Protecting Florida's Springs

Land Use Planning Strategies and Best Management Practices

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

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Introduction

With over 600 freshwater springs, Florida is blessed with perhaps the largest concentration of these natural features in the world. Springs are intricately woven into the fabric of Florida's history. For thousands of years, humans have been drawn to their crystalline waters, as rich archeological remnants scattered on their banks attest. They are supplied by the Floridan aquifer, the source of drinking water for much of Florida.

Most of Florida's springs are located in the region stretching from Hillsborough, Orange, Seminole and Volusia counties north and west to Walton County. This manual focuses on this region's springsheds—the land areas that feed water to the springs.

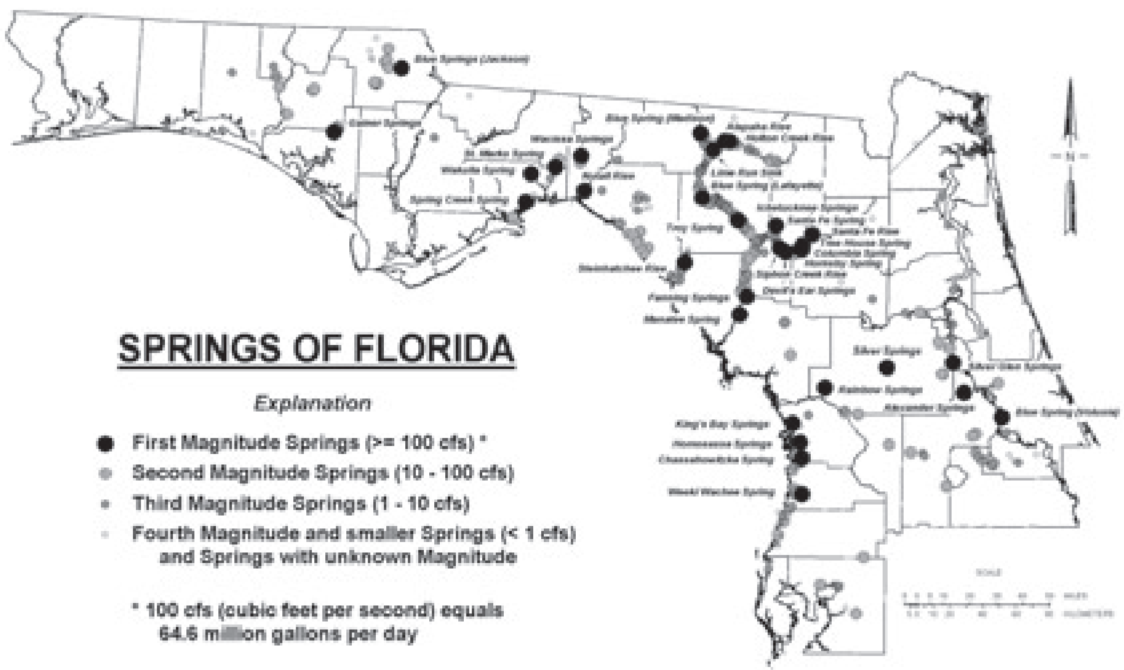


Figure 1.1 Springs are important resources in Florida.

As Florida's population continues to grow, our springs are facing increasing pressures. This growth brings an inevitable rise in water use, as well as extensive land use changes. Water shortages could become a controlling factor in the location and timing of new development. Each year, lands within springsheds are developed, altering the quality and quantity of water flowing to the springs. Springs serve as windows into the quality of our ground water, which continues to decline as development pressures increase.

Florida's Geology Creates Our Springs

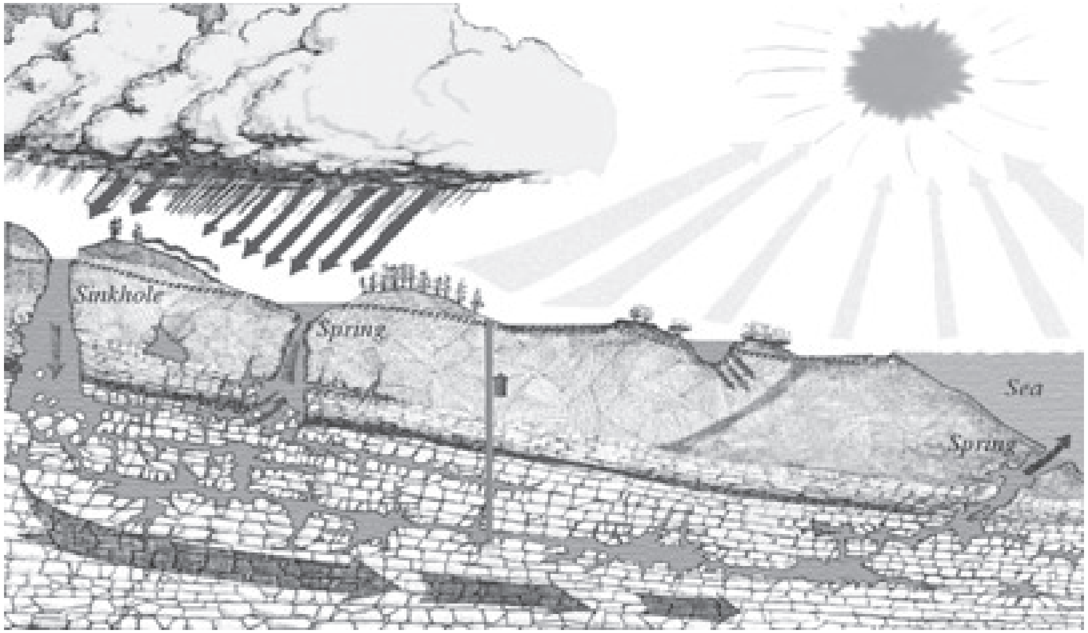
Florida rests on a bed of limestone. Rainwater, made slightly acidic by carbon dioxide picked up from the atmosphere, slowly works its way through the limestone, dissolving channels and caves to form an underground drainage system. Where larger cavities are created, the overlying rock sometimes collapses, forming a sinkhole or spring.

Most Florida springs exist where the limestone of the Floridan Aquifer is exposed at the land surface and ground water is forced out from underground. This type of landscape is commonly referred to as "karst."

Within this very porous topography, soils are often sandy. Water passes through rapidly and is poorly filtered, so pollution from the land passes quickly into the underlying aquifer. Additionally, sinkholes, streams, and lakes act as conduits, further polluting the aquifer. These pollutants then emerge in the spring water.

Figure 1.2. Karst areas may resemble Swiss cheese when exposed.

Figure 1.3. In a karst area, sinks and springs connect ground and surface waters.

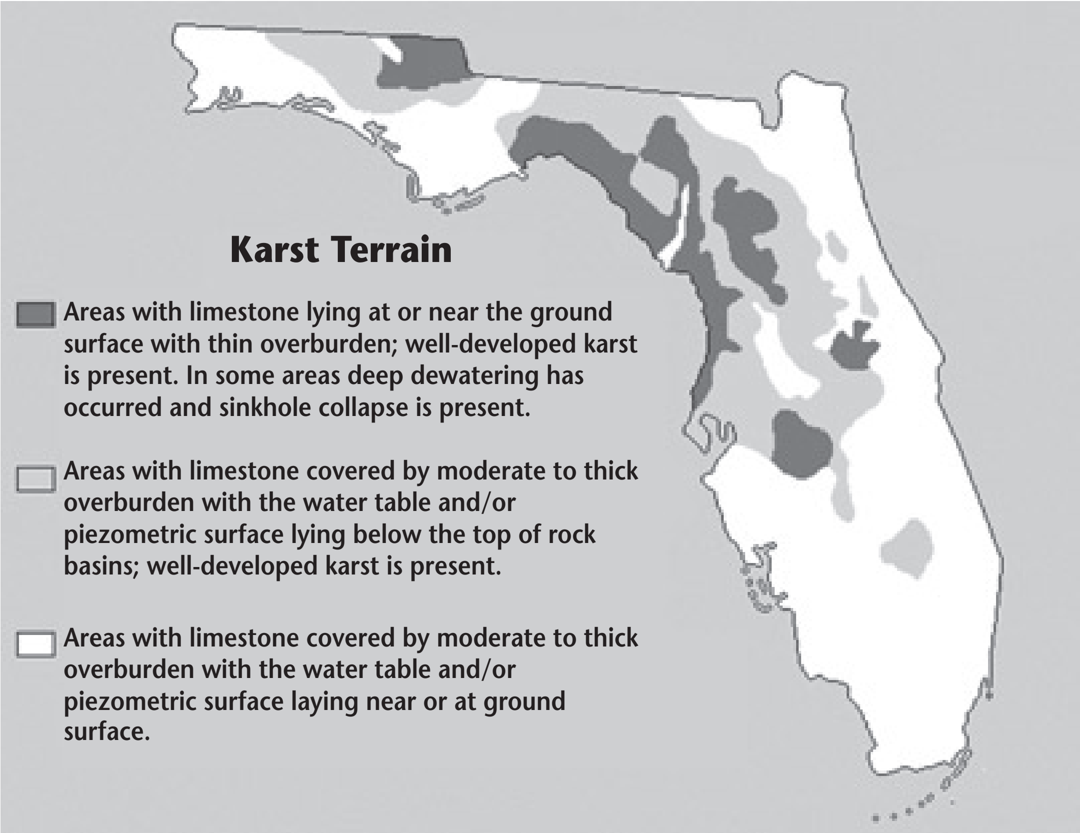


In recognition of the pressures facing Florida's springs, the Florida Springs Task Force was convened in 1999 to recommend strategies for the protection and restoration of these fragile resources. Created by Secretary Struhs of the Department of Environmental Protection, the task force was comprised of sixteen scientists, planners, and other citizens. After meeting for a year, their final report, *Florida's Springs: Strategies for Protection and Restoration*, was issued in November, 2000. It identifies a wide variety of strategies, including outreach, information, management, and funding approaches, and identifies roles for all levels of government and Florida residents in spring protection. The work by Florida Springs Task Force directly led to the development of this best management practices manual.

The entire state of Florida is a karst region, resting on a limestone plateau formed millions of years ago when the area was a shallow sea. Karst activity is most visible in those areas where there is little to no overburden (clay and sandy soils) on top of the limestone, and ground water is near the surface. Comparing Figure 1.4 with Figure 1.1 reveals the strong correlation between areas with well-developed karst terrain and the location of major springs.

Springs are classified by their rate of discharge. First magnitude springs produce the greatest amount of water—100 cubic feet per second or more. Eighth magnitude springs

Figure 1.4. Although all of Florida is a karst region, in those areas where the karst is more developed there is a higher potential for spring development.



produce the least—less than one pint per minute. Florida has 33 of the nation's 75 first magnitude springs, more than any other state.

There Are Many Unseen Connections to a Spring

Just as a watershed for a lake or river can be delineated, the area of land that feeds a spring can also be identified. The extent of this recharge area, or springshed, is influenced by topography and also by what is happening unseen under the ground—the presence of cave systems, fissures and other karst features as well as hydrological or water pressure.

Many different features interact with a spring and its springshed. Water falling miles away seeps into the ground water, eventually enters the cave system and emerges through a spring. A stream disappears underground, but can travel through the karst landscape and reemerge through a spring. Sinkholes can also be connected to a spring. Pollutants entering any of these apparently unrelated systems can travel underground to the spring. This movement can be relatively quick or can take years. Thus, in a karst landscape, what cannot be seen is just as important as what can be seen. Understanding the hydrology and geology of these landscapes is important to developing effective strategies for springs protection.

Springs Contribute to Florida's Economy

Springs have always played an important role in this state's history. Among Florida's first major "modern" tourist attractions, the waters of many springs were perceived to have therapeutic qualities. In the early 1900s, for example, Panacea Mineral Springs in Wakulla County was the site of a 125-room hotel, drawing visitors from all over for their healing powers.

Florida springs continue to provide recreational opportunities for swimmers, boaters, wildlife watchers, and cave divers. Their constant temperatures provide a cool contrast to a hot summer afternoon for young and old alike. Smaller springs and sinkholes serve as important local recreation areas. Ginnie Spring is the most popular freshwater diving location in the world. Silver Springs, Ichetucknee Springs, Warm Mineral Spring, and Wakulla Springs continue to be major tourist attractions.

Facilities like these play an important part in local economies. The twelve state parks with springs bring in over $7 million in annual revenue.

A recent surge in the demand for bottled water has inspired a renewed interest in spring water. Some look at bottled spring water as having better health benefits than tap water. Several brands commonly found on grocery

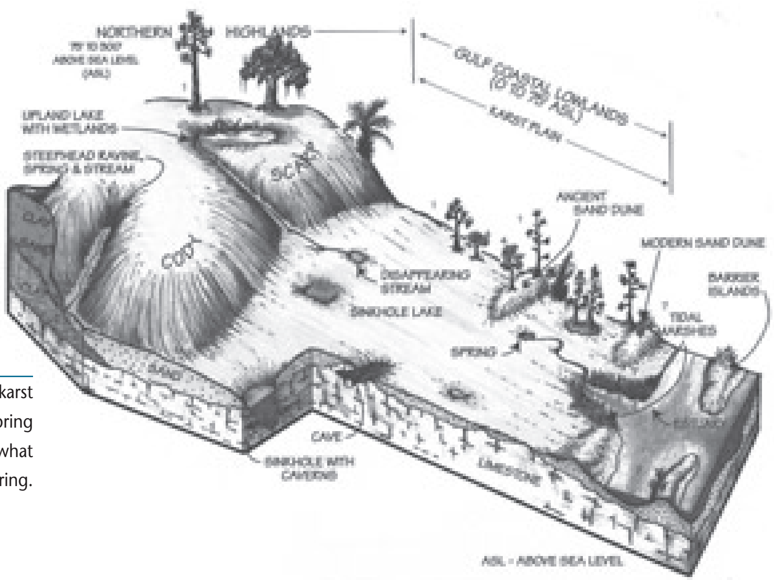


Figure 1.5. Other karst features around a spring can impact what happens in the spring.

Figure 1.6. Ichetucknee Springs is one of the state's most popular tubing sites and has stimulated many local businesses outside the park.

shelves draw water from Florida's springs. Spring water is becoming an industry with an attached economic value; however, production puts additional pressures on the quantity of water withdrawn from the spring.

The challenge is to preserve the values of Florida's springs while balancing the needs of the state's many water users.

Land Use Can Have a Negative Impact on Springs

The ground water that feeds springs is recharged by seepage from the surface and through direct conduits such as sinkholes. Numerous studies by Florida's water management districts and the United States Geological Survey clearly demonstrate contamination attributable to changes in land use in springsheds.

The nature and magnitude of water quality threats to a spring vary according to land use practices and the geology within each springshed. What occurs on the land directly and indirectly affects the quality of water moving through the subsurface karst matrix.

Contamination is a major threat. Sulphur Springs in Tampa, for example, is closed to public use due to poor water quality. Water can carry contaminants from the land surface into springs. Stormwater runoff can carry oil, fertilizer, pesticides, and bacteria. Septic tanks and underground storage tanks can contribute nutrients, bacteria and chemicals via seepage. This contamination seeps to the ground water and travels to the spring.

Increased nutrients, including soluble forms of nitrogen, essentially fertilize the water in springsheds. Nitrogen arrives from numerous sources: urea and ammonia from animal wastes, nitrogen and nitrates from automobile and industrial exhaust, and inorganic nitrates

The Florida Springs Task Force identified three major concepts that must be the foundation for education about Florida springs:

1. **A spring is only as healthy as its recharge basin or springshed.**
2. **Activities within springsheds can and do have adverse impacts upon the quality and quantity of ground water. This affects spring flow, water quality, and the health of spring-run ecosystems.**
3. **Protection of spring water must occur before the water reaches the spring.**

(Florida Springs Task Force Report, 2000)

Figure 1.7. Increased nutrients can result in heavy algae growth in a spring or spring run.

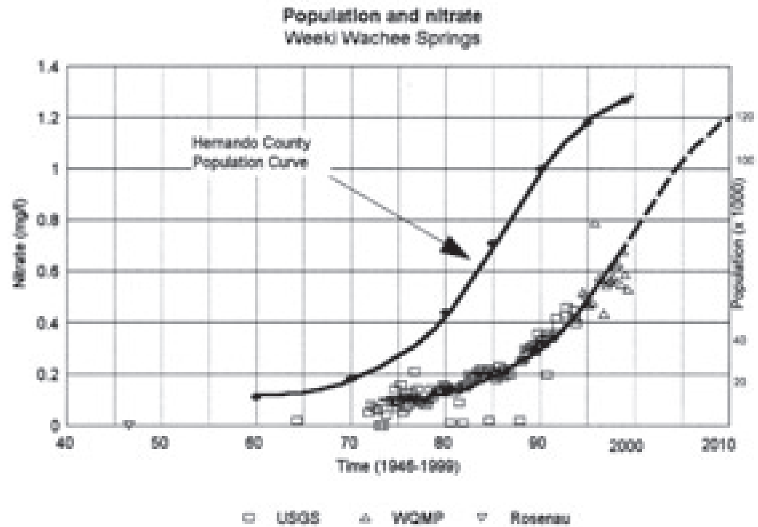


Figure 1.8. The bottom line traces the increase in nitrate levels in Weeki Wachee Springs since the 1940s. This mirrors the population increase in the spring recharge basin during those same years.

derived from lawn, golf course or agriculture field fertilization. While these nutrients are required by aquatic organisms for growth and reproduction, when they make their way into ground and surface waters at higher than natural levels, problems often arise. Clear, low-nutrient waters that once sustained a diverse mix of plants and animals become clouded by algae that thrive on the increased nutrient load, reducing light and, correspondingly, the diversity of plant and animal communities.

The quantity of water feeding a spring and its corresponding discharge can also be dramatically affected by land use. The natural flow of water to springs is controlled by complex interactions. These include the amount and frequency of rainfall, the porosity and permeability of the aquifer, the hydrostatic head within the aquifer, and the hydraulic gradient of the land. Flows can be reduced or eliminated by over-pumping water from the aquifer for irrigation or potable water needs. Kissengen Spring and Hampton Spring, once popular swimming holes, have diminished to a trickle.

Any of these negative impacts are unlikely to remain confined to a spring. Springs drain large amounts of ground water from the Floridan Aquifer, contributing to the relatively constant temperature and steady flow rate of many of Florida's spring runs—rivers that stem from the outflow of a spring. Other rivers receive significant portions of their flow from seeps—water table springs that issue from the riverbank. Thus, contaminated spring water is carried directly into the ensuing rivers and can dramatically impact the health of this riverine environment as well. Reducing the amount of water discharged from a spring also reduces the flow in the river, creating additional impacts.

This manual recommends planning strategies and best management practices to protect springs. Individual chapters address:

- **Comprehensive Planning Strategies**
- **Managing Development Impacts**
- **Golf Course Siting, Design and Management**
- **Agriculture and Silviculture**
- **Public Recreation**

Planning Strategies and Best Management Practices Are Effective Tools for Springs Protection

Spring protection is not a lost cause. Springs and spring runs once damaged by overuse have been restored through good stewardship, including Madison County's Blue Spring, Ichetucknee Springs in Columbia County, and Blue Spring in Volusia County.

Good stewardship includes using effective planning strategies and implementing best management practices (BMPs) to preserve and protect the spring and its springshed. BMPs are actions, based on sound science and professional judgement, that can be taken to eliminate or reduce adverse impacts to a spring. They can include the way decisions are made, the way a project is designed and managed, the types of inputs (such as fertilizers or pesticides) that are added to the land, or specific structural improvements.

A multitude of informational and financial resources to assist in springs protection efforts are highlighted in this manual. Each chapter includes a resource box identifying other sources of information. The bibliography contains even more resources.

Be Sure To Check Out These Resources!

Florida Springs, on the Florida Department of Environmental Protection website, **www.dep.state.fl.us/springs/index.htm**, has a wealth of information on this subject.

Springs of Florida, Geological Bulletin No. 31 Revised, published by the Florida Geological Survey, is a comprehensive look at springs in Florida. It can be viewed by going to **www.dep.state.fl.us/geology/**, then going to the List of Publications and clicking on "Bulletins."

Florida's Springs: Strategies for Protection and Restoration, is the report of the Florida Springs Task Force, issued in November 2000. It can be accessed at **www.dep.state.fl.us/secretary/info/pubs/FlSprings.PDF**.

Springs Fever: A Field and Recreational Guide to Florida Springs, by Joe Follmand and Richard Buchanan, is an excellent source of information about Florida's springs. It can be found at **www.tfn.net/Museum/Springbook/**.

Floridasprings.com is a web site that contains information about springs, as well as many beautiful pictures. Access it at **www.floridasprings.com/sitemap.htm**.

The Florida Geological Survey has a publication, *Sinkholes in Florida*, which provides reliable information on this topic. Go to **www.dep.state.fl.us/geology/geologictopics/sinkhole.htm**.

Comprehensive Planning Strategies

What happens on the land in a springshed determines the impacts on the spring itself. A variety of tools are available for Florida communities to manage impacts from the land. Florida's comprehensive planning process provides the foundation for any city or county land management activity. Chapter 163, Part II, Florida Statutes, the Local Government Comprehensive Planning and Land Development Regulation Act, legally empowers a local jurisdiction to plan for and guide future growth and development. Steps to plan for springshed protection include:

- Use Florida's Comprehensive Planning Process Effectively
- Establish a Working Group
- Adopt a Resolution of Support for Springshed Protection
- Collect Data and Map the Resources
- Establish Springshed Protection Zones
- Create an Overlay Protection District
- Use Other Appropriate Land Use Planning Tools
- Use Acquisition and Easement Strategies to Protect the Most Sensitive Areas
- Establish Voluntary Stewardship Programs
- Adopt Comprehensive Plan Policies for Springshed Protection

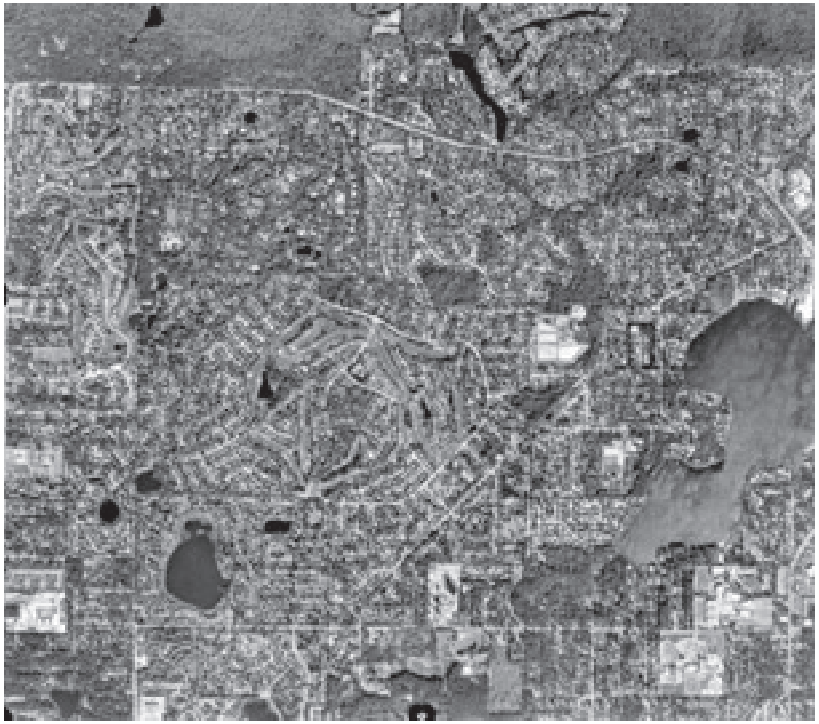


Figure 2.1. This aerial of Seminole and Orange counties shows Wekiwa Springs and State Park to the north and extensive development to the south within the springshed. Sand Lake and Lake Brantley can be seen along with golf courses and residential road networks.

Many of Florida's springs exhibit signals of distress, including increasing nutrient loads, turbidity, and lowered water flows. These impacts often can be attributed to the nature and intensity of development of the land in the springshed. Prudent land use planning decisions can protect and improve water quality, quantity and upland resources of a springshed.

Land use planning is best conducted at a local scale where the connections between particular land uses and water quality and quantity impacts are strongest. Managing land use types and their allowable densities and intensities of development, followed by specific site planning to further minimize impacts, rank as perhaps the most important goals of a springshed protection effort.

A local jurisdiction should recognize the particular sensitivities of the springshed and use land management tools to minimize impacts to the springshed. These tools include the comprehensive plan, the future land use map, land development regulations, overlay zones, and other best management practices to:

- Preserve sensitive areas;
- Direct development away from the environmentally-sensitive areas and toward areas that can support a particular land use type and density or intensity of use; and
- Minimize impacts resulting from existing or approved development through the use of best management practices.

When developing a springshed protection program:

- Obtain community consensus on the most important water resource goals in the springshed;
- Identify resources and assess the impacts of future land uses on water resources;
- Develop future land use strategies including identifing protection zones and designating appropriate land uses that will meet these goals;
- Select the most acceptable and effective land use management standards to reduce nutrients and other pollutant inputs and minimize impacts from land uses;
- Use acquisition and easement strategies to further protect the most sensitive areas; and
- Devise an ongoing management structure to adopt, implement and periodically revisit the springshed program.

Starting a springshed protection effort can follow many paths. Almost all locally-based efforts begin when an individual or a group become concerned with decreased water flow or reduced water clarity, or when aquatic plant and algae begin to grow beyond the norm affecting the quality of water in the spring. Often they begin to recognize that there is a direct relationship between land use changes and water quality and quantity impacts. Concern may turn to action when a group of citizens take the initiative, or local, regional or state agencies recognize a threat and the need for protection.

Use Florida's Comprehensive Planning Process Effectively

A starting point for any city or county is Florida's comprehensive planning process. Chapter 163, Part II, Florida Statutes, the Local Government Comprehensive Planning and Land Development Regulation Act, legally empowers a jurisdiction to plan for and guide future growth and development. This act directs local governments to:

> ***"preserve and enhance present advantages; encourage the most appropriate use of land, water, and resources, consistent with the public interest; overcome present handicaps; and deal effectively with future problems that may result from the use and development of land. Through the process of comprehensive planning local government can work to preserve, promote, protect, and improve the public health… prevent the overcrowding of land and avoid undue concentration of population… and conserve, develop, utilize, and protect natural resources within their jurisdictions."***

For all communities in Florida, the comprehensive plan provides the foundation for developing programs, actions and specific land development regulations needed to protect sensitive resources. The comprehensive plan is the legal instrument to provide clear, rational and specific guidance for the long term springshed protection.

The comprehensive plan contains interrelated "elements" that deal with issues such as intergovernmental coordination, future land use, conservation, recreation and open space, sanitary sewer, potable water, stormwater management, natural ground water aquifer recharge, and capital improvements. These elements include specific goals, as well as objectives and policies that outline how the local government will reach its goals. The process of comprehensive planning begins with gathering and analyzing data, and adopting comprehensive plan goals, objectives and policies. A future land use map that identifies the location of allowed land uses and establishes densities and intensities of use based on land use suitability is also adopted.

All local government land use decisions must be consistent with the comprehensive plan and future land use map. The comprehensive plan provides the basis for developing and adopting specific land development regulations, including development ordinances, programs and best management practices and government supported voluntary land stewardship programs. The comprehensive plan provides the basis for developing the springshed protection program. The rest of this chapter outlines the steps for springshed protection.

Key Practices for Using the Planning Process

- Use the local government comprehensive planning process and land development regulations to develop a springshed protection program.
- Establish a local working group or technical advisory committee to help gather and analyze available information.
- Educate landowners and the public about the springshed and its vulnerabilities—this is crucial to a springshed protection effort.
- Solidify support for springshed protection by communicating with the public and drafting a springshed protection resolution for adoption by the local governing body(s).
- Use a gradient approach to springshed protection by establishing environmental overlay zones (primary, secondary, etc) in the comprehensive plan.
- Locate conservation lands, parks and open space, low intensity silviculture lands that are less intense, low pollutant generating land uses nearer the spring in a primary zone, and place land uses with greater potential to contribute pollutants further away from the spring in a designated secondary zone.
- Implement voluntary and incentive-based programs to protect a springshed.

Florida Studies Link Land Uses to Impacts

Nitrate pollution can be traced to two general categories of origin: inorganic and organic. Inorganic nitrate sources may include fertilizer runoff associated with residential, golf course turf/landscape and agricultural operations. Organic sources may include naturally occurring organic decay, sewage effluent disposal, land disposal of sewage sludge, effluent from septic tanks servicing residential and commercial development, land disposal of septage sludge, poultry, dairies, and cattle.

For the Homosassa, Chassahowitzka, Weeki Wachee, and Aripeka spring complexes in Citrus and Hernando counties, nitrogen isotopic data suggest that the dominant source of nitrate discharging in ground water from the springs is inorganic. Residential and golf course turf and landscape fertilizations were identified as the principal source of such inorganic nitrate. Supporting data implicate the inorganic nature of the source, the close proximity of the source to the springs, and the rapid increases in nitrate concentrations in the springs that began in the late 1960s, which correlates with the development of large coastal residential subdivisions containing the largest densities of residential and golf course turf and landscape.

For Crystal Springs in Pasco County, citrus fertilization was identified as the most likely source of nitrate in the basin. Supporting data include the inorganic nature of the source, the regionally extensive coverage of citrus which closely matches the distribution of nitrate in the ground water of the recharge basin, and the rapid increases in nitrate concentrations in the springs that began in the 1960s,which correlates with the increased coverage of citrus across the Brooksville Ridge in the decades preceding the increase.

For King's Bay, nitrogen releases resulting from land uses (residential and golf course turf fertilizers, septic tanks, and effluent disposal from sewage treatment) are elevating ground water nitrogen concentrations. Ground water enriched in nitrogen from both development-related and natural sources is moving toward the coast in well-defined plumes. Within 20 years, this nitrogen will reach the King's Bay Springs and likely increase nitrogen concentrations significantly.

For each of these basins, stormwater runoff in the karst terrain may be partially responsible for conveying fertilizer-derived nitrogen into the ground water system.

Adapted from "Water-Quality and Hydrology of the Homosassa, Chassahowitzka, Weeki Wachee, and Aripeka Spring Complexes, Citrus and Hernando Counties, Florida, Origin of Increasing Nitrate Concentrations, Southwest Florida Water Management District (SWFWMD), October 1997 and, Origin of Nitrate in Ground Water Discharging from Crystal Springs, Pasco County, Florida, SWFWMD, June, 2000; and, Origin of Nutrients in Ground Water Discharging from The King's Bay Springs, SWFWMD, Revised Version, January 1998.

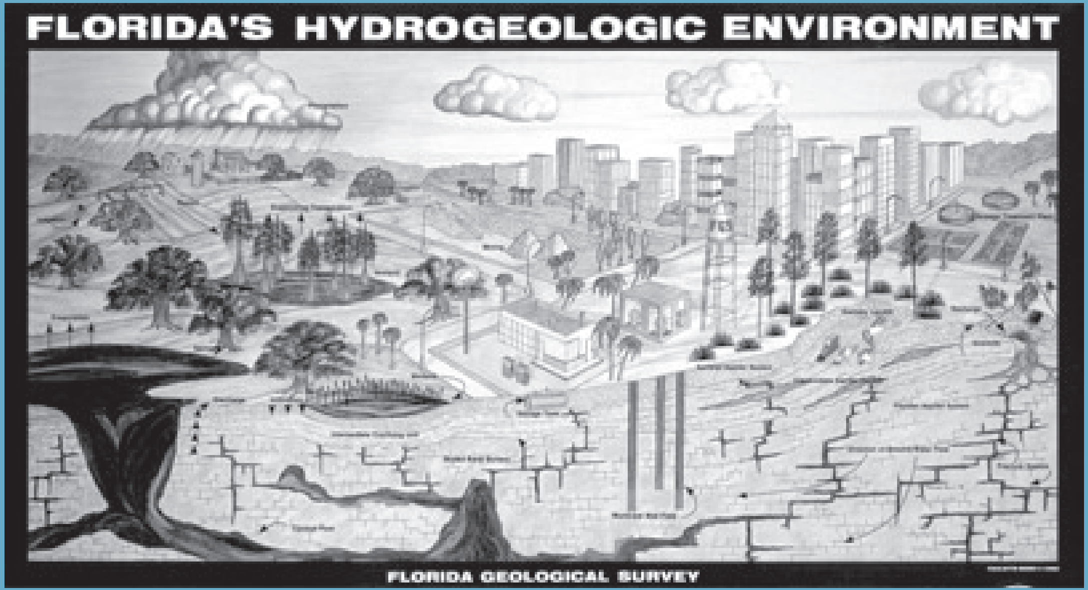


Figure 2.2. Our activities upon the land within Karst areas are quickly reflected in the ground water and golf courses.

Establish a Working Group

To initiate a springshed protection program, a local government may establish a "working group" or "technical advisory committee" (TAC) to evaluate the threat to the spring system, gather and map information, and recommend actions that the local government and others can take to protect the spring.

The value of a springs protection working group cannot be overstated. Initially, an ad hoc group can consist of interested citizens and representatives of local governments, the water management district, regional planning council, local university or community colleges, and others. A mix of backgrounds will strengthen the resource base and effectiveness of the working group.

The group can assist with collecting basic springshed physical data and evaluating and recording important cultural and historical facts about the springshed. The local government may formalize this ad hoc group, as well as any future spring protection actions, through the preparation and adoption of a springshed protection resolution.

Early in any springshed protection planning effort it is important that the local governing body, local planning commission, and the public be aware and supportive of protection efforts. To foster this, local advocates and working groups should educate others about the environmental, historical and cultural values of the springshed, its condition, and the steps needed to better protect the resources.

Adopt a Resolution of Support for Springshed Protection

To support the springshed protection program, the local government may adopt a resolution for springshed protection. The resolution establishes the springshed protection program and actions required to protect the spring system.

The Wakulla Springs Working Group

A working group was established in Wakulla County to look into the springshed protection needs of Wakulla Springs and Wakulla Spring State Park. Situated near Tallahassee, Wakulla Springs is one of Florida's largest first magnitude springs. The spring had been experiencing reduced water clarity and increased algal and aquatic plant growth. The Florida Department of Environmental Protection established a working group including federal, state and regional resource agency personnel, the Wakulla County planner, adjacent Leon County water quality personnel, local cave diving club members and other citizens. The group researched the threat to the spring system and helped develop recommendations to address identified problems. To address the threat, this group expanded Wakulla County's researching and informational gathering abilities and accessed expertise not found within the county offices.

A number of actions have followed to help protect Wakulla Springs. Existing data was collected, organized and analyzed, the area was mapped, and the Wakulla County Commission adopted a local resolution identifying the area as sensitive and noting its importance. These initial actions led to the development of a specific environmental protection overlay zone to guide certain land use activities. In addition, after identification of particularly sensitive parcels, land acquisitions have occurred and others are planned to provide additional protection around Wakulla Springs State Park and other karst features in the springshed.

Sample Local Springshed Protection Resolution

WHEREAS, springsheds are a rare and crucial component of the Florida hydrogeologic landscape and the continued existence of these valuable natural resources is important to the sustainability of local, state and global ecosystems; and

WHEREAS, the State of Florida is endowed with a limited number of pristine springsheds, including ________ Spring located in___________ County/City; and

WHEREAS, the Board of County Commissioners/City Council finds that the Spring, Spring Run and the emanating Springshed (collectively, the "Spring" and the""Springshed") are valuable natural resources, recreational centers, and economic development assets to the citizens of the County/City and the State of Florida; and

WHEREAS, the Board/Council finds that land use and development practices have the potential to degrade the Spring and the Springshed; and

WHEREAS, conventional land use and development practices have the potential to threaten and diminish the natural health and integrity of springsheds; and

WHEREAS, the Board/Council supports the protection of the water quality, quantity and ecological integrity of the ________________ Springshed so that the citizens of our jurisdiction and visitors alike may continue to enjoy this important natural resource; and,

WHEREAS, the Board/Council finds it necessary and in the best interests of the citizens of the County/City and the State of Florida to protect the Spring and the Springshed;

BE IT RESOLVED that the Board/Council is committed to taking those actions necessary to protect the Spring and the Springshed, including:

- Appointing a technical working group to help research and identify the particular areas of concern, collect relevant data, and produce a working base map and other maps showing the known springshed features of importance and sensitivity;
- Identifying reasonable springshed planning boundaries to assist efforts to preserve and protect the springsheds;
- Developing planning and land management strategies and other programs to protect springshed resources; and
- Suggesting amendments to the Comprehensive Plan and Land Development Regulations to implement actions of protection.

What is Happening in Other States?

Protection of springs is not just a Florida problem. In springsheds across the country, similar problems are shared. Overwithdrawal of water, high nutrient and other pollutant inputs and alterations to the natural springshed landscape are common problems. Here are summaries of efforts to protect springsheds in other parts of the country.

