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An integrated approach to stormwater management in the coastal zone

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AN INTEGRATED APPROACH TO STORMWATER MANAGEMENT IN THE COASTAL ZONE

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Dedication

For Linda and Ernie Spinner

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Abstract

Undeveloped lands are inherently capable of handling the precipitation rates and severe storm events of a given area. As our communities continue to grow and expand, the stormwater management capabilities of an area's natural systems will be impacted. Without thoughtful intervention, existing natural systems will be overwhelmed to the point of dysfunction, an unfortunate circumstance that has been the case in some of this country's more urbanized areas.

The main objective of this thesis is to demonstrate the process of applying an integrated greenway stormwater management system as an alternative approach to managing the present and future stormwater needs of a developing coastal community. Research gathered from this investigation is applied to the coastal community of Bay County, Florida in the form of a case study. A greenway system for Bay County is defined as the preservation of existing and connected undeveloped areas, particularly wetlands, shorelines, and natural drainage ways, in order to conserve and protect the natural systems that are inherently capable of handling normal stormwater occurrences. Structural, nonstructural, and natural engineering stormwater best management practices are recommended as supplements to the capabilities of the greenway system's preserved areas. These best management practices are alternative approaches to the conventional concrete and steel method of stormwater management.

An important outcome of this study is the development of a three-step process for creating an integrated greenway stormwater management system. The first step is the preservation of natural systems and their inherent stormwater management capabilities. The second step is the application of appropriate greenway planning and stormwater management techniques to assist impacted or overburdened natural systems. The third step is the

development of a stormwater utility as a means of implementing an integrated greenway stormwater management system on a comprehensive scale. An integrated approach to stormwater management that incorporates the principles of greenway planning supplemented with stormwater best management practices will enable an given area's remaining natural systems to function more efficiently, thereby reducing a community's long-term costs associated with the construction and maintenance of stormwater infrastructure.

Chapter One: Introduction

Introduction

Millions of tourists travel to Florida each year for its warm, lively seas, miles of sandy beaches, coral reefs, mysterious swamps, limestone caves, and balmy, sunny days. Although not described in Florida's advertising campaigns and glossy travel brochures, rapid growth and urbanization are also characteristic of much of the state. The most recent census figures reveal a population increase of twenty-three percent in the last decade. This rapid growth rate has been accompanied by a multitude of problems ranging from insufficient infrastructure to environmental degradation to rampant suburban sprawl. While the majority of this expansion has occurred in the central and southern portions of the state, northwest Florida has also recently begun to experience this phenomenon. Conscious of the development mistakes made in central and southern Florida, city planners and concerned citizens of developing communities in northwest Florida are grappling with the issues and challenges of sustainable growth.

One such community is Bay County, Florida, a rural, coastal community that my family has called home for the last sixteen years. Located in the Florida panhandle with its southern border framed by the Gulf of Mexico, Bay County is in the early stages of the rapid growth and development being experienced by the rest of the state. With an economy based largely on tourism, Bay County takes a great deal of pride in its abundant and diverse natural resources, as is evidenced by the county's motto: "The World's Most Beautiful Beaches." This motto refers to the miles of wide, white, sandy beaches that frame the emerald green waters of the Gulf of Mexico. Fortunately, government employees, elected officials, and local citizens are making

strides to plan for and manage the approaching development in a sustainable manner so that they may preserve the very features that are driving the anticipated growth and expansion.

Problem Statement

As a graduate student of landscape architecture, I have watched Bay County's public meetings and planning efforts with a great deal of interest over the last two years. I have found the public debate both exciting and intriguing because the subject of my academic pursuits in landscape architecture and a place I know so intimately are converging. I began to wonder how I might combine my research interests in stormwater management with the environmental issues and development challenges facing Bay County.

To gain a better understanding of the issues pertaining to the environment as well as those concerning growth and development in the county, I reviewed all of the articles appearing in the "Local/State" section of Bay County's only newspaper, the Panama City News Herald, from January 1996 continuing through to the present. During this time period, the vast majority of the environmental issues concerns the county's coastal setting and includes such elements as hurricanes, flooding, erosion, and habitat destruction. The articles reporting on matters of growth focused on planning and economic development, as well as issues of insufficient infrastructure as it relates to the handling of stormwater, wastewater, and traffic problems. Of particular interest was an August 26, 2001 article reporting that the creation of a greenway is actively being considered in Bay County. Supported by the Florida Department of Environmental Protection's Office of Greenways and Trails and enthusiastically promoted by city and county officials, the Bay County greenway is intended to serve as a means of recreation and conservation.

With the information from this review of newspaper articles, an idea for a research topic began to take shape. In the realm of stormwater management, my interest lies in alternative approaches to the expensive and strictly engineered management of stormwater systems. I am also interested in the use of greenways to reconcile problems between urbanization and the resulting dysfunction of natural systems, including water systems. I wondered if the greenway being proposed for Bay County could be used to address some of the environmental issues facing the community. More specifically, could the proposed Bay County greenway be used as a sustainable means of stormwater management and an alternative approach to the expensive sea walls and underground storm sewers that will only become more extensive as the community continues its rapid expansion?

Scope

This thesis addresses the use of greenway planning in combination with stormwater treatment and mitigation practices for the purpose of stormwater management in a developing coastal community. Research gathered from this investigation will be applied as a case study to Bay County, Florida. Although matters of wastewater treatment, conservation, and recreation may be discussed in this document, they are not the main focus of this investigation. In addition, although a comparison between the costs associated with conventional approaches and those of the integrated greenway stormwater management system will be briefly mentioned, an exhaustive cost benefit analysis between the two approaches is not within the scope of this project.

Objectives

Presently there are many thousands of acres of undeveloped land in Bay County that are inherently capable of handling stormwater occurrences such as rainfall and storm surges. A

paper company-turned-real estate development corporation owns vast portions of these lands, and there are plans in place for the development of many of these acres. This anticipated growth and expansion will impact the ability of the area's natural systems to handle normal stormwater occurrences. Without thoughtful intervention, the area's existing natural systems will be overwhelmed to the point of dysfunction, an unfortunate circumstance that has been the case in some of the county's more urbanized areas.

The main objective of this thesis is to demonstrate the process of applying an integrated greenway stormwater management system as an alternative approach to managing the present and future stormwater management needs of a developing coastal community. For the purposes of this thesis, a greenway system for Bay County is defined as the preservation of existing and connected undeveloped areas, particularly wetlands, shorelines, and natural drainage ways, in order to conserve and protect the natural systems that are inherently capable of handling stormwater occurrences such as rainfall and storm surges. Structural, nonstructural, and natural engineering stormwater best management practices will supplement the capabilities of the greenway system's preserved areas. These best management practices are alternative approaches to the conventional concrete and steel method of stormwater management and include such elements as constructed wetlands, vegetated buffers, retention and detention ponds, protection of natural drainage routes, and the implementation of new technologies such as the incorporation of oil and grease separators into sewer inlets. By employing these strategies, the area's remaining natural systems will function more efficiently and thereby reduce the community's long-term costs with regard to the construction and maintenance of stormwater infrastructure.

The research gathered in this thesis will be applied to Bay County, Florida in the form of a case study. Without an integrated approach to stormwater management that incorporates the

principles of greenway planning supplemented with stormwater best management practices, future growth and development will require extensive and costly underground stormwater systems and treatment facilities.

An important outcome of this study is the development of a three-step approach to an integrated greenway stormwater management system (Figure 1.1). The first step is preserving natural systems and their inherent capacities to handle the precipitation rates and severe storm events of a given area. The second step is applying appropriate greenway planning and stormwater management techniques as an intervention strategy for assisting impacted or overburdened natural systems. The third and final step is developing a stormwater utility as a means of implementing an integrated greenway stormwater management system on a comprehensive scale.

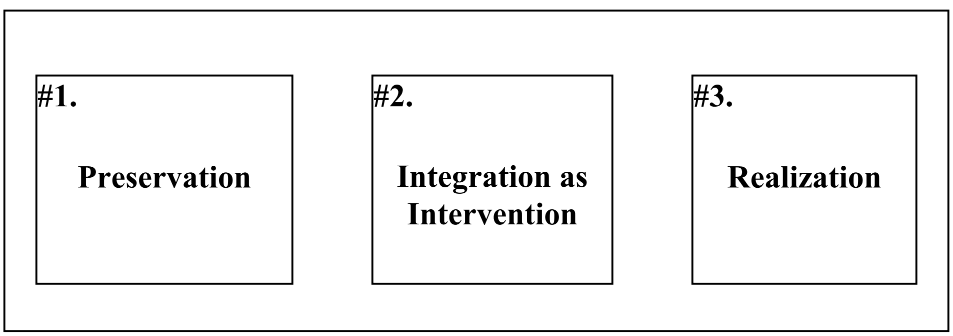

Figure 1.1 The Three Step Process

While Chapter One serves as an introduction to the background and objectives of this thesis, Chapter Two contains a review of the literature pertaining to stormwater management, coastal resource management, and the theory and practice of sustainable development. The literature review also examines greenways and the ways in which they have been used to

reconcile problems between urbanization and the resulting dysfunction of natural water systems. It also explores which of those methods of reconciliation has applicability to coastal communities. Chapter Three begins the case study portion of this thesis by establishing a visual overview of Bay County, Florida through an inventory and analysis of its natural and human resources as well as its physical and social history. A review of the county's planning documents and current stormwater management practices also occurs in this chapter. Chapter Four contains an analysis of contemporary environmental issues confronting the community from January 1996 through December 2001 as reported in the county's only newspaper, the Panama City News Herald. The application of an integrated greenway stormwater management system to Bay County is demonstrated in Chapter Five. A decision-making tool developed to aid in determining appropriate greenway planning and stormwater management techniques for various situations is also presented in this chapter along with recommendations for the development of a stormwater utility. Chapter Six presents the conclusion of this thesis and recommendations for further study.

Chapter Two: Literature Review

Prologue

Before beginning this literature review in earnest, I would like to present two writings on the subject of stormwater management. The first piece is an excerpt from a presentation made by Frederick Law Olmsted to the Boston Society of Architects in 1878. The second is a poem by Robert Frost, written in 1921. These perspectives on stormwater management are offered here in this manner for two reasons. First, it is valuable to present the human side of what can be often a very technical and mechanical topic. Second, the different times and eras in which these words and this thesis were written demonstrate the length of time in which stormwater has been evoking thoughts and ruminations in our communities.

Muddy River: A Conversation Between Frederick Law Olmsted and a Boston City Engineer

"What are your plans for dealing with the Muddy River above the Basin?"

"We have none."

"What are you likely to have there eventually-- a big conduit of masonry to carry the flood, several miles in length, and intercepting pipes for the sewerage from both sides?"

"That is not unlikely."

"Such arrangement will be very costly and will be delayed many years because of its cost. Meantime and before many years the Muddy River valley will be very dirty, unhealthy, squalid. No one will want to live in the neighborhood of it. Property will have little value and there will grow up near the best residence district of the city an unhealthy and pestilential neighborhood."

"All that is not impossible."

"Why not make an open channel there and treat the banks of it as we are going to treat the banks of the Basin. Would that not be an economical move?"

"I don't see but it would."

...."Suppose then that we put our two professional heads together again and see if we can't make a practicable plan for that purpose and get the city to adopt it" (Rybczynski, 1999, pp. 343-344).

"A Brook in the City" by Robert Frost, 1921

> "The farmhouse lingers, though averse to square
> With the new city street it has to wear
> A number in. But what about the brook
> That held the house as in an elbow-crook?
> I ask as one who knew the brook, its strength
> And impulse, having dipped a finger length
> And made it leap my knuckle, having tossed
> A flower to try its currents where they crossed.
> The meadow grass could be cemented down
> From growing under pavements of a town;
> The apple trees be sent to hearthstone flame.
> Is water wood to serve a brook the same?
> How else dispose of an immortal force
> No longer needed? Staunch it at its source
> With cinder loads dumped down? The brook was thrown
> Deep in a sewer dungeon under stone
> In fetid darkness still to live and run-
> And all for nothing it had ever done,
> Except forget to go in fear perhaps.
> No one would know except for ancient maps
> That such a brook ran water. But I wonder
> If from its being kept forever under,
> The thoughts may not have risen that so keep
> This new-built city from both work and sleep" (Lathem, 1969, p. 231).

Introduction

The topic of hydrologic systems and their interaction with human settlements is an enormous one, the entirety of which is well beyond the scope of this thesis. The purpose of this study is to demonstrate an alternative approach to conventional stormwater management through the design of a greenway system that utilizes natural systems and processes. The research findings will be applied to Bay County, Florida, a developing coastal community in the Florida panhandle that has high yearly rainfall and is prone to hurricanes and tropical storms. Much work has been done with greenways and stormwater management in upland communities, both those communities that are developing and those with a history of development. The application of integrated greenway stormwater management systems in coastal areas has not yet received the

same degree of attention. Stormwater issues in coastal communities differ from those in upland areas in that they include not only stormwater runoff but flooding from storm surges as well. The intent of this thesis, then, is to explore the following question: Can a greenway system be used as an effective approach to stormwater management in a developing coastal community? Inherently, I believe it can be, but to build a solid foundation for this argument, I set out to explore and become familiar with the existing literature. In preparation for this literature review I gathered information from several topic areas: stormwater management; coastal resources management; greenway theory and planning; and sustainable development. This literature review is organized by topic area.

Stormwater Management

<u>Stormwater and Landscape Architecture</u>

Before examining the more technical literature of this topic, this section begins with a brief history in order to demonstrate the value of landscape architecture as it contributes to stormwater management. In the profession of landscape architecture, the concept of understanding, protecting, and promoting nature's processes to formulate design solutions has been in practice since the profession's earliest days. During the 1870s Frederick Law Olmsted, the father of landscape architecture, employed this very process in the design of portions of Boston's park system. During the nineteenth century Boston experienced tremendous growth, and with this increase in population came an increase in the need for developable land. This land shortage was quickly solved with a busy period filling in much of the city's surrounding marshlands. The continuing pace of urbanization soon overwhelmed Boston's remaining tidal basins. By the mid-nineteenth century the citizenry faced serious flooding and sewage issues. The city's superintendent of sewers devised a solution that involved an extensive network of

underground pipes and masonry-lined storage facilities. Olmsted offered a suggestion for mitigating the flooding and sanitation issues that were plaguing the city by making use of Boston's coastal location. Not only did Olmsted's suggestion convince the city to disregard the heavily engineered solution in exchange for his design, but his natural system approach to urban stormwater management proved revolutionary.

With the natural processes of the area's tidal system as a guide, Olmsted designed a meandering stream and tidal basin to mitigate the impact of floodwater and filter the city's wastewater through a reconstructed salt marsh. The science of hydrology informed the design of the curving, naturalistic stream, not the pleasing aesthetics of such a form: "'the object of this crookedness is to prevent the surface of the water from being raked by the wind for any considerable distance and consequently to prevent a swell from forming'"(Rybczynski, 1999, p. 342-343). Although bridle paths and walking trails were woven through the area, its main purpose was not for recreation and pleasure. In fact, Olmsted did not view this project as a park: "The central purpose of this work is simply that of a basin for holding water, as an adjunct of the general drainage system of the city" (Rybczynski, 1999, p. 342). More than a century later, many people are unaware that Boston's Back Bay Fens was designed to address the city's serious stormwater and sanitation issues. As Olmsted said in his 1884 address to the Board of Commissioners of Boston's Department of Parks, this tidal marsh in the middle of the city "...would be novel, certainly, in labored urban grounds, and there may be a momentary question of its dignity and appropriateness...but [it] is a direct development of the original conditions of the locality in adaptation to the needs of a dense community"(Zaitzevsky, 1982, p. 57).

Stormwater Management

In order to understand stormwater management, a general knowledge of the hydrologic cycle is necessary (Figure 2.1). When rain falls to the earth, it can take several paths. The leaves and roots of plants can absorb rain. It can replenish surface water bodies or percolate into the soil thereby replenishing the groundwater. It can even evaporate back into the atmosphere. When rain falls on impermeable surfaces, like buildings, roads, and parking lots, or when it falls in quantities so large that it cannot all be absorbed by ground surfaces, it flows over the surface of the earth and is called runoff. Stormwater is the accumulation of runoff in any given area, and it has the potential for great destruction. This unfortunate fact is known by any community that has experienced flooding as a result of rivers overflowing their banks or overwhelmed storm sewer systems flooding streets and houses.

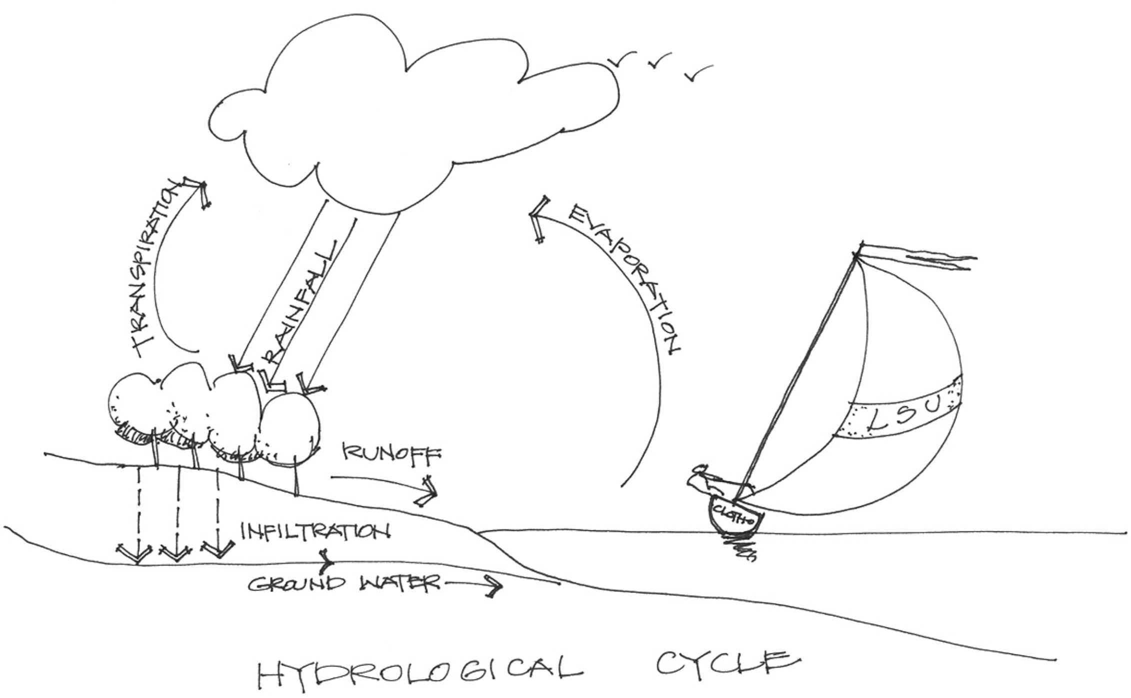

Figure 2.1 Illustration of earth's hydrologic cycle, courtesy of Professor Sadik C. Artunc, FASLA.

Stormwater management is an integral part of any community's infrastructure. It is a set of controls and practices designed to mitigate the impact of stormwater on a community and greatly reduce or even eliminate the potential for severe destruction. A broad understanding of a given region's hydrologic cycle and the effects of stormwater management on that region is representative of the macroscopic approach to stormwater management advocated by David Pyzoha, a civil engineer and the author of Implementing a Stormwater Management Program. Pyzoha's purpose is to provide a desk reference guide for public officials and consulting professionals involved in the development of stormwater management programs in their communities.

Stormwater is one element of a given region's hydrologic system that is often viewed separately from the other elements of that system. Pyzoha argues that by managing the hydrologic system as a whole and accepting that each of the elements is interconnected, the various steps taken to address or manage the macroscopic issues will address the microscopic issues as well. "The cause and effect of a myriad of controversial problems such as erosion and sediment control, wetlands preservation, and establishment of greenways can be discussed not as unrelated problems but in a comprehensive manner" (p. 5). While Pyzoha does present a straightforward, easy to understand process for developing and implementing a stormwater management program, this book is particularly valuable because of the broad-based philosophy it uses to approach the issue.

In the book Stormwater: Best Management Practices and Detention for Water Quality, Drainage, and CSO Management, authors Ben Urbonas and Peter Stahre examine stormwater as both a source of water supply as well as an issue of waste. They explain the two main questions that drive the development and application of all stormwater management plans: 1) Where does

stormwater go when it rains? 2) What does it do while it's traveling to its final destination and once it gets there? The focus of their book is best management practices for addressing the quality and quantity of stormwater in urban environments. They define and examine numerous types of best management practices in existence today, the technical composition of these practices, why and where they work, and their economic feasibility in terms of implementation and maintenance. Of the many stormwater management approaches critiqued in this text, some will be further examined and applied in the case study portion of this thesis. Those of particular interest fall into the category of nonstructural techniques such as constructed wetlands and detention basins.

The integration of science and art is one of landscape architecture's most distinguishing characteristics. To design stormwater management systems not solely for utility but for aesthetic quality and ecological integrity through the promotion of a natural systems approach is well suited to the skills and capabilities of a landscape architect. In the opening pages of Introduction to Stormwater: Concept, Purpose, Design, landscape architect and professor Bruce K. Ferguson eludes to the opportunities missed when the approach to stormwater management is solely quantitative: "The point is not a number. The point is what you are doing to the land. The goal is to solve human and environmental problems.... I offer this book as a reflection of the reciprocal evolutions of the science of hydrology and the art of design" (p. xi). While this text is similar to those mentioned previously in its analysis of stormwater management techniques, it goes further in two important ways. First, it provides a thorough tutorial on the principles of hydrology including extensive discussions of mathematical formulas and their applications for determining quantitative information needed to design stormwater management systems such as the speed and quantity of runoff, soil moisture content, evapotranspiration rates, and

groundwater and base flow quantities. Secondly and most importantly, Ferguson advocates the recognition and utilization of natural processes for stormwater management: "Hydrologic restoration is not an economic or technological imposition upon nature. It is just nature. Nature wants to work. It evolves to work. If we can just stay out of nature's way, it will work" (p. 11).

This idea of stormwater management through natural process is the underlying foundation for many of Ferguson's published works. He pursues this concept in greater detail in <u>Stormwater Infiltration</u>. On the opening page of the book's preface and with even greater conviction than in his previously mentioned text, Ferguson boldly states his position on contemporary stormwater management practices: "Too many American cities are caught up in stormwater management practices that are self-defeating and destructive" (p. 1). In this book, Ferguson argues infiltration is the most efficient, cost effective means of stormwater management not only because it prevents flooding by containing peak flows but also because it maintains ecological integrity by supporting base flows of subsurface water systems:

> Infiltration is not just a means of mitigating the hazardous aspects of stormwater; it is a means of reclaiming water resources and rehabilitating urban watersheds. Infiltration deserves to be the beginning of stormwater management, the fundamental tool for solving stormwater problems, the approach that is implemented to its fullest feasible extent before anything else is attempted (p. 4).

It is revelatory that this natural systems approach to stormwater management is advocated by a descendent, in the professional sense, of Frederick Law Olmsted, the promoter of this very idea to the Boston City Engineer in the discourse quoted at the beginning of this chapter. Natural systems were a sustainable approach to stormwater management during Olmsted's time just as they are today, so many decades later.

Best Management Practices

The topic of stormwater best management practices has been actively explored and developed for the last several decades. While there is a wealth of information in existence, two sources are particularly valuable due to their thoroughness and their capacity to make accessible the most current research, practices, and applications: the Center for Watershed Protection and the Environmental Protection Agencies Office of Wetlands, Oceans, and Watersheds. Because a detailed discussion of stormwater management best management practices occurs in chapter five, this portion of the literature review will briefly introduce the primary information sources.

The Center for Watershed Protection is a non-profit agency independent of any governmental organization, although it does have a close working relationship with the Environmental Protection Agency. Established in 1992 in Ellicott City, Maryland, the mission of the Center for Watershed Protection is to "provide local governments, activists, and watershed organizations around the country with the technical tools for protecting some of the nation's most precious natural resources: our streams, lakes and rivers" (www.cwp.org). Under the leadership of its executive director, Tom Schueler, the Center has published extensively on the topic of watershed protection. The Center has also taken an active role in promoting watershed planning on a nationwide scale through efforts such as the 'Site Planning Roundtable,' a watershed planning and site design workshop that is conducted on a local level in communities throughout the country.

The best management practices displayed in Table 2.1 below and recommended in the case study portion of this thesis are derived from publications produced by the Center for Watershed Protection and the EPA's Office of Wetlands, Oceans, and Watersheds.

Table 2.1 Best Management Practice Suitability Matrix

	Urban	Suburban	Rural	Stormwater Hotspot	Stormwater Retrofit	Slope (Max)	Groundwater Contact	Visual Amenity	Property Values	Negatives	Peak Flow Reduction	Decrease Total Runoff	Channel Protection	Groundwater Recharge	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Bacteria	Metals	Cost Effective
Infiltration Basin	N	Y	Y	N	L	0%	2-5'	-	-	M	Y	Y		Y	75%	60-70%	55-60%	90	85-90%	Y
Infiltration Trench	L	Y	Y	N	L	0%	2-5'	-	-	F	N	Y	L	Y	75%	60-70%	55-60%	90	85-90%	Y
Vegetated Swale	N	Y	Y	N	Y	1-4%	2-5'	-	-	M	N	L	N	Y	81%	29%	-	50%	14-55%	Y
Bioretention	Y	Y	Y	Y	Y	1-5%	N	Y	Y	-	N	N	N	N	-	65-87%	49%	-	43-97%	Y
Vegetated Buffer	Y	Y	Y	Y	L			Y	Y	-	Y	Y	Y	Y						Y
Vegetated Filter Strip	N	Y	Y	N	L	2-6%	2-4'	Y	-	M	Y	Y	N	Y	84%	40%	-	-	52%	Y
Dry Extended Detention Pond	L	Y	Y	Y	Y	<15%	N	N	Neg.	M	Y	N	L	N	61%	19%	31%	0%	26-54%	N
Wet Pond	L	Y	Y	Y	Y	<15%	N	Y	Y	S	Y	N	L	N	67%	48%	31%	65%	24-73%	Y
Stormwater Wetland	L	Y	Y	Y	Y	<15%	L	Y	Y	-	N	Y	L	N	71%	56%	19%	50%	14-55%	Y
Porous Pavement	Y	Y	Y	N	Y		2-5'	-	-	F	N	Y	N	Y	90%	65%	55-60%	-	98-99%	N
Sand and Organic Filters	Y	Y	Y	Y	Y	<6%	2'	-	-	M	N	N	N	Y	87%	51%	44%	55%	34-80%	Y

Key:
- Y= Yes
- N= No
- L= Limited
- M= Potential for Mosquitoes
- F= Significant Failure Rate
- S= Safety Issues

Wetlands: Natural and Constructed

Acknowledging that the purpose of stormwater treatment is the protection of public health and the health of the environment, the Environmental Protection Agency has also recognized that the "high cost of some conventional treatment processes has produced economic pressures and has caused engineers to search for creative, cost-effective and environmentally sound ways to control water pollution" (Environmental Protection Agency, 1988, p. 1). It has long been recognized that wetlands possess an inherent cleansing capacity. This knowledge has resulted in wetlands being utilized as an alternative to conventional water treatment facilities. The EPA has published several documents to meet the growing demand for alternative solutions, including a design manual for constructed wetlands and aquatic treatment systems as well as a national management measures guidance report for the protection and restoration of wetlands and riparian areas, both of which are discussed here.

Defined as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to maintain saturated conditions," a wetland's shallow, slow-moving water creates an ideal environment for dense plant growth whose roots and stems host nutrient-consuming microorganisms (Environmental Protection Agency, 1988, p. 2). This environment is also conducive to the settlement and decomposition of solid pollutants. Unless a wetland has already been degraded or severely impacted by stormwater runoff, using a naturally occurring wetland for water treatment is generally not recommended because the increased nutrient load and change in water flow will cause permanent alterations in the ecosystem. It is also more difficult to control water filtration and cleansing processes in naturally occurring wetlands. In

addition, the use of natural wetlands for wastewater treatment is limited by their designation as U.S. waters with requirements for influent water quality. For these reasons, it is better to conserve healthy, naturally occurring wetlands and create constructed wetlands for wastewater treatment. This approach "avoids the regulatory entanglements associated with natural wetlands and allows design of the wetland for optimum wastewater treatment."(Environmental Protection Agency, 1988, p. 15).

Constructed wetlands have all of the positive aspects of natural wetlands with the added benefit of greater system control for optimum water treatment performance. Designed to act as naturally occurring ecosystems, constructed wetlands have been used successfully to treat urban, agricultural, mining, and industrial wastewaters in both warm and cold climates. They can be used to treat waters with high nutrient loads as well as to finish or polish pretreated wastewater. In addition, constructed wetlands offer aesthetic amenities, the opportunity for recreational use, the ability to create wildlife habitats, and a great flexibility in location making it possible to utilize previously undesirable lands.

The costs associated with constructed wetlands can be considerably less than those of conventional wastewater treatment facilities. Energy requirements are minimal because these systems depend on sunlight, gravity, and periodic maintenance. Unlike conventional treatment plants, extensive training is not necessary to operate and maintain constructed wetlands. Limitations to the use of constructed wetlands include their land intensive nature and the potential lack of appropriate plant materials. For example, creating a constructed wetland in an area with high land values would not be cost effective and therefore likely not appropriate. It should also be noted that information regarding economic comparisons is somewhat limited. For example, the EPA cites the

cost effectiveness of constructed wetlands in their production of "a consistent effluent from a low capital investment with low labor and energy requirements as a key benefit that is noteworthy"(Environmental Protection Agency, 1988, p. 18), while an initial study by A.J. Cueto on aquatic treatment systems in Texas found that constructed wetlands were more cost-effective than conventional treatment systems only for communities with populations under 50,000.

In addition to water cleansing capabilities, constructed wetlands can be designed for multiple uses and to meet multiple needs. An excellent resource on this topic is the recently published text by Craig Cambell and Michael Ogden entitled Constructed Wetlands in the Sustainable Landscape. A multiple use approach to water management issues results in economic and environmental benefits. A constructed wetland can be designed not only for the treatment of wastewater or urban runoff but for the provision of habitat for local wildlife populations, for the purpose of educating children at a local school or nature center, or for the aesthetic enhancement of a public park, neighborhood, or commercial area. In addition to multi-use constructed wetlands, this text promotes the concept of a natural systems approach to stormwater management for reasons of economy, sustainability, and environmental integrity.

