormwater components are higher at the outfall and fall at each progressive distance. Dissolved oxygen improves, nitrogen, phosphates and fecal coliform all decrease.

Ammonia and nitrate are both at the lowest detection limit. Dissolved oxygen, ammonia and total nitrogen all meet the state standard or the 50th percentile by the last sample, while phosphates and fecal coliform do not. This series shows that if the starting levels for some pollutants are lower, they do indeed improve enough over short distances to meet state standards.



	CSA	Site 1	Site 2	Site 3
Dissolved Oxygen	3.09	3.72	4.77	4.86
Nitrate	0.05	0.068	0.05	0.05
Ammonia	0.05	0.05	0.05	0.05
Fecal Coliform	920	170	180	79

FIGURE M-2: RESULTS OF DISTANCE SERIES, CSA (TIDAL INLET NEAR THE MOUTH)

The following is a more detailed discussion than appears in Chapter 3 of the soils and their suitability for onsite sewage disposal systems in the watershed and corridor of Broad Creek.

The majority of the Town of Hilton Head Island has soils which are not well suited for disposal of effluents, particularly for onsite sewage disposal systems. The reasons for this originate with the geology of the area and the morphology of the soils. The Lower Coastal Plain was inundated by the ocean many times over the millennia. It is estimated that the sea level was 270 feet higher than it is today at the end of the Pliocene Epoch. Since then the sea has risen and fallen a number of times. The significance of this is that marine sediments were deposited and eroded continuously through the period, and is the reason that Hilton Head has a significant amount of fine sands and clays in the soils.

The following paragraphs give short descriptions of the soils which occur in the Broad Creek watershed. They are listed in order of soil suitability for onsite sewage disposal systems, from the best soils to the worst.

Wd – Wando Fine Sand: This is an excessively drained soil on the higher ridges of the lower marine terraces. It has a rapid permeability. The soil has a high potential for most urban uses. It is rated as having slight limitations for septic system absorption fields. However, given the rapid permeability, septic system absorption fields could lead to inadequately treated effluent reaching waterways via the groundwater or as seepage into drainage ways or other water bodies. Nonetheless, it is the only soil in the Broad Creek watershed which is rated “slight” for septic system absorption fields.

Fb – Fripp-Baratari Complex: This complex consists of excessively drained soils interspersed in a regular and repeating pattern with poorly drained soils. These soils formed in sandy marine sediment. The Fripp soils occupy ridges, and are excessively drained; they are moderately suited for septic system absorption fields with the limitation being slope. The Baratari soils occupy the troughs, and are poorly drained. They are rated severe for septic system absorption fields, due to wetness. For the purpose of this study, the severe rating was assigned to this soil complex, as a conservative approach is being taken since one of the main goals is to protect the water quality of Broad Creek.

Rd – Ridgeland Fine Sand: This is a somewhat poorly drained soil with a moderate or moderately rapid permeability, located on low ridges of the Lower Coastal Plain. It is rated severe for septic system absorption fields due to wetness, but this can be overcome with the use of carefully designed and maintained drainage systems.

Sk – Seabrook Fine Sand: This is a moderately sandy soil with rapid permeability on intermediate ridges. It has medium potential for urban uses, but it too has a high water table for part of the year, causing it to be rated severe for septic system absorption fields due to wetness and seepage. It is, however, more easily modified using drainage systems to improve the condition of the soil for septic system absorption fields. However, with a rapid permeability, the effluent leaving the septic system absorption fields will likely not be adequately cleansed before reaching the groundwater.

Sw – Seewee Fine Sand: This is a somewhat poorly drained, sandy soil on low ridges. It has a moderate to moderately rapid permeability, and the water table is within 1 to 2 feet of the surface for about five months of the year. It is rated severe for septic system absorption fields due to wetness, and has a low potential for most urban uses. However, the wetness limitation can be overcome with a well designed and maintained drainage system.

Ba – Baratari Fine Sand: This is a poorly drained fine sand, which is low in natural fertility and content of organic matter. It has a high water table, which makes it poorly suited to urban development. In some areas the high water table can be reduced somewhat through the use of underdrains, but this can be difficult if not impossible in many areas due to the low topography. This soil is rated severe for suitability for septic system absorption fields, primarily due to wetness of the soil.

Po – Polawana Loamy Fine Sand: This is a very poorly drained soil in low areas. It has a high water table and is subject to flooding, making it unsuitable for urban uses, including septic system absorption fields. These limitations can be costly to overcome, even for residential dwellings. It is rated severe for septic system absorption fields, due to flooding and wetness.

Ro – Rosedhu Fine Sand: This is a very poorly drained soil on the lowlands of the Lower Coastal Plain. This soil has a low potential for urban uses, due to the fact that it has a water table at or near the surface for eight months of the year. It is rated severe for septic system absorption fields due to flooding and wetness.

Bk – Bohicket Association: These soils make up the tidal marshes; they are inundated twice daily by tides, and they formed in silty and clayey marine sediments. Consisting of silty clays, they have very slow permeability and very low bearing capacity, making them highly unsuited to any urban uses, including onsite sewage disposal systems.

Ce – Capers Association: These soils are also marsh soils, they lie between the upland soils and the Bohicket soils. They too formed in silty and clayey marine sediments, and

consist of silty clay underlain by clay. They are very poorly drained and also have very low permeability. They are unsuited to urban uses, including onsite sewage disposal systems.

