CHAPTER VI

COMPREHENSIVE PLAN GUIDANCE

INTRODUCTION

This Chapter provides guidance to local governments preparing a comprehensive plan or plan amendment to protect water quality consistent with the Act and Regulations. Recommendations are process-oriented and designed to be integrated into the local planning process. Where possible, step-by-step guidelines are provided to aid local governments in data collection efforts and development of policy alternatives.

The focus of the Chapter is planning for the protection of water quality, with an emphasis on resource protection policy development. The Chapter does not attempt to provide a truly comprehensive guide to developing local land use policy with consideration of economic and social issues. In this sense, the Chapter is not a primer on land use planning or the comprehensive planning process. Local governments should, therefore, ensure to the greatest extent possible that there is consistency among individual policies developed in different policy categories. For example, a policy to "protect water quality in surface waters" should also be reflected in policies addressing economic and community development which potentially affect surface water quality. Suggestions of such interrelationships among policy areas are addressed throughout the Chapter.

CHAPTER VI

DESIGNING A COMPREHENSIVE PLAN TO PROTECT WATER QUALITY

A comprehensive plan provides a framework to guide local leaders in decisions affecting community development. The process of updating and revising comprehensive plans in accordance with the Act and Regulations affords local governments an important opportunity to **evaluate existing development patterns and their impact on water quality protection** and resource conservation. This process also represents a significant opportunity to proactively guide future development so as to assure the long-term viability of sensitive environmental resources. In order to comply with the Act and Regulations, comprehensive plans should explicitly identify the relationships between water quality protection and other land use considerations within the locality such as population growth, economic development, and the provision of public facilities and utilities. Plan recommendations should be based on a sound analysis of these relationships.

There are many benefits of a comprehensive planning approach to water quality protection. By determining the capacity of an area to support development through a detailed inventory and analysis of environmental resources, localities can prevent problems such as failed septic systems, which are both costly to remedy and damaging to natural resources. Significant cost savings may be realized by the local government and the private sector in the long term. Moreover, the information base developed will provide the public with useful information about ongoing natural processes, physical features which constrain certain types of development, and the potential consequences of resource exploitation and development in sensitive areas.

The relationships between resource protection and land development are too often ignored. The distribution and intensity of development directly influence energy conservation, efficiency in the provision of services, and the protection of environmental and cultural resources. Other factors influencing land use patterns such as accessibility, availability of public utilities, and real estate market forces, however, are more immediate and usually overshadow factors relating to land suitability. This chapter identifies steps that local governments should take in order to ensure that planning adequately considers the impact of land use on water quality.

Balancing Economic Development And Water Quality Protection

The Chesapeake Bay Preservation Act opens with the observation that "[h]ealthy state and local economies and a healthy Chesapeake Bay are integrally related; balanced economic development and water quality protection are not mutually exclusive."[1] This finding was based on decades of data showing a direct relationship between water quality and economic vitality in the Bay region. Every sector of the Tidewater economy is in some way dependent on a healthy Bay.[2]

Economic development specialists have long realized that the only successful strategy for improving local economies is diversification. When the business cycle is in decline, a locality dependent on one or two business sectors is likely destined to experience a longer and more dramatic downturn than a locality with a more diversified economy.

AUTHORITY

The Code of Virginia sets forth the scope and purpose of the comprehensive plan.[9] Virginia law required all local governments to prepare and adopt a comprehensive plan by July 1, 1980[10] and requires local governments to review and, if necessary, to revise those plans every five years.[11]

Under the Dillon Rule, Virginia local governments do not have broad latitude to shape and fashion land use and environmental protection measures unless those powers are explicitly granted by the General Assembly. During the 1988 session of the Virginia General Assembly, the Virginia Code was amended to add surface water studies to the items that may be considered in developing a local comprehensive plan.[12] As companion legislation to the Preservation Act, this provision enables local governments to base land use plans and policies on water quality considerations.

In addition, the Act requires local governments to "incorporate the protection of the quality of state waters" into their comprehensive plans consistent with the provisions of the Act.[13] The Regulations require local governments to "review and revise their comprehensive plans, as necessary, for compliance" with the Act (§ 5.6.A). This Chapter explains the provisions of § 5.6 and is designed to help local governments review and revise comprehensive plans in a manner consistent with the Act and Regulations.

The Board and Department are mindful that proper revisions to comprehensive plans require time and effort. Recent amendments to the comprehensive planning provisions of Title 15.1, as well as the requirements of the Chesapeake Bay Preservation Act, place increasing significance on the legal relationship between comprehensive planning and zoning.[14] Therefore, local governments should take care in the preparation of the comprehensive plan to ensure that the provisions of local ordinances are not arbitrary and capricious.[15]

PUBLIC PARTICIPATION

The Code of Virginia establishes minimum requirements for public notice and comment prior to the adoption of a local plan or ordinance.[16] Although local governments are familiar with these provisions, localities are encouraged to solicit additional public involvement in the development of the comprehensive plan. The comprehensive plan element provides local elected officials with the opportunity to gain public acceptance and a commitment for the long-term implementation of the Chesapeake Bay Preservation Act.

The comprehensive plan establishes local public policy on land use and water quality protection; local governments should attempt to involve the public in every aspect of plan development. A number of Tidewater localities have developed meaningful citizen involvement processes that exceed the Code's minimum requirements. All local governments should consider ways to enhance citizen participation so that recommendations in the plan are representative of public policy.

An effective public participation program will provide the opportunity for citizens to be involved in all phases of the planning process (see Table 6-1). It should engage a cross-section of the community, broadly representative of geographic areas and interests related to land use and land use decisions. **Citizen advisory committees** can be a

particularly effective way of achieving widespread public involvement.

Citizen advisory committees can enhance communication between citizens and elected and appointed officials. One or more citizen committees, bringing diverse interests to the table, can be useful and productive in building consensus and developing creative solutions to difficult issues. Moreover, the citizen advisory committee can be highly effective in assisting the governing body with the development of a program that promotes and enhances public participation in land use planning, the implementation of the program, and evaluation of the process for citizen involvement.

Requirements of the Act and Regulations

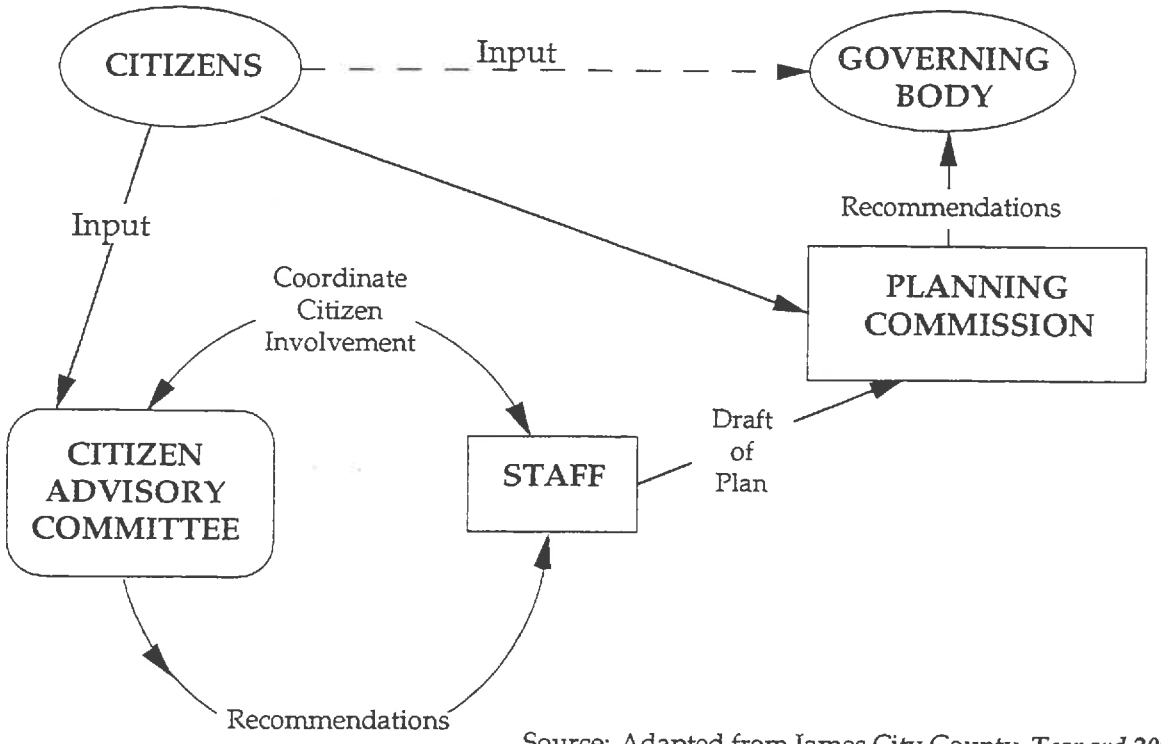
Section 10.1-2109 of the Act states:

Counties, cities, and towns in Tidewater Virginia shall incorporate protection of the quality of state waters into each locality's comprehensive plan consistent with the provisions of this chapter.

Section 2.1 of the Regulations provides guidance to local governments in the development of local programs necessary to comply with the Act and Regulations:

In conjunction with other state water quality programs, local programs shall encourage and promote: (i) protection of existing high quality state waters and restoration of all other state waters to a condition or quality that will permit all reasonable public uses and

Comprehensive Planning Process — *Figure 6-1*



Source: Adapted from James City County, *Toward 2007: Designing Our Future* (Draft), 1991

policies and other decisions set forth in the plan. They have been designed to avoid placing an unnecessary burden on local planning resources. The requirements can generally be fulfilled by utilizing existing local plans and studies as well as information provided by regional planning offices and state agencies. However, certain inventories and other forms of data outlined in this Chapter, which are critical as a basis for water quality protection policies, may not be typical to the local planning process in the past. Each of these items, as well as others important for water quality issues, are more thoroughly explored in other sections within the Chapter.

Generally, the process suggested by the data collection and analysis requirements of the Regulations begins with an examination of a community's current situation. This typically includes information on existing land use, land suitability, and identification of fragile or environmentally sensitive areas. Significantly, most local governments have already established an inventory of environmental resources to serve as a basis for the designation of Chesapeake Bay Preservation Areas (see Chapter III).

This information base establishes a solid foundation for water quality protection planning and decision-making by defining the physical characteristics of the community. Analysis of this data base will indicate areas that are fragile or environmentally sensitive and have an intrinsic value to water quality, like certain wetlands. Other areas, because of soil type or drainage patterns, pose constraints to septic systems or certain development. If these areas are improperly managed or developed, water quality degradation is likely to result. Understanding the natural characteristics of the land and directing growth and development in a way which reflects this character will ensure the long-term use and enjoyment of quality water resources.

When layered with the local environmental inventory, other data describing a locality's reliance and influence on water resources will establish a more comprehensive information base for protecting water quality. It will be important to analyze additional information in the following areas:

- population information indicating growth trends and seasonal fluctuations;
- local business and industry, including an analysis of the economic impact of water-related activities;
- local water supply sources, quality, demand level, and treatment. For groundwater sources; information on location of wells, depths of seasonal high water table, and identification of aquifers used;
- shoreline erosion and accretion patterns in comparison to proposed land use and development;
- drainage systems, including agricultural canals;
- known sources of pollution such as older septic tanks, industrial sites, wastewater treatment plants, landfills, and underground storage tanks;
- location of existing and planned public access to water resources.

Plan Formulation and Policy Development

As part of the comprehensive plan, local governments should clearly indicate local policy on land use issues

tion. The community benefits from a coordinated water quality/development strategy which provides a sound basis for land use decisions, and should simplify reconsideration of the comprehensive plan in future years by providing a thorough benchmark against which to judge the success of the plan.

IMPLEMENTATION

The General Assembly intended local comprehensive plans consistent with the Act to be *implemented;* local plans should identify specific measures for carrying out adopted policies. The plan should discuss how local policies will be implemented -- what must be done, by whom, and within what time frame. This may include revisions to existing procedures and ordinances such as the zoning and subdivision ordinances, the site plan review process, and the capital improvements program.

Although local governments will revise their zoning, subdivision, and other land use ordinances in order to implement the performance criteria, it may be necessary to revisit ordinances after the comprehensive plan element is in place. Specifically, local governments should ensure that ordinances reflect and implement plan recommendations. For example, the plan may recommend special impervious surface and density restrictions in groundwater protection areas. Local governments should then consider amendments to the zoning ordinance to reduce required dimensions for parking areas and the widths of drives. Similarly, localities should review local policies and requirements for curb and gutter. Certain standards that have developed in response to aesthetics ("quality development"), convenience, and design preference should be carefully reexamined in the context of water quality protection goals and objectives.

The fundamental purpose of this Manual Chapter is to provide local governments guidance on the complex interrelationships between water quality and land use and development policies. The first section, *Comprehensive Water Resources Management*, introduces a conceptual framework for such a planning process, given the broad range of water resource issues facing localities in the 1990s. The remainder of the Chapter is devoted to developing specific guidelines for protecting potable water supply, comprehensive strategies to address shoreline erosion problems, identifying physical constraints to development, and integrating water quality improvement objectives for redevelopment within Intensely Developed Areas. The Chapter concludes with a section on conservation and development strategies which identifies the wide variety of community benefits that can be derived from an integrated planning process to protect water quality.

This Chapter works from the premise that a piecemeal approach to water resource planning is counter-productive: given the interrelatedness of the issues, the benefits of one element can be negated when another element is not similarly protected. For that reason, local governments are encouraged to consider the spectrum of issues presented and discussed herein, and develop a plan which addresses each of the policy areas within the context of **a comprehensive local strategy**. Where time and staff are available, individual elements can be strengthened over time. A coordinated, broad-based plan will have greater water quality benefits and fewer administrative obstacles in the long term.

Globally, there are approximately 330,000,000 cubic miles of water (a cubic mile equals 1.1 trillion gallons) on the earth's surface, underground, or in the atmosphere. Over 70 percent of the earth's surface is covered with water, but approximately 97 percent is salty, leaving only a small, precious supply of fresh water (Table 6-2).