> Optimum design of the stormwater management system should mimic (and use) the features and functions of the natural stormwater system which is largely capital, energy, and maintenance cost free. Most sites contain natural features which contribute to the management of stormwater under the existing conditions…. 'Natural' engineering techniques should be used as much as possible to preserve and enhance the natural features and processes of a site to maximize the economic and environmental benefits….Design should seek to improve the effectiveness of natural systems, rather than to negate, replace, or ignore them" (Livingston and McCarron, 1991, quoted in Cambell and Ogden, 1999, p. 128).

Designing constructed wetlands to serve multiple purposes involves the multidisciplinary collaboration of design professionals. To meet the differing needs of various communities each constructed wetland must be designed for site specificity. Due to the holistic foundation of the profession of landscape architecture, it is not surprising that landscape architects are involved in developing new and innovate ways of addressing stormwater management needs.

> Landscape architects are appropriately leading the effort to develop more natural means of handling stormwater in ways that promote groundwater recharge, as well as assisting in removal of pollutants. There are now, and will be in the future strong objections to such systems by many engineers and public officials who are still looking for cookbook designs and formulas for all installations dealing with either stormwater or wastewater (Cambell and Ogden, 1999, p. 139).

"Strong objections" to the natural systems approach to stormwater management reinforces the need for interdisciplinary collaboration. The more design professionals who become involved with one another to achieve common goals in environmental design, planning and problem solving, the more successful the outcomes will be. As Cambell and Ogden write in the prologue to their text, "the most pressing need in today's world is for more meaningful integration of diverse disciplines and areas of knowledge (p. vii).

Coastal Resource Management

A coastal zone is defined as "the interface or transition...area in which processes depending on the interaction between land and sea are most intense...That part of the land affected by its proximity to the sea and that part of the ocean affected by its proximity to the land" (Sorensen and McCreary, 1990, p. vi). Coastal resource management is the management of renewable natural resources occurring in the coastal zone. In addition to

the myriad fragile ecosystems that exist in coastal zones, economic prosperity derived from the wealth of natural resources is also characteristic of these areas. In fact, a relationship of interdependence and mutual benefit exists between economic development and coastal resource management, although it is not uncommon to initially view them as at odds with one another. This position is an important theme in the text Coasts: Institutional Arrangements for Managing Coastal Resources and Environments.

The economic strength of a coastal zone is dependent upon the continuing availability of the natural resources upon which these economic enterprises are based. The Coasts text names four dominant economic sectors in a coastal zone. In the order of prosperity, these factors are fisheries, tourism, ports, and oil and gas extraction. The connection between coastal resource management and economic development is explained with the concept of coastal resource value. This value is quantified by measuring the monetary value of coastal resource production, the export earnings of coastal resource production, the number of people directly or indirectly employed in this production, and the cultural value of coastal resources that serve dietary, social, or religious needs. Destructive coastal events such as flooding, storm surge damage, and coastal erosion have a direct impact on coastal resource value and therefore on the zone's economic productivity and prosperity. By taking steps to minimize destructive forces in coastal zones and managing coastal resources for sustainability and long-term production, ecological integrity and economic prosperity both can be achieved.

The dynamic coastal zone adds another layer of complexity to the issue of stormwater management in coastal environments. In 1989, at the request of the EPA, the National Research Council's Water Science and Technology Board conducted a study on

wastewater management practices in coastal urban areas in order to make recommendations for improvement in water quality and the practice of wastewater management in coastal regions. The results of this study were later published in a book entitled Managing Wastewater in Coastal Urban Areas. Included in a list of elements impacting wastewater management, the study names stormwater and wastewater discharges, combined sewer overflows, urban runoff, agricultural runoff, contaminants leaching from soils, dredging, fish and shellfish harvesting, land development, and shipping commerce (p. 1). The book includes a thorough inventory and analysis of wastewater management practices in existence across the country as well as the identification of problem areas and recommendations for improvement to those areas.

The board found that although there have been vast improvements in water quality since the passage of the Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977 and 1987, there are still serious problems facing the health of the nation's waters. Managing wastewater in coastal areas involves a complex system of human and environmental activities. The study identifies several key issues concerning stormwater and wastewater management in coastal areas; all are based on the recognition of regional differences. The impact of water contaminants on any given region will depend on the physical, chemical and biological characteristics of the receiving waters. Policies and procedures implemented at a national level will not be effective because they will provide too much protection in some areas and not enough in others. While the current approach focuses mostly on technology for treating stormwater and wastewater, other important elements such as education, water quality monitoring, source control, and environmental studies are also valid and should be included. The board's

recommendation for managing stormwater and combined sewer overflows is a good example of this regional approach: “Stormwater and CSO abatement requirements should be based to the greatest extent possible on an understanding of regional and local hydrology and coastal oceanography. They should be designed in conjunction with other regional environmental protection programs to produce the most cost-effective program for achieving the desired level of protection for receiving waters” (National Research Council, 1993, p. 10-11).

A most interesting part of the board’s study is its proposal for an efficient and effective regional approach to the management of coastal resources resulting in coastal environmental quality. Coined ‘integrated coastal management,’ this approach “is an ecologically based, iterative process for identifying and implementing, at the regional scale, environmental objectives and cost-effective strategies for achieving them” (p. 14). Several of the principles of integrated coastal management have a great deal of merit for the case study undertaken in this thesis and are included below:

> 1. Management actions need to be developed on the basis of the best scientific knowledge available about ecological functions as well as on a comprehensive understanding of human needs and expectations.
> 2. A trans-disciplinary perspective is critical in coastal problem solving.
> 3. The system should function in a context that is responsive to scientific uncertainty about functions of coastal ecosystems.
> 4. The system should be driven by science and engineering together with public expectations (p.14).

The critical concept of integrated coastal management is the recognition of the interdisciplinary nature of coastal resource management. As with Pyzoha’s argument for engaging in a macroscopic analysis of a given region and Ferguson’s advocacy for utilizing nature’s existing hydrology, there is once again this acknowledgment of the

interwoven, connected quality of our natural systems. In fact, it is this very concept of connection that serves as the foundation for greenway theory.

Greenways

In 1987, the President's Commission on Americans Outdoors recommended that a network of greenways be built across the United States. A greenway is an outdoor, linear corridor; a place for movement and for connection. Greenways can be composed of a natural feature, like a river or ridgeline, or a man-made feature such as a utility corridor or railroad right of way. The purpose of a greenway is to join together "parks, nature reserves, cultural features, or historic sites with each other and with populated areas" (Little, 1990, p.2).

The Conservation Fund established the American Greenways program in support of the nationwide greenway network recommended by the Presidents Commission on Americans Outdoors. The American Greenways program serves as a source of information and provides services to greenway builders. It has sponsored several books on and about greenways to meet the growing demand for information. The first of these, Greenways for America, was written in 1990 by Charles Little, a conservationist and community planner. Even though greenways had been around for well over a century by the time this book was published, (Frederick Law Olmsted was designing greenways as early as 1865), this was the first comprehensive text to be written on the subject. Little provides an incisive introduction to the history and benefits of greenways:

> This is the story of a remarkable citizen-led movement to get us out of our cars and into the landscape- on paths and trails through corridors of green than can link city and country and people to nature from one end of America to the other. It is a movement that is not as well known as it should be, for it holds much promise to make the places we live and work

> a great deal more livable and a great deal more workable. My purpose is to show why and how this is so (p. 3).

One part 'Greenways 101' and one part catalyst, Greenways for America generated such excitement about the greenway movement as well as a lot of practical questions about greenway development and design that the American Greenways program sponsored a second text for use as a reference. Published in 1993, Greenways: A Guide to Planning, Design, and Development, is a resource and practical guide for greenway planners, public officials, and citizens interested in implementing a greenway system in their community. In a straightforward manner this text explains the practical aspects of developing a greenway system. It covers everything from Federal funding, to safety and liability, to management of natural features and resources. From the outset, this book emphasizes the importance of a citizen-led movement because the success rate of establishing a greenway system is simply much greater if it has grass roots support. The editor Loring B. Schwarz writes, "Because most greenways are community resources, the lifeblood of most greenway initiatives is volunteer energy and landowner support.... Citizens themselves must take control, mold their greenways to reflect the needs of their community, and develop a sense that the greenway's success is a vital part of the community's future" (p. xvii). Since the citizenry of towns and cities across the nation is the very audience that drove the production of this follow-up text, it becomes clear then why, in Greenways for America, Little writes "to make a greenway...is to make a community. And that, above all else, is what the movement is about" (p. 38).

The combination of science and design to maintain the integrity of natural systems is explored in depth in the Ecology of Greenways: Design and Function of Linear Conservation Areas. Written because there were "few practical tools to

help...ecologically minded planners and designers...apply ecology to the design of greenways," this text recognizes the interaction between humans and nature and the importance of synthesizing the human and natural environments to achieve mutually beneficial outcomes (p. ix). This approach is representative of the interdisciplinary foundation of natural systems based design. That greenways should not be seen as the answer to all of the earth's plights, but as one element of a system that will help to maintain the ecological health of our environment is an important point that is made in the introduction to this text. "In light of the fact that natural systems are inherently interactive, Ecology of Greenways stresses the need to look beyond single issues and functions and to consider multiple attributes and their interactions" (p. xiii).

The chapters in Ecology of Greenways are written by practitioners from different fields. This organization in and of itself is indicative of the interdisciplinary nature of greenway planning. Covering topics from wildlife corridors, to riparian greenways and water resources, to conflicts between recreation and nature, this text is a valuable resource whose practical, environment-specific information will be utilized for the greenway design recommendations in the case study portion of this thesis.

Sustainability

Consider for a moment the concrete drainage channels that wind through many urban communities. They do what they were designed to do and work well at whisking away stormwater at a good clip and preventing flooding in the surrounding neighborhoods. Why change this approach? Why look for another solution to address the necessity of stormwater management when the one that exists performs fairly well to the degree it was intended? There are several reasons. The most visible reason is a

sensory one: a concrete-lined drainage channel is an eyesore, as well as a periodic pain in the nose. It is little wonder that property values plummet when the neighborhood stream undergoes a concrete metamorphosis.

These canals are also quite dangerous. Although often surrounded by some sort of walls or fencing, such barriers are easily and often breached by the curious and nimble. During severe weather, water and debris travel at high speeds through these canals. With unforgiving concrete walls and no overhanging branches or roots to grasp onto, a person caught up in the surge would have little chance of survival.

There are less visible, but arguably more important reasons to rethink this approach. In our efforts to get the water out as quickly as possible, we are taking away too much of it; by trying to stay dry and prevent flooding, we're causing drought-like conditions. When rainfall and stormwater runoff are allowed to infiltrate into the soil, the groundwater system is recharged. When infiltration doesn't occur because stormwater is conveyed off site, groundwater levels will drop.

There must be a way to address these development related issues without causing harm to our surroundings or ourselves. That is where the concept of sustainability comes in. Based on the principle that it is possible for environmental conservation and community growth to mutually coexist, sustainability was defined by the United Nations World Commission on Environment and Development as "development that meets the needs of the present without compromising the ability of the future to meet its own needs"(p. 3). The point of this philosophy and the point of this thesis is that with thoughtful, science and nature based design, development becomes not only more sustainable, but much more economically responsive as well.

The analysis and understanding of natural systems for design decisions was published as a philosophy and methodology with the 1969 publication of Ian McHarg's Design with Nature. This text removes much of the complexity from understanding the ecological composition of a given region. McHarg explains the method of analyzing a regional landscape layer by layer, using a natural systems approach as his guide. Like Carson and Olmsted, McHarg expresses the importance of maintaining healthy, functioning natural systems in order to insure the health and well being of man. Accepting that man is a part of the natural environment, the balanced interaction of the human and natural ecosystems is necessary for a healthy environment. "Nature is an interacting process, a seamless web...[that] is responsive to laws...[and] constitutes a value system with intrinsic opportunities and constraints to human use" (p. 34).

McHarg was a practitioner as well as a scholar, and he applied his design-with-nature methodology in many different types of projects throughout his career. The residential community of the Woodlands, outside of Houston, Texas, is a McHarg project that is particularly applicable to this thesis. This development is cited as a precedent not only for its successful use of natural processes to address stormwater issues but also for its financial success.

Established in 1975, the Woodlands is a suburban development following McHarg's unique site suitability and land planning process. Physically developed through the recognition, understanding and conservation of natural drainage patterns, the Woodlands "is and will continue to be a showpiece of drainage design, from the most mundane details of pavement and channel design to the coordination of soils, ponds, swales, and flood plains into a comprehensive drainage system" (Spirn, 1984, p. 166).

Primary roads and major building areas were sited at the higher elevations of the wooded and relatively flat 18,000-acre site. In order to handle major storm events, the flood plain was maintained as a conservation area for park, recreation, and conservation uses. The resulting network of green spaces resulted in a landscape for wildlife habitat and corridors, multi-use recreation trails, and a sustainable stormwater management system. In addition to the use of swales, check dams, and detention and retention ponds throughout the town, special attention was given to maintaining the character and capacity of the soils in order to insure their continued drainage and filtering capabilities. By applying the principles of sustainability to the Woodlands, not only did its developers save over $14 million dollars by avoiding an extensive subsurface storm sewer conveyance system, it has remained a fashionable address for nearly thirty years (Spirn, 1984, p.163-166). As McHarg said in reference to the Woodlands, “there is no better union than virtue and profit” (McHarg and Sutton, 1975, p. 78 quoted in Lyle, 1994, p. 308).

In a report entitled <u>A Long-Term, Comprehensive Management Plan for Coastal Louisiana to Ensure Sustainable Biological Productivity, Economic Growth, and the Continued Existence of Its Unique Culture and Heritage</u>, Dr. Ivor Van Heerden discusses the benefits of applying a natural process solution to the problem of expansive wetland loss. While the focus of Van Heerden’s report is different from the focus of this thesis, the resource management principles are applicable. A natural process solution recognizes that ecological processes and systems are ever changing, so it is designed to work along with the natural order of things. By understanding nature instead of trying to control it, dynamic and adaptable solutions are created. Not only is this approach environmentally

responsive, it is economically sound in that its cost savings with regard to energy, materials, and maintenance. These principles have direct applicability to the integration of stormwater management in the design of greenway systems.

The idea of natural processes serving as the foundation for sustainable development is promoted in John Tillman Lyle's book Regenerative Design for Sustainable Development. 'Regenerative' design, meaning self-renewing, is the term he's given his philosophy of taking a natural systems approach to land-based resource planning and design. Lyle's approach to sustainable design makes the connection between humans and nature. He notes that the development of the last two centuries has been tweaked and honed into an efficient module that meets human needs and requirements- an easily repeatable solution that has been stamped across the landscape. Conversely, the natural processes of evolution and adaptation result in diverse solutions that are unique and tailored to each setting. He calls for a reconnection between people and nature and between art and science to achieve balanced developments of "environmental design...where the earth and its processes join with human culture and behavior to create form"(p. ix).

Like McHarg, Lyle was both a professor and practitioner, and he promoted the notion that human development doesn't have to mean destruction or degradation of the natural environment. He demonstrates the implementation of his theory with a set of twelve strategies based on natural processes and the interaction of these processes with human technology. For example, in the chapter entitled "Water: Going with the Flow" he explains how the first strategy, Letting Nature Do the Work, can be applied to managing water systems in a given area by "providing optimum conditions under which nature can

work most effectively" and utilizing soils, topography, vegetation, and biological processes (p. 148). An example of the fifth strategy, Matching Technology to Need, is the recognition that it is unnecessary to treat water to potable standards if irrigation is its intended use. Treating runoff for irrigation is also an example of strategy eight, Common Solutions for Disparate Problems, as is harvesting aquatic plants for animal feed. Lyle put his regenerative design philosophy to the test with the creation of the Center for Regenerative Studies at California State Polytechnic University, a research laboratory and living facility and the embodiment of Lyle's philosophy. At the Center, sustainable water consumption is implemented through the capture of rainwater with rooftop gardens, while any remaining runoff from roof spouts or paved surfaces flows into retention ponds for underground storage and irrigation. Treated effluent is also utilized for irrigation and for the Center's aquaculture ponds.

Anne Whiston Spirn's The Granite Garden is yet another important work that makes a compelling case for embracing natural systems in the planning and design of urban places. In order to make cities both more livable and sustainable, Spirn proposes nothing less than altering the all too common perception of the city from an entity at odds with nature to one that is part of nature: "This is a book about nature in cities and what the city could be like if designed in concert with natural processes, rather than in ignorance of them or in outright opposition.... Nature in the city must be cultivated, like a garden, rather than ignored or subdued"(p.ix, p. 5). Dedicating a chapter each to air, earth, water, and life, Spirn has developed a series of recommendations that directly address existing urban conditions. Even though Spirn's focus is on urban areas while this thesis concentrates on developing communities, her recommendations for managing

water resources are applicable and provide a fitting conclusion to this chapter: "The successful management of water in the city will require comprehensive efforts, many individual actions, and the perception that storm drainage, flood control, water supply, water conservation, waste disposal, and sewage treatment are all facets of a much broader system" (p. 167).

Conclusion

From the management of stormwater and coastal resources to theories of greenway systems and sustainability, the breadth of topic areas covered in this literature review demonstrates the interdisciplinary nature of environmental systems-based design. This thesis is not just about greenways, or stormwater management, or developing coastal communities in a sustainable manner, but about the integration of all of these things. It's about looking at what we already have in order to get what we need and using existing natural processes as a guide. The design of a community-wide greenway system to effectively address the impacts of storm surge and stormwater runoff is an obvious continuation of the theories and practices set forth in this chapter. A natural systems approach to stormwater management through the development of a greenway system that not only conserves greenspace and environmentally sensitive lands but that makes the greenway an integral part of a community's infrastructure is the intent of the case study portion of this thesis.

The next chapter introduces the case study portion of this thesis by establishing a visual overview of Bay County, Florida through an inventory and analysis of its natural and human resources as well as its physical and social history. A review of the county's planning documents and current stormwater management practices is also included.

Chapter Three: An Inventory and Analysis of Bay County, Florida

Introduction

To understand a landscape is to understand the features and processes that combine to form a unique environment. In simplest terms, any landscape is the sum of its parts. The purpose of this chapter is to present an inventory and analysis of the human and natural resources of Bay County, Florida. It is necessary to recognize and understand these elements in order to propose a system of greenways and soft-engineered stormwater management strategies appropriate for this area.

Natural Features and Resources

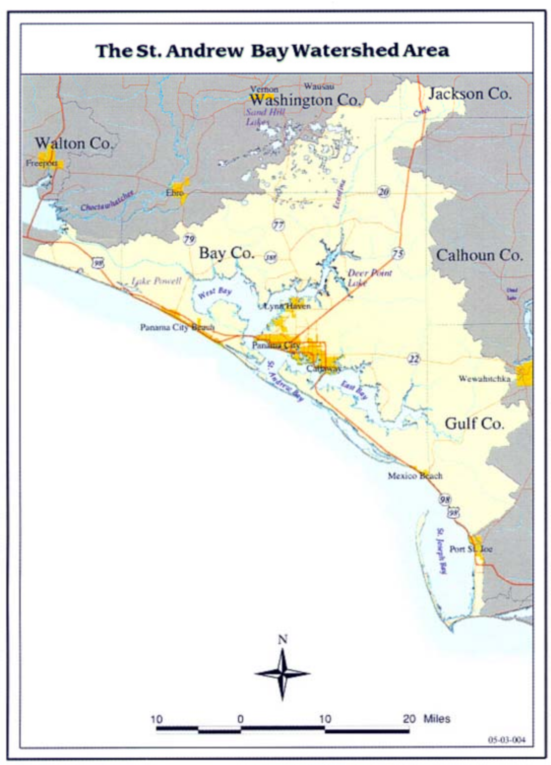

Figure 3.1 A map of the St. Andrew Bay Watershed.

Hydrology: The St. Andrew Bay Watershed

Ecologically, physically, historically, economically... in nearly every way, Bay County is inextricably linked to the St. Andrew Bay watershed. Even the name of the county reflects the significance of this water system. Bay County lies almost entirely within the St. Andrew Bay watershed, and in turn the watershed is almost entirely composed of Bay County. Two significant and unusual features characterize the St. Andrew Bay watershed. First, not only does it lie completely within the state of Florida, it lies almost entirely within the political boundaries of a single county (BEST p. 3). This physical location presents a significant opportunity in that the management of the watershed is essentially the responsibility of one county and that county's cooperative relationships with state and federal agencies. Composed of St. Andrew Bay and its contributing bayous, lagoons, lakes, and creeks, the watershed's second unusual aspect is that is does not include a river. This absence has played a meaningful role in the composition and characteristics of the bay's ecology.

St. Andrew Bay is believed to have formed about 5,000 years ago when the sea levels rose to their present heights and flooded coastal creek valleys. Long shore currents and wave action formed a sand barrier that enclosed the flooded area thereby creating the bay. Classified as a high salinity estuary, St. Andrew Bay is actually a composite of four smaller bays totaling an area of 69,120 acres: West Bay, North Bay, East Bay, and Lower St. Andrew Bay. The main tributaries to the bay are Bear Creek, Big Cedar Creek, Econfina Creek, Sandy Creek, and Wetapo Creek, all of which when combined form a drainage area of 3500 km and a total freshwater discharge of less than 1000cfs. Econfina Creek, composed of flow from springs fed by the Floridan aquifer, is the bay's largest

inflow of freshwater with a discharge rate of 538 cubic feet per second (cfs). The relatively small amount of freshwater inflow combined with limited sediment deposition has resulted in a bay that is naturally deep, clear, and high in salinity. This combination of elements has created an environment of diverse habitats that support an array of species during various life cycle stages.

Subsurface Hydrology

Bay County is underlain by the Floridan aquifer, a major source of potable water for Florida, Alabama, and Georgia. A shallow, surficial aquifer overlays the Floridan in some areas of the county, and it is this shallow sand aquifer that supports the area's surface streams. The majority of Bay County is classified as a high recharge area for the aquifers, a classification given to upland areas with poorly developed stream drainage systems and well-drained, porous, sandy soils that allow for efficient rainfall infiltration.

In the Florida panhandle, surface water and ground water are closely connected and what happens to one will certainly affect the other. All of the panhandle's potable water floats on a saline groundwater layer supported by the Atlantic Ocean and the Gulf of Mexico. Saltwater intrusion is a disastrous consequence that occurs when more potable water is drawn out of the aquifer than is replaced. This causes the saline layer to rise and push the less dense, potable water closer to the surface permanently loosing depth and capacity. Fortunately saltwater intrusion in Bay County has not occurred to the extent experienced in central and south Florida because the development pressures have not yet reached the same levels of intensity.

Regulating Agencies

The Environmental Protection Agency (EPA), through the Clean Water Act of 1972 and the Water Quality Act of 1987, regulates water quality in Bay County federally. The EPA issues national pollutant discharge elimination system (NPDES) permits to individuals, companies, and agencies whose facilities are sources of water pollutants. In the state of Florida the Florida Department of Environmental Protection (FDEP) administers the issuance and regulation of these permits. Furthermore, water management districts established by the state legislature's Surface Water Improvement and Management (SWIM) Act of 1987 manage Florida's regional water resources. The waters of Bay County fall within the Northwest Florida Water Management District (NWFWMD). The Bay County Comprehensive Plan serves to carry out state and federal water quality regulations at the local level.

Water Quality Research and Recommendations

The state of Florida has a water classification system that rates surface waters from Class I to Class V. Bay County's waters fall into Classes I, II, and III, with Class I designated for potable water, Class II for shellfish propagation and harvesting, and Class III for recreation and the healthy existence of fish and wildlife. Portions of St. Andrew Bay and the Gulf of Mexico, including 25,000 acres of submerged lands have been designated a Florida State Aquatic Preserve. Because of this designation, the water within the preserve is classified as an Outstanding Florida Water. Falling within the boundaries of St. Andrews State Park and managed by the Florida Department of Environmental Protection, state law requires that the water quality in aquatic preserves not be degraded. Maintaining the water quality of an Outstanding Florida Water will be a

challenge because this area includes two federally maintained dredge channels and the county's highest concentration of boat traffic. In addition, the preserve is in the area of the bay system that receives the most stormwater runoff because the surrounding lands are the county's most developed. Furthermore, because this preserve includes the two channels through which the exchange of salt water and fresh water occurs during the 1.2 foot diurnal tides, pollutants from the bay system pass through the preserve daily which must certainly impact the water quality.

United States Fish and Wildlife Service

For a twelve-year study period (1985-1997), the U.S. Fish and Wildlife Service (USFWS) gathered sediment samples from 105 locations throughout St. Andrew Bay to evaluate environmental contaminants. Overseen by Michael Brim, environmental contaminants specialist for the USFWS, the purpose of this study was to determine the chemical health of the bay and to begin a sediment mapping record. In a published report entitled Environmental Contaminants Evaluation of St. Andrew Bay, Florida, Brim concluded that sediment contamination had occurred in some locations of the bay, particularly in its bayous. The St. Andrew Bay watershed contains fifty-nine bayous that generally have poor flushing capabilities and clay content soils that retain toxins. Of the pollutants recorded in the bayous, the most notable contamination levels were in Watson Bayou, Massalina Bayou, Martin Lake, and Shoal Point Bayou. All of these bayous are located in densely developed areas of Bay County with decades of human use and impact. Both point and nonpoint sources of pollution were identified as the sources of contaminants.

In this report, Brim makes recommendations for all of the bays that make up the St. Andrew Bay system. In North Bay, East Bay and Lower St. Andrew Bay he sites stormwater runoff as the biggest contributor of pollutants. In West Bay, a water body surrounded by the least amount of developed land in the county, Brim sites effluent from a wastewater treatment plant and a power plant as the major sources of pollutants. West Bay is classified as a Class II water body, or suitable for shellfish propagation and harvesting. Unfortunately, because wastewater effluent is emptied into this bay, shellfish harvesting is prohibited. Even though the lands around West Bay are the county's least developed and currently used almost exclusively for silviculture, there are plans to begin developing this area for housing and commercial use immediately. Included in these development plans is the new, 4800-acre Bay County/Panama City International Airport. Wetlands currently make up 46 percent of the site selected as the location of the new airport. Although stormwater runoff is not presently the main contributor of pollutants to West Bay, it seems only a matter of time until it takes that position. Brim's report on the bay system's environmental contaminant levels concludes with one main recommendation to the county and its municipalities, and that is to address stormwater runoff: "Design and implement a coordinated management system that provides for the control of urban stormwater draining into St. Andrew Bay, and the conservation of wetlands, the Bay, and its tributaries" (p. 82).

Bay Environmental Study Team

The Bay Environmental Study Team (BEST) is a nonprofit organization that formed in 1987 from a volunteer group of concerned citizens, educators, researchers, government and military agencies, and representatives from the economic sector whose

shared concern was the preservation of St. Andrew Bay and its environs. BEST states that its purpose is "to maintain and restore a healthy St. Andrew Bay Ecosystem for the benefit of the people. The mission of BEST is to evaluate the status of St. Andrew Bay, identify problems, and initiate corrective actions were necessary" (BEST and FDEP, 1998, p. 4). Conducting extensive research, promoting education and awareness, and lobbying for the bay's protection, BEST has been an active participant in the preservation of the St. Andrew Bay ecosystem.

In a joint effort between BEST and the FDEP, a management plan for the St. Andrew Bay watershed was written and published in 1998 with a follow-up supplement in 2001. Entitled Managing the Nearshore Waters of Northwest Florida: St. Andrew Bay, A Look to the Future, this thorough and thoughtful publication presents a set of guidelines and management measures on a watershed scale. The plan recognizes the interaction between the natural and human systems within the watershed and has developed a set of actions and strategies to address the management of those systems in an effort to insure the continued health of the ecosystem. In fact, when the Florida legislature required its water management districts to prepare management plans for each of their watersheds, much of the ecosystem management plan developed by BEST was incorporated into the NWFWMD plan for the St. Andrew Bay Watershed.

Stormwater runoff is identified in the BEST plan as the greatest threat to water quality within the watershed: "Stormwater runoff has been identified as the primary threat to the maintenance of the water and sediment quality of St. Andrew Bay Ecosystem by BEST" (p. 109). In the section devoted to stormwater management, the following four strategies are recommended: improve maintenance of existing stormwater

treatment facilities; survey stormwater sediment quality in existing treatment ponds; and retrofit stormwater infrastructure constructed prior to 1982. All of these strategies revolve around issues of maintenance that necessarily require funding. A fourth strategy is listed in the 2001 supplemental publication: investigate the advantages and disadvantages of organizing a stormwater utility for Bay County (Keppner and Keppner, 2001, p. 71). The BEST recommendations for stormwater system maintenance and upgrades combined with the legitimate concern for financing presents a genuine opportunity for the implementation of the integrated stormwater management approach proposed in this thesis.

Physiography

Bay County lies almost entirely within the terraced Coastal Lowland region of the Coastal Plain province. The Coastal Lowland is subdivided into eight terraces, each formed from previous sea levels. The terraces are categorized by their current elevations above sea level. The eight terraces occurring in the county are: Hazelhurst Terrace with an elevation of 215 to 300 feet; Coharie Terrace with an elevation of 120 to 215 feet, Sunderland Terrace from 100 to 170 feet, Wicomico Terrace from 70 to 100 feet, Penholoway Terrace from 42 to 70 feet, Talbot Terrace from 25 to 42 feet, Pamlico Terrace from 8 to 25 feet, and Silver Bluff Terrace from 0 to 10 feet above sea level. The soils are well drained on the terraces of higher elevations and become more poorly drained as elevation decreases. Of the nine general soil categories occurring in the county, all are sandy with the exception of an area of loamy soil around Youngstown in the northeastern section of the county. A more thorough examination of the soil types and their characteristics will occur in the matrix portion of this chapter.

Small portions of northern Bay County fall within the Northern Highlands region of the Coastal Plain province and contain portions of the Greenhead Slope, the Fountain Slope, and the New Hope Ridge. These slopes are massive sand deposits that formed when the sea stood at a higher level. It is thought that they were the beginnings of barrier islands. Greenhead Slope contains many karst lakes which are small, round lakes that have formed inside circular depressions. These lakes have well-drained soils that are very low in nutrients making the water very clear, soft, and acidic. Karst lakes serve as recharge areas for the Floridan aquifer, and they are considered some of the most pristine environments of the panhandle. The Greenhead slope also has steepheads, a small number of which occur in Bay County. Steepheads are a unique formation caused from groundwater leaking out from a slope composed of very porous sediment at the head of a stream catchment. Sand is carried away by the groundwater and over time a U-shaped, amphitheater-like valley is formed.