Co – Coastal Beaches: These are the sandy shorelines that border the Atlantic Ocean. These beaches are in a constant state of flux, and are subject to severe erosion during storms. They are unsuited for urban uses, including septic system absorption fields, for which they have not been rated.

The Soil Conservation Service (SCS), who published soil maps for Beaufort County in 1980, also developed a number of ratings for the soils for their suitability for various uses, from agriculture to constructing buildings on. One of these suitability ratings is for septic tank absorption fields. The SCS considered the following soil properties to develop these ratings for the soils on Hilton Head: permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding.

If the degree of soil limitation for these soil properties is rated “slight”, then the soil is generally favorable for use for septic tank absorption fields. If rated moderate (although no soils in the Broad Creek watershed are so rated) then the limitations can be overcome with relative ease. If the soil is rated “severe” then the soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special design of the system, or intensive maintenance is required to have a successfully operating onsite sewage disposal system.

Nearly all the soils in the Broad Creek watershed are rated “severe” for septic tank absorption fields. In order to make this analysis more useful, and to try to identify areas where the Town should concentrate on installing sewer systems, these ratings were further broken down by the degree of problems that must be overcome to successfully use an onsite sewage disposal system. Thus, in Map N-3, a rating of “slight” means exactly what the SCS originally stated – there are few if any soil properties which need to be addressed in order to use an onsite sewage disposal system. A rating of “severe” means the soil has one soil property which must be overcome, which in the case of the soils here is wetness – generally a high seasonal water table. While this can be costly to overcome, it is possible, and therefore these soils are not quite as bad as the next two categories.

A soil in Map N-3 rated “cost prohibitive” has such severe problems that it would be extremely costly if not impossible to install an onsite sewage disposal system that would be functional. These soils generally have flooding problems as well as a high seasonal water table, and in some cases the seasonal high water table is too high for more than

half the year. The soils rated "unsuitable" in Map N-3 are marsh soils which are inundated by tidal waters and therefore are completely unsuitable for use for onsite sewage disposal systems. Finally, there are some areas of beach sand that fall within the Broad Creek watershed which are not rated by the SCS, since they are always changing – eroding, accreting, etc., and are clearly unsuitable for onsite sewage disposal systems.

Analysis

Map N-1 shows the location of each known onsite sewage disposal system within the watershed of Broad Creek. These are color coded as follows: blue is within the corridor of Broad Creek, and is expected to have the highest potential direct impact on the creek and green is within the watershed but not within the corridor, and is expected to have a lower potential of causing pollution within the creek. Figure N-1 shows the distribution of the onsite sewage disposal systems in the watershed and corridor of Broad Creek. 66% of the systems are in the corridor.

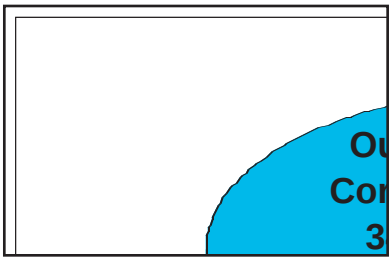


FIGURE N-1: SEPTIC LOCATIONS

Map N-2 shows the location of each onsite sewage disposal system by the availability of centralized sewer. Each dot on the map represents an existing onsite sewage disposal system: brown indicates areas with no sewer system available and no plans for installation within the foreseeable future; teal indicates areas where sewer lines have been installed already or will be within a few months of the completion of this Plan; and green indicates areas where sewer lines are planned. Of those (green) areas, Muddy Creek will be serviced with sewer within a year (it is being financed with a CDBG grant), Calibogue Cay in Sea Pines Plantation will be sewered within three years, and Stoney Creek and Twin Pines, also in Sea Pines, will be sewered within five years. Figure N-2 shows the relative distribution of onsite sewage disposal systems in the watershed and corridor (remember that the watershed includes the corridor) to the potential availability of centralized sewer.

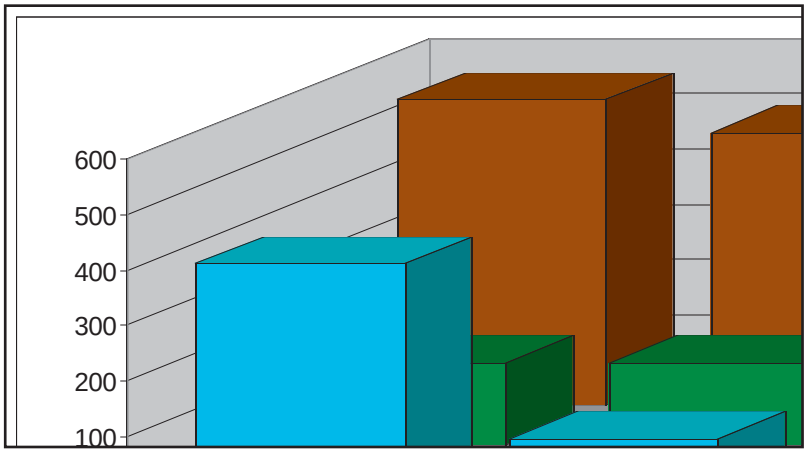


FIGURE N-2: DISTRIBUTION OF SEPTIC SYSTEMS TO SEWER AVAILABILITY

All of the areas shown with teal dots on Map N-2 (mean-

ing there are sewer lines available) most likely have at least some onsite sewage disposal systems still being used. Policies of the Public Service Districts on the island do not mandate that people connect to the sewer line immediately, or even within any specified period of time. However, SC DHEC regulations do require that if an onsite sewage disposal systems fails or needs repairs, and a centralized sewer system is available, then the onsite sewage disposal system must be abandoned and the home (or business) must connect to the sewer line. Thus, the potential of serious pollution problems arising from failing onsite sewage disposal systems in these areas is diminished, but is not eliminated.