Scientists generally recognize four main mechanisms to move water molecules from one location to another: **precipitation, infiltration, evaporation and transpiration** (sometimes called evapotranspiration). Surface runoff, soil moisture, and depression storage are additional variables to the water cycle equation (Figure 6-3). In a global sense, this system is closed. If the water is not on the surface or underground, it's in the air.

Most of us think of precipitation as the beginning of the cycle. Precipitation can come in many forms: rain, snow, hail, or any combination of these. In the lower altitudes, rain

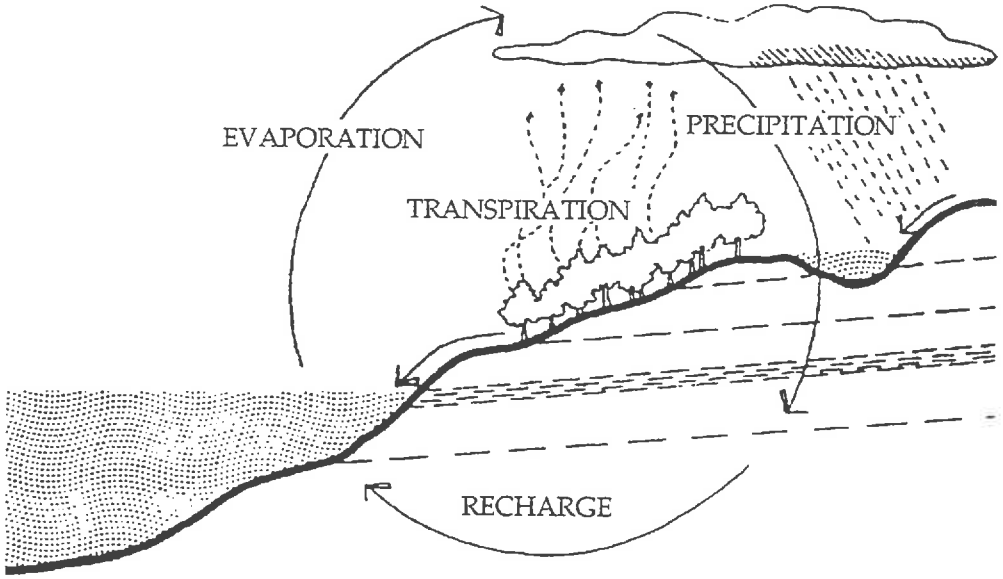
ESTIMATED WORLD WATER SUPPLY *TABLE 6-2*

Item	Area (km^2)	Volume (km^2)	% of Water
Fresh water:	147,900,000	37,300,000	2.70
Polar ice and glaciers	15,100,000	28,200,000	2.04
Groundwater 800-4,000 m deep	130,900,000	4,710,000	0.34
< 800m deep	130,900,000	3,740,000	0.27
Lakes	830,000	125,000	0.009
Soil moisture	130,900,000	69,000	0.005
Atmospheric vapour	510,100,000*	13,500	0.001
Rivers	—	1,500	0.0001
Salty water:		1,348,000,000	97.3
Oceans	362,200,000	1,348,000,000	97.3
Saline lakes and inland seas	700,000	105,000	0.008
Total supply		1,385,000,000	100

* Area of Earth's surface

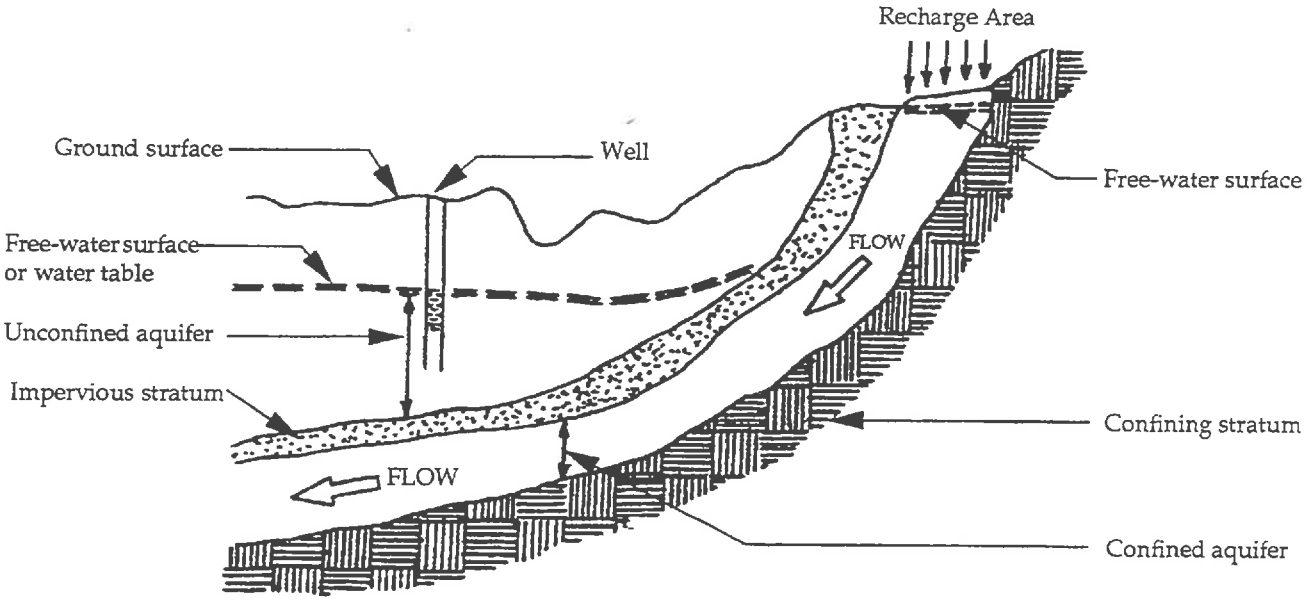
Source: ***Encyclopaedia Britannica***, Volume 20

THE HYDROLOGIC CYCLE *FIGURE 6-2*



Source: Day and Crafton, ***Site and Community Design Guidelines for Stormwater Management***, 1978

AQUIFER CLASSIFICATIONS — FIGURE 6-4

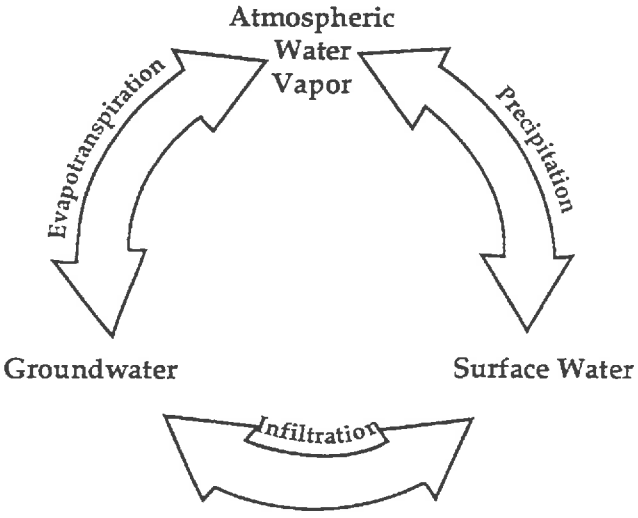


Source: Adapted from Veissman, Knapp, Lewis, and Harbaugh, *Introduction to Hydrology*, 1977

the surface. **Groundwater and surface water are interlinked**. Changing or stressing one will likely change or stress the other (Figure 6-5).

Water not infiltrated will run off to fill streams, lakes, and oceans. Any exposed water has the potential to evaporate into the Earth's atmosphere, where the process begins again. **Surface water and the atmosphere's water vapor are also interlinked.** Changing or stressing one will likely change or stress the other. The system is closed: what goes up, must come down -- but not necessarily in the same place. The moisture evaporated from Virginia's vast George Washington National Forest doesn't necessarily translate into rains for those same mountain slopes.

INTERLINKED WATER SYSTEM — FIGURE 6-5



Many localities have watershed boundaries already established for other purposes; water supply or wastewater service districts. Matching resource planning watershed boundaries to those already established is strongly recommended (Figure 6-7).

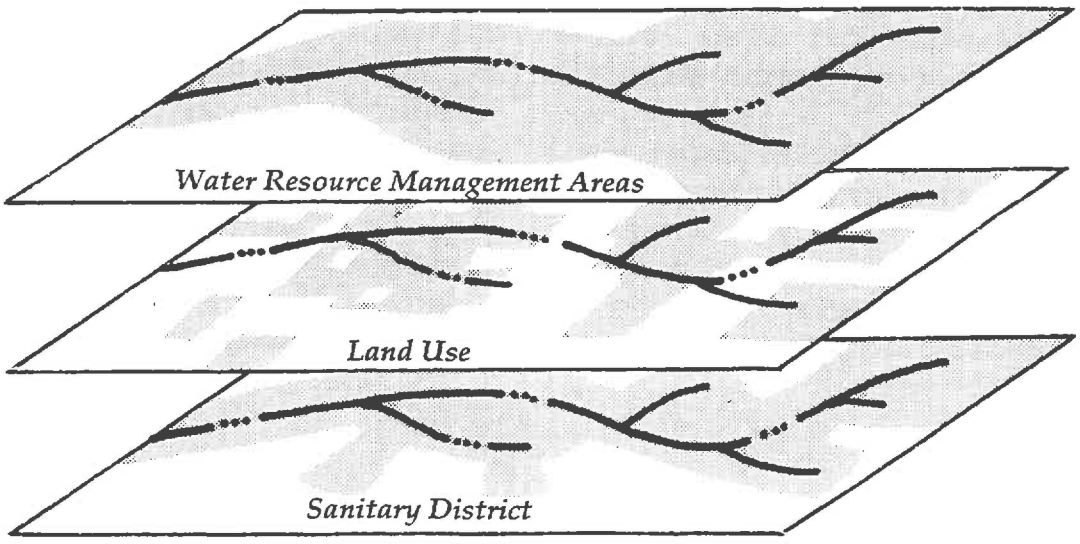
Unfortunately, many local comprehensive plans are based on magisterial district boundaries. Because nature doesn't follow political boundaries, such divisions needlessly aggravate water resource planning and protection. Computer models must still be based on real watersheds, resulting in constant frustration over attempts to reconcile the technical with the political. Moreover, magisterial districts typically change every ten years based on the most recent census. Water resource solutions will take longer to accomplish than the 10 years a district boundary remains current. It is important that planning area boundaries remain constant while long-term water resource management strategies are being implemented.

Watershed boundaries may be the focus of political aggravation when they are shared. Two localities that share a stream or river as a jurisdictional boundary may have conflicting agendas regarding the same water body. The Chesapeake Bay watershed states, with their sometimes conflicting political priorities, provide an apt example of this. Just as the Bay states have agreed on a regional approach to restoring the Bay, localities should consider developing joint solutions for their own water resource problems.

Once watersheds have been designated, localities need to determine how much water is available. Stream flow and groundwater withdrawal characteristics are most useful in developing this data. Predictably, this information is prepared on a stream-by-stream basis.

The U.S. Geological Service maintains stream flow gauges throughout the country. Selected gauge information can be found in Chapter One of the Virginia Department of

GEOGRAPHIC INFORMATION SYSTEM LAYERS *FIGURE 6-7*

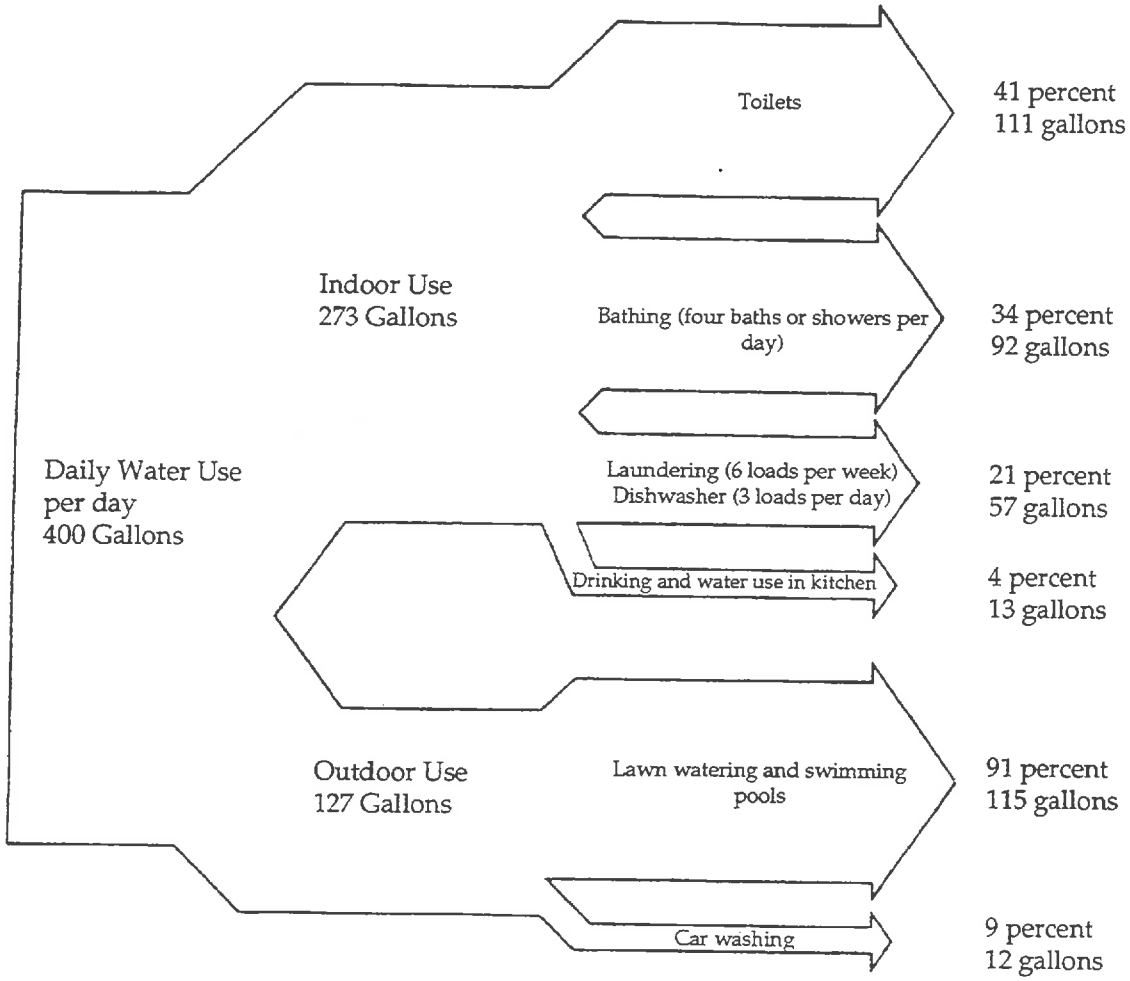


estimated. For instance, domestic use is generally based on 100 gallons per person per day (Figure 6-8). Some evidence indicates, however, that more rural populations use less per day than urban dwellers.[20] Water quality requirements vary for different uses. The more polluted the "raw" water, the more expensive the treatment to produce water fit for human consumption. Commercial and industrial uses are highly dependent on specific applications and are thus more difficult to estimate. Many of these uses are required to obtain withdrawal permits. Those permits may be valuable information sources for determining non-residential needs.