Geology

Bay County is located within the Apalachicola Embayment geologic structure of the Florida panhandle. This structure is known as a graben, or a portion of land lower than its surroundings. It is composed largely of clastic, or fragmental, sediments that play an important role in the ecology of the panhandle because they differ from the carbonite sediments of the surrounding, higher, geologic structures in their physical composition, chemistry, and weathering (Wolfe, Reidenauer, and Means, 1988, p. 5). Most of the county's soils are Pleistocene or recent in age. The following sediments compose the county's surface geology: Holocene undifferentiated, Pleistocene Biloxi formation, Pleistocene fine sand and silt, Pliocene bluff formation, and the Miocene

citronelle formation. The county's surface geology is relatively recent and while it does influence the area's infiltration and drainage characteristics to some degree, it is the area's soils that have the greatest impact on these elements. A discussion of the county's soils appears in the next section.

The barrier islands of the Florida panhandle are recent geologic features that have formed in the last 6,000 years when the present sea level was established. Although often described as a barrier island, Bay County's Shell Island is actually a spit that became an island when the East and West passes were dredged. In the early 1970s an interesting discovery was made off the coast of Panama City Beach. Under 18 meters of sand and 6 to 15 meters of water, an ancient forest was discovered with wood dating back 27,000 to 36,500 years. This forest is thought to be part of a forest system that covered a large portion of this area when the sea was at a lower level. The wood of this ancient forest consists mostly of pine and a few hardwood species such as elm, oak, beach and hickory. This mix is very similar to that presently existing 32-48 km to the north of Panama City. The discovery of this ancient forest lends credence to the theory that the panhandle's barrier island formations are recent.

A present coastline that is relatively stable and a sea floor that is tectonically inactive characterize the marine geology of Bay County. The county's beaches are composed of a white, quartz sand, and Panama City Beach anchors one end of a mainland beach that stretches unbroken for 85 kilometers westward to Destin, Florida. A littoral drift travels from west to east forming a concave shoreline until it reaches the eastern portion of Bay County where the drift changes from east to west and marks an area of the panhandle coastline that is presently eroding.

Soils

Bay County contains fifty-three soil types. These types are grouped into nine map units that are then organized into five categories. For the purposes of this thesis, any discussion of soils and soil characteristics will occur mostly on the unit and category levels. A detailed description and analysis of the county's fifty-three soil types is available in the Soil Survey of Bay County Florida, for which a complete citation appears in the bibliography of this thesis. The Soil Survey labels Bay County's soil map units 'one' through 'nine,' with one being the most well drained and nine being the least. The soil units and their categories are organizes as follows: soil types in units one and two are categorized as Soils of the Sand Ridges; soils in unit three are Soils of the Low Uplands and High Flatwoods; soils in units four, five, and six are Soils of the Flatwoods; soils in units seven and eight are Soils of the Wet Depressions, Flood Plains, Swamps, and Marshes; and soils in unit nine are Soils of the Tidal Marshes.

All soil types are unique. Depending on their characteristics, some soil types are more suitable for farming, while others provide a good foundation for roads and built structures. One characteristic of particular relevance to this thesis is the excess water storage capacity of the different types of soils present in Bay County. This information is valuable because it enables the community to make informed decisions about the impacts of development in a particular area.

Using the information provided in "Table 15.--Chemical and Physical Properties of the Soils" of the Bay County Soil Survey, the excess water storage capacity for a given design storm can be determined. Assuming that all soil types are twelve percent air by volume, the available water storage capacity is calculated by multiplying the depth of

Table 3.1 Available Water Storage Capacity in Bay County Soils for a 25-Year Design Storm*

Soil Groups		Soil Name	Drainage	Depth of Permeable Soil	Least Depth to Seasonal Water Table	Available Storage Capacity	Clearance/ Undisturbed	% Clearance	Hydrologic Group/Rate of Infiltration**
Soils of the Sand Ridges	1	Kureb	Excessive	80”	>72”	8.64%	6.39:1	74%	A
		Resota	Moderate	80”	42”	5.04”	2.79:1	55%	A
		Mandarin	Poor	25”	18”	2.16”	--	--	B/D
	2	Lakeland	Excessive	37”	>72”	8.64”	6.39:1	74%	A
		Foxworth	Moderate	80”	42”	5.04”	2.79:1	55%	A
		Centenary	Moderate	73”	42”	5.04”	2.79:1	55%	B
Soils of the Low Uplands and High Flatwoods	3	Leefield	Poor	28”	18”	2.16”	--	--	C
		Albany	Poor	54”	12”	1.44”	--	--	C
		Stilson	Moderate	34”	30”	3.6”	1.35:1	38%	B
Soils of the Flatwoods	4	Hurricane	Poor	51”	24”	2.88”	.63:1	22%	C
		Chipley	Poor	8”	24”	2.88”	.63:1	22%	C
		Albany	Poor	48”	12”	1.44”	--	--	C
	5	Pottsburg	Poor	64”	0”	0”	--	--	B/D
		Leon	Poor	15”	0”	0”	--	--	B/D
		Rutledge	Poor	80”	0”	0”	--	--	B/D
	6	Plummer	Poor	48”	0”	0”	--	--	B/D
		Pelham	Poor	34”	6”	.72”	--	--	B/D

Notes for Table 3.1: * A 25-Year Storm in Bay County, Florida has a rainfall intensity rate of 3.5 inches per hour.

** A= High Infiltration; B= Moderate Infiltration; C=Slow Infiltration; D= Very Slow Infiltration; -- = Unsuitable for excess water storage capacity.

Soils of the Wet Depressions, Flood Plains, Swamps, and Marshes (Soil Groups 7 and 8) and Soils of the Tidal Marshes (Soil Group 9) are not listed in Table 3.1 because they are unsuitable for excess water storage capacity.

unsaturated permeable soil above the seasonal high water table by .12. Subtracting the design rainfall from the amount of water storage capacity gives the land clearance rate for any given soil (Wallace, McHarg, Roberts, and Todd, 1974, p. 19). For example, a Resota soil (unit one, Soils of the Sand Ridges category) has an unsaturated permeable soil depth of forty-two inches (Soil Conservation Service, 1984, p. 136). Assuming that twelve percent, or 5.04 inches, is available for excess water storage, subtract the design storm rainfall (in this case a 25-year storm with a

precipitation rate of 3.5” per hour) from the available storage capacity to get a clearance ratio of 5.14: 1. This ratio means that one acre of undeveloped Resota soil can manage the runoff from 5.14 developed acres, or that one-acre of Resota soil can be developed to 31 percent without producing excess runoff. This method enables development densities to be determined by existing environmental factors, thereby serving as a sustainable alternative to density decisions based on existing utilities or political factors. Table 3.1 below displays the excess water storage capacity and clearance rates for Bay County’s soils.

Vegetation

From the upland areas of the Hazelhurst Terrace to the coastal shorelines, there is an array of diverse vegetative habitats existing in Bay County today. In examining each of these habitats, it is clear that they are all related to or dependent upon either fire or the past and present influences of the Floridan aquifer and the Gulf of Mexico, or both.

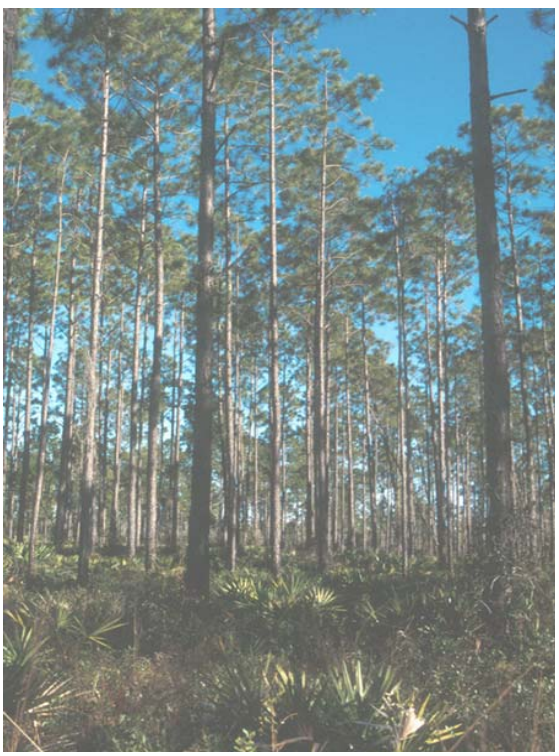

Figure 3.2 Slash pine and saw palmettos in pine flatwoods ecosystem.

Figure 3.3 Sand pine, saw palmetto, and turkey oak in a pine scrub ecosystem.

Pine flatwoods make up the majority of the county (Figure 3.2). Very little of this ecosystem has remained in it's natural state. Originally composed of virgin yellow long-leaf pine forests, these areas were almost completely logged in the early part of the twentieth century. Today these pine flatwoods range from open forests with a dense understory of shrubs and grasses to dense pine forests with little understory, and most are managed for timber production. Characterized by frequent fires and sandy, poorly drained, acidic soils the dominant species are slash pine (*Pinus elliottii*) and long-leaf pine (*Pinus palustris*). The shrubs are mostly saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), yaupon holly (*Ilex vomitoria*), and members of the Heath Family (*Ericaceae* spp.). Wiregrass (*Aristida stricta*) is the dominant grass.

The high pine habitat occurs on the uplands and deep sand ridges in the northern portions of the county. Containing well-drained soils, this type of habitat generally emerges from the pine flatwoods at the higher elevations. Open woodlands and frequent fires of low intensity characterize these ecosystems. The dominant species are long-leaf pine (*Pinus palustris*) and several deciduous oak species including turkey oak (*Quercus laevis*), bluejack oak (*Quercus incana*), southern red oak (*Quercus falcata*), sand post oak (*Quercus margaretta*), and blackjack oak (*Quercus marilandica*).

Pine scrub occurs along the coast and in areas of well-drained soils (Figure 3.3). The soils are very low in nutrients and are composed of mostly white or light-colored sands. The dominant tree species is the sand pine (*Pinus clausa*). Several hardwoods with evergreen or persistent foliage are also present in the scrub and these include sand live oak (*Quercus geminata*) and myrtle oak (*Quercus myrtifolia*). Pine scrub often has a dense, thicket-like aspect, and fires are infrequent but of high intensity. Due to the dense nature of this environment, shrubs and grasses are sparse and the groundcover is mostly lichen and bare sand.

Figure 3.4 The stable dune zone.

The coastal beach is subdivided into three categories: the upper beach and fore dune zone, the transitional zone, and the stable dune zone. The upper beach and fore dune zone is the most dynamic of these areas, always changing as a result of the weather and the tides. Composed mostly of white quartz sand, this area supports a few grasses, shrubs, and herbaceous plants, all salt and drought tolerant with extensive root systems. The dominant flora in this area is sea oats (*Uniola paniculata*), beach cordrass (*Spartina patens*), beach morning glory (*Ipomoea stolonifera*), and salt grass (*Distichlis spicata*). The transitional back dune zone is on the leeward side of the fore dune and upper beach zone. Although not entirely stable, this zone is certainly less active than the former. The vegetative cover is less than fifty percent with the major species being Gulf bluestem (*Schizachyrium maritimum*), woody goldenrod (*Chrysoma*

pauciflosculosa), and Florida rosemary (*Ceratiola ericoides*). It is also common to see sand live oak, yaupon holly, saw palmetto, and cabbage palm scattered throughout this area. The stable dune zone is, as its name implies, rather firm and steady (Figure 3.4). The dominant species in this area are sand live oak, myrtle oak, slash pine, Florida rosemary, shrubby mint, and woody goldenrod. Hardwood forests *(Quercus* spp.) known as maritime hammocks are also prevalent.

Figure 3.5 Salt Marsh

Several different types of wetland and aquatic habitats exist in the county. Bogs, which often occur in or near the pine flatwoods, are wetland areas of saturated, acidic soils. They contain a variety of interesting and unusual plant species including pitcher plants and bladderwarts. There are also several kinds of swamps in the area such as ti-ti swamps, cypress swamps, and tupelo swamps. Both fresh and saltwater marshes are prevalent. In the freshwater

marshes there are various types of sedges, grasses, and rushes including sawgrass, beakrush, and cattail. The saltwater marshes are dominated by needle rush (*Juncus roemarianus*) and also contain smooth cordgrass (*Spartina alterniflora*) (Figure 3.5).

Within the bay system there are 6,200 acres of sea grasses, with the majority occurring in West Bay and Grand Lagoon. These sea grass beds are extremely valuable to the bay's ecosystem and are very important for the productivity and shelter of finfish and shellfish. They are also quite vulnerable to pollutants such as those carried in stormwater runoff. The dominant grasses are turtle grass (*Thalasia testudinum*), shoal grass (*Halodule wrightii*), manatee grass (Syringodium filiforme), star grass (*Halophila engelmannii*) and widgeon grass (*Ruppia maritima*).

Fauna

With the exception of its southern portion, Bay County is still largely undeveloped and rural in character. Fortunately a lot of wildlife habitat remains and supports many different species. Some of these species are pursued for recreational hunting such as white tailed dear, turkey, quail, and waterfowl. Other wildlife living in the area includes gray fox, red fox, coyote, bobcat, raccoon, opossum, rabbits, amphibians, reptiles, and a large variety of both migratory and resident birds. The Bay County Audubon Society's annual Christmas migratory bird counts consistently list around 130 different bird species. A 1996 inventory of marine life in or around the St. Andrew Bay system listed 2,049 different animal species ranging from invertebrates to marine mammals. The loggerhead turtle, green turtle, and leatherback turtle nest on Panama City Beach from late May until mid August, followed by young turtles hatching through late October (Figure 5.6). Volunteers for the Bay County Turtle Watch patrol the beaches looking for turtle nests to rope off and monitor during the nesting season. In December 2001, an ordinance was

Figure 3.6 Green turtle after nesting
(Tammy Summers, Public Information Bulletin 01-4, NWFWMD)

passed mandating that all hotels, motels, and homes along the beach must have light-dimming mechanisms on all of their gulf-facing light fixtures so that the young turtles don't head in the wrong direction because they have confused the shore lights with the moon light.

Many endangered, threatened, or sensitive animal species reside in Bay County. Several turtle species appear on this list including all of those species nesting on the beaches as well as the hawksbill turtle, the Atlantic ridley turtle, and the alligator snapping turtle. Other endangered species include the east indigo snake, the gopher tortoise, the brown pelican, the Arctic peregrine falcon, and the West Indian manatee.

Figure 3.7: A pair of dolphins in St. Andrew Bay.

Climate

Long, humid summers and short, mild winters characterize Bay County's warm subtropical climate. Summer temperatures range from 74 to 87 degrees Fahrenheit, although temperatures reach 90 degrees Fahrenheit or higher on an average of nineteen days a month from June through September. Winter temperatures range from 51 to 68 degrees Fahrenheit, although freezing temperatures are not uncommon. The average first frost date falls in late November with the last frost date falling in early March. Nearly half the days in January experience low temperatures at or below 32 degrees Fahrenheit. Wind speed averages 7.5 miles per hour with prevailing winds coming from the south and southwest except for the winter months when the winds blow from the northwest.

Rainfall averages 60 inches per year, with generally 5 inches per month falling in the winter and spring, and six inches in the summer. July experiences the most amount of rainfall at nearly 8 inches. Summer showers rarely last all day and are generally brief and of high intensity. October and November are the driest months with little rainfall and low humidity. Hurricane season lasts from June until November, and as the newspaper articles demonstrated in the last chapter, hurricane and tropical storm activity is common in this area. On average, Bay county experiences the impacts from one named storm per season.

Human Resources and Features

Geo/Political Contex

Bay County is located in northwest Florida on the Gulf of Mexico and has a total land area of 764 square miles. At its widest and longest the county measures 36 miles by 44 miles with an average elevation of 21 feet above sea level. The county is composed of eight municipalities: Callaway, Cedar Grove, Lynn Haven, Mexico Beach, Panama City, Panama City Beach, Parker

and Springfield. Panama City, in southern Bay County, is the largest municipality and the county seat. It is located 98 miles southwest of Tallahassee, Florida, 100 miles east of Pensacola, Florida, and 81 miles south of Dothan, Alabama.

Figure 3.8 Bay County is located in northwest Florida on the Gulf of Mexico

History of Bay County

It is believed that sixteenth century Spanish explorers named St. Andrew Bay. These early expeditioners were accompanied by representatives of the Catholic Church whose practice was to name new land discoveries after the saint on whose day the discovery was made. Because Cape San Blas in neighboring Gulf County to the east is believed to have been named after Saint Blais whose day is February 3, it follows that the saint of February 4, St. Andre, would be the namesake of the next significant feature along the coast, a bay that is now called St. Andrew Bay. Because of the narrow, treacherous water passages that linked the Gulf of Mexico with St. Andrew Bay, early explorers passed by this area for the easier accesses to the east and west.

Figure 3.9 Creek Indian Village entrance sign

Settlers did not begin to arrive in this area until the early 1800s, and even then they were largely composed of planters from the northern portions of the state who built vacation cottages here. Early settlers reported hundreds of Indian mounds around St. Andrew Bay, a testament to the long presence of the Creek Indian tribe in this area of Florida. Although most of these mounds are no longer in existence, there remains a Creek Indian village in northern Bay County.

By the mid-1800s there were enough residents to warrant the opening of the St. Andrew's Bay Post Office on October 23, 1845. The town's people made a living off of fishing and citrus, and during the Civil War the area became an important salt-making location. Although very little fighting took place along the bay during the Civil War, Union soldiers leveled all of the homes in St. Andrew's in March 1863 in retaliation for the death of two soldiers. Lured by the vast, virgin forests of yellow long-leaf pine, the next wave of settlers arrived in the late nineteenth century. Photographs from that time depict men standing beside trees with trunks

fifteen feet in diameter. Wanted for timber and turpentine, these forests were decimated in a span of thirty years.

Bay County was officially incorporated on April 24, 1913 from portions of Washington and Calhoun counties. The deep water bay and the vast stretches of scraggly pines that emerged after the extensive logging made the area an attractive location for a paper mill, and in 1931 International Paper company built Florida's first paper mill in Bay County. Because the natural pass connecting the gulf with the bay was so dangerous, the US Army Corps of Engineers dredged a new pass in 1934. World War II brought prosperity to Bay County with the establishment of Tyndall Air Force Base in 1941, the US Navy's Naval Coastal Systems Station in 1942, and the Wainright shipyard (later to become the Port of Panama City) in 1942 for the production of Liberty Ships. Due to its coastal location and the depth and clarity of the St. Andrew Bay system, Bay County continues to serve as a strategic military location.

Demographics

The 2000 Census figures show a Bay County population of 148,217, a seventeen percent increase over the 1990-2000 decade. All of Bay County's municipalities experienced growth in population, with the greatest being an 89 percent increase in Panama City Beach. Since the 1940s, the county has continually experienced sizeable growth increases, a trend that shows no signs of wavering. The University of Florida's Bureau of Economic and Business Research estimates that the county's population will increase another 18.5 percent to 175,499 by the year 2010. The average age in the county is 36.3, with women making up 51 percent and men 49 percent of the total population. According to the 2000 Census, Caucasians are by far the majority 84.2 percent of the population, followed by African Americans at 10.6 percent,

Hispanic or Latino at 2.4 percent, Asian 1.7 percent, Native Americans at 0.9 percent, and 2.6 percent listed their ethnicity as Other.

Economy

Tourism is the driving economic force of Bay County. According to the Florida Statistical Abstract for the year 2000, 15 percent of the state's tourists, or 7,310,000 people, visited Bay County in 1999. These visitors have an estimated total economic impact of $1.5 billion on the county. With an estimated 14,000 people making their living in tourism, it is also the largest industry in the county. Fortunately for the economy, the Panama City Beach Tourist Development Council conducts an aggressive and creative marketing campaign that insures the continued presence of large numbers of yearly visitors. With more than 7 million people visiting a county whose resident population currently numbers less than 150,000, the strain on infrastructure is evident. Millions of people combined with insufficient infrastructure negatively impact the environment. Maintaining and preserving the county's natural resources is imperative to the health of the economy. Without the area's vast expanse of sugar white beaches and the warm, clear waters of St. Andrew Bay and the Gulf of Mexico, there will be little to draw the millions of tourists who serve as the county's vital economic foundation. In addition, the tourists form a tax base without which the county would be unable to fund many of its projects such as the $30 million beach renourishment.

Bay County's military installations have the second largest impact on the community's economy. Situated on 29,000 acres in southeastern Bay County, Tyndall Air Force Base is the headquarters of the Southeast Air Defense Sector, serves as an air-to-ground combat training command, and houses the 325th Fighter Wing, the 1st Air Force, and the nations first F-22 Raptor wing. Tyndall employs 6700 military and civilian personnel and has an economic impact

of $422.1 million. The Naval Coastal Systems Station (NCSS) is located on 648 acres of the southwestern shore of St. Andrew Bay. This base serves as a research and development facility for naval operations concerning explosive ordinance (EOD) and amphibious assault (SEAL). It is also the headquarters of the Naval Diving and Salvage Training Center. The NCSS employs 2308 military and civilian personnel and has an economic impact of $290 million. Maintaining the health of the county's water systems is also imperative for the continued presence of these military installations, particularly the Navy base with its focus on subsurface warfare research and training.

Table 3.2 Bay County Employment Percentages

Industry	Percentage Employed
Service	29.0%
Retail Trade	26.3%
Government	16.0%
Construction	7.4%
Manufacturing	6.6%
Finance, Insurance, Real Estate	5.8%
Transportation, Public Utilities	4.2%
Wholesale Trade	3.9%
Agriculture	0.5%
Other	0.2%

(www.panamacity.org)

As of March 2001, total employment for the county was 65,889 people. Table 3.2 above shows the county's employment percentages by industry. Per capita income from 1998, the most recent year in which figures are available, was $22,163. Figures for median household income are more recent with $30,860 being reported for 2000

Land Use

The land use information presented in Table 3.3 below is borrowed from the 2001 revision of the BEST publication on ecosystem management measures in the St. Andrew Bay Watershed. The information provided in the table demonstrates that nearly 87 percent of the county is either forest or wetlands. As the BEST publication points out, the table does not show what percentage of the forested areas are used for silviculture. From the land ownership information presented in Table 3.4 below, a reasonable estimation of silviculture lands can be made from the landholdings of The St. Joe Company and the Chipola Land Company. Interestingly, The St. Joe Company has recently changed its focus from forest products to real estate development. As Table 3.4 makes clear, St. Joe owns nearly half of the county. The company's change in business focus will have a far-reaching impact on the future of Bay County. This change in focus also presents a tremendous opportunity for the implementation of an integrated approach to stormwater management in the coastal zone.

Table 3.3 Bay County Land Uses

Land Use	Percentage of County
Agriculture	5.75%
Barren Land	0.54%
Commercial & Services	0.87%
Industrial	0.39%
Institutional	0.24%
Recreational	1.37%
Residential	5.75%
Transportation, Comm., & Utilities	1.28%
Upland Forests	67.95%
Water	1.70%
Wetlands	14.75%

(Keppler and Keppler, 2001, p. 14)

Table 3.4 Bay County's Primary Land Owners

Land Owner	Percentage of County
The St. Joe Company	49.35%
Remaining Private, County, Municipal	24.10%
FL. Fish & Wildlife Conservation Comm.	7.64%
John Hancock Insurance Company	7.64%
NW Florida Water Management District	6.06%
Tyndall Air Force Base	4.82%
FL. Division of Recreation & Parks	0.21%
Naval Coastal Systems Station	0.11%
Hunt Oil Company	0.05%
U.S. Bureau of Land Management	0.04%
FL. Department of Agriculture	0.01%

(Keppler and Keppler, 2001, p. 14)

Planning: For Growth and Development

On May 14, 1990 the Bay County Board of Commissioners adopted the Bay County Comprehensive Plan as mandated by Florida state law. With periodic updates and amendments, the Comprehensive Plan is intended to serve as a management tool to guide the county's growth and development. Certain portions of the document are applicable to this thesis, particularly those dealing with land use planning. Any county planning information presented here will come from "Heading 2010: Charting Our Course," the most recent version of the Comprehensive Plan.

Planning: For Stormwater Management

In 1994, the Bay County public works department produced a stormwater management plan entitled Bay County Strategic Plan for Stormwater Infrastructure. Essentially a financial document, this publication was the county's first attempt at examining its stormwater management system. The plan focuses on the first five years of a fifteen-year stormwater management program. The mission of this program is stated as: "The Stormwater Capital Infrastructure Program must protect the health, safety, and welfare of the Citizens of Bay County by preserving the integrity of the potable water supply, reducing pollution to receiving waters and attenuating flood waters" (p. 2). The tone of this plan is clearly an appeal for assistance.

The introduction begins with proposals for additional funding sources and the plan states early on that without the proper facilities, little treatment can be accomplished: “Treatment requires facilities; facilities require funding...The present General Fund stormwater budget devotes 95% of revenue to operation, repair and maintenance; little is available for needed capital improvements” (p. 4). In order to minimize the need for expensive treatment facilities, the plan advocates treating pollution at its source with nonstructural techniques such as vegetated buffers, grass swales, and educating the public about the responsible application of chemical fertilizers and pesticides.

From the descriptions of the county’s stormwater management approaches, the system is archaic and in need of remediation. The following excerpt is telling:

> Present stormwater program operation and maintenance activities are mostly reactive in nature: when flooding occurs efforts are directed toward drainage; when pipes break they are replaced; erosion is repaired rather than prevented, and catch basins are manually cleaned after they plug. Little is done to prevent orange plumes from forming in Grand Lagoon after each rainfall....The data required to solve stormwater problems on a sound engineering basis are not presently available. Maps which accurately represent the size and location of existing drainage conduits are rarely available to assist in problem definition and solution (p. 4-5).

The majority of stormwater runoff treatment occurs in roadside swales throughout the county. Of the 1,975 miles of grass swales, only 75 miles are cleaned of accumulated debris and contaminants on an annual basis. Manpower, necessity, and accessibility are the main reasons for this low number. A great majority of these grass swales are located on private property and the county simply doesn’t have the drainage easements and rights-of-way needed to legally access these swales for maintenance and upkeep. In addition, the roadside ditches are unable to handle runoff from storms greater than the brief, high intensity storm events common in the summer months (p. 5-6).

Assembled from citizen complaints logged over a five-year period, the Bay County public works department identified 403 problem flood areas, few of which have been remedied. Of the stormwater pipes that do exist, most are bare steel, a material that has only a brief period of usefulness in a coastal environment. With a life span of ten years, these steel pipes are failing faster than they can be replaced with new pipes of a more appropriate material. The failing pipes and overburdened roadside swales result in "massive washouts" during storms that produce two inches of rain or more per hour (p. 6).

The Strategic Plan for Stormwater Infrastructure concludes with a series of proposals that focus on the most critically lacking elements such as accurate data, the development of a master storm drainage plan, and the acquisition of easement rights for maintenance and construction purposes. Although the plan states that roadside swales will continue to be the primary stormwater treatment methods, it also states the intention of implementing more piping and larger treatment facilities in the future, although no mention is made of whether these facilities are structural or non-structural.

The public works department released the Bay County Stormwater Master Plan in 1997 Josee Cyr, the county's stormwater engineer, discussed the current status of the county's stormwater management system in a March, 2002 telephone interview. Capital resources still come mainly from the county's General Fund, a revenue source that also funds the county's emergency services including the police and fire departments. Grants have also become a significant source of funding. While stormwater management is still largely reactive in nature, aggressive inventory and mapping efforts are underway to help define and locate the existing infrastructure. Once these efforts are achieved, a proactive approach will be much more feasible.

As Cyr stated with regard to the county's current stormwater management approach, "it's hard to be proactive unless you know what you've got" (Cyr, 3/22/02).

The 403 stormwater problem areas identified in the 1994 Stormwater Infrastructure report have been reorganized into a list of sixty problem areas. The majority of these have not been remedied largely because their solutions are complex. Again, once an accurate inventory of the county's infrastructure is completed, an overall system design that addresses these problems will be possible to identify. Although the majority remains, there have been some success stories. Significant progress has been made in the vicinity of Econfina Creek and Deer Point Lake with regard to the erosion and increased sedimentation resulting from many miles of dirt roads. Using a permeable pavement material known as an open-graded asphalt mix, erosion and sedimentation have been curtailed while runoff is minimized.

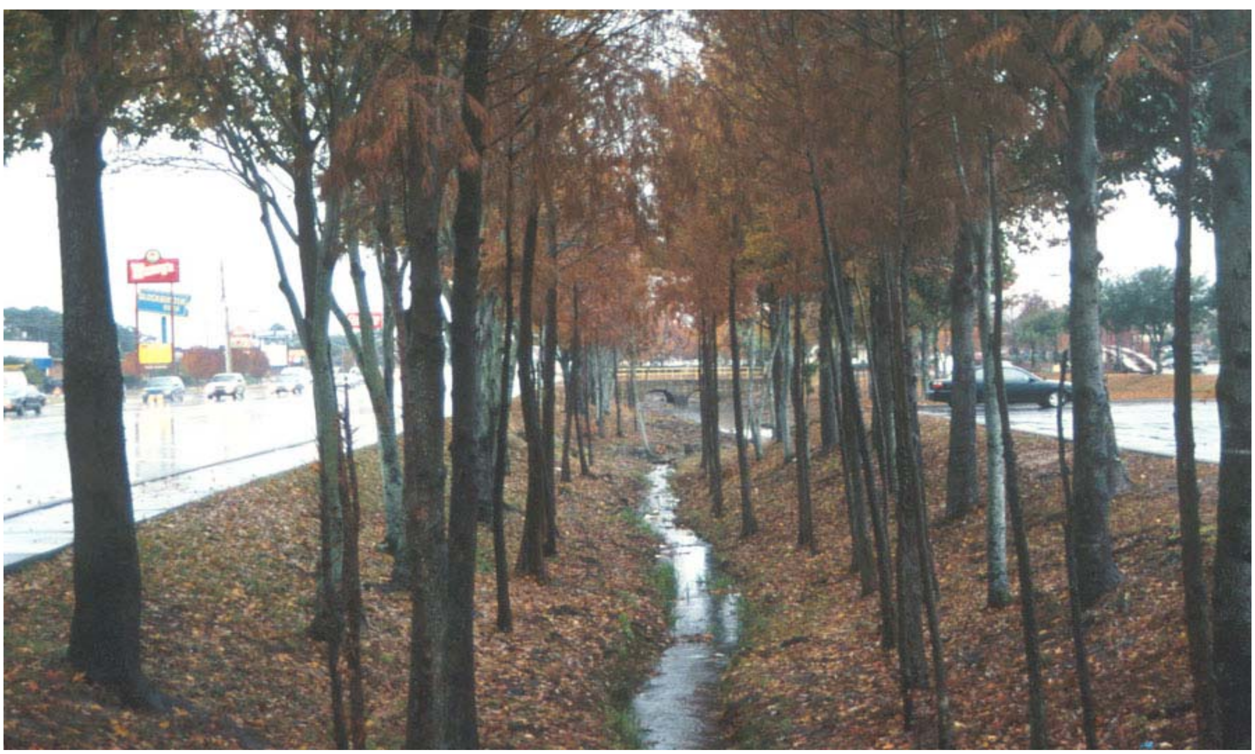

Figure 3.10 Natual engineering stormwater management technique treating runoff from 23rd Street and adjacent commercial shopping center parking lot in Panama City.