Map N-3 shows the soils within the watershed of Broad Creek as rated for their suitability for septic system absorption fields. Overlain on this is the location of each of the onsite sewage disposal systems within the watershed. 311, or 28%, are located in soils which are rated as having slight limitations for septic system absorption fields, meaning onsite sewage disposal systems should function properly with no additional soil manipulations necessary. 787, or 72%, are located in soils that are rated “severe” for septic system absorption fields. However, 692 of those 787 systems are in soils which can be modified to overcome the limitations that give them the “severe” rating. 95 systems (or 9% of the 1,099) are located in soils which would be difficult if not impossible to overcome the limitations (rated “cost prohibitive”), and 1 system is located in a soil which is completely unsuitable for septic systems. It is these last two categories which pose the greatest hazard to water quality, due to the greater possibility of failure of the septic system absorption fields. Figure N-3 shows the relative distribution of the existing onsite sewage disposal systems and the soil suitability for the soil in which they are built.

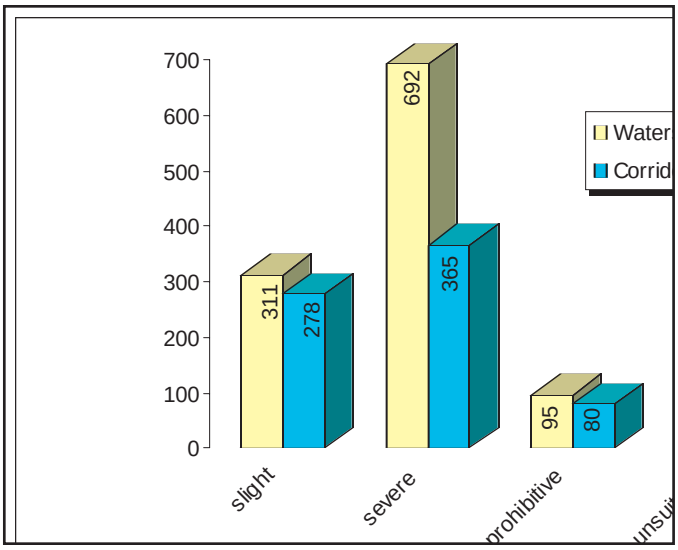
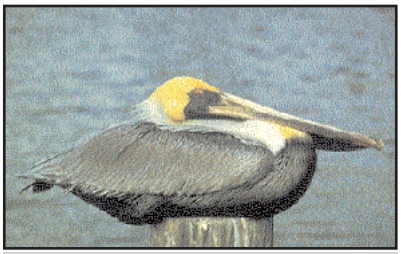


FIGURE N-3: SEPTIC SYSTEMS AND SOIL SUITABILITY

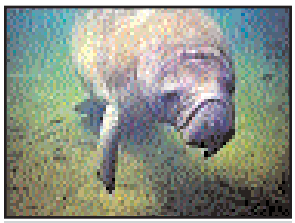
Endangered Species Observed on Broad Creek

In all, six species were observed that were or currently are listed as threatened or endangered. A brief description of these species is included below.


BROWN PELICAN

The brown pelican (*Pelecanis occidentalis*) was listed on the Federal endangered species list in 1970, but the Atlantic coast population was considered recovered and was removed from the list in 1985. It is not currently listed as threatened or endangered in South Carolina. These large birds with the distinctive throat pouch inhabit sandy coastal beaches and lagoons along the Atlantic coast from North Carolina south to Venezuela. Their apparent recovery is considered a success story of the endangered species program.

One West Indian Manatee (*Trichechus manatus*) was observed in Broad Creek. Often spotted in the waters around Hilton Head Island, these large mammals are considered endangered both Federally and in South Carolina. Manatees are found in the Southeastern United States, in the Caribbean Sea, and in South America. In the U.S., manatees are generally limited to peninsular Florida in the winter, but have been known to range as far north as southeastern Georgia, and the area around Hilton Head Island. In summer, manatees increase their range as far north as Virginia. They inhabit both salt and fresh water, and eat any type of aquatic vegetation available to them. Occasionally manatees will eat fish. They are slow moving animals who spend up to five hours per day grazing. Because of the lack of submerged aquatic vegetation, our area is not ideal manatee habitat.


MANATEE

Manatees were first listed as endangered in 1967. Their initial decline is a result of overharvesting for meat, oil, and leather. Hunting was outlawed, and current declines are thought to be the result of heavy mortality from collisions with boats and barges. In addition, destruction of seagrass beds due to coastal development has eliminated valuable manatee habitat. Efforts to increase manatee numbers are underway, but results have not been encouraging.