Legal Principles Regarding Water Use

The planning process must also account for limitations imposed by law. The Commonwealth of Virginia recognizes the common law concept of **riparian rights**. Riparian rights generally entitle the owner of land *directly adjacent* to a water body to receive the full natural flow of the stream without change in quality or quantity. Riparian owners are legally protected from excess flood waters being dumped on their property. A property owner is theoretically protected

Typical Residential Water Use by a Family of Four — *Figure 6-8*



Source: Adapted from Sanders and Thurow, *Water Conservation in Residential Development: Land-Use Techniques*, 1982

A comprehensive plan establishes public policy which sets the direction of a jurisdiction's growth and development. Water resource planning also requires identification of priorities and development of policy statements. Combining a water resource management plan with the local comprehensive plan increases the likelihood of identifying long-term issues and developing long-term solutions. Some localities have been known to examine critical water resource issues only after arriving at a crisis or facing a state or federal mandate. Such localities typically are forced into more costly short-term solutions because they react to problems after-the-fact rather than proactively planning to avoid the problems. For example, localities that must comply with the new EPA stormwater management regulations[25] will find addressing water resource management issues within the comprehensive plan an effective way to integrate several required programs.

Since the hydrologic system is closed, we cannot create more water. We can only decrease the demand *or* improve allocation of available resources. The more intense the competition for water, the more important management of the resource becomes. When considering solutions, it is important to recognize that things we do to one part of the water system have the potential to affect other parts we do not intend to change. The comprehensive plan process provides an excellent forum for recognizing water resource relationships and avoiding unintended problems.

On the East Coast, rainfall is abundant and people are surrounded by water. Many stream networks criss-cross Virginia. The Chesapeake Bay and Atlantic Ocean are on the Commonwealth's doorstep. Obviously much of the world's water is unexploitable in its present form. We cannot "drink" water vapor. However, some communities have tried to solve critical water supply problems with unconventional approaches of the past, present and future, such as cloud seeding, iceberg towing, and desalination plants.

Not only is most of the world's water unusable, it's often inaccessible. Communities located far from a river must pump the water through pipes. Aquifers deep within the earth's surface can be tapped only by expensive well drilling rigs. Creation of reservoirs is made more difficult by conflicting and competing regulations. The inaccessibility of water is a problem that can be overcome, but often only at great expense. Comprehensive water resource management planning, by itself or as part of the local comprehensive planning process, provides an opportunity to plan for the optimum use of available water resources while minimizing expenses.

After accumulating the data and setting parameters, hard questions must be answered. Is there a balance between the supply and demand in each watershed? Is the supply adequate? For quantity? For quality? Now? In the future? If the answer is yes, how can those characteristics be maintained?

PHYSICAL CONSTRAINTS TO DEVELOPMENT

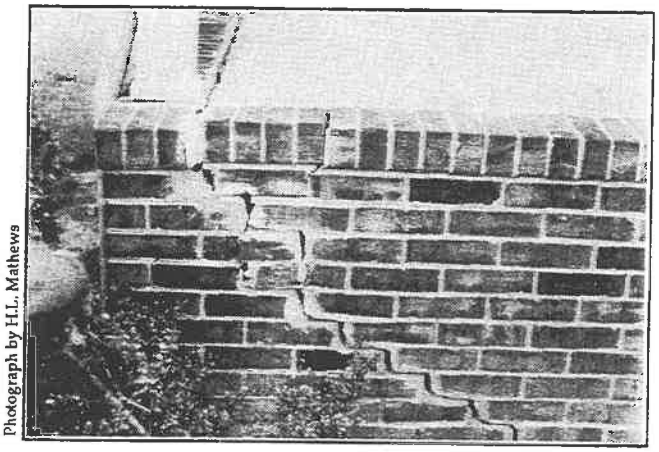
As part of the comprehensive plan, local governments should clearly indicate local policy on land use issues relative to water quality protection. Local governments should ensure consistency among the policies developed.

# # #

b. As a minimum, local governments should prepare policy statements for inclusion in the plan on the following issues:

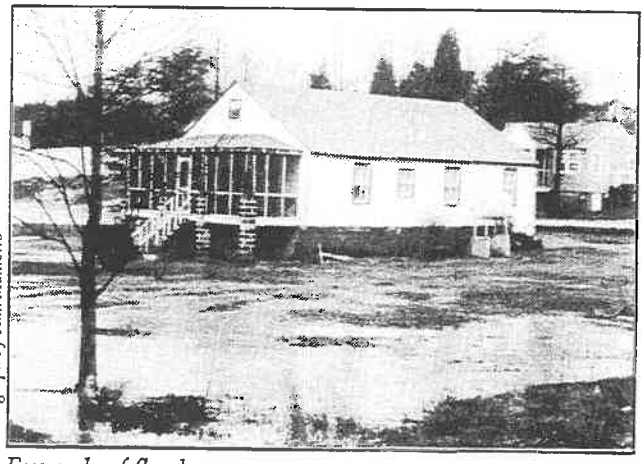
(1) Physical constraints to development, including soil limitations, with an explicit discussion of soil suitability for septic tank use[.] (§ 5.6.A.2)

The starting point for developing policies to implement a sound local development strategy is a careful assessment of physical conditions which naturally limit development. These factors include flood-prone areas, steep slopes, poor soils, wetlands, and other environmentally sensitive features which may have been designated as Chesapeake Bay Preservation Areas. The existence of these features **should** be major considerations for site design and development but have too often been ignored. Cracked building foundations, chimney separations, settling, wet basements, eroded roadways, and failing septic systems are just a few examples of environmental and economic harms that result from development in areas with physical constraints. A local government can help developers and property owners avoid hazards and high corrective costs by identifying and considering physical constraints to development during the comprehensive planning process. Moreover, matching the intensity, type, and location of development with the capacity of the land to accommodate development will have fiscal and water quality benefits for the locality as well. For example, failing septic systems can contaminate groundwater and eventually the Bay, and necessitate costly public sewer extensions in remote areas. Even though there are engineering solutions to some physical constraints, planning to avoid expensive site development or construction is much more cost-effective.



Photograph by H.L. Mathews

Cracked wall from construction in shrink/swell soil.



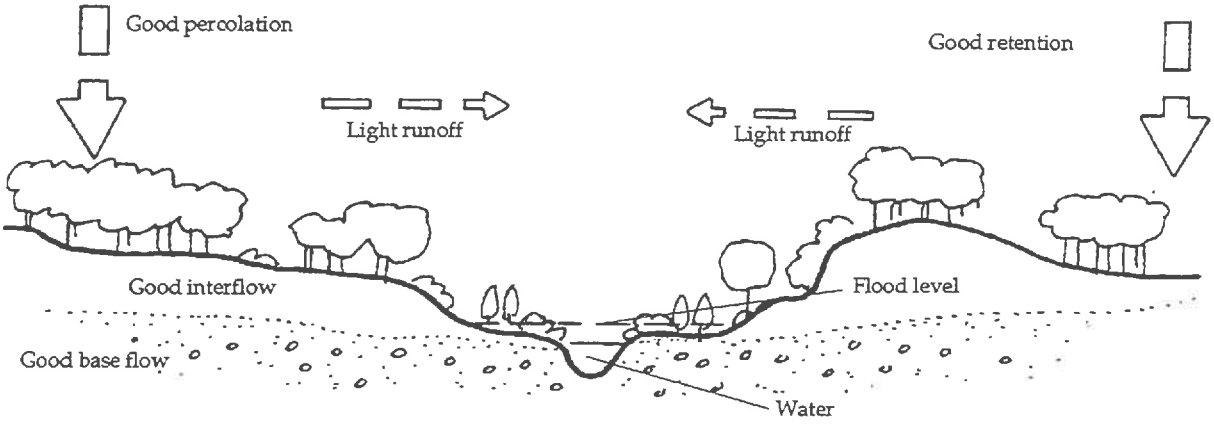
Photograph by H.L. Mathews

Example of flood-prone area.

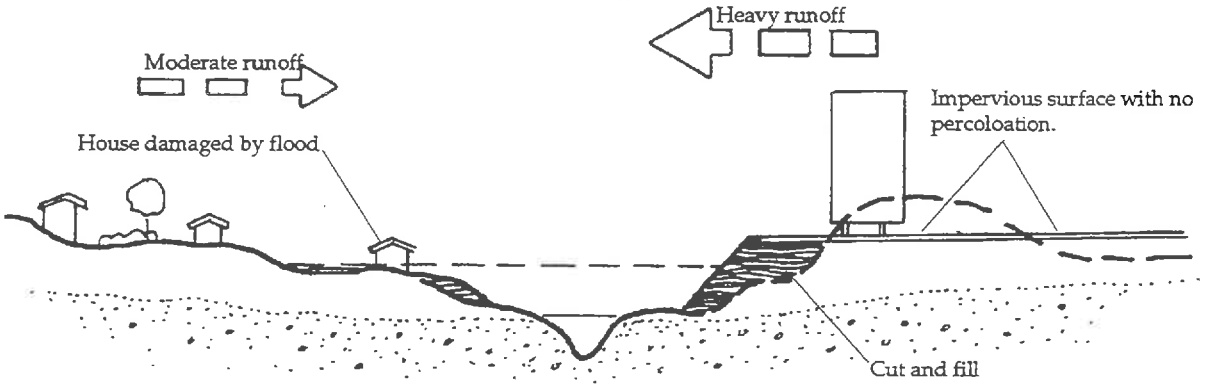
A variety of land features constrain development. Assessing the location and prevalence of these features will be a critical step in formulating local policy addressing suitable areas for development. A brief description of the major limiting features follows.

IMPACT OF DEVELOPMENT IN FLOODPLAINS *FIGURE 6-10*

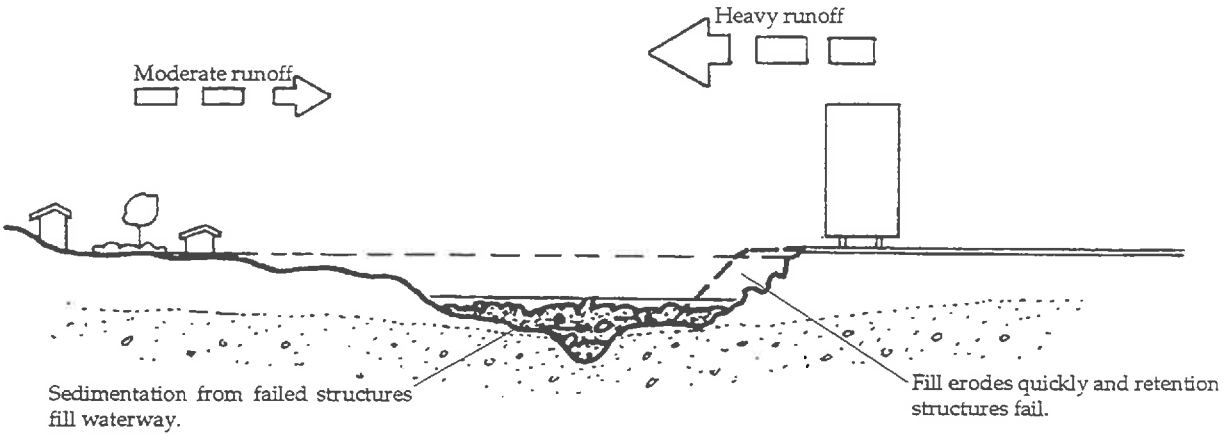
1. Undeveloped stream area with water cycle in balance.



2. Fill placed in floodplain will change flood patterns and may increase erosion.



3. Sedimentation and increasing erosion raises flood levels and increases flood frequency and severity.



For proper treatment, septage should not leach too quickly nor too slowly. When soils are saturated, or when drainfields are located on steep slopes or highly erodible soils, septage may not be sufficiently treated. Moreover, highly erodible soils and unsuitable slopes often occur near streams, creeks, and river banks, where failing septic systems would have severe and immediate water quality impacts.

Highly permeable soils, such as dry, sandy soils, even where slope is moderate, are also unsuitable for installation of septic systems. Highly permeable soils are defined in § 1.4 of the Regulations. This type of soil allows effluent to move too quickly to provide adequate treatment, and the potential for groundwater contamination is significant. Septic systems may also be unsuitable where highly permeable soils exist in combination with bedrock or seasonally high water tables less than four feet from the surface. Highly permeable soils in combination with these characteristics are particularly unsuitable for mass drainfields. [29]

If development is to occur in a manner which will protect natural resources and public health and safety, all of these factors should be considered in determining areas where septic systems will be allowed and those areas where public sewer or alternative on-site treatment are more appropriate. Local land use policy should direct incompatible development away from areas which are characterized by poor soils and toward areas where the extension of public sewer lines is planned. Areas which are unsuitable for septic tank use and where public sewer lines are not planned should be designated as potentially unsuitable for development or as areas where development should be restricted or delayed until proper infrastructure can be provided.

Prime Agricultural Lands

Soil types are also rated by the U.S. Department of Agricultural Soil Conservation Service for suitability for agricultural uses. Those soils best suited to producing food, feed, forage fiber, and oilseed crops are defined as "prime farmland" by the USDA.[30] These soils produce greater yields with less energy, fertilizer, and other expenditures, often with fewer impacts to the environment than from production on less suitable soils. However, development pressure is also higher on prime farmland because the topography is relatively flat, the land is substantially cleared, soil stability is good, and land ownership is generally consolidated into large parcels.