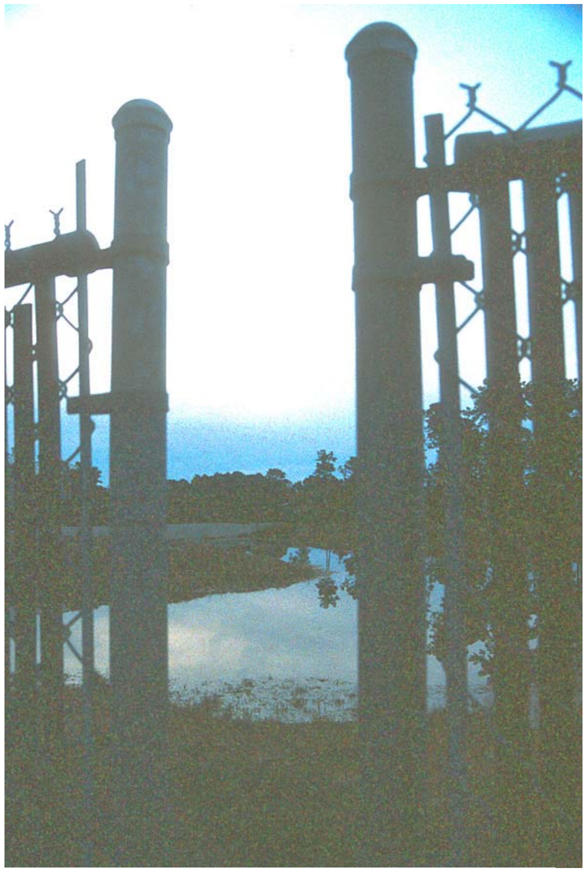

Figure 3.11 A glimpse of the North Lagoon Drive stormwater pond through the chain link fencing

As for the larger treatment facilities proposed in the 1994 report, several have been constructed as of this writing. One such example is a joint project between the Bay County and the Florida Department of Transportation. Located on a well-traveled road in an upscale, water-front residential section of Panama City Beach, this facility is composed of a series of small, stormwater treatment ponds that are fenced off by a chain-link fence embellished with the mark of a spray-paint artist. Looking through the gap between the fence and the padlocked gate, one can see these naturalistically shaped ponds backed by a wooded area and Grand Lagoon. While the use of natural engineering stormwater management techniques is to be commended, this project is an example of a missed opportunity. Built on a donated parcel of land, it was

necessary for the ponds to have 3:1 side slopes in order to create the volumetric space needed to receive runoff from 1,000 acres. While the steep side slopes do present a danger, alerting the public to the potential hazard could have been addressed in a manner more pleasing than six-foot tall chain link fencing. These ponds could be an aesthetic amenity for the neighboring community instead of an unsightly utility poorly camouflaged from its neighbors.

The facility was constructed to treat stormwater runoff, yet it could also have been designed for multiple uses such as public park land, an estuarine wildlife habitat area, and an educational feature for the children attending the four public schools located within a 5-mile radius of this site. The addition of a few minor adjustments such as aesthetic enhancement through plant materials, the provision of safe public access such a boardwalks or clearly defined pedestrian areas, and informative signage explaining the biological processes occurring in the stormwater pond and the use of natural engineering techniques for public works projects, could transform this utilitarian stormwater pond into a multiuse water feature that meets the stormwater needs of its watershed while serving as an amenity to the high end residential neighborhood in which it currently exists. Fencing off stormwater treatment facilities only serves to perpetuate the mistaken belief that places of utility and places of beauty must be two separate entities.

Figure3.12 The view of the stormwater pond from North Lagoon Drive

Figure 3.13 A view of the stormwater pond through a gap in the fence reveals a potentially attractive water feature

Conclusion

It is necessary to identify and understand Bay County's human and natural resources in order to develop an integrated stormwater management system that is appropriate for this area. Through the inventory and analysis presented in this chapter, valuable assets such as the county's rich, physical beauty become clear. Also made apparent are areas of opportunity such as the need for secure and adequate funding for stormwater management and a thoughtful, aesthetic design approach to stormwater management facilities. The information provided in this chapter establishes a sense of place within which the remainder of this thesis is presented. In the next chapter, a review of articles from the county's only newspaper presents a contemporary look at the stormwater issues confronting the county.

Chapter Four: Stormwater-Related Environmental Issues

Introduction

In order to gain a better understanding of the stormwater-related environmental issues that have confronted Bay County, Florida in recent years, I reviewed all of the relevant newspaper articles appearing in the "Local/State" section of the county's only newspaper, the Panama City News Herald, from January 1996 until December 2001. During this time period, the vast majority of articles reporting on environmental issues concerned the county's coastal setting and included such elements as flooding, erosion, hurricanes, and tropical storms. There is an almost equal amount of articles concerning growth and development within the county. These articles focused on issues of planning, urbanization and economic development as well as problems resulting from insufficient infrastructure as it relates to stormwater, wastewater, and traffic congestion. Because the scope of this thesis is limited to stormwater management in a developing coastal community, articles reporting on issues of economic development, wastewater, and traffic congestion were not considered. The purpose of this chapter is to provide an overview of the issues concerning Bay County's coastal environment, its insufficient stormwater infrastructure, and its increasing urbanization as reported in the newspaper. These issues are often interrelated, and the prevalence of articles concerning them demonstrates the need for a solution. By means of a sustainable approach to stormwater management through the integrated use of greenways and stormwater best management practices, this thesis is an attempt at just such a solution.

Environmental Impacts: Stormwater

Hurricanes and Tropical Storms

Bay County's location on the northwest Florida coast of the Gulf of Mexico makes it particularly prone to hurricane and tropical storm activity. A year 2000 study conducted by Dr. Michel Ochi, a professor of civil and coastal engineering at the University of Florida, found that Bay County is more vulnerable to wave action than any other coastal area in Florida. Dr. Ochi found that the county's offshore topography has a slope that is much steeper than other areas of the state, a characteristic that makes this area particularly vulnerable to a hurricane's wind driven waves. His study examined the behavior of waves as they move from deep water to shallow water, the influence of water depth, and the ways in which waves break (Twilley, 08/11/00).

Storm records indicate that one hundred hurricanes and tropical storms impacted Bay County from 1885 to 1985. The 1990s was a particularly busy hurricane period. The most devastating storm to hit the area during this time was Hurricane Opal in October of 1995. Hurricane Opal, a category 3 storm, caused billions of dollars of damage. The newspaper articles reviewed in this thesis span a six-year period and begin just a few months after Opal. During this period Bay county experienced three hurricanes and two tropical storms: Hurricane Danny, July 19, 1997; Hurricane Earl, September 2, 1998; Hurricane Georges, September 28, 1998; Tropical Storm Allison, June 11, 2001; and Tropical Storm Barry August 6, 2001.

Flooding

Severe flooding due to rainfall and storm surges is one of the most damaging impacts of hurricanes and tropical storms in this area. The examples are numerous. In September of 1998 Hurricane Earl dumped twenty-five inches of rain on Bay County in a twenty-four hour period. Severe flooding was experienced throughout the county with more than sixty roads reported

flooded. The county's 350 miles of unpaved roads were particularly affected. Earl's storm surge prevented stormwater runoff from emptying into the Gulf through stormwater outfalls, causing it to back up within the system. This combination of storm surge and runoff overwhelmed the stormwater infrastructure. In the Gulf Highlands area of Panama City Beach, 315 homes and fifty-three businesses experienced flood damage from Hurricane Earl (Porter, 09-04-98). Believing that insufficient stormwater infrastructure was a major contributor to the extreme flooding problems experienced in this area, the city of Panama City Beach passed a resolution asking the Florida Department of Transportation to " 'give the highest priority to funding design and construction improvements to the Lake Florida outfall structures to eliminate the present danger of continued flooding'" (Porter, 09-11-98). Larger pipes were installed the following year.

Three weeks after Hurricane Earl, Bay County experienced the effects of Hurricane Georges. Even though this hurricane landed in Mississippi, the county was still impacted by a destructive three to five foot storm surge. The next morning's headline gives an indication of the damages: "Hurricane's pounding surf lays waste to Bay's beaches" (Middlemas, 09-29-98). Extensive flooding was again experienced, and again it was blamed on an inadequate stormwater infrastructure system. A resident of the eastern Bay County community of Cedar Grove, Mr. Frank Coatney Sr. said of the flooding: " 'We're growing, and the city is not adequately prepared with the drainage.... We're killing people who already live here" (Cazalas, 09-30-98).

Flooding from stormwater is not only caused by hurricanes and tropical storms but by other storm events as well. On March 7, 1998 a severe storm dropped more than five inches of rain on Bay County. Twelve roads were closed due to flooding. During this storm an elderly woman ran off the road into a concrete drainage channel that had filled with six feet of

stormwater runoff. The woman's car sank and she would have drowned if people passing by hadn't rescued her. The drainage channel is located on Panama City Mall property and mall security guards reported that a similar accident had occurred a few months prior (Angier, 03-08-98).

The following year, three inches of rain fell during a late spring storm and nine roads were closed (Angier, 04-29-99). A little more than a week later another storm dropped eight inches of rain on Bay County. This time businesses flooded, sidewalks washed out, road beds on two major streets eroded, trees were downed, and four schools were damaged. Panama City Manager Kenneth Hammons said his desk was full of reports about flooding. He speculated that since the storm arrived at high tide and since the storm sewers empty into the bay, the high tide caused the waters to back up and cause severe flooding (Angier, 05-08-99). Business owner Jim Bus blamed the city of Panama City for not maintaining the drainage system: " 'This is just plain silly.... They can go out and put all these red bricks along Harrison Avenue and plant trees but they can't spend the money to fix the drainage system' " (Angier, 05-08-99).

Erosion

Erosion from storm surges, wave action, and stormwater runoff is another serious problem faced by Bay County. By 1996, years of storm activity had greatly eroded the county's coastline, and in December of that year the county declared a state of emergency (Zukeran, 12-11-96). In an effort to restore its beachfront, the county initiated a beach renourishment project in 1998. At a cost of $30 million, 8 million cubic yards of sand were dredged from offshore and pumped onto the beach. This was followed by the planting of 750,000 sea oats to stabilize the sand dunes. The project renourished 17.5 miles of beachfront to an average width of 100' and remains the longest beach renourishment project ever undertaken in the state of Florida. The

effects of storm surges and wave action have been significantly reduced since the beach renourishment project was completed (Porter, 08.05.01). In fact, the US Army Corps of Engineers estimates that 70 percent of the damage from Hurricane Opal could have been avoided if the beach renourishment project had been completed before the arrival of that storm (Croft, 04.15.98).

Florida's state government created the Ecosystem Management and Restoration Trust Fund in the annual of amount of $30 million to help communities throughout the state finance preservation and restoration projects such as beach renourishment and erosion control. The Florida Department of Environmental Protection (DEP) oversees the distribution of funds (Croft, 04-15-98). In order to receive the maximum funding for the continued maintenance of its beach renourishment project, Bay County was required by the DEP to construct 152 stormwater outfalls, 100 of which would be located on private property and fifty-two along the beach. The outfalls were to be designed in such a way as to prevent the "erosive effects of stormwater discharge onto the restored beach" (Moore, 05.06.98).

For those outfalls located on private property the county instructed property owners on methods of controlling and managing drainage. According to a May 12, 1999 memorandum from Panhandle Engineering to beachfront property owners, these methods included "extending the pipe, installation of exfiltration system and hiring of a Professional Engineer or Contractor" (Panhandle Engineering memorandum, 05.12.99). For the outfalls occurring along the beach, fifteen are large, continuous-flow outfalls and thirty-seven are smaller intermittent-flow outfalls (Middlemas, 03.29.99). For the smaller intermittent-flow outfalls, a perforated pipe with a sock around it was the chosen method for filtering the stormwater into the sand. The large continuous-flow outfalls release stormwater directly onto the beach.

Figure 4.1 Beach erosion resulting from stormwater runoff after the installation of the new outfall structures.

The design of the continuous flow outfall structures does not seem to have been successful in preventing erosion due to stormwater discharge. Even during periods of little rainfall, a walk down the beach reveals serpentine channels of stormwater runoff winding their way from the outfalls to the gulf (Figure 4.1). Not only are these channels unsightly, the sharp drop-offs caused by the eroding sand descend several feet posing safety hazards. In addition, no filtering mechanisms are designed into the system, so the water being discharged from the pipes onto the beach is draining directly from roadways and parking lots carrying oil, grease, and other contaminants. This situation only intensifies during severe storm events as was evidenced during Tropical Storm Barry on August 6, 2001. While Barry's eight feet of adjusted storm surge (storm surge plus wave action) had little erosive impact on the renourished beaches, the effects

Friday, August 17, 2001

LOCAL/STATE

SECTION B

THE NEWS HERALD

Beaches need erosion repair

News Herald Photo: Dana Miserez

…erosion, caused by runoff water from drains, is a concern near the County Pier in Panama …each.

SWALES: Moving water dug channels as the runoff funneled onto the beach.

KEVIN PORTER
THE NEWS HERALD

Bay County beaches will need about $160,000 of work to restore areas damaged by Tropical Storm Barry, according to an assessment report.

The document, prepared to obtain state and federal disaster assistance, concluded that, as a whole, beaches held up well against the 8 feet of adjusted storm surge — storm surge coupled with wave action.

However, the report listed 117 damaged areas that need additional sand and reshaping.

"We are estimating that it's going to take about 40,000 cubic yards of sand to restore the beach back to its original shape," said Bob Hopper of the Bay County Tourist Development Council. At roughly $4 per cubic yard, the cost of the patchwork comes to about $160,000.

The cost would have been higher, but there are several areas along the beaches where excess sand was piled during the renourishment project a few years ago, Hopper said.

That sand, along with sand clumped together in various spots along the coast, could be used to restore the eroded areas, he said.

"Our concern is if another storm comes it could use the channels to erode the rest of the beach."
— Bob Hopper, Bay County Tourist Development Council

The majority of the 117 spots that need work are "runoff swales," or channel dug by moving water. Most are associated with outfall where stormwater from beachfront properties is funneled onto the beach. Other channels were carved as water from tidal pools drained back into the gulf.

"Our concern is if another storm comes it could use the channels to erode the rest of the beach," Hopper said.

His report was handed Thursday to Harrison Evans, who handles assessment with the Federal Emergency Management Agency. He will make a recommendation on whether the beach should qualify for financial assistance.

"We had a storm prior to (Barry) called Allison and between those two storms there was some erosion," Evans said. "I can't say right now what my recommendation will be."

Another area of concern for beaches is trash that washed up from the storm surge in early August. There is also a meandering line of driftwood and miscellaneous junk, a testament to how high the water rose.

Hopper said the TDC had to await a permit from the Department of Environmental Protection that will enable it to

See BEACH, page 3B

Figure 4.2 Stormwater runoff erodes beaches after Tropical Storm Barry.

of stormwater runoff was another matter. The county applied to state and federal agencies for disaster relief funds in the amount of $160,000 to repair 117 damaged spots along the beaches. The majority of these spots were caused from stormwater runoff, not wave impacts (Porter, 08-17-01). The News Herald reported, "the most noticeable erosion was around stormwater outfalls, where the twelve inches of rain associated with Barry were funneled onto the beach from nearby parking lots and streets. The rushing water, which exceeded containment capacity, formed miniature canyons leading toward the gulf" (Porter, 08.07.01).

Stormwater Management Plan for Bay County

For several years, Bay County's municipalities have acknowledged the importance of addressing the stormwater issues facing their communities. An excerpt from a December 1998 article highlights its importance: "If Bay County had a Christmas wish list... a countywide stormwater management plan likely would have been close to the top. It would have asked for all the flood-prone areas in incorporated and unincorporated parts of the county to be alleviated [from damages due to stormwater runoff] and for a steady revenue stream to be in place to address new problems" (Porter, 12-26-98).

There are twenty-eight drainage basins within the county, the boundaries of which wind in and out of both incorporated and unincorporated areas thereby posing some funding challenges. The matter of stormwater management seems to have weighed heavily on the county and its municipalities in recent years. The implementation of a stormwater management plan for the county's unincorporated areas alone was estimated at $85 million in 1998, while a September 1999 article reported that Panama City's 1999-2000 proposed budget focused heavily on stormwater management, with almost half of the city's new capital expenditures being stormwater drainage related (Porter, 09-12-99). The 1999 Bay County Comprehensive Plan also addresses the need for stormwater management attention by devoting an entire section to stormwater management and including a series of goals to be accomplished by 2010. Chapter Four contains a more comprehensive look at the county's stormwater management plan.

Including representatives from all of the municipalities, the county sponsored a stormwater summit in August 2000 to prepare for the March 2002 Phase II implementation of the 1987 amendments to the EPA's Clean Water Act. Phase II concerns federal permitting requirements for nonpoint source pollution, a type of pollution to which stormwater is a major

contributor. As of December 2001 the DEP has not completed its list of nonpoint source pollution control requirements (personal communication with Bay Co. stormwater engineer). Even so, the county recognizes that its biggest stormwater problems are pollutants carried in stormwater runoff and the erosion and sediment accumulation from the county's 350 miles of dirt roads (Twilley, 08-25-00).

It is evident from this review of newspaper articles that issues of stormwater management have plagued the county for some time. Be it flooding and erosion from tropical storm activity and storm surges or simply from passing storm fronts, Bay County's current stormwater infrastructure is overwhelmed too often and too severely. Repairing the damages caused by this insufficient system has cost taxpayers millions of dollars in recent years. As the next section will demonstrate, the county is in the early stages of an anticipated period of growth and expansion. The county's infrastructure is unable to handle its current damaging stormwater impacts, and the situation will only worsen as growth continues.

Environmental Impact: Anticipated Expansion

Growth and Development

Tourism is Bay County's main source of revenue, and with fifteen percent of Florida's tourists visiting the county each year, it is not surprising that the area is experiencing rapid growth. As discussed in Chapter Three, the most recent census figures indicate that Bay County grew 17 percent in the1990-2000 decade. Government employees, elected officials, local landowners, and private citizens are actively engaged in the planning and management of this growth. When Governor Jeb Bush visited Bay County in May of 2001 he repeatedly expressed the importance of an intelligent and sound approach to planned growth: "'This is a huge

opportunity for Northwest Florida to get it right'… to avoid mistakes made in South Florida, where 'shattered dreams occurred' at the hands of unfettered growth" (Middlemas, 05-25-01).

Despite the impressive growth of the last ten years, all signs indicate this period of tremendous expansion is only the beginning of the growth that lies ahead. Development projects abound in Bay County. Some of the more high profile projects include a new north/south highway corridor connecting Bay County to Alabama and a 78,000-acre development that will include the new Bay County International Airport in addition to industrial, commercial, residential, and conservation areas. Development activities such as these and many others currently underway or in the planning stages will only further tax the already overburdened stormwater facilities. Even without all of this anticipated and realized expansion, the county has no option but to upgrade its stormwater infrastructure. A choice does exist, however, for the method the county chooses to implement its system changes and upgrades: either the often prohibitively expensive, conventional concrete-and-steel approach with requisite treatment facilities or an alternative approach that lessens the use of concrete and underground conveyance mechanisms by utilizing the area's existing natural systems through the integration of greenway theory and stormwater best management practices. This alternative, sustainable approach is largely non-structural and therefore much less expensive to implement and maintain.

Conservation Measures

As discussed in the literature review, greenways have a long and successful history of mitigating problems between urbanization and the resulting impairment of natural systems. A News Herald article of particular interest reported on the creation of a greenway in Panama City Beach (Porter, 08-26-01). This proposed greenway will connect the beach to the upland pine

forests to St. Andrew Bay and its canoe trail, and eventually to the greenway system of neighboring Walton County (personal communication with Mel Leonard, Dec. 20, 2001).

Although the proposed greenway system is intended for recreation and conservation uses, it can be combined with other conservation and revitalization efforts taking place within the county to create an area-wide greenway system that could serve as an integral part of stormwater management in Bay County. Conservation and revitalization efforts within the county that can be linked to the Panama City Beach greenway include: a rails-to-trails project in the city of Lynn Haven that involves the adaptive reuse of an abandoned air force oil depot and its connecting rail line; the Northwest Florida Water Management District purchase of more than 30,000 acres in the Econfina Watershed for the protection of a vital Floridian aquifer recharge area; and a 6,000-acre wetland wastewater treatment area proposed by the US Fish and Wildlife Service that would treat 3 million gallons of effluent daily and include trails and informative signage.

Conclusion

Stormwater management is a serious issue facing Bay County, an issue that has already caused millions of dollars in damage and will continue to worsen as growth and development increases. As evidenced by the newspaper articles reviewed in this chapter, the county has recognized the importance of stormwater management and is making strides towards improving infrastructure and mitigation. For these reasons, Bay County is a suitable case study location for the combined application of greenway systems and stormwater best management practices as an alternative approach to conventional stormwater management practices. In the next chapter, an integrated greenway stormwater management system is applied to Bay County in the form of a case study.

Chapter Five: Case Study

Introduction

Chapter Five demonstrates the process of applying an integrated greenway stormwater management system to a developing coastal community. This natural systems-based approach to stormwater management is applied to six of Bay County's twenty-eight watershed sub basins for the purpose of illustration. A three-step process has been developed to facilitate the implementation of this system. The three-step process is composed of the following elements: **1.) preservation**, where wetlands, shorelines, and natural drainage ways are protected from development and development impacts through their designation as greenway corridors with delineated buffer zones; **2.) integration as intervention**, where greenway planning and stormwater best management practices are implemented as intervention measures against the impacts of development; and **3.) realization**, where a comprehensive greenway stormwater management system is implemented on a countywide scale with the help of a stormwater utility that encourages sustainable development decisions.

This chapter is arranged according to the three-step process. A discussion of buffer zone delineation is followed by a series of maps depicting each of the six watershed sub basins and their proposed buffer zones. Included in the analysis of each sub basin are examples of potential stormwater management or greenway planning problems followed by a series of solutions identified with the application of a decision-making tool. Developed for use by professionals as well as ordinary citizens, this decision-making tool is intended to be used as an aid in determining appropriate greenway planning and stormwater management techniques for various environmental situations and development circumstances. Some of these solutions can be

implemented on individual parcels or properties while others require a community effort. Illustrated examples of selected techniques are also demonstrated in a site-specific context applicable to Bay County. Chapter Five concludes with recommendations for realizing the implementation of an integrated greenway stormwater management system on a county-wide scale through the establishment of a stormwater utility that is based on soil types, development densities, mitigation strategies, and impacts to wetlands, shorelines, and natural drainage ways.

Step One: Preservation

<u>Buffer Zone Delineation</u>

This thesis proposes that wetlands, shorelines, and natural drainage systems be designated as greenways for the purpose of preserving these natural systems and their inherent capacity for managing normal stormwater occurrences. In addition to their greenway designation, these systems will be further protected with the addition of buffer zones. The combination of greenways and buffer zones creates a greenway corridor that not only preserves the integrity of the natural systems, but also provides multi-use opportunities such as wildlife habitat and recreational uses.

A buffer zone is an area of vegetated land that borders a wetland or water body for the purpose of protecting water quality and aquatic and riparian ecosystems from the negative impacts resulting from development. Buffer zones can also serve to protect upland areas and areas of development from the impacts of erosion, flooding, and storm surges. Buffer zones are the natural systems-based foundation of the integrated greenway/stormwater management system proposed in this thesis.

The process of establishing an appropriate width for the buffer zones recommended in this thesis was a challenging task. The state of Florida has not developed uniform guidelines for

creating buffer zones, which led to researching the topic of aquatic and riparian buffer zones in communities throughout the United States. A statement made by Duncan Cairnes of the Northwest Florida Water Management District best sums up my investigation regarding recommended buffer widths: "Not even the experts can agree" (personal communication 03/05/02).

A brief summary of my findings is as follows. In one survey of thirty-six urban communities with established stream buffer systems, it was found that buffers ranged in width from 20 to 200 feet on each side of the waterway (Center for Watershed Protection, 1995, Vol. 1 No. 4, p. 1). Including all areas within the 100-year flood plain is a common approach, as is developing a three-zone buffer system in which each zone has a different width and purpose ranging from a very restricted conservation zone to a largely unrestricted transition zone encompassing lawns, turf, and stormwater best management practices (Figure 5.1 and Table 5.1).

Two sets of buffer width data were particularly applicable because they were developed with the coastal zone in mind. The following sources provided the data from which the buffer width recommendations applied in this case study were derived: Table 5.2 below was created for use in Bay County by Mary Mittiga of the US Fish and Wildlife Service Panama City field office. This table displays buffer zone widths and their associated benefits to water quality and wildlife habitats. The Coastal Resources Center at the University of Rhode Island also developed a list of buffer widths and their associated wildlife habitat value and pollutant removal effectiveness. This information is displayed in Table 5.3. For the purposes of this thesis, the proposed buffer zones will include the 100-year flood plain as well as the storm surge area of a Category 3 hurricane and will be no less than 75' for wetlands and 300' for all coastlines and riparian areas.

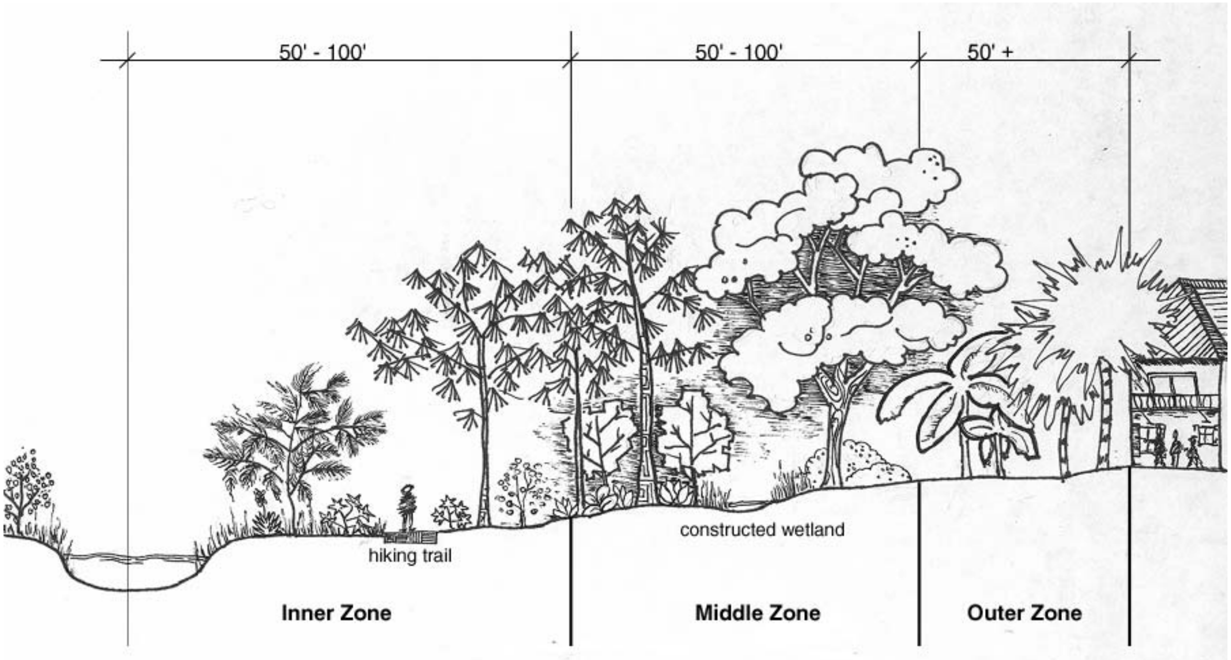

Figure 5.1 Diagram of Three Zone Buffer Zone (derived from the Center for Watershed Protection, 1995, 1(1): 15 and 1(4):1)

Table 5.1 Buffer Zone Characteristics (derived from the Center for Watershed Protection, 1995, 1(1): 15 and 1(4):1)

CHARACTERISTICS	INNER ZONE	MIDDLE ZONE	OUTER ZONE
Width	50 to 100 feet, plus wetlands and critical habitats	50 to 100 feet, depending on stream order, slope, and 100-year floodplain	50 feet minimum setback to structures
Vegetative Target	Undisturbed forest. Reforest if grass	Managed forest, some clearing allowable	Forest or turf
Allowable Uses	**Very Restricted**. Flood control, utility right of ways, footpaths, etc.	**Restricted** Some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	**Unrestricted** Residential uses including lawn, garden, compost, yard wastes, and most stormwater BMPs

Table 5.2 Buffers: An Efficient Tool for Watershed Protection

What Are Buffers?
A **buffer** is a strip of naturally vegetated land along a lake, stream, or wetland that provides numberous benefits. Preserving a buffer zone protects water resources from neighboring land uses. Nutrient inputs are of great concern because of their abundant sources (fertilizer, septic tank drain fields, leaking sewage lines, animal waste). Excess nutrients in lakes and estuaries cause toxic algal blooms and depleted oxygen. Natural chemical and biological processes within buffers alter or uptake nutrients and pollutants *before* they enter a water body, thus providing a cost-effective treatment system. Buffers preserve native habitat for wildlife and enhance aquatic habitat. The range of benefits includes:

- Water quality protection
- Erosion control
- Storage of flood waters and flood damage reduction
- Aquatic habitat enhancement
- Habitat for terrestrial riparian wildlife
- Maintenance of base flow in streams
- Improved aesthetic appearance of stream corridors
- Recreational and educational opportunities

Buffer Width: Bigger is Better
Choosing a buffer width depends on your planning goals. As buffer width increases, the buffer provides greater benefits. As seen in the table below, a 30-foot buffer provides minimal service. At 50 feet, the buffer meets minimum water quality protection recommendations and gives some aquatic habitat benefits. For effective water quality and aquatic habitat protection, a buffer width of 100 feet is needed. Buffers to enhance riparian wildlife should be 300 feet or greater. Special buffer zones may be required to protect vulnerable species. Width should be increased where slope, impervious surface, and soil type reduce buffer effectiveness. The consequences of an indadequate buffer may be an increased need for stormwater ponds, increased flooding, decreased abundance of sportfish, and/or loss of certain species such as some salamanders or crayfish.