Also observed only once in Broad Creek was the loggerhead sea turtle (*Caretta caretta*). The loggerhead is listed as threatened in the U.S. and in South Carolina. First listed in 1978, loggerhead turtles can be found in temperate and subtropical waters throughout most of the world. Loggerheads prefer to feed in coastal bays and estuaries


LOGGERHEAD SEA TURTLE

or in the shallow water along the continental shelves of the Atlantic Ocean. Loggerhead numbers have declined due to entanglement in fishing nets and marine debris, and by a decrease in hatching success. Loggerhead hatchlings emerge from their nests on the beach and use the light of the night sky to guide them toward the sea. Lights from increased coastal development disorient turtle hatchlings, and instead of crawling to the sea they often crawl up the beach and are killed by predators. It has been estimated that only 1 of every 10,000 hatchlings survives to adulthood.

Observed twice on Broad Creek, but known to occur more often is the bald eagle, *Haliaeetus leucocephalus*, (bald eagles were spotted 6-10 times on recreational trips on Broad Creek, but only twice during wildlife monitoring trips). The bald eagle is an apparent success story. First listed as endangered in 1967, the bald eagle was downlisted to threatened in 1995 and is currently being considered for delisting entirely. Bald eagles declined in the middle of this century due in part to the widespread use of the pesticide DDT. Accumulation of DDT in the body of the bald eagle led to reproductive difficulty, and the bald eagle population (as well as many other bird species) declined dramatically. DDT use was banned in the U.S. and bald eagle numbers have rebounded.


BALD EAGLE

An additional stress on bald eagle populations has been increased loss of nesting habitat due to development. Bald eagles inhabit quiet coastal areas, rivers, and lakeshores. They feed primarily on fish, water birds, and carrion, and require large trees for nesting. The lowcountry of South Carolina offers excellent bald eagle habitat, but as development continues in the Hilton Head area, bald eagle numbers may decline.

Another endangered species observed using Broad Creek was the wood stork (*Mycteria americana*). Wood storks are considered endangered both in the U.S. and in South Carolina. First listed in 1984, wood stork numbers have declined because of loss of habitat due to wetland destruction. Wood storks inhabit fresh and brackish marshes and nest primarily in cypress and mangrove trees. They feed on small fish in the shallow water of freshwater and tidal creeks by opening their bill underwater and snapping it shut when a fish swims by. This unique snapping reflex has been


WOOD STORK

measured to be as fast as 25 milliseconds. In the U.S., wood storks were originally found mostly in southern Florida, but increased development in and near the Everglades has pushed wood stork populations northward into Georgia and South Carolina. In our area wood storks can be found in relatively high numbers at Pinckney Island National Wildlife Refuge, and can be seen feeding on Broad Creek. During our study, 30 wood storks were spotted on Broad Creek.

The piping plover (*Charadrius melodus*), a Federal and state threatened species was observed on Broad Creek six times. This sparrow-sized shore bird was listed as endangered in 1985. It inhabits the bare, dry, sandy areas of the coast that have been increasingly used for development. The piping plover ranges from Newfoundland south along the Atlantic Coast to Virginia, and winters along the Gulf and south Atlantic coasts.

PIPING PLOVER

There are five marinas that provide access to the creek. Broad Creek Marina, Palmetto Bay Marina and Shelter Cove Marina are all public marinas that provide dock space on a rental basis as well as some other basic marina services such as pump-out stations and ship's stores. Long Cove and Wexford are both private marinas whose slips are only available to landowners and guests within those communities. The following sections will discuss these marinas and their amenities in detail.

Shelter Cove Marina

Shelter Cove Marina, the largest of the three marinas, is located mid creek near the headwaters. Unlike the other two public marinas on Broad Creek, this one is tucked back into a protected cove and therefore is sheltered from the wind and currents in the main channel area of the creek; hence the name – Shelter Cove. (See Figure P-1). This marina, which has 218 slips on 13 docks, includes a fuel dock, a sewage pump-out station, a harbormaster's office, restrooms with showers, a laundry facility and a small ship's store. The average slip size is 20 to 40 feet in length, but boats up to 150' can be accommodated. Electric, water, cable television and telephone services are available at most slips.

FIGURE P-1: SHELTER COVE MARINA

Approximately one-third of the slips are rented weekly and one-third are rented monthly or yearly. The remaining one-third are occupied by permanently docked boats. Docked boats include houseboats, powerboats, sailboats and several tour boats. Kayaks are launched from the fuel dock near the harbormaster's office and generally stay in the marsh areas just outside of the entrance to the marina. The Disney resort, which is located near the marina, keeps several small power boats docked for tours and also launches kayaks from a small area near the entrance to the marina.

FIGURE P-2: THE *ADVENTURE* TOUR BOAT

Several tours also leave out of this marina. Among them are a few small powerboats which take people out on dolphin watches, a large sailboat which frequently goes on sunset cruises, and two large powerboats, the *Adventure* and the *Holiday*, which take customers around the creek and

Calibogue Sound (see Figure P-2). A parasail business has also recently begun operating out of Shelter Cove Marina, it travels out to Calibogue Sound for the parasail rides.

Surrounding Shelter Cove Marina are commercial and residential facilities that draw many tourists to the area. Several restaurants and a number of small shops line one side of the Marina. Three multi-family developments are located here, one above the commercial development on the ground floor. There is one parcel still available for additional multi-family development, although there are no plans currently under review. Although the majority of the multi-family developments are occupied by permanent residents, approximately 25% are interval occupancy (time-share) units. Map P-1 is an aerial view of Shelter Cove Marina.