Nine Springs, Wisconsin. The Nine Springs watershed presented an opportunity for Dane County and the State of Wisconsin to protect and preserve a rare and valuable riparian ecosystem. The Nine Springs watershed consists of 8,144 acres of land situated along the south border of the City of Madison. The idea was to develop a model where natural and manmade areas are linked for the purposes of environmental education and environmental issue identification. This model system is called the E-Way. "E" stands for Educational, Ecological, Esthetic and Environmental. The boundary has been delineated based on a system of water, wetlands and steep topography that create a buffer between urban areas.

Barton Creek/Springs, Austin, Texas. Barton Springs, a natural limestone pool 1000 feet long, is fed by 28 million gallons of water each day from several underground springs. Barton Springs is part of 360-acre Zilker Park, located in the heart of Austin. The water from Barton Springs and Barton Creek flows into the lower Colorado River. The City has developed a very wide array of tools to protect to the system. These tools include water quality ordinances that limit the amount of impervious cover that a development can lay on the landscape, construction setbacks to prevent building too close to creeks, caves, springs and wetlands, and stormwater controls like water quality ponds to capture contaminated runoff and treat it before it is discharged back into waterways.

The City's efforts are further supported by the Save Barton Creek Association (SBCA) and the Save Our Springs Alliance (SOS), nonprofit citizen groups working to protect and conserve watersheds. SBCA incorporated in September 1979 in response to community concerns about the impacts of urbanization. Through research, public education, and land conservation, SBCA and SOS both work to protect and conserve the flora, fauna and water quality of Barton Creek and the Barton Springs Edwards Aquifer, a sole-source drinking water aquifer. SBCA helped write ordinances designed to protect the creeks and watersheds and provides funding and scientific expertise for public education opportunities.

Mammoth Cave, Kentucky. The Mammoth Cave Area Biosphere Reserve in Kentucky is a karst system of underground watercourses that includes the longest cave in the world. Long-term hydrological studies have delineated the extent of the system. Mammoth Cave National Park is the core of the designated biosphere reserve, and the ground water recharge area for the park's cave is a designated zone of cooperation. A Biosphere Reserve Cooperative, administered by the regional development authority, monitors for water pollution sources, establishes a regional geographic information system, and conducts educational and cultural heritage projects. These complement ongoing park research and have attracted considerable financial support.

Collect Data and Map the Resources

The springshed protection working group should collect and evaluate existing information about the spring, spring run and springshed. Some springshed features will be easily identified—the spring, spring run, and larger sinkholes near and upgradient to the spring. Much less information may be available regarding the overall extent of the springshed and its detailed hydrogeology. Given limitations on information, an incremental approach to collecting data and mapping the springshed should be pursued, starting from the spring and spring run, and progressing upgradient into the springshed area of water recharge.

Base Maps and Sources. As a first step, a working base map of the springshed, its extent as currently understood and known vulnerabilities should be created. Other important geographic features to map include wetlands, floodplains, soils and habitat areas to help identify flow ways and other spring connections. Soils maps also help in determining the rate of movement of surface water to ground water through the soil where the aquifer is vulnerable because of high permeability.

Determining ground water movement and identifying potential pollution sources are complex activities. Even after the basic information and mapping have been assembled and analyzed, it is likely that the detailed delineation and evaluation of the springshed will be far from complete. Additional resources will be needed. These resources, when linked with the geographic coverages, will increase the level of detail and certainty regarding the extent of the springshed.

A computer-based Geographic Information System (GIS) helps display important geographic features of the springshed. The University of Florida's GeoPlan Center, at www.geoplan.ufl.edu, has compiled GIS information that is available for a relatively low cost. Water management districts (WMD), the Florida Department of Environmental Protection (FDEP), the Florida Department of Community Affairs (FDCA), the Florida Fish and Wildlife Conservation Commission, and regional planning councils also have GIS capabilities and should be consulted for help in mapping information about a springshed. These agencies can assist the working group in mapping critical geographic features and interpreting information.

There are a variety of useful federal, state, local and private sources of data for mapping a springshed. Some of the more valuable are described here:

USGS Maps. One of the best starting points for developing a base map is to use topographic maps produced by the United States Geological Survey (USGS). These maps

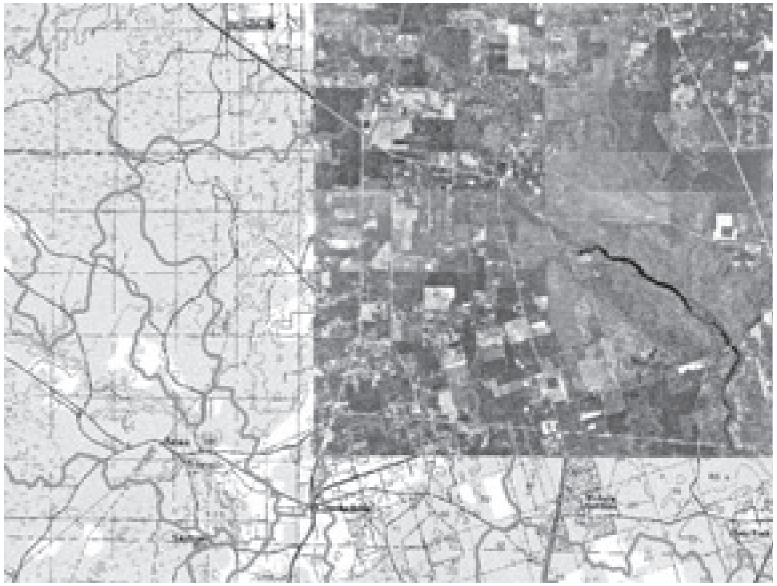


Figure 2.3. USGS topographical maps can be used as base maps. Here, a Wakulla Springs topographical map is overlain with digital aerials showing land use patterns.


Figure 2.4. This aerial (left) of Crystal River Springs Bay and surrounding area shows the area upgradient of the spring is developing intensively. The second aerial (right) shows a sinkhole that developed in Winter Park.

show major surface features, land elevation features to determine surface water movement, roads, and county boundaries. Obvious springshed characteristics, such as sinkholes, closed depressions, stream-to-sink drainages, the spring and spring run, can usually be identified using these maps.

Aerial Photography. Basic aerial photography is also an extremely important tool in land use planning within any springshed. Aerials are available from the University of Florida's GeoPlan Center, the Florida Department of Transportation, or from the county property appraiser's office. The photos can be used as an image backdrop for planing purposes and feature identification. The photos are generally of good quality with some having two meter resolution or better.

Underwater Cave Maps. Maps of underground caves, conduits and caverns are very limited and have no central repository. Possible sources of such maps include the National Speleological Society, Florida Chapter Cave Diving Section and the Global Underwater Explorers (GUE) in High Springs, Florida. For more information, visit their web sites at www.cavediver.org and www.gue.com/info/index.html.

Sinkhole Data. Because of the karst geology found throughout Florida, sinkholes need to be considered in the data collection and mapping effort. They occur when overlying sediment collapses into underground cavities and can result in a direct connection to the aquifer. The Florida Geological Survey maintains information on sinkhole types and locations. This information is available at www.dep.state.fl.us/geology/geologictopics/sinkhole.htm.

Aquifer Vulnerabilty Models. Both the U.S. Environmental Protection Agency and the Florida Department of Environmental Protection use models to determine aquifer vulnerability to pollution. Such modeling can provide valuable guidance when identifying the types of land uses appropriate for areas within a springshed. The DRASTIC and FAVA models are discussed below. DRASTIC is used nationally while FAVA is presently being developed as a Florida-specific model.

DRASTIC. The U.S. Environmental Protection Agency (EPA) has identified the following seven key factors that determine aquifer vulnerability: (1) **D**epth to ground water; (2) **R**echarge rate to ground water; (3) **A**quifer media; (4) **S**oil type; (5) **T**opography; (6) **I**mpact of the vadose zone; and (7) **C**onductivity of the aquifer. Each of these factors is assigned a combination of weights and ratings, and a numerical index, called the DRASTIC index, is computed.

The DRASTIC index is then used to evaluate the relative vulnerability of different aquifers or different segments of a given aquifer. The methodology utilizes existing hydrogeological information to produce color-coded maps which display areas that are more or less likely to be affected by pollution introduced on the ground's surface. These maps depict areas of high ground water recharge sensitive to land use changes which may affect ground water quality and quantity.

DRASTIC maps are useful as a generalized tool for assessing regional aquifer vulnerability rather than for site-specific analyses. Most of the source maps used to create the DRASTIC maps were regional in scale. Nevertheless, they are a good source of information for the working group to begin a springshed vulnerability assessment, especially with regard to identification of the springshed areas with high ground water recharge.

DRASTIC index values range from 0 to about 250; the larger the index, the greater is the relative vulnerability of the aquifer to contamination. In some areas, the aquifer is overlaid with deposits of permeable sand and is easily and directly recharged. A high DRASTIC index of 224 suggests that ground water contamination is highly likely in this area. In contrast, a thick deposit of impermeable clay over the aquifer will result in a lower DRASTIC index of 150, indicating a much lower vulnerability to

Other Sources of Springshed Data

- Federal Emergency Management Agency, Flood Prone Area Maps (available from the Florida Department of Community Affairs, Division of Emergency Management);
- National Wetlands Inventory Maps; Drainage Basin Maps (available from the FDEP or WMD);
- County Soil Survey Maps (available from the local agricultural extension agent or WMD);
- Florida Department of Transportation road coverages;
- County geological maps and sinkhole location maps (available from FDEP, Florida Geological Survey); and
- Vegetation and habitat maps (available from the Florida Fish and Wildlife Conservation Commission or the GeoPlan Center).

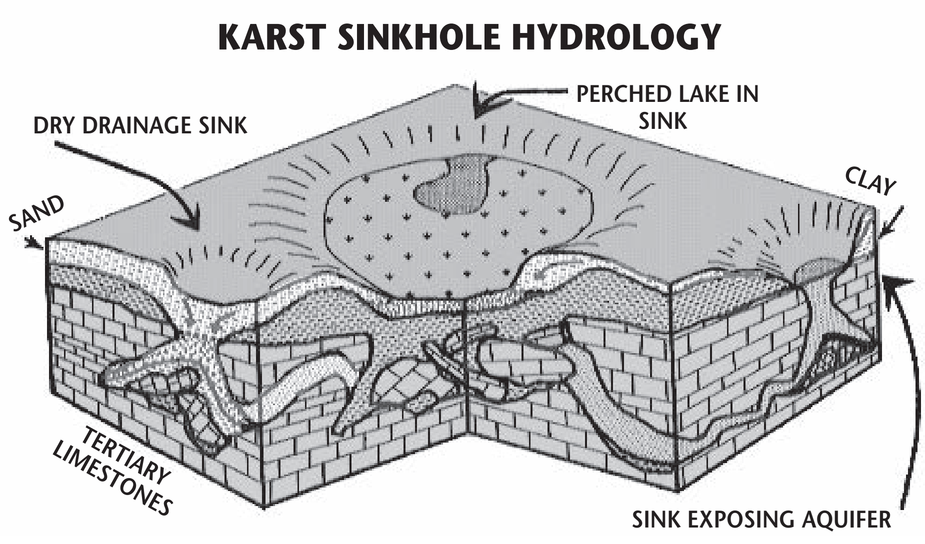


Figure 2.5. This diagram depicts the formation of a sinkhole.

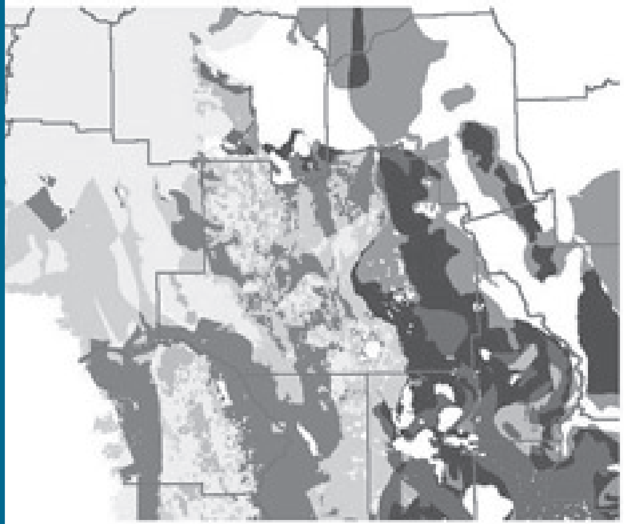


Figure 2.6. These DRASTIC maps of the north central Florida region (top) and Wakulla Springs (bottom) reflect the aquifer's relative vulnerability to pollution. The darker the color, the higher the relative vulnerability.

contamination. DRASTIC maps for Florida counties with karst terrain are available from the water management districts or the FDEP.

The Florida Aquifer Vulnerability Assessment (FAVA). FAVA is an ongoing project to develop a Florida-specific model using existing GIS data to predict the vulnerability of Florida's major aquifer systems to contamination. Model development is underway with a focus on small-scale pilot mapping projects in Alachua, Hillsborough and Polk counties. The objective of FAVA is to develop a tool that can be used by environmental, regulatory, and planning professionals to facilitate protection of Florida's ground water resources, and thus the health and safety of Florida's residents. For more information, contact the Florida Geological Survey at www.dep.state.fl.us/geology/programssections/hydrogeology.htm.

Florida Aquifer Vulnerability Assessment Conceptual Model

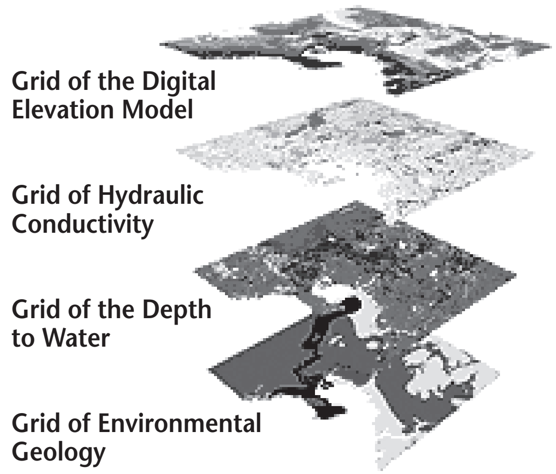


Figure 2.7. The Florida Aquifer Vulnerability Assessment process should provide a better tool for assessing the groundwater vulnerability than DRASTIC maps.

Hydrogeology Consortium

This group was established to provide scientific knowledge about ground water resource management and protection. The Consortium's primary goal is improved effectiveness and efficiency of management and protection of water resources, particularly ground water, through better understanding and application of scientific knowledge. The Consortium can also help the working group interpret springshed information useful for land use planning purposes. For more information go to **www.hc.gfdi.fsu.edu/**.

Woodville Karst Plain Project

The Woodville Karst Plain Project, an official project of the National Speleological Society's Research and Advisory Committee, included extensive surveys of the underwater cave system associated with Wakulla Springs. The Society developed three-dimensional maps of the larger underwater caves and conduits.

SCUBA divers collected physical measurements such as depth, width, and height at multiple survey stations along linear paths through the conduits. These measurements were used to produce coordinates for points along the cave network. Through linear interpolation, additional points were generated between survey stations. Using the coordinates and Earth Vision modeling software, relatively accurate three-dimensional geometric models were generated for the cave systems.

Hydrologic and topographic maps were then superimposed onto the three-dimensional conduit map to investigate the relationship between the land surface and underground conduits. Through this process, the most significant local recharge areas—where the conduits approach the land surface and are not overlain by confining layers of clay or rock—were more easily identified. In addition, water chemistry and other data collected by researchers can easily be incorporated into these models. Similar mapping studies are being performed by the Global Underwater Explorers for other karst springshed systems along the Ichetucknee and Santa Fe Rivers in north central Florida.

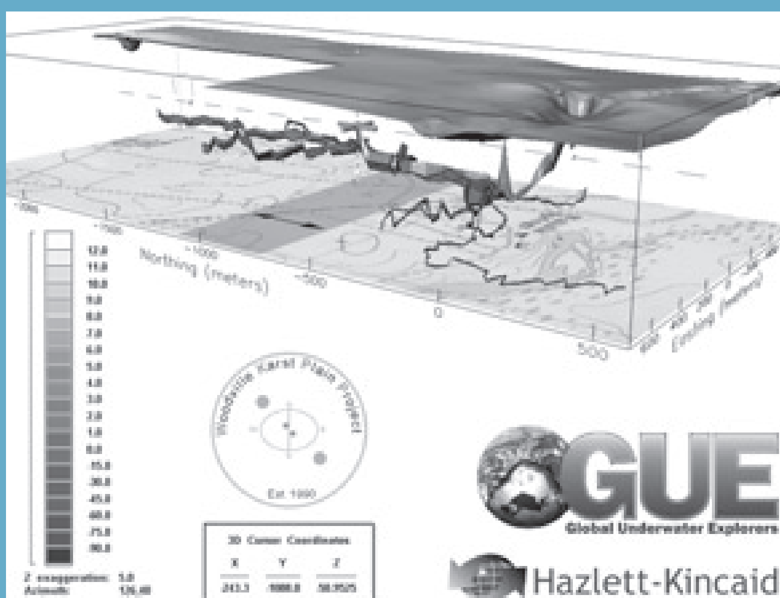


Figure 2.8. This three-dimensional conduit map shows part of the Wakulla Springs system.

Establish Springshed Protection Zones

The springshed usually covers an expansive area that exhibits varying degrees of ground water vulnerability. Using the data previously identified, the springshed should be studied and then divided into zones with similar vulnerability characteristics in order to identify appropriate land uses and management strategies for the differing springshed zones.

The primary protection zone should include the most sensitive areas that are critical to maintaining the springshed's health and physical integrity. Not necessarily one contiguous area, this zone may resemble an "archipelago" that follow streams, lines of sinkholes or known surface or underground conduits that feed the spring. Outlying "islands" of known high ground water recharge that collect and pass water on to the spring should be included within the primary zone. Primary zone features should include:

- Areas that provide significant water recharge to the springshed;
- Surface waters that link to the spring, either directly or indirectly (stream-to-sink water connections);
- Large underground conduits, caves or geological fractures that direct water to the spring;
- Sinkholes and other surface depressions that link to the conduits and fractures that lead toward the spring;
- The spring and the spring run; and
- Buffers surrounding sensitive springshed features.

Lands within the secondary protection zone are not as vulnerable to contamination as lands within the primary zone, but are important for collection, treatment and the release of water to the spring system. The secondary zone typically includes areas that contribute and treat water up-gradient of the primary zone. To help establish the extent of both primary and secondary zones, modeling can be used to determine the likely rate of ground water movement to the springs and natural treatments. In the absence of modeling, designating an adequate distance around critical springshed features until modeling can be completed is the accepted alternative.

> The primary zone is the springshed's major veins, while the secondary zone is its kidneys. Each is vital to a springshed's health and integrity, and cannot function as a healthy system without the other.

Create an Overlay Protection District

Once the zones have been identified, a recommended strategy is to create an overlay protection district to include in the comprehensive plan and future land use map. Overlay districts allow differential treatment of land relative to its vulnerability to contamination. In addition to including the underlying land uses, this district should include special development

Overlay Protection District

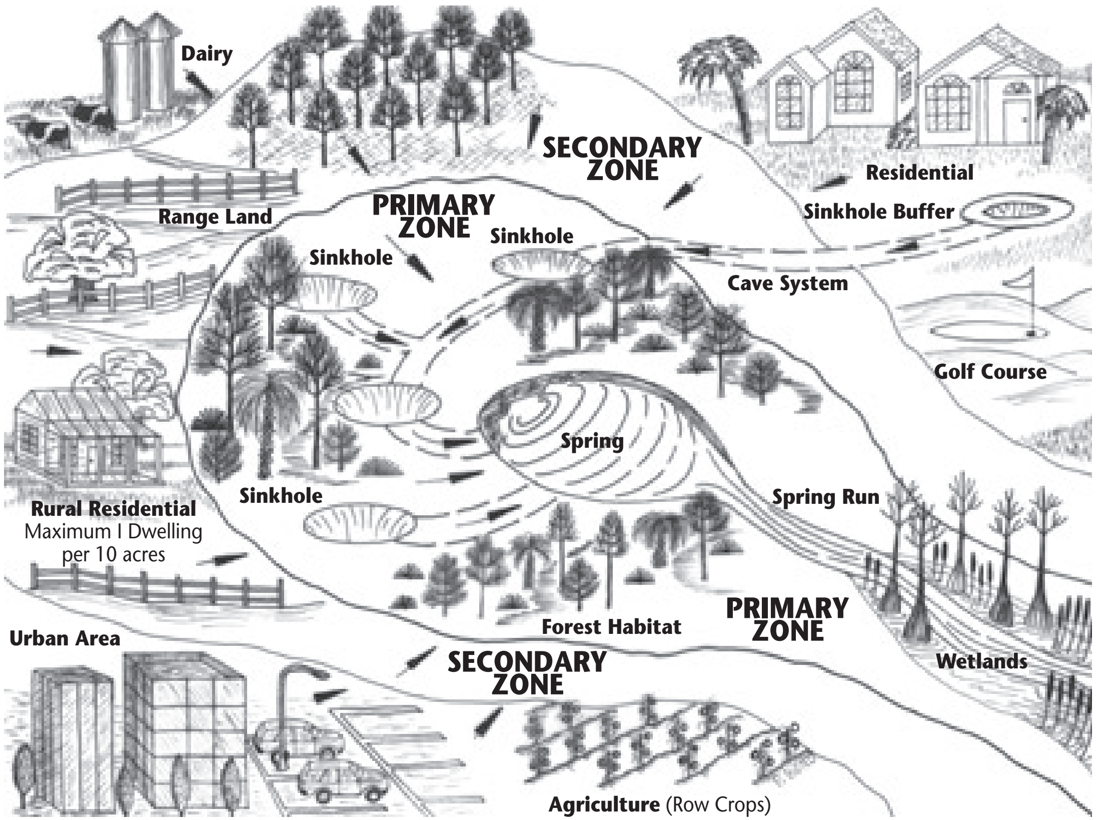


Figure 2.9. The primary zone closest to the springshed should have the lowest intensity land uses, while the secondary zone can include slightly more intensive but still compatible uses. Arrows indicate the direction of water flow.

or redevelopment conditions for both the primary and secondary zones. These conditions, described more fully in the following section and other parts of this manual, can include provisions to shift development away from the most sensitive areas and to establish performance standards to limit or mitigate pollution impacts.

In the primary protection zone, land uses include preservation, conservation, recreation and open space, unimproved rangeland or low intensity, long crop rotation silviculture uses. In the secondary protection zone, in addition to primary protection zone uses, land uses of moderate density and intensity such as silviculture, rangeland, low density rural residential are also appropriate. Land uses to minimize or avoid within the primary and secondary zones include mining, industrial, heavy commercial, intensive agriculture, golf courses and urban uses with extensive impervious surfaces.

The comprehensive plan and future land use map need to be modified to include the protection district's location, allowable land uses and density and intensity of uses, and special performance standards. These guidelines and standards should be used to develop land development regulations specific to the overlay district. Using a district approach acknowledges a springshed's vulnerable characteristics and creates a special area wherein land uses, land development regulations and special programs may be employed to protect springshed characteristics.

Overlay Districts in Developed Springsheds

Many of Florida springsheds are located in already developed or rapidly-developing areas. Examples include Weeki Wachee in Hernando County, Crystal River in Citrus County, and a significant part of the Wekiva Springs in Orange and Seminole counties. Even in a developed springshed, the local government should identify the primary and secondary zone. In these areas, it is important to manage development impacts using protection strategies and best management practices discussed in later sections.

In springsheds heavily developed with residential and commercial land uses, excessive nutrient input problems require careful land management, mitigation and minimization of existing pollution sources. In developed springshed areas, local governments should establish programs that:

- Educate homeowners regarding proper lawn and landscaped area fertilization and irrigation. This can be easily accomplished by supporting local implementation of the Florida Yards and Neighborhoods Program managed by the local county agricultural extension office;
- Use natural vegetation and xeriscape approaches to lawn and landscape design;
- Employ active street sweeping;
- Review existing land development codes to determine if changes are needed to minimize impervious surfaces, preserve natural vegetation, require additional planting of vegetation (especially as riparian buffers), and promote low impact development design options;
- Encourage water conservation and foster local stewardship through "adopt a spring" programs, incentives, and volunteer springshed awareness and protection programs;
- Develop and implement a stormwater master plan designed to reduce stormwater pollution from development;
- Specify any land use differences from the underlying use;
- Specify permit, procedural and approval requirements for the district; and
- Specify targeted overlay criteria or performance standards necessary to protect springs.

Wakulla Springs Special Planning Area

Wakulla County has designed the Wakulla Springs Special Planning Area to ensure additional water quality protection to ground water affecting Wakulla Springs. A major component is the protection of mapped underground flow corridors which feed Wakulla Springs. The County's Comprehensive Plan requires "that the land development regulations be amended to protect water quality at Wakulla Springs; educate the public on water quality issues; regulate land uses which may adversely impact water resources; identify toxic and hazardous materials, and prohibit the discharge of pollutants."

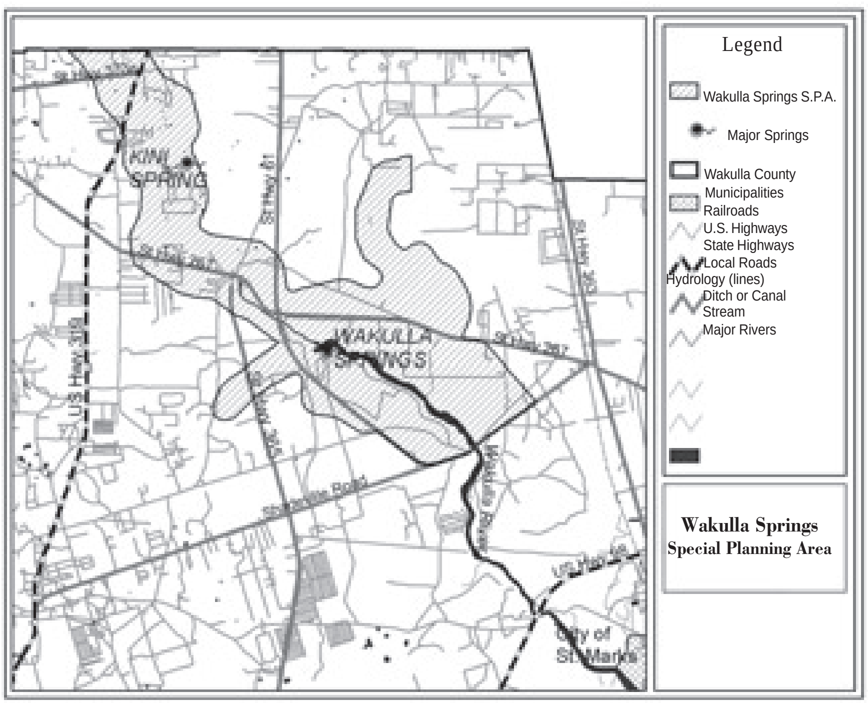


Figure 2.10. The overlay zone to designate the Wakulla Springs Special Planning Area in Wakulla County is depicted on the future land use map.

Use Other Appropriate Land Use Planning Tools

Other land use planning tools can be used in conjunction with the overlay protection district to protect water quality in a springshed. These tools work well in relatively undeveloped areas, and can also assist in areas that have already been substantially developed.

Open Space Zoning. This involves the clustering of density on a site. It allows the on-site transfer of residential units in order to cluster development away from environmentally-sensitive areas. The intent is to cluster development on small lots within a compact portion of the property, leaving the remaining portion open. This undeveloped portion is placed under a conservation easement to preserve it as open space. This reduces the development's overall impacts by changing the shape, orientation, size and layout of residential lots. Open space zoning supercedes conventional zoning, which assigns a development designation and unit density to every acre of land and can lead to sprawling patterns of development that are more likely to negatively affect sensitive landscape features.

Open space zoning is often applied as an overlay district. It is especially useful where land use densities and intensities have already been established at levels not particularly suitable for springshed protection. A landowner or developer retains the right to develop at established densities and intensities of use, but clusters that development on one portion of the parcel. The more sensitive springshed features such as the spring, spring run, sinkholes and streams can be set aside in a conservation easement. Thus, the open space area can buffer the more sensitive springshed features of the site.

On-Site Density Transfer. On-site density transfer, similar to open space zoning, relocates development away from a particularly sensitive portion of the site to a location more capable of accommodating development impacts. However, this tool does not require the special zoning designation that open space zoning does. Development is guided to locations suitable for growth while at the same time protecting areas that require preservation, and achieves the same beneficial results as open space zoning. This technique is usually applied early in the development review process. It is further discussed in the following chapter on managing development impacts within a springshed.

Large Lot Zoning. Large lot zoning, which lessens the impacts of development on water quality, is commonly used throughout Florida. It involves zoning at very low densities to disperse impervious cover over very large areas. Densities of one unit per 5 or 10 acres are not uncommon. From the standpoint of springshed protection, large lot zoning is more effective as lot sizes increase to the 10- to 40-acre range.

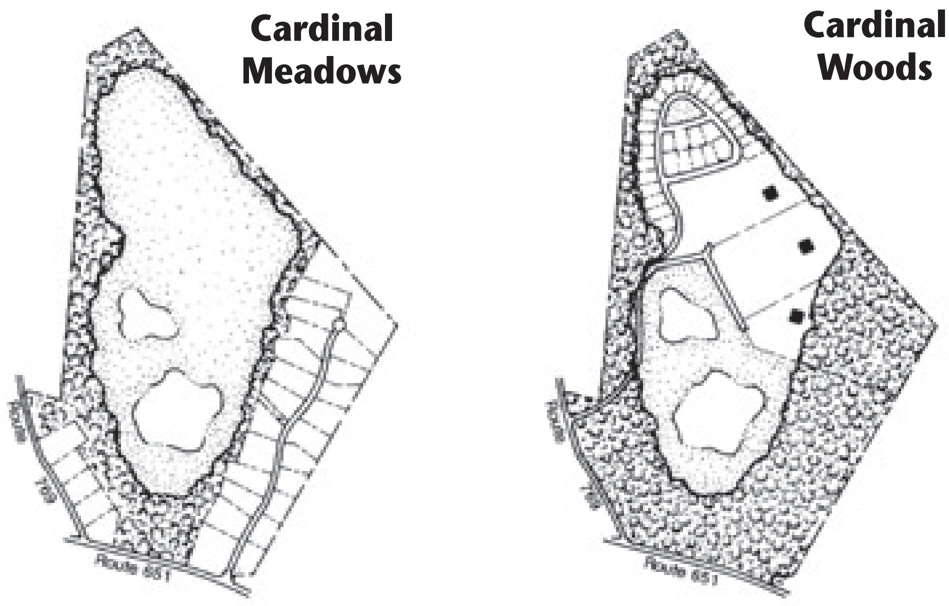


Figure 2.11. The original 1984 site plan, and a hypothetical alternative tree-saving layout produced 16 years later, show contrasting approaches to conservation design. When farmland and rural character preservation are the primary objectives, the original design illustrates a logical and skillful design solution. When the conservation of woodlands, wildlife habitat, water quality, and aquifer recharge issues are of greater concern, a layout that minimizes forest disturbance is generally preferred.

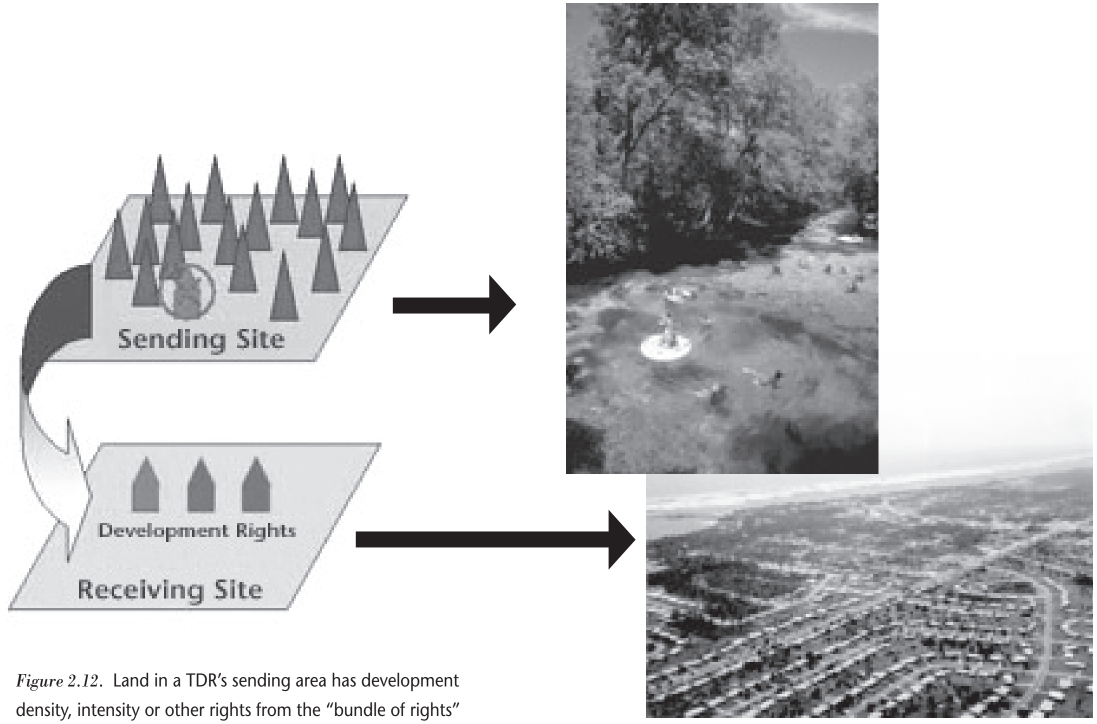


Figure 2.12. Land in a TDR's sending area has development density, intensity or other rights from the "bundle of rights" reduced, while land in the receiving area(s) accepts the transferred density, intensity or other rights.

While large lot zoning does reduce the impervious cover and, therefore, the amount of stormwater runoff at a particular location, it also spreads development over vast areas, which represents a form of sprawl. Road networks constructed of impervious material reduce the benefits derived from dispersing residential impervious cover over large lots. Sprawl-like development increases the expense of providing community services such as fire protection, water and sewer systems, and school transportation. Sprawl also increases the amount of land converted from forest or farmland to golf courses and lawns, which are notable contributors to springshed pollution.

Performance Zoning. Performance zoning evaluates a development plan on density, amount of open space provided, amount of impervious surface created, and the overall impact of the development on the area. It is designed to ensure development achieves an acceptable level of performance within a given zoning district. Performance factors may include desirable density standards, open space standards for protection of wildlife and vegetation, stormwater runoff quality and quantity criteria and impervious surface standards.

Transfer of Development Rights (TDRs). TDRs put to creative use the premise that ownership of land entails a "bundle" of property rights (e.g., mineral rights, air rights, water rights, etc.) and that individual rights can be bought and sold to accomplish various objectives. TDRs may involve transferring development rights from a more environmentally-sensitive property (the sending zone) to another property more capable of handling intensive development (the receiving zone). The receiving area densities are established within the comprehensive plan.

There are two basic types of TDR programs. The most common allows the landowner to sell development rights on a piece of property in a sending zone to a developer who then increases the density on another piece of property in the receiving zone (for example, going from one unit per acre to four units per acre). The higher the density that developers are able to realize, the greater the incentive for them to buy development rights.

A second method allows a local government to establish a TDR bank. In this method, property owners who wish to develop at a higher density purchase development rights from the TDR bank, often administered by the local government. The local government can then use these funds to purchase development rights of properties in areas that it wants to protect from urban development.

To work effectively, TDR programs generally require a high demand for housing or other development in the receiving zone, and an administering governmental unit capable of overseeing the program. TDRs are most appropriate for large-scale efforts where keeping land in private ownership is considered desirable. This land use management technique can facilitate springshed protection by transferring development potential from sensitive areas within the springshed to less sensitive areas that have been identified as suitable for development.

Rural Land Stewardship Areas. A new program in Florida allows the FDCA, in cooperation with the Department of Agriculture and Consumer Services, to authorize counties to designate certain lands as Rural Land Stewardship Areas. A Rural Land Stewardship Area is intended to strengthen the county's capacity to promote economic development, maintain a viable agricultural economy, preserve the environment and character of rural areas, and control urban sprawl. The program may have applicability in rural springsheds where low intensity agricultural activities such as silviculture or rangeland exists and there is a threat of land use change toward more intense use.

In support of creative land use and planning strategies, "transferable land use credits" will be assigned to Rural Land Stewardship Areas by the county in its comprehensive plan. The comprehensive plan will include standards for designation of receiving areas. Transferable land use credits increase density and cluster development rights in receiving areas, while discouraging growth in environmentally-valuable sending areas.