Benefit Provided:	**Buffer Width:** 30 ft.	50 ft.	100 ft.	300 ft.	1,000 ft.	1,500 ft.
Sediment Removal- Minimum	•	•	•	•	•	•
Maintain Stream Temperature	•	•	•	•	•	•
Nitrogen Removal- Minimum		•	•	•	•	•
Contaminant Removal		•	•	•	•	•
Large Woody Debris for Stream Habitat		•	•	•	•	•
Effective Sediment Removal			•	•	•	•
Short-Term Phosphorus Control			•	•	•	•
Effective Nitrogen Removal			•	•	•	•
Maintain Diverse Stream Invertebrate			•	•	•	•
Bird Corridors				•	•	•
Reptile and Amphibian Habitat					•	•
Habitat for Interior Forest Species					•	•
Flatwoods Salamander Habitat- Protected Species						•

(Mittiga, United States Fish and Wildlife Service, 2001).

Table 5.3 Coastal Buffer Programs: Summary of Pollutant Removal Effectiveness and Wildlife Habitat Values for Given Widths of Vegetated Buffer

Buffer Width (m)	Pollutant Removal Effectiveness	Wildlife Habitat Value
5	Approximately 50% or greater sediment and pollutant removal	Poor general habitat value; useful for temporary activities of wildlife
10	Approximately 60% or greater sediment and pollutant removal	Minimally protects stream habitat; poor general habitat value; useful for temporary activities of wildlife
15	Approximately 60% or greater sediment and pollutant removal	Minimal general wildlife and avian habitat value
20	Approximately 70% or greater sediment and pollutant removal	Minimal general wildlife habitat value; some value as avian habitat
30	Approximately 70% or greater sediment and pollutant removal	May have use as a wildlife travel corridor as well as providing minimal to fair general wildlife habitat
50	Approximately 75% or greater sediment and pollutant removal	May have use as a wildlife travel corridor as well as providing minimal to fair general wildlife habitat
75	Approximately 80% or greater sediment and pollutant removal	Fair to good wildlife and avian habitat value
100	Approximately 80% or greater sediment and pollutant removal	Good general wildlife habitat value; may protect significant wildlife habitat
200	Approximately 90% or greater sediment and pollutant removal	Excellent general wildlife value; likely to support a diverse community
600	Approximately 99% or greater sediment and pollutant removal	Excellent general wildlife value; supports a diverse community; protection of significant species

(Desbonet, Lee, Pogue, p.97)

Step Two: Integration of Intervention

Greenway Stormwater Management Drainage Basin Maps

Six of Bay County's twenty-eight watershed sub basins have been selected for demonstrating the application of an integrated greenway stormwater management system. Watersheds have been selected as the sites of application because they are definable areas determined by natural instead of political processes and because they are directly related to the movement of water over the earth. Selected for their representation of the county's various land uses, development densities, and landscape types, the six basins are contiguous and each borders either the Gulf of Mexico or the county's bay system. Beginning with the northern most basin and proceeding southward toward the Gulf, the six basins are: 1. Econfina basin; 2. Bayou George basin; 3. Panama City basin; 4. Harrison Bayou basin; 5. Grand Lagoon basin; and 6. the Lower Coastal basin.

As discussed in the literature review, a natural environment supports a balanced hydrologic cycle. When development occurs, the percentage of imperviousness increases and the hydrologic cycle is negatively impacted. Sustainable development makes adjustments for these impacts by protecting those environments significant to a healthy, balanced, and functioning hydrologic systems such as wetlands, coastlines, and riparian areas. Using GIS data compiled by the Bay County GIS department, the following diagrammatic maps illustrate the wetlands, coastlines, natural drainage ways, and the respective buffer zones for each of the six watersheds. Primary and secondary roadways are also depicted in each of the maps as a way of providing a general understanding of existing development. Each diagrammatic map is preceded by a brief description of the qualities and characteristics specific to that watershed.

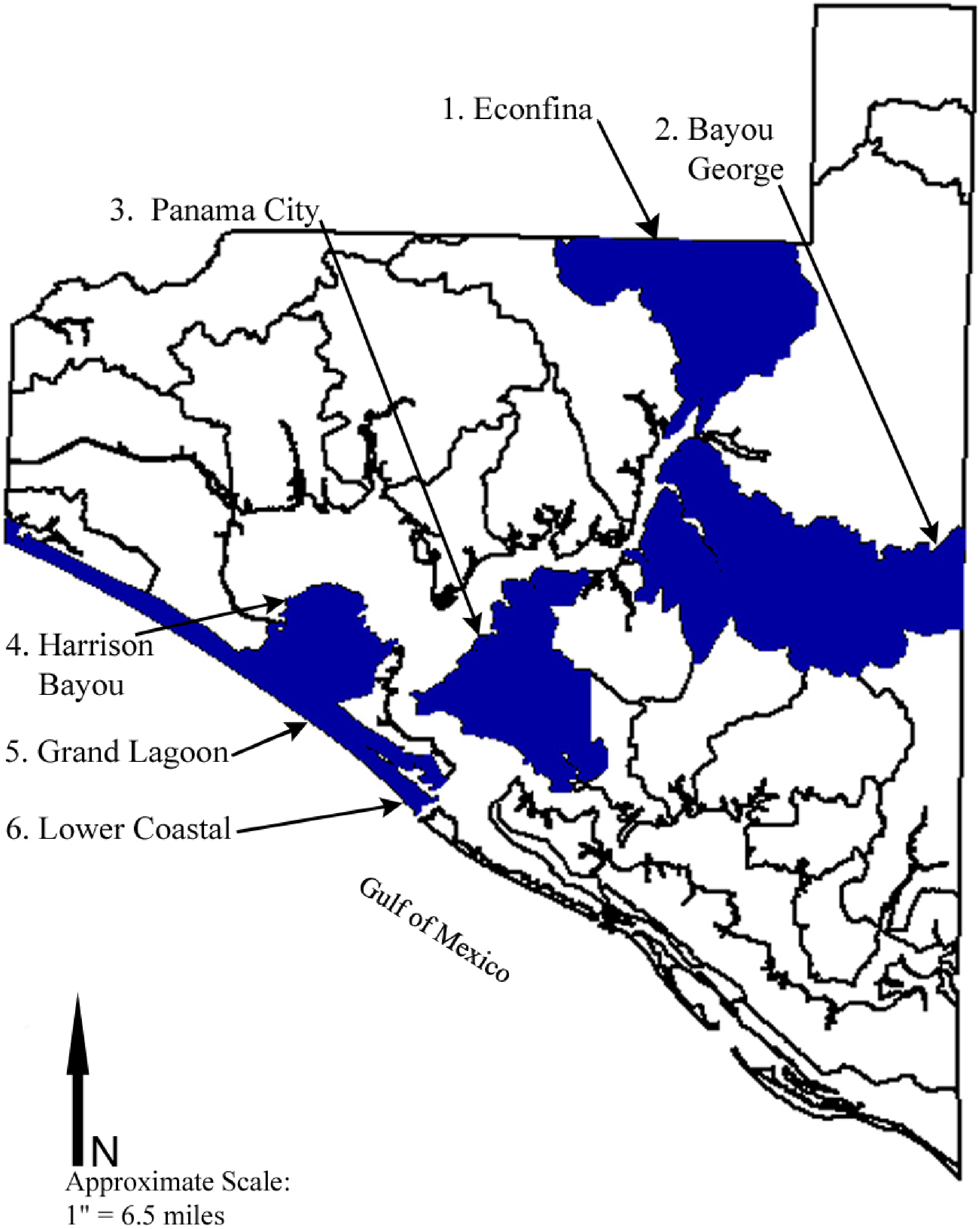

Figure 5.2 Bay County and Selected Watershed Sub Basins

Econfina Drainage Basin

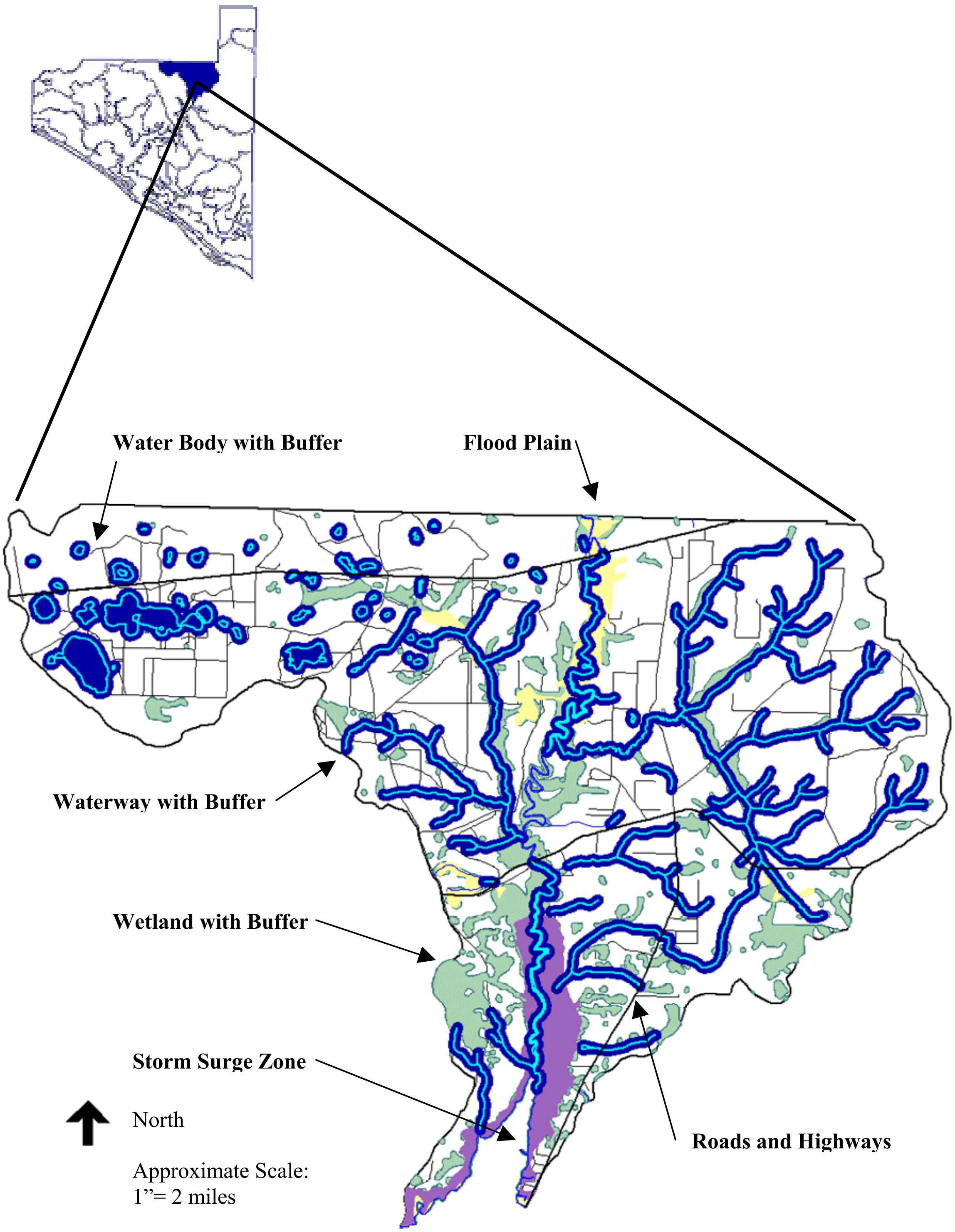

Figure 5.3 Econfina Drainage Basin

The Econfina Basin is a 24,264-acre area in northern Bay County. Bordered to the north by Washington County and to the south by Deer Point Lake Reservoir, this basin's defining characteristic is Econfina Creek, the main source of freshwater to the St. Andrew Bay system. This basin is a high recharge area for the underlying aquifers and features karst lakes in its northwestern section. A significant portion of the basin has been purchased by the Northwest Florida Water Management District to protect the integrity of Econfina Creek and its tributaries as well as some of Florida's last remaining virgin stands of long leaf pine. Rural in character, the county's future land use map indicates that it will remain so with all of the lands in the basin designated as either rural residential, conservation/preservation, or agricultural timberland.

Rich in natural and cultural resources including Native American artifacts and the fossilized bones of ancient mammals, this basin presents abundant opportunities for combining recreational and educational features with a natural systems-based approach to stormwater management. In addition, according to the USGS 7.5 minute quad maps there are extensive jeep trails throughout the area (USGS, Econfina, 1982). An opportunity exists in converting these jeep trails to multiuse recreational trails and incorporating them into a greenway system. The map in Figure 5.3 depicts a diagrammatic representation of the area's lakes, drainage ways, wetlands, and shorelines including their respective buffer zones.

Identifying drainage ways, shore lines, and wetlands and delineating their respective buffer zones to form the basis of an integrated greenway/stormwater management system is fairly straightforward when an area is undeveloped. The process becomes more complex when, for example, a wetland or a portion of a proposed buffer zone has already been developed. The decision-making tools presented in this chapter were developed for situations such as this. For a watershed like the Econfina Basin, the appropriate decision-making tools are: 'Suburban/Rural

Coastal Communities: Stormwater Management' and 'Suburban/Rural Coastal Communities: Greenway Planning.' For example, if an area was experiencing flooding due to overflowing roadside vegetated swales and drainage ditches, the community planner could go to the 'Suburban/Rural Stormwater Management' tool and follow the series of questions to determine the probable causes and possible solutions available to her community. By following the series of questions she would discover several possible solutions ranging from building a wet pond (retention pond), to implementing a suburban forestry program, to reducing the speed of runoff through the implementation of check dams and baffles in the roadside swales.

Using techniques such as those mentioned above decreases the speed of runoff and encourages infiltration in vegetated swales. Implementing these techniques throughout a watershed, particularly at its upper reaches farthest from the point of concentration, will greatly reduce the amount of runoff leaving the watershed thereby reducing the chances of downstream flooding. Although reducing the speed of runoff and encouraging infiltration is a utilitarian function, it can serve multiple uses and create aesthetic appeal as the above image demonstrates.

Bayou George Drainage Basin

Bayou George Basin is a 38,758-acre basin in eastern Bay County. It is bordered to the west by North Bay and to the east by Gulf County. Bayou George and its extensive system of tributaries is this basin's defining characteristic. Home to the city of Lynn Haven (pop. 12,796) Bayou George basin is mainly suburban in character with significant portions delineated as wetlands. The area's current and future land use designations include suburban residential and commercial, a small urban area to the southwest, a pocket of industrial land use, conservation/recreation areas, and agricultural timberland which makes up a large portion of the basin's eastern half.

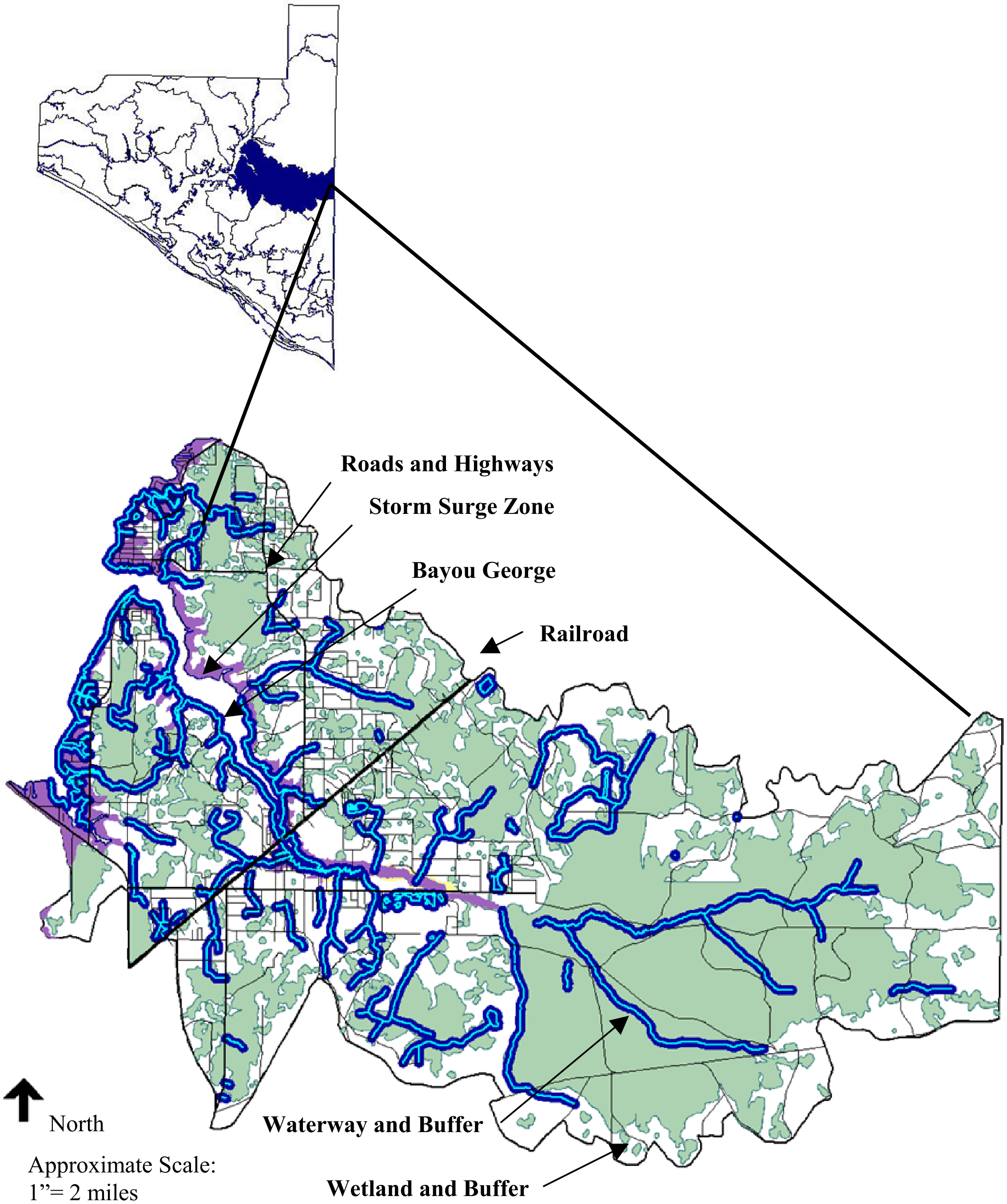

Figure 5.4 Bayou George Drainage Basin

Development pressures combined with the many wetland acres and Bayou George's extensive tributary system, create great opportunities for implementing an integrated greenway stormwater management system. Again there are ample opportunities to combine recreational and educational features, especially as they relate to the value of wetlands in the environment for wildlife habitat and their natural ability to filter pollutants. The map in Figure 5.4 above depicts a diagrammatic representation of the area's lakes, drainage ways, wetlands, and shorelines including their respective buffer zones. Primary and secondary roads are also depicted.

Bayou George basin is an excellent example of a watershed that contains both developed and undeveloped areas. Implementing a natural-systems based approach to stormwater management in this basin presents the creative challenge of determining which greenway planning and stormwater best management practices will meet this area's diverse needs. For this watershed, the 'Suburban/Rural Coastal Communities: Stormwater Management' and the 'Suburban/Rural Coastal Communities: Greenway Planning' decision-making tools are the most appropriate. For example, if an area was experiencing flooding due to storm sewers backing up and overflowing, a county engineer could find several possible solutions from the decision-making tool ranging from stepping up maintenance procedures, to increasing pipe sizes, to decreasing runoff by increasing the amount of permeable surfaces through such techniques as on-lot treatment and green parking.

The photograph of the conventional parking lot shown in Figure 5.5 was taken in a Bay County shopping center parking lot at 12:15 pm on a Saturday in April. Like many parking lots, this one has been designed to accommodate the maximum amount of shoppers during the busiest season. For all but those few days a year, however, parking lots such as this one are underutilized. According to the Center for Watershed rotection, 65 percent of "impervious cover

Figure 5.5 Underutilized parking lot

in the landscape…can be classified as 'car habitat'" (p.4). Rethinking the design of car habitats is the foundation for innovative techniques such as green parking. According to the Environmental Protection Agency, green parking is a combination of techniques including "setting maximums for the number of parking lots created, minimizing the dimensions of parking lot spaces, utilizing alternative pavers in overflow parking areas, using bioretention areas to treat stormwater, encouraging shared parking, and providing economic incentives for structures parking" (EPA, 2001).

The illustration in Figure 5.6 demonstrates the application of the green parking technique by designing for average parking demand instead of maximum demand during the peark season. Other features of the parking lot include alternative paving materials in the overflow parking stalls, bioretention areas to filter stormwater runoff, and stall dimensions designed to reflect the percentage of compact cars on the road. According to the Center for Watershed Protection, 40 to 50 percent of all cars on the road are compact cars ("Do-It-Yourself," 1999, p.35).

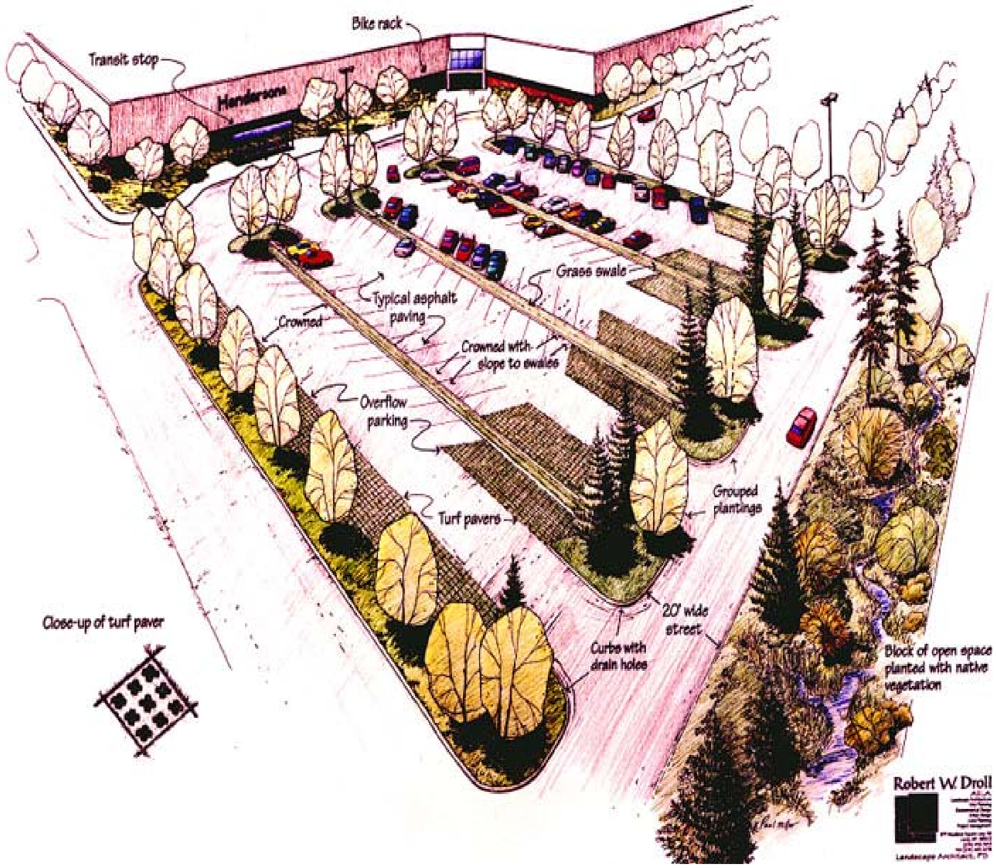

Figure 5.6 Green Parking. (Center for Watershed Protection, e Show, 2001, p.)

Panama City Drainage Basin

This 17,884-acre basin is roughly triangular in shape and bordered on two sides by water, North Bay to the northwest and St. Andrew Bay to the southwest. The most developed of the county's basins, it contains the county seat, the Port of Panama City, the Panama City/Bay County International Airport, and many of the county's public schools including Gulf Coast Community College and the Florida State University Panama City campus. Urban in character, this basin's future land use designations include general and community commercial, recreational, industrial, public/institutional, and urban and suburban residential. The map in

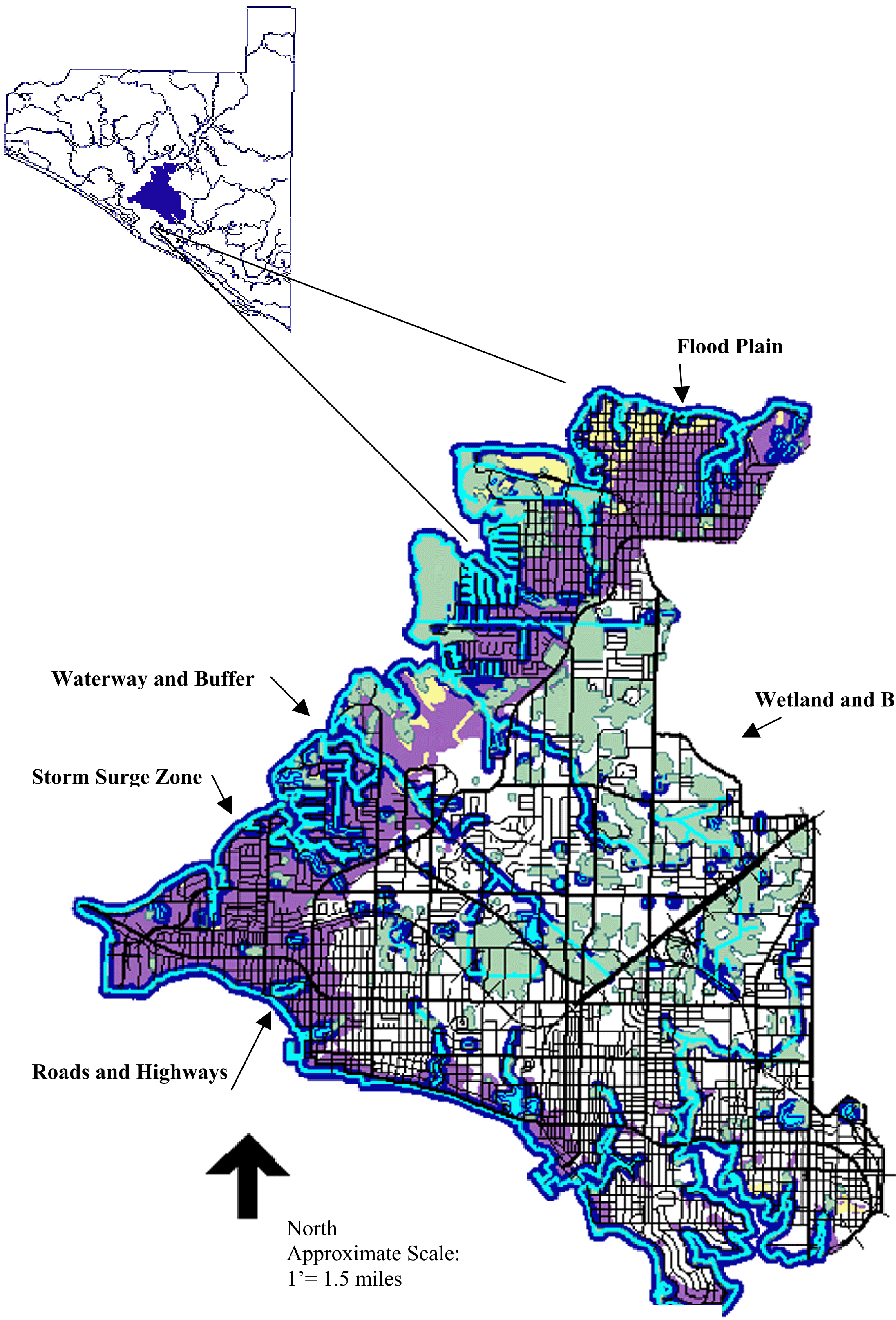

Figure 5.7 Panama City Drainage Basin

Figure 5.7 depicts a diagrammatic representation of the area's lakes, drainage ways, wetlands, and shorelines including their respective buffer zones. Primary and secondary roads are also depicted.

Figure 5.8 Opportunity for aesthetic enhancement of busy street corner through the creation of a corner park incorporating greenway planning and stormwater management.

The ability to create buffer zones in this basin is limited, yet their establishment is all the more important because of the significant developement that has already occurred. An integrated greenway/stormwater management system for this area will rely heavily on best management practices. For this watershed, the 'Urban Coastal Communities: Stormwater Management' and 'Urban Coastal Communities: Greenway Planning' decision-making tools are the most appropriate. Because of the limited open space remaining in this watershed, any multi-use opportunities would be highly valued. A very visible opportunity exists at the corner of 23rd Street and Stanford Avenue where a stormwater canal and detention basins for a shopping center meet a power line right-of-way (Figure 5.8). Thoughtful design could convert this utilitarian space from a neglected spot into a lively corner park. By using stormwater runoff as an asset,

this space could add aesthetic interest to a busy thoroughfare, serve as an entry point for a greenway that follows the existing power line right-of-way, and create an amenity not only for the adjacent middle class neighborhood but for the basin as a whole.

Harrison Bayou Drainage Basin

Harrison Bayou Basin is a 10,865-acre, roughly semi-circular area that is bordered by North Bay to the east and West Bay to the north and west. Lying completely within the storm surge zone and composed of wetlands and pine flatwoods, the land composing this basin is owned almost entirely by the St. Joe Company. The county's future land use map indicates that much of it will remain agricultural timberland with conservation zones along its shorelines and an area of urban and residential development along US Highway 98, the basin's southern border. The map in Figure 5.9 depicts a diagrammatic representation of the area's drainage ways, wetlands, and shorelines including their respective buffer zones. Primary and secondary roads are also depicted.

This basin is mostly wetland and largely undeveloped. Maintaining the natural systems in this basin and restoring any that may have been degraded by silviculture or mosquito control practices would be important efforts toward the overall health of the county's bay systems. By incorporating the undeveloped portions of this basin into the proposed Panama City Beach greenway, much of it could be preserved while serving the mulitple uses of recreation, education, habitat conservation, and as a buffer for the impacts of severe storms. Implementing silviculture best management practices (Florida Division of Forestry, 1992) and stormwater best management practices would help to insure the continuing Class II designation for shell fish propagation and harvesting of the surrounding water bodies.