Broad Creek Marina

Broad Creek Marina is located east of the Cross Island Bridge in the middle area of the creek. Map P-2 is an aerial view of this marina. Located on the north shore of the creek, this marina is subjected to strong winds and currents because of its unprotected location. The dock area is separated from the land by 700' of marsh. There is one wooden foot access pier crossing the marsh to the docks, and one concrete drive-on pier, also with foot access to the docks. This marina consists of a fueling area, a ship's store and a dry storage facility. Boats are transported by boat forklift to the water via the concrete pier (see Figure P-3). This marina is in disrepair but plans are underway for improvements.

FIGURE P-3: BOAT FORKLIFT

This marina does not offer slips but rather has 2,400' of side dockage available. This can be translated into approximately 57 slips. The majority of the dock space is rented by Island residents on a yearly basis. Boats moored along the outer dock are subject to wave action from their exposed location and to wakes from passing boats.

Visitors to this marina may rent single and double personal watercraft (PWC) or embark on one of several boat tours. The marina also offers one parasail boat that takes customers for rides out in Calibogue Sound. The PWCs use the area between the marina and the Cross Island Bridge, which is not designated as a no-wake zone.

Palmetto Bay Marina

Palmetto Bay Marina (Map P-3) is located to the west of the Cross Island Bridge on the southern shore of Broad Creek (see Figure P-4). It is also subject to strong winds and tidal currents due to its unprotected location along the main channel. Boats docked along the outer dock are subjected to wave action from the wakes of passing boats and from naturally occurring waves.

FIGURE P-4: PALMETTO BAY MARINA

This marina has 158 slips that are used for docking sailboats, powerboats (including houseboats), and tour boats. The average slip size is 20 to 40 feet in length. Most of the slips are rented on a yearly basis, while a very small percentage are rented either by the week or the month. A dry storage facility, fuel dock, pump-out station, small ship's store and a harbormaster's office are also components of this marina. The marina includes a large hoist to lift boats in or out of the water. There is a marine repair service available, as well as limited land storage.

A number of small companies operate out of Palmetto Bay Marina and rent boats or offer tours, including PWCs, kayaks, parasail rides, and several tour and charter fishing boats. All PWCs are led by a guide at idle speed through Broad Creek out into Calibogue Sound where speeds may be increased. Tours are available on two sailboats: the six-seater *Flying Circus* and a larger boat called the *Pau Hana*. Both take customers further down Broad Creek and into Calibogue Sound, often for sunset cruises.

Other uses in the Palmetto Bay Marina area include several small retail shops, a few restaurants and some multi-family residential buildings. The condominiums that are a part of this residential area are owner-occupied, the apartment complex rents its units on a yearly basis. This area also houses the clubhouse and pool facilities for the Hilton Head Yacht Club. This social and boating club, which is open to anyone, rents a small portion of the Palmetto Bay Marina dock for storage of club boats and members' dinghies.

Long Cove and Wexford Marinas

As mentioned above, there are also two private marinas located on the south shore of Broad Creek within planned unit developments. These marinas are available for use by

landowners and guests of Long Cove Club and Wexford.

FIGURE P-5: LONG COVE CLUB MARINA

Long Cove Club has two docks on Broad Creek. The smaller dock has eight slips and is privately owned. The second dock is much larger (100 slips) and has a pump-out station for boat owners in Long Cove Club (see Figure P-5). These spaces are available to Long Cove Club property owners on a first come, first served basis. Fueling service is not available at this marina. This marina is shown in detail on Map P-4.

The Wexford Marina is located behind several single-family homes and thus is not as visible as the Long Cove Marina. Boats pass through a small inlet, which leads to the Wexford Harbor locks. Within this marina, boats are protected from tide changes by the lock system. Wexford Marina has nine docks which provide a total of 142 slips. These slips may only be rented by Wexford Plantation landowners or their guests. There are also 136 homes on the waterfront which have an individual slip in front of them. The Wexford Marina does not have a fueling center, but a pump-out station is available for all residents and guests of Wexford Plantation. Map P-5 is an aerial view of this marina.

In order to fully understand the dock issue, it was determined that an up-to-date map was needed showing every dock on the creek. To create that, an existing geographic information system (GIS) line file was converted to a polygon file. The original line file had been made in 1995 by tracing the outlines of the docks from aerial photographs of the island. Data was collected for each dock for the following attributes: a dock number, date built, the number of slips and boatlifts, the general location of the dock, and a notation of whether it was located with a Global Positioning System (GPS) unit during the survey. Later an address id number was added so this database could be merged with the Town's address database, enabling each dock to be connected to a street address. It is expected that this will assist rescue personnel responding to emergencies on the creek.

The initial survey was done in October 2000 by boat, with stops at each dock to record the information listed above. For docks that were not on the 1995 map, the location of the end of the dock (farthest into the water) was recorded with a Magellan GPS unit. The shape of the dock was traced on a map. Upon completion of the field work, all data was entered into a Microsoft Access database. This was later transferred to the Town's GIS, and the points located with the GPS unit at the new docks were included in the new map.

Once that process was complete, it became apparent that the map would be out of date very quickly, as new docks were being constructed all the time. In order to accomplish quick and accurate updates to the map, it was determined that a new GPS unit which allowed the entering of polygons and attribute data in the field would be needed. A Trimble Pathfinder Pro GPS unit was purchased in the spring of 2001, and the dock database was updated in July 2001. This time the attribute data was entered into the system at the same time the polygon was created. The only office work needed was to download the new file and merge it with the existing file in the GIS.