Localities that desire to maintain agriculture as a viable land use should recognize prime farmland areas in the planning process in order to protect these operations in the long-term. The U.S. Department of Agriculture has developed a suitability analysis for farmland protection called the Land Evaluation and Site Assessment (LESA) system. LESA helps localities identify prime farmlands for protection and also helps identify areas to target for growth.

The LESA system evaluates each parcel by assessing its soil suitability, productivity, and compatibility with primary crops. Each parcel's soils are ranked in comparison with the best soil type in the locality. LESA also factors in conservation methods, farm size, adjacent land uses, proximity to villages, infrastructure, and land use regulations to help produce a rating that allows each site to be compared with others in the locality. The system provides a valuable tool for land use decision makers to employ when trying to protect prime farmlands.[31]

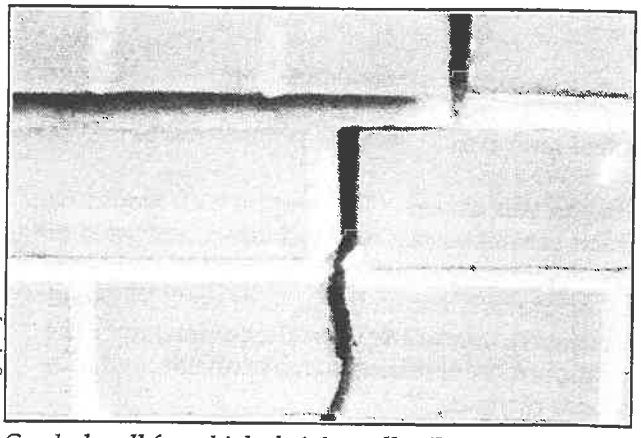
to the height differences indicated by the lines themselves. For example, topographic lines running very close together and adjacent to a water body would indicate significant relief at that point, such as a bluff. Smaller scale topographic maps (e.g., 1:400 scale) may be more useful in identifying significant relief. See Figure 6-9 for an example of reading contour lines on a topographic map.

Delineating slope suitability can be accomplished as follows:

Land Features	General Description
Flat Land	0-2% slope
Low Slope	3-7% slope
Moderate Slope	8-15% slope
Steep Slope	16-25% slope
Very Steep Slope	> 25% slope

Define slope categories which are suitable, moderately suitable, and unsuitable for development. As an example, a locality might classify low slopes (from 0-7 %) as suitable, moderate slopes (from 8-15 %) as moderately suitable, steep slopes (from 16-24%) as potentially suitable, and very steep slopes (>25 %) as unsuitable.

Then, using VirGIS maps, USGS maps, or smaller scale topographic maps, locate the moderately suitable, potentially suitable, and unsuitable slopes. Locating these slopes can usually be determined by visually examining the maps. However, calculating these slopes (rise over run) may be necessary for some areas. For example, a 20 percent slope indicates 20 feet vertical drop over 100 feet horizontal distance. The slope information should be transferred to a working map to again identify areas suitable for development and areas where development should be avoided.



Photograph by H.L. Mathews

Cracked wall from high shrink-swell soils.

STEP THREE

Identify and map sensitive soils.

Areas characterized by soils with extremely low permeability may be identified using local soil survey data or the VirGIS soil maps provided by the Department. Hydric soils and depth to water table also appear on VirGIS maps. If VirGIS is unavailable, local governments may use SCS data, ASCS data, local soil surveys, and local health department inventories to identify soils with extremely low permeability, or combinations of high permeability and depth to bedrock or water table. If a soil survey does not exist, preparing one should be a high priority. Localities interested in having a soil survey completed should contact the Department of Conservation and Recreation, Division of Soil and Water Conservation in Richmond (see Appendix A).

As part of the information base, the location of poor soils may be delineated as follows:

A VirGIS map, local soil survey, or other available resources may be used to identify the areas with low soil permeability (i.e., less than 0.6 inches per hour), highly permeable soils, and high water tables. An overlay

area with few or no constraints should be considered highly suitable. For water quality protection, this composite technique should include at least three layers of information (flood-prone areas, steep and very steep slopes, and poor soils) as well as any other features which may be of local significance. The final composite map will then depict those areas with one or more constraints.

Finally, the identified areas should be ranked according to development suitability. A locality should consider using several categories ranging from highly suitable to unsuitable.

Once the working composite maps of flood-prone areas, slopes, and soil characteristics have been developed, it is then possible to determine areas suitable for various types of development by overlaying all the maps of significant physical features. The chief objective is to determine what, if any, types of development will be allowed in sensitive areas, and this analysis should be integral in formulating the plan's future land use recommendations. Table 6-A in Appendix E describes the tolerance and suitability of various environmental features for development. This matrix includes recommended development policies for each natural characteristic and may be used to aid general decision-making about appropriate land uses. For example, impervious soils will not tolerate septic system use and areas with such soils should be designated unsuitable for development unless public sewerage is to be provided.

Plan Formulation and Policy Development

Although physical constraints to development may be a factor in the decisions of both developers and consumers, it usually is not a major factor. Location, dwelling unit character, availability of public services, and economics traditionally play much more important roles in such decisions. The course of development will be influenced by public policy and the land market. By understanding the capabilities and the limitations of land features and using this information to help determine how the land will be used, local governments can derive benefits in addition to water quality protection. Public policy which directs development into areas with little or no constraints to development also results in such community benefits as lower direct construction costs for developers, reduced renovation costs or losses in property values, and land values that are maintained or increased. [34]

Based on findings in the environmental inventory, localities should consider policies which limit or prohibit development in areas which have been classified as having low suitability or as being unsuitable for development. Comparing existing development patterns with the composite land suitability map may identify situations which pose difficult policy choices for a local government. The following discussion is designed to help identify ways in which those choices can be made.

PROPERTY SUBJECT TO FLOOD DAMAGE
TABLE 6-4

Year	Households	Total Value of Property ($1,000)
1980	320,600	14,800,000
1983	338,600	15,800,000
1987	368,900	17,400,000
1998	462,100*	22,600,000*

Note: * FEMA projections based on the rate of floodplain development in 1987.

Source: Federal Emergency Management Administration, *1987 Donnelley Report*, 1987

NOTE: Enrollment by a local government in the National Flood Insurance Program administered by the U.S. Federal Emergency Management Agency (FEMA) enables property owners to be compensated for flood damage. While enrollment limits development within the 100-year floodplain, property owners who build houses under FEMA safety standards are eligible for significantly reduced flood insurance premiums.[35]

Soil Suitability for Septic Tanks

Septic tank suitability is a local economic consideration as well as a water quality consideration. Local policies should ensure that septic systems are used only in locations where their operation will not create health hazards or have adverse effects on natural systems, especially surface and groundwater systems.

Designing, constructing, and maintaining adequate sewage treatment systems on lots with flood-prone areas, steep slopes or poor soils may be especially difficult. If the drainfield is not located in a relatively level position or in good soils, effluent will drain to the end of the field and prevent adequate treatment of bacteria. In such situations, effluent may also rise to the soil surface, posing a threat to human health.

Whether alternative sewage systems or public sewer is to be used, careful consideration should be given to potential impacts of proposed land uses (impervious surfaces and density) and potential soil limitations on sewage treatment systems. In addition, minimum low-flow levels should be considered for streams which will receive effluent from treatment plants. The proposed level of development should be balanced with the environment's ability to support sewage treatment systems. Proper design, installation, and long-term maintenance is essential to guarantee safe sewage treatment. It is the responsibility of the local government to ensure that the most suitable type of sewage treatment system is chosen. In some instances, there may be areas which are not suitable for development. These areas should be mapped and protected by local government policy.

Areas Unsuitable for Development

Areas where sewer extensions are not planned and that are also unsuitable for alternative sewage treatment systems could be designated as conservation areas or areas for other low intensity uses. Such areas are often found along waterways and may also be designated as part of the buffer area adjacent to

Resources. The Task Force has recommended several amendments to Virginia Department of Health (VDH) regulations.[36]

Increased Vertical Separation

There must be adequate unsaturated soil between the drainfield and the water table for the system to provide biological treatment. Otherwise, bacteria, viruses, and other pollutants will leach nearly unimpeded into ground and surface waters. The Septic Tank Task Force has recommended new minimum vertical separation requirements in order to minimize contamination of surface and ground waters. It proposes separations of 24 inches for Group I soils (sand and sandy loam) and 18 inches for all other soils.[37]

Setback Restrictions

In addition to vertical flow requirements, many localities have adopted increased horizontal distance requirements -- setbacks of 70 feet from shellfish waters and 50 feet from all other surface waters. In addition, septic drainfields must be located at least 25 feet from any structure and 100 feet from any well. Several localities have adopted a 100 foot setback from all surface waters to minimize the incidence of poorly treated effluent being released into surface waters.

Additionally, some localities have increased the structure setbacks to minimize impervious cover immediately adjacent to the drainfield. This allows a drainfield to operate under more optimal conditions by decreasing the quantity of runoff onto the drainfield and maximizing vegetated soil around the drainfield to provide better treatment. Localities may want to consider adopting minimum setbacks of 50 feet for structures and 100 feet for surface waters as part of amendments to the subdivision ordinance.

Lot Size

Lot size requirements directly relate to the ability of septic systems to properly function. A North Carolina coastal plain study has suggested that areas with sandy and sandy loam soils should have a minimum lot size of seven acres to prevent groundwater supplies from being contaminated with bacteria and improperly treated effluent.[38] Similar soils are prevalent in some parts of Tidewater. In addition, significant increases in nitrate concentrations in groundwater have been detected where density exceeds three drainfields per acre. Localities should consider requiring mandatory open space subdivision design or increasing the minimum lot size where public sewer is unavailable and is not planned for extension.

Alternative On-Site Systems

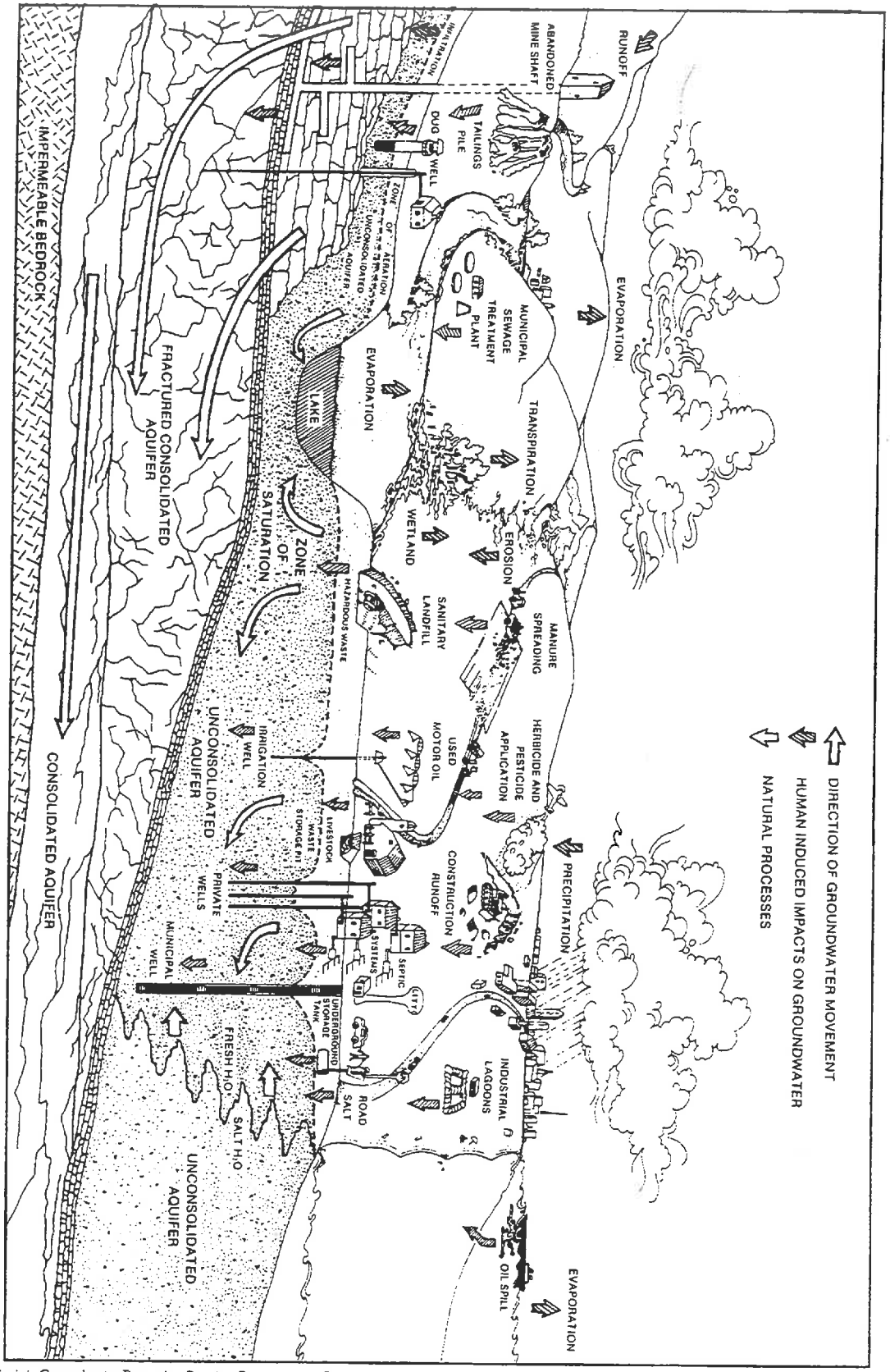
Alternative septic systems, such as Wisconsin sand mounds and low pressure distribution (LPD) systems , have gained increasing popularity among scientists as technology has improved. LPDs are particularly common in parts of North Carolina. Although a few localities in Virginia have restricted or even prohibited the use of alternative systems (mounds especially), many localities have found them to be beneficial in areas with very low or very high perk rates. Clarke County requires alternative systems in such areas.