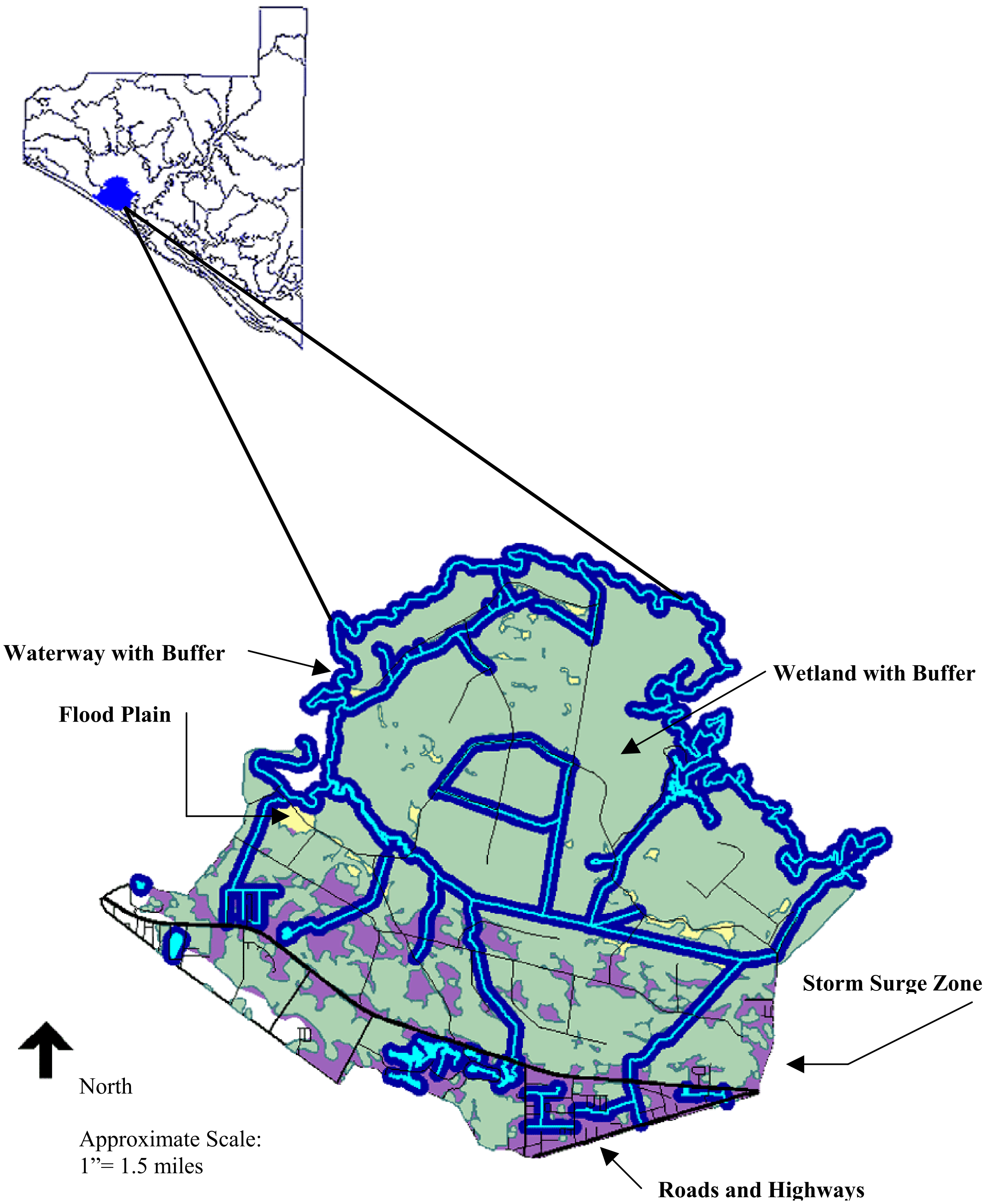

Figure 5.9. Harrison Bayou Drainage Basin

Preserving the wetlands, shorelines, and existing vegetated buffers not only protects human life and property from the potentially severe damage of storm surges, but it also safeguards the integrity of coastal habitats and their associated waterbodies from the negative impacts of stormwater runoff. While it is immediately obvious that these measures are good for the environment, they are economically beneficial as well. Maintaining the integrity of coastal habitats and water quality levels insures a continuing economic foundation for many of the county's residents, from those who make their living in the tourist industry to those in the commercial fishing industry. In addition, by maintaining the fragile coastal zones in areas such as Harrison Bayou, the costs associated with development in sensitive areas can be avoided, such as insurance increases due to storm damage and tax increases due to excess stormwater treatment needs. Lastly, because an area is protected doesn't mean it can't be used. The preservation aspects of the proposed buffer areas create an excellent opportunity for the muli-use function of a greenway system for recreation, education, and wildlife habitat.

Figure 5.10 Salt marshes and pine flatwood ecosystems typical of Harrison Bayou.

Grand Lagoon Drainage Basin

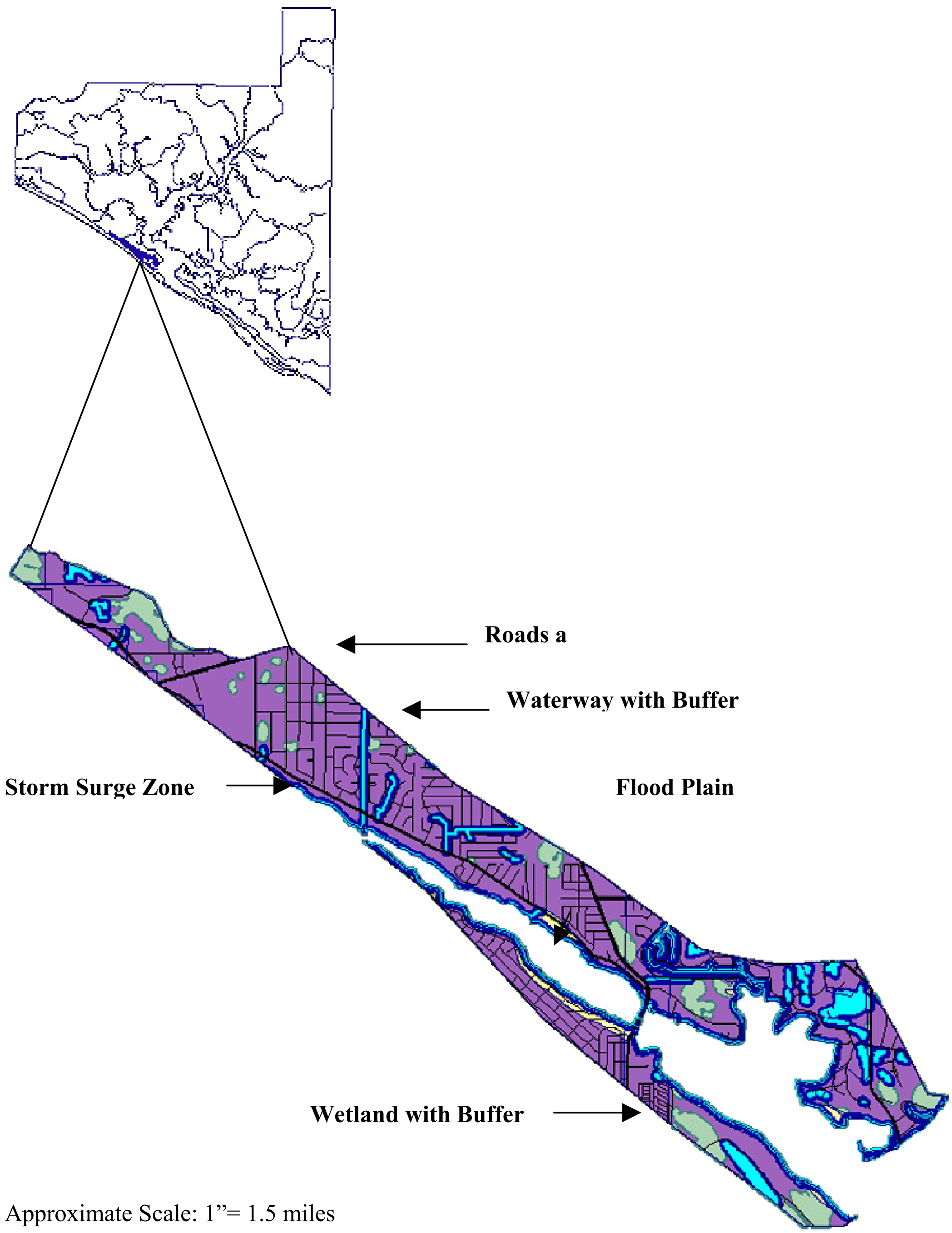

Figure 5.11 Grand Lagoon Drainage Basin

Grand Lagoon basin is a 2,769-acre area surrounding Grand Lagoon, a shallow, fairly-narrow water body that empties into Lower St. Andrew Bay, the water body that forms the basin's eastern border (Figure 5.11). Suburban in character, Grand Lagoon basin is composed of moderate to high-income residential neighborhoods, supporting commercial zones, recreational land use, seasonal/resort uses, a small urban area, and a conservation/recreation area that is St. Andrew's State Park. The county's future land designations indicate these current land uses are predicted to remain the same.

Figure 5.12 A wooden bridge and boardwalk adds aesthetic and recreational features to a stormwater pond.

This basin lies entirely within the storm surge zone. For this reason, great care should be taken in maintaining natural drainage ways and a buffer of native vegetation along the shorelines. In addition to the effects from storm surges, nonpoint source pollution is another significant stormwater management issue for these areas. If evidence of nonpoint source pollution was found in the surface waters of Grand Lagoon basin, for instance, a concerned

citizen could go to the ‘Suburban Coastal Communities Stormwater Management’ tool, answer a series of questions to determine probable causes for pollution and then proceed to the tool’s possible solutions. In this case, the citizen could have noticed algal blooms in Grand Lagoon after heavy rains. The decision-making tool indicates that contaminated runoff is the likely cause of these blooms and offers a series of solutions ranging from establishing vegetated buffer zones to creating stormwater ponds and wetlands to placing oil/grease separators inside storm sewers. The image in Figure 5.12 above depicts a multiuse stormwater pond with a boardwalk for viewing access and educational signage to inform visitors. As recommended in the ‘Suburban Coastal Communities: Greenway Planning’ tool, such a system can serve as a node or destination point along a greenway network.

Lower Coastal Drainage Basin

Because the Lower Coastal Basin runs the length of the county’s western beaches, a full seventeen miles, only the eastern portion is represented in the image above. With the Gulf of Mexico as its southern border, this 5,945-acre basin has a significant impact on the county’s economic base because it is the area’s primary tourist destination. The Lower Coastal basin is urban in character due to the development density of the many tourism-related accommodations and businesses. It also contains the southern portion of St. Andrew’s State Park. The map in Figure 5.13 depicts a diagrammatic representation of both basins’ drainage ways, wetlands, and shorelines including their respective buffer zones. Primary and secondary roads are also depicted.

Much of this basin lies within the storm surge zone. For this reason, great care should be taken in maintaining natural drainage ways and a buffer of native vegetation along the shorelines. The ‘Urban Coastal Communities’ decision-making tools are suitable for the Lower

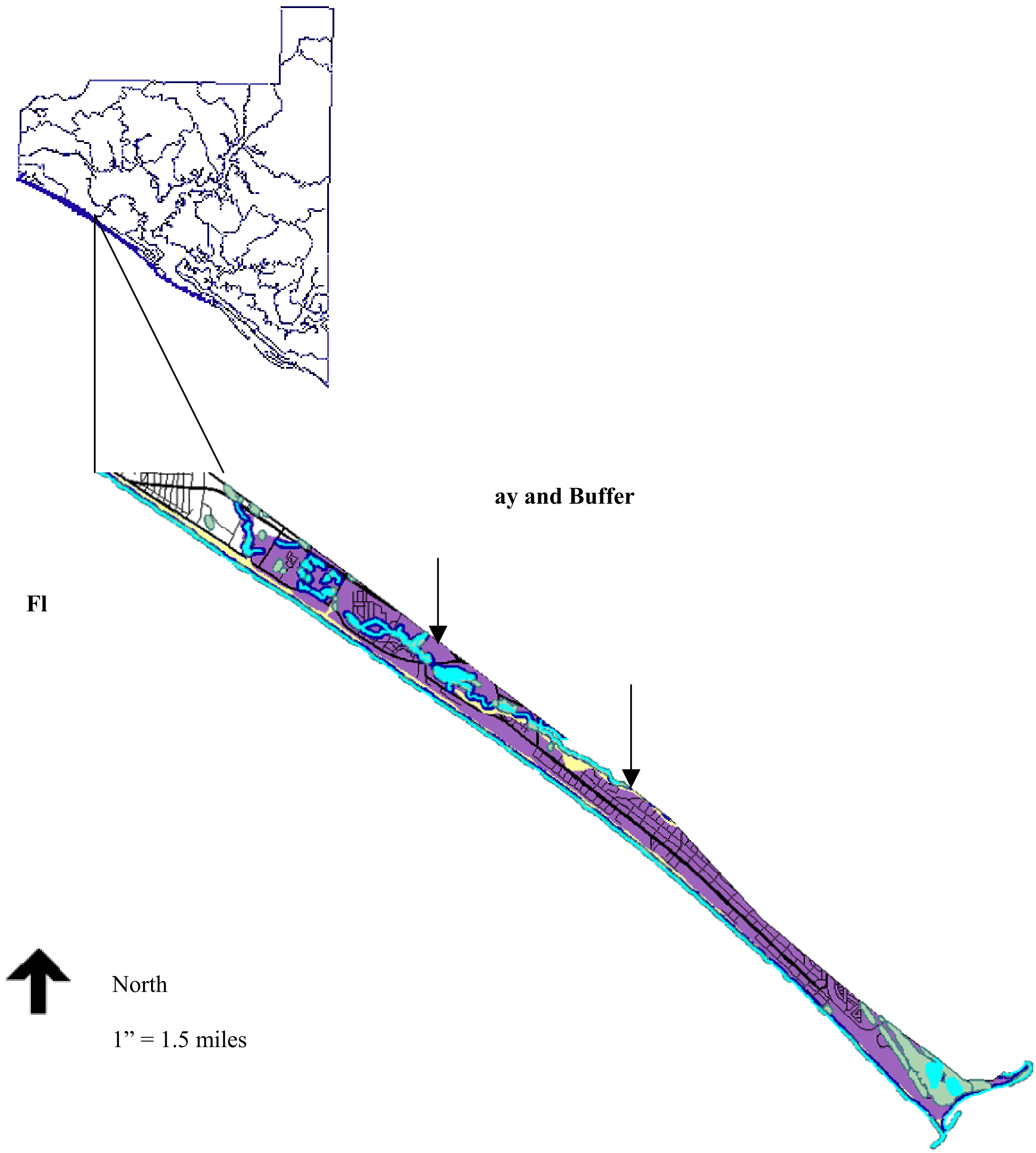

Figure 5.13 Map of Lower Coastal Drainage Basin

Coastal basin. While this basin is composed of the county's best draining soils, high development densities result in large amounts of runoff. This runoff has a negative impact not only on aesthetics, but on water quality and property values as well. In addition, this basin is extremely vulnerable to hurricane activity. Combined, these factors are of great significance because the county's economic strength is built upon the natural resources of the Lower Coastal basin. Using the 'Urban Coastal Communities: Stormwater Managment' tool, nonpoint source pollution is again the example. Infiltration ponds and stormwater wetlands may not be possible in a basin that is so densely developed. One method of addressing nonpoint source pollution is to decrease the quantity of runoff by reducing impervious coverage. The decision-making tool lists many possible solutions for achieving this, including the reduction of parking space requirements, implementation of an urban forestry program, promoting rooftop gardens, and harvesting runoff for use on the landscapes of the many resort properties located in this basin. Because the runoff from this basin empties directly into the Gulf of Mexico, oil/grease separators should be installed in all storm sewers at the very minimum. Finally, it is highly recommended that the stormwater outfall system along the beaches be redesigned. To avoid health and safety hazards as well as continuing maintenance costs, the 152 existing outfalls can be combined into one main outfall and released at one location, such as beneath the county pier. This approach has been used successfully throughout the United States and abroad (Van Heerden, personal communication).

Step Two: Integration as Intervention

Stormwater Decision-Making Tool

A multitude of greenway planning techniques and stormwater best management practices have resulted from the research and design efforts of organizations such as the American

Greenways Program, the Environmental Protection Agency, and the Center for Watershed Protection. For any given situation, choosing the appropriate techniques and practices from the assortment of possible solutions can be a daunting task. The decision-making tool presented in this thesis is meant to be used as an aid in selecting appropriate solutions for various environmental situations and developmental circumstances. Intended for use by both design professionals and lay citizens, the decision-making tool is composed of greenway planning and stormwater management related questions. The decision-making tool has been developed in this manner so that greenway planning techniques and stormwater best management practices are easily accessible and have a clarity of application for all who are interested, be they design professionals or private citizens.

The decision making tool is organized into four sections. The first section addresses stormwater management in urban coastal communities, with the second section concentrating on stormwater management in suburban and rural coastal communities. The third and fourth sections focus on greenway planning techniques, with urban coastal communities addressed in section three and suburban and rural communities in section four. Although by no means exhaustive, this decision-making tool demonstrates a process of applying the recommendations of the experts to the environmental and developmental issues facing the community next door.

1. Urban Coastal Communities: Stormwater Management

- **Are there any existing, visible stormwater management issues?**

If the answer is yes, proceed to 1.1. If the answer is no, skip to 1.5 below.

1.1. Is flooding a regular occurrence during average storm events?

If yes, proceed to 1.1A. If the answer is no, skip to 1.2.

<u>1.1A What could be the cause?</u> Read and select one or more of the following scenarios that accurately describes the flooding problem. Beneath each scenario appears the question ‘why?’ and an answer. Recommended solutions to these stormwater problem scenarios appear in section 1.1B below.

a. The storm sewers are backing up and overflowing.

Why? The storm sewers are overwhelmed by the quantity and speed of water. The quantity of impervious surfacing has increased to such a degree that the storm water pipes are too small to handle the current amount of runoff. The pipes may also be clogged with debris.

Solutions: See 1.1B-a through 1.1B-f below.

b. The streets are flooding.

Why? There is too much water and it has nowhere to go.

Solutions: See 1.1B-a through 2.1B-f below.

c. Structures such as buildings and houses are flooding.

Why? There is too much water and it has nowhere to go.

Solutions: See 1.1B-a through 2.1B-f below.

<u>1.1B Recommended solutions</u>

a. **Infiltration:** direct runoff to all remaining pervious areas such as landscaped areas and roadside swales for the purpose of infiltration. The objective is to reduce the amount of runoff by maximizing the use of all remaining pervious areas.

b. Urban Forestry: implement a street-scaping program, increase the tree population in urban parks, encourage the establishment of roof-top gardens on top of structures such as parking garages, office buildings, hospitals, and educational institutions. The objective is to reduce the amount of runoff by increasing the amount of pervious areas and breaking up continuous areas of impervious surfacing.

c. **Water Harvesting:** utilize runoff for irrigation and water features by capturing roof top runoff in cisterns for landscape irrigation and using treated runoff to supply water features. The water features themselves can act as finishing treatment processes through aeration. The objective is to take advantage of runoff as a water resource instead of viewing it as a waste in need of disposal.

d. **Reduce speed of runoff:** implement check dams and baffles in swales to slow the speed of the runoff, aerate the runoff, and allow the growth of vegetation to help cleanse stormwater. Slowing the speed and volume of runoff will encourage infiltration when flows are small. The objective is to reduce the effect of down stream flooding and ditch overflows throughout the system while encouraging infiltration.

e. **Regular maintenance**: implement a regularly scheduled maintenance program to clean any muck and debris from roadside swales and storm water pipes. The objective is to reduce overflow of turf-lined

drainage ditches and underground storm water conveyance systems.

f. **Increase pipe size:** this is a very expensive alternative and should be considered only after other possible solutions are determined to be inadequate.

1.2. Is there evidence of erosion?

If the answer is yes, proceed to 1.2A. If the answer is no, skip to 1.3.

1.2A What could be the cause? Read and select one or more of the following scenarios that accurately describes the erosion problem. Beneath each scenario appear the questions 'why?' or 'so?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 1.2B below.

a. Stormwaters are eroding the ground surface in roadside swales or when emerging from stormwater pipes into detention areas or receiving waters.

Why? The water is moving too fast. Runoff is not encountering enough friction and obstacles in its conduction in swales or pipes to reduce its velocity. The impact of quickly moving water on the earth's surface when it leaves a storm pipe or travels in a turf-lined swale can cause sediments to become dislodged and carried along in the runoff resulting in scouring and further erosion.

Solution: See 1.2B-a and 1.2B-b below.

b. Soil is washing away in even the smallest storm events.

Why? Water is moving over highly erodable soil. Soils such as sands and disturbed soils that are lacking vegetation like those found on construction sites are easily washed away in stormwater runoff resulting in an increased sediment load in the receiving waters.

Solution: See 1.2B-a through 1.2B-d below.

c. Storm driven waves are eroding the shoreline.

Why? Some erosion along a coastal shore is a naturally occurring phenomenon. When the erosion results in loss of property or in extreme cases loss of life, then remedial measures should be taken.

Solution: See 1.2B-c through 1.2B-e below.

1.2B Recommended solutions

a. **Reduce speed of runoff in a vegetated swale/drainage ditch:**

implement check dams and baffles in swales to slow the speed of the runoff, aerate the runoff, and allow the growth of vegetation to help cleanse stormwater. Slowing the speed and volume of runoff will encourage infiltration in vegetated swales when flows are small. The objective is to minimize erosion by limiting the speed by which runoff travels over the ground surface.

b. Reduce speed of runoff in a storm water pipe: To reduce the velocity of runoff inside a pipe is an expensive endeavor that involves either reducing the slope of the pipe or making the pipe smaller to increase the wettable surface area of the pipe thereby increasing the friction. Another alternative would be to reduce the force of the runoff as it leaves the pipe by breaking its momentum with the use of a baffle. The objective is to reduce erosion by minimizing the speed at which runoff travels through a closed conveyance system and the force with which it exits the system.

c. Construction zone best management practices: special care should be taken in a construction zone to minimize the loss of any disturbed soils via suspension in runoff. An abbreviated list of bmps appears below. For a detailed description of these practices please see the chapter entitled "Construction Site Stormwater Runoff Control" the EPA's National Menu of Best Management Practices publication.

c1. Minimize clearing

c2. Stabilize drainage ways

c3. Erosion control

c4. Protect steep slopes

c5. Protect waterways

c6. Phase construction

c7. Sediment control

c8. Good housekeeping practices

d. Bioengineering: engineered erosion prevention techniques composed of earth, plant materials, and decomposing fastener materials such as ropes, twines, and fabrics, often for the stabilization of banks or other steep slopes. The objective is to use inexpensive, naturally occurring, low maintenance materials to protect highly erosive surfaces.

e. Vegetated Buffer: the shorelines of coastal water bodies and their tributaries should be buffered from development in order to maintain the fragile ecosystems that exist in these marginal areas. Vegetated buffer zones protect the integrity of coastal ecosystems by restricting development and uses in critical areas and by filtering contaminated runoff as it passes through the layers of soils and vegetation. Buffers are also ideal for separating incompatible land uses and protecting water resources from high contaminant producing activities. Properly designed vegetated buffers also protect human life and property from flooding and storm surges.

1.3. Is there evidence of non-point source pollution in surface waters or ground waters?

If yes, proceed to 1.3A. If no, skip to 1.4.

1.3A What could be the cause? Read and select one or more of the following scenarios that accurately describes the pollution problem. Beneath each scenario appears the question 'how?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 1.3B below.

a. Algal blooms, death or deformation of marine life, disappearance of plant life such as sea grasses, disappearance or degradation of wetlands, contaminated well water.

Why? Contaminated runoff. Contaminated runoff results from the accumulation of many different types of pollutants that cannot be linked to a specific location but instead occur in many locations at differing times. This helps to explain the challenges of managing and mitigating this type of pollution.

Sources of nonpoint source pollution include: oil dripping from cars, nutrients from pet wastes or fertilizer applications, toxins from pesticide and fungicide applications, and runoff from stormwater hotspots which are areas that produce runoff that has high concentrations of contaminants, much more than what is typically found in runoff. Examples of storm water hot spots include such as gas stations, commercial parking lots, marinas, industrial roof tops, and car washes.

Solution: See 1.3B-a through 1.3B-j below.

b. After a storm event, waters stay muddier longer than they used to or are permanently muddier than they used to be, degradation or disappearance of wetlands, reduction or disappearance of marine life and aquatic plant life.

Why? Erosion. Erosive flood waters carry soils and other earth particles which results in an increased sediment load of the receiving waters. This problem is compounded when the materials

suspended in the flood waters are contaminated. Increased sediment loads can have devastating impacts on the ecosystems of a waterhsed's receiving waters by blocking sunlight, altering chemical composition of the water, and decreasing water clarity.

Solution: See solutions under section 1.2B above.

c. Disappearance or degradation of wetlands.

Why? Hydromorphology. An increase in impervious surfaces results in a greater quantities of runoff. Wetlands develop under certain hydrological conditions and when there is a change in those conditions, such as an increase in the amount of water entering the wetland, negative impacts are often the result.

Solution: See solutions 1.1B-a through 1.1B-c above and 1.3B-f through 1.3B-j below.

<u>1.3 B Recommended solutions</u>

**** important note:** the reduction of contaminants in stormwater runoff often involves a combination of solutions used in conjunction with one another. The appropriate combination should be determined on a site-by-site basis.

a. Identify contaminants and their sources: depending on the contaminant and the circumstance in which it comes in contact with storm water runoff, different solutions will apply. The BMP Suitability Matrix (Table 2.1) indicates contaminant removal rates and site suitability of various practices.

b. Bioretention: suitable for construction in urban parking lots, bioretention basins receive runoff from impervious surfaces. As the runoff filters through the bioretention basin's vegetation and soil layers, substantial amounts of both soluble and insoluble contaminants are removed. There may or may not be a perforated drainage pipe at the bottom of the bioretention basin to collect the runoff and convey to the storm sewer system.

c. Sand and organic filters: requiring little space, these filters are designed to remove insoluble contaminants from runoff. In some instances, microorganisms living in the chosen filter media can act on soluble contaminants as well. There may or may not be a perforated drainage pipe at the bottom of the filter to receive the runoff and convey it to the storm sewer system.

d. Oil and Grease Separators: manufactured storm sewer inserts that separate oil and grease from runoff entering the underground conveyance system. The objective is to reduce or eliminate petroleum products from entering receiving waters via runoff. If the conveyance system directs runoff to a treatment facility before being released into receiving waters, the reduction or elimination of petroleum products reduces treatment costs.

e. Catch basins: this design feature of a storm sewer is intended to capture sediments and other solids (garbage, leaves, twigs, etc.) before they enter the conveyance system. The objective is to reduce the pollutant load and minimize pipe clogging.

f. Curb Cuts: breaks in the curb line along a roadway allow runoff to enter roadside swales, bioretention facilities and other surface conveyance and treatment systems. The objective is to reduce the concentrated accumulation of runoff by distributing it to several conveyance and treatment systems within an area instead of funneling all of it into a storm sewer system. Minimizing the amount of water entering a storm sewer system also minimizes costs associated with treatment and infrastructure.

g. Infiltration: reducing the amount of impervious surface encourages infiltration, and infiltration substantially reduces the pollutant loads in runoff, particularly the insoluble contaminants. Opportunities for infiltration in an urban setting exist in vegetated swales, alternative paving materials, directing runoff toward landscaped areas, infiltration trenches, bioretention areas, and sand and organic filters. It is important to note that infiltration of runoff should only be permitted when the acceptable level of water quality, as determined by federal and state agencies, has been achieved.

h.Wet Pond: the use of wet ponds (also called retention ponds) is limited in urban environments because of their space requirements. For a full description see solution 2.3B-e in the following section on stormwater best management practices for suburban coastal communities.

i. **Stormwater wetland**: limited in urban environments because of space requirements. For a full description see solution 2.3B-f in the following section on stormwater best management practices for suburban coastal communities.

j. **Stormwater retrofit**: Urban infill of abandoned or underutilized properties will require a retrofit of the existing stormwater features to meet contemporary standards. Adaptive land reuse presents an opportunity for creative stormwater management applications in the guise of aesthetically pleasing urban water features.

1.4. Has there been a decrease in groundwater levels ?

If the answer is yes proceed to 1.4A. If the answer is no skip to 1.5.

<u>1.4A What could be the cause?</u> Read and select one or more of the following scenarios that accurately describes the groundwater problem. Beneath each scenario appears the question 'how?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 1.4B below.

a. Less water is available from wells or they are drying up completely.

Why? There is less water in the aquifer because more water is being withdrawn from the aquifer than is being replaced.

Solution: See 1.4B-a through 1.4B-c below.

b. Built structures are sinking, foundations and walls are cracking, or sink holes are forming.

Why? Subsidence. When runoff is captured and conveyed to a disposal or treatment facility instead of infiltrating into the soil, groundwater levels drop, resulting in a sinking or compacting of the earth's surface.

Solution: See 1.4B-a through 1.4B-c below.

c. Freshwater wells are delivering salt water.

Why? Saltwater intrusion occurs when more potable water is drawn out of the aquifer than is replaced. This causes the subsurface saline layer to rise and push the less dense, potable water closer to the surface permanently loosing depth and capacity.

Solution: See 1.4B-a through 1.4B-c below.

<u>1.4 B Recommended Solutions</u>

a. **Balance**: the amount of water deposited into an aquifer should not be less than the amount of water withdrawn. Balance can be achieved through infiltration as well as restrictions on water usage in extreme circumstances.

b. **Infiltration**: infiltration should be encouraged at every opportunity through the protection of recharge soils and the methods discussed in sections 1.1B-a and 1.3B-g above.

c. **Maximum use of remaining recharge soils:** It is likely that very few recharge areas have remained pervious in an urban environment. For those that are remaining their infiltration capacity should be utilized by accepting the

maximum quantity of uncontaminated runoff as determined by their porosity and permeability.

1.5 If stormwater management issues are not currently obvious but there are concerns about the future, the watershed approach to community growth and development is an applicable solution.

1.5 A What is the watershed approach?

The watershed approach is an integrated, science-based method of planning and managing growth and development within a given watershed. The objective of the watershed approach is to maintain the integrity of water resources while taking into account the qualities and characteristics of a watershed, such as its ecosystems, economies, land uses and regulations, and social and cultural activities. The watershed approach is composed of seven main points: education and awareness; partnerships and coordination; monitoring and research; planning and prioritization; funding and technical assistance; implementation: protection and restoration; evaluation. For a thorough discussion of the watershed approach, please see the EPA document Protecting and Restoring America's Watersheds: Status, Trends, and Initiatives in Watershed Management (June 2001).

2. Suburban and Rural Coastal Communities: Stormwater Management

- **Are there any existing, visible stormwater management issues?**

If the answer is yes, proceed to 2.1. If the answer is no, skip to 2.5 below.

2.1. Is flooding a regular occurrence during average storm events?

If yes, proceed to 2.1A. If the answer is no skip to 2.2.