Maps Q-1, Q-2, Q-3 and Q-4 show the docks in detail in the four general areas of the creek: the headwaters, middle area, Spanish Wells and the mouth. Starting at the headwaters and working down the creek, there are only 8 docks in the headwaters area (Map Q-1). There are 23 in the Marshland Road/Indigo Run area, and 96 in the Shelter Cove/Long Cove area (which includes Shelter Cove Marina and the community docks at Long Cove Club). There are 220 docks total in Wexford Harbour (Map Q-2). The Palmetto Bay Marina area has 26 docks (including Haig Point Embarkation), and 56 docks in Spanish Wells (Map Q-3). Finally, the Point Comfort area has 14 docks, and Sea Pines has 74 (Map Q-4).

In the past, no-wake zones were only determined through local legislation initiated and passed in the General Assembly. Beginning in 1996 the Department of Natural Resources was also given authority to designate areas as no-wake zones. When a DNR official is contacted by either an individual or a corporate body about establishing a no-wake zone, a study is conducted to determine the need and feasibility of the proposed no-wake zone. Only about 5% of these proposed no-wake zones are established.

Prior to 1998, the only no-wake zone on Broad Creek was the area between Palmetto Bay Marina and Calibogue Sound. In the early 1990s, the Town, the Clean Water Task Force and many waterfront property owners met to determine ways in which the water quality could be protected and erosion prevented. This group reviewed various studies of other tidal creeks in South Carolina to develop recommendations for the Island's waterways. As discussed in Chapter 5, these studies showed that boat wakes have a detrimental impact on the environment.

As a result of that, the Town passed a resolution in 1996 to make all Island waters no-wake zones. The Town's rationale in requesting the no-wake zones on its territorial waters included:

To protect the aesthetics of its pristine waterways;

To preserve its fish, shellfish, and wildlife;

To reduce the impact of soil erosion and accretion;

To protect the area's sensitive ecosystem; and

To uphold water quality.

Mayor Peeples stated that this request would meet the Town's goal of providing environmental protection for sensitive areas, including the creek's headwaters where wakes can cause erosion problems and harm fish and wildlife.

On December 17, 1996, the Town Council asked then Senator Cork and Representative Mullen to introduce legislation to make all Island waters no-wake zones. The House passed this bill in May of 1997. This bill was supported by environmentalists who stated that wakes can cause erosion and ecological damage to the waterways and by property owners who said that wakes damage their boats and docks.

Area commercial fisherman and watersport business owners, though, stated that a no-wake designation for the entire Creek would add to travel time and hurt their businesses. Town citizens, including members of the Hilton Head Island Fishing Club and the Association of Island Marinas, submitted documentation that stated that a trip from Shelter Cove Marina to the Calibogue Sound currently takes forty minutes. The designation of the entire creek as a no-wake zone would increase that time to one hour. Customers would then be spending two hours simply getting to and from their destination. These citizens stated that all commercial vessel operators that provide trips out of Broad Creek would soon go out of business because of an inability to provide a cruise or fishing trip that would be worth the cost. Data showed that over 55,000 residents and visitors boarded commercial vessels at Shelter Cove Marina alone in 1997.

These citizens also produced a report prepared by a local environmental scientist, Todd Ballantine, which stated that the proposed exempted two mile portion of the Creek is so wide that any wake produced in this area would be dispersed before it could reach the shorelines or marshes. In response to these objections, the Town asked for a two-mile exemption for a portion of Broad Creek in December of 1997. This portion, which runs from Shelter Cove to the Cross Island Bridge, has several no-wake zones within it in the areas of Long Cove Plantation, River Club, Otter Hole and the Broad Creek Marina.

In April of 1998, Senator Cork amended the no-wake bill to include a measure that would prohibit boats from anchoring near private docks. The House objected to the no-anchoring measure and tabled the bill on April 7, 1998. Cork then added the no-wake and no-anchoring bills to a shrimp boat bill. The House sent this to the Joint Committee which passed the no-wake zones but killed the no-anchoring zones. On May 14, 1998, the House passed the no-wake zone bill. The entire Creek except for an area from the Cross Island Bridge to the number 19 green navigational marker (a point just downstream from the first entrance to Shelter Cove Marina) was designated a no-wake zone.

Boating Safety courses should be a must for any person operating a powerboat or personal watercraft on the creek. It is important to be aware of the rules and regulations that govern the safe operation of vessels on the creek. The following section provides specific information regarding the various boating safety courses that are offered to the public.

SCDNR offers a boating safety course by both video and the Internet. Once the student completes the course, he can then take a certification test as part of that same program. Potential students may also pick up a “Boat South Carolina” handbook at their local Department of Motor Vehicles (DMV). They can then return to the DMV and take the test in that location. In all instances, if a student passes the test, he will receive a State of South Carolina boating safety certificate by mail.

In South Carolina, boat operators under the age of 16 must complete a SCDNR approved boating course in order to operate a boat or personal watercraft with a 15 horsepower motor or greater, unless accompanied by an adult age eighteen years or older. They must pass this test by 80% in order to receive a certificate and they must have this certificate with them whenever operating a boat or a personal watercraft.

United States Power Squadrons (USPS) is a non-profit educational organization established in 1914 to make boating safer and more enjoyable. They offer courses in seamanship, navigation and related subjects. This organization has 60,000 members organized into 450 squadrons across the country. The boating safety courses are open to the public and there is no age limit for participants. Successful completion of a USPS boating safety course meets the educational requirements for boat operation in all states. Courses include Seamanship, Piloting, Weather, Sail, Engine Maintenance, Celestial Navigation, Marine Electronics and Cruise Planning.