The process for the Rural Land Stewardship Areas is as follows:

- Selected counties will be authorized by the FDCA, through a written agreement, to develop Rural Land Stewardship Area designation. Such an agreement will include the rationale for authorizing, and criteria for evaluating the success of the designation.
- Once selected, the county designates the Rural Land Stewardship Area through a plan amendment to its future land use element. The plan amendment will encourage visioning, outline the criteria for designating receiving areas, assign and distribute the transferable land use credits and implement innovative planning strategies within the Rural Land Stewardship Area.
- The County must assign, by ordinance, a certain number of transferable land use credits to the Rural Land Stewardship Area and ensure that the use of transferable land use credits includes the recording of all transactions as public records in the county in which the land is located.
- Receiving areas for transferable land use credits within the Rural Land Stewardship Area are designated by land development regulation and the density within the receiving area is increased through a local development order based on the assignment of land use credits.

Impervious Surface Overlay Zoning

Impervious Surface Overlay Zoning, a specific type of performance zoning, limits the creation of impervious surface area. It is particularly useful in protecting water quality in the springshed. In general, watersheds with excessive impervious surface coverage will not be able to support a high quality stream system. Large areas of impervious surface may also contribute to erosion, sedimentation, decreased biological diversity, and poor water quality in the springshed.

In this type of zoning, the environmental impacts of impervious surfaces are estimated, and limits are set on the maximum amount of impervious surfaces allowed within a given planning area. Site development proposals and subdivision layout options are then reviewed in this context.

Threshold requirements for the Rural Land Stewardship Areas include the following:

- Applies to lands classified in the future land use element as predominantly agricultural, rural, open, open rural, or equivalent land use;
- Encompasses an area between 50,000 and 250,000 acres in size; and
- Is located outside of municipalities and urban growth boundaries.

For more information on this program, go to www.dca.state.fl.us/fdcp/DCP/.

Use Acquisition and Easement Strategies to Protect the Most Sensitive Areas

The most effective strategy to limit the impacts of development is to reduce the amount of development allowed. This objective can be accomplished through: outright fee simple acquisition of the land (e.g., the local government or a not-for-profit land trust buys and holds the land); purchasing an individual's right to develop his land; or buying a conservation easements on all or some portion of a parcel of land. Below are descriptions of acquisition and easement tools that can be used in a springshed protection program. It is recommended that the most sensitive springshed features be acquired in fee simple, or be protected through the purchase of development rights or through conservation easements.

Fee Simple Purchase. Also known as "fee simple acquisition," this is the outright purchase of land, and gives full control over all rights to the acquired property. Local governments that choose this option most always do so with a willing seller. However, if there is sufficient public need (such as protecting drinking water sources) they may choose to exercise the power of eminent domain. Outright purchase by a unit of government requires:

1. The determination that the land serves a public purpose. In general, natural areas serve multiple public purposes (flood control, enhancement of air and water quality and offer recreation oportunities);
2. The provision of necessary funds to finance the purchase. Acquisition may be financed through general revenue funds, bond referenda, special taxation, government grants, trust funds, land swaps and matching fund programs. Cost of acquisition may be reduced by use of "bargain sale" in which the seller agrees to sell at below market value (the difference is recognized by the IRS as a

TDR Success Stories

- In the Washington, DC, area, Montgomery County, Maryland, established a TDR program in 1980. By the end of fiscal year 1997, this program had protected 39,180 acres under easement. Prior to 1980, the county lost an average of 3,500 acres of farmland per year to development. In the decade following the establishment of its program, the county only lost a total of 3,000 acres to development, a drop of approximately 92 percent.
- The New Jersey Pinelands, an environmentally-sensitive area of about one million acres, was targeted for protection through the New Jersey Pinelands Protection Act of 1979. The Pinelands Commission, the regional land use authority, established a TDR program in 1980. By 1991, 5,300 acres had been protected.
- In Washington, the Kings County Farmland Protection Program, considered one of the most successful programs in the country included a voter-approved bond to purchase development rights and establish exclusive agricultural production districts and a transfer of development credits program.
- In 1997, the Minnesota legislature passed enabling legislation to explicitly allow local units of government to develop and utilize TDR programs. The Green Corridor Project is working to develop Minnesota's first formal Transfer of Development Rights program.

Red Hills Conservation Program (RHCP)

Through conservation easements the RHCP of the Tall Timbers Research Station in North Florida has protected nearly 71,000 acres of longleaf pine-wiregrass community that had traditionally been used as hunting plantation lands. These private undeveloped lands from Tallahassee to Thomasville, Georgia replenish the Floridan Aquifer and form a significant area for wildlife and a relatively intact longleaf pine-wiregrass ecosystem.

For a local program such as the RHCP to be successful in preserving environmentally sensitive areas and working landscape, the voluntary cooperation and shared stewardship ethic of individual landowners must be a guiding theme. According to the RHCP conservation easements offer several benefits to landowners:

- Landowners retain title to their property and continue to live on it, sell it, or pass it onto heirs, knowing that it will always be protected;
- Easements may eliminate or greatly reduce estate taxes, preventing the forced sale of properties;
- Easements can also provide landowners with substantial federal income tax reductions;
- Easements are flexible, adapted to the particular needs of the landowner and the resources of the property;
- Easements can reduce the potential for disagreement among family members when lands are passed on to the next generation; and,
- Easements offer permanent protection, applying to all future landowners.

Figure 2.13. Longleaf pine and wiregrass communities have been preserved through conservation easements as a treasured heritage for the region of the Red Hills.

charitable contribution for the seller's income tax purposes); and

3. Financial and staffing resources to provide for site management and maintenance.

Acquisition is considered a key to secure core environmentally-sensitive springshed areas, including the spring and spring run, larger sinkholes, critical recharge areas, and buffers surrounding critical spring resources and surface waters and other stream to sink water connections. Federal, state, regional and local governments, along with nonprofit organizations, usually have the authority to acquire land under a variety of natural, cultural and historical land acquisition programs.

Purchase of Development Rights (PDR). Federal, state and regional agencies, local governments and nonprofit organizations may purchase development rights to protect environmentally-sensitive areas, open spaces or agricultural lands. The purchase of the development rights is denoted in the land's title or through establishment of a conservation easement that runs with the land. Unlike transfer of development rights or other density transfer programs, the development rights are bought and "retired," not to be transferred or placed elsewhere. PDR programs are generally applied as part of a formal program with specific criteria used to select purchases.

PDR programs require an administering governmental unit capable of overseeing the program and a mechanism to finance the acquisition of development rights. A PDR program requires willing participation of the seller. PDR is appropriate for efforts where keeping land in private ownership is desired.

Conservation Easements. A conservation easement is a legally-binding agreement between a landowner and a qualifying government agency or nonprofit organization (e.g., a local land trust), in which the landowner voluntarily agrees to specified terms that limit the use and development of a given property for the purpose of protecting agricultural, open space, cultural, or environmental values. An easement runs with the land's title and is binding on all future owners or for some set period of time. The easement may be sold by the landowner or donated. A donation of an easement provides a benefit to the landowner since it is a tax-deductible charitable gift. The amount of the income tax deduction is equal to the difference between the fair market value of the property without the easement and its value with the easement.

In addition, many landowners take advantage of estate tax relief offered by easements. Under the Taxpayer Relief Act of 1997, heirs can exclude an additional 40 percent of the value of the land, over and above the charitable gift value, for lands under easement. Contributions may be staged over a number of years to gain the maximum economic advantage for the landowner.

Conservation easements may be used to:

- Establish buffers around environmentally-sensitive areas or to protect entire areas or working landscapes;
- Promote landowner stewardship and conservation while keeping land in private ownership and on the tax rolls; and
- Ensure permanent protection of required open space in subdivisions and other developments.

Establish Voluntary Stewardship Programs

Communities need to invest in ongoing springshed stewardship. The goals of springshed stewardship are to increase public awareness about management efforts, and to get local landowners' participation in the process to ensure good stewardship of their properties and homes. A number of programs may be considered to promote greater springshed stewardship.

Springshed Education. Some of the most effective springshed education programs merge learning, the enjoyment of outdoor recreation, and personal involvement in stewardship activities. Education programs can include:

Springshed awareness – raising basic awareness using signs, storm drain stenciling, sinkhole identification, stream walks, and maps and articles in local newspapers and magazines;

Funding Sources for Land Acquisition

Florida's land acquisition programs are some of the largest in the country. Since 1990, the state has purchased more than one million acres of environmentally-sensitive land through Preservation 2000 (P2000), Conservation and Recreational Lands (CARL), Land Acquisition Trust Fund (LATF) and Florida Communities Trust (FCT). From 1990 to 1998, more than three billion dollars was spent through P2000 alone, with bonding taxes collected from every real estate transaction in the state.

The Florida Forever Act, the successor to P2000, uses documentary stamp tax revenue for the acquisition of land. However, more money is being allocated for water source and resource lands and land purchases in urban areas to establish or maintain open space and parks. Florida Forever distributes an annual allocation of $300 million to the CARL program and the Florida Recreational Development Assistance Program at the FDEP, the Water Management Districts; the Florida Communities Trust Program at the FDCA; and to the Fish and Wildlife Conservation Commission; the Division of Forestry at the Department of Agriculture and Consumer Services; and the Division of Recreation and Parks and Office of Greenways and Trails at the FDEP. Uses of these funds are set forth in the Florida Statutes, Section 259.105, **www.onlinesunshine.com**. To find out about how lands are selected for purchase, contact the Florida Department of Environmental Protection, Bureau of Land Acquisition at **www.dep.state.fl.us**. For information about the Florida Communities Trust program, contact them at **www.dca.state.fl.us**. For information about the Greenways and Trails Program, call visit **www.dep.state.fl.us/gwt**.

Florida Communities Trust (FCT), one of the major programs funded under the Florida Forever Act, provides grants to eligible applicants for the acquisition of land for community-based parks, open spaces and greenways that further the outdoor recreation and natural resource protection needs identified in local government comprehensive plans. This program pays particular attention to local government's comprehensive plan to see if there are goals, objectives and policies guiding or directing the local land acquisition. Springshed protection activities closely tied to a local government's adopted plan will provide an added advantage under scoring for FCT grants.

In addition to these state programs, about one-third of the counties in Florida have passed referenda to create and fund open space, recreation and environmentally-sensitive land purchases. Some of these funds are used to match state program grants or private land conservation efforts. Land acquisition efforts, including springshed protection, in counties with locally-funded acquisition programs have a distinct advantage because of their leveraging potential. They can meet monetary match requirements for regional, state or federal grant programs.

At the federal level, the USDA Forest Service has a program to acquire land to provide a route for the Florida National Scenic Trail (FNST). The Florida Trail Association works with the USDA Forest Service to build and maintain this and other hiking trails in Florida. For more information contact the Florida National Scenic Trail liaison, Florida Trail Association in Tallahassee or visit **www.florida_trail.org**.

Personal stewardship – educating residents about the role individuals can play in springshed protection, and communicating specific messages about positive and negative behaviors (e.g., limiting nutrients and other pollutants);

Professional training –educating the development community on how to apply the tools of springshed protection; and

Springshed engagement – providing opportunities for the public to actively engage in protection and restoration activities.

Springshed Advocacy. Advocacy is very important because it provides the foundation for public support and greater stewardship. One of the most important investments that can be made is to seed and support a management structure to carry out the long-term stewardship function. Often, because of their local focus, use of volunteers, low cost and ability to reach into communities, grassroots organizations are uniquely prepared to handle stewardship functions. Such organizations can be effective advocates for better land management and can develop broad popular support and involvement for springshed protection. Local governments also can play an important role in such advocacy as they create or help direct the management structure.

Springshed Maintenance and Restoration. Most springshed protection tools require maintenance if they are to properly function over the long run. Some of the most critical "maintenance" functions include management of conservation areas and buffers, stormwater and wastewater treatment facilities and septic systems. Additionally, maintenance of the quality of springsheds may require replanting of natural vegetation cover, providing another opportunity for public involvement and education. Springshed maintenance and restoration are activities well suited to participation by volunteer organizations where group projects can be arranged to clean up areas, remove exotic species, replant native vegetation, mark trails, and undertake other group activities.

Springshed Pollution Prevention. Some businesses may need special training on how to manage their operations to prevent pollution and thereby protect the springshed. In some cases, local or state government may have a regulatory responsibility and may also have to develop pollution-prevention programs for certain businesses and industries. FDEP has such a program, and offers on-site technical assistance through its Pollution Prevention Program. It offers site visits to provide companies with the ability to solve their future environmental problems in a more cost effective manner than traditional end permitting. The "Retired Engineers" segment of the program often lends a hand and valuable industrial expertise. Program information is available at (850) 921-9227 or at www.dep.state.fl.us/waste/categories/p2/default.htm.

Springshed Indicator Monitoring. An ongoing stewardship responsibility is to monitor key indicators to track the health of a springshed. Public agencies, as well as private corporations, citizen groups, and even landowners, should seriously consider monitoring to provide appropriate indicator data and analysis. Monitoring water quality can include assessing flow, the quantity and quality of aquatic biota, pollutant levels, and many other characteristics as appropriate to the type of water body and its problems. City and county governments may also consider working with local land trusts to help monitor and manage lands under conservation easements.

Registry Programs. Registry programs are a way to acknowledge and encourage the voluntary protection of natural features by private citizens. Landowners make a non-binding agreement to protect their land by enrolling in a registry. In turn, they are provided with information and technical assistance regarding appropriate conservation practices for their particular site. Local governments may either start their own registry program, or educate citizens about the availability of registry programs offered by other government agencies or nonprofit conservation organizations.

Special Designation. High quality natural areas may qualify for special designation under a state, regional or a federal program, such as the National Natural

Landmark Program (Code of Federal Regulations: Title 36, part 62), or Florida Regional Planning Council's Strategic Regional Policy Plan designations for "regionally significant natural resources." Special designation may increase legal protection, as well as the potential for financial support for acquisition and management of selected sites. For sites appropriate to special designation, an outside agency may be interested in acquiring the property and managing it for protection of its natural features. This allows the local community to benefit from protection of a site without being obligated for the cost of acquisition or management. Special designation is only appropriate for natural areas with features of regional, state or national significance.

Adopt Comprehensive Plan Policies for Springshed Protection

Using Florida's comprehensive planning process effectively is key for the protection of springs and springsheds. Protection strategies need to be incorporated into the local comprehensive plan by the local government. Differing landscape types—developed, not developed, agricultural or suburban—require local governments and landowners to evaluate their particular circumstances and craft appropriate protection strategies.

The comprehensive planning process legally empowers a local government to plan for and guide future growth and development to protect sensitive natural areas. Through this process, strategies can be developed for a springshed's protection, and be publically debated, adopted and implemented. Every springshed is unique and requires strategies to meet specific protection needs.

The attachment on page 35 contains sample goals, objectives and policy suggestions to draw from when developing specific strategies and actions. They cover a range of potential actions that may be used. Each jurisdiction will ultimately determine the planning tools appropriate for their use. The following chapters address land development management actions that implement the comprehensive plan policies for springshed protection. The chapters move from managing larger landscapes to managing development impacts on particular development sites and from particular land use types.

In assisting the local government in developing comprehensive plan policies for springshed protection, the earlier-described ad hoc working group should evaluate the adequacy of existing measures included in the local comprehensive plan. In cooperation with the springshed protection program partners, the working group should propose revisions to the comprehensive plan that are needed to help implement the springshed protection program. The proposed amendment should map protection zones and address land uses within the protection zones, development controls and standards appropriate for the springshed, and standards for the design and management of development.

The sample goals, objectives and policies for springshed protection presented in the attachment on page 35, should be tailored to site-specific conditions and community needs. They should be supported by appropriate data and analysis to justify and explain their use. Supporting information should discuss the importance of the springshed to the community and describe a vision for future protection, levels of development and include, for example, maps depicting the springshed and important karst features, the principal areas of ground water recharge, and the water resource impacts to be addressed by any proposed development guidelines and strategies.

Be Sure to Check Out These Resources!

The Stormwater Center, **www.stormwatercenter.net/**, offers resources to technically assist decision-makers and the public on stormwater management issues. Resources include publications and manuals, slide shows, ordinance information, monitoring and assessment methods, and best management practices fact sheets.

EPA's Watershed Academy, **www.epa.gov/owow/watershed/wacademy.htm**, provides online training courses and educational materials on the basics of a watershed approach. There are six training modules: overview; watershed ecology; watershed change; analysis and planning; management practices; and community/social context.

Design with Nature, by Ian McHarg, is a seminal book introducing the foundation of the ecological landscape planning method. It can be ordered on-line from the publisher by going to **www.wiley.com**.

Landscape Ecology Principles In Landscape Architecture and Land-Use Planning, (Island Press, 1996, ISBN 1-55963-514-2) is a concise handbook that lists and illustrates key principles in ecological landscape planning and presents specific examples of applications.

Planning for TDR: A Handbook for New Jersey Municipalities, designed to provide assistance at the local level, is available from the Burlington County Office of Land Use Planning by calling (609) 265-5787.

Purchase of Development Rights May Become A Valuable Farmland Protection Tool in Wisconsin in the Next Century looks at the role purchasing development rights can have in farmland protection. It is found in the Law of the Land Review, November 1997, and is available from the University of Wisconsin Extension Service by calling (715) 346-2386.

Attachment

Sample Goals, Objectives and Policies

Future Land Use Element

Goal: Recognizing the economic, recreational and environmental values spring resources provide the community, protect, maintain and where possible enhance the resource quality of spring systems.

Objective: Define and delineate environmental overlay protection zones to protect the springshed and spring system resources and designate appropriate land uses in these zones.

Policy: In and around critical springshed resources and sensitive springshed areas, low density and intensity land uses will be designated, including conservation lands, silviculture, parks and recreation areas, and pasture.

Policy: Primary and secondary zones are geographic areas established to protect vital springshed features.

Primary Zone. The primary zone includes the springshed features that are most sensitive to contamination, including the principal areas of ground water contribution and recharge, sinkholes, depressions and "stream-to-sink" features, the buffer area immediately adjacent to the spring and the spring run. To protect these sensitive areas, land uses will be low density and intensity uses including preservation, conservation, recreation and open space. In addition, low-intensity, long-crop rotation silviculture and unimproved rangeland uses are appropriate within the primary zone.

Secondary Zone. The secondary zone is land outside the sensitive primary zone but is also vulnerable to contamination. Land uses will be moderate density and intensity including: conservation, recreation and open space, silviculture, rangeland, or very low density rural residential (no more that one unit per 10 acres or greater).

Policy: Within the primary and secondary protection zones, avoid mining, industrial and heavy commercial land uses, golf courses, and urban uses with extensive impervious surfaces. Intensive agriculture should be discouraged in the primary and secondary protection zones.

Objective: Use development, design and management practices that reduce impacts to springshed resources.

Policy: New development that is allowed and the expansion of existing development throughout the springshed will employ Low Impact Development (LID) practices in order to minimize the impact of development on springshed resources and provide the highest standards for water quality protection. Land development regulations adopted to implement the springshed protection program will specify the required practices.

Policy: In the event existing or previously approved development fails to meet recommended standards, LID and best management practices are required.

Policy: Throughout the siting, design, construction and management of the golf course, all golf courses will implement the prevention, management and monitoring practices, detailed in the Golf Course Siting, Design and Management Chapter of the *Protecting Florida's Springs Manual*. These practices are derived from the Audubon International Signature Program. Local governments will incorporate these practices into their Land Development Regulations.

Objective: Regulate land use activities to avoid contamination of surface and ground water resources within springsheds.

Policy: All new development projects in designated springshed protection secondary zones will provide at least 50 percent dedicated open space. Development will be clustered on the least sensitive portion of the development site.

Policy: Establish undisturbed buffer areas of at least 100 feet, adapted from those developed for the Wekiva, Econlockhatchee, and Suwannee Rivers, for protection of sensitive karst features and to minimize stormwater impacts.

Policy: Prior to development approval, identify all surface and sub-surface features that are potential pathways for contamination of the aquifer. A hydrogeologic survey shall be performed for the entire site with emphasis on potential locations of stormwater management facilities, such as swales and basins. A map depicting limestone outcroppings, sinkholes, solution pipes and general depth of soil to limerock will be included. Borings shall be taken at potential locations of swales and basins. These borings shall be made to the limestone and then an additional 10 feet deep. The overburden material shall be characterized (grain size, percent organic matter) to determine its permeability, filtering capacity and ability to bind pollutants. [Note: local governments may establish project size thresholds for this requirement.]

Policy: Using this information, require the use of karst criteria, buffers, open space and other best practices to minimize impacts. Site swales and retention areas will only be allowed in locations with the greatest depth of overburden and the least potential for solution pipe sinkhole formation.

Parks and Recreation Element

Goal: Within the springshed, establish a greenway network to integrate critical springshed resources, provide for resource management and protection, resource-based recreation, educational and historical interpretive opportunities, and pathways that connect these resources.

Objective: Delineate critical lands to be acquired, preserved or otherwise included in the greenway network, and develop a management plan for the protection of the springshed greenway network. The management plan will address natural resource and habitat protection, public access, recreation, education and opportunities for economic development consistent with protecting the greenway network.

Policy: Connect existing dedicated open space areas, trails, pedestrian pathways and, where appropriate, utility corridors to form a greenway system.

Policy: Provide incentives to private landowners to encourage their participation in the creation and maintenance of the springshed greenway system.

Policy: Adopt a greenway land acquisition priority list to coordinate the acquisition and protection of the system.

Conservation Element

Goal: Maintain and restore important environmental features within springsheds and springshed protection zones.

Objective: Protect the most sensitive resources within the springshed, including the principal areas of ground water contribution and recharge, sinkholes, depressions and stream-to-sink features, the area immediately adjacent to the spring and the spring run.

Policy: Use acquisition funding programs such as the Florida Forever Program, Florida Community Trust, Rural and Family Lands Protection Program and others to acquire fee simple or less-than-fee ownership through conservation easements on land within the delineated springshed that has been identified as critical or sensitive resources.

Policy: Use other innovative approaches to protect sensitive resources, such as the transfer of development rights, performance zoning, open space zoning, on-site density transfer and other techniques to maximize the establishment of open space areas.

Objective: Provide for periodic sampling and testing of the surface and ground water quality within springsheds and springshed protection zones.

Policy: Coordinate with sampling and testing programs of the USGS, State Department of Environmental Protection and the Water Management Districts and seek funding to establish a local program.

Objective: Establish programs to educate the public and community leaders about the importance of the springsheds to their community and region and how they can better protect them.

Policy: Coordinate with local colleges, the school board and individual schools to develop environmental education programs for school-aged children regarding springsheds.

Policy: Formulate a media campaign to enhance the environmental literacy of the public and community leaders with respect to the natural values and threats facing local springs.

Policy: Encourage and assist farmers and the agricultural industry within springsheds to use best management practices that minimize use of water, fertilizers, herbicides and pesticides and that reduce erosion.

Policy: Encourage and assist residential and commercial land owners within springsheds to use best management practices as set forth in the Florida Yard and Neighborhoods program to minimize use of water, fertilizer, herbicides and pesticides.

Objective: Promote agricultural and silvicultural activities that protect spring resources.

Policy: Within the springshed, follow the best management practices outlined in Silviculture and Agriculture Best Management Practices Manuals (Florida Department of Agriculture and Consumer Services).

Policy: Promote low-intensity, long-crop rotation silviculture and unimproved pasture within the primary zone.

Policy: Promote minimum tillage farming within the springshed.

Natural Ground Water Aquifer Recharge Subelement

Goal: Protect and maintain the natural functions of springsheds.

Objective: Minimize impacts from development by designating high recharge areas as part of the primary and secondary protection zones.

Policy: Avoid inappropriate development within high recharge areas as identified in the future land use element.

Policy: Direct incompatible land use away from high recharge areas, including mining, industrial, heavy commercial, golf courses and urban uses with extensive impervious surfaces.

Policy: Use best management practices and performance standards to maximize open space, limit impervious surfaces and turf grass areas, promote protection of natural vegetation, promote the use of pervious parking areas, and treat stormwater to protect water quality.

Objective: Establish a water quality protection strategy for the springshed.

Policy: Require the following actions within the springshed:

1. If not required by the regional water management district or FDEP, adopt design criteria for stormwater management practices that minimize the leaching or discharge of nutrients. Use karst area requirements similar to those required by the SJRWMD or to the criteria presented in the attachment on page 64;

2. Provide funding for the Florida Yards and Neighborhoods program to educate the public about proper lawn and landscaped area fertilization and irrigation;

3. Incorporate the principles of the Florida Yards and Neighborhoods Program into local landscaping ordinances;

4. Require frequent and active street sweeping;

5. Adopt water conservation programs;

6. Educate the public about the proper operation and maintenance of septic tanks. Implement a local septic management program to assure that these systems are regularly inspected, pumped out, and brought up to current standards whenever a parcel is sold; and

7. Promote the local stewardship "adopt a spring" type program and other incentive and volunteer springshed awareness and protection programs.

Solid Waste Subelement

Goal: Minimize springshed water quality impacts from solid waste and hazardous waste facilities.

Objective: Avoid the siting of solid waste and hazardous waste facilities within springshed protection zones.

Policy: Solid or hazardous waste disposal, treatment and transfer facilities are prohibited within the primary and secondary protection zones of a springshed.

Stormwater Management Subelement

Goal: Maintain or improve the quality of stormwater within springsheds.

Objective: Minimize erosion, sedimentation, and stormwater runoff within the springshed.

Policy: Minimize land disturbance, clearing of native vegetation and removal of top soil. Utilize construction best management practices, such as use of silt fences and sediment basins to retain sediment onsite.

Objective: Work with the regional water management district and FDEP to modify current rules to incorporate karst stormwater management system design criteria similar to those used by the St. Johns River Water Management District.

Policy: The following general requirements apply to stormwater management systems throughout springsheds:

1. No direct discharge of stormwater to active sinkholes;

2. When soil and water table conditions allow, require the use of offline retention systems for stormwater treatment. Promote the use of the BMP Treatment Train concept by promoting the use of swales and landscape infiltration system;

3. Swale conveyances shall be used to the greatest extent possible;

4. Projects in areas zoned for industrial land uses shall assure that industrial pollutants do not enter the stormwater system or come in contact with ground water;

5. Natural depressions shall be used for stormwater management only when hydrogeologic evidence shows that the geologic structure and soils are stable and unlikely to form a direct connection to the ground water. To verify geologic stability, an applicant shall provide soil boring information and/or supplemental data such as ground penetrating radar;

6. If the hydrogeologic conditions are suitable and the depression is proposed for use as part of the stormwater management system, a spreader swale shall be employed at the inflow location;

7. Require regular inspection by developer/maintenance entity to visibly check for existence or beginnings of solution pipes; and

8. Remedial plugging activities shall employ methodologies acceptable to the applicable regulatory agency.

Policy: Within the primary and secondary protection zones, require the use of these additional karst stormwater management criteria:

1. More than five feet of material between the limestone bedrock surface and the bottom and sides of the stormwater basin;

2. Basin liners —clay or geotextile;

3. Sediment sumps at stormwater inlets;

4. Off-line treatment;

5. Special stormwater system treatment train design;

6. Ground water monitoring; and

7. Paint/solvent and water separators.

In addition, stormwater systems in these areas shall:

1. Use swales, preferably with cross block or raised driveway culverts, to promote retention/infiltration within swale; and

2. Use shallow, vegetated, offline infiltration systems that are incorporated into a projects open space/landscaping areas.

Sanitary Sewer Subelement

Goal: Protect water quality within the springshed by using the necessary wastewater treatment processes to ensure water quality within the spring.

Objective: Achieve and maintain a nitrate value of less than 1 milligram per liter.

Policy: Avoid disposal of effluent from wastewater treatment facilities within designated primary or secondary springshed protection zones.

Objective: Remove nutrients from the springshed system by the central sewering of existing developed areas and limiting the expansion of central sewer lines into the undeveloped portions of the primary and secondary springshed protection zones.

Policy: Maintain recommended densities of 1 dwelling unit per 10 acres in the secondary zone.

Policy: Areas of high densities of on-site treatment and disposal systems (OSTDS, commonly referred to as septic systems) within springsheds will receive high priority toward their central sewering to help reduce the input of nutrients into the springshed waters.

Objective: Minimize the impact of OSTDS within the springshed, particularly within the designated primary and secondary springshed protection zones.

Policy: Establish an OSTDS management program to ensure that these systems are inspected at least once every three years and maintained as needed to assure proper treatment. Require existing systems to be inspected and upgraded to meet current standards whenever a property is sold, modified or expanded to accommodate additional residents or at least every 10 years.

Policy: Establish standards for the use of nutrient reduction OSTDS within the springshed.

Traffic Circulation or Transportation Element

Goal: Protect springsheds and protection zones from sedimentation and siltation resulting from the construction of roads, ditches, and other transportation-related improvements.

Objective: Create and adopt low impact development regulations applicable to all transportation-related construction activities.

Policy: Low impact development standards for the construction of all roads, ditches, and other related improvements in or near the delineated springsheds or protection zones will be applied to reduce the effects of increased sedimentation and siltation on the springs water quality.

Intergovernmental Coordination Element

Goal: Coordinate inter-jurisdictional efforts to preserve and protect delineated springsheds and protection zones.

Objective: Springsheds often cover expansive areas affecting multiple jurisdictions. Coordinate with all federal, state, regional, and local governing bodies in which the springsheds or protection zones are located to develop consistent springshed protection strategies.

Policy: Develop and adopt consistent plan policies and strategies for protecting valuable springshed resources affected by multiple jurisdictions.

Economic Element

Goal: Protect springshed water quality and quantity to maintain and protect the environmental, aesthetic and economic values of spring resources.

Objective: Recognize the economic value of the springs and protection zones.

Policy: Create a greenway system leading through the most sensitive areas of the springshed in order to draw visitors to spring resources without jeopardizing the environmental integrity of these valuable resources.

Policy: Market and educate visitors about the springshed and greenway for use and enjoyment as a natural recreational and educational center.

Managing Development Impacts

An undeveloped springshed has a natural equilibrium of water, nutrients and other chemical inputs and outputs. As a springshed becomes developed, this equilibrium is progressively altered. To minimize environmental impacts in developed or developing springsheds, site design and management issues should be carefully addressed in the following manner:

- Select the Most Appropriate Site for Development
- Design the Site Appropriately
- Use Sensitive Landscape Design and Management Strategies
- Use Effective Erosion and Sediment Controls
- Address Stormwater Management Issues
- Address Wastewater Management Issues
- Utilize a Combination of Best Management Practices
- Encourage Appropriate Water Conservation Measures
- Increase Public Awareness

Studies have shown that the cumulative impact of constructing homes and businesses changes the natural system, and has a variety of negative impacts. A developed springshed differs from an undeveloped one in several important ways:

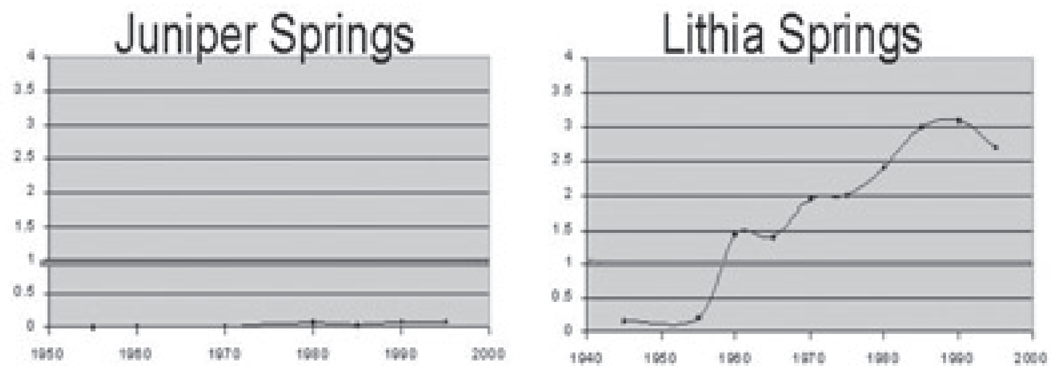
- A developed springshed consists of modified natural landscapes, altered vegetation types and much more impervious surface. Previously existing forests, wetlands and open areas are replaced by roof tops, roads and parking areas interspersed with highly managed green spaces of lawns, golf courses, and managed landscapes. The increase in hardened impervious surface can decrease spring flows and increase pollutants.
- A developed springshed tends to use more water. Through rapid runoff, evaporation and water transport, less water is delivered to the spring than the natural system.
- A developed springshed imports and applies more chemicals and nutrients than a natural system. These chemicals can eventually impact the water quality of the spring.

As a springshed develops, there is a need to carefully address specific issues such as stormwater, lawn and landscape management, excessive water use, nutrient and chemical applications, and to design landscapes to better mimic the natural springshed in form and function. As previously discussed, one of the most important land planning actions that can be taken within a springshed is to identify and designate sensitive features and areas, establish primary and secondary zones of protection, and manage development to minimize impacts.

Springsheds are often quite large. Even with the establishment of protective zones, extensive areas within a springshed may be developed. To protect water quality and quantity, local governments and landowners must minimize specific impacts within a springshed through hydrogeologic analysis, careful site planning and sensitive site design. This chapter discusses techniques that can be used to minimize the impacts of development on water quality and quantity.

Figure 3.1. Impacts from development need to be managed to protect springs.

Figure 3.2. In the last half century, nitrate concentrations in Juniper Springs (left) in the Ocala National Forest have remained low and relatively constant. In contrast, Lithia Springs (right) is surrounded by agricultural uses and its nitrate levels have risen considerably above the one milligram per liter (bold horizontal line) where water quality becomes degraded by out-of-control plant growth.



Select the Most Appropriate Site for Development

A landowner or developer wishing to develop an area within a springshed needs to choose an appropriate site for that development. The cardinal rule is to evaluate the landscape and geology of the land and seek locations that avoid karst features that have a direct or indirect connection to the aquifer and other environmentally-sensitive features, such as sinkholes, streams, wetlands, or major springshed recharge areas. Development should be clustered on the portion of the property best able to accommodate the development with minimal impact to water resources within the springshed.

Design the Site Appropriately

Water is the common resource and carrier of pollutants within a springshed, and its protection and management is a primary concern. Site-specific planning and design standards are instrumental in reducing the impact of development upon a springshed landscape. Property owners and local governments should view site planning and design from a pollution prevention-based approach to protect environmentally-sensitive spring and karst features. This prevention approach is much more cost-effective than relying on post-development structural treatments to correct problems.

Key Practices for Managing Development Impacts

- Select development sites that avoid karst features with direct or indirect connections to the aquifer and other environmentally-sensitive features.
- Design and develop the site to avoid or minimize water quality and quantity impacts.
- Use site design, stormwater treatment provisions and pollution prevention techniques to save natural landscapes and functions, and create an environmentally-sensitive landscape which mimics natural features and ecological functions.
- Concentrate on reducing nutrient pollution inputs and over use of water. Increase public and property owner awareness regarding their role in springshed protection efforts through prudent lawn and landscape fertilization and watering that minimizes pollutant inputs.
- Plan and design buffers within development sites to prevent erosion and sedimentation and stabilize sinkhole sides, streambanks and other surface-to-ground water conduit areas.

There are a number of points to consider when working to reduce developmental impacts through site planning and design, including street and parking lot design and conserving natural areas in the springshed. The following summary is adapted from The Center for Watershed Protection's *Better Site Design: A Handbook for Changing Development Rules in Your Community*, August 1998 and *Consensus Agreement On Model Development Principles To Protect Our Streams, Lakes, and Wetlands*, April 1998. These strategies are important for any community drafting land development regulations (LDRs) that address development within designated primary and secondary protection zones.

Residential Street and Parking Area Design. The following guidelines are designed to reduce the development footprint (total amount of impervious surface), and thus reduce pollutant input and water usage.