<u>2.1A What could be the cause?</u> Read and select one or more of the following scenarios that accurately describes the flooding problem. Beneath each scenario appears the question 'why?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 2.1B below.

a. The vegetated swales and drainage ditches are overflowing.

Why? The ditches are overwhelmed by the quantity and speed of water. An accumulation of muck in the bottom of the ditches is interfering with the infiltration capacity of the soils below.

Solutions: See 2.1B-a through 2.1B-h, 2.1B-j, and 2.1B-k below.

b. The storm sewers are backing up and overflowing.

Why? The storm sewers are overwhelmed by the quantity and speed of water. The quantity of impervious surfacing has increased to such a degree that the storm water pipes are too small to handle the current amount of runoff. The pipes may also be clogged with debris.

Solutions: See 2.1B-a through 2.1B-k below.

c. Retention and detention ponds are overflowing.

Why? There is too much water. The amount of impervious surfacing has increased to such a degree that the storage capacity of existing retention and detention ponds is no longer sufficient.

Solutions: See2.1B-a through 2.1B-d, 2.1B-f, 2.1B-h, 2.1B-j, and 2.1B-k below.

d. The streets are flooding.

Why? There is too much water and it has nowhere to go. Also see sections 2.1A-a through 2.1A-c above.

Solutions: See 2.1B-a through 2.1B-k below.

e. Structures such as houses and buildings are flooding.

Why? There is too much water and it has nowhere to go. Also see sections 2.1A-a through 2.1A-d above.

Solutions: See 2.1B-a through 2.1B-k below.

2.1B Recommended solutions

a. **Reduce speed of runoff:** implement check dams and baffles in swales to slow the speed of the runoff, aerate the runoff, and allow the growth of vegetation to help cleanse stormwater. Slowing the speed and volume of runoff will encourage the infiltration when flows are small. The objective is to reduce the effect of down stream flooding and overflows throughout the system while encouraging infiltration.

b. **On-lot Treatment:** the idea is to capture and utilize rainfall and runoff on site.

b1. Infiltration: direct runoff to all pervious areas such as landscaped yards and roadside swales for the purpose of infiltration and groundwater recharge. The objective is to reduce the amount of runoff by maximizing the use of all remaining pervious areas.

b2. Water Harvesting: utilize runoff for irrigation and water features by capturing roof top runoff in cisterns for landscape irrigation and using treated runoff to supply water features. The water features themselves can act as finishing treatment processes through aeration. The objective is to take advantage of runoff as a water resource instead of viewing it as a waste in need of disposal.

c. **(Sub)Urban Forestry:** implement a street-scaping program, increase the tree population in public parks, encourage the establishment of roof-top gardens on top of structures such as parking garages, commercial buildings, hospitals, and educational institutions. The objective is to reduce the amount of runoff by increasing the amount of pervious areas and breaking up continuous areas of impervious surfacing.

d. **Green Parking:** a combination of best management practices applied to a parking lot such as permeable paving materials, bioretention, reduced lot size and reduced parking space dimensions.

e. **Dry Extended Detention Pond:** also called a detention pond, this practice helps to reduce the peak flow of flood waters but does not reduce the amount of flood waters leaving the watershed.

f. **Infiltration basin:** although similar in appearance to a detention pond, an infiltration basin is designed to allow runoff and flood waters to infiltrate into the soil and recharge the groundwater. Not only does this method reduce the peak flow of flood waters, but it also reduces the amount of water leaving a watershed in the form of runoff.

g. **Wet Pond:** also called a retention pond, this type of pond maintains a permanent body of water while being able to store a predetermined additional amount of water. This practice helps to reduce the peak flow of flood waters but does not reduce the amount of flood waters leaving the watershed.

h. **Regular maintenance:** implement a regularly scheduled maintenance program to clean any muck and debris from road side swales and storm water pipes. The objective is to reduce overflow of vegetated drainage ditches and underground storm water conveyance systems.

i. **Increase pipe size:** this is a very expensive alternative and should be considered only after other possible solutions are determined to be inadequate.

j. **Flood zones and storm surge zones:** constructing roads and buildings outside of the 100-year flood plain and the storm surge zones of category one through five hurricanes will greatly reduce the threat of damage to life and property. By leaving flood and storm surge zones undeveloped they become protective buffers during severe storm events. The objective is to reduce the costs associated with damages from storms and flooding.

k. **Design Guidelines for Development:** several design techniques can be implemented to reduce the amount of impervious surface and runoff in a watershed and encourage infiltration. Examples include: siting buildings on impermeable soils or on raised foundations above permeable soils narrow or 'skinny' streets in residential neighborhoods to reduce

impervious surfaces, limit or eliminate curb and gutter construction to encourage infiltration, utilize alternative paving materials to reduce amount of impervious surfaces and encourage infiltration, implement the watershed approach to planning and design for the preservation of open spaces, reduce size of parking lots and concentrate driveways to reduce impervious surfaces.

2.2. Is there evidence of erosion?

If the answer is yes, proceed to 2.2A. If the answer is no, skip to section 2.3.

2.2A What could be the cause? Read and select one or more of the following scenarios that accurately describes the erosion problem. Beneath each scenario appear the questions 'why?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 2.2B below.

a. Stormwaters are eroding the ground surface in roadside swales or when emerging from stormwater pipes into detention areas or receiving waters.

Why? The water is moving too fast. Runoff is not encountering enough friction and obstacles to reduce its velocity. The impact of quickly moving water on the earth's surface when it leaves a storm pipe or travels in a turf-lined swale can cause sediments to become dislodged and carried along in the runoff resulting in scouring and further erosion.

Solution: See 2.2B-a, 2.2B-b, and 2.2B-d below.

b. Soil is washing away in even the smallest storm events.

Why? Water is moving over highly erosive soil. Soils such as sands and disturbed soils that are lacking vegetation like those found on construction sites are easily washed away in stormwater runoff resulting in an increased sediment load in the receiving waters.

Solution: See 2.2B-a through 2.2B-f below.

c. Storm driven waves are eroding the shoreline.

Why? Some erosion along a coastal shore is a naturally occurring phenomenon. When the erosion results in loss of property or in extreme cases loss of life, then remedial measures should be taken.

Solution: See 2.2B-d, 2.2B-e, and 2.2B-g below.

2.2B Recommended Solutions

a. Reduce speed of runoff in a vegetated swale/drainage ditch:

implement check dams and baffles in swales to slow the speed of the runoff, aerate the runoff, and allow the growth of vegetation to help cleanse stormwater. Slowing the speed and volume of runoff will encourage infiltration in vegetated swales when flows are small. The objective is to minimize erosion by limiting the speed by which runoff travels over the ground surface.

b. Reduce speed of runoff in a storm water pipe: To reduce the velocity of runoff inside a pipe is an expensive endeavor that involves either reducing the slope of the pipe or making the pipe smaller to increase the

wettable surface area of the pipe thereby increasing the friction. Another alternative would be to reduce the force of the runoff as it leaves the pipe by breaking its momentum with the use of a baffle. The objective is to reduce erosion by minizing the speed at which runoff travels through a closed conveyance system and the force with which it exits the system.

c. Construction zone best management practices: special care should be taken in a construction zone to minimize the loss of any disturbed soils via suspension in runoff. An abbreviated list of bmps appears below. For a detailed desription of these practices please see the chapter entitled "Construction Site Stormwater Runoff Control" the EPA's National Menu of Best Management Practices publication.

c1. Minimize clearing

c2. Stabilize drainage ways

c3. Erosion control

c4. Protect steep slopes

c5. Protect waterways

c6. Phase construction

c7. Sediment control

c8. Good housekeeping practices

d. Bioengineering: engineered erosion prevention techniques composed of earth, plant materials, and decomposing fastener materials such as ropes, twines, and fabrics, often for the stabilization of banks or other

steep slopes. The objective is to use inexpensive, naturally occurring, low maintenance materials to protect highly erodable surfaces.

e. Vegetated Buffer: the shorelines of coastal waterbodies and their tributaries should be buffered from development in order to maintain the fragile ecosystems that exist in these marginal areas. Vegetated buffer zones protect the integrity of coastal ecosystems by restricting development and uses in critical areas and by filtering contaminated runoff as it passes through the layers of soils and vegetation. Buffers are also ideal for separating incompatible land uses and protecting water resources from high contaminant producing activities. Properly designed vegetated buffers also protect human life and property from flooding and storm surges.

f. Vegetated filter strips: this infiltration and pollutant removal technique has been adapted from agricultural applications and is suitable for the interception and treatment of runoff from roads and highways, small parking lots, roof tops and pervious surfaces. It is well suited for combination with other management practices such as the vegetated buffer system.

g. Flood zones and storm surge zones: constructing roads and buildings outside of the 100-year flood plain (?) and the storm surge zones of category one through five hurricanes will greatly reduce the threat of damage to life and property. By leaving flood and storm surge zones undeveloped they become protective buffers during severe storm events.

The objective is to reduce the costs associated with damages from erosion caused by storms and flooding.

2.3. Is there evidence of non-point source pollution in surface waters or ground waters?

If yes, proceed to 2.3A. If no, skip to 2.4.

<u>2.3A What could be the cause?</u> Read and select one or more of the following scenarios that accurately describes the pollution problem. Beneath each scenario appears the question 'why?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 2.3B below.

a. **Algal blooms, death or deformation of marine life, disappearance of plant life such as sea grasses, disappearance or degradation of wetlands, contaminated well water.**

Why? Contaminated runoff. Contaminated runoff results from the accumulation of many different types of pollutants that cannot be linked to a specific location but instead occur in many locations at differing times. This helps to explain the challenges of managing and mitigating this type of pollution.

Sources of nonpoint source pollution include: oil dripping from cars, nutrients from pet wastes or fertilizer applications, toxins from pesticide and fungicide applications, and runoff from stormwater hotspots which are areas that produce runoff that has high concentrations of contaminants, much more than what is typically found in runoff. Examples of storm water hot spots

include such as gas stations, commercial parking lots, marinas, industrial rooftops, and car washes.

Solution: See 2.3B-a through 2.3B-l below.

b. After a storm event, waters stay muddier longer than they used to or are permanently muddier than they used to be, degradation or disappearance of wetlands, reduction or disappearance of marine life and aquatic plant life.

Why? Erosion. Erosive flood waters carry soils and other earth particles which results in an increased sediment load of the receiving waters. This problem is compounded when the materials suspended in the floodwaters are contaminated. Increased sediment loads can have devastating impacts on the ecosystems of a watershed's receiving waters by blocking sunlight, altering chemical composition of the water, and decreasing water clarity.

Solution: See solutions under section 2.2B above.

c. Disappearance or degradation of wetlands.

Why? Hydromorphology. An increase in impervious surfaces results in a greater quantities of runoff. Wetlands develop under certain hydrological conditions and when there is a change in those conditions, such as an increase in the amount of water entering the wetland, negative impacts are often the result.

Solution: See solutions 2.3B-a through 2.3B-h, and 2.3B-j below.

2.3 B Recommended solutions

**** important note:** the reduction of contaminants in stormwater runoff often involves a combination of solutions used in conjunction with one another. The appropriate combination should be determined on a site-by-site basis.

a. **Identify contaminants and their sources:** depending on the contaminant and the circumstance in which it comes in contact with storm water runoff, different solutions will apply. The BMP suitability matrix in Table 2.1 indicates contaminant removal rates and site suitability of various practices.

b.**Bioretention**: Bioretention basins are constructed to receive runoff from impervious surfaces. As the runoff filters through the bioretention basin's vegetation and soil layers, substantial amounts of both soluble and insoluble contaminants are removed. There may or may not be a perforated drainage pipe at the bottom of the bioretention basin to collect the runoff and convey to the storm sewer system.

c. **Infiltration:** reducing the amount of impervious surface encourages infiltration, and infiltration substantially reduces the pollutant loads in runoff, particularly the insoluble contaminants. Opportunities for infiltration in a suburban setting exist in vegetated swales, alternative paving materials, directing runoff toward landscaped areas, infiltration trenches, bioretention areas, and sand and organic filters. It is important to note that infiltration of runoff should only be permitted when the acceptable level of water quality, as determined by federal and state

agencies, has been achieved. Also see **Infiltration basin** in section 2.3B-c above and **Green parking** in section 2.4B-g below.

d. On-lot Treatment: the objective is to capture and use rainfall and runoff on site.

d1. Infiltration: direct runoff to all pervious areas such as landscaped yards and infiltration trenches for the purpose of infiltration and groundwater recharge. See solution 2.3B-c above.

d2. Water Harvesting: utilize runoff for irrigation and water features by capturing roof top runoff in cisterns for landscape irrigation and using treated runoff to supply water features. The water features themselves can act as finishing treatment processes through aeration. The objective is to take advantage of runoff as a water resource instead of viewing it as a waste in need of disposal.

e.Wet Pond: Wet ponds (also called retention ponds) maintain a permanent water level and are designed to handle additional quantities of water resulting from stormwater runoff. These ponds reduce contaminant levels by the settling and of suspended solids which is often followed by biological action upon those solids. Soluble contaminants are also reduced by being exposed to sunlight, aerated via mechanical means within the pond such as fountains, and the biological action of algae and microorganisms.

f. Stormwater wetland: Stormwater wetlands can be constructed wetlands or naturally occurring wetlands that have been degraded by changes in hydrology or pollutant loads. They are specifically constructed and controlled ecosystems that treat contaminated runoff through reuptake by plants and microorganisms.

g. Vegetated buffer: the shorelines of coastal water bodies and their tributaries should be buffered from development in order to maintain the fragile ecosystems that exist in these marginal areas. Vegetated buffer zones protect the integrity of coastal ecosystems by restricting development and uses in critical areas and by filtering contaminated runoff as it passes through the layers of soils and vegetation. Buffers are also ideal for separating incompatible land uses and protecting water resources from high contaminant producing activities. Properly designed vegetated buffers also protect human life and property from flooding and storm surges.

h. Vegetated filter strip: this infiltration and pollutant removal technique has been adapted from agricultural applications and is suitable for the interception and treatment of runoff from roads and highways, small parking lots, roof tops and pervious surfaces. It is well suited for combination with other management practices such as the vegetated buffer system.

i. Sand and organic filters: requiring little space, these filters are designed to remove insoluble contaminants from runoff. In some instances, microorganisms living in the chosen filter media can act on soluble contaminants as well. There may or may not be a perforated drainage pipe at the bottom of the filter to receive the runoff and convey it to the storm sewer system.

j. Curb Cuts: breaks in the curb line along a roadway allow runoff to enter roadside swales, bioretention facilities and other surface conveyance and treatment systems. The objective is to reduce the concentrated accumulation of runoff by distributing it to several conveyance and treatment systems within an area instead of funneling all of it into a storm sewer system. Minimizing the amount of water entering a storm sewer system also minimizes costs associated with treatment and infrastructure.

k. Oil and Grease Separators: these manufactured storm sewer inserts separate oil and grease from runoff entering the underground conveyance system. The objective is to reduce or eliminate petroleum products from entering receiving waters via runoff. If the conveyance system directs runoff to a treatment facility before being released into receiving waters, the reduction or elimination of petroleum products reduces treatment costs.

l. Catch basins: this design feature of a storm sewer is intended to capture sediments and other solids (garbage, leaves, twigs, etc.) before they enter the

conveyance system. The objective is to reduce the pollutant load and minimize pipe clogging.

2.4. Has there been a decrease in groundwater levels ?

If the answer is yes proceed to 2.4A. If the answer is no skip to 2.5.

2.4A What could be the cause? Read and select one or more of the following scenarios that accurately describes the groundwater problem. Beneath each scenario appears the question 'why?' and an answer. Recommended solutions to these stormwater problem scenarios appear in section 2.4B below.

a. Less water is available from wells or they are drying up completely.

Why? There is less water in the aquifer because more water is being withdrawn from the aquifer than is being replaced.

Solution: See 2.4B-a through 2.4B-h below.

b. Built structures are sinking, foundations and walls are cracking, or sink holes are forming.

Why? Subsidence. When runoff is captured and conveyed to a disposal or treatment facility instead of infiltrating into the soil, groundwater levels drop, resulting in a sinking or compacting of the earth's surface.

Solution: See 2.4B-a through 2.4B-h below.

c. Freshwater wells are delivering salt water.

Why? Saltwater intrusion occurs when more potable water is drawn out of the aquifer than is replaced. This causes the subsurface saline layer to rise

and push the less dense, potable water closer to the surface permanently loosing depth and capacity.

Solution: See 2.4B-a through 2.4B-h below.

2.4 B Recommended Solutions

a. **Balance:** the amount of water deposited into an aquifer should not be less than the amount of water withdrawn. Balance can be achieved through infiltration as well as restrictions on water usage in extreme circumstances.

b. **Infiltration:** reducing the amount of impervious surface encourages infiltration, and infiltration recharges groundwater levels. It is important to note that infiltration of runoff should only be permitted when the acceptable level of water quality, as determined by federal and state agencies, has been achieved. Opportunities for infiltration in a suburban setting exist in vegetated swales, vegetated filter strips, alternative paving materials, directing runoff toward landscaped areas, infiltration trenches, and some bioretention areas. Also see **Infiltration basin** in section 2.3B-c above.

c. **Maximum recharge potential of permeable soils:** The infiltration capacity of recharge soils should be utilized by directing to them the maximum quantity of uncontaminated runoff as determined by the soil type.

d. **Vegetated buffer:** the shorelines of coastal water bodies and their tributaries should be buffered from development in order to maintain the fragile ecosystems that exist in these marginal areas. Vegetated buffer

zones protect the integrity of coastal ecosystems by restricting development and uses in critical areas and by filtering contaminated runoff as it passes through the layers of soils and vegetation. Buffers are also ideal for separating incompatible land uses and protecting water resources from high contaminant producing activities. Properly designed vegetated buffers also protect human life and property from flooding and storm surges.

e. Vegetated filter strip: this infiltration and pollutant removal technique has been adapted from agricultural applications and is suitable for the interception and treatment of runoff from roads and highways, small parking lots, roof tops and pervious surfaces. It is well suited for combination with other management practices such as the vegetated buffer system.

f. Curb Cuts: breaks in the curb line along a roadway allow runoff to enter roadside swales, bioretention facilities and other surface conveyance and treatment systems. The objective is to reduce the concentrated accumulation of runoff by distributing it to several conveyance and treatment systems within an area instead of funneling all of it into a storm sewer system. Minimizing the amount of water entering a storm sewer system also minimizes costs associated with treatment and infrastructure.

g. Green Parking: a combination of best management practices applied to a parking lot such as permeable paving materials, bioretention, reduced lot size and reduced parking space dimensions.

h. Design Guidelines for Development: several design techniques can be implemented to reduce the amount of impervious surface in a watershed and encourage groundwater recharge. Examples include: building foundations placed on impermeable soils or elevated above permeable soils, narrow or 'skinny' streets in residential neighborhoods to reduce impervious surfaces, limit or eliminate curb and gutter construction to encourage infiltration, utilize alternative paving materials to reduce amount of impervious surfaces and encourage infiltration, implement the watershed approach to planning and design for the preservation of open spaces, reduce size of parking lots and concentrate driveways to reduce impervious surfaces.

2.5 If stormwater management issues are not currently obvious but there are concerns about the future, the watershed approach to community growth and development is an applicable solution.

2.5 A What is the watershed approach?

The watershed approach is an integrated, science-based method of planning and managing growth and development within a given watershed. The objective of the watershed approach is to maintain the integrity of water resources while taking into account the qualities and characteristics of a watershed, such as its ecosystems, economies, land uses and regulations, and social and cultural activities. The watershed approach is composed of seven main points: education and awareness; partnerships and coordination; monitoring and research; planning and prioritization; funding and technical assistance; implementation: protection and restoration; evaluation. For a thorough discussion of the watershed approach, please see the EPA document

Protecting and Restoring America's Watersheds: Status, Trends, and Initiatives in Watershed Management (June 2001). An integrated greenway/stormwater management system can be incorporated into the watershed approach by serving as the foundation for sustainable, conscientious approach to community growth and development.

3. Coastal Communities: Greenway Planning

Greenways have many different uses ranging from public recreation to water quality improvements to habitat conservation. The first step in the greenway planning process is to determine the purpose of the greenway and its potential users: what is the community trying to accomplish by establishing a greenway system, who will use it, and where will it be located? For a comprehensive understanding of the many uses of greenways, refer to the texts Greenways: Planning, Design, and Development edited by Schwarz and written by Fink and Searns and The Ecology of Greenways edited by Smith and Hellmund. Both of these texts are discussed in the literature review section of this thesis.

3.1. What is the purpose of a greenway?

a. What is the community trying to accomplish by establishing a greenway system?

In the case of this thesis, a greenway system is being proposed in combination with stormwater best management practices as a method of mitigating the effects of stormwater runoff and coastal storm surge in Bay County, Florida.

b. Who will use the greenway? Although the greenway would be designed primarily for stormwater management, this should not be its only use. In fact, a creative design solution would disguise the utilitarian purpose of the greenway, making it appear instead as a place designed for other uses. In the case of the Bay County greenway system, it's users would be fresh water in the form of runoff and salt water in the form of storm surge, people engaged in

recreational activities, and wildlife (both plants and animals) traveling within or between habitats.

c. <u>Where will the greenway be located?</u> Deciding where to locate the greenway will depend on many factors, some of which are discussed below in sections 3.2 through 3.4. The type of land use and the degree of development density in any given area will have a tremendous influence on the design of the greenway. Although by no means exhaustive, the sections below discuss the greenway planning process for urban, suburban, and rural coastal communities.

3.2. Urban Coastal Community

Establishing a greenway in an urban locale poses more challenges than in other, less dense environments. This is not a reason for discouragement, it is a reason for creativity, community partnerships, and the promotion of the greenway idea.

3.2A <u>Where will the greenway be located?</u> Read and select one or more of the following scenarios that accurately describes existing challenges to establishing a greenway. Beneath each scenario appears a response statement and a list of potential opportunities.

a. There isn't any green space left.

Response: Even very large and densely populated cities like Denver, Seattle, and New York City have developed greenway systems. Although suitable locations for a greenway may not be immediately obvious it does not mean they are not there.

Opportunities: See 3.2B-a through 3.2B-o below.

b. There are some green spaces remaining, but they are separated by intensely developed urban areas.

Response: Every effort should be made to link as many spaces together as possible. While the overall purpose of the greenway system in Bay County is stormwater management, the amount of space needed to achieve this goal may not be available in all urban environments. In this case, stormwater management would be handled primarily by best management practices while the greenway would be an asset to the community by providing a place for recreation and conservation and adding to the quality of life.

Opportunities: See 3.2B-a through 3.2B-o below.

c. If the greenway isn't large enough for stormwater management why create one at all?

Response: This thesis proposes stormwater management and treatment as the primary reasons for establishing a greenway system in Bay County. If some portions of the greenway are unable to achieve all of the primary intentions, it will still be of great value to the community. Its presence will add to the community's quality of life by offering such amenities as a naturalistic place in the city, a place for recreation, habitat conservation, trees for cool places and clean air, a tourist attraction, an educational opportunity for school children, and an increase in property values.

Opportunities: See 3.2B-a through 3.2B-j and 3.2B-l through 3.2B-o below.

d. Establishing a greenway system in an urban coastal community will require a considerable amount of funding and the community has very few resources.

Response: An initial lack of funds should not deter a community from pursuing a greenway system. There is a substantial amount of public and private money available to fund greenway planning, design, and development initiatives. A dedicated and resourceful greenway planning committee will be able to acquire the funds needed to accomplish the community's goals.

Opportunities: See opportunities 3.2B-l through 3.2B-o below.

3.2B <u>Opportunities for creating a greenway system</u>

a. **Drainage ways:** identify all of the existing drainage ways both those that have been channeled and those that remain relatively natural.

b. **Wetlands:** identify all of the existing wetlands, both healthy and compromised.

c. **Open space:** locate existing parks, recreation areas, schools, government owned conservation areas.

d. **Significant places:** locate culturally and historically significant places. Information resources include the National Register of Historic Places, The Historic American Buildings Survey, The Historic American Engineering Record, and the State Historic Preservation Office.

e. **Shorelines:** Determine what areas of the shoreline can be made

accessible to public use by means of trail systems, board walks, and viewing areas.

f. **Buffers:** taking into account soils, slopes, flood plains, and adjacent land uses determine the width of a buffer zone for all water bodies: rivers, streams, wetlands, lakes, and shorelines. The purpose of the buffer is to help protect surface waters from non point source pollution and to mitigate the impacts of from storm surges.

g. **Civic areas:** identify significant public gathering areas such as civic centers, community centers, town halls, court houses, libraries, public squares.

h. **Established trails:** identify established trails or popular areas for activities such as walking, biking, jogging, and roller blading.

i. **Corridors:** locate the corridors and rights-of-way for drainage ways, utilities, and railroads.

j. **Abandoned or underutilized property:** identify any abandoned or underutilized properties that could be revitalized into open space or whose revitalization could include open space. Factories, military bases, industrial areas, and shopping centers that are no longer in use provide great opportunities for revitalization.

k. **Stormwater:** identify stormwater problem areas. Determine if there is an opportunity for establishing green space as a method of mitigation or as part of a stormwater retrofit project.

l. **Agreements/Informal Cooperation:** determine interest level of landowners in establishing a greenway by means of both formal agreements and informal cooperation. Strategies for acquisition include conservation easements, right of public access easements, fee simple purchase, transfer or purchase of development rights, and land management agreements to name a few. A more comprehensive list can be found in Greenways: A Guide to Planning, Design, and Development.

m. **Ask for assistance:** enlist the aid of local citizens groups and conservation groups. The state of Florida's Office of Greenways and Trails is also an excellent resource.

n. **Promotion:** promote the concept and benefits of greenway planning through public education and advocacy at local levels.

o. **Funding:** Funding is available through local, state, and federal government agencies as well as through private sources such as endowment grants, gifts and donations, and corporate sponsorships. For a comprehensive list of funding sources, please see Greenways: A Guide to Planning, Design, and Development and the Florida Department of Environmental Protection's Office of Greenways and Trails.

3.3 Suburban Coastal Community

For communities facing the threat of suburban sprawl or those already experiencing it, the establishment of a greenway system can help limit the extent of that sprawl in addition to its primary purpose of stormwater management. By participating in the greenway planning process, communities develop a clear understanding of appropriate land uses for particular landscape

types. Greenway planning in a suburban coastal community has some of the same challenges as the urban environment discussed above and many of the benefits of the rural coastal community discussed in the next section.

3.3A <u>Where will the greenway be located?</u> Read and select one or more of the following scenarios that accurately describes existing challenges to establishing a greenway. Beneath each scenario appears a response statement and a list of potential opportunities.

a. The community's existing green spaces are separated by development.

Response: Every effort should be made to link as many spaces together as possible. While the overall purpose of the greenway system in Bay County is stormwater management, the amount of space needed to achieve this goal may not be available in all areas of a suburban community. In such instances, stormwater management would be handled primarily through best management practices. In areas where the greenway is not large enough to incorporate many stormwater management techniques, the greenway would still be an asset to the community, adding to its quality of life.

Opportunities: See 3.3B-a through 3.3B-q below.

b. The greenway will take away portions of privately owned land.

Response: Establishing a greenway system is a voluntary community effort. Private property rights are protected and respected. If the alignment of a proposed greenway system places it on private property, the landowner has the right to object. In

many cases it's simply a matter of establishing open communication and clearing up misconceptions.

Opportunities: See 3.3B-a through 3.3B-q below.

c. The greenway will increase the occurrence of crime in the area.

Response: Several studies have examined the relationship between greenways and crime rates. In every instance, crime rates did not increase after the establishment of a greenway, and a few studies found that the occurrence of crimes decreased. For more information, please refer to Greenways: A Guide to Planning, Design, and Development or contact the American Greenways Program division of The Conservation Fund.

Opportunities: See 3.3B-a through 3.3B-q below.

d. Establishing a greenway system in a suburban coastal community will require a considerable amount of funding and the community has very few resources.

Response: An initial lack of funds should not deter a community from pursuing a greenway system. There is a substantial amount of public and private money available to fund greenway planning, initiatives. A dedicated and resourceful greenway planning committee will be able to acquire the funds needed to accomplish the community's goals.

Opportunities: See opportunities 3.3B-n through 3.3B-q below.

3.3 B Opportunities for Creating a Greenway System

a. **Drainage ways:** identify all of the existing drainage ways both those that have been channeled and those that remain relatively natural.

b. **Wetlands:** identify all of the existing wetlands, both healthy and compromised.

c. **Soils:** identify the soil types in the area and determine their permeability and excess storage capacity.

d. **Flood plains:** identify existing flood plains for a selected design storm.

e. **Slopes:** identify steep slopes that are unsuitable for development.

e. **Open space:** locate existing parks, recreation areas, schools, government owned conservation areas.

f. **Significant places:** locate naturally, culturally and historically significant places. Information resources include the US Fish and Wildlife Service, the Environmental Protection Agency, state conservation agencies such as the Florida Fish and Wildlife Commission and the Florida Department of Environmental Protection, the National Register of Historic Places, The Historic American Buildings Survey, The Historic American Engineering Record, and the state Historic Preservation Office.

g. **Shorelines:** Determine what areas of the shoreline can be made accessible to public use by means of trail systems, board walks and viewing areas.

h. **Buffers:** taking into account soils, slopes, flood plains, and adjacent land uses determine the width of a buffer zone for all water bodies: rivers, streams, wetlands, lakes, and shorelines. The purpose of the buffer is to help protect surface waters from non point source pollution and to mitigate the impacts of from storm surges.

i. **Civic areas:** identify significant public gathering areas such as civic centers, community centers, town halls, court houses, libraries, public squares.

j. **Established trails:** identify established trails or popular areas for activities such as walking, biking, jogging, and roller blading.

k. **Corridors:** locate any remaining wildlife corridors as well as the rights-of-way for drainage ways, utilities, and railroads.

l. **Abandoned or underutilized property:** identify any abandoned or underutilized properties that could be revitalized into open space or whose revitalization could include open space. Shopping centers and strip malls that have lost one or more anchor stores are a good example.

m. **Stormwater:** identify stormwater problem areas. Determine if there is an opportunity for establishing green space as a method of mitigation or as part of a stormwater retrofit project.

n. **Agreements/Informal Cooperation:** determine interest level of landowners in establishing a greenway by means of both formal agreements and informal cooperation. Strategies for acquisition include conservation easements, right of public access easements, fee simple

purchase, transfer or purchase of development rights, and land management agreements to name a few. A more comprehensive list can be found in Greenways: A Guide to Planning, Design, and Development.

o. **Ask for assistance:** enlist the aid of local citizens groups and conservation groups. The state of Florida's Office of Greenways and Trails is also an excellent resource.

p. **Promotion:** promote the concept and benefits of greenway planning through public education and advocacy at local levels.

q. **Funding:** Funding is available through local, state, and federal government agencies as well as through private sources such as endowment grants, gifts and donations, and corporate sponsorships. For a comprehensive list of funding sources, please see Greenways: A Guide to Planning, Design, and Development and the Florida Department of Environmental Protection's Office of Greenways and Trails.