The USPS also offers self study courses on Water Sports, Boat Insurance, Oceanography, Introduction to Sailing and Preparation for Coast Guard Licensing. The USPS also offers the Squadron Boating Course and Boat Smart, both of which are designed to be useful to all types of boaters. These courses, which include homework questions at the end of each section, teach nautical rules and regulations as well as traditional boating courtesies.

The USPS also participates in the Vessel Safety Check Program, which is a proactive preventative safety program unique to the recreational boating community. It ensures that key marine safety equipment is present, is within prescribed functional limits and is compliant with Federal, State and local regulations.

The United States Coast Guard Auxiliary is a service organization open to anyone age seventeen or older. It was chartered by Congress in 1939 and its purpose is to assist the Coast Guard in any of its missions except where prohibited by statute, such as in direct law enforcement and military actions. The Auxiliary's main thrust is boating safety education. The Auxiliary offers a variety of seminar courses as well as several multi-lesson courses.

Seminar courses include the following:

Boating Fun – Adventure on the Water: teaches the basic safety concepts to children in grades K-3.

Waypoints – A Guide to Boating Safety: for older children and youths in grades 4-6.

Personal Watercraft: for those who want a brief, very basic introduction to the safety issues involved when operating a PWC.

Navigating with GPS: for those who want a brief, very basic introduction to navigating with GPS.

Multi-lesson courses include the following:

Boating Safely: Oriented towards hunters, anglers, skiers and operators of PWCs.

Boating Skills and Seamanship: for both beginning and experience powerboaters.

Sailing Fundamentals: for both beginning and experienced sailors.

Basic Coastal Navigation: an introduction to coastal piloting.

Advanced Coastal Navigation: for serious boaters who want to learn piloting techniques.

Another service that the Auxiliary offers is the Vessel Safety Check. A qualified Auxiliary Vessel Examiner, at no cost, will check boats of all sizes and types for the proper approved inventory of safety equipment carried aboard each vessel. Some of the items that this inventory includes are flares, life jackets and fire extinguishers. If all requirements are met, a decal is issued for the boat. This demonstrates that the vessel is in compliance with minimums set up by the US Coast Guard. The Auxiliary also provides a virtual safety check that allows the individual boat owner to perform a self-inspection before contacting one of the Auxiliary Vessel Examiners.

During the course of the survey of recreational use of the creek, over 1600 vessels were observed. Details and pertinent information regarding these vessels is provided in the following sections.

Commercial Vessels

Several types of commercial vessels were observed during the course of this study. The type of vessel observed most often were the commercial tour boats. The tour boats ranged from very large powerboats to small six-seater powerboats. One of the most interesting tour boats is the *Cool Stuff* amphibious vehicle which gives tours on both the land and the water.

Several tours are also offered in smaller (less than 20 feet long) power boats. These are often dolphin watching tours and are generally conducted by boats out of the Disney Resort near Shelter Cove Marina. Other small tour boats also use Broad Creek.

The *Haig Point I* and *Haig Point II* ferries disembark from the Haig Point dock, located near the Cross Island Bridge between Wexford and Palmetto Bay Marina (Figure T-1). These ferries are used to transport residents, visitors and employees to Daufuskie Island. These boats were always in use and were observed frequently coming and going throughout the course of this study.

FIGURE T-1: HAIG POINT FERRY

FIGURE T-2: *CRABBER J*

The third type of commercial vessel observed was commercial fishing tours. There are over ten charter fishing companies on Hilton Head Island. Most of these tours leave out of Palmetto Bay Marina. Some stay near the mouth of the creek while many go out to Calibogue Sound or the Atlantic. These tours typically consist of a guide taking four to five customers out to prime fishing locations. The *Crabber J*, another boat frequently seen, anchors in the creek and allows customers to drop a fishing line with bait into the water in an effort to catch a crab (see Figure T-2).

While not recorded in the survey, barges were occasionally seen. Most of these were used by companies building or re-building docks along the shoreline of Broad Creek. One small barge was anchored in the creek near River Club in Indigo Run for nearly a month.

Kayaks

The vast majority of kayaks were seen in the headwaters, and were part of small eco-tour groups led by a guide. There are currently more than ten companies on the island that offer kayak tours. Many visitors take advantage of these tours to get out on the creek and experience the natural beauty (Figure T-3). Most tours included both single and two person (double) boats.

FIGURE T-3: KAYAKERS

During the course of the survey, several locations were noted where kayaks were launched most often. These include the Old Oyster Factory restaurant, the Beaufort County public landing on Marshland Road, and less frequently at Shelter Cove Marina and Palmetto Bay Marina. Occasionally personal kayaks were also observed being launched from residential docks.

Motorized boat traffic seldom enters the headwaters of the creek, which allows the kayakers the freedom to travel along the creek in relative safety. This is important because most of the kayakers are inexperienced and would have difficulty moving out of the way of the way of a fast moving vessel. The guides typically would provide basic instruction on how to kayak and kept a close eye on the customers while out on the water.