- Design residential streets with the minimum required pavement width needed for travel lanes, on-street parking, and emergency service vehicle access. These widths should be based on estimated traffic volume, not existing requirements in local LDRs.
- Adopt a Traditional Neighborhood Design (TND) ordinance as an option to promote more compact community design and decrease the total amount of impervious surface.
- In springshed karst landscapes, minimize the use of roadside curbs and gutters. Instead, require the use of grassed roadside swales to maximize both onsite treatment of stormwater runoff and stormwater seepage into the ground water.
- Reduce the total length of residential streets by designing street layouts to increase the number of homes per unit length of street.
- Wherever possible, design residential street right-of-way widths at the minimum required to accommodate the travel-way, the sidewalk, and vegetated roadside swales. Utilities and storm drains should be located within the pavement section of the right-of-way, wherever feasible.
- Minimize the number of residential street cul-de-sacs.
- Where cul-de-sacs are used, either increase the radius to incorporate a landscaped area in the center of the cul-de-sac to reduce impervious cover and provide a vegetated stormwater infiltration area, or reduce the radius to the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
- Where density, topography, soils, and slope permit, use vegetated swales in the street right-of-way to convey and treat stormwater runoff.
- Relax required parking space standards and require shared parking between adjacent businesses. The required parking ratio governing a particular land use activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance, taking into account local and national experience to see if lower ratios are warranted and feasible. Some parking standards are designed for peak holiday loads. This results in excessive amounts of paved impervious surface.
- Parking requirements can be lowered where transit is available or enforceable shared parking arrangements are made.
- Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious concrete or other types of pervious materials in the spillover parking area. Pervious concrete has been successfully used in Florida since the mid 1970s.
- Provide meaningful incentives to encourage structured and shared parking to make it more economically viable. Use the local development review process to suggest and initiate shared parking opportunities for adjacent properties.
- Wherever possible, provide stormwater treatment for parking lot runoff by using the BMP treatment train concept. For example, a parking lot could include pervious concrete for the parking areas, and recessed (not curbed up) landscape infiltration.

Site Design. The location of development on a parcel can affect environmental resources.

The cumulative impacts of many developed parcels within a springshed can impact the health and viability of the spring. The following site design features can help reduce individual and cumulative impacts:

- Require open space design development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote springshed protection.
- Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.
- Allow flexible design standards for residential sidewalks. Where practical, locate sidewalks on only one side of the street and provide common walkways linking pedestrian areas.
- Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.
- Clearly specify how community open space will be managed over the long term and designate a sustainable legal entity responsible for managing both natural and recreational designated open space.
- Direct rooftop runoff to pervious areas such as yards, swales and other vegetated areas. Avoid routing rooftop runoff to the driveway and then onto the roadway and the stormwater conveyance system.

Natural Area Conservation. Often individual karst features (e.g., sinkholes, depressions, near-surface conduits, stream-to-sink waters) scattered widely throughout the springshed are not in public ownership. These areas can be impacted by development activities. Local governments, land owners and developers can each work to protect these important springshed assets by using the following natural resource conservation techniques:

- Preserve or create a 100-foot wide naturally-vegetated buffer system along all streams that also encompasses critical environmental features such as the 100-year floodplain, sinkholes, karst depressional features, stream-to-sink waters, slopes, and wetlands.
- Limit the clearing and grading of forested and native vegetation areas. Clear the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner. The best situation is to have these open space areas dedicated and a permanent ease-

EPA's Watershed Academy Web

The Watershed Academy provides a way to learn how to protect watersheds, including springsheds. It provides a set of self-paced training modules that include a basic but broad introduction to watershed management. The goal of the program is to provide useful information on how to manage a watershed to improve water quality.

The training modules cover many important watershed management topics that watershed managers, local officials, involved citizens, decision makers, and others should have at least an introductory level of knowledge. Web modules include interactive "guest lectures" by leaders in watershed management. Unlike an average technical paper, many modules are visually rich and contain numerous color illustrations and photos.

Typically, a module contains internet links for those seeking greater detail, while module-specific glossaries are there for beginners. Self-tests enable trainees to check their retention and see immediate results. The length and complexity of each module varies, but most are at the college freshman level of instruction. Completing a series of 15 of these modules earns the participant the Watershed Academy Web Training Certificate. To access the Watershed Academy Web Training, visit **www.epa.gov/watertrain**.

ment established and recorded. In addition, the amount of time between clearing and construction should be minimized.

- Conserve trees and other vegetation at each site. Plant additional vegetation where impacts have occurred, clustering tree areas, and using native plants that do not require excessive fertilization or watering. Wherever practical, manage community open space, street right-of-ways, parking lot islands, and other landscaped areas to minimize hardened surfaces. Include shallow grassed swales and multipurpose retention and detention areas with natural biological filtering capacity and vegetated edges.
- Use incentives such as density bonuses, buffer averaging, property tax reduction, stormwater credits, and by-right open space development to promote conservation of stream buffers, forests, meadows, and other areas of environmental value.
- Ensure that stormwater outfalls do not discharge untreated stormwater directly into sinkholes, wetlands, springshed recharge areas, or other identified sensitive areas.

Low Impact Development. A new approach to environmentally-sensitive site development that should be considered for springshed settings is called Low Impact Development (LID). The LID approach focuses on designing and developing a site to avoid or minimize impacts to the environment, especially regarding water quality and quantity. LID uses a variety of site design, stormwater treatment train provisions and pollution prevention techniques to create an

Landscape Infiltration

One type of low impact development, retention practices (also called infiltration practices) allow stormwater to infiltrate into the soil or evaporate helping to maintain the site's hydrology and reduce stormwater pollutants. Retention areas should be vegetated allowing the plants and soil to trap and treat petroleum products, metals, nutrients, and sediments. Retention areas, integrated into a site's landscaping, are relatively inexpensive to build, easy to maintain, and add aesthetic value to a site. However, due to Florida's sandy soils, organic matter may need to be added to the soil to promote biological breakdown of pollutants and prevent migration of the pollutants into ground water. What looks like a nicely-landscaped area is in fact an engineered system for the storage, infiltration, and biological removal of pollutants. Placing landscape retention areas in parking lot islands, at the edge of paved areas, at the base of buildings, or in open space areas is easily accomplished.

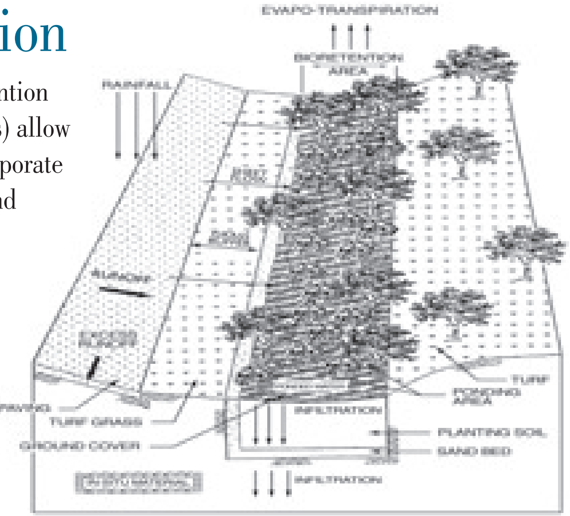


Figure 3.3. Landscape infiltration should be incorporated into the design of parking areas to collect and treat stormwater. The top two pictures show what it can look like to the user, while the bottom schematic depicts how landscape infiltration functions.

environmentally-sensitive site landscape which preserves natural features and ecological functions. LID is often equated with environmentally-sensitive design, green development, ecological site planning, and conservation planning.

LID integrates green space, native landscaping, natural hydrologic functions, and other techniques to generate less runoff from developed land. One of the primary objectives of LID design is to reduce runoff volume by infiltrating rainfall water to ground water, evaporating rain water back to the atmosphere after a storm, and finding beneficial uses for water rather than exporting it as a waste product down storm sewers.

The result is a landscape functionally equivalent to pre-development hydrologic conditions, which means less surface runoff and less pollution damage to surface and ground waters of the springshed system. Within the context of the primary and secondary springshed protection zones described in the previous chapter, development allowed within the zones would greatly benefit from use of LID principals, especially when linked to on-site clustering of developed areas and concurrent preservation of the remaining open space.

LID not only minimizes environmental impacts, but also saves money by addressing runoff close to the source. Developers save money because LID reduces imperviousness (such as road widths, lengths) which reduces stormwater runoff.

In contrast to standard stormwater management, which collects and conveys water to a centrally located stormwater treatment and discharge facility, LID's principal goal is to ensure maximum protection of the ecological integrity of the receiving springshed waters by maintaining the natural hydrologic regime of the developed site. Objectives of LID include:

- Generating less runoff from development;
- Integrating stormwater management early in site planning activities by such strategies as clustering development and preserving open space;
- Distributing small-scale practices throughout the landscape of a development project;
- Using natural on-site functions to capture and treat pollutants (i.e., interception, infiltration, and evapotranspiration of intercepted stormwater to facilitate soil stabilization, sediment removal and chemical and biological filtration and volatilization of pollutants);
- Avoiding impacts rather than mitigating impacts;
- Emphasizing simple, nonstructural, low-tech, and low-cost methods;
- Managing as close to the source as possible;
- Relying on natural features and processes; and
- Creating a multi-functional developed landscape to collect, treat and retain stormwater along natural cycle lines.

An understanding of local natural systems and a commitment to work within their limits is essential.

Use Sensitive Landscape Design and Management Strategies

Management of pollutant inputs and water withdrawal are major concerns in a springshed. Every individual and each piece of property contributes to the overall pollutant load from such activities as lawn fertilization, pest management and the over use of water for lawn and landscaping maintenance.

Maintaining or improving water quality depends on how well landowners and local governments minimize their use of water, nutrients and chemicals. For developed lands in a karst setting, the design, installation and management of the landscapes is critical to a spring's sustainability.

Site Analysis. The first step in sensitive landscape design and maintenance is to conduct a site analysis. This consists of studying site characteristics, identifying features, and answering a number of questions regarding the environmental conditions at the site:

- What are the soil types, pH, drainage, etc.?
- How far below the surface is the water table?
- What are known vulnerabilities of surface and ground waters?
- Are there identifiable surface to ground water conduit features (fractures, sinkholes, depression ponds and lakes)?
- Are there identifiable natural protective fea-

tures (existing forested or vegetative buffers, protective clay layers between the surface and the ground water)?

- Is irrigation necessary?
- Is water available for irrigation and what is the quality of the water?
- Can it be easily mowed?
- Is it shaded or in full sun?
- Will it be shaded in a few years?

Characteristics will most likely differ between areas on the same property, with some areas more sensitive and others less. The larger the parcel the more likely it is that variations in site characteristics will exist.

Landscape Design. The next step in the landscape design process is to answer questions regarding site expectations and impacts. In designing landscapes, the principles of the Florida Yards and Neighborhoods Program should be followed.

- What type of lawn and landscape is desired or expected? Landscape plans that maintain existing natural vegetation and features are preferable to those that do not. That is, a landscape plan that minimizes use of large areas of managed lawns and which retains forested, scrub or natural open space areas is better for the springshed than a landscape plan that features large managed lawns and altered natural landscape features.

- What level of maintenance can be provided? To answer this question, think about the reality of having professionally trained lawn and landscape managers versus having "average

Lawn Fertilization's Impacts on Springshed Protection

In a developed springshed, public education on how to manage property to minimize both pollutant input and water usage is of critical importance. Part of the solution is to convince home and business owners that they contribute to the problem, and that by altering their behavior the springshed health will be protected. As the Florida Springs Task Force reported in November 2000, the importance of developing best management practices for residential lawn fertilization is highlighted in studies conducted by the Southwest Florida Water Management District from 1995 to 1997. They determined that nitrate levels in water discharging from the Weeki Wachee, Chassahowitzka, and Homosassa Springs had increased from < 0.1 mg/l in the 1960s to approximately 0.5 mg/l in the mid 1990s – a greater than a fivefold increase. The studies also determined that approximately 360 tons of nitrate were discharging from the springs annually into the Weeki Wachee, Chassahowitzka, and Homosassa Rivers. Furthermore, the studies found that the principal source of nitrate in spring discharge was inorganic nitrogen fertilizers applied to lawns. At that time, 440 tons were being applied annually to residential lawns in the portions of the springshed recharge basins closest to the springs.

The studies concluded that much of the fertilizer applied to residential lawns simply leached through the soil into ground water without being utilized by the lawns, and that strategies must be developed and employed to increase the efficiency of fertilizer use and to reduce the need for fertilizers. The Florida Springs Task Force stated that outreach programs are necessary to change existing landowner behaviors. This is one reason FDEP has worked with IFAS and local county extension offices to implement the Florida Yards and Neighborhoods Program.

The report correctly notes that when citizens understand the problems and dynamics of a springshed, they will help protect it. The point is to educate students, citizens, and local leaders about the values, function, and protection needs of springsheds. This strategy will spread awareness of the problems faced and of the impacts each of us has on the water quality of springs. Further, a strategy of education will foster teamwork, action and creative solutions by landowners, citizens and government and will make a difference in springshed health and vitality.

citizen or local, nonprofessional workers" taking care of the developed landscaped area. This could be the difference between a professionally-managed golf course and suburban/urban neighborhood. Where the likelihood of marginally-trained lawn and landscape managers is the reality, the emphasis should be on less acreage of lawns and retention of more natural vegetation.

- What are the likely impacts to surface and ground waters from the desired landscape? The answer to this question should focus on protecting the site's sensitive environmental features and assessing the expected level of fertilization, pesticide and water usage, and the level of landscape management over time. All managed landscapes will have impacts. However, through early identification of potential problems the area can be designed and managed to minimize impacts. Thus, for example, if there are sinkholes on a site, have they been well buffered? Are lakes and stream edges well buffered? Has the landscape plan incorporated opportunities to cluster development and preserve sensitive areas?

Landscape Management. Once a site has been designed and developed to minimize pollutant impact problems and especially to protect sensitive areas, then the principal actions of landscaping and lawn management turn to:

- Irrigation system design and best management practices;
- Fertilization; and
- Pest control.

These activities, and how they may be performed to minimize impacts to a springshed, are described below.

Irrigation System Design. Nearly half of all water withdrawn for public supply in Florida is used to water lawns and landscaping. Irrigation consumes more water than any other use category in Florida. More aggressive programs by local government, industry and homeowners associations to encourage native landscaping around homes and businesses would make a major difference in water consumption and pollutant input. Wherever possible, it is important to design lawns and landscapes using the existing native vegetation on the site or to plant native vegetation before installing the irrigation system. This allows the irrigation system to be designed to meet the needs of the plants. Irrigation design depends on several factors: locations, soils, landscape vegetation, water supply, and water quality. The following BMPs summarize critical elements for irrigation system design in karst areas.

- A system's application rate must not exceed the ability of the plants and soil to absorb and retain the water applied during any one application. This approach prevents runoff.
- A system should have enough flexibility to adapt to various water demands and local restrictions.
- Using micro-irrigation can cut water use in half compared to traditional irrigation techniques.
- Design for flexibility to meet a site's peak water requirements and allow for modification of the system's operation to meet seasonal irrigation changes or local restrictions.
- Lawns and landscaped areas should be zoned separately based on plant water requirements. Distribution equipment (sprinklers, rotors, micro irrigation devices) in a given zone must have the same precipitation rate.
- Non-planted areas, including impervious surfaces, should not be irrigated.
- Include rain sensor and soil moisture devices with an automatic switch to shut off the irrigation when it is not needed. This equipment will override the irrigation cycle of the sprinkler system when adequate rainfall has occurred or there is sufficient soil moisture present, thus avoiding the sprinkler's-on-when-it's-raining problem.

Fertilization. In karst areas, prudent fertilization following prescribed BMPs is one of the key actions with the potential to protect springshed water quality. In Florida springsheds, where the natural ground water nutrient values are very low, the importance of minimizing fertilization to limit leaching into the water cannot be overstated.

To avoid loss of nutrients to the surface or ground water it is important to apply a little fertilizer at a particular time, irrigate and then wait for results. Rate and timing of nitrogen fertilization are dependent upon location, the grass species, season of the year, level of maintenance desired, source of nitrogen applied (for example, slow release inorganic granules, sprayed in solution). In general, other than when watering restrictions apply, irrigate an area with one quarter inch of water following fertilization to avoid loss of nitrogen to the ground water and to increase uptake efficiency. To measure the amount of water being applied, a pan or rain gauge may be placed in the area being watered. If water restrictions apply, irrigate as allowed. More than one half inch may cause some nitrogen to be leached past the root zone.

Lawns commonly require high rates and more frequent applications of nitrogen-source fertilizers. In most cases, slow-release nitrogen sources should be used to reduce the potential for leaching. In order to obtain the desired growth and color response, in most cases a mixture of soluble and a slow-release nitrogen source is recommended for use on lawns. Many fertilizers available for homeowners have varying ratios of soluble to slow-release nitrogen. Products with a relatively high slow-release content, such as 30 percent, may be preferable.

Although slow release fertilizers provide benefits in terms of less opportunity to leach and longer term response from the fertilizer application, it is important to realize that lawns may be very efficient nitrogen-absorbing ground covers. University of Florida research has shown that nitrogen does not leach from a well-managed lawn that has been fertilized at the recommended rate, frequency and has been irrigated properly. Poor quality, slow-growing and improperly fertilized and irrigated lawns, on the other hand, leach significant nitrogen. For Florida lawns, the best yearly fertilization program usually begins with a soil test to determine whether and what types of nutrients are needed. Usually, fertilization will include a combination of one or two applications of multiple nutrient fertilizers and several supplemental applications of a nitrogen fertilizer. Nitrogen fertilization is often based on the desired growth rate and type of grass being grown.

Due to past fertilization history and the inherent nature of some Florida soils, phosphorus fertilization may not always be required. Use a recent soil test to determine if phosphorus is required for optimum lawn management. If the soil test indicates an adequate level of extractable soil phosphorus, choose a fertilizer blend that does not contain phosphorus as one of the supplied nutrients. That blend would be represented by an X-O-X, such as a 15-0-15. Excess phosphorus application can result in phosphorus runoff or leaching into surface and ground waters.

Second only to nitrogen in total fertilization requirement is potassium. Potassium influences root growth and water and stress tolerance relationships in lawns, and should be maintained at adequate levels for optimum growth. The potassium fertilization program should be based on a recent soil test. Potassium is highly mobile in most of Florida's sandy soils, but an annual soil test is adequate for determining the fertilization requirement. As with all highly mobile nutrients, careful, monitored application in karst environments is necessary.

No matter which type or formula of fertilizer is used, avoid dispersing fertilizer on driveways, sidewalks and other impervious surfaces. This common mistake wastes fertilizer and results in nutrient rich runoff during the next rain event or irrigation that will likely not be available to the targeted grass or landscape. Because springsheds are hypersensitive to nutrient inputs, the general guideline is to apply as little fertilizer as necessary.

Pest Control. In the lawn and landscape business, Integrated Pest Management (IPM) has been translated into Targeted Pest Management (TPM). TPM is a philosophy of managing pests to reduce expenses, conserve energy, and protect the environment. TPM is a broad, interdisciplinary approach using a variety of methods to systematically control pests that adversely affect people and plants. TPM does not mean, as many believe, that no pesticides are used. Rather, it means that pesticides are only one weapon against pests and that they should be used judiciously, and only when necessary. The goals of a TPM program are:

• Improved control of pests, through a broad

spectrum of practices that work together to keep pest populations below significant thresholds;
- More efficient pesticide management, through less frequent and more selective use of pesticides;
- More economical plant protection, resulting from reduced chemical costs and more efficient methods of protection; and
- Reduction of potential hazards to people and the environment, through reduced pesticide exposure.

TPM accomplishes these goals using resistant plant varieties, cultural practices, parasites and predators, other biological controls such as Bacillus thuringiensis and more recently, genetic engineering, and other methods including chemical pesticides as appropriate. The basic steps for TPM programs are:
- Identify key pests and beneficial organisms, and the predominant life stages and the factors affecting their populations;
- Select preventive cultural practices to minimize pests and enhance biological controls. These practices may include soil preparation, resistant varieties, and modified irrigation methods;
- Evaluate economic losses and risks so that the cost of various treatments can be compared to the potential losses to be incurred;
- Decide which pest management practice is appropriate and carry out corrective actions; and
- Continue with follow-up monitoring of pest populations to evaluate results of the decision and the effectiveness of corrective actions. Record and use this information when making similar decisions in the future.

To determine which pesticides are most appropriate to use, and when and how to use them, consult the appropriate pesticide selection guides produced by the University of Florida Institute of Food and Agricultural Sciences (IFAS). The county extension agent, chemical distributor, product manufacturer, or an independent lawn maintenance consultant might have additional information.

Use Effective Erosion and Sediment Controls

One of the most damaging times for sensitive springshed features, such as sinkholes, stream-to-sink areas, spring runs and any wetlands associated with these features, is when land is being prepared for development. Further, once developed, impervious areas such as roads and parking lots can add significant pollutants to a springshed from the day-to-day accumulation of oil, wearing tire materials, sand and sediments and other debris. Local governments, land owners, businesses and home owners associations all have a part to play in protecting a springshed by using BMPs to control erosion and sedimentation. It is important to buffer sensitive areas, employ on-site techniques to provide erosion and sediment control during construction, and to establish a regular street and parking lot sweeping program to remove accumulated sediments and debris.

Buffers. The areas in a springshed where land and water meet deserve special protection in the form of buffers, undisturbed vegetated zones. Buffers should be placed along a stream, sinkhole, any obvious surface-to-ground water conduits, and around wetlands. A buffer has many uses and benefits. Its primary function is to physically separate and protect environmentally-sensitive areas from a wide variety of impacts. Buffers are especially important because they:
- Help to prevent erosion and sedimentation and stabilize and protect sinkhole sides, streambanks and other surface-to-ground water conduit areas;
- Regulate light and temperature conditions, improving the habitat for aquatic plants and animals; and
- Assist in removing sediment, nutrients, and bacteria from stormwater before it enters the surface or ground water.

Buffers vary in width depending on their intended function and on site-specific conditions. A buffer is often subdivided into three zones that differ in function, width, vegetation, and allowed uses. The streamside zone is vegetated and maintained as mature forest, with strict limitations on all other uses; it should be a minimum of 50 feet wide. It produces shade, woody debris and a good root zone for bank stability, features important to stream quality and biota. A middle zone, typically a 50- to 100-foot wide forested area, is managed to allow some clearing. A third zone, usually about 25 feet wide, is ideally forest but also can include turf and shrubs.

Once established, the boundaries of buffers need to be clearly mapped, marked on the site, and enforced. A buffer that is well-designed and maintained can help provide many natural functions. Buffers are an integral part of any protection strategy, and complement other efforts to protect water quality.

Local greenways and trails can be planned in coordination with the establishment of a buffer system. A linear system of buffers around major fracture lines, sinkholes, limestone out-croppings, the spring and the spring run can form the backbone of a local greenway and trail system.

Construction Techniques. Potentially the most destructive period in the development process is the time between when vegetation is cleared and a site is graded to create a buildable area. During this time period, stormwater runoff can easily erode the bare soil. The eroded soil may be deposited into surface waters, sinkholes, or other sensitive karst features. These sediments can cover or destroy important springshed habitats such as fish and invertebrate spawning beds or submerged aquatic vegetation. And in many cases, these sediments are laden with nutrients, heavy metals, and toxic chemicals that also affect the

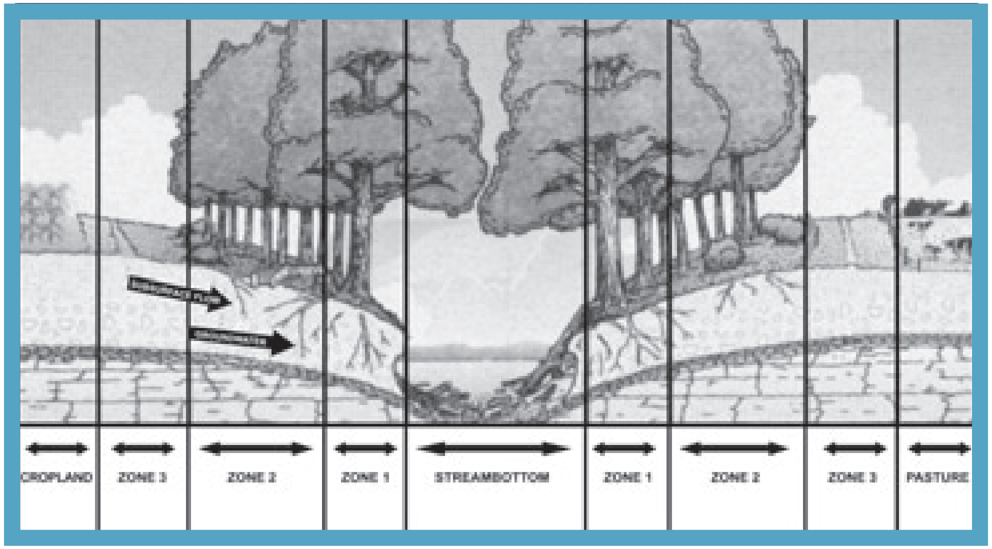


Figure 3.4. Springside, streamside and sinkhole buffers can serve as pollution prevention defense mechanisms within a springshed.

overall health of the springshed. Under some circumstances, the mouth of a spring can become blocked or severely restricted.

State and federal stormwater permits require erosion and sediment control during construction. Local governments can help assure this effort is effective by not issuing building or grading permits until state or water management district permits are obtained. They can also conduct inspections to assure that the BMPs are working and being maintained. Additionally, local government land development regulations can help assure that conservation areas, buffers, and forests are not cleared or otherwise disturbed.

There are numerous techniques to minimize erosion and control sediment. Avoidance of impacts is the first rule of thumb, followed by minimizing impacts, and then mitigating where impacts do occur. The most effective means are to:

- Schedule construction in the dry season if possible;
- Minimize and phase clearing, leaving much of the original natural area undisturbed;
- Provide buffers adjacent to sensitive areas;
- Require exposed soil to be stabilized within seven to ten days by planting quick growing ground covers, and spreading straw and mulch;

Figure 3.5. Forest areas left intact along streams can serve as buffers in agricultural settings.

- Install sedimentation basins and silt fences; and
- Use PAM (polyacrilimide) to coagulate sediments and be sure only clean water is discharged from construction sites.

Pavement Cleaning Practices. Pavement cleaning practices, such as street sweeping on a regular basis, can minimize pollutant movement to receiving waters. Street sweeping is practiced in most urban areas, often as an aesthetic practice to remove sediment buildup and large debris from curb gutters. But they also

Leon Sinks Geological Area

Seven miles south of Tallahassee on U.S. Highway 319, this unusual area of the Apalachicola National Forest features nine wet and ten dry sinks which have formed on the Woodville Karst Plain that extends from Tallahassee southward to the Gulf of Mexico. Hammock Sink, one of the wet sinks, has been explored and mapped by the National Association for Cave Diving. A loop trail that allows easy viewing of the sinks has been developed. The trail even crosses a natural bridge over a disappearing stream. The majority of the trail is hard packed dirt or sand with the exception of a section of boardwalk that cuts through the center of a gum swamp. It is a major natural attraction in the region.

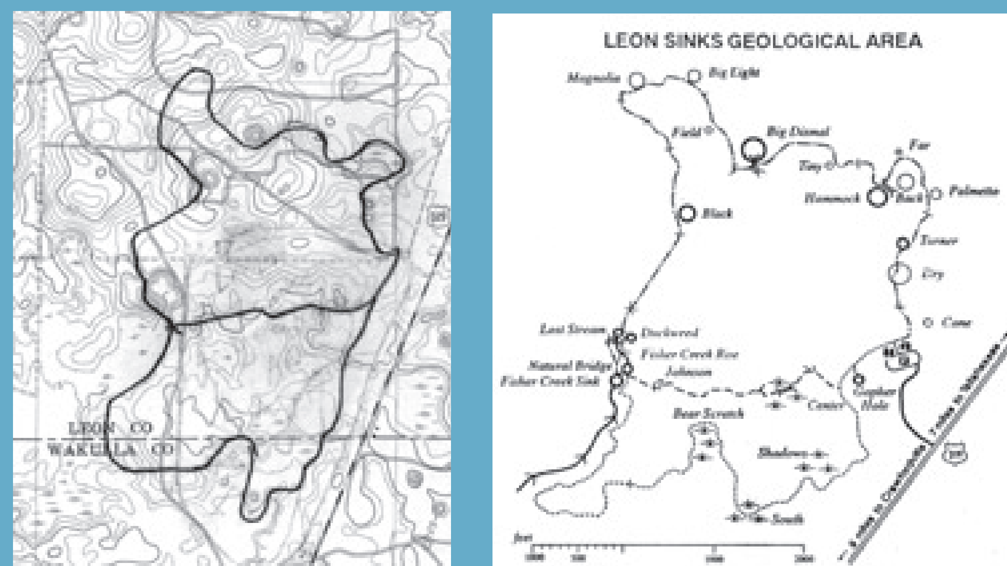


Figure 3.6. Springshed features can become a valuable asset for an area. A trail can link sinkholes, spring and spring run and become a "ecotourism" destination.

remove sediment, debris, and other pollutants from road and parking lot surfaces that impact waterways and open karst conduit features. Innovations in sweeper technology, especially those that use vacuum-assisted dry sweeping to remove particulate matter, have improved the ability of these machines to remove finer sediment particles. By using the most sophisticated sweepers in areas with the highest pollutant loads, greater reductions in sediment and accompanied pollutants can be realized. For more information, see The Stormwater Manager's Resource Center at www.stormwatercenter.net.

Address Stormwater Management Issues

The protection and management of water needs to be a primary concern in springshed protection efforts. All land uses within a springshed will produce some level of impact to water quality. Development affects the balance of water by increasing the amount of stormwater runoff and generally lowering ground water levels. Likewise, development increases the overall pollutant load of nutrients, pesticides, metals and other chemicals to surface and ground waters. It also leads to a decrease in the infiltration of water into the soil, an increase in surface water temperature, increase in sedimentation, oxygen depletion and decline in associated upland riparian and instream habitat extent and quality. Areas of particular vulnerability are springshed recharge areas, sinkholes, shallow underground conduit systems, contributing surface streams, the spring and the spring run.

A characterizing feature of urban and suburban development is the large amount of impervious surfaces. Wide streets, rooftops, cul-de-sacs, long driveways, and sidewalks are all aspects of site design that create impervious cover which, in turn, increases runoff and reduces ground water recharge. To accommodate the effects of land use changes, stormwater management practices must be developed and applied that do not exceed the natural hydrologic system's capacity to assimilate and handle pollutants and retain water. Careful attention to stormwater management during the site planning process can sharply reduce the impacts of development. Stormwater management practices help control nonpoint source pollution through the use of nonstructural and/or structural BMP techniques to intercept surface runoff from developed areas, filter and treat this runoff, and then discharge it at a controlled rate. The attachment on page 66 outlines structural and nonstructural stormwater management BMPs.

The amount of impervious surface on a property governs the quantity of stormwater runoff. Stormwater quality, however, is determined by the accumulation of pollutants on the entire surface area, regardless of whether it is grassed or paved. The increased use of chemicals around homes and businesses, including fertilizers, pesticides, engine oils, and other products, increases the likelihood that stormwater runoff from the entire site will carry pollutants. Stormwater management facilities and strategies should be specific to each development site, but should be developed within the context of designated springshed protection zones and the larger watershed within which the development exists.

Special Stormwater Management Concerns for Karst Areas. Stormwater management design can present special problems in karst areas. For example, solution-pipe sinkholes tend to form in the bottom of basins, including stormwater retention ponds and wastewater treatment lagoons. Solution-pipe sinkholes create a direct connection between the bottom of the basin, where design pollutants are concentrated, to the aquifer below. Water entering the aquifer by this route bypasses natural soil treatment and can funnel contamination directly into the aquifer.

One solution is to construct larger, shallower stormwater collection and treatment basins and to perform careful geological analysis of the site to predict the likelihood of solution-pipe sinkhole formation. An even better approach, however, is to incorporate site design and stormwater management strategies and actions to reduce the quantity of stormwater generated by projects.

Stormwater best management practices include:

- Holding runoff in shallow vegetated infiltration areas;
- Using clay or geotextile liners for wet detention ponds;
- Employing offline stormwater retention areas;
- Constructing many small retention areas rather than only a few large retention areas;
- Installing sediment sumps at inlets to retention and detention areas;
- Using shallow grassed swales for the conveyance for stormwater;
- Constructing swales with cross blocks or raised driveway culverts;
- Fully vegetating stormwater retention basin side slopes and bottom (recommend St. Augustine or Bermuda grass be used);
- Using the treatment train concept and low impact development principals, discussed earlier;
- Minimizing the amount of impervious surfaces;
- Maximizing the amount of open space left in natural vegetation;
- Maximizing the use of pervious pavement in parking areas;
- Maintaining existing native vegetation where feasible; and
- Buffering sinkholes and other surface-to-ground water conduits, stream channels and springshed recharge areas (unconfined or minimally confined ground water exposure areas).

The St. Johns River Water Management District has adopted stormwater management guidelines for protecting karst areas (found in its *Management and Storage of Surface Waters Handbook* at: http://sjr.state.fl.us/search.html). To further protect karst areas, FDEP, the WMDs and local governments need to include such provisions in their rules. Additional pre-treatment (in the form of swales, berms, ponds, or dry basins) for runoff that currently discharges into sinkholes, solution pipes or springs is also highly recommended. Specific policy and permitting considerations for karst areas are identified in the attachment on page 64.

Problems Associated with Impervious Surfaces

Understanding the effects of impervious surfaces is essential to understanding the management of stormwater. Impervious surface is defined as the sum total of all hard surfaces within a watershed, including rooftops, parking lots, streets, sidewalks, and driveways. Impervious surfaces change the natural landscape, and have a major impact on water-based resources. Instead of allowing precipitation to permeate into the ground to be filtered, slowed and held (attenuated), impervious surfaces foster rapid runoff, with little attenuation or treatment. The more impervious surface there is, the less ground water recharge, the less pollutant treatment, and the greater the volume of rapid surface water runoff following storm events, causing flooding problems.

Approximately 65 percent of total impervious surface in urban areas is for the use and storage of cars, including parking lots, roads, and driveways. Studies show a strong correlation between the percentage of impervious surface in a watershed and the level of degradation to aquatic systems. Studies have also shown that the greater the percentage of impervious surface, the less surface water is attenuated, or held within the watershed in wetlands, lakes, ground water and slowly released over time. This results in a reduction in ground water recharge and the lowering of local ground water tables. It also causes streams to flow at full bank conditions much more frequently, leading to stream channel erosion and loss of the riparian zone.

High percentages of impervious surface in a watershed also make land more prone to larger and more frequent floods and lower base flows. In addition, impervious surfaces raise the temperature of stormwater runoff. All of these impacts harm fish and other aquatic organisms by reducing dissolved oxygen and promoting excess algal growth. They also tend to reduce the aesthetics of the stream.

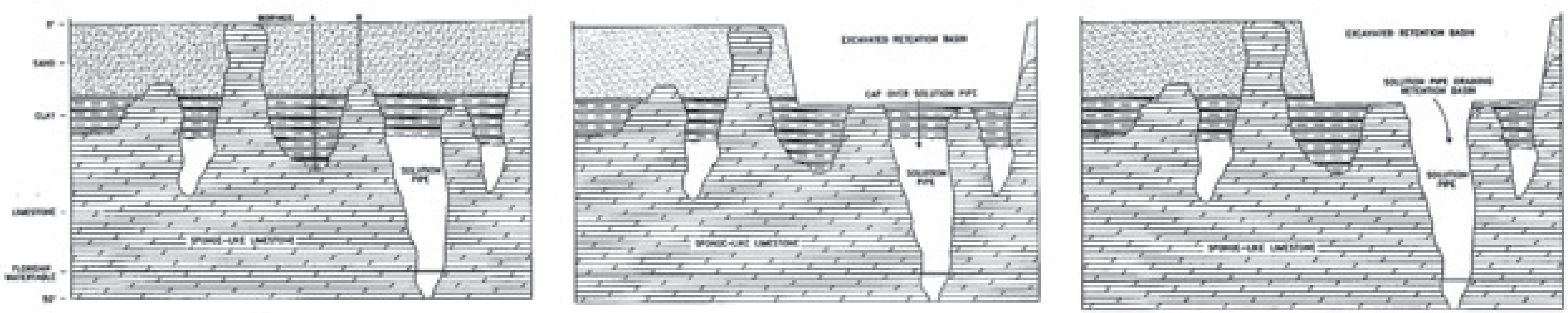


Figure 3.7. Solution-pipe formations can form in the bottom of excavated basins, including stormwater retention ponds and wastewater treatment lagoons.

Stormwater Treatment Train

The term "stormwater treatment train" is used to indicate a connected series of features, each planned and designed to treat a different aspect of stormwater runoff. These features are implemented together in a linear series (like a train) to maximize pollutant removal effectiveness for one or multiple constituents. In Tampa, Florida, the treatment train concept was used to capture and treat runoff from the street and parking areas at the Florida Aquarium. Vegetated swales, narrow forested strands and wet detention ponds were linked together to provide treatment of stormwater prior to its discharge to the bay.