Capital Improvements Program

The Capital Improvements Program (CIP) is an implementation tool for public expenditures, and has been used indirectly as a means for controlling the timing and rate of development. However, the CIP can also be used to implement water quality protection measures. CIP allocations should be examined for adequacy in addressing current and future physical constraints, especially those for septic systems. For example, a locality should determine whether it has the facilities to inspect and pump-out septic systems. Corrective measures for areas with known septic problems can be tied into the CIP process. Over the longer term, localities should focus on the provision of public sewerage to areas targeted for growth which are unsuitable for septic systems.

GROUNDWATER AND LAND USE IN THE WATER CYCLE

FIGURE 6-11



Source: Virginia Groundwater Protection Steering Committee, A Groundwater Protection Strategy for Virginia, 1987

tices must be applied consistent with the characteristics of the water supply and the sensitive areas affecting that supply.

For groundwater, the zone of contribution (ZOC) is that area of the aquifer from which a public well draws its water (see Figure 6-12). The ZOC's boundaries can be estimated using various modelling techniques. The size, shape, and location of the ZOC vary with the characteristics of the aquifer and the well.

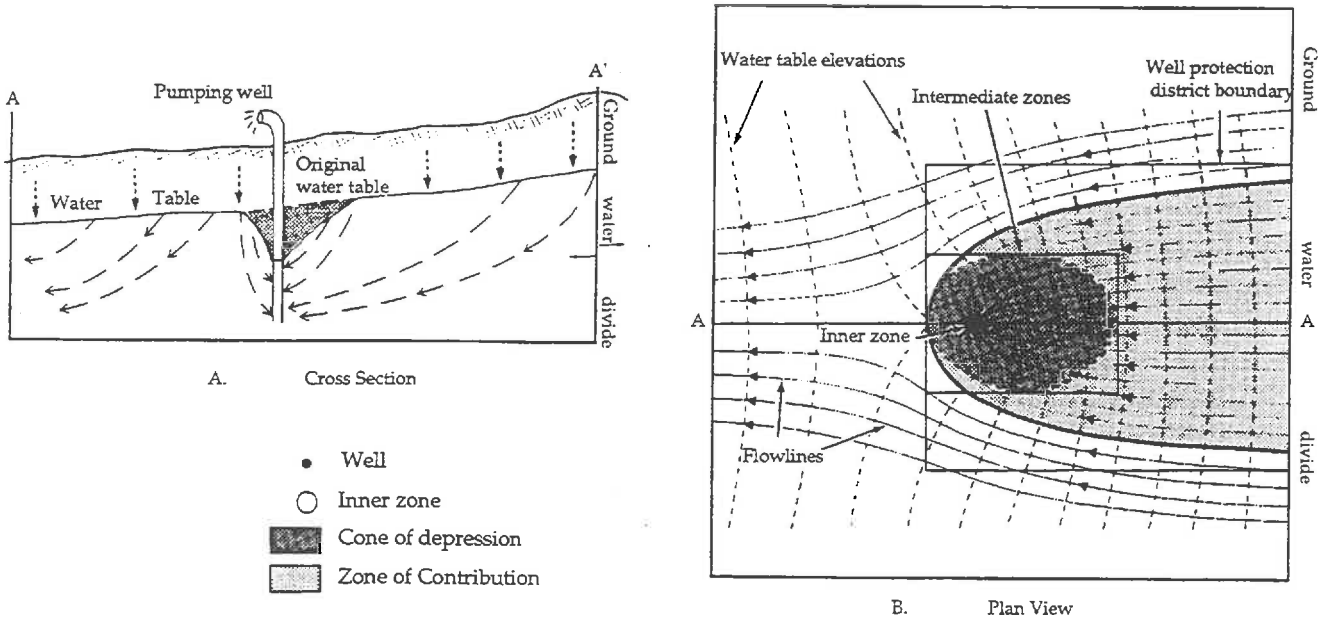
Other sensitive areas for groundwater protection are groundwater recharge areas. These areas are where groundwater flow tends to recharge aquifers. While replenishing an aquifer's water supply, these areas also have the potential to introduce contaminants into that aquifer.

For surface water, the sensitive area is the watershed contributing to the water supply. The entire watershed is included since all lands within the watershed are potential contributors of pollutants.

Regulations need to be established within sensitive areas to protect water supplies from contamination. While most human activities have the potential to pollute, the potential varies with the activity. Certain land uses such as landfills have an obvious potential to cause pollution. Land disturbances associated with residential and commercial land uses such as septic systems, roads, and underground storage tanks have just as much, or greater, potential to pollute water supplies.

For both surface water and groundwater, the rate of withdrawal and the withdrawal mechanism are important to consider in protecting the water supply. A withdrawal rate greater than the supply capacity will result in a drawdown of the water supply.

WELL PROTECTION DISTRICT AND MANAGEMENT ZONES *FIGURE 6-12*



Source: Born, Yanggen, and Zaporozec, *A Guide to Groundwater Quality Planning and Management*, 1987

(This chapter treats groundwater and surface water separately; however, many of the steps are similar and may be conducted concurrently.)

Several state agencies have useful information on both ground and surface water. Localities should contact these agencies to obtain this information. Table 6-5 provides a brief list of information available from state agencies on groundwater. The *Virginia Groundwater Management Handbook* provides a more comprehensive overview and even contains some information on surface water.[41]

Before beginning a data collection effort, a locality should define planning units and map scale. Planning units apportion a locality into logical areas for the purpose of studying areas in detail. When considering water systems, the logical planning unit is a **watershed** (see Appendix E).[42] The watershed boundaries identified in the **hydrologic units** (HU) maps (see page VI-14) should establish planning area boundaries for the water supply inventory.

STEP ONE

Inventory surface water and groundwater supply systems.

Surface Water

Identify the stream and river networks within the jurisdiction using the USGS and the HU maps. Differentiate between fresh and salt water streams and rivers where possible. Identify all impounded water bodies and their uses. This information should be used as the basis for classifying watersheds for their water supply potential.

Groundwater

In order to understand the characteristics of a groundwater system, it is important to understand the hydrologic cycle and hydrogeology of the area. Hydrogeology is the study of groundwater – its origin, occurrence, movement, and quality. Groundwater is also part of the hydrologic cycle and, in order to understand the influence of the hydrologic cycle on groundwater, it is essential to have some basic knowledge of precipitation, infiltration, the relationship between groundwater and surface water, and the influence of the geologic framework on water resources.[43] All of these characteristics have an impact on the locations and relative importance of sensitive areas, zones of contribution and aquifer recharge areas.

Identify and describe all aquifers present in the locality. Describe the location and types of each aquifer. Information on direction and rate of groundwater flow should be included. Most Tidewater localities are within the Virginia Coastal Plain which is typified by a water table aquifer underlaid by several semi-confined aquifers (see Figure 6-13). The *Ground Water Map of Virginia* (SWCB Information Bulletin 560) is a good source of general information on the location and description of these aquifers.[44] The map also provides some information on the pollution potential of each aquifer.

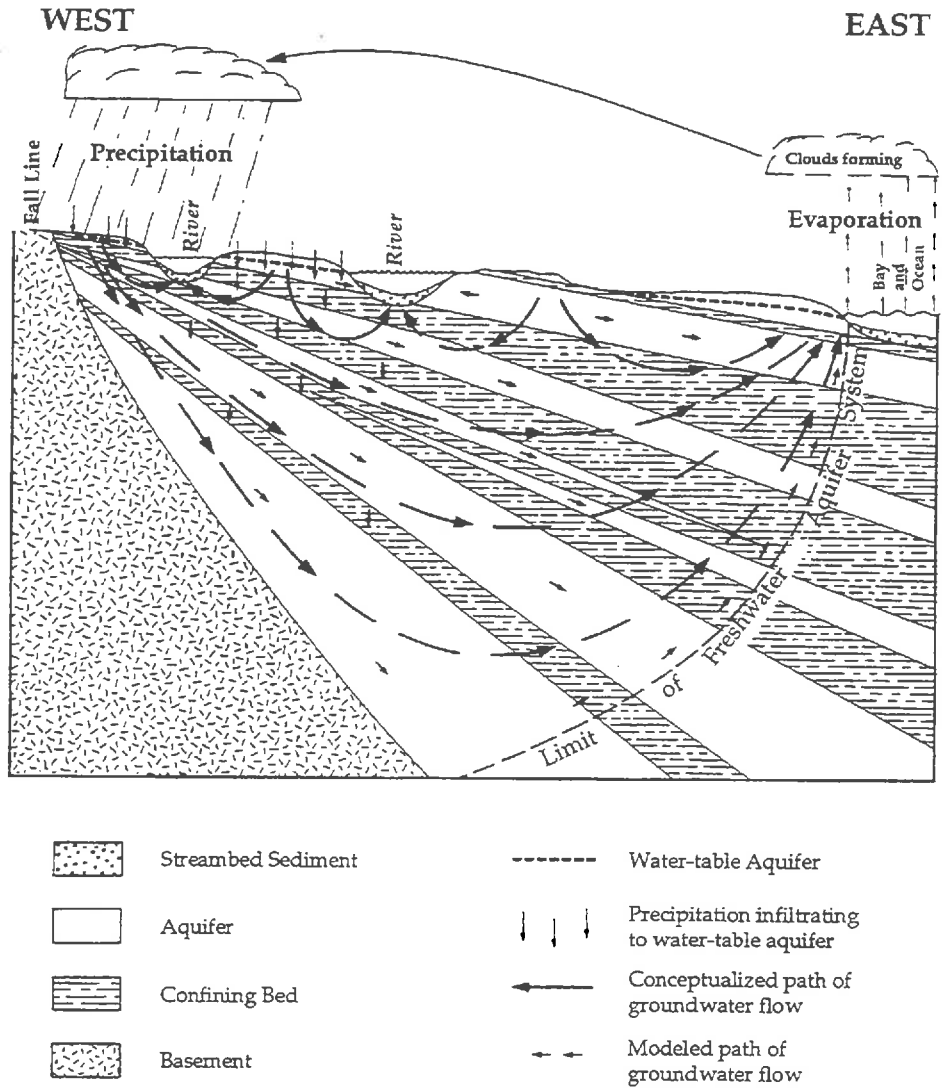
If available, a primary source of hydrogeologic data is a USGS groundwater study of the area. These studies provide maps of aquifers and confining units, accurate information about occurrence, movement, use and quality of groundwater, and hydraulic characteristics. The studies also model groundwater flow to determine characteris-

tics such as transmissivity, storage, vertical leakance, recharge, and projected effects of increased groundwater withdrawals.[45]

The State Water Control Board (SWCB) also performs groundwater studies. These studies are currently available for a limited number of localities and can be useful for information on geology, occurrence and use of groundwater, hydrology, and groundwater quality.[46]

If neither USGS nor SWCB studies are available, other resources can be used to evaluate characteristics of area aquifers. To assess the yield and importance of individual aquifers to the water supply, information on the specific characteristics (i.e. porosity and transmissivity) of the aquifers is necessary. Useful information for the surficial (water table) aquifer includes depth to groundwater and soil permeability. Information gathered from the Virginia Department of Health on well drill-

GENERALIZED HYDROLOGIC CYCLE FOR YORK-JAMES PENINSULA *FIGURE 6-13*



Source: U.S. Geological Survey, *Ground-Water Resouces of the York-James Peninsula of Virginia,* 1988

uses (within the watershed) by category: agriculture, high and low density residential, commercial, industrial, and conservation, for example. Identify potential contamination associated with each land use. For example, low density residential development may be associated with failing septic systems, runoff from extensive land clearing, and improperly constructed wells. The description should also include factors in the watershed which could impact water quality such as point source pollution discharges. Those watersheds with steep slopes and highly erodible soils should be noted, as should watersheds with a high percentage of impervious cover. The information collected should provide a picture of each watershed and its characteristics relative to water supply and degradation.

Identify the amount, location, and use of surface water withdrawals within each watershed. This information is useful to evaluate the importance of each watershed within the locality's overall water budget (supply/demand situation). The SWCB administers a program requiring the registration and reporting of water withdrawals over 10,000 gallons per day (GPD). The program does not require water users to get a permit, nor does it limit or restrict the right of water users to withdraw water. Exemptions from SWCB program include: withdrawals less than 10,000 GPD, withdrawals of saline surface water, and withdrawals made for the purpose of irrigating crops. The SWCB publishes the results of the water withdrawal reports as an aid in evaluating water use.[50]

Groundwater

Identify the amount, location, and use of groundwater withdrawals by watershed. This information is useful to evaluate the importance of groundwater within each watershed and throughout the locality. It is also useful in determining areas experiencing excessive withdrawals (see Figure 6-14).

The SWCB program requiring the registration and reporting of water withdrawals over 10,000 gallons per day (GPD), as discussed earlier in this step includes groundwater withdrawals. Again, information (available from the SWCB) on these withdrawals should be collected, and the amount, location, and use of withdrawals noted.

Information on agricultural withdrawals is difficult to obtain and may have to be estimated. Information on minor groundwater withdrawals (less than 10,000 GPD) can be obtained primarily from the Virginia Department of Health (VDH). The VDH maintains a database of all public supply wells in the Commonwealth. The local health department has information on private wells. Existing land use data can also be used to estimate location, amount, and use of withdrawals.

The public supply wells should be mapped and the information collected in STEP ONE should be used to identify the zones of contribution for each well. Sensitive areas should be considered for protection since land uses in these areas have the greatest potential to contaminate wells.

STEP THREE

Assess the quality of surface water and groundwater resources.

Surface Water

To properly evaluate the viability of existing and potential surface water supplies, surface water quality must be evaluated. The

Groundwater

Monitoring the presence of substances in groundwater is important in revealing existing conditions, trends, and potential pollution problems. This should include collecting information on total dissolved solids, pH level, heavy metals, chloride, fluoride, toxics, nutrients, dissolved oxygen, and bacteria levels. The SWCB groundwater reports will have the most detailed information on the presence of these substances and groundwater quality.

Localities without a SWCB groundwater report or those wishing to gather additional groundwater quality information can collect data from water well completion reports and well logs (of public wells) within the locality. This information is available in hard copy at the VDH Regional offices (see Appendix A).[52] Localities can also sponsor their own well testing programs, like the Cooperative Extension programs in Warren and Clarke Counties.