3.4. Rural Coastal Community

Of the three types of land use categories addressed in this section, rural communities generally offer the most opportunity for establishing greenway systems. This is mainly due to the amount of undeveloped and/or agricultural land that exists in rural communities. Bay County has vast stretches of undeveloped land that have been used primarily as timberland for the last fifty to seventy-five years. Many of these areas have been identified for future development. This circumstance presents an exciting opportunity to implement an integrated greenway/stormwater management system from the beginning of the development process. This

natural systems approach will not only define the most suitable areas for development but it will also establish the foundation for sustainable community design.

3.4A **<u>Where will the greenway be located?</u>** Read and select one or more of the following scenarios that accurately describes existing challenges to establishing a greenway. Beneath each scenario appears a response statement and a list of potential opportunities.

a. There is so much undeveloped land- where do we begin?

Response: If there is a lot of land for the establishment of a greenway system, the possibilities can seem overwhelming. By examining the natural and human resources of an area in a systematic way, the project will become manageable.

Opportunities: See 3.4.B-a through 3.4B-q below.

b. Even though most of the land is not developed in the sense of having many buildings and roads, much of the land is privately owned and used for agricultural purposes. Will a greenway take away portions of this privately owned land?

Response: Establishing a greenway system is a voluntary community effort. Private property rights are protected and respected. If the alignment of a proposed greenway system places it on private property, the landowner has the right to object. In many cases it's simply a matter of establishing open communication and clearing up misconceptions.

Opportunities: See 3.4B-a through 3.4B-q below.

c. There is so much land available for acquisition. Where does a community find the funds to support such a project?

Response: An initial lack of funds should not deter a community from pursuing a greenway system. There is a substantial amount of public and private money available to fund greenway planning, design, and development initiatives. A dedicated and resourceful greenway planning committee will be able to acquire the funds needed to accomplish the community's goals.

Opportunities: See 3.4B-o through 3.4B-q below.

4.1B <u>Opportunities for Establishing a Greenway System</u>

a. Drainage ways: identify all of the existing drainage ways.

b. Wetlands: identify all of the existing wetlands, including any that have been compromised from previous development.

c. Soils: identify the soil types in the area and determine their permeability and excess storage capacity.

d. Flood plains: identify existing flood plains for a selected design storm.

e. Slopes: identify steep slopes that are unsuitable for development.

f. Open space: locate existing parks, recreation areas, schools, government owned conservation areas.

g. Significant places: locate naturally, culturally and historically significant places. Information resources include the US Fish and Wildlife Service, the Environmental Protection Agency, state conservation agencies such as the Florida Fish and Wildlife Commission and the

Florida Department of Environmental Protection, National Register of Historic Places, The Historic American Buildings Survey, The Historic American Engineering Record, and the State Historic Preservation Office.

h. Shorelines: Determine what areas of the shoreline can be made accessible to public use by means of trail systems, board walks and viewing areas.

i. Buffers: taking into account soils, slopes, flood plains, and adjacent land uses determine the width of a buffer zone for all water bodies: rivers, streams, wetlands, lakes, and shorelines. The purpose of the buffer is to help protect surface waters from non point source pollution and to mitigate the impacts of from storm surges.

j. Civic areas: identify significant public gathering areas such as civic centers, community centers, town halls, court houses, libraries, public squares.

k. Established trails: identify established trails such as hiking trails, four-wheel drive jeep trails, and fire access roads.

l. Corridors: locate wildlife corridors as well as rights-of-way for drainage ways, roadways, utilities, and railroads.

m. Stormwater: in a rural community there will be little in the way of runoff related stormwater problems. Identify those areas that have been impacted by storm surges and stream and river flooding.

n. Agreements/Informal Cooperation: determine interest level of landowners in establishing a greenway by means of both formal agreements and informal cooperation. Strategies for acquisition include

conservation easements, right of public access easements, fee simple purchase, transfer or purchase of development rights, and land management agreements to name a few. A more comprehensive list can be found in Greenways: A Guide to Planning, Design, and Development and the Florida Department of Environmental Protection's Office of Greenways and Trails.

o. **Ask for assistance:** enlist the aid of local citizens groups and conservation groups. The state of Florida's Office of Greenways and Trails is also an excellent resource.

p. **Promotion:** promote the concept and benefits of greenway planning through public education and advocacy at local levels.

q. **Funding:** Funding is available through local, state, and federal government agencies as well as through private sources such as endowment grants, gifts and donations, and corporate sponsorships. For a comprehensive list of funding sources, please see Greenways: A Guide to Planning, Design, and Development and the Florida Department of Environmental Protection's Office of Greenways and Trails.

Step Three: Realization

Stormwater Utility

This chapter began with a discussion of buffer zone delineation as a means of protecting the integrity and healthy functioning of a community's existing natural water systems. As demonstrated when applied to six of Bay County's watershed sub basins, these buffer zones often overlapped with existing development. In such instances, appropriate solutions for

mitigating development impacts and reducing environmental damage can be selected with the use of the decision-making tool. At this point in the three-step process, a sense of environmental responsibility and a commitment to improving a community's quality of life are the main incentives for delineating buffer zones and implementing greenway planning techniques and stormwater best management practices. As the final step in the process, an economic incentive for encouraging sustainable development decisions and implementing an integrated greenway stormwater management system is introduced in the form of a stormwater utility. Encouraging sustainable design and development decisions while serving as a dependable source of funding for stormwater management, a stormwater utility is an administrative means of realizing the implementation of an integrated greenway stormwater management system on a countywide scale.

A cursory review of the many benefits, challenges, and methodologies of stormwater utilities with a brief introduction to the merits of such systems will be useful for understanding the application presented here. Stormwater utilities first emerged in the early 1970s in the western states of Washington and Colorado. Over the last three decades they have been implemented successfully throughout the United States, arriving in Florida when Tallahassee adopted the state's first stormwater utility in 1986. This recognition by Florida's capitol city of the need for an independent, reliable source of funding for maintaining and constructing stormwater management systems was an important precedent. Since that time, ninety-one utilities have been established in Florida, according to a 1997 survey conducted by the Florida Association of Stormwater Utilities (p.1).

Creating a steady source of income for stormwater management is the main reason cited for the implementation of such utilities (FASU, 1999, p.1). Quite often, funding for stormwater

programs comes from a community's General Fund, as is the case in Bay County. The unreliable nature of General Fund allocations coupled with the multiple pressures of overburdened stormwater infrastructures and federally mandated water quality standards has made the steady, dependable source of stormwater management funds a necessity. According to the communities surveyed in the 1997 FASU study, stormwater utilities funded on average 80 percent of operating budgets and 75 percent of capital improvement expenditures (p. 2). The benefits of stormwater utilities are many. In addition to the reliable and dedicated stream of revenue mentioned previously, stormwater utilities serve as bondable revenue for capital improvements, enable stability and long-term vision in stormwater management programs, and help communities meet federal compliance standards required by the NPDES permitting process (p. 4).

Developing a stormwater utility system appropriate for Bay County will take considerable time and the collaboration of many government and private entities. The formula presented here is simply an initial attempt at incorporating the idea of a stormwater utility with the integrated approach to stormwater management put forth in this thesis. Determining stormwater utility rates based on the percentage of imperviousness is the most common method used in Florida. The formula applied in this thesis takes into account an area's percentage of imperviousness (paved surfaces) as well as its soil types, development densities, and the presence of wetlands, shorelines, and natural drainage areas. The formula combines each soil type's excess water storage capacity as illustrated in Chapter Three, Table 3.1, the presence of wetlands, shorelines and drainage ways as determined from the GIS data and presented in the diagrammatic maps, and the development densities listed in the Bay County Comprehensive Plan. The combination of all of these factors determines a rate structure that not only increases

in revenue as imperviousness increases but that discourages unsustainable development by applying steeper rates to those developments that increase stormwater impacts and liabilities because of their existence. The formula for determining the stormwater utility fee for a given parcel or property appears below.

$$\text{Impact on Stormwater System} - \text{Mitigation Techniques} = \text{Adjusted Impact} \times \text{Size of Land Parcel} = \text{Amount of Impact} \times \text{Utility Coefficient} = \text{Monthly Stormwater Fee}$$

Each element of the stormwater utility formula is defined below:

1. Impact on Stormwater System is the amount of impact a given parcel or property has on a community's existing stormwater management system. A numerical value is generated using the Stormwater Impact Point System in Table 5.3. This numerical value is determined by the percentage of impervious cover resulting from development, the types of soils present on the site, the development density of the area in which the site exists, whether or not the development is located within flood plain or storm surge areas, whether development on the site has impacted buffer zones, wetlands, natural drainage areas or shorelines on the site, and lastly whether the property contains any dirt roads or stormwater hotspots. This last item is defined by the Center for Watershed Protection as "a land use or activity that produces higher concentrations of trace metals, hydrocarbons or priority pollutants than normally found in urban runoff, [such as] auto recycling, commercial parking lots, fleet storage areas, industrial roof tops, landscaping/nursery, industrial (outdoor storage and loading), public work areas, vehicle service and maintenance areas, gas stations, and vehicle washing/steam cleaning areas" (CWP, 1999).

2. Mitigation Techniques are the degree to which the impact of development is lessened through the implementation of greenway planning principles and stormwater best management

practices. A numerical value is generated using the Stormwater Impact Point System that appears in Table 5.4. This numerical value increases with the amount of mitigation measures employed on site. These measure include wetland mitigation, greenway implementation, and structural, nonstructural, and natural engineered stormwater best management practices.

3. Adjusted Impact is a numerical value determined by subtracting the total value for Mitigation Techniques from the total value for the Impact on Stormwater System.

4. Size of Land Parcel is the size of the parcel or property in acres.

5. Amount of Impact is the numerical value resulting from multiplying the Adjusted Impact by the Size of the Land Parcel.

6. Utility Coefficient is a standard dollar value determined by the stormwater utility agency that serves as a millage rate. This rate is multiplied against the Amount of Impact to determine the monthly stormwater fee for a given property.

<u>Application of the Stormwater Utility Formula</u>

Using the point system outlined in Tables 5.3 and 5.4 below, the monthly stormwater utility fee for any property in the county can be determined. The point system in this thesis has been developed for illustrative purposes only. Should Bay County decide to implement a stormwater utility in the future, a monthly-fee formula can be determined at that time.

The two diagrams in Figures 5.14 and 5.15 demonstrate the application of the stormwater utility formula. The parcels in each diagram are identical, however their site designs and development decisions are not. The site represented in the diagrams is a fictitious suburban location in Bay County totaling fourteen acres. A wetland composes the northwest portion of the site, while a bay borders the northeast corner and a perennial stream travels along its eastern side. The developable portion of the parcel is composed of Stilson soil, a type B soil that can support a

thirty-eight percent clearance rate before generating excess runoff (Chapter Three, Table 3.3). Each parcel contains a development supporting three residential homes.

Diagram A shows a five-acre residential development that has kept its clearance rate below thirty-eight percent and has respected the buffer zones along the shoreline, wetland, and perennial stream (Figure 5.14). The development does fall within the storm surge area for hurricane categories 1 through 3. Each of the homes has been designed with a water harvesting mechanism to use for landscape irrigation purposes. The entrance road and private drives are composed of alternative paving materials, and there is a bioretention pond in the entrance road median designed to treat runoff from the road, drives, and other impervious surfaces. The development's design guidelines call for narrow streets and the absence of a curb and gutter system. Using the Stormwater Utility Point System (Tables 5.3 and 5.4) to determine the numerical value of the design development decisions illustrated in Diagram A, the impact point total equals 14 while the mitigation point total equals 7. Inserting these numbers into the Stormwater Utility Formula produces the following results:

Impact on Stormwater System	_	**Mitigation Techniques**	=	**Adjusted Impact**	x	**Size of Land Parcel**	=	**Amount of Impact**	x	**Utility Coefficient**	=	**Monthly Stormwater Fee**
14	**-**	**7**	**=**	**7**	**x**	**5 acres**	**=**	**35**	**x**	**.5**	**=**	**$17.50/month**

This total of $17.50 per month is the developer's stormwater utility fee. Assuming that the developer sells each of the residences, then each homeowner would pay $17.50 divided by three or $5.83 per month as the stormwater utility. Therefore, this developed parcel would generate $210.00 per year in revenue for the county's stormwater management needs.

Table 5.3 Stormwater Utility Point System for Impact

Stormwater Utility Point System

Impact			Points
I.	Soils		
	A. Type A		
	1. Developed at or below % clearance rate as specified in Chapter 3, Table 3.1	=	2
	2. Developed above % clearance rate as specified in Chapter 3, Table 3.1	=	8
	B. Type B		
	1. Developed at or below % clearance rate as specified in Chapter 3, 3.1	=	2
	2. Developed above % clearance rate as specified in Chapter 3, Table 3.1	=	4
	C. Type C and D		
	1. Developed to any degree	=	2
		Total:	_____
II.	Development Density		
	A. Pristine	=	0
	B. Rural	=	2
	C. Suburban	=	4
	D. Urban	=	8
		Total:	_____
III.	Development in Flood Plains and Storm Surge Areas		
	A. 500-year flood plain	=	1
	B. 100-year flood plain	=	2
	C. 50-year flood plain	=	4
	D. 25-year flood plain	=	8
	E. Storm surge area for hurricane categories 1 through 3	=	8
	F. Storm surge area for hurricane categories 4 and 5	=	4
		Total:	_____
IV.	Development Impacts to Wetlands, Buffers, Natural Drainage Ways		
	A. Degradation of buffer	=	8
	B. Degradation of wetland	=	8
	C. Impedes natural drainage way	=	16
	D. Destruction of wetland	=	16
		Total:	_____
V.	Other Sources of Nonpoint Source Pollution		
	A. Dirt road(s)	=	8
	B. Stormwater Hotspots (ie., car wash, gas station, marinas, etc.)	=	8 x each
		Total:	_____
	Total of Impacts I through V	=	________

Table 5.4 Stormwater Utility Point System for Mitigation

Stormwater Utility Point System, continued

Mitigation

I.	Wetland Mitigation		
	A. Constructing a wetland on site where one has been degraded or destroyed or restoring a degraded wetland	=	4
	B. Constructing a stormwater wetland where one has not previously existed	=	4
		Total:	______
II.	Nonstructural Best Management Practices		
	B. Buffer for Wetlands, Shorelines, and Natural Drainage Ways		
	1. Re-establish vegetated buffer to specified width	=	4
	C. Storm-drain stenciling	=	2
	D. Water harvesting of stormwater runoff for irrigation and/or water features	=	2
	E. Planning and Design Measures		
	1. Eliminate road-side curb and gutter system	=	1
	2. Residential design guidelines for narrow streets, alt. turnarounds	=	1
	3. Parking lot built to average parking demand	=	1
	4. Parking stalls reflect community's percentage of compact cars	=	1
	F. Establish stormwater management system maintenance program	=	2
		Total:	______
III.	Structural and Soft-Engineered Best Management Practices		
	A. Basins		
	1. Detention	=	1
	2. Retention	=	1
	3. Bioretention	=	2
	4. Infiltration	=	2
	B. Swales		
	1. Vegetated swales	=	.5
	2. Vegetated swales with check dams and baffles	=	1
	3. Dry swales	=	1
	C. Grass or vegetated filter strip	=	1
	D. Infiltration trench	=	1
	E. Alternative paving materials	=	1
	F. Sand or organic filters	=	1
	G. Curb cuts	=	.5
	H. Storm sewer insert (swirl separator/ oil and grease separator)	=	.5
	I. Catch basin	=	.5
		Total:	______

Sum of Mitigation Totals I through III= ______

In comparison, Diagram B shows a seven-acre residential development that has surpassed its clearance rate of thirty-eight percent and has not respected the delineated buffer zones along the shoreline, wetland, and perennial stream (Figure 5.15). One of the residences exists within the fifty-year flood plain, and the entire development falls within the storm surge area for hurricane categories one through three. As an added amenity for this cluster of homes, the developer has placed a tennis court in the northwestern portion of the site which required the elimination of some of the existing wetlands. For the purpose of mitigation, a constructed wetland has been established to treat stormwater runoff. There are vegetated swales with check dams along the roads, and there are water-harvesting mechanisms designed for each of the residences. Although there is a curb and gutter system, it does include catch basins, storm drain stenciling, storm sewer inserts, and curb cuts to allow runoff to enter the vegetated swales.

Using the Stormwater Utility Point System to determine the numerical value of the design development decisions illustrated in Diagram B, the impact point total equals 36 while the mitigation point total equals 10.5. Inserting these numbers into the Stormwater Utility Formula produces the following results:

Impact on Stormwater System	_	**Mitigation Techniques**	=	**Adjusted Impact**	**x**	**Size of Land Parcel**	=	**Amount of Impact**	**x**	**Utility Coefficient**	=	**Monthly Stormwater Fee**
36	**-**	**10.5**	**=**	**25.5**	**x**	**7 acres**	**=**	**178.5**	**x**	**.5**	**=**	**$89.25/month**

The site design and development decisions made in Diagram B result in a stormwater utility fee of $89.25 per month for the developer, or $29.75 per month for each of the homeowners. If developed as illustrated, this parcel would generate $1071.00 per year in revenue for the county's stormwater management needs.

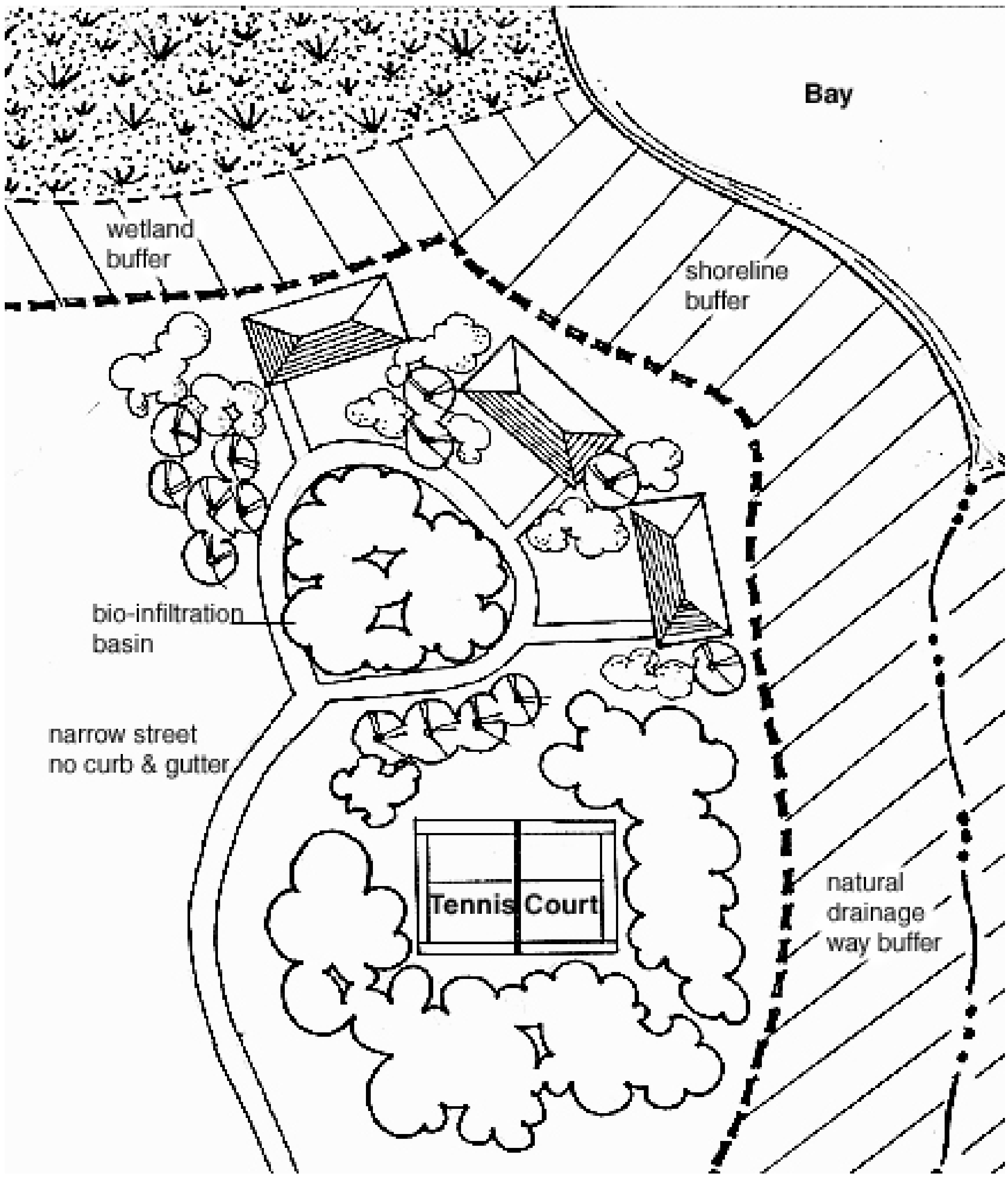

Figure 5.14 Diagram A generates a monthly stormwater fee of $17.50 per month.

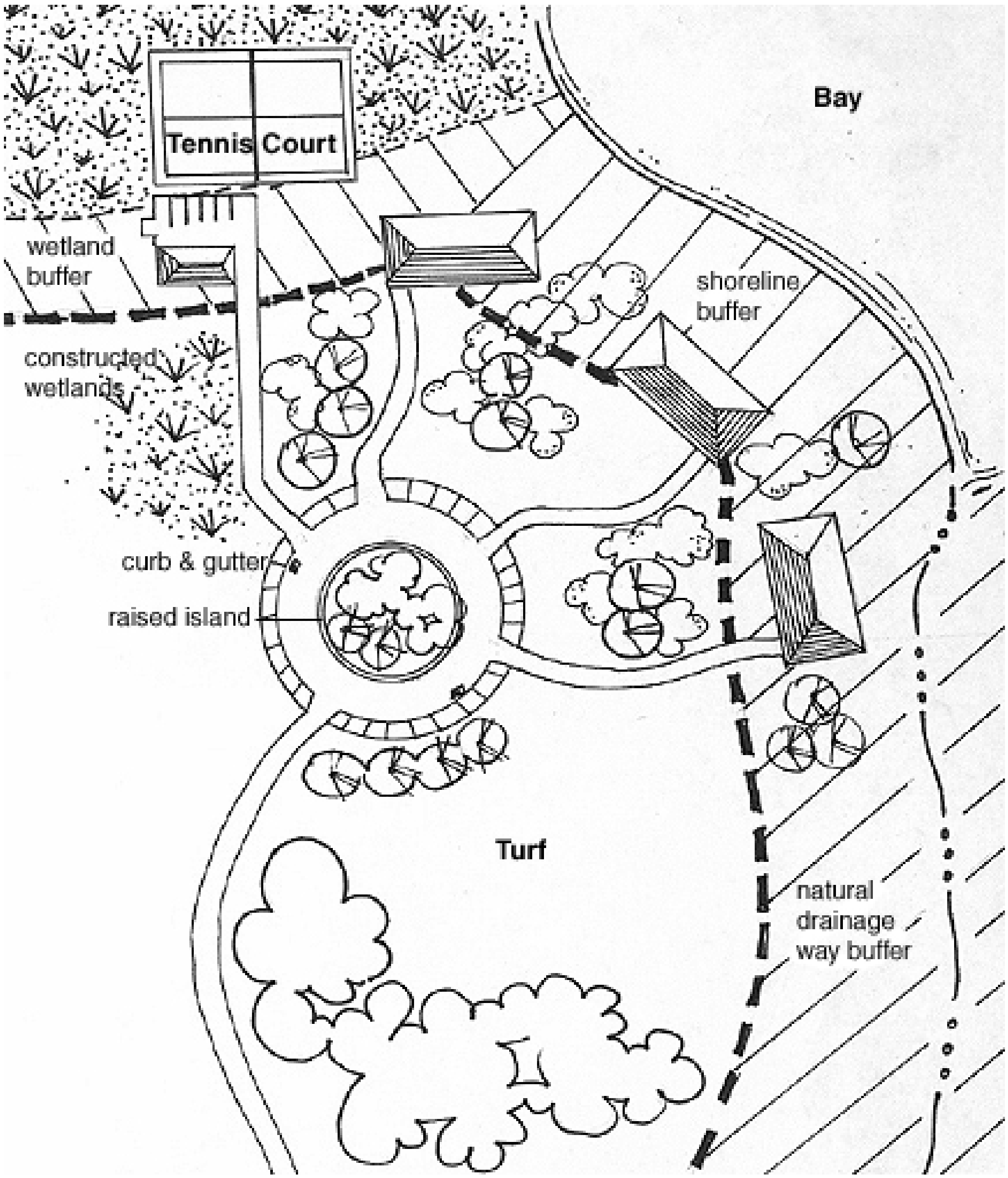

Figure 5.15 Diagram B generates a monthly stormwater fee of $89.25 per month.

Depending site design and development decisions, any given parcel of land can have significantly different impacts on the environment. The examples illustrated above demonstrate the process of applying a stormwater utility to Bay County, Florida for the purpose of mitigating development impacts. A stormwater utility is valuable not only because it generates a steady source of funding for stormwater management programs but also because it is a financially-based incentive for encouraging sustainable development decisions. For this reason, stormwater utilities can be less contentious than zoning laws because they do not regulate land development decisions, they simply encourage decisions that help to maintain the integrity of the environment.

A stormwater utility recognizes that some development decisions place a greater burden on the environment than others. When damage results because of these decisions, it effects both public and private property. It can also decrease the quality of an area's natural resources, a devastating impact for communities like Bay County who depend on their natural resources for economic prosperity. Whenever damage occurs it is repaired with funds from the county, or more accurately the county's tax payers. By implementing a stormwater utility, the burden of costs is distributed in a manner that reflects the origin of these development decisions and their resulting impacts.

Conclusion

Chapter Five has demonstrated the application of an integrated greenway stormwater management system to Bay County, Florida in the form of a case study. Using the three-step process of **1. preservation**, **2. integration as intervention**, and **3. realization**, this application procedure is the culmination of research findings presented in earlier chapters. This case study is an initial attempt at developing an integrated approach to stormwater management in the coastal zone. Although researched and written as a means of partially fulfilling the requirements for the

degree of Master of Landscape Architecture, this thesis should not be viewed simply as an academic exercise. There is a great need for sustainable approaches to stormwater management in developing coastal communities across the country and around the globe. With further development, the process demonstrated in this thesis will benefit these coastal communities by satisfying stormwater management needs in a sustainable manner.

Chapter Six: Conclusion

Summary

This thesis began with the following question: Can an integrated system of greenways and stormwater best management practices effectively reduce stormwater impacts resulting from severe weather and urbanization in a developing coastal community? A breadth of topic areas was explored in search of an answer, from theories of greenway systems and sustainability, to the management of stormwater and coastal resources, to an inventory and analysis of the natural, cultural, and economic resources of Bay County, Florida. A review of newspaper articles from the Panama City News Herald revealed that stormwater management is a serious issue facing Bay County. The county's stormwater problems, combined with its status as a developing coastal community, made it a suitable case study location in which to explore the application of an integrated greenway stormwater management system.

A three-step process was developed as a method of applying the information gathered during the research phase of this project to Bay County. Created to demonstrate the integration of greenway planning and stormwater management in the coastal zone, this process can be implemented on a watershed scale, as it is in this thesis, or on a larger, regional or national scale. The three-step process is composed of the following elements: **1) preservation**, where wetlands, shorelines, and natural drainage ways are protected from development and development impacts through delineated buffer zones; **2) integration as intervention**, where greenway planning and stormwater best management practices are implemented as intervention measures against the impacts of development; and **3) realization**, where a comprehensive greenway stormwater management system is implemented on a countywide scale supported by a stormwater utility that

encourages sustainable development decisions. Can a greenway system be used as an effective approach to stormwater management in a developing coastal community? Yes, I believe it can, and the three-step process not only helps to elucidate its importance but also to demonstrate its implementation in a comprehensible manner.

The concept of a connected system of greenways linking habitats and communities while preserving natural systems and their inherent stormwater management capacities is an important one. The three-step process presented in this thesis helps to make the concept of connectedness an understandable and realizable notion, which in turn enables its benefits and importance to become a matter of public understanding. This thesis is not just about greenways, or stormwater management, or developing coastal communities in a sustainable manner, but about the integration of all of these elements. In simple terms, it's about looking at what we already have in order to get what we need and using existing natural processes as a guide for stormwater management in the coastal zone.

While admittedly ambitious for a master's thesis, the research and applications presented in this work successfully demonstrate the viability of an integrated greenway stormwater management system as a strategy for reducing stormwater impacts caused by urbanization and severe weather in the coastal zone. As stormwater management and community planning initiatives continue to evolve in Bay County and other developing coastal communities, this thesis can serve as the basis for recommendations regarding sustainable development through the implementation of an integrated greenway stormwater management system.

Recommendations for Further Study

The interdisciplinary nature of this topic presents the possibility for research in many different academic areas. Recommendations for further study in the field of design would

include developing the theories and tools presented in this thesis to a more comprehensive level of detail, or conducting a design-based analysis of the natural engineering approach to stormwater management. In the field of economics, a very practical and much needed research project is a cost/benefit analysis of an integrated greenway stormwater management system as compared to the conventional 'concrete and steel' approach. This thesis also presents many research opportunities for those in the science disciplines. For example, measuring the performance and success of an integrated greenway stormwater management system in a coastal zone by establishing a baseline from which to gather data. Such a study could be used to measure performance rates for flood control, surface and subsurface water quality, wildlife habitat, even real estate values. Socially based research efforts could include methods of educating the public about the value of integrated greenway stormwater management systems and measuring public perception as a means of determining the success of those methods. Lastly, this discussion of an integrated approach to stormwater management in developing coastal communities in general, and Bay County in particular, should continue. Not simply an academic exercise, the theories and techniques put forth in this thesis are of genuine value to communities like Bay County and are therefore deserving of further exploration and development.

The profession of landscape architecture is an interdisciplinary one, a fine collaboration of art and science. Trained to observe, to listen, and to draw inspiration from a landscape's interdependent natural and cultural systems as well as the ways in which a landscape fits into its larger environment, landscape architects should be principally involved in addressing community stormwater management needs. While this thesis has established a foundation for future research endeavors, it has also demonstrated a market opportunity for landscape architects in which to

promote their global approach in the multidimensional, collaborative environment of stormwater management.

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