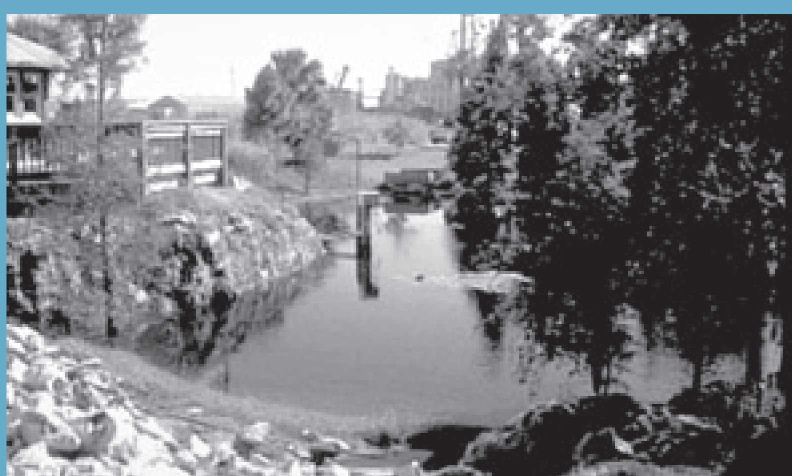


Figure 3.8. An integrated stormwater treatment train, including a wet detention pond, were used at the Florida Aquarium.

Figure 3.9. A diver looks up from a the solution-pipe in a sinkhole.

Address Wastewater Management Issues

Florida springsheds are extremely susceptible to nutrient pollution. Wastewater treatment and disposal systems such as septic systems or centralized systems may present problems in a springshed setting even if they are designed and properly operating under the standard design. To protect water quality in springs, an added level of treatment or other measures may be necessary to minimize nutrient inputs.

Septic Systems. Septic systems, or on-site sewage treatment and disposal systems (OSTDS), collect, treat, and discharge wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items that can be sources of pollutant loads. Contaminants of concern include nutrients such as nitrogen and phosphorus, and human pathogens in the form of bacteria and viruses. Florida OSTDS rules are not designed to protect water quality, only public health. Consequently, within springsheds, local governments should consider adopting more stringent OSTDS regulations. In karst areas with a high ground water table or sandy soils, an OSTDS can be a potential source of water pollution. OSTDS have been shown, as documented in USGS Report 99-4252, to contribute up to 5 percent of total nitrogen loading in karst regions of the state. Systems installed prior to1985 met a less stringent rule regarding surface water setbacks and separation from the wet season water table elevation.

Because of their widespread use in Florida and high volume discharges, septic systems have the cumulative potential to pollute ground water and springs if they are improperly sited and are not properly maintained or concentrated in densities too high for the area's natural suitability. The following are recommendations that can be incorporated into local ordinances for the design, siting, inspection and maintenance of OSTDS to reduce potential ground water impacts.

When designing a system, considerations should include requiring the use of performance-based treatment systems rather than conventional OSTDS. These are designed to significantly reduce nutrient and pathogen inputs into the environment, as compared to standard septic systems. The ANSI/NSF standard 40 class 1 aerobic treatment unit is an example of a OSTDS designed to increase the level of treatment. An OSTDS that is designed to use re-circulating sand filters can also achieve significant nutrient reduction.

When siting a system:

- Increase minimum lot size to one-half acre or larger to reduce system density;
- Require a four-foot separation zone between the drainfield plane of discharge and the level of the receiving ground water below, versus the standard two-foot zone of separation requirement. This unsaturated zone – the area before the ground water level is reached, along with the drainfield "biomat" (the area of high microbial activity directly under drainfield discharge points) – provides very important nutrient treatment;
- Require at least a 100 foot set back between the edge of the drainfield and wetlands or water bodies;

- Require failing systems to be replaced with systems that meet new construction standards;
- Use a lower density threshold for requiring connection to central systems–this can also be linked to open space zoning; and
- Require OSTDS to be inspected and, if needed, maintained or upgraded whenever a property is sold.

The U.S. Environmental Protection Agency's "Guidelines for Management of Onsite/ Decentralized Wastewater Systems" offers a range of management options to consider, including implementing a local septic system inspection program to identify and replace failing systems. A local septic system management program can be established, charging septic system users a yearly fee to support an inspection and repair program. Charlotte County is implementing a model program using DEP grant funds. Such a program can also identify areas that should be centrally sewered. Existing development within the primary protection zone should be required to come under a local OSTDS utility system to ensure proper functioning of the systems and to report and correct problem systems as they arise. Problem systems could be required to upgrade to more efficient systems, or be linked into central collection and treatment systems.

The Green Swamp in Central Florida, St. George Island in the Panhandle, and the Florida Keys are areas where OSTDS siting and performance standards have been developed and applied to help protect water quality. Escambia County requires a septic system to be inspected and brought up to standard whenever a property transaction (sale) is made.

A good source of options, management tools, and technologies available for septic system and small scale wastewater treatment design can be found at:

The National Small Flows Clearinghouse (NSFC)
National Environmental Services Center
West Virginia University
PO Box 6064
Morgantown, WV 26506-6064
Phone: (800) 624-8301
www.nesc.wvu.edu/nsfc/nsfc_index.htm

The NSFC is a nonprofit organization that helps America's small communities solve their wastewater problems to protect public health and the environment.

Central Sanitary Sewers Collection and Treatment. In areas where development is planned or has already been permitted at suburban levels or higher, collection and treatment of wastewater by a central system or hybrid systems is needed to protect spring water quality. Ideally, central wastewater treatment systems permit more efficient collection of wastewater, higher levels of pollutant reduction and, if possible, out-of-springshed discharge.

Most community central systems with available treatment capacity may be willing to provide service to new developments within a service area where the developer is willing to pay for line extensions or where existing lines are available. Nevertheless, though central sewering may solve existing problems of pollutant discharge in a springshed, the extension of sewer lines is not without risk because their extension into an area may induce more development than had been possible when the area was served by on-site sewage disposal systems. Thus, a decision to extend lines into undeveloped areas must be weighed against the fact that the presence of sewers will allow development at higher densities and intensities in the area serviced.

Another important consideration for the planning and development of any central wastewater treatment system within springsheds is how and where treated wastewater is to be disposed. Even though such systems may treat to a relatively high standard, the long-term discharge of treated wastewater within nitrate-sensitive springsheds may result in a gradual buildup up of nitrates and other constituents to levels that pollute. Long-term studies of treated wastewater disposal via land application have shown a

Figure 3.10. The City of Tallahassee's treated wastewater disposal sprayfields in southern Leon County may affect Wakulla Springs several miles to the south in Wakulla County.

buildup of nitrates in the ground water at levels that would be detrimental to most Florida springs (above 2 milligrams per liter). Studies by the USGS and the Northwest Florida Water Management District have detected the gradual buildup of nitrate in ground water (threefold in the 25 years prior to 2002) attributable to septic systems, livestock and fertilizers (estimated 49 percent) and wastewater treatment facilities (estimated 51 percent).

Given the fact that springs are valuable local resources, added nutrient impacts should be avoided. When considering wastewater treatment and disposal options, preference should be given to keeping added nutrients and other pollutants out of the springshed.

When a wastewater treatment plant must be located within a springshed, the point of discharge should be located as far as possible from that spring and its karst conduits. Since springs are extremely sensitive to increases in nitrates, advanced levels of wastewater treatment should be considered when allowing the disposal of effluent within a springshed. As noted above, even properly designed and managed wastewater treatment and disposal systems result in the gradual buildup of nitrates and other pollutant levels. Advanced wastewater treatment (AWT) options can reduce nutrient discharges. This option, though more costly than standard wastewater treatment, may be necessary to protect spring water quality.

Utilize a Combination of Best Management Practices

A combination of land use planning and site-specific best management practices can help minimize developmental impacts within a springshed. BMPs that reduce polluted runoff can be among the most effective and feasible practices to protect Florida's springs, and can either be non-structural or structural in form.

Non-structural BMPs reduce the generation of pollutants from a site through planning, design, management and education strategies. Structural BMPs include engineered infrastructure solutions to delay, capture, store or infiltrate stormwater runoff.

Both non-structural and structural BMPs are necessary to protect a springshed. In many cases, good planning and site design can be more effective than structural BMPs at mitigating stormwater impacts to a spring. In areas that are already densely developed and have limited open space opportunities, however, structural BMPs are usually required to control polluted runoff. By being familiar with options for reducing the generation and accumulation of pollutants at the development design stage, reliance on more costly structural BMPs can be reduced.

Often non-structural BMPs may be best incorporated as amendments to the comprehensive plan. Specific goals, objectives and policies are adopted to guide the placement of land uses and specify infrastructure needs for sensitive springshed areas. Environmental overlay areas and the allowable uses, densities and intensities within the springshed should also be incorporated into the plan if utilized. Structural BMPs are often described in the local land development code and implemented through the local land development review process.

Attachment 2 on page 66 contains basic information about non-structural and structural BMPs in a chart form to help identify the best way to manage stormwater runoff in your community. The chart is adapted from one prepared by the National Wildlife Federation, which can be found at www.nwf.org/northeastern/resources/bmp.pdf.

Encourage Appropriate Water Conservation Measures

As mentioned previously, over-withdrawal of water within a springshed eventually reduces the flow of water from the spring and increases the concentration of pollutants in the spring. Water conservation measures should be used to minimize necessary water withdrawals which will help maintain spring flows.

Water conservation is often implemented by water management districts through the consumptive use permitting (CUP) programs. Applicants for water withdrawal permits may be required to implement conservation measures. The reuse of reclaimed water is a critical component for meeting Florida's existing and future water supply needs while sustaining the state's natural systems. Other actions that local governments and developers should follow are discussed below.

Florida Friendly Landscape Ordinance. Xeriscaping, as defined by the Florida Legislature, means "a landscaping method that maximizes the conservation of water by the use of site-appropriate plants and an efficient watering system" (Section 373.185, FS). As mandated by the legislature, water management district rules require that all local governments consider a xeriscape ordinance and that the ordinance be adopted if the local government finds that xeriscape would be of significant benefit as a water conservation measure relative to the cost of implementation. The xeriscape landscape ordinance affects new construction and landscapes undergoing renovations which require a building permit from the local government. Xeriscaping encompasses planning and design, soil analysis, efficient irrigation, practical turf areas, appropriate plant selection, and mulching. The legislation requires that the water management districts establish incentive programs and provide minimum criteria for qualifying xeriscape codes. These codes prohibit the use of invasive exotic plant species, set maximum percentages of turf and impervious surfaces, include standards for the preservation of existing native vegetation, and require a rain sensor for automatic sprinkler systems.

While xeriscaping saves water it does not address water quality. The Florida Yards and Neighborhoods Program, discussed later in this chapter, does both. FDEP, in cooperation with the landscape industry, has just prepared a model landscape ordinance that local governments can use to minimize irrigation and protect water quality.

Rain Sensor Device Ordinance. This type of ordinance would require any person purchasing or installing an automatic sprinkler system to install, operate, and maintain a rain sensor device or an automatic switch to override the irrigation cycle of the sprinkler system when adequate rainfall has occurred. This avoids running sprinklers when it is raining.

Ultra-Low Volume Fixture Ordinance. This would require ultra-low volume (ULV) plumbing fixtures in all new construction. The fixtures should have a maximum flow volume when the water pressure is 80 pounds per square inch (psi) as follows: toilets, 1.6 gal/flush; shower heads, 2.5 gal/min.; and faucets, 2.0 gal/min. The normal standards for plumbing devices are: toilets, 3.5 gal/flush; shower heads, 3.0 gal/min.; and faucets, 2.5 gal/min. ULV fixtures use less water to provide the services desired. Available data indicate that the performance of these systems is such that the savings per flush or per minute will not be lost if users increase the number of flushes (double flushing) or length of a shower. Thus, permanent ongoing water savings can be realized with or without any behavioral changes by users.

Conservation Rate Structure. Utilities can design their charging system to provide a financial incentive for users to reduce demands. Water conservation rates are generally either: (1) increasing block rates, where the marginal cost of water to the user increases in two or more steps as water use increases; or, (2) seasonal pricing, where water consumed in the season of peak demand, such as from October through May, is charged a higher rate than water consumed in the off-peak season. The most frequently used conservation rate structure is increasing block rates. This generally has the largest impact on heavy irrigation users. Users faced with higher rates will often use less water in order to save money. The responsiveness of the customers to the conservation rate structure depends on the existing price structure, the water conservation incentives of the new price structure, and the customer base and their water uses.

Increase Public Awareness

Education is an important component of springs protection. The following resources already exist to help educate landowners, local governments and the general public about the importance of springs and how to protect them.

Florida Yards and Neighborhoods Program. This program educates home and business owners on pragmatic, Florida-based yard management. It was developed to address surface and ground water pollution, water overconsumption and disappearing habitats. Special educational activities help residents reduce pollution and enhance their environment by improving home and landscape management. Objectives include working with home and business owners to reduce stormwater runoff, conserving water and enhancing wildlife habitats

Regional Water Supply Plans

In response to growing water demands and uncertain supplies, all Florida WMDs are required to prepare water supply plans for regions where water sources are deemed inadequate to meet projected demands. In these areas, the WMDs are to identify potential sources of water to meet demands over a 20-year planning period while protecting water resources and the environment. The plans must be updated every five years.

Spring flows should be protected in the water supply planning process by identifying alternative water consumption sources to ground water, such as surface water, desalination, and reuse of reclaimed water. The plans should include conservation measures to help reduce demand. Alternative water sources can be more expensive and difficult to develop than traditional ground water sources. However, the statute encourages utilities and local governments to develop alternative sources by providing water management district funding for these kinds of projects (sections 373.0831(4) and 373.1961, F.S. and the Florida Forever Act). Further, spring flows should also be protected through the establishment of minimum flows for springs and minimum levels for spring runs.

through the creation of carefully designed landscapes. The Florida Yards and Neighborhoods program encourages homeowners and businesses to do the following:

- Water efficiently;
- Mulch to help retain moisture and suppress pests;
- Compost and recycle yard waste;
- Select the least toxic pest control measures;
- Put the right plant in the right spot;
- Fertilize only when necessary;
- Provide food, water and shelter for wildlife; and
- Protect surface water bodies and minimize stormwater runoff.

Yard managers are taught to cooperate with local natural conditions, rather than battle the elements. The Florida Yards and Neighborhoods program handbook describes the concepts, tools and techniques for creating a Florida Yard. The program teaches the basics of designing a landscape featuring plants suited to Florida's climate, natural conditions and wildlife. Tips on cost-savings and environmentally-friendly landscape maintenance also are included to help reduce water, fertilizer and pesticide use. A section on shoreline management assists waterfront homeowners. Those interested in this program should contact their county Agricultural Extension Service office and ask about this program or go online to http://hort.ufl.edu/fyn/.

Florida Green Industries, Best Management Practices for Protection of Water Resources in Florida. Landscaping and lawn best management practices for protection of a springshed's water resource are a critical need. This publication has been developed to provide guidance on landscape and lawn management. This publication was developed through a collaborative effort of the lawn management and landscaping industries and state and regional water quality and quantity management agencies. As outlined in that document, the goals were to:

- Reduce nonpoint source pollution and promote efficient use of water;
- Reduce off-site transport of sediment, nutrients, and pesticides through surface or ground water;
- Promote use of appropriate site design and plant selection;
- Promote appropriate rates and methods of applying fertilizer and irrigation; and
- Promote use-targeted pest management to apply appropriate amounts of chemicals.

The publication details how best management practices for lawns and landscapes should integrate plant selection, irrigation, fertilization and pest management in a manner that minimizes environmental impacts yet meets expectations. The manual emphasizes that lawns and green spaces often predominate in developed landscapes, and that practices reducing environmental stresses should be utilized.

Moderating Nitrogen Fertilization. Nitrogen encourages the plant to form new tissue and grow. When nitrogen is applied in excess, the grass and landscape plants become more vulnerable to stresses. Less reserve material is then available for recovery from, or avoidance of, other problems.

Citrus County's Florida Yards and Neighborhoods Ordinance

Hoping to lead by example, this ordinance implements government facilities management procedures that will result in the reduction of nitrate infiltration into ground and surface waters, and encourages practice changes by employees and citizens in the County through education. The ordinance establishes guidelines for managing existing and future lawns and landscapes at all Citrus County facilities using the educational guidelines of the University of Florida Extension's Florida Yards and Neighborhoods Program, Environmental Landscape Management (ELM) principles and Best Management Practices. The ordinance is available online at **www.dep.state.fl.us/water/stormwater/pubs.htm** (then look for Nonpoint, Publications, BMPs; the ordinance is listed under Florida Yards and Neighborhoods Program).

What is a Florida Yard?

With a Florida Yard you win and so does the environment. You don't waste water, fertilizers or pesticides and Florida's springsheds are better protected.

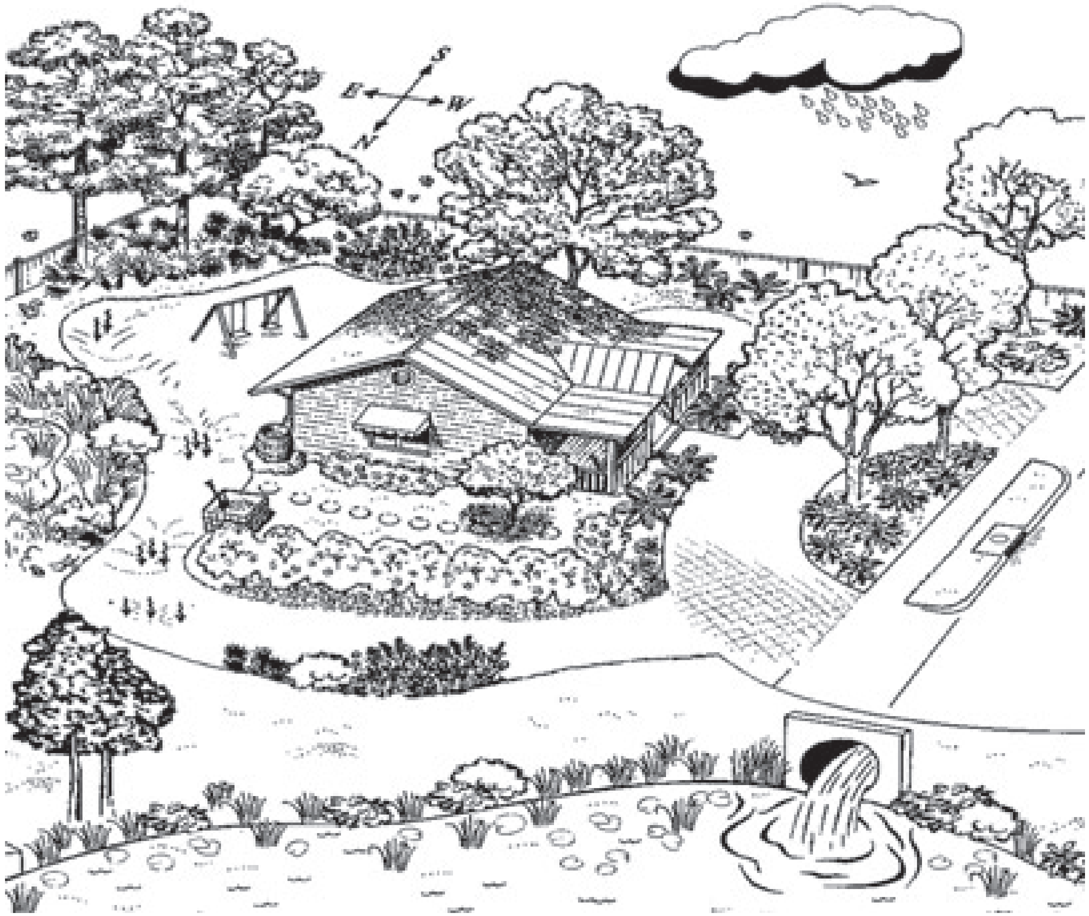


Figure 3.11. The *Florida Yardstick Workbook* guides homeowners through an evaluation of their yard and yard care practices. Each action taken earns "inches" on the Florida Yardstick. A yard that "measures up" to at least 36 inches is a "Florida Yard".

Irrigating When the Grass and Landscaping Needs Water. Over-irrigating leads to lawn failure by increasing fungal problems and limiting the root system to the top few inches of the soil. These lead to increased disease or insect problems, which are often treated chemically.

Mowing at Proper Heights. Mowing below recommended heights removes a large portion of the shoot tissue available for photosynthesis. This leaves the grass less able to support itself or recover from injury. Managed turf areas should be mowed regularly, with sharp blades at recommended cutting heights for the given environmental circumstances. Clippings should be left on the turf.

Mulching. All landscape plants should be mulched to a depth of 2 to 4 inches. Mulch rings should extend to at least 3 feet around freestanding trees and shrubs. All mulch should be renewed periodically, and mulches kept at least 6 inches away from any portion of a building or structure.

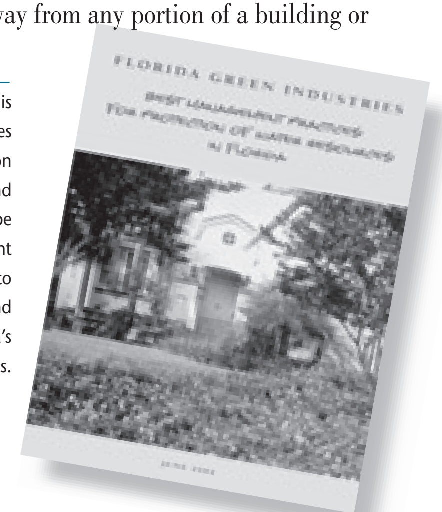


Figure 3.12. This manual provides guidance on turfgrass and landscape management practices to conserve and protect Florida's water resources.

Be Sure to Check Out These Resources!

The Center for Watershed Protection, **www.cwp.org/22_principles.htm**, has developed *Site Planning Model Development Principles* and *A Technical Support Document, Better Site Design: A Handbook for Changing Development Rules in Your Community*. They include benchmarks to indentify where existing ordinances may be modified to reduce impervious cover, conserve natural areas, and prevent stormwater pollution.

Stormwater Strategies, Community Responses to Runoff Pollution, a May 1999 report from the Natural Resources Defense Council, documents some of the most effective strategies being employed by communities around the country to control urban runoff pollution, which is among the top sources of water contamination in the country today. Go to: **www.nrdc.org/water/pollution/default.asp**.

The Environmental Protection Agency's website, **www.epa.gov/owow/watershed**, includes a section on watershed protection. The EPA also has *Model Ordinances to Protect Local Resources*, examples of local ordinances directed at a number of resource protection needs, e.g. buffer, erosion and sediment control, stormwater management and open space development. The model ordinances can be found at **www.epa.gov/owow/nps/ordinance/**.

The Florida Concrete Products Association, **www.fcpa.org/**, has developed a manual and training video tape on the use of pervious concrete to help reduce stormwater impacts.

Florida Yards and Neighborhoods Handbook: A Guide to Environmentally Friendly Landscaping, **www.dep.state.fl.us/water/stormwater/docs/nonpoint/fynxord.pdf**, is published by IFAS and describes how to minimize nonpoint source pollution from landscapes, especially residential ones. This booklet is an integral part of the Florida Yards and Neighborhood program.

Published in 1988, *The Florida Development Manual: A Guide to Sound Land and Water Management*, is the state's official urban BMP manual. It summarizes nonstructural and structural best management practices for erosion and sediment control, stormwater management, OSTDS, and site planning. It is available for free from the Stormwater and NSP Management Section, FDEP. 2600 Blair Stone Road, Tallahassee, FL 32399-2400.

The Low Impact Development (LID) Center, Inc., **www.lowimpactdevelopment.org/**, is a non-profit 501(c)(3) organization dedicated to research, development, and training for water resource and natural resource protection issues. The Center focuses on furthering the advancement of Low Impact Development technology, a new comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds.

The Stormwater Resources web site, **www.stormwater-resources.com**, is dedicated to providing a source of information regarding stormwater pollution, treatment methodologies, and related issues. With this on-line library you can download research papers and information regarding Nonpoint Source Pollution, Best Management Practices, upcoming conferences, NPDES, TMDLs, and other stormwater topics.

The Stormwater Finance web site, **stormwaterfinance.urbancenter.iupui.edu**, is designed to help communities find ways to pay for stormwater management projects. The site includes: an annotated bibliography of existing stormwater finance materials; a discussion of the financing options available to communities for stormwater management programs; a set of case studies that describe successful finance mechanisms that have been used in seven communities around the country; and a group of other useful web sites about stormwater management.

Attachment 1

Specific Policy and Permitting Considerations for Karst Areas

Local governments with jurisdiction over karst areas can incorporate specific guidelines and standards into their comprehensive plan to better address stormwater management. FDEP has developed recommendations for special design and performance standards for new stormwater facilities constructed in karst areas or that discharge to sinkholes. These general criteria are presented below. If the FDEP or appropriate water management district have not implemented these requirements in their stormwater or environmental resource permitting rules, local governments should request that they do. If they do not, then local governments should work with FDEP and their appropriate water management district office to incorporate these suggested criteria into local regulations. Areas where special karst policies apply (for instance within designated springshed primary and secondary protection zones) should be indicated on the Future Land Use Map series.

General Criteria for Siting and Design of Stormwater Management Facilities in Karst Areas

1. Require the use of swales, preferably with a cross block or raised driveway culverts, to promote retention/infiltration within the swale.

2. Require the first one inch of runoff in impervious area to be treated in shallow (generally less than two feet deep), grassed retention areas. These retention areas should be incorporated into a project's open space/landscaping areas. Rather than concentrating the runoff into one large retention area, several small retention areas should be used.

3. Manage Discharges to Sinkholes:

Active sinkholes

- No direct discharge of untreated stormwater is allowed.
- Since sinkholes are conduits to ground water, stormwater discharges to them must meet primary and secondary drinking water standards.
- Projects in areas zoned for industrial land uses should assure that industrial pollutants do not enter the stormwater system or come in contact with ground water.

Relic sinkholes or natural depressions

- Natural depressions should be used for stormwater management only when hydrogeologic evidence shows that the sub-geologic structure and soils are stable and unlikely to form a sinkhole that creates a direct connection to the ground water.
- Soil boring information and/or supplemental data such as ground penetrating radar should be provided by an applicant to verify geologic stability.
- If the hydrogeologic conditions are suitable and the depression is proposed for use as part of the stormwater management system, a spreader swale should be employed at the inflow location.

4. Conduct a special review of projects in areas zoned for industrial land to assure that industrial pollutants do not enter the stormwater system or come in contact with the ground water.

5. Require regular inspection by developer/maintenance entity to visibly check for existence or beginnings of solution pipes.

6. Require supplemental information for permit applications in karst areas:

- A hydrogeologic survey should be performed for the entire site with emphasis on potential locations of swales and basins.

- A map depicting limestone outcroppings, sinkholes, solution pipes and general depth of soil to limerock will be included. Borings should be taken in potential locations of swales and basins. These borings should be made to the limestone and then an additional 10 feet deep.
- The overburden material should be characterized (grain size, percent organic matter). This information should then be used to site swales and retention areas in locations with the greatest depth of overburden and the "strongest" limestone.

7. Require special permit conditions:

- Acceptance of this permit requires the owner/maintenance entity to accept financial responsibility for the prompt repair of solution-pipes should they occur.
- The appropriate City/County department should approve and/or supply repair criteria.

8. Require special permit conditions:

- Site inspection by field personnel when swales and basin are excavated to a final grade to visually inspect for limerock or solution-pipes;
- Site inspection upon completion to assure that vegetation (sod) is growing well.
- That all construction is according to approved design (for detention and retention areas, generally shallow depth and flat bottoms).

Depth to limerock considerations:

In areas where the overburden thickness is:

0-5' Require clay liner to minimize downward percolation, encourage lateral percolation. Minimize excavation.

5-10' Require geotextile liner. Restrict excavation to maximize depth of overburden beneath retention areas.

>10' Normal dual basin system, minimize excavation.

9. Require special operation/maintenance conditions to mitigate the potential for direct connections from on-site stormwater basins to the ground water:

- Stormwater swales and retention basins should be monitored by visual observations following significant storm events. If open solutions or pipes and/or sinkhole-like depressions are noted, this information should be relayed to an on-site maintenance coordinator.
- Where small shallow depressions are noted, these may be filled to pre-existing grade with clayey sand materials, graded and vegetated.
- If chimney-type solution pipes are exposed within the retention basins, these may be plugged in accordance with acceptable water well plugging and abandonment procedures. Where these features are small in diameter and of a limited vertical depth, bridging of the pipe with indigenous limestone boulders is recommended. Once the bridge is in place, the pipe may be filled with clay and/or clayey sand back to the land surface and then vegetated.
- Remedial plugging activities should employ methodologies acceptable to the applicable regulatory agency.

Golf Course Siting, Design and Management

MILES M. (BUD) SMART, PH.D., AUDUBON INTERNATIONAL
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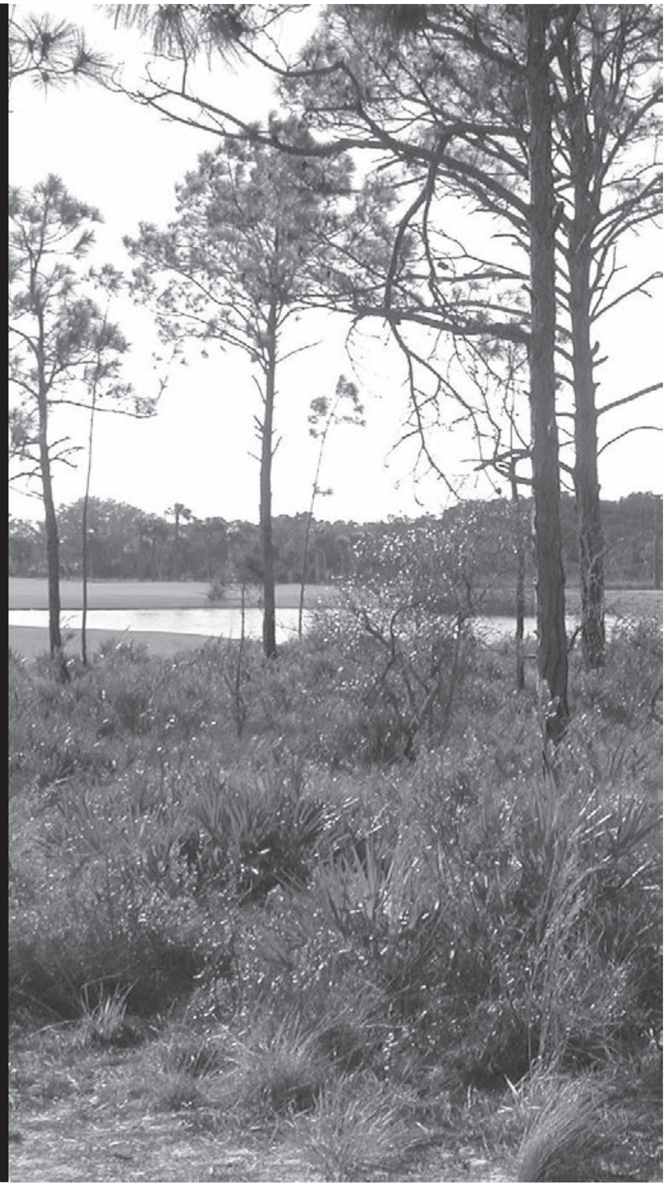
To protect springs, golf course best management practices focus on preventing the movement of nutrients, pesticides and sediments into these environmentally-sensitive systems. This section covers the basic issues that must be considered when developing a golf course:

- Use a Springshed-Based Approach to Golf Course Siting and Development
- Select an Appropriate Site
- Integrate Environmental Planning into Golf Course Design
- Establish and Follow a Construction Management Program
- Create a Golf Course-Specific Natural Resource Management Plan



Golf courses are important amenities for residents and tourists in Florida. With golf's increasing popularity and the state's ever growing population, more courses are being built each year. In 2000, there were over 1,500 golf courses that encompassed over 200,000 acres. Golf courses may occupy a significant part of the springshed; individually golf courses range in size from approximately 100 to 250 acres.

Golf course best management practices focus on preventing the movement of nutrients, pesticides, and sediments from a golf course to the spring, and minimizing ground water withdrawal. Water is the primary vehicle for moving contaminants; therefore, both surface and ground water connections to the spring must be evaluated. Since water movement does not recognize property boundaries, the golf course should be developed in context of the entire springshed.

Figure 4.1. Golf courses within a springshed need to be located and designed appropriately.

Use a Springshed-Based Approach to Golf Course Siting and Development

A springshed-based approach applies scientific decisions to the siting, design, construction and operation of golf courses. This approach integrates environmental attributes and agronomic practices, and promotes managing golf courses within the context of the larger springshed ecosystem. The potential for negative impacts to springshed water resources is minimized with this approach. The objective is to design the course so that it functions as though it were part of the natural surface water drainage system.

The springshed-based approach involves two key components: 1) implementing prevention, management, and monitoring practices throughout the siting, design, construction and management of the golf course; and 2) incorporating these practices into a natural resource management plan to protect the quality and limit the quantity of water moving from a golf course.

Prevention, Management and Monitoring. Through the use of best management practices, these are implemented at each phase of golf course development, from siting through long-term operations.

Prevention. This involves preventing potential environmental problems by reducing or eliminating the availability of pollutants to surface and ground waters. Selecting an appropriate location for a golf course and reducing pollutants at the source are critical to protecting water quality within the springshed.

Management. A comprehensive management program is essential in order to protect spring water quality. The program should provide appropriate management of all materials used in the day-to-day operation of the course (such as, fertilizers, pesticides, oil, gasoline and solvents) and of maintenance and storage facilities so that environmental problems do not occur. Potential environmental problems may be minimized by incorporating BMPs into the design, construction and operations of a golf course and its maintenance and storage facilities. The management program must address materials used to maintain the turf, and facilities for the storage and mixing of fertilizers and pesticides, as well as equipment washing. The objective of the management program is to avoid detrimental impacts to water quality. A well-managed program involves the use of Integrated Pest Management. Implementation of BMPs should be included in each phase of golf course development. BMPs for golf course development are identified throughout subsequent sections.

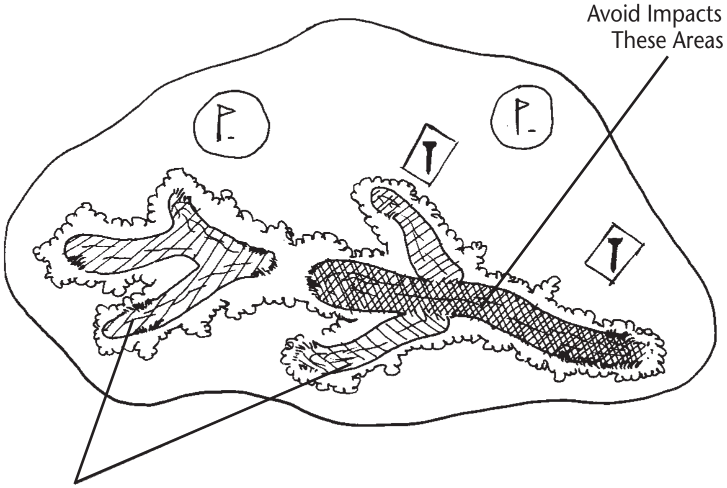
Monitoring. An environmental monitoring program that evaluates the effects of development on spring resources and associated natural resources is very important. Key components of monitoring include establishing base line data prior to site development and the periodic collection of water quality data to access changes in water quality.

Natural Resource Management Plan. The prevention, management and monitoring practices used to protect the spring are documented in a golf course-specific Natural Resource Management Plan. This plan begins with the site evaluation, and moves through design and construction to daily maintenance and operation. The management plan uses each of these stages to build upon and support the various activities involved in developing an environmentally-sensitive golf course. The management plan ties all of the information and management practices together and ensures that every action supports and enhances every other action. The management plan becomes the "owners manual" or "guidebook" for the golf

Effective Strategies for Protection of Springs

- Implement prevention, management and monitoring practices throughout the siting, design, construction and management of the golf course.
- Select an appropriate site; identify resources on the property, including significant site characteristics that require protection; conduct a springshed scale investigation of the site.
- Employ nature-based course design that includes Special Management Zones, Best Management Practices (BMPs), and Integrated Pest Management (IPM) using ecological risk assessment to select pesticides for use.
- Develop construction guidelines to minimize disturbance and promote revegetation programs.
- Conduct a monitoring program.
- Prepare a Natural Resource Management Plan for the golf course.
- Participate in a nationally-recognized golf course certification program, such as Audubon International's Signature Program.
- Conduct annual reviews and renew certification.

Figure 4.2. The springshed-based approach is comprehensive and includes analysis of the entire springshed, incorporation of natural drainage systems instead of traditional piped systems, and the implementation of prevention, management, and monitoring practices and associated BMPs. This springshed system functions as though it were part of the natural surface drainage system.



course developer, manager and superintendent to follow at every stage of golf course development and operation. The Natural Resource Management Plan should be updated as part of a yearly review of operations.