Based on the collected data, identify those watersheds experiencing groundwater quality problems. Problems may be evident by the presence of high total dissolved solids, high or low pH, heavy metals, chloride, fluoride, coliform bacteria, or nitrate. If historical data are available on groundwater quality, comparisons should be made with current data to determine trends in water quality degradation.

STEP FOUR

Identify point sources of pollution.

Point sources of pollution are those which reach state waters through a single source such as a pipe outlet. The outfall structures of sewage treatment plants, industrial plants, or other facilities are examples of point sources of pollution. All legal point source discharges to surface water are regulated by the SWCB through its Virginia Pollution Discharge Elimination System (VPDES) permit program.[53] Each permittee must monitor to ensure the discharge meets certain quantity and quality parameters. These parameters include flow, BOD (biochemical oxygen demand), DO (dissolved oxygen), suspended solids, settleable solids, chlorine residual, fecal coliform, pH, oil and grease, and temperature.

In this step, gather a list of point source discharges permitted under the VPDES program. This information is available either from SWCB's regional offices or from the SWCB Office of Water Resources Management in Richmond (see Appendix A). The SWCB regional office may also be able to provide additional information identifying the quality of the effluent being discharged from each source. All permitted sites other than single family dwellings are required to monitor and report information to the SWCB characterizing the quality of their effluent.

STEP FIVE

Identify nonpoint sources of pollution.

Surface Water

Nonpoint sources of pollution are those sources that cannot be traced to a single point of discharge. It is difficult to monitor and identify nonpoint source pollution, but information can be collected and analyzed to provide qualitative indicators.

Review the Department of Conservation and Recreation Division of Soil and Water Conservation's (DSWC) "Nonpoint

The Groundwater Protection Steering Committee (GWPSC) consists of representatives from eleven state agencies, all of which have programs dealing with groundwater. In 1987, the GWPSC developed a *Groundwater Protection Strategy for Virginia* and agreed upon a goal for that Strategy:

The Groundwater Protection Strategy should confirm and advance the legislatively mandated anti-degradation policy of the Commonwealth by initiating 'anticipate-and-prevent strategies' designed to protect the state's groundwater from any degradation that would be harmful to human health or the natural environment, now or in the future.

Since the development of the Strategy, the GWPSC has monitored achievements consistent with the goals presented in the Strategy and, in 1990, published a *Supplement* to the Strategy. This Supplement assesses the current situation, reviews past accomplishments, and sets an agenda for the future. Copies of these documents are available from the SWCB.

Tidewater's groundwater is also threatened by the regional problems of saltwater intrusion, excessive groundwater withdrawal, nonpoint sources of pollution in areas with highly permeable soils and/or a high water table, and contamination of confined aquifers from improperly abandoned and improperly constructed wells.

Underground Storage Tanks: Identify the location of all underground storage tanks (USTs) in the locality. There are more than 64,000 USTs in Virginia.[58] A UST leak has the potential to cause serious groundwater contamination and recent EPA studies reveal that as many as 35 percent of all USTs eventually leak.[59] USTs have been identified by the GWPSC as one of the top five priorities for groundwater protection. The SWCB administers the Virginia Underground Storage Tank Program and maintains a computer data base of all USTs in Virginia.[60] For a list of USTs, localities should contact the SWCB (see Appendix A).

Landfills: Collect information from the Department of Waste Management on groundwater contamination occurrences relating to landfills, dumps, and other disposal sites. Map the location of these occurrences, as well as the location of all known landfills, dumps, and disposal sites.

Hazardous Waste Facilities: Identify the location of hazardous waste facilities in the locality. Contact the Department of Waste Management (DWM) for a list of these facilities. DWM is also the source for sites designated as Emergency and Remedial Response Investigation Sites (ERRIS). There are 16,000 of these sites nationally. If there is an ERRIS site in the locality, check to see if it is on the National Priority List (NPL) for remediation. Over 1,000 sites nationally are on this list.[61]

Waste Lagoons: Identify all VPA permitted activities as potential sources of groundwater contamination. This would include pits, ponds, and lagoons for waste storage, treatment, or recycling.

Septic Systems: Estimate the location and number of existing on-site sewage treatment systems in the locality from the existing land use map. The local sanitarian may be able to help estimate numbers and locations of septic systems, in order to identify high densities of septic systems. Estimate the total number of future septic systems from the future land use map.

Pesticides and Fertilizers: From the existing land use map, identify those areas of the

an evaluation of alternative growth and development scenarios, policies should be developed and adopted to address local water supply protection issues and the larger issue of water resource management. The adopted policies should be interrelated with other plan policies such as economic development policies, growth areas and appropriate densities.

The local comprehensive plan should include a discussion of alternatives considered, as well as a discussion of the scope and importance of potable water supply protection (§ 5.6.A.2.c). The relationship between water supply protection policies and other land use and economic development policies should also be analyzed. If water supply protection policies are in conflict with other policies, these conflicts must be reconciled. For example, the future land use plan may designate a growth area within a future drinking water supply watershed. If the locality has no other future water supplies from which to draw, the growth area should be located elsewhere or modified so that development minimizes impacts on the water supply.

The comprehensive plan should, at a minimum, include policies to ensure the most appropriate water supply protection strategies will be utilized to provide high quality drinking water to the citizens of the locality. These policies should address a range of issues relating to water supply:

- water quality protection;
- water supply conservation and allocation;
- regional cooperation; and
- comprehensive water resource management.

Water Quality Protection

Water supply must be protected from existing and potential pollution. This requires the identification and protection of sensitive areas. For surface water, pollution sources should be regulated or restricted within the supply's contributing watershed. Strong plan policies establishing a protection strategy for critical watersheds will reduce the need for costly water treatment and increase the life of the water supply by reducing the rate of eutrophication. For a river water supply, watershed protection is more difficult since the watershed of the supply is extensive and usually goes far beyond local jurisdictional boundaries.

Groundwater protection is very important since a groundwater supply is difficult or impossible to purify once it becomes contaminated. Groundwater protection is more cost-effective than remediation.[62] Localities identified as State Groundwater Management Areas should prioritize their groundwater protection policies. These areas have been identified as having significant groundwater quality or quantity problems. These localities should also consider water supply sources other than groundwater for future supplies.

Local policies should specifically address protection of sensitive areas including critical groundwater recharge areas and zones of contribution. The greatest potential for groundwater contamination occurs in these areas. For this reason, land use and development must be carefully managed.

Groundwater recharge areas should be evaluated in terms of their significance and their ability to be managed. Deep flow re-

In areas of existing development, water conservation measures can be employed to extend the capacity of a water supply to sustain development. Several Tidewater localities have instituted voluntary water conservation during periods of peak water usage. Water supply rationing is the most drastic of water conservation measures. Rationing has also been used in Tidewater during drought times. Another water conservation strategy is requiring water-conserving plumbing fixtures through the local building code. Some localities have instituted programs and incentives to encourage or require retrofitting existing structures with such devices.

Consistent with growth and development policies, localities can also address the issue of allocation of water resources in their plan policies. Allocation policies can address expansion priorities for public water systems and priorities for allocation of water resources. Minnesota, for example, has established priorities as follows:

1. Domestic water supply;
2. Other withdrawals less than 10,000 GPD;
3. Agricultural irrigation (less than 10,000 gpd) and processing of agricultural products;
4. Power generation withdrawals over 10,000 gpd; and
5. Other withdrawals over 10,000 gpd. [68]

Allocation and expansion priorities should be established within the plan to guide future economic development within the locality.

Regional Cooperation

Water resources are a regional concern and localities should work together to develop regional water supply policies. Surface and groundwater resources often flow across political boundaries. Entire watersheds, not just the area within a locality, should be considered when developing water supply plan policies. This is especially relevant for river supplies. Entire groundwater aquifers should also be considered in regional policies. This system is extensive, especially in the coastal plain where the aquifers run the width of the region. Without a regional approach and regional cooperation, localities will not be able to properly protect their resources and may actually work against one another in their protection efforts.

In Northern Virginia, regional cooperation between all jurisdictions located within the Occoquan reservoir's watershed has protected that water supply from increased levels of nonpoint source pollution. Albemarle County and the City of Charlottesville have also cooperated in protecting their mutual water supplies.

Comprehensive Water Resource Management

Ideally, localities should develop a comprehensive water resource management plan which establishes policies and recommendations for each hydrologic unit within the locality and region. As a part of the

Albemarle County, Virginia depends on surface water resources for its (and the City of Charlottesville's) drinking water. In light of this dependence on surface water, the County instituted a management plan for all drinking water supply watersheds.

This management plan includes:

- Runoff Control Ordinance - "to protect against and minimize the pollution and eutrophication of the public drinking water supply impoundments resulting from land development in the watershed areas."

- Rezoned all publicly owned properties except school sites within water supply watersheds to a conservation district designation.

- Construction of a $5.3 million sewer interceptor and a $5 million sewage collection system for a community in a water supply watershed to eliminate several point discharges and failing septic systems. Construction of a sedimentation basin has also been proposed to alleviate non-point discharge in the community.

- The 1977 Comprehensive Plan was amended to remove all land in one water supply watershed from the "Urban Area" designation.

- The county underwent a comprehensive rezoning which placed major limitations on development in the "Rural Area" designated parts of the county. Special Use permits requirements addressed proposed developments located within water supply watersheds.

- The Comprehensive Plan was amended in 1982 which removed "Growth Areas" designations from four communities within water supply watersheds. These areas were later rezoned to "Rural Areas."

- Other activities are ongoing to continue protecting the county's water supply watersheds.

Source: Albemarle County, *The Comprehensive Plan for Albemarle County 1989-2010*, 1989

Amending Local Ordinances

Overlay Districts for Water Supply Protection

The zoning ordinance is the primary tool for protecting water supply quality. Zoning overlay districts can be used to protect critical areas within a locality that, if improperly developed, have the potential to impair a water supply. Watershed protection overlays have been implemented effectively in a number of Virginia communities to protect drinking water impoundments.[70] Use and density restrictions, performance standards, and specific design criteria applying within the overlay can ensure the water supply is protected from contamination.

Implementing aquifer recharge overlay districts can protect the both the quality and quantity of groundwater. Impervious surface restrictions, density limitations, and standards to ensure that stormwater runoff is retained on-site allow for the recharge of the aquifer.[71] The overlay district mechanism can also be an effective tool for managing land use and development within public wellhead protection areas. This technique can apply special use restrictions and best management practices which, if used in conjunction with emergency response plans, may be especially helpful in protecting public groundwater supplies.[72]

In areas not to be served by public water, community water systems are preferred where provided with strict requirements for well lot size and location.[73] Localities should consider increasing the horizontal stand-off distance between septic systems and wells to reduce the potential for well contami-

Criteria that can be incorporated into a local landscaping ordinance to help decrease water demand include:

- minimization of turf areas;
- using drought tolerant plant species;
- appropriate soil conditioning;
- grading for water flow and/or stormwater harvesting.

Water demand and usage varies greatly depending upon the type of landscape involved. Large open turf areas with no tree cover or shading require considerably more water than areas where turf is limited and existing trees are retained. Although turf can be minimized and water use reduced by designing a greater portion of the site as deck, patio, or driveway, this approach intensifies runoff and stormwater management problems and decreases groundwater recharge. Homeowners and landscape professionals can decrease impervious areas *and* promote water conserving landscape design by leaving large areas of natural vegetation in place or, when portions of a site are not left in a natural state, by using large planting or mulched beds instead of turf.

Although water conservation has not been an expressed objective of most landscape ordinances, some of the provisions included in them also save water. Trees that must be preserved or planted save water by cooling the air and soil and, in turn reducing evaporation. Incorporating water-conserving principles into local landscape ordinances would not be difficult. Specific criteria have been established for many localities that are readily available and easily adapted to any region.

Clarke County, Virginia has incorporated groundwater protection into its comprehensive plan and implemented a groundwater protection plan throughout the County. The plan was developed because the major portion of the County's population relies on groundwater as their source of drinking water and groundwater contamination has been a problem in the County.

The plan consists of a number of strategies:

1. **On-site wastewater treatment system management**
2. **Sinkhole Ordinance**
3. **Well standards**
4. **Underground storage tank requirements**
5. **Community education**
6. **Geographic information system**

These strategies were developed after a number of groundwater studies showed that groundwater resources in the County were vulnerable to contamination. Septic system siting and installation requirements were developed which relate to soil and geology conditions of the County more closely to those of the state. The sinkhole ordinance protects those sensitive areas which can act as conduits for polluted runoff to contaminate groundwater. Well standards were improved to insure that new wells would not increase the potential for groundwater pollution. Underground storage tank requirements were developed to limit the risk of pollution by petrochemical leakage. An education program was instituted to inform the public of the potential for groundwater contamination and how to reduce that risk. Finally, a geographic information system was installed to track and analyze natural resource data to achieve a higher understanding of the County's groundwater resources.