Kayakers may also choose to remain in the headwaters area of the creek because it provides a wonderful array of natural beauty. Here kayakers may observe wildlife such as dolphins, great blue herons, cormorants and egrets as well as enjoying the solitude that a trip deep into the spartina grass provides. At low tide, oyster beds are visible and many birds can be seen foraging for food among the oysters and along the shoreline. At high tide, kayakers can explore parts of the salt marsh that are normally out of reach of boats.

Personal Watercraft

There are only two locations on Broad Creek that rent personal watercraft: Broad Creek Marina and Palmetto Bay Marina. Personal watercraft that depart from Broad Creek Marina travel a short distance to an area between the Marina and the Cross Island Bridge. This area is one of the sections of the creek that is not

FIGURE T-4: A GROUP OF PWCS

designated as a no-wake zone (see Figure T-4). PWC from Palmetto Bay Marina are led by a guide past the docks along Spanish Wells Plantation to the Calibogue Sound.

A total of 158 PWCs were observed during the survey, which is 11% of the total number of vessels observed. Of these 158 PWCs, 9 had 3 riders, 78 had 2 riders, and 71 and a single rider. Roughly half of the PWCs were out of Broad Creek Marina and half were rented from Palmetto Bay Marina. A few of the PWCs observed were privately owned and departed from individual docks along the creek.

Powerboats

During the course of the survey many small and large powerboats were observed. (See Figures T-5 and T-6). In fact, more small powerboats were seen than any other type of vessel during each of the survey trip. Most powerboats use the creek as a type of water road to access Calibogue Sound. It is believed that this is largely due to the fact that most of the creek is designated a no-wake zone while the same is not true for Calibogue Sound.

FIGURE T-5: TYPICAL SMALL BOAT


FIGURE T-6: LARGEST PRIVATE BOAT OBSERVED

During shrimping season in October, several small powerboats were observed anchored near the mouth of the creek at sunset. Throughout the course of the survey, boats were also observed anchored either near the Cross Island Bridge, the docks at Spanish Wells, or near the entrance to the Point Comfort inlet as the occupants of these boats fished. While large powerboats occasionally violated the no-wake areas, small powerboats were by far the vessel that most often ignored the no-wake designations. It was found that many children were not wearing lifejackets while aboard small powerboats and that these vessels were sometimes overcrowded.

Sailboats

Although both small and large sailboats were seen throughout this survey, large sailboats were observed in a much greater number. (See Figure T-7 on the next page). Sailboats usually were not under sail in the creek, most often the motor was in use. The sailboats observed most often were two charter boats. Both boats were viewed during the day but more often during the very early evening as they set out on sunset cruises.

FIGURE T-7: SAILBOAT

Skulls and Shells

The Hilton Head High School Rowing team, college rowing teams, and members of the Palmetto Rowing Club use Broad Creek for their rowing. These vessels typically remain in the headwaters and middle areas of the Creek, rarely will one see a skull on the west side of the Cross Island Bridge (Figure T-8). These groups currently use the dock at the Old Oyster Factory to launch these self-propelled vessels.

Members of the Palmetto Rowing Club usually use single skulls, which can be launched in any type of tide. The high school and college rowing teams typically use 6 or 8-man boats. This makes it very difficult, if not impossible, for the rowing teams to practice at low tide.

FIGURE T-8: SINGLE SKULL

These limitations, combined with a lack of adequate boat storage, have led these groups to begin the search for a new facility to launch and store their boats. Members of the Palmetto Rowing Club have approached the Town and expressed interest in finding a new location. A public-private partnership which would allow the club to build a facility on a piece of Town owned property that has better access to the creek might be a reasonable solution. This facility should only be open to non-profit rowing or kayaking groups who promote the preservation of the creek and should be used to store and launch only non-motorized boats.

The recreational survey results are in a Microsoft Access database. The following tables are summaries of the data collected. For more specific information from the database, please contact the Hilton Head Island Planning Department.

SUMMARY BY TYPE OF RECREATION

Type of Recreation	# of Observations
boating	240
fishing from land	12
other	2
sight seeing	1

SUMMARY BY TYPE OF VESSEL

Vessel	# of Observations
canoe	2
commercial - ferry	83
commercial - fishing	31
commercial - tours	111
kayak - double	134
kayak - single	253
power - double pwc	88
power - sinlge pwc	71
power - small	619
power- large	105
sail - large	24
sail - small	18
skull	15

SUMMARY BY TIME OF DAY

Time Period	Number of Trips	Number Boats Observed	Average Number Boats Observed
morning	13	359	28
afternoon	22	1,141	52
evening	2	58	29

SUMMARY BY TYPE OF DAY

Type of Day	Number of Trips	Number Boats Observed	Average Number Boats Observed
weekday	20	909	45
weekend	9	233	26
holiday	1	13	13
holiday weekend	6	403	67

SUMMARY BY WEATHER CONDITIONS

Type of Weather	Number of Trips	Number Boats Observed	Average Number Boats Observed
clear & calm	17	801	47
clear & windy	8	226	28
cloudy & calm	6	357	60
cloudy & windy	4	169	42
rainy & calm	1	5	5
rainy & windy	no trips went out under these conditions		

SUMMARY BY TIDAL CONDITIONS

Type of Tide	Number of Trips	Number Boats Observed	Average Number Boats Observed
high	9	462	51
coming in to high	2	133	67
going out from high	5	257	51
low	7	269	38
coming in from low	4	193	48
going out to low	1	55	55
mid, coming in	5	80	16
mid, going out	3	109	36

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