An annual review of operations should be conducted, using the Natural Resource Management Plan as the template for review of all aspects of operations. The annual review should be conducted by a nationally-recognized golf course certification program. Local governments may not have sufficient in-house expertise to evaluate plans, potential construction impacts, operations of golf courses, and conduct an annual review. As an example, the Audubon International Signature Program offers third-party oversight and ongoing re-certification and ensures that this oversight continues for as long as the course is in operation.

Siting, Design, Construction and Management Overview. The following steps should be used to design, construct and manage a golf course. The steps begin at a relatively general level with siting and become progressively more specific through each development phase. The steps are:

1. Identify the biological, chemical and physical resources at the property. Knowing the characteristics of the site facilitates informed decisions about the site. The first step is to identify environmental and ecological areas on the property that require protection. Identification allows protection of the sensitive areas or species.

2. Examine the golf course and its surroundings relative to its position in the springshed. Land use changes must be understood in terms of the landscape and surrounding land uses.

3. Identify construction and management practices that will afford protection for the spring or pathways to the spring. Management practices that should be included in a comprehensive program include: construction management; conservation management zones; drainage; Best Management Practices; and Integrated Pest Management including selection of pesticides and fertilizer and restrictions on the use of certain materials. These topics will be

Key Points for Golf Course Uses

- Protect ground water beneath the golf course from fertilizer and pesticide contamination.
- Protect surface waters that flow into sinkholes from the above contaminants.
- Restrict/minimize pumping ground water for irrigation to reduce loss of spring flow.
- Avoid locating golf courses in the primary or secondary protection zones.

Figure 4.3. A properly sited, designed, constructed and managed golf course can co-exist with nature and other land uses in the springshed. If the site is not appropriate for the activities associated with developing and maintaining a golf course, there are likely to be problems.

covered in the Design and Management Sections of this chapter.

4. Implement an environmental monitoring program. Done at all stages of golf course development and operation, this would establish a baseline of water and environmental quality and provide data, over time, to determine if protection measures are properly functioning. Monitoring is discussed in detail in the Management Section of this chapter.

The first three steps should be conducted during site selection to make sure that the site has the appropriate key characteristics—that there is enough land to design a course and protect water resources, and that environmentally-friendly construction, design and management practices will work on the property. Before a site is selected for a golf course, it is critical to work through this process to ensure that all phases and various practices of golf development protect spring resources.

Select an Appropriate Site

Site selection and evaluation of potential golf course locations within a springshed is the first step in the golf course development process. A properly sited, designed and managed golf course can co-exist with nature and other land uses in the springshed. If the site is not appropriate for the activities associated with developing and maintaining a golf course, there are likely to be problems. As shown previously in Figure 2.9, golf courses should not be located in the primary or secondary protection zones of the spring. To avoid siting a golf course at an inappropriate location, a thorough analysis of the site should be done to evaluate its suitability.

BMPs alone will not be able to resolve environmental problems if the golf course is located in an unsuitable location.

Key indicators of the suitability of a site include geology, soils, and topography.

Because of the karst geology of springsheds, sinkholes, fractures, and fissures may link the site directly to the spring, making the site unsuitable for a golf course. Soils on a site should not be highly transmissive (a transmissive soil allows materials to move readily through the soil profile); rather they should retard the movement of potential pollutants to the ground water and spring. Ideally, the site should be over an aquaclude (a confining layer that does not allow downward movement of water). Regarding topography, avoid sites with excessive slopes; surface runoff should not be directed to a karst feature.

Additional indicators of site suitability include the presence of wetlands, important habitat areas and natural buffers. These site elements are important because they will determine the availability of enough suitable area for a course, they are critical in determining natural drainage systems for water management, and they serve to naturally filter water. An added benefit to preserving natural areas, buffers, and other significant site elements is that they provide habitat for wildlife and connections between habitat area (uplands and wetlands). When integrated into a well-designed course, these features can be an important amenity for players.

Site-Specific Evaluation. To determine the appropriateness of a site, a site inventory and analysis is conducted. The site inventory provides a means of gathering information about the site and its surroundings, and putting it into a form that can be used as a basis for assessing site suitability and for design. Information that should be gathered and evaluated includes:

- Physical location of the site;
- Topography;
- Soils;
- Hydrogeology (presence of karst conditions, depth to aquifer, direction of ground water flow);
- Surface water on site (including presence of sinkholes or springs);
- Existing and surrounding land uses;
- Vegetation;
- Sensitive areas; and
- Regulatory requirements (for example, for wetlands, buffers or setbacks).

Site-specific investigations may need to be conducted, depending on the amount of information available and the unique characteristics of each site. Within springsheds, the investigations should focus on assessing key indicators of site suitability, including geologic connections, soil transmissivity, and the location of aquacludes and surface water connections with the spring. The presence and extent of sinkholes, cave entrances, or fissure systems connecting to springs can make the site unsuitable.

Site evaluation of potential golf course locations is critical. A thorough analysis of the site should be done to evaluate potential pollution pathways to springs. The analysis may include use of existing information and additional site-specific investigations.

Assessments may include geotechnical evaluations to determine soil structure, location of aquacludes and geologic connections to the

Important Site Characteristics

Geology—should not be in proximity to any feature (such as a sink hole) that is a pathway to the ground water.

Soils—should not be highly transmissive (materials should not readily move through soil profile); ideally, the site should be over an aquaclude (a confining layer that does not allow downward movement of water).

Topography— avoid sites with excessive slopes and where surface waters flow directly to a karst feature.

spring. Identifying the pathways of surface water movement may augment the sub-surface investigations so that all potential pollution pathways that may link the golf course site to the spring are identified. This is an important step and is often complex, time consuming, and therefore, costly. Once the potential pathways are identified, site-specific data should be used to determine the extent to which water can be directed away from those pathways. If pollution pathways are too numerous or not able to be reduced, another location should be sought.

Other significant features to inventory include the presence of wooded areas, other native or restored areas, water resources and associated buffers, corridors or filter strips, and wildlife habitat areas, especially for species of special interest because these areas can be important components of the natural drainage system for water management and serve to filter water.

The FDEP, water management districts (WMDs), US Geological Survey (USGS) and many private companies often have the required expertise to evaluate the site. Local governments should work with these agencies to collect and map the above data. The information should be depicted on a series of maps, beginning with a base map and adding layers of information. Geographic Information Systems (GIS) are powerful and widespread tools for developing the maps necessary to evaluate the suitability of the site. GIS can produce a relatively simple layered map or it can be used to model the natural system. Mapping tools are discussed in the chapter on Comprehensive Planning Strategies, and should be used to evaluate the site.

Areawide Evaluation. The golf course location should be evaluated relative to its position within the context of the springshed for two primary reasons. First, the springshed-wide processes that directly influence spring water quality operate throughout the entire springshed, not just within the site being evaluated. These processes include drainage patterns, riparian corridors, and other land uses in the springshed. Secondly, potential pollutant pathways to the spring may not be within a single political or legal boundary, and thus to establish these pathways the entire springshed must be evaluated. If a golf course is located miles away from a spring but over a connecting cave system, the course has the potential to adversely impact that spring. Not only should the specific site characteristics be taken into account, but the interaction of this development with the greater springshed needs to be considered.

Examine the golf course relative to its position in the springshed.

A map should be prepared to help understand how the site relates to features found on surrounding properties. This map is sometimes called the context map or site context map. The map should depict surrounding land uses, natural and open space areas, greenways and trails, and critical natural features located near the course, floodplains, wildlife corridors, as well as karst features that may extend through the site of the proposed course or linkages that extend from the course to critical karst features. This can help inform decisions about what features on the proposed site are important to conserve because of their connection to features outside the site. In other words, the site design should attempt to complement development and preservation activities that may exist or be planned for areas near the golf course. The goal is to examine whether the course can be linked to a larger network of existing or proposed open space areas.

Integrate Environmental Planning into Golf Course Design

Golf course design should be based on the detailed inventory and analysis of the site and the following basic concepts: 1) design in context with the springshed landscape; 2) use design to increase the ecological sensitivity and biodiversity of the golf course site; and, 3) design in an environmentally proactive manner. Applying these concepts will result in a golf course that is a compatible land use for the springshed, and the probabilities of negative environmental incidents can be significantly reduced.

Designing the course includes the following four components: 1) identification of special management zones; 2) identification of Best Management Practices (BMPs) to be used during maintenance and operation; 3) development of an Integrated Pest Management (IPM) with an ecological risk assessment to select the pesticides that will be used; and 4) development of guidelines to minimize disturbance during construction to protect ground water resources.

Basic components for golf course design

- Design in context with the springshed landscape;
- Design to increase the ecological sensitivity and biodiversity of the golf course site; and
- Design in an environmentally proactive manner.

Including components to protect the spring:

- Landscaping considerations;
- Integrated Pest Management (IPM) with an ecological risk assessment to select pesticides for use;
- Irrigation management for water conservation; and
- Construction guidelines to minimize disturbance and protect the spring and springshed.

Even though some of the BMPs will not be implemented until the course is operational, they should be identified during the design phase. By getting the design "right," the potential for negative environmental impacts is greatly reduced. Also, identification of special management areas and BMPs early in the design phase provides the greatest opportunity to protect the spring for the least cost. Once implemented, these practices should work together to provide protection for the spring.

Design Considerations. By designing in context with the springshed landscape, overall site disturbance is minimized. This is important because clearing, dredging, filling, slope alterations, vegetation removal and other such activities can upset the ecological systems related to springs, which can increase the potential for pollutants to enter the spring, and decrease the site's ability to filter stormwater.

Integrating natural diversity and biological elements of the site into the course design should be a priority. Allowing the site biology to dictate the design of the golf course will ensure greater harmony between the course and the springshed and will result in greater protection of the spring. In addition, post-development operation and maintenance of the course can be positively affected, and operational costs can be reduced. Maximizing conservation areas and open space will also reduce land-use intensity and provide components of the stormwater management plan.

During the design of the golf course, identify environmentally-sensitive areas and karst features that provide direct connections to the spring. Once identified, these areas will require protection, and the golf course should be designed to avoid impacts to these areas, and to maximize the distance between the more intensively developed portions of the course and these areas. As discussed later, special management zones and BMP treatment trains should be established during the design phase of golf course development to protect these sensitive areas.

Finally, the maintenance facility, including a chemical storage building, equipment handling facility and fuel island, often gets overlooked in the design process. But it is another area of the golf course where there is a high potential for pollution of soil, surface water and ground water. Here is where equipment, pesticides, fertilizers and fuels are stored. Equipment is loaded with these materials and washed after use. Contamination can occur when pesticides are spilled, containers or equipment cleaned and the rinse water dumped on the ground or discharged into surface water, or improperly cleaned containers are stockpiled. For ease of operation and maintenance, the facility should be centrally located. However, it should be located as far from karst sensitive features as possible.

Landscaping Considerations. One way to reduce the potential for pollutants to migrate

Figure 4.4 Turfgrass is planted where the game is played, otherwise native vegetation is used. Tee boxes are examples of areas that should be maintained for use of native vegetation.

to springs is to reduce the need for pesticides, fertilizers and water on the golf course. The type of vegetation selected for use on the golf course is a key to reducing inputs to the course. The design of the golf course should retain as much native vegetation as possible. Vegetation selection not only reduces the need for pesticide and fertilizer use, but also conserves water, and maintenance costs are reduced on the completed course. As an additional benefit, native vegetation will benefit wildlife on the site. Five primary areas should be taken into consideration when addressing issues of vegetation.

Natural Landscaping. Retain and enhance areas of vegetation that are already part of the natural habitat of the property makes both environmental (e.g., storm water management, wildlife) and economic good sense. Such areas should contribute to lower-maintenance costs by allowing self-sustaining vegetation in out-of-play areas;

Native Plant Selection. Choose plants that are native to a particular area. They will be better adapted to the site than non-native plants and thus require less water and pesticides. As a result, maintenance costs should be lower;

Turfgrass Selection. Select turfgrass with rapid recuperative ability, adaptability to required cutting heights, tolerance to soil compaction, and ability to wear. The turfgrass selected for use should have a low spreading or creeping growth habit so that it can tolerate close mowing heights and achieve rapid healing, and it should be well adapted to the area;

Biofilters or Buffers. Establish transition zones between areas of high golf course maintenance and sensitive environmental areas. Not only will these areas provide transition buffers, but they will also provide filtration for water and cover for wildlife; and

Amount of Turfgrass. Do not use turfgrass in areas where the game is never played (e.g., backs of tees, between tees, beyond the reach of accepted guidelines for width of rough). Use native vegetation in those areas. Reducing the amount of turf where golf is not played makes good environmental sense (native vegetation is less intensively maintained than turf areas) and economic sense (less cost for these materials as well as manpower, energy and wear and tear on equipment).

Identifying Sensitive Features

"When designing a golf course, it is important to begin identifying sensitive features on the proposed site. Utilizing what nature has provided is both environmentally and economically wise. Emphasizing the existing characteristics of the site can help retain natural resources, allow for efficient maintenance of the course and will likely reduce permitting, mitigation and site development costs. Good design incorporates protection of ground and surface water and existing sensitive features, as well as anticipates future maintenance needs and sustainability of resource use."

(Excerpted from Voluntary Environmental Guidelines Recommended for Golf Courses in Worcester County & the Delmarva Peninsula, Worcester County, Maryland)

In the design phase, areas and protocols for land clearing should be clearly defined. By defining these protocols at this stage of the process, the spring will have the greatest amount of protection.

Special Management Zones. The process of constructing and managing a golf course in an environmentally-sensitive and responsible manner involves establishing management zones throughout the golf course. Management zones are areas on the course that have distinct management practices that coincide with their position in the watershed. The management zones should be based on a springshed analysis and established during the design phase of the development, implemented during construction, and maintained throughout the life of the course. Management zones work hand-in-hand with establishment of Best Management Practices and Integrated Pest Management to protect springs. Management zones include:

Regulatory Zones. All areas that are governed by applicable rules and regulation must be identified. Activities within these zones must be specified so that management activities are consistent with the applicable rules.

No-spray Zones. No-spray zones are established around each resource identified for protection, and should include all resources that are potentially part of the pathway to a spring. For example, no-spray zones should be established at least 25 feet landward from the normal water elevation or edge of moist area. This

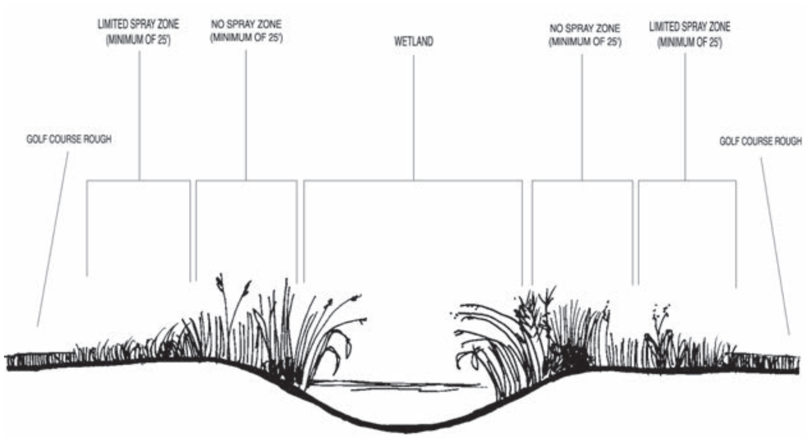


Figure 4.5. Special Management Zones are implemented adjacent to resources in the springshed to protect the resource, which in turn protects the spring. This is a cross-section of potential zones.

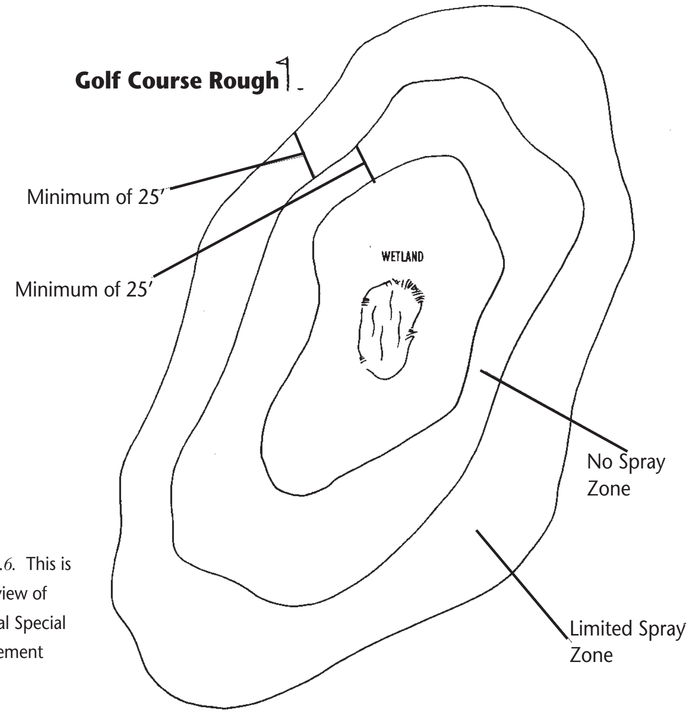


Figure 4.6. This is a plan view of potential Special Management Zones.

Important Design Considerations

Areawide Design Considerations

- Site the course based on regional and site-specific elements (contextual design).
- Meet both human and wildlife habitat needs (ecocentric design).
- Minimize land clearing.
- Maximize preserves and open space, and connections between them (positive for wildlife and for stormwater management and filtration).
- Identify areas and protocols for protection of the intersection of golf and natural resources (e.g., wetlands, riparian corridors).
- Identify the footprint for the maintenance facility.

Landscaping Considerations

- Retain native vegetation in areas not in play and use native vegetation to replant disturbed areas not part of the golf course.
- Select turf best adapted to local environmental conditions.
- Look for ways to reduce the amount of turf where golf is never played (e.g., backs of tees, between tees).
- Identify areas and protocols for land clearing (e.g., service roads, haul roads, mulch piles, limits of clearing).

Water Considerations

- Establish Special Management Zones to protect connections to springs.
- Establish water quality protection with BMP trains for drainage and stormwater.
- Use a proper irrigation system and locate heads to deliver the right amount of water to the right place at the right time.
- Do not drain directly into a surface water body. Try to maximize the contact between drainage water and vegetation (i.e., springshed-based water management).
- Design the course to reduce irrigation demands where possible. Use water reuse strategies for irrigation when economically feasible, and when environmentally and agronomically acceptable.
- Implement conservation measures on the golf course and in the club house.
- Monitoring Considerations
- Establish baseline surface- and ground-water conditions.

(From Sustainable Resource Management Guidelines, Audubon International, 1998)

distance should be based on the site, with distance increasing with slope of the land, and organic fertilizers only should be used. Similarly, no-spray zones should be established around habitat areas, corridors, or in areas of shallow ground water.

Limited Spray Zones. Limited spray zones are established 25 to 50 feet landward from the normal water elevation or edges of moist areas. This distance should be based on the site, with distance increasing with slope of the land. A limited set of pesticides should be used in this zone, and a program that limits quantities and types of fertilizers that can be applied at one time should be implemented. Light, frequent applications of water-soluble materials or greater amounts of water-insoluble materials should be used. Pesticides that can be used must be identified and must be selected with appropriate risk assessment techniques. Additionally, when wind speed is greater than 10 mph, a shroud should be used on spray equipment to avoid drift. Similarly, limited spray zones may be established around habitat areas, corridors, or in areas of shallow ground water.

Hand Clearing and Maintenance of Sensitive Areas. Sensitive areas (for example, pathways to the spring, wetlands, streams) should be managed using hand tools only, unless a mechanical tool "arm" can reach into the sensitive area to perform a task. No mechanical clearing should occur. Maintenance of sensitive areas may include siltation, erosion, and compaction. Accumulated silts should be removed, eroded channels should be filled, and compacted areas should be raked.

Best Management Practices. BMPs protect springs by either preventing or managing potential contaminants. The goals are: 1) reducing the off-site transport of sediment, nutrients and pesticides; 2) controlling the rate, method and type of chemicals being applied; 3) reducing the total chemical load; and 4) reducing irrigation water needs. BMPs include preventive and structural controls which constitute the building blocks of the springshed protection program. As with management zones, BMPs should be established during the design phase of the development, implemented during construction, and maintained throughout the life of the course.

Preventive measures include nonstructural practices that minimize or prevent the generation of runoff and the contamination of runoff by pollutants. Preventive measures are considered the "first line of defense" in an integrated storm water management system. A system of preventive measures, if properly implemented, offer an effective means of storm water management.

Common preventive BMPs include use of resistant crop varieties, cultural control of pests, irrigation water management, soil testing to determine fertilizer requirements, timing and placement of fertilizers, use of slow-release fertilizers, biological control of pests, pesticide selection, rotation of pesticides, correct

Best Management Practices for Golf Course Drainage

Inlet Control Practices. Inlet control measures are designed to protect water quality by managing runoff before it is collected in the drainage system. Practices that can be used include:

- Inlets located in natural/unmanaged area
- Inlet protection (e.g., inlet covers)
- Inlet management plan (e.g., 25 foot diameter no-spray zones)
  (Under most circumstances, inlet controls must be selected in combination with one or more practices from the following list of golf course BMPs)

Vegetative Practices. Vegetation can be used to reduce the velocity of stormwater, which helps promote infiltration into the soil and settling of solids. Plants also protect against erosion and remove pollutants through uptake. Options include:

- Dry/Wet Swale
- Filter Strip/Outlet to Natural Area
- Vegetated Buffer

Infiltration Practices. Treatment structures promote water entering into the soil and recharging or replenishing ground water. If properly designed and maintained, infiltration devices can effectively remove pollutants through adsorption to soil particles. These include:

- Infiltration Basin/Trench
- Bioretention Area
- French Drain

Outlet Control Structures. Outlet control measures are designed to treat runoff collected and transported to them through the drainage system. These control practices treat runoff at the point of discharge through settling, biological uptake of substances, and infiltration. Measures include:

- Constructed Wetland
- Dry Detention Basin
- Vegetated Outlet Structures
- In-Line Filter

(From Sustainable Resource Development Guidelines, Audubon International, 2000)

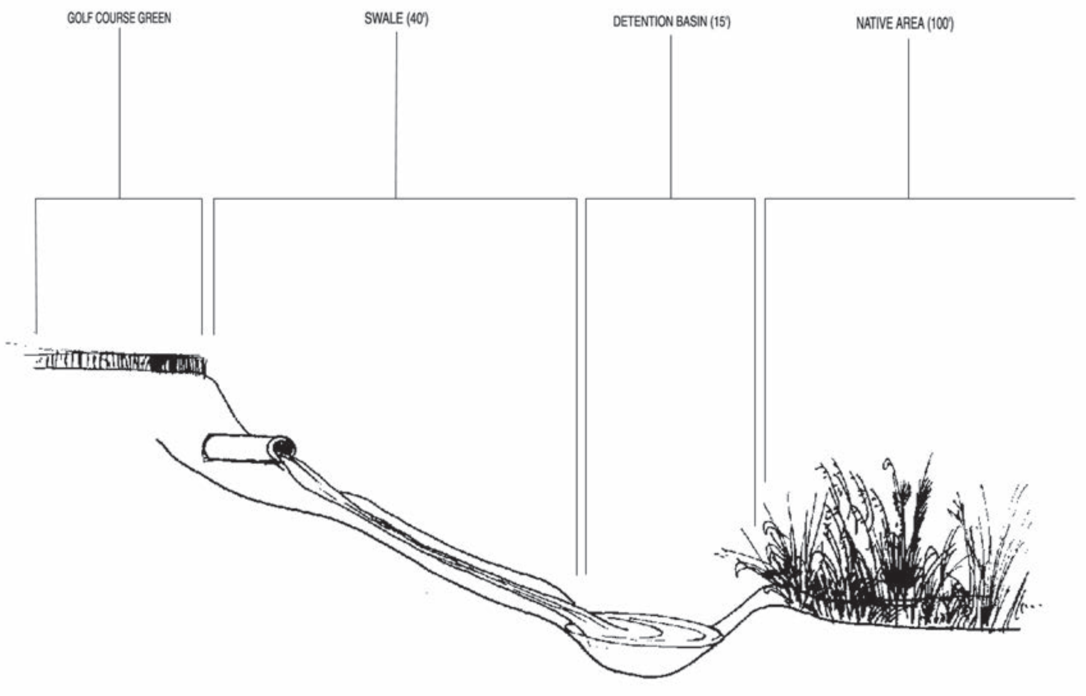


Figure 4.7. "BMP trains" in the springshed provide the optimum protection for springs, and are a critical component of effective surface water management. Coupled with a comprehensive systems approach that combines the use of natural drainage systems with preventive practices and structural controls, the use of many different "BMP trains" in the design will provide maximum water quality protection. Above, for instance, "green" drainage flows through a 40 foot swale, a detention basin and sheet flows through a native planting area.

application of pesticides, and correct pesticide container disposal.

Structural controls are capital improvements designed to remove, filter, detain, or reroute potential contaminants carried in surface water.

BMP controls are given in detail at www.audubonintl.org , the Audubon International website.

BMP Trains. The most effective way to manage surface water is by using a comprehensive systems approach that combines the use of natural drainage systems with integration of preventive practices and structural controls. This comprehensive systems approach should be used throughout the golf course. The use of many different "BMP trains" in the design will provide maximum water quality protection.

The effectiveness of pollutant removal is a function of three interrelated factors: 1) the removal mechanisms used by the BMP, which include physical, chemical, and biological processes; 2) the fraction of runoff treated by the BMP; and 3) the nature of the pollutant being removed. Thus, an effective BMP train is one that treats 100 percent of runoff by physical, chemical, and biological processes. By including as many removal mechanisms as possible, the probability of success for removal of a particular pollutant is increased.

A stormwater management system should be considered as a "BMP train" in which the individual BMPs are considered the cars. The more BMPs incorporated into the system the better the performance of the treatment "train." The first cars might include BMPs to minimize generation of runoff (e.g., irrigation management) and use of fertilizer (e.g., IPM) and the final car may include sheetflow through a forested area.

Integrated Pest Management (IPM). IPM is an ecologically-based system that uses both biological and chemical approaches to control pest. IPM strategies should be incorporated into every aspect of the Natural Resource Management Plan for the golf course. These strategies should take into consideration the entire spectrum of golf course operations as they relate to environmental impact.

Irrigation Management for Water Conservation. Irrigation system design and operational strategy must fulfill all environmental requirements for protecting the spring and resources in the springshed. In addition, the irrigation system should be designed to meet the water requirements of the turf by supplementing natural rainfall. Irrigation should be managed with a computer-controlled system and integrated with a weather station. The weather station should monitor and record the following parameters: air temperature; soil temperature; wind speed; wind direction; barometric pressure; rainfall; humidity; and solar radiation.

These are linked with a computer programmed to calculate irrigation requirements based on these parameters. This information is then used by the superintendent and irrigation technician to apply the amount necessary to replace soil moisture.

Monitoring Considerations. The monitoring program should be established during the design phase of the development and continued throughout the life of the course. The baseline conditions should be established during the design phase, with monitoring during course construction and operation to ascertain changes from baseline conditions.

Establish and Follow a Construction Management Program

The following components of a construction management program should minimize site disturbance and provide the foundation for protection of the spring and natural resources of the springshed:

Prevention Practices. Prevention of environmental problems begins with a design that clearly identifies areas that will be protected during construction. Having the following items clearly marked will assist in providing continuity between the planning team and the construction team. Prevention practices include the following characteristics:

1. Clearly define all jurisdictional limits. This includes springs, wetlands, waters of the United States; wildlife management or protection areas (e.g., eagle management areas); and pipelines or other right-of-ways. Significant site elements are defined (e.g., old growth forest, specimen trees). These are identified on the plans so that they are insulated from any impact during construction.

2. Identify areas involved with clearing vegetation for the golf course. The plan includes identification of the following: storage area for wood chips; storage area for soil; area for removal of all vegetation between the marked limits; area for removal of all undesirable or invasive (exotic) vegetation; service roads; limits of second phase clearance; and wooded zones, springs, wetlands, buffers, and corridors.

3. Identify service roads. Service roads to the various areas associated with clearing and construction are identified.

4. Mark and define all areas designated for clearing. This should be completed by the golf course project manager with input from appropriate personnel, which may include a Natural Resource Manager, Audubon International, golf course architect, landscape architect, and associated team members. Marked areas should employ color coding that is consistent throughout the project.

5. Identify clearing lines with a uniform color coding. Clearing lines should be identified with a uniform color coding to protect areas from disturbance. Care needs to be taken so that flagging does not fade, and that the different colors do not fade and become indistinguishable.

6. Develop an education program for construction workers. A 15- to 20-minute session with the contractor, including the supervisors and operators, provides a common vision for the property. The program establishes expectations and guidelines of the project. An effective way to present this is with an 8-1/2" x 11" brochure. Bulleted points should highlight the major protection areas, and clearly illustrate what the contractors should and should not do in particular areas.

7. Respect all wildlife as an important part of the ecosystem. Avoid harming wildlife, both plants and animals, and call for help in removing animals you are not comfortable with.

8. Prevent any littering. Contain trash and remove it to an approved disposal site.

9. Establish a nursery if quality landscape material is available on site for transplanting. Natural vegetation that is removed from the site should be appropriately potted and held in the nursery until it is time to revegetate the property. The nursery needs to be in an area that has electricity and water, and that is convenient to revegetation locations.

10. Attempt to preserve specimen trees, significant sites, or other important features wherever possible. In many cases, the final determination of what can be preserved successfully will not be made until clearing begins. This is the heart of adaptive management, in which decisions are made based on the results of previous actions.

Management Practices. Construction of golf courses in a springshed often involves significant land areas. The average golf course in Florida is approximately 140 acres. For each golf course site in the springshed, the following guidelines should reduce site disturbance and potential environmental problems by incorporating BMPs into all construction activities.

1. Make golf course clearing an iterative process. A golf course may initiate clearing of the first phase by starting with the center line of the fairways and clearing 50 feet on either side. Phase II may include selective clearing, and will begin only after Phase I has been inspected and approved by the team. Phase III will include selective removal of remaining vegetation, depending upon the requirements of each golf hole. Throughout the clearing process, all karst features are provided adequate protection (these areas should be clearly marked on the site plan and flagged in the field).

2. When clearing wooded areas, identify and protect specimen trees.

3. Maintain, restore or create edge conditions. This is particularly important with proposed clearing within or adjacent to wooded

Construction Management Considerations

Prevention Practices

- Define all jurisdictional limits.
- Identify areas that will be cleared of vegetation with a uniform color coding system.
- Identify service roads.
- Respect all wildlife as an important part of the ecosystem.
- Have an education program for environmental considerations during construction.
- Attempt to preserve specimen trees, significant sites, or other important features.
- Establish a nursery if quality landscape material is available on site for transplanting.
- Don't litter.

Management Practices

- Clear in an iterative manner.
- When clearing wooded areas, identify and protect specimen trees.
- Maintain, restore or create edge conditions.
- Mark haul routes and follow roads.
- Follow an erosion control plan.
- Follow guidelines for on-site fuel storage.
- Follow response procedures for containment and cleanup in the event of a fuel or chemical spill.
- Do not wash out concrete equipment in drainage ways or storm drains.
- Use appropriate BMPs to treat stormwater runoff.
- Follow approved dewatering practices.
- Treat surface and subsurface drainage from greens with BMPs before discharging to water.
- Route drainage from fairways away from direct input to surface waters.
- Construct and locate the maintenance facility with regard to spring pathways.
- Build bridges at crossings that minimize environmental damage.
- Follow the same precautions for cart path construction as for the golf course.

Monitoring Practices

- Conduct environmental monitoring during golf course construction.

(From: Construction Guidelines for Communities and Golf Courses, Audubon International, 1999)

areas that contain karst features. Construction activity (actual clearing as well as haul road activity) should be kept within the specified boundaries and follow the prescribed pattern of clearing. Regrading is to be kept to an absolute minimum within these transitional areas. Where minor regrading is necessary, native topsoil should be reinstated. Native topsoil contains a seed bank that will encourage the development of a natural edge. Plantings along these edges should allow for the rapid establishment of appropriate native species.

4. Identify haul routes and follow the roads at all times. Unacceptable environmental damage may occur if the vehicles deviate from the haul roads. For example, soil compaction may occur and cause stress to plants; habitat may be destroyed; and foraging and nesting sites may be damaged.

5. Prepare and implement an erosion control plan. The plan should be used each time the golf course undergoes any type of construction or reconstruction.

6. Follow guidelines for on-site fuel storage. Fuel tanks that are temporarily stored on site must be properly located and protected to minimize the possibility of spills and environmental impacts. Fuel or chemical storage tanks should not be placed within 100 feet of any potential connection to the spring, or other environmentally-sensitive areas (lakes, creeks, wetlands, or stormwater treatment structures). All storage tanks should have secondary containment. At a minimum, an earthen berm must be constructed around the tank, and the containment area should be lined with an impervious material. This berm must be sized to contain at least a third of the total tank volume in case of a tank rupture or equipment failure.

7. In case of a fuel or chemical spill, follow appropriate response procedures for containment and cleanup. Report spills to on-site supervisor, and if possible, collect information such as type of fuel or chemical, estimated volume of spill, and any other hazardous/safety information.

8. Do not wash out concrete equipment in drainage ditches or storm drains. Conduct concrete wash out in contained areas, allow materials to harden, and remove them to an approved disposal site.

9. Use appropriate best management practices to treat storm water runoff. The use of vegetated swales to direct runoff waters or buffers constructed from native plant materials are effective in minimizing the effect from the direct input of drainage waters. “Soft” engineering is preferred over the use of concrete or “hard” piping of water, where this is appropriate for storm water management.

10. Follow approved dewatering practices. Dewatering activities must meet all regulatory requirements. Springs and potential pathways to springs should be protected from dewatering discharges. Care must also be taken to ensure that erosion and sedimentation control practices are properly installed and functioning.

11. Direct surface and subsurface drainage from greens over vegetative buffers, through vegetative swales, or into sumps or similar devices before discharging to water. The use of swales, sumps or other devices that retain or move drainage water away from surface waters are meant to be protective of spring waters or ground water (protect them from unwanted chemical inputs). A combination of prevention and control practices (BMP trains) will provide protection.

12. Route drainage from fairways away from direct input to surface waters. This is to protect the resource from unwanted inputs, and it also protects the property owner. Best management practices can be used effectively.

13. Locate and construct the maintenance facility with regard to spring pathways. The location should be maximized for efficiency of operations, safe operations of equipment, correct siting of washpads, pesticide storage and mixing areas, fuel islands, equipment maintenance, etc., to minimize the potential for negative incidents, and ease of deliveries. The maintenance facility should be located as far as possible from any pathway to the spring.

14. Build bridge crossings so that the impact to the environment is minimized during construction. Erosion barriers described in the Erosion Control Plan (silt fence with hay bales, and sedimentation ponds where needed) will be in place for bridge crossings. Bridge construction will be conducted so that construction equipment does not enter a stream, wetland or other waterbody; rather, only the location of the footings will disturb the bottom areas. The bridges are built with the bridge itself as the work platform. Clearing should be by hand to avoid damaging the wetland or waterbody with heavy equipment.

15. When clearing for the cart path, follow the guidelines for clearing of the golf course. The cart path should be routed to avoid sensitive areas and areas that have been identified for protection (specimen trees). Erosion barriers described in the Erosion Control Plan (silt fence with hay bales, and sedimentation ponds where needed) will be in place for construction. Construction will be conducted so that equipment does not enter sensitive areas, or disturb areas that are otherwise undisturbed.

Monitoring Practices. Environmental monitoring during golf course construction is conducted to establish environmental conditions during construction and provide a basis for measuring compliance with environmental regulations. Data are also compared to baseline conditions established for the site during previous phases.

Results of the monitoring program will also measure the success of the construction management strategies and practices on the springshed. By ongoing monitoring, the success of the construction practices program is continuously evaluated and the construction team must be ready to revise and adjust practices should the data indicate negative impacts during construction.

Create a Golf Course-Specific Natural Resource Management Plan

As with siting, design and construction, golf course management must be approached holistically. Impacts to and from a golf course do not respect property lines. Creating a golf course-specific Natural Resource Management Plan is the best vehicle to do this. Starting at the site evaluation stage, and moving through the development process to the daily maintenance and operation stage, the management plan uses each stage and analysis to build upon and support the various activities involved in developing an environmentally-sensitive golf course. The management plan ties all the information and management practices together to ensure that every action supports and enhances every other action. The management plan becomes the "owners manual" or "guidebook" for the golf course developer, manager and superintendent to follow at every stage of golf course development and operation. The Natural Resource Management Plan should be updated as part of a yearly review of operations.

Although not discussed in this here, the management plan should also address wildlife conservation and enhancement, energy conservation, and waste management.