Source: Lord Fairfax PDC, *Clarke County Groundwater Protection Plan*, 1987

SHORELINE EROSION PROBLEMS AND CONTROL MEASURES

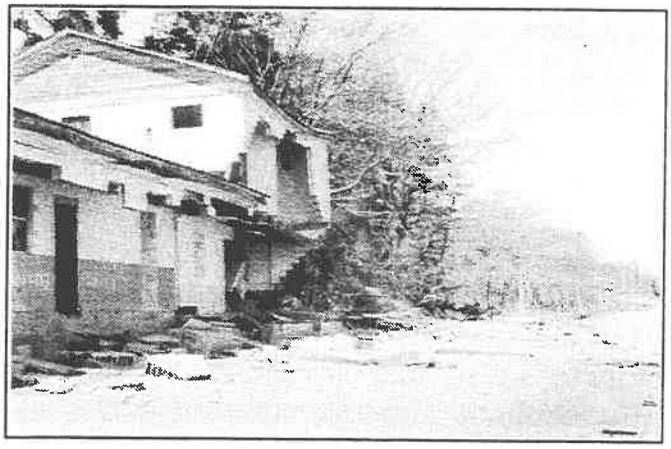
Local governments should establish an information base from which to make policy choices about future land use and development that will protect the quality of state waters. This element of the plan should be based upon the following:

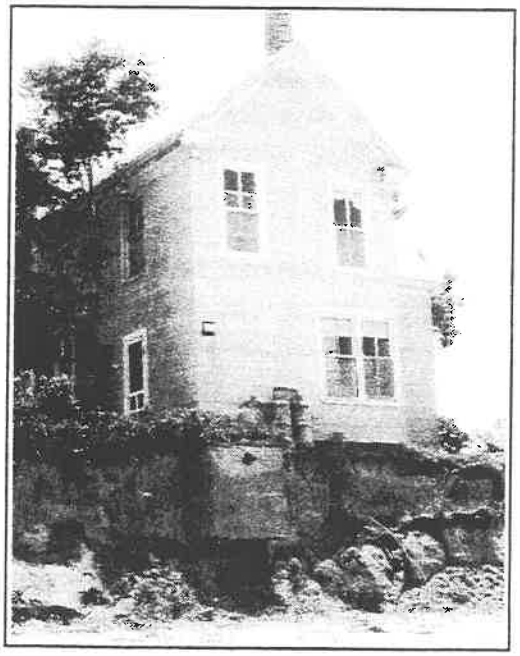
# # #

c. Shoreline erosion problems and location of erosion control structures[.] (§ 5.6.A.1.c)

Virginia has over 5,000 miles of tidal shoreline, very dynamic areas marked by the natural process of erosion and accretion. Human activity on or near the shoreline tends to increase erosion. Traditionally, *ad hoc* and post-development measures have been used to protect structures and beaches from natural and accelerated erosion. By considering erosion during the local comprehensive planning process, prior to development, localities may reduce or even prevent the need for future shoreline hardening efforts. A comprehensive approach would limit development in areas not appropriate for any type of structural control or where certain shoreline hardening measures would actually worsen erosion. Natural forces which cause shoreline erosion include wave action, storm events where water or wind damage occurs, and upland runoff. Grading, removing vegetation, and over-building usually increase stormwater runoff and erosion.

Shoreline erosion also has a significant negative effect on water quality. Initial studies have found that tidal shoreline erosion in Virginia introduces 1.37 million pounds of nitrogen and 0.94 million pounds of phosphorus into the Chesapeake Bay each year,[77] more than five percent of the total nitrogen and 23 percent of the total phosphorus in Virginia's controllable pollutant load.[78] Sedimentation in the Bay is another result of shoreline erosion, and the U. S. Army Corps of Engineers has estimated 15 to 20 percent of sediment reaching the Bay from this source could be eliminated by appropriate shoreline erosion control projects.[79] Such a reduction in pollution and sedimentation would, of course,





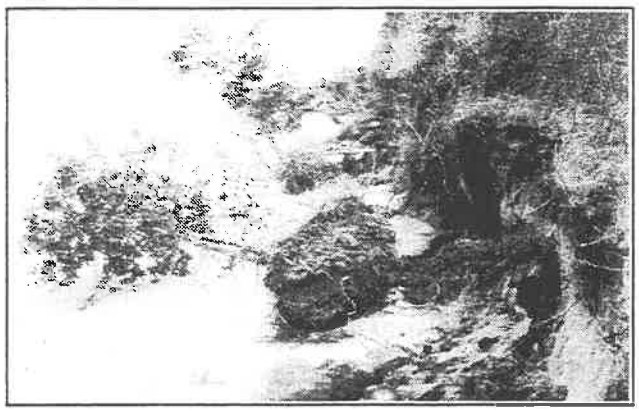
Right: Building damaged by erosion in Isle of Wight County. (James River)
Left: Farmhouse endangered by erosion on the Eastern Shore. (Chesapeake Bay)

Source: Department of Conservation and Recreation, Division of Soil and Water Conservation, Shoreline Programs Bureau

The Process of Shoreline Erosion

Daily shoreline erosion along the Chesapeake Bay is gradual, but its cumulative effect is significant. In the 100 years between 1850 and 1950, shoreline erosion accounted for a loss of approximately 21,000 acres within Virginia alone. Today's average erosion rate for Virginia's Bay shoreline is 0.7 feet per year, a loss of about 201 acres each year due to erosion.[81] Certain areas of the shoreline experience much higher shoreline erosion rates -- two or more feet per year[82] -- and nearly 40 miles of shoreline are eroding at a rate exceeding five feet per year.[83]

The climate affects a shoreline's rate of erosion. Storm events and a rise in sea level are the two climatic factors most frequently cited. High energy storms such as northeasters or hurricanes usually cause severe erosion. Storm frequency, direction, intensity, duration, and storm surges resulting from wind-driven tides are all factors that determine the impact of a particular storm event.[84] Further, sea level is rising due to melting of continental ice. As a result, higher water levels and tides will reach normally protected areas.



Trees downed by shoreline erosion resulting from storms which often pull considerable soil from bank face. (Potomac River)

Source: Department of Conservation and Recreation, Division of Soil and Water Conservation, Shoreline Programs Bureau

The physical factors involved in shoreline erosion are complex and highly variable. Planners need not be specialists in coastal processes to prepare a land use plan which takes these into account, although a general understanding of factors contributing to erosion will be helpful. Assessing the influence of these factors on the local shoreline may require assistance from a coastal engineer. A brief description of these factors is provided below.

Abundance of Vegetation: Submerged aquatic vegetation (SAV) in the near-shore area and shore grasses on either the shore bank or beach retard the movement of sediment and act as shock absorbers to baffle wave action.

Bank Composition: Consolidated soils (such as clay) resist erosion more effectively than sandy, unconsolidated soils.

Bank Height: This is the vertical area located immediately behind the beach or on the shoreline. Bank height determines a given erosion rate. Bank composition and height affect erosion along Tidewater shorelines, where a significant amount of shore is characterized by bluffs. Bluffs fail due to gravity, wave action, and freshwater runoff. Typically a bluff is weakened by runoff resulting from rainwater flowing down the bluff face and from groundwater seepage which occurs because of a clay layer at the base (see Fig. 6-15).

Boat Wakes: Shorelines fronting navigation channels are especially vulnerable to wave action created by passing vessels.

erosion control option must be chosen. Options range from the natural to the structural and should be chosen based on actual site conditions. Some options are to "do nothing," relocate threatened buildings, plant vegetation, provide beach nourishment, or establish permanent structures.

"Do Nothing"

The "do-nothing" option costs nothing and allows for natural erosion and accretion of the shoreline. This approach generally is unacceptable when development is already on-site or off-site forces influence erosion rates. The "do nothing" approach is best suited for situations where development can be carefully located and can incorporate site design features to prevent erosion from off-site sources.

Relocation

Whenever possible, threatened buildings should be relocated. Again, this option does not interfere with natural shoreline dynamics. Once buildings are relocated, no control structures must be maintained. This option may not be feasible where the building's construction does not lend itself to relocation or if the site is too small. Like the "do nothing" option, a major disadvantage of relocation is that neither technique controls shoreline erosion.

Vegetation

This method is often called a "soft barrier." Vegetation such as grasses, shrubs, trees, and wetland habitats absorbs and breaks up wave energy. Root systems also hold soil in place. Depending on the type selected, vegetation can be the least expensive means of shoreline stabilization. Where appropriate, soft barriers / natural barriers are preferable to structural mechanisms because of their ability to adapt to changing erosion forces. Vegetation is especially effective in allowing wetlands to migrate with fluctuations in sea level. In case of extreme high tide, vegetation may not be enough to provide protection. Further, it is effective only for low-energy shorelines. To remain functional, vegetative barriers require periodic maintenance, including replacement of dead or diseased vegetation. One consideration in the placement of vegetation should be the intended use of the shore. Pedestrian and vehicular traffic will quickly destroy vegetation if proper access points are not provided (see Table 6-6).

Beach Nourishment

This method is also a soft barrier. Beach nourishment consists of replacing sand on a beach. Beach nourishment is especially useful when the goal is to create or preserve a recreational beach. However, it is costly, estimated at $1 million per mile for an open-ocean beach and is a temporary solution at best.[86] Like the "do nothing" option and the relocation of buildings, nourishment does not control shoreline erosion, but may be appropriate in conjunction with other measures.

Permanent Structures

Permanent structures are useful to shield land from high energy wave action and some structures can build up beaches on the updrift side. However, there are potentially many significant negative water quality impacts from their use. Increased erosion from improperly placed and constructed structures may result in the destruction and ultimate loss of wetlands, tidal shores, and shoreline vegetation, especially downdrift and

FRESHWATER SYSTEMS	BRACKISH OR ESTUARINE SYSTEMS

MARSH SPECIES
(Reed Bank Zone)

Softstem Bulrush(*Scirpus validus*)	Saltmarsh Cordgrass (*Spartina alterniflora*)
Common Threesquare(*Scirpus americanus*)	Big Cordgrass (*Spartina cynosuroides*)
Soft Rush (*Juncus effusus*)	Saltmeadow Cordgrass (*Spartina patens*)
Cattails (*Typha spp.*)	Black Needlerush (*Juncus roemerianus*)
Sweetflag (*Acorus calamus*)	
Southern Wild Rice (*zinzaniopsis miliacea*)	
Rice Cutgrass (*Leersia oryzoides*)	

SHRUBS AND GROUNDWATER SPECIES
(Shrub Zone)

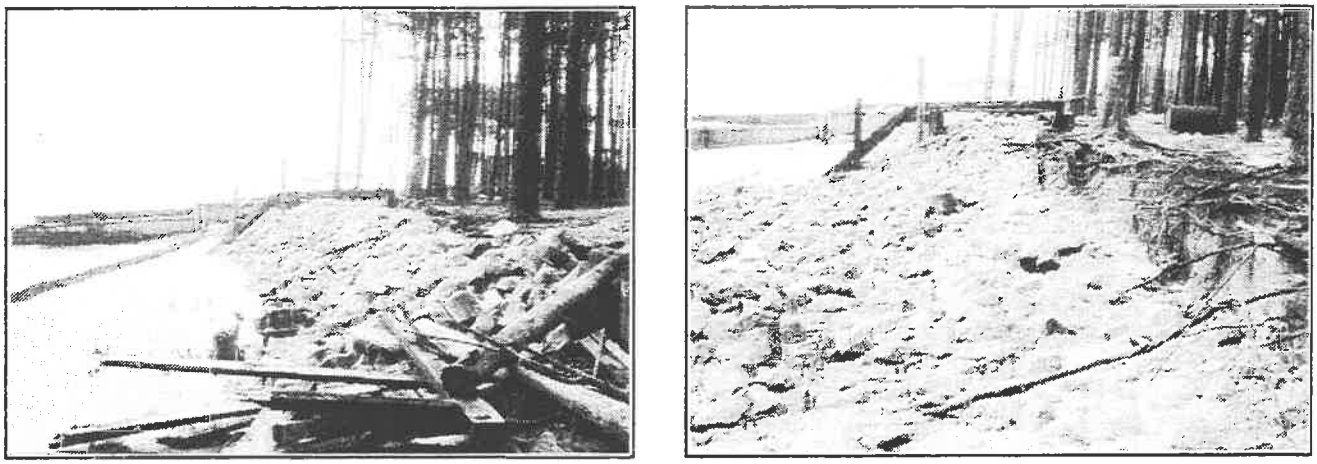
Smartweed (*Polygonum spp.*)	Saltmarsh Aster(*Aster tenuifolius*)
Sweet Pepperbush (*Clethra alnifolia*)	Wax Myrtle (*Myricacerifera*)
Button Bush (*Cephalanthus occidentalis*)	Tidemarsh Waterhemp (*Amaranthuscannabinus*)
Red Bay (*Persea borbonia*)	
Highbush Blueberry (*Vaccinium corymbosum*)	
Black Willow (*Salix nigra*)	

TREES
(Tree Zone)

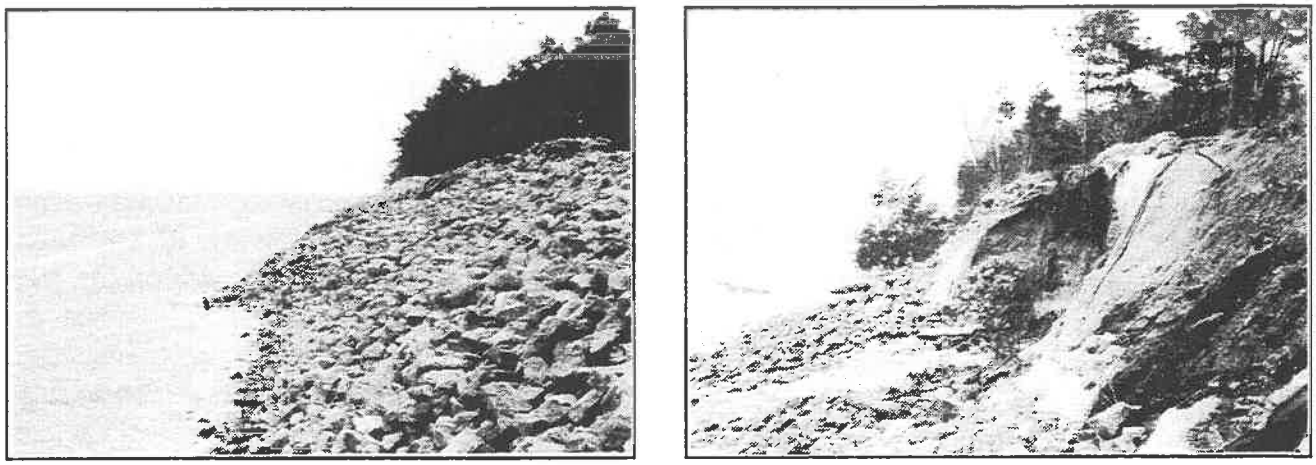
Red Maple (*Acer rubrum*)	Live Oak (*Quercus virginiana*)
Sweet Gum (*Liquidamber styraciflua*)	False Willow(*Baccharish almifolia*)
Black Gum (*Nyssa sylvatica*)	
Bald Cypress (*Taxodium distichus*)	
Black Willow (*Salix nigra*)	
River Birch (*Betula nigra*)	
American Elm (*Ulmus americana*)	
Hackberry (*Celtis occidentalis*)	
Willow Oak (*Quercus phellos*)	

Source: Chesapeake Bay Local Assistance Department, 1991

SHORELINE STABILIZATION PROJECTS - BEFORE AND AFTER — FIGURE 6-18



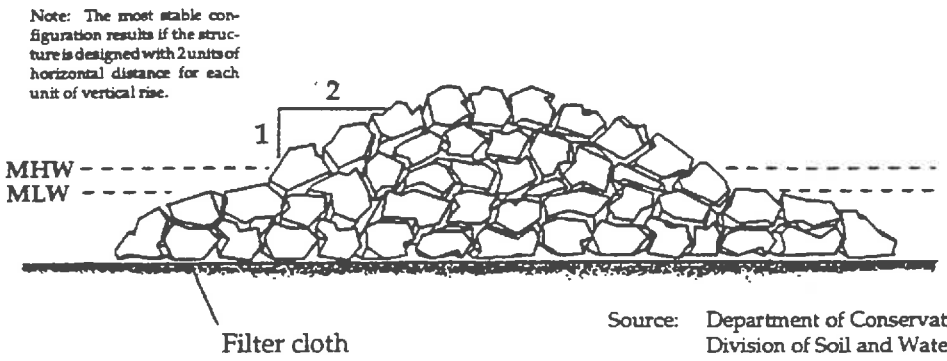
Undersized riprap reventement may afford only short-term shoreline stabilization. The photograph on the left shows a riprap reventment. The riprap structure failed (photo on right) during a storm. (Potomac River)



Riprap structures should be designed and constructed to withstand expected wave energy at any given time.

Source: Department of Conservation and Recreation, Division of Soil and Water Conservation, Shoreline Programs Bureau

RIPRAP BREAKWATER *FIGURE 6-20*



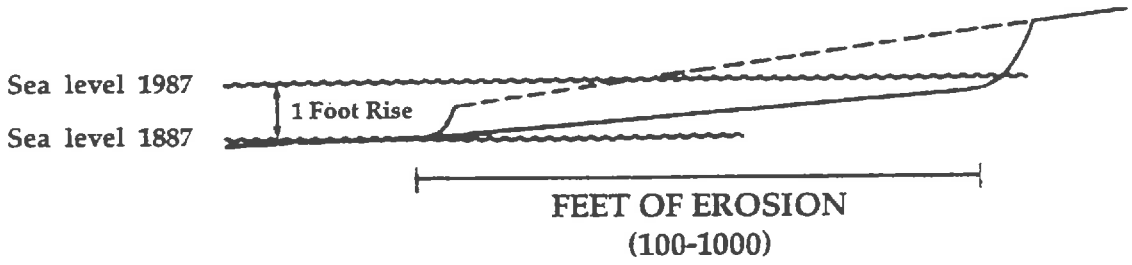
Source: Department of Conservation and Recreation, Division of Soil and Water Conservation, Shoreline Programs Bureau

tures are designed to modify wave action, reduce deep-water wave energy, and promote beach nourishment. The effect of breakwaters is to allow some transport of sand; however, the downdrift effect must still be considered in breakwater design. Because breakwaters are effective in protecting relatively long stretches of shoreline, they ultimately yield a lower cost per linear foot[89]

SEA LEVEL RISE

Localities must also begin to consider the long-term effects of sea level rise, attributed principally to global warming.[90] The burning of fossil fuels increases carbon dioxide and associated combustion gases in the atmosphere, which retains heat. The net result appears to be a slight warming of the earth's climate, leading to thermal expansion of the oceans and accelerated melting of continental ice. Sea level currently has a vertical rise rate of slightly greater than one foot per century and is expected to accelerate to several feet per century. In low-lying areas, one foot of vertical sea level rise can cause a shoreline to shift horizontally by as much as 1000 feet over 100 years (See Figure 6-21).[91]

SHORELINE EROSION AND SEA LEVEL RISE *FIGURE 6-21*



Source: Copyright 1989, Duke University Press. Reprinted by permission of the publisher.

STEP ONE

Determine planning units.

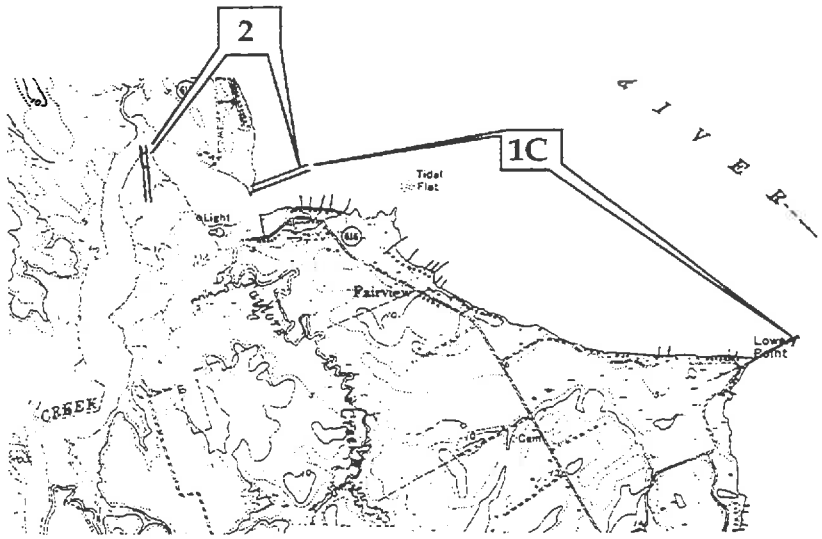
The most readily available data for local shoreline conditions are in the ***Shoreline Situation Reports*** prepared by the Virginia Institute of Marine Science (VIMS). Although somewhat dated, the *Reports* are the only comprehensive resource currently available. The *Reports* present information on shoreline types, upland land use, erosion rates, and the location of existing erosion control structures for localities in the Tidewater region. Assistance from VIMS or the Department of Conservation and Recreation, Division of Soil and Water Conservation, Shoreline Programs Bureau, can help local planners divide the shoreline into reaches. Reaches are segments of shoreline (a few yards to miles) where shoreline processes and materials are similar. Reaches become the planning units for shoreline management (see Figure 6-23).

STEP TWO

Determine existing erosion rates for each reach; define ranges for low, medium, and high rates of erosion; and identify critically eroding areas of the shoreline.

Again, the *Shoreline Situation Reports* provide a base of information from which to begin. Although erosion rates included in these reports were, in most cases, calculated ten to fifteen years ago, the rates are based upon historic trends which indicate relative changes in the shoreline. Erosion can be

EXAMPLE OF REACH DELINEATION — *FIGURE 6-23*



MAP 4A
PISCATAWAY CREEK
Segment 2 and Subsegments 1C

Source: Virginia Institute of Marine Science, ***Shoreline Situation Report for Essex County,*** 1976

= Segment Boundary. Segments are groups of subsegments. Segment boundaries are determined by physiographic features such as necks or peninsulas between tidal creeks.

= Subsegment Boundary. In the *Shoreline Situation Reports*, subsegments correspond to reaches in that the pattern of erosion or accretion is simliar. Subsegment/reach length may vary from a few hundred to several thousand feet.

ing permanent structures are effective and identify reaches where structures are aggravating erosion updrift.

Whether a locality decides to perform an itemized inventory or to conduct a less detailed investigation, **the data should be mapped by reach.** Preparing an overlay to the existing land use map will help with the analysis discussed in Step Seven.

Another effort in progress at VIMS, in cooperation with the Department of Conservation and Recreation (DCR), Division of Soil and Water Conservation (DSWC), is the *Bank Erosion Impact Study*. The study will include a digital data base delineating shoreline defense structures along 1600 miles of tidal shoreline. The study is directed toward analyzing the decrease in nutrients eroded into the Chesapeake Bay due to shoreline hardening. Using historic erosion rates estimated over 89 years (1855 to 1944) the study will compute the volume of sediment kept from the Bay between 1985 and 1990 by mapping the position of various types of shoreline defense structures. Land use conditions for 1985 and 1990 are also included in the project's database. The digital database, stored in the VIMS CCI Geographic Information System, is expected to be available through DWSC in May 1991. This information is recommended as a primary source of data for identifying the location of shoreline erosion control structures.

STEP FOUR

Conduct selective field surveys/site assessments.

Although the Comprehensive Coastal Inventory Program (CCI) at VIMS is updating available data on shoreline conditions, most Tidewater jurisdictions will not have the benefit of CCI reports prior to beginning timely comprehensive plan revisions. For most localities, the identification of critically eroding areas will require a comparison of current conditions with historical data on the shoreline. A comparison of aerial photos taken at different points in time may be useful; some aerial photos are available from the Virginia Department of Transportation, U.S. Geological Survey, and USDA Agricultural Stabilization and Conservation Service. Ideally, site visits should be made to structurally modified areas in order to determine the impacts and effectiveness of erosion control structures on the shoreline, particularly along adjacent reaches. It is important to observe evidence of scouring around the base of permanent structures and evidence of shoreline erosion downdrift.

STEP FIVE

Identify and map areas where control structures should be avoided.

For some reaches, storm frequency and intensity and shoreline geometry and orientation will rule out the construction of permanent erosion control structures. Further, where existing structures have aggravated erosion rates downdrift, as determined in Step Four, additional structural erosion controls should be prohibited, with exceptions made only when necessary to prevent the loss of an existing building. This analysis will require technical advice from a shoreline engineer. The Shoreline Programs Bureau of the DSWC may be able to assist (see Appendix A).

STEP SIX

Identify areas which require stabilization.

Based on prior evaluation, identify and prioritize areas for shoreline erosion management efforts. This evaluation should include

collected in each preceding step has been prepared as an overlay to the land use plan map, areas of potential conflict between land uses and natural processes may be readily identified.

STEP EIGHT

Consider shoreline management alternatives.

A locality should consider a number of shoreline management strategies before making policy determinations. With this analysis, a jurisdiction will most likely have several options, depending upon the specific circumstances.

One strategy would be to leave shoreline protection up to individual property owners; this may or may not include provisions for local government oversight to ensure a coordinated strategy. Another, and recommended, alternative would be the development of a **comprehensive** shoreline management plan in order to ensure the most appropriate erosion mitigation strategies for the protection of the jurisdiction's entire shoreline. This alternative may include the designation of certain reaches where only vegetative protection measures may be used, limiting structural measures to the areas where they are necessary and most effective. The policy discussion in the local comprehensive plan as required by the Regulations will necessitate a discussion of alternatives considered and justification of the final selection.

STEP NINE

Revise future land uses or intensities based on shoreline inventory findings.

At a minimum, localities should consider appropriate revisions to the land use plan map in light of shoreline factors and the feasibility of various erosion management techniques. For example, a critically eroding shoreline in a reach where intense development is proposed presents a clear land use conflict. A revision to the land use plan may avoid altogether the need for costly erosion control measures which would provide only a temporary solution. Again, a locality may have a number of options in such a situation, depending upon the circumstances.

One option would entail the recommendation of other, more appropriate land uses along the shore. Planning for the eventual acquisition of extremely vulnerable areas for public open space could be another option. Another strategy would be to reduce the intensity of allowable development. Amendments to the zoning ordinance may implement shoreline protection goals by establishing special setbacks so new development would be out of the projected range of shoreline erosion for a specified duration. Open space subdivision or cluster housing provisions could offset the loss of developable area with little effect on overall intensity of development.

Plan Formulation and Policy Development

To comply with the Act and Regulations, local governments will need to develop an overall policy framework which establishes appropriate responses to shoreline erosion. Based upon shoreline data and an evaluation of the technical merits of various shoreline stabilization techniques and their suitability for different shoreline environments, policies should be developed and adopted to address local shoreline erosion problems and mitigation structures.

Mapping

If analysis indicates that land uses should be revised in light of shoreline conditions, the future land use map must be amended. Other maps can be considered for inclusion in the plan that are useful for displaying backgound data. Maps depicting reach delineations, shoreline erosion rates, and critically eroding areas will be especially effective in support of final plan recommendations. A map or maps showing the location of existing control structures and summarizing shoreline conditions may also be helpful. A more detailed shoreline management plan might include mapping which identifies the appropriate control measures for each reach.

Since the scale of the general land use map would likely be ineffective in displaying data by reach, a map showing reach boundaries might be prepared as an overlay to local hydrologic units or other planning areas. Ultimately, the more detailed management plan might display background data and plan recommendations at a tax map or zoning map scale.

Implementation

The first step in implementing shoreline management policies is adoption of the amended local comprehensive plan in order to guide future activity. The amendment should include a thorough discussion of the benefits and hazards of various types of erosion mitigation strategies and should also establish shoreline protection priorities. Once plan policies or the shoreline erosion control element of the comprehensive plan has been adopted, the local Wetlands Board should refer to the document in the course of its permit review process in order to ensure decisions are in accordance with the plan.

The zoning ordinance should be amended to establish necessary shoreline setbacks. In any district where it has been determined that structural shoreline hardening in reaches in the district will have damaging impacts on adjacent reaches, shoreline hardening should be prohibited or conditioned.

The City of Hampton's *Beachfront Master Plan* includes a recommendation for the City to stabilize privately owned shorelines in exchange for public access to private beaches. This policy is designed to provide an incentive to owners to relinquish some of their property rights as a trade off for improved shoreline protection and also better beach access. Localities implementing shoreline management districts might use a similar strategy to increase public access along their waterfront.

Localities may wish to consider adopting an overlay district in order to implement the plan policies for appropriate erosion protection. An overlay district could be particularly effective in reconciling management strategies by reach with property boundaries and zoning lines. The creation of special shoreline management districts for critically eroding areas may be another method of implementing plan policies and a more comprehensive strategy for addressing shoreline problems. Local governments could also amend their Chesapeake Bay Preservation Area Overlay District, where applicable.

The community facilities planning process is another vehicle to achieve shoreline protection. Planning for the extension of public facilities, including shoreline stabilization, should steer facilities away from vulnerable shoreline areas and toward areas most suitable for development, given shoreline conditions. This process also enables a locality to plan for the purchase of particularly sensitive shoreline segments.