Every new golf course in a springshed should be required to prepare a Natural Resource Management Plan and should participate in a nationally-recognized golf course certification program, such as the Audubon International Signature Program or equivalent program. The attachment on page 94 contains an outline of a plan developed by Audubon International.

Environmental Planning. This portion of the plan focuses on identifying sensitive resources on the site and developing the BMPs needed to protect them. The information generated during the site evaluation and selection stage forms the backbone of this analysis. Additionally, the design and construction activities,

Natural Resource Management Plan Considerations for Springs

- Environmental Planning
- Integrated Pest Management
- Water Conservation Management (Irrigation)
- Water Quality and Environmental Monitoring
- Maintenance Facility
- Oversight and Ongoing Evaluation/ Response

(Natural Resource Management Plans for Golf Course Management, Audubon International, 1995)

described earlier, are incorporated into this portion of the management plan.

Using the site evaluation information, preventive measures can be incorporated into the course design to protect sinkholes or other areas which are a potential pollution path to a spring. Once the resources are clearly identified, specific management zones can be delineated. These could include buffer zones, no-spray zones, limited spray zones or erosion control zones. BMPs should then be identified for implementation in each individual zone based on the specific site characteristics and location. Examples of this are maintaining a undisturbed buffer zone around a sinkhole, or ensuring that the turf variety most suited to the specific climatic conditions of the course is utilized so that pesticide/fertilizer needs are reduced.

Integrated Pest Management (IPM). The primary cultural practices that produce and sustain a healthy turf are mowing, irrigation, fertilization and cultivation. The best deterrent to weed, insect and disease infestation is a healthy turf. Thus, maintaining hearty grasses will minimize the need to apply pesticides. The Natural Resource Management Plan should include detailed information on mowing, fertilizing, irrigation and cultivation, including a basic annual maintenance plan.

IPM uses information about turfgrass pest problems and environmental conditions which may precipitate these problems, and integrates this information with turfgrass cultural practices

The Audubon International Signature Program

The Audubon International Signature Program is the only nationally-recognized golf course certification program for new golf courses. The program is based on a proactive, holistic, watershed approach that applies scientifically-based environmental decisions to siting, design, construction and operations of golf courses. This approach integrates watershed environmental attributes and agronomic practices and provides maximum protection of watershed water resources, and minimization of the potential for negative impacts. Costs associated with this program have a payback of approximately one year, and annual savings in operations are realized for the life of the golf course.

The Signature Program involves:

1. Preparation and implementation of a Natural Resource Management Plan for a site;
2. Implementing prevention, management and monitoring practices throughout the siting, design, construction and management of the golf course;
3. Incorporating these practices in a springshed-based approach to water management that stresses optimum site planning and the use of natural drainage systems;
4. Use of BMP trains, IPM, and environmental monitoring; and
5. Annual site reviews and re-certification.

There are three levels of the Signature Program: Bronze, Silver and Gold. The primary difference between the levels is based on the stage at which the project applies for membership, the complexity of the project, and the level of Audubon International involvement in the planning, design and oversight of the project. At the Silver level, environmental and agronomic experts at the Audubon International Institute actually prepare the Natural Resource Management Plan; and at the Gold level, scientists from the Institute work with the developer in siting, planning, design, construction and operations, and they prepare the Natural Resource Management Plan, an Ecological Design, a Community Education Program, and a Green Building Program. See www.audubonintl.org for additional information.

Audubon International also has a program for existing golf courses, the Audubon Cooperative Sanctuary Program.

Audubon International is a not-for-profit environmental organization that is not associated with any other environmental organization. Audubon International is affiliated with the Audubon Alliance.

and pest control measures to prevent or control unacceptable levels of pest damage. It is itself a Best Management Practice. IPM is not a new idea, as these practices have been an integral part of general agriculture for almost 40 years. However, as concern over the protection of natural resources has increased, it has become more refined and taken more of a systematic approach. This approach integrates a number of efforts including:

- Development of a healthy turf that can withstand pest pressure;
- Judicious and efficient use of chemicals;
- Enhancement of populations of natural, beneficial organisms; and
- Effective timing of handling pest problems at the most vulnerable stage, often resulting in reduced pesticide usage.

As a component of IPM, the golf course superintendent must make decisions about pest problems and develop control recommendations including the judicious use of pesticides. Strategies must include identifying an anticipated pest complex and understanding the biology behind the pest. For example, determining the interrelationship of disease infection and expression of symptoms, noting temperature ranges when diseases are active, and identifying timing for optimum insect and weed control must be understood. Thresholds should be set for each specific local pest problem and then adjusted as necessary based on effectiveness of IPM options. As part of the strategy, an approved pesticide list based on the pesticide risk assessment previously noted should be compiled for each specific pest problem.

IPM programs rely on six basic approaches for plant and environmental protection. These include the following:

Regulatory. Use certified seed and sod to prevent unwanted weed contamination and select the best adapted turfgrass species.

Genetic. Select improved grasses which perform well in specific areas and show a resistance to pest problems.

Cultural. Follow recommendations made for proper primary and secondary cultural practices which will maintain the turf in the healthiest condition and influence its susceptibility and recovery from pest problems. Practices such as aerification, vertical mowing, topdressing, maintenance of proper soil nutrient levels, sound irrigation management and proper mowing techniques should produce a high quality turf.

Physical. Clean equipment to prevent spreading of diseases and weeds from infected areas.

Biological. For a limited number of pest problems, use biological control whereby natural enemies are introduced to effectively compete with the pest.

Chemical. While pesticides are a necessary and beneficial approach to turf pest problems, their use can be restricted in many cases to curative rather then preventive applications, thus reducing environmental exposure. Pesticides selection is based on a risk assessment approach. Pesticides selected for use on specific pest problems should be limited to those which

Components of the IPM Approach

- Monitoring potential pest populations and their environment
- Determining pest injury levels and establishing treatment thresholds
- Decision making in developing and integrating all biological, cultural and chemical control strategies
- Educating personnel on all biological and chemical control strategies
- Timing and spot treatment utilizing chemical, biological or cultural methods
- Evaluating the results of treatment

IPM Approaches

- ***Regulatory*** – using certified planting stock
- ***Genetic*** – selecting improved grasses
- ***Cultural*** – proper implementation
- ***Physical*** – isolating infected areas
- ***Biological*** – using or favoring natural control
- ***Chemical*** – use of pesticides approved through risk assessment

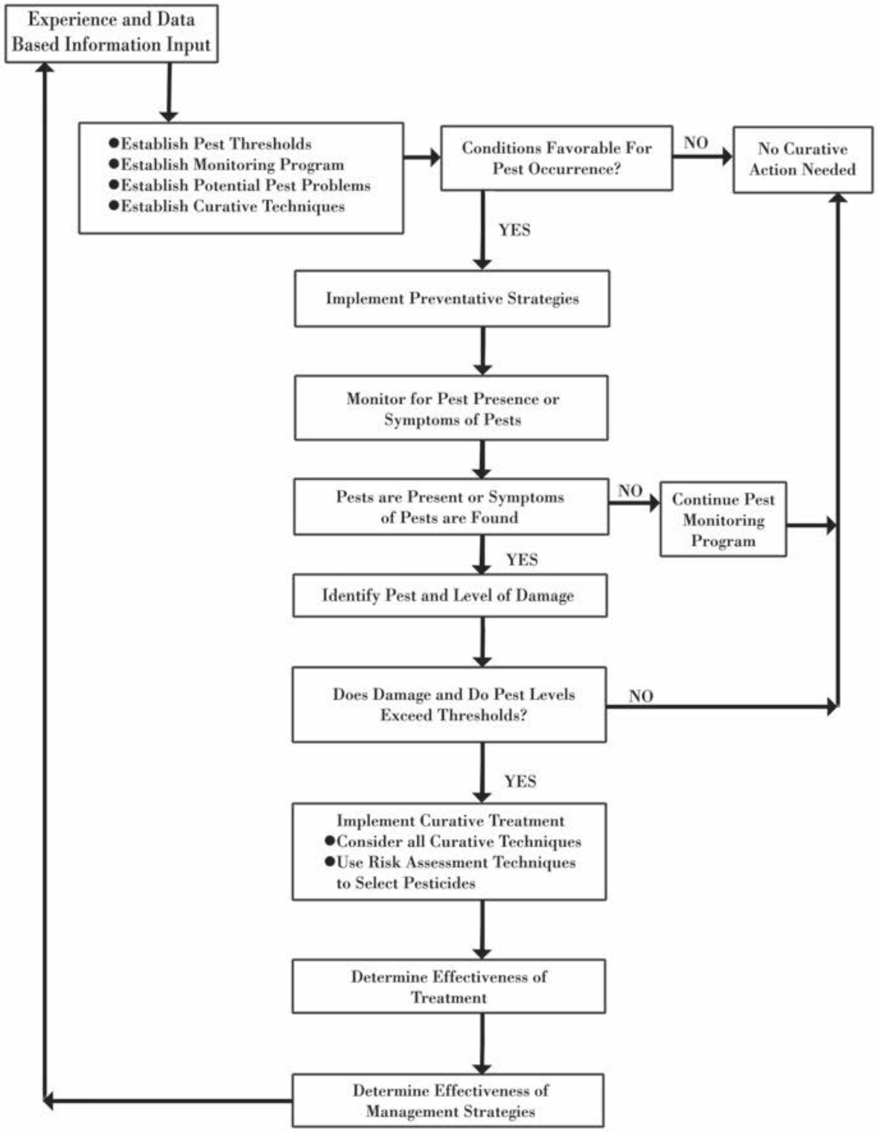


Figure 4.8. There are a series of steps for decision-making using Integrated Pest Management.

have demonstrated a high degree of effectiveness, are not toxic to non-target species, act quickly and degrade quickly, and are not soluble and not persistent. Few pesticide applications will be made on a regularly scheduled basis. Exceptions may include preemergence herbicides and fungicides used to control certain diseases. Additionally, materials must be applied strictly in accordance with label instructions, at labeled rates, under appropriate environmental conditions (no spraying on windy days or when rain is forecast), with a low-volume sprayer to reduce the possibility of drift. Materials should be used on a rotating basis to deter the development of resistant strains of pests which may require more frequent and/or higher rates of pesticide applications.

One of the most critical components to IPM programs is monitoring. A well-trained and experienced employee should scout on a daily basis to detect symptoms of a pest problem. A site specific history should be maintained. Other golf course superintendents in the area or specialists in turfgrass management should be consulted, as needed. A successful IPM scouting and monitoring plan must ensure that the following steps are followed:

1. Assign individuals to conduct the scouting, record the results, evaluate the information and make appropriate decisions based on this information. This may be done in a team approach with the scout consulting with specific members of the staff, or it may be an individual IPM specialist.

2. Provide proper education and training of all involved in any aspect of the IPM program. This should include formal seminars, workshops, conferences, short courses, and other IPM training opportunities. In-house training sessions for the maintenance crew should be held to inform them of IPM strategies.
3. Review, at least annually, the complete program and evaluate its effectiveness. Changes will constantly be made as the golf course matures, changes in design are made, or as new information concerning handling of turf management or pest problems becomes available.

Irrigation Management and Water Conservation. Water management, through irrigation practices and conservation techniques, is important for golf courses in a springshed. As noted earlier, too much or too little water leads to maintenance problems, contributing to the need for pesticide/fertilizer applications. Water is the mode of transportation for contaminants into surface and ground water resources, including springs, so the use of water on the course is important. Additionally, excessive water withdrawal for irrigation can impact water levels in springs.

The overall management plan should address irrigation and water conservation practices, with one of the goals being to reduce the demand for water. To assist in this effort, a number of BMP strategies can be used. Initially, the various golf areas should be prioritized in terms of whether irrigation will be necessary, and what level of irrigation will be required. Greens, for example, would be given the highest irrigation priority, while roughs or out-of-play areas may be given no irrigation. This prioritization will help in the design of an appropriate irrigation system, as well as help managers determine what should be watered in times of water restrictions or drought. Reducing the amount of irrigated turf areas where possible can help. Where available, effluent water for irrigation should be used.

Irrigation patterns and control systems should be planned and programmed to meet the needs of the plant and turf species. Using the right plants initially can reduce irrigation requirements, so wherever possible, use native, naturalized or specialized drought-tolerant plant materials. Choose turf species that are well suited to the local climate and soils. Additionally, make sure that the irrigation system distributes the water uniformly over the designated area and only as fast as the soil can absorb it. Regularly inspect the irrigation system and quickly fix any leaks or operational problems. Water at the appropriate time to minimize evaporation and reduce disease potential. Avoid watering at peak evaporation periods. Automatic irrigation systems reduce unnecessary watering and should include a shut-off mechanism if it begins to rain.

Water Quality and Environmental Monitoring. Maintaining water quality at the golf course includes the processes described in the siting, design and construction sections of this chapter. In this section, under IPM programs, cultural practices including careful selection of materials for use on the golf course were identified to provide protection to spring water quality. The environmental monitoring program is an important aspect of the overall water protection program. An environmental monitoring program should:

1. Establish a baseline of water and sediment quality prior to construction;

Characteristics of an Environmental Monitoring Program

- Establishes a baseline
- Provides data to assess compliance
- Provides information on management
- Is developed in phases
- Includes surface and ground water
- Identifies where samples are taken, how often they are taken, what should be analyzed, and what should be done if established criteria are exceeded

2. Provide data that will establish environmental conditions, thus providing a basis for measuring compliance with environmental regulations; and
3. Ensure that Integrated Pest Management is functioning properly.

The golf course management program is evaluated based on the results of the monitoring program. Based on this evaluation, the management plan may need to be revised and adjusted. This kind of adaptive management is a key to successful conservation management.

The environmental monitoring program is usually established in three phases that coincide with golf course development. Phase I is background; Phase II is construction and development; and Phase III is the post-development, operational golf course. During each phase, samples are collected and analyzed, and the results evaluated.

There are several steps to setting up a water monitoring program.

1. Identify what will be sampled. The goals of the program will dictate what needs to be sampled. In springsheds, it is important to sample both surface and ground water resources because of the geologic connection between them. Consideration should also be given to sampling shallow sediment. Sediment generally accumulates material and is considered a good indicator of environmental quality.

2. Identify the sample locations. To determine sample locations, survey the water bodies on the golf course. If there are only a few, all of them may be sampled. Golf courses with many water features may choose to sample representative water bodies. The number of sample locations is highly site dependent. For ground water, sample locations are chosen based on the projected flow of ground water. Three or four sample locations are the minimum number required to assess water quality. When establishing the program, remember that sampling the same location over time is important so that comparisons can be made.

3. Determine sampling frequency. Identify how often each location will be sampled over a year's time. It is important to sample during different seasons because the environment responds differently during each season.

4. Determine the variables that will be sampled. Test for general water characteristics (temperature, pH, conductance, dissolved oxygen) as well as nutrients (primarily phosphorus and nitrogen) and pesticides. Select pesticides for analysis based on their aquatic toxicity, water solubility and adsorption coefficient (Koc), using the procedure for selecting pesticides to reduce adverse water quality impacts in the Florida Cooperative Extension Service's Managing Pesticides for Golf Course Maintenance and Water Quality Protection. Pesticides may also be selected based on an ecological risk assessment.

5. Identify the sampling field methods. Clearly identify the methodology for taking samples.

6. Identify the laboratories to perform the sample analysis. Make sure that these labs are certified by the State of Florida and have strong quality assurance and control practices in place. Also, make sure that the lab can detect variables at appropriate concentrations as this is often a concern with pesticides.

7. Determine the data storage techniques. Storage of data should be determined in the beginning of the monitoring program. Storage should be both on a computer diskette and on paper. The computer storage allows the data to be easily analyzed and used to better manage the course.

8. Establish criteria for management response. There should be specific criteria against which the sampling results can be compared. If a criterion is exceeded, then a problem is occurring and a management response is required. Specific, step by step responses that will be undertaken if the criteria are exceeded should be identified in Phase I of the monitoring program.

Maintenance Facilities. The importance of locating the maintenance facility in an appropriate location was previously discussed. Management practices should be implemented at these maintenance areas that will prevent the contamination of natural resources by the materials that are stored or handled at these sites. Prevention of problems is the goal and the general approach to management of maintenance facilities involves three principles:

- Isolate all potential contaminants from soil and water;
- Do not discharge any material, other than clean storm water, onto the ground or into surface water bodies; and
- Minimize irrigation, fertilizer, and pesticide use requirements through use of Integrated Pest Management and native vegetation.

The design of the maintenance facility must adequately address: equipment wash area (including, blowing-off equipment, clipping disposal, wash water disposal and recycling); pesticide storage, mixing, loading and pesticide equipment wash area; fuel island (including containment of spills and leaks, and mixing with rain water); and fertilizer storage, including application tanks.

At the maintenance facility the areas that require extra attention include the pesticide storage and mixing facility, the wash pad area, and the fuel island. Attention must also be given to degreasers, oil (new and used) storage, and battery storage. Degreasers are usually supplied by a service that removes and recycles used material and replenishes with clean material on a routine basis; used oil and batteries should be recycled.

Size and access to the maintenance facility are important considerations. The maintenance area is generally 2 to 3 acres, and must be readily accessible. The layout of the facility should allow easy and safe access by trucks with 10 wheels or more. One layout that works well allows large trucks to circle the facility, thus entering and exiting without backing.

Figure 4.9. This pesticide storage, mixing and loading facility helps to prevent environmental problems by containment and recycling of rinsate water.

Pesticide Storage and Mixing. Pesticide storage and mixing should be in a separate room or building designated for these materials only. This facility should be located away from the spring, pathways to the spring, and other water bodies (wells, ponds, streams). The building must be kept locked and posted as required by law. All pesticides should be stored in their original containers with visible labels.

The following are best practices for the pesticide mixing and storage facility:

- Install a complete alarm system, with battery backup, for burglary and fire;
- Install a telephone;
- Use locks and bolts should be of the highest quality materials available;
- Use high quality durable plastic or metal materials to avoid adsorption of chemical residues or vapors; and shelving must be sturdy and secured to avoid sagging and falling;
- Install an explosion-proof fan and explosion-proof light;
- Ensure adequate ventilation;
- Store pesticides at least 6 feet off the floor on non-absorbent shelving;

- Segregate pesticides by liquid, powder or granular class;
- Store all powders and granules above liquids;
- Slope the entire floor to the center of the room with a centrally-located recessed sump;
- Seal the concrete pad with a solvent resistant material (e.g., epoxy paint) to prevent leaching of any contaminants;
- Locate a light and fan switch outside of the door entering the control center, as well as locating an emergency equipment box on the outside of the building and include a fire extinguisher, respirator, first aid supplies, goggles, respirators, gloves, and rubber boots;
- Include a sink with potable water, spigot and hand blower with the drainage funneled back into the sump;
- Attach a mixing table to the sink at a slightly higher elevation to allow overspill to be washed into the sink;
- Locate a portable eye wash bottle over the sink, and install an eye wash/shower station supplied by potable water immediately outside the facility;
- Locate a refill hose above the sump to allow proper and timely filling of spray tanks with water;
- Keep absorbent floor-sweep materials, sawdust or cat litter and activated charcoal on hand to be prepared for spills and/or leaks; and
- Keep readily accessible an inventory of pesticides and other chemicals and MSDS and labels for each pesticide used.

Figure 4.10. This wash pad and fuel island complex helps to prevent problems by containment and recycling.

Wash Pad. The runoff associated with wash water and debris from equipment wash areas have the potential to cause environmental problems. The following are best practices for the wash pad:

- Recycle water used to wash equipment and filter contaminating materials, such as grease, oil and gasoline, from this recycled water;
- Wash pesticide equipment in the pesticide facility, not in the wash pad;
- Roof the wash-down area to keep rain off the pad and prevent excessive water from going into the recycling system;
- Elevate the pad along the outer edges to direct rain water away from the area, but recess the center area from normal ground level to allow for wash water to be collected for recycling. The roof should be high enough to allow golf course equipment the proper amount of clearance, yet low enough to meet any aesthetic requirements (visibility to homeowners, etc.);
- Attach air hoses to posts near the wash pad and use them to remove excessive grass residue off equipment prior to moving onto the wash-down pad; this practice will reduce the amount of grass clippings/debris entering the water recycle system;
- Use a pad with triple screen baskets, weighing less than 40 pounds each, to prevent an excess of grass clippings and debris from

entering the recycling system; grass clippings should be composted and recycled on the golf course;

- Utilize hoses with attachable spray bottles of liquid wax at the wash-down pad so valuable equipment can receive a brief application of liquid wax (cut with water) after each use;
- Use impermeable concrete in the pad to prevent leaching of any contaminates; and
- Install lightning protection in this area for worker and equipment protection.

Fuel Island. Fuel islands have the potential to cause environmental problems. Leaks or spills of gasoline and diesel fuels can result in expensive clean-up efforts as well as environmental contamination. General considerations for fuel islands include the following actions:

- Cover the fuel island to reduce the amount of rainwater that enters the area;
- Install adequate lighting around and beneath the roof to allow for operation during periods of darkness or inadequate light;
- Install lightning protection on the fuel island roof;
- Store fuel in above ground, double vaulted tanks from a reputable manufacturer;
- Utilize above ground devices for fuel carrying mechanisms, if possible;
- Elevate the pad along the outer edges to direct rain water away from the area, but recess the center area from normal ground level to allow for containment in the event of a fuel spill;
- Use impermeable concrete in the pad to prevent leaching of any contaminants; and
- Have the Fire Marshall and other appropriate authorities review the specifications prior to construction of the fuel island.

Oversight and Ongoing Evaluation. Oversight and ongoing evaluation of the golf course is a major building block for golf course management. Periodic site evaluations provide a means to assess the operations of the golf course with field observations and review of monitoring and IPM data. An annual onsite review should be conducted. This review should use the Natural Resource Management Plan as a template, and review pesticide, fertilizer, and irrigation records, the IPM program, BMPs, special management zones, the maintenance facility, and cultural management practices.

Often local governments do not have sufficient in-house expertise to evaluate plans, potential construction impacts, operations of golf courses, and conduct an annual review. The annual review should be conducted by a nationally-recognized golf course certification program, such as the Audubon International Signature Program. It offers third-party oversight, and ongoing re-certification ensures that this oversight continues for as long as the course is operational. By having golf courses enrolled in a nationally-recognized certification program, the technical expertise is available to evaluate the operations of the golf course and monitoring data. Also available is education for golf course superintendents on pertinent topics such as research results for practices or new pesticides that may be appropriate for the golf course. Enforcement of the plan rests with maintaining certification in the nationally recognized certification program.

Coordination and communication with local governments is important in this process, whether for a golf course that will be constructed or an existing course. Field observations, monitoring and IPM data should be communicated to the local government via an annual report. Should remedial actions be required, these actions are specified and follow-up site visits are conducted to determine completion and compliance.

Be Sure To Check Out These Resources!

Best Management Practices for Florida Golf Courses, Second Edition, was published by the Institute of Food and Agricultural Sciences at the University of Florida, in 1999. This book covers putting green construction, water management , fertilization, cultural practices and pest management. It is available through county extension offices or by contacting UF/IFAS Publications at 1-800-226-1764.

Best Management Practices for Golf Course Maintenance Departments, **www.dep.state.fl.us/water/stormwater/pubs.htm**, was published by the Florida Department of Environmental Protection in 1995. It provides specific BMPs covering pesticide storage, mixing and loading, equipment washwater; solvents and degreasers; fertilizers storage and loading; used oil, antifreeze, and lead-acid batteries; fuel storage; and general equipment washing and storage.

A Guide to Environmental Stewardship on the Golf Course, published by Audubon International in 1996, provides a good overview of practical conservation management strategies for a golf course and how to integrate them into on-going maintenance activities. It covers environmental planning, wildlife and habitat management, integrated pest management, water conservation, water quality management, and outreach/education. Call 1-518-767-9051 to order a copy.

Audubon International Signature Sanctuary Program, **www.audubonintl.org/**, is a recognized comprehensive management approach for the development and operation of golf courses. It is administered by Audubon International, a not-for-profit environmental organization.

United States Golf Association's (USGA) Green Section, **www.usga.com/green/index.html**, is the group within the USGA that is involved with every aspect of golf course design and maintenance. This web site has a variety of information about various construction techniques for golf courses, as well as links to related industry sites.

The Natural Resource Conservation Services' *National Conservation Practices Standards*, **www.ftw.nrcs.usda.gov/nhcp_2.html**, identifies national standards for various conservation practices commonly used to treat natural resource problems (soil, water, plants, animals). For each standard, information is provided regarding application, criteria, considerations, plans and specifications, and operation/maintenance. Examples of standards included are riparian forest buffer, filter strip, and nutrient management.

Attachment

Elements of A Natural Resource Management Plan

1.0 INTRODUCTION

- 1.1 MANAGEMENT APPROACHES AT THE PROJECT SITE
  - 1.1.1 Prevention
  - 1.1.2 Management
  - 1.1.3 Detection
- 1.2 CONCEPT OF BEST MANAGEMENT PRACTICES AND INTEGRATED PEST MANAGEMENT
  - 1.2.1 Best Management Practices
  - 1.2.2 Integrated Pest Management

2.0 ENVIRONMENTAL PLANNING

- 2.1 SITE DESCRIPTION AND EVALUATION
  - 2.1.1 Physical Setting
  - 2.1.2 Topography
  - 2.1.3 Surface Water
  - 2.1.4 Soils
  - 2.1.5 Climate
  - 2.1.6 Vegetation and Wildlife
- 2.2 ENVIRONMENTAL CONSIDERATIONS AND REQUIREMENTS
  - 2.2.1 Environmentally Sensitive Areas and Management Zones
  - 2.2.2 Management Zones at Project Site
  - 2.2.3 Best Management Practices to Protect Environmentally Sensitive Areas

3.0 INTEGRATED PEST MANAGEMENT

- 3.1 AGRONOMIC CONSIDERATIONS AND REQUIREMENTS
  - 3.1.1 Soil Mixes and Modifications
  - 3.1.2 Turfgrass Selection
- 3.2 GOLF COURSE CULTURAL PRACTICES
  - 3.2.1 Mowing
  - 3.2.2 Fertilizing
  - 3.2.3 Cultivation Practices
- 3.3 BASIC ANNUAL MAINTENANCE GUIDE
- 3.4 PESTICIDE SELECTION
  - 3.4.1 Pesticide Use Restrictions
- 3.5 SPECIFIC LOCAL PROBLEMS
  - 3.5.1 Disease Control
  - 3.5.2 Insect Control
  - 3.5.3 Weed Control
- 3.6 SOLUTION PROGRAM FOR PROJECT SITE
  - 3.6.1 Scouting Program for Project Site
  - 3.6.2 Record Keeping
- 3.7 MANAGING THE PROGRAM - PERSONNEL
  - 3.7.1 Superintendent
  - 3.7.2 Assistant Superintendent
  - 3.7.3 Irrigation Technician
  - 3.7.4 Pesticide Technician
  - 3.7.5 Mechanic
- 3.8 PESTICIDE SAFETY
  - 3.8.1 Storage
  - 3.8.2 Handling and Application
  - 3.8.3 Disposal
  - 3.8.4 Pesticide Record Keeping
  - 3.8.5 Spill Prevention and Response

4.0 IRRIGATION MANAGEMENT FOR WATER CONSERVATION

- 4.1 IRRIGATION
- 4.2 IRRIGATION WATER MANAGEMENT

Attachment 2 *(Source: this chart is adapted from one prepared by the National Wildlife Federation, www.nwf.org/northeastern/resources/bmp.pdf)*

Non-Structural Best Management Practices

	Applications	Examples	Tools
Land Use Planning and Zoning	• Balance development needs with the protection needs of the resource area	• Create environmental overlay zones (primary and secondary) • Restrict activities or set aside land near critical springshed features	• Natural resource inventory and mapping • Springshed protection plans • Land use designation • Conservation easements • Land acquisition
Protected Areas	• Protect certain resource areas by restricting development and certain land uses	• Identify critical areas • Establish buffer zones • Establish setback requirements • Employ use restrictions • Transfer development rights • Concentrate development and maintain open space	• Comprehensive Plan and FLUM • Zoning regulations • Land use and subdivision regulations • Land Trust involvement • Acquisition • Innovative site design • Natural resource inventory
Comprehensive Site Planning	• Minimize site development problems through careful planning	• Identify total area to be developed • Identify priority natural resources for protection • Limit site disturbance • Protect steep slopes • Phase development • Maximize internal capture • Cluster development	• Natural resource inventory • Comprehensive plan's goals, objectives and policies that direct development to appropriate areas • Future Land Use Map • Growth center plan • Subdivision regulations • Developer agreements
Reduced Impervious Areas	• Minimize impervious surfaces • Increase contact between impervious surfaces and vegetated areas	• Concentrate development and maintain open space • Incorporate open spaces into urban areas • Separate or disconnect different impervious surfaces by maintaining or creating vegetated areas • Use permeable pavements as alternatives to concrete and asphalt • Add shared parking provision • Reduce parking requirements	• Innovative site design • Land use regulations that require inclusion of greenways and open spaces in new developments • LDRs and local development review processes that reduce parking requirements and provide for shared parking
Sanitary Waste Management	• Reduce or eliminate pollution from sanitary sewers and private septic system	• Sewer critical areas to serve existing development • Require proper septic design, installation and maintenance • Establish septic tank management programs	• Health ordinances • Septic ordinances • Septic management plan • Allocation ordinances

Structural Best Management Practices

	Applications	Requirements	Limitations/Problems
Erosion and Sediment Control BMPs *(control erosion and resulting sediment pollution)*			
Erosion Control			
• Schedule projects during dry season and growing season • Stage Construction • Seeding/mulching • Check dams • Runoff diversions • Vegetated swales	• Reduce erosion by disturbing the smallest area of land possible for the shortest period of time; stabilize soils to prevent erosion from occurring	• Climate, topography, soils, drainage patterns, and vegetation will affect how erosion and sediment should be controlled on a site	• Proper placement and maintenance are essential • Delays in stabilizing exposed soil can have huge impacts • Exposing soils in the winter runs the risk of failing to establish vegetative cover
Sediment control			
• Sediment basins/traps • Filter fabric/silt fences • Use PAM (polyacrilimide) • Inlet Protection	• Retain sediment onsite during and after construction	• Climate, topography, soils, drainage patterns, and vegetation will affect how erosion and sediment should be controlled on a site	• Proper placement and maintenance are essential
Infiltration BMPs *(control pollutants such as nutrients, pathogens, trace metals and organics)*			
Infiltration BMP's			
• Infiltration basins • Trenches • Swales • Leaching catch basins • Infiltration islands • Pervious surfaces (porous pavement, modular paving blocks)	• Provide holding area for runoff to allow infiltration into the soil profile • Provide for pollutant removal • Promote ground water recharge • Protect fisheries by reducing the temperature of stormwater runoff • Reduce stormwater volume	• Porous soils • Sufficient depth to ground water • Integrate into a site's landscaping • Do not always require large tracts of land	• Must consider local conditions like soil type and depth to avoid ground water contamination • Use and maintain filter strips or sediment basins to remove excess loads of sediment, grease, oils and trash before stormwater is allowed to enter the infiltration device • To maximize life span of practice careful planning must precede implementation • Do not use for erosion and sediment control • Proper construction and maintenance are essential
Retention BMPs *(control pollutants such as nutrients, suspended solids, organic matter and trace metals)*			
Retention BMPs			
• Wet ponds	• Provide for storage of stormwater runoff in a permanent pool • Promote settling of suspended solids and associated pollutants • Remove pollutants through vegetative uptake	• Nonporous soils or liner necessary • Not suited to areas with extreme slopes	• Proper construction, inspection, and maintenance are essential • Safety concerns may warrant fencing of structure
• Constructed wetlands	• Control peak stormwater discharges to minimize flooding • Provide temporary storage of stormwater runoff with gradual release	• Not suited to areas with extreme slopes	

Agriculture and Silviculture

The primary concerns associated with agricultural and silvicultural activities are the leaching of nutrients and pesticides into surface and ground water and the withdrawal of ground water for irrigation. Sedimentation and turbidity around sinkholes and other karst features are secondary concerns.

This section provides an overview of common BMPs for agricultural and silvicultural activities, and identifies additional resources and assistance opportunities:

- Implement Agricultural BMPs
- Take Advantage of Assistance Opportunities for Agriculture
- Implement Silvicultural BMPs
- Take Advantage of Assistance Opportunities for Silviculture

Springs are vulnerable to changes in nutrient levels resulting from agricultural and silvicultural activities within the springshed. Instead of entering the system from a single point, such as a pipe, runoff from agricultural and silvicultural activities occurs when water flows over or through the ground, picking up contaminants and transporting them to surface and ground water. This type of runoff is defined as "nonpoint." Because there are many areas on a site that contribute contaminants, BMPs for nonpoint source pollution target water movement and the substances carried in that water. BMPs must address the operation as a whole in order to be effective.

Springs are also sensitive to the withdrawal of ground water from the aquifer for irrigation. Water withdrawals from the aquifer can directly reduce the spring's flow. Some BMPs target reducing the need for irrigation withdrawals by encouraging irrigation efficiency.

The Florida Department of Agriculture and Consumer Services (FDACS) has authority for BMP development for the nonpoint source water quality impacts associated with agricultural practices. BMPs address the protection of ground water and surface water from potential impacts associated with the use of fertilizers and other agrichemicals.

In Florida, the 1999 Watershed Restoration Act, codified under section 403.067, Florida Statutes, directs BMP

Key Practices for Agricultural and Silvicultural Operations

- Focus on reducing the movement of nutrients, pesticides and sediments off-site and to surface and ground waters, and reducing water withdrawal for irrigation purposes.
- Implement agricultural and silvicultural BMPs to reduce impacts to springs.
- Discourage intensive agricultural and silvicultural activities such as concentrated animal feeding operations, row crops, or short-rotation timber operations on intensively prepared sites within the primary zone of a springshed.
- Encourage silviculture and low intensive agricultural activities, such as range land, in the secondary protection zone of a springshed.
- Discourage intensive agricultural or silvicultural activities in close proximity to the spring head or other karst features.
- Buffer agricultural and silvicultural operations from springs and other karst features.

development, implementation and cost-share as the preferred means to address nonpoint source water quality impacts.

Current BMP initiatives center around building partnerships, thus providing a framework for the successful development and delivery of BMPs statewide. Several sectors of Florida's agricultural industry are already working in a proactive manner to develop and adopt BMPs.

Implement Agricultural BMPs

Agricultural activities commonly use pesticides and fertilizers to increase crop yield and control pests. Dairy farms, or other concentrated feeding operations, produce significant amounts of manure and other animal waste that are a major source of phosphorus and nitrates. Excess nutrients from these activities can leach into surface and ground water, contributing to the contamination of springs. This can lead to problems in streams and rivers flowing from the spring, including increased growth in nuisance aquatic vegetation. BMPs address animal waste management and the application of fertilizers and pesticides.

BMPs are effective tools for controlling potential nonpoint source water quality impacts associated with agricultural practices. When using them, it is critical that the BMPs be compatible with the agricultural activity for which they are intended, and that they strike a balance between water quality improvement and agricultural productivity. In general, agricultural BMPs are designed to reduce the movement of pesticides, fertilizers and sediments off the site and into surface and ground waters. Again, water is the primary form of transport of these pollutants.

Section 403.067, F.S. provides that, once FDACS adopts and the Florida Department of Environmental Regulation (FDEP) verifies the effectiveness of agricultural BMPs in reducing nonpoint source pollution, farmers will have a rebuttable presumption of compliance with state water quality standards if they implement BMPs. This exemption provides landowners with incentives to use BMPs.

Many farms in Florida implement some type of BMPs. Some options follow.

Conservation Tillage. This low- or no-tillage cultivation practice involves leaving crop residue(s) on the soil surface to reduce runoff, soil erosion, conserve soil moisture, and to help keep nutrients and pesticides on the field.

Crop Nutrient Management Budgeting. Proper nutrient management focuses on soil testing, identifying crop needs, and precisely applying fertilizer materials based on sound agronomic practices. This helps to reduce the amount of excess nutrients available to move offsite. All sources of plant nutrients are incorporated into this management tool.

Integrated Pest Management. IPM is a comprehensive approach combining biological,

Nitrate Levels in Spring Water

In 1996, the Southwest Florida Water Management District completed a study of nitrates in Rainbow Springs, entitled *Origin of Nitrate in Ground Water Discharging from Rainbow Springs.* Rainbow Springs is a first magnitude complex of springs located in southwest Marion County. It forms the headwaters of the Rainbow River, one of the longest spring runs in the world. The study examined the origin of increased nitrate levels in the spring water and concluded that the main source of nitrate was inorganic fertilizer from pasture fertilization.

While a local government can recommend the use of IPM techniques, they are precluded from regulating specific pesticides — this is the prerogative of state and federal government.

cultural and/or other methods to manage pests. Examples of IPM practices include visually looking for pests (known as scouting), rotating crops, planting pest resistant crops, encouraging beneficial insect populations, and selectively utilizing crop protection chemicals. Incorporating buffer areas between pesticide application areas and karst features is especially important.

Conservation Buffers. With this approach, strips of land are maintained in permanent vegetation to help control pollutants and convey water more slowly. Buffers can help to stabilize soil, reduce wind effects, intercept sediments, nutrients and pesticides in surface runoff, and prevent potential pollutants from getting into springs. As recommended in the Florida Springs Task Force Report published in 2000, a 100-foot undisturbed buffer should be left around sinkholes and other karst features that are connected to springs conduits.

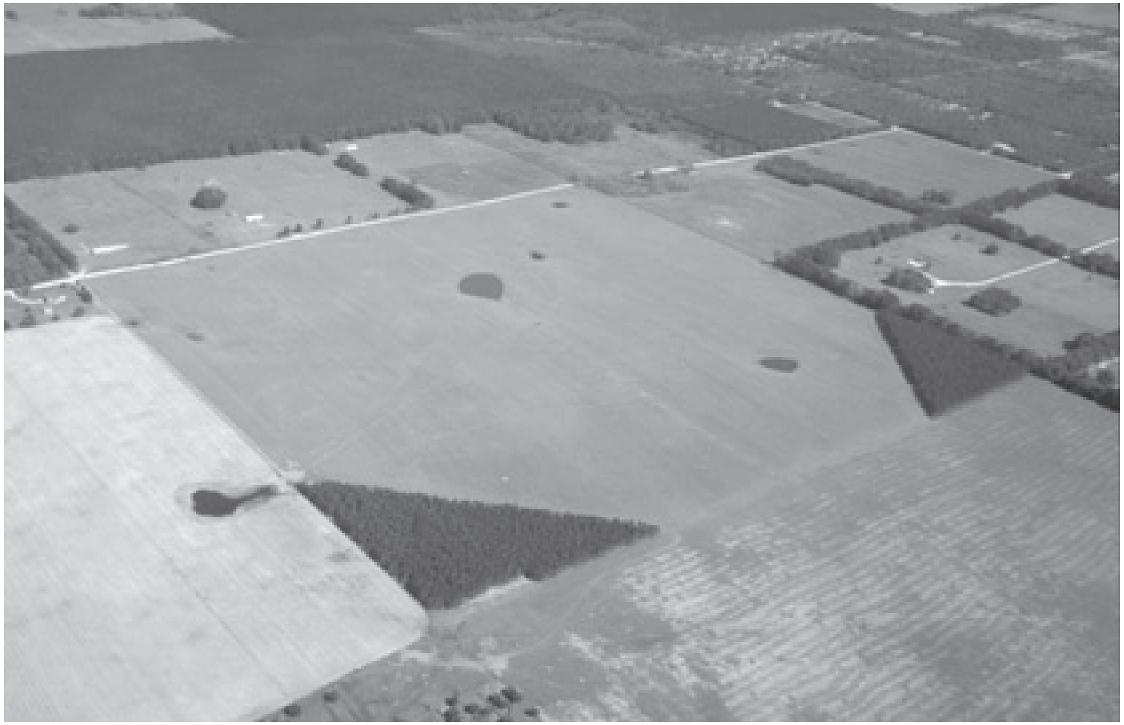


Figure 5.1. (Top) Nutrients and other contaminants can be carried by runoff from these fields directly to the sink.

Figure 5.2. (Bottom) Providing a buffer around a sink helps to trap contaminants before they reach the sink.

Irrigation Management. This important practice can maximize the efficient delivery of irrigation water through operational management practices such as irrigation scheduling, system performance evaluation, reusing irrigation run-off, and proper management of drainage water. Converting irrigation systems to drip irrigation or micro-irrigation is very useful in reducing overall water consumption and controlling the delivery of fertilizers and pesticides. Many of Florida's agricultural industries have done this. Monitoring is also an important aspect of irrigation management. The various water management districts can be contacted for assistance with this issue.

Concentrated Animal Feeding Operations Management. If improperly sited or managed, concentrated animal operations (dairies, feed lots and poultry operations) can result in water quality problems from accumulated animal wastes and facility wastewater. These facilities should be located in areas above an aquaclude to reduce potential contamination to the aquifer. If located within the springshed, they should be extensively buffered, sited away from springs, sinkholes, other surface waters, and areas with high ground water recharge. These facilities should not be sited in the springshed primary and secondary protection zones.

Erosion and Sediment Control. Erosion around karst features can cause widespread

Commodity-Specific BMP Manuals

Commodity-specific BMP manuals are available through local extension offices. Many of these manuals have been printed in bulk and distributed to the agricultural community:

Guide for Producing Container Grown Plants. Through a cooperative effort between the University of Florida, Auburn University, Tennessee Tech University, and Virginia Polytechnic Institute, a BMP manual for nursery cultivation was produced in 1995 and published by the Southern Nurserymen's Association. It includes irrigation and fertilization BMPs for the container cultivation of nursery plants. This is being used as the foundation for the development of a manual specifically for Florida. For more information, contact the Office of Agricultural Water Policy in the Florida Department of Agriculture and Consumer Services.

Best Management Practices for Blended Fertilizer Plants in Florida. Cooperatively produced by the Florida Fertilizer and Agrichemical Association, Florida Department of Agriculture and Consumer Services, and the Florida Department of Environmental Protection, this manual was published in October of 1997, and can also be found at **www.dep.state.fl.us/water/stormwater/pubs.htm**.

BMPs for Agrichemical Handling & Farm Equipment Maintenance. Developed jointly in 1998 by the Florida Department of Agriculture and Consumer Services, the Florida Department of Environmental Protection and several industry associations, the manual has recently been revised and gives producers guidance on hazardous materials, pesticide handling, and the proper disposal of waste products. It is available at **www.dep.state.fl.us/water/stormwater/pubs.htm**.

Water Quality Best Management Practices for Cow/Calf Operations. The Florida Cattlemen's Association worked with several state, federal and local agencies in the development of this manual. Many cattle operators throughout the state have been trained in the use of this manual, which was distributed in 2000, and is available at **www.dep.state.fl.us/water/stormwater/pubs.htm**.

Water Quality/Quantity BMPs for Indian River Area Citrus Groves. The Indian River Citrus League led a cooperative effort involving 15 agencies and industry associations in the development of this manual. Although this regionally-specific manual applies to seven east coastal counties, other Florida flatwoods citrus operations can benefit through its use. It is also available at **www.dep.state.fl.us/water/stormwater/pubs.htm**.

Row Crops and Ridge Citrus BMPs. Currently under development, these manuals are expected to be released in 2003. For information about these manuals, contact the Office of Agricultural Water Policy in the Florida Department of Agriculture and Consumer Services.

damage to waterways and springs. Conservation buffers and conservation tillage, as described above, will dramatically reduce the risk of offsite sediment transport.

Take Advantage of Assistance Opportunities for Agriculture

A variety of federal and state cost-share programs can assist cooperating growers with the implementation of on-farm BMPs. This is important because, while agricultural BMPs have emerged nationally as a water quality cornerstone, some BMPs are almost entirely dependent on federal and state funding to help offset significant capital costs to both construct and implement the specific on-farm BMPs.

Other government assistance opportunities such as conservation easements, less-than-fee simple acquisitions, and grower incentive payments can be beneficial to agricultural operations in protecting sensitive resources. In addition, technical assistance also exists in many state agencies and water management districts. Additionally, the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) has local district conservationists who can help a landowner with site selection based on soil science, conservation planning, engineering specifications, and/or cost-share assistance.

A Cooperative Basin Approach

The Suwannee River Partnership is an excellent example of the public and private sectors working together to protect water resources in the Suwannee River Basin. It includes representatives from the agriculture industry, state and federal agencies, local governments and related associations. It focuses on addressing nitrogen loading to water resources, including springs, by emphasizing voluntary incentive-based programs for implementing BMPs in the basin.

Approximately 80 percent of the targeted poultry farmers and all of the dairies are now participating. Among other things, conservation plans using Natural Resource Conservation Service standards and practices are developed for each participating farm. The dairy conservation plans provide for collection of waste, waste storage, waste transfer and waste utilization. Roof runoff, heavy use area, pest management, livestock exclusion, and nutrient management are also addressed. Poultry conservation plans outline practices for composting or incineration of dead birds, waste storage, waste utilization and nutrient management. The partnership is also working with the row crop, vegetable, and forage farmers to implement nutrient and irrigation BMPs on their farms.

In addition to BMP implementation, the partnership has developed BMP effectiveness research and BMP follow-up programs. The research program has been developed to verify the BMP effectiveness on farm scale operations. The BMP follow-up or Quality Assurance Program has been developed to verify BMPs are being maintained and operated as designed over time. For more information about this effort, contact the Suwannee River Partnership at 1-800-226-1066.

While the listing that follows is not all inclusive, it provides an overview of the major assistance programs available to Florida agriculture.

Environmental Quality Incentives Program (EQIP). This provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally-beneficial and cost-effective manner. The USDA-NRCS administers this program, establishes key Geographical Priority Areas on a yearly basis, and incorporates conservation planning as an adjunct.

FDACS Total Maximum Daily Load Program. The Office of Agricultural Water Policy in FDACS has funds to participate with agriculture on research, demonstration projects, BMP development and implementation, and cost-share programs statewide in impaired basins under the provisions of the Clean Water Act, Section 303d. Landowners who submit a Notice of Intent to Implement BMPs that have been adopted by FDACS, and are also located in priority listed watersheds, are eligible for cost-sharing. It should be noted, however, that not all BMPs are eligible for cost-sharing under this program. For example, surface water control structures or irrigation system upgrades/retrofits are eligible for cost-sharing, but applying Institute of Food and Agricultural Sciences (IFAS) recommended rates of fertilizer would not be eligible.

> Besides conservation, silviculture can be one of the most compatible land uses with Florida's springs.

Farm-A-Syst. Offered through the IFAS at the University in Florida, this program enables a farmer to obtain confidential environmental assessments by completing a worksheet to identify potential sources of pollution. Farm-A-Syst can help determine what risks—whether from livestock waste disposal, pesticide management or petroleum storage—could threaten a farm family's health and financial security.

Wetlands Reserve Program (WRP). This program, administered by the USDA-NRCS, enables participating landowners to establish conservation easements in order to restore degraded wetlands and other environmental features. Agencies, local governments or land trusts hold the easements.

Mobile Irrigation Laboratory. A joint project of the water management districts and the USDA-NRCS, its purpose is to help farmers and growers conserve water through efficient irrigation. The lab operator helps test the performance of irrigation systems, plan system improvements and establish irrigation schedules. In addition, the lab operator helps growers install tensiometers, water table observation wells and other watersaving devices.

Implement Silvicultural BMPs

Typically, silviculture operations require few added fertilizers and pesticides and are, therefore, one of the land uses more compatible with springs. Even under intensive silviculture, forestry activities typically have minor impacts, because harvest typically occurs only at intervals of 25 to 50 years, or longer.

Silviculture activities can, however, still result in adverse impacts to water quality from soil erosion and sedimentation, alteration of surface hydrology, and excess nutrients. Herbicides and fertilizers applied through aerial application can enter the ground water system though karst windows, such as sinkholes. In addition, operation of forestry equipment near springs and other karst features can damage the structure and integrity of stream and spring banks, further degrading water quality. Use of vegetated buffers will help reduce impacts.

To address water quality and related environmental issues for silviculture, the FDACS, Division of Forestry, in cooperation with a Technical Advisory Committee representing many stakeholder groups, has developed a *Silviculture Best Management Practices* manual. These BMPs were established in the midseventies and have been revised periodically, most recently in 2000. Although historically focused on water quality protection for streams and lakes, the current BMP manual addresses other water resource features including sinkholes.

Silviculture BMPs are designed as minimum standards necessary for protecting and maintaining water quality, but include practices to address ecological and wildlife habitat values. Virtually all silviculture activities are addressed in the manual including wetlands, roads, stream crossings, timber harvesting, site preparation, firelines, pesticide and fertilizer application, waste disposal, wet weather operations and emergency operations.

A key practice in the manual is the Special Management Zone (SMZ), which provides a buffer between forestry operations and sinkholes. Specifically, the SMZ focuses on the area immediately adjacent to streams, lakes, and sinkholes and has a variable width based on the size and type of the water resource, and the Site Sensitivity Class (SSC) which is based on soil type and slope percent.

The purpose of the SMZ and other BMPs is to reduce forestry-related nonpoint pollutants such as sediment, nutrients, logging debris, chemicals and water temperature fluctuations. The SMZ also protects in-stream and near-stream habitat functions and values.

The SMZ may include one or more of the following components: Primary Zone, Secondary Zone and Stringer. A Primary Zone has

Figure 5.3. The Division of Forestry developed this manual of best management practices intended for silviculture operations.

SMZ Widths for Lakes, Sinkholes & Special Waters

	Perennial		Intermittent	
	Primary Zone	*Secondary Zone*	*Primary Zone*	*Secondary Zone*
Lakes	35′	varies with SSC	(Stringer)	min. 35′
Sinkholes	35′	varies with SSC	(Stringer)	min. 35′
OFW*	200′	varies with SSC	200′	varies with SSC
ONRW**	200′	varies with SSC	200′	varies with SSC
Class 1	200′	varies with SSC	200′	varies with SSC

** Outstanding Florida Waters   ** Outstanding National Resources Waters*

Figure 5.4. Taken from the *Silviculture Best Management Practices*, this table identifies the special management zone widths for sinkholes.

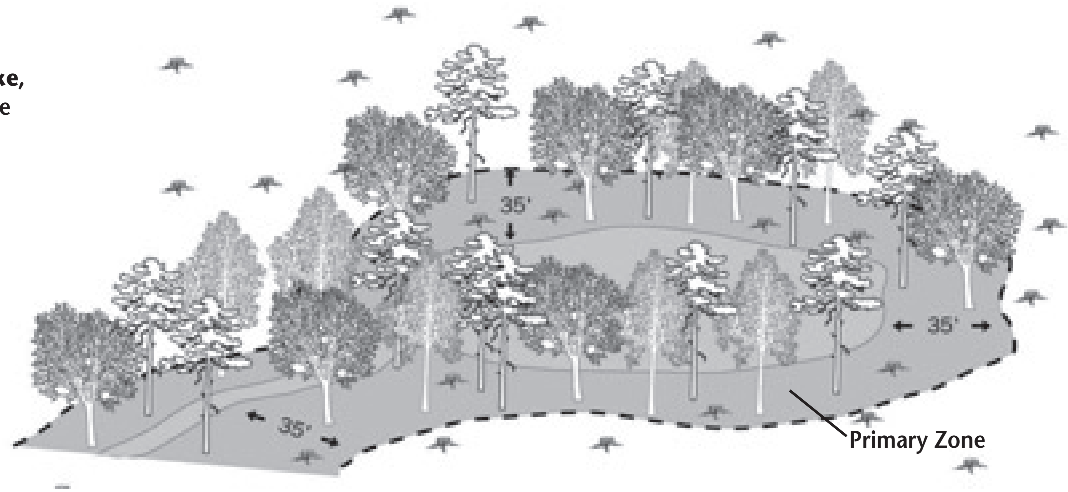


Figure 5.5. The SMZ approach requires a 35-foot zone around a perennial sinkhole and harvesting restrictions apply.

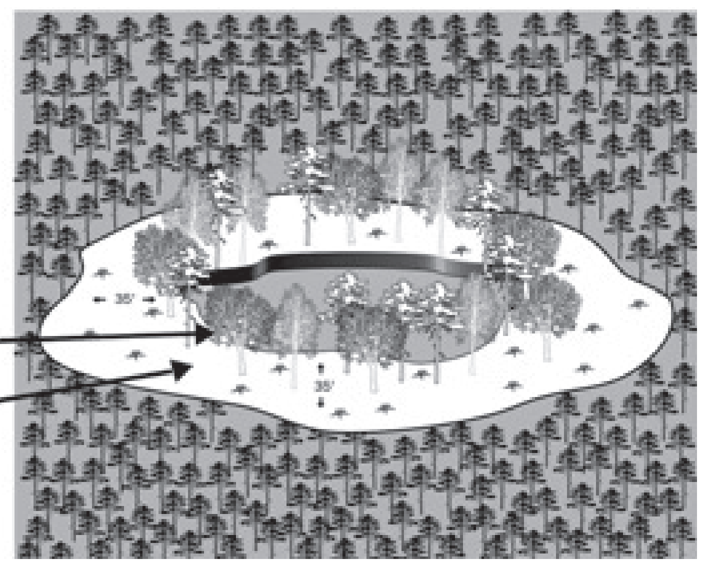


Figure 5.6. Applying the Division of Forestry's SMZ approach in this example would result in restricting operations around the sinkhole and leaving trees to act as a barrier.

Pertinent BMPs from *Silviculture Best Management Practices*

(Consult that manual for the complete listing.)

Wetlands: Do not significantly alter the natural drainage of flow patterns on forest lands immediately adjacent to wetlands. Avoid fill road construction, especially in flood plains or other wetlands with flowing water.

Sinkholes: For sinkholes with perennial or intermittent open water, or which connect to an intermittent or perennial stream, apply the appropriate Special Management Zone to the sinkhole. Do not alter land surface slope to direct surface drainage into the sinkhole.

Forest Roads: Minimize stream and wetland crossings. All road drainage practices that divert ditch flow or road surface runoff must direct such flows onto vegetated areas where it can be adequately dispersed—do not direct ditch flow or road runoff into streams lakes or other water bodies.

Stream Crossings: Minimize the number of crossings on a given stream and cross streams perpendicular to the flow at the most narrow section. Periodically inspect all culverts to prevent clogging, plugging and eventual failure.

Timber Harvesting: Locate skid trails along the contour whenever practical to promote revegetation and reduce soil erosion. Do not pile or push logging slash into cypress ponds or strands, swamps, marshes, grassy ponds, or water bodies such as streams, lakes, sinkholes or similar water resource features.

Site Preparation & Planting: When conducting site preparation activities near surface waters, follow the specific criteria provided in the Special Management Zone section. Arrange windrows and soil beds parallel to a waterbody or wetland in order to provide a barrier to overland flow, prevent concentration of runoff and reduce erosion.

Pesticide & Fertilizer Use: Do not conduct aerial application or mist blowing of pesticides or fertilizer within any part of the (Special Management) Primary Zone. Consider the use of slow release fertilizer when conditions are appropriate.

Waste Disposal: Do not discharge waste oil or other pollutants on the ground, in sinkholes, or in water bodies of any kind. Do not dispose of solid waste into water bodies of any kind.

Wet Weather Operations: The best alternative for logging during wet weather conditions is to postpone the operation until drier conditions prevail.

Available Assistance Programs

- Florida Forest Stewardship Program
- Cooperative Forestry Program
- BMP Training

significant timber harvesting restrictions and varies from 35 to 200 feet per side, depending on the type and size of the waterbody. A Secondary Zone has no timber harvesting restrictions but it does include operation restrictions. A Stringer refers to an area where trees are left on or near the bank along both sides of certain water bodies to provide limited wildlife habitat and acting as a barrier to heavy equipment operation around the waterbody.

The Division of Forestry monitors forestry operations statewide for compliance with silviculture BMPs and to determine effectiveness. The most recent compliance survey reported 96 percent compliance, and a recent FDEP/EPA funded study showed that BMPs are effective in protecting water quality.

Take Advantage of Assistance Opportunities for Silviculture

As with agricultural BMPs, there are a number of state and federal programs designed to provide training and monetary assistance for the implementation of silviculture BMPs.

Florida Forest Stewardship Program. This program is designed to help people manage their forest land for a variety of natural resources, based on the strategy of multiple-use management. This voluntary program provides federal cost share dollars for developing and implementing forest management plans on private non-industrial lands. BMPs are required and are an integral part of this program. A typical multiple-resource plan might provide for conservation of soil and water, protection of wildlife habitat and wetlands, timber production, livestock grazing, recreation, and beauty.

Cooperative Forestry Assistance. This program provides on-the-ground assistance in BMP implementation to landowners.

BMP Training. The Division of Forestry conducts BMP Training for landowners, professionals, practitioners and other interested parties. The resources identified in the adjacent box describe other training opportunities.

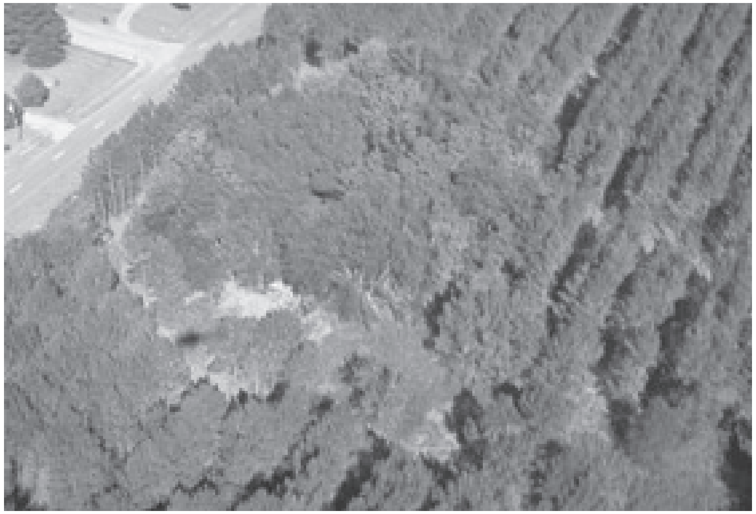


Figure 5.7. Silviculture BMPs are important in the effort to protect sinks and springs.

Be Sure To Check Out These Resources!

Agricultural Management Practices for Water Quality Protection found at **www.epa.gov/watertrain/agmodule/index.htm**, is an interactive training module developed by the Environmental Protection Agency and includes BMPs for agriculture. Topics include conservation tillage, crop nutrient management, pest management, conservation buffers, irrigation water management, grazing management, animal feeding operations management, and erosion/sediment control.

The Office of Agricultural Water Policy, in the Florida Department of Agriculture and Consumer Services, has authority for BMP development for nonpoint source water quality impacts associated with agricultural production. This is an excellent resource and can be reached at (850) 488-6249 or SunCom 278-6249.

Silviculture Best Management Practices Manual (2000), by the Florida Department of Agriculture and Consumer Services, Division of Forestry, identifies a variety of best management practices including special management zones, wetlands, sinkholes, forest roads, stream crossings, pesticide/fertilizer applications and other activities. It can be viewed on-line at **http://fl-dof.com/Conservation/hydrology/index.html**.

Forestry Best Management Practices in Watersheds is an interactive training module covering BMPs for forestry and developed by the Environmental Protection Agency. Topics include preharvest planning, streamside management zones, forest wetlands protection, road construction, timber harvesting, revegetation, fire management, and forest chemical management. It can be viewed on-line at **www.epa.gov/watertrain/forestry**.

USDA Conservation Programs, found at **www.ncrs.usda.gov/NCRSProg.html**, provides a summary of the various federal programs available to agricultural and silvicultural operations.

Florida's Forest Stewardship Program: An Opportunity to Manage Your Land for Now and the Future, (Circular 1020), describes the Forest Stewardship Program in Florida. This document can be viewed at **www.sfrc.ufl.edu/Extension/pubtxt/tocc1020.htm**.

The Natural Resources Conservation Service, **www.nrcs.usda.gov**, is an excellent source of information about available programs and assistance in Florida, including local district conservationists. In addition, their *National Conservation Practices Standards* identifies national standards for various conservation practices commonly used to treat natural resource problems (soil, water, plants, animals). These can be viewed on-line at **www.ftw.nrcs.usda.gov/practice_stds.html**.

The U.S. Environmental Protection Agency has compiled extensive management measures for dealing with nonpoint source pollution at **www.epa.gov/owow/nps/**. Forestry, agriculture and wetlands management measures can be accessed at this site.

Public Recreation

Springs and sinkholes have always been popular recreation sites for local residents and tourists alike. Unfortunately, springs and sinkholes become seriously damaged when public use and access to the spring is not properly managed. Erosion of the banks, submerged vegetation destruction, and littering are some of the major concerns.

The most effective way to deal with impacts of public recreation is to:

- Develop a Management Plan
- Control the Impact of Public Use

Florida's springs are owned by public and private entities. In 1949, Manatee Springs was the first spring to be purchased by the State of Florida. Since then, dozens of springs have been purchased by federal, state, regional and local governments to provide protection for the springs while making them available for outdoor recreation.

Unfortunately, springs with uncontrolled public access can become seriously damaged. In the absence of steps, fencing, directional signs, and on-site staff, considerable harm can be done to the scenic and biological values of a spring. Typically, vegetation that stabilizes the slope and shoreline becomes trampled and uprooted. Foot traffic and stormwater further erode the soils, and the spring begins to fill with sand and debris. Submerged aquatic plants in the spring and spring run become trampled or uprooted by swimmers and divers. Vehicle traffic on the uplands around the spring also causes damage. Frequently, littering and dumping further degrade the site.

Uncontrolled boat access can also be a problem for spring protection. For those springs which are accessible by water, boaters can cause the same problems as pedestrian traffic in an area. Tying boats up along the banks of the spring or spring run can cause erosion and vegetation loss. Additionally, engine props from oversized vessels or in shallow areas can stir up silt and dredge up aquatic vegetation. Most springs and runs are too shallow to permit motorboats without damaging aquatic plants or the bottom of the run.

When springs and sinkholes are located off the beaten path, it is difficult to control public use. The public will find a way to get to these swimming holes, but often the lack of staff hinders local government control of use. If warranted by unique aesthetic, paleontological, archeological, or biological values (or vulnerability to damage), a spring may have to be protected from active recreational use.

Develop a Management Plan

A management plan should be developed to guide site improvements and access to a spring. The owner or manager should work with experts, such as the Department of Environmental Protection, U.S. Geological Survey, Florida Geological Survey and the appropriate water management district, to develop a clear understanding of the site. This would include spring characteristics, location of caves or other

Key Practices for Public Recreation Use

- Reduce erosion and sedimentation by controlling how people approach and enter the spring.
- Focus use of the spring to areas where impacts to submerged vegetation will be reduced.
- Provide facilities for litter and human waste control.
- Educate users on the sensitivity of springs and spring runs, and how to reduce their personal impact on those systems.

Figure 6.1. If best management practices are not implemented, public use can adversely impact a spring.

karst features, and physical attributes of the site. This information would then be utilized to develop a management plan for the site that protects the spring. For example, roads and structures should not be placed over cave systems. Restrooms, drainage fields or other waste management facilities should also not be placed over caves or in areas that will drain into the spring.

Control the Impact of Public Use

The following practices should be applied to help control the effects of public use:

- Control foot and vehicle traffic through the use of steps, fencing and directional signs.
- Minimize the amount of upland/shoreline clearing of vegetation and only clear in the areas where direct access is allowed.
- Use exhibits, interpretive signs, leaflets or staff to help educate users about the values of the spring and how to minimize impacts.
- Use stormwater management and erosion control methods to protect the spring from contamination, sedimentation, and turbidity problems from upland activities. Direct stormwater away from the spring and maintain a buffer between the uplands and the spring/spring run.
- If motorboats are permitted, designate and control the number and locations of specific mooring spaces for boats.
- If motorboats are permitted, when pulling the boat out of the water, do not pull the drain plugs until the boat is away from the boat ramp and on a pervious area. This will prevent pollutants in the bilge water from entering surface waters.
- Provide trash receptacles and routinely empty them to reduce littering.
- Provide a system for human waste disposal.
- Delineate a specific swimming area with buoyed lines to reduce impacts of swimming on submerged vegetation in the spring or spring run.
- Prohibit fossil or artifact collecting by the public.
- Prohibit feeding of wildlife associated with the spring or spring run, including alligators.

Figure 6.2. This 1973 photo, on the left, shows Blue Spring in Volusia County when purchased by the State. Erosion along the spring banks can be clearly seen. After the State purchased Blue Spring, it restricted foot traffic and re-established native vegetation on its banks, as shown in the photo to the right.

- Control the number of divers in the spring at any one time by requiring they receive permission from the owner to dive.
- Develop educational programs targeting swimmers, boaters and SCUBA divers, which focus on:
  1) the sensitive ecology of spring runs; and
  2) how to avoid disturbing the bottom and accidentally uprooting submerged aquatic vegetation.

In those instances where a spring owner does not have the resources to provide adequate control or protection, a local Adopt-A-Spring effort could be initiated. With the permission of the owner, volunteers would implement appropriate erosion controls and other access-control BMPs. They could also provide periodic maintenance and repairs. This is a good tool for involving the users of a spring in its protection, as well as potentially giving them a more personal stake in reducing impacts on the spring. Adopt-A-Spring groups would also provide another venue for educating the public about the importance of these unique resources.

Be Sure To Check Out This Resource!

Springs Fever: A Field and Recreational Guide to Florida Springs, by Joe Follmand and Richard Buchanan, is an excellent source of information about recreational opportunities at Florida's springs. It can be viewed at **www.tfn.net/Museum/Springbook/**.

Glossary

Algae - non-vascular water plants. Analyses of types and abundance of algae provide indicators of aquatic ecosystem health.

Aquaclude - the opposite of an aquifer, these formations (often made of clay) do not allow for the movement of water. They therefore can act as a barrier for the movement of water between surface and deeper aquifers.

Aquifer - an underground geological formation that allows for the movement of water; aquifers are the source of spring water and well water.

Area of contribution - those areas of the springshed landscape that accept rain and surface water inputs to the ground water. Certain areas often are much better at delivering the ground water than others. Identifiable areas of high contribution should be protected.

Best Management Practices (BMPs) - a practice or combination of practices, including preventive actions or structural improvements, based on sound science and professional judgement to be the most effective and practicable on-site means of preventing negative water quality impacts at a spring.

Buffers - undisturbed vegetated zone between a land use and a spring. These zones are meant as a protective barrier between the resources and harmful activities.

Dissolved oxygen (DO) - the oxygen freely available in water, which is vital to fish and other aquatic life. DO levels are an important indicator of a water body's ability to support desirable aquatic life.

DRASTIC - The U.S. Environmental Protection Agency (EPA), working with the National Water Well Association and a large number of other experts, identified the following seven key factors that determine aquifer vulnerability: (1) Depth to ground water; (2) Recharge rate to ground water; (3) Aquifer media; (4) Soil type; (5) Topography; (6) Impact of the vadose zone; and (7) Conductivity of the aquifer. Each of these factors is assigned a combination of weights and ratings, and a numerical index called the DRASTIC index is computed.

Ecosystem - the interacting system of a biological community and its non-living environmental surroundings.

Fee simple acquistion - also known as "fee simple purchase," this is the outright purchase of land and it gives the owner (a local government, for example) full control over all rights.

First magnitude spring - a spring with a flow rate of 100 cubic feet per second (64.6 million gallons per day) or more.

Florida Aquifer Vulnerability Assessment (FAVA) - an ongoing project to develop a Florida-specific model, using existing geographic information system (GIS) data, that will predict the vulnerability of Florida's major aquifer systems to contamination. The object of FAVA is to develop a tool that can be used by environmental, regulatory, and planning professionals to facilitate protection of Florida's ground water resources, and thus the health and safety of Florida's residents.

FLUM - future land use map which is included in the adopted local comprehensive plan.

Golf Course Special Management Zones - areas on the course that have distinct management practices that coincide with their position in the watershed, and are based on the location of karst features in the springshed. The management zones are established during the design phase of the development, implemented during construction, and maintained throughout the life of the course. Zones include regulatory zones, no-spray zones, limited spray zones, and hand-clearing zones.

Ground water level - the measurement, in feet, of the elevation of the top of an aquifer. The level can fluctuate in response to aquifer recharge and ground water withdrawals.

Ground water withdrawal - the act of removing water from aquifers by pumping it from a well, whether it be a small domestic supply well or a large public supply well.

Habitat - the place where a population, whether human, animal, plant, or microorganism, lives, and its surroundings, both living and non-living.

Hydrogeology - the study of subsurface waters in their geologic context.

Hydroperiod - the pattern of water level rise and fall over time.

Impermeable - not permitting the passage of fluids. In the case of geologic formations, an impermeable layer of earth is one through which ground water cannot pass.

Integrated Pest Management (IPM) - a method to control, not eliminate, pests through a combination of approaches including plant selection, monitoring, cultural practices, biological controls and careful use of pesticides.

Karst - a limestone region with underground drainage and many cavities and passages caused by the dissolution of the rock.

Land development regulations (LDRs) - regulations, including zoning, adopted by a local government to implement the comprehensive plan.

Less-than-fee-simple acquisition - when considering property ownership as a bundle of rights. Less than fee acquisition or purchase is to purchase some portion of the bundle or rights but not all (e.g., easements, development rights, etc.).

Loading - the amount of pollutants entering a system (concentration times flow rate).

Low Impact Development (LID) - a strategy which uses a variety of techniques (site design, stormwater treatment trains, and pollution prevention) to develop a site in an environmentally-sensitive manner.

Nitrate - a compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water. Nitrates are essential plant nutrients, but in excess they can be dangerous to spring ecosystems.

Nonpoint source - pollution that does not result from a discharge at a specific, single location or point, but generally results from land runoff (i.e., from homes, parking lots, building sites, etc), precipitation, atmospheric deposition, or percolation. Pollution from nonpoint sources occurs when the rate at which pollutant materials entering water bodies or ground water exceeds natural levels.

Primary Zone - see "springshed protection zone."

Point Source Pollution - pollutants that come from a concentrated originating point like a pipe from a factory or a large registered feedlot with a specific point of discharge.

Secondary Zone - see "springshed protection zone."

Sinkhole - a hole in the earth that is formed when an underlying limestone collapses.

SJRWMD Karst Procedure - a set of protective measures applied to those portions of western Alachua and western Marion counties within the St. Johns River Water Management District boundaries. The procedure was developed to protect the Floridan aquifer from contamination by stormwater. The design criteria can be found in SJRWMD Implementing Rule 40C-41.063(7), FAC.

Springshed Protection Zone - a land planning area wherein special features such as environmentally-sensitive karst landscape and associated spring require differing or added type of management and protection. A springshed protection zone for the comprehensive plan and corresponding future land use map could be:

Primary Zone - the primary zone encompasses land, inclusive of springshed features, that is most sensitive to environmental contamination and merits special protection. This includes the principal areas of ground water contribution and recharge, sinkholes, depressions and stream-to-sink features, the areas around the spring itself, and the spring run. These are areas deserving critical protection actions. Compatible land use in this area includes very low density and intensity uses such as conservation, recreation and open space; and

Secondary Zone - the secondary zone includes land abutting the primary zone that is also vulnerable to contamination, but offers some limited opportunity for buffering impacts from potential sources of contamination. Compatible land uses include low density and intensity land uses such as conservation uses, recreation and open space, silviculture, rural pasture areas or very low density residential.

Spring recharge basin - the land areas that contribute surface and rainwater to the spring flow. This may be used interchangeably with springshed or spring watershed, though in many instances, the recharge basin is focused more upon those areas within the springshed that collect and contribute significantly to the water budget.

Spring run - a spring-fed stream or river.

Springshed - the area of land whose water will eventually end up in a spring and spring run. The shape of this recharge area, or springshed, is influenced not only by topography but also by what is happening unseen under the ground—the presence of cave systems, fissures and other karst features.

Stormwater - rainwater that flows overland after falling. In developed areas, stormwater typically becomes polluted by materials it picks up from roofs, streets, parking lots, and other impermeable surfaces, and may deliver pollutants to surface and ground water.

Targeted Pest Management - a philosophy of managing pests that aims to reduce expenses, conserve energy, and protect the environment. TPM is a broad, interdisciplinary approach using a variety of methods to systematically control pests.

Tensiometer - a tool for monitoring soil moisture in the root zone, helping growers make decisions about irrigation system management.

Transfer of development rights (TDRs) - this land use management technique transfers development potential from sensitive areas to less sensitive areas that have been identified as suitable and designated for growth. In a TDR program, two or more zones are established in a given geographic area, a “sending” (preservation) zone and a “receiving” zone. The most common TDR program allows the landowner to sell the development rights to a developer who then uses those development rights to increase the density of development on another piece of property at another location. A second method allows a local government to establish a TDR Bank to transfer development rights.

Transmissivity - the rate at which ground water travels through a permeable geologic layer.

Treatment Train - a series of Best Management Practices and/or natural features, each planned to treat a different aspect of potential pollution, that are implemented in a linear fashion to maximize pollutant removal.

Watershed planning and management - water resource management that is organized on the basis of the natural boundaries formed by surface water basins or ground water divides, which often overlap the borders of governmental jurisdictions.

Withdrawal - see ground water withdrawal.

Xeriscape - a landscaping method that maximizes the conservation of water by the use of site-appropriate plants and an efficient watering system.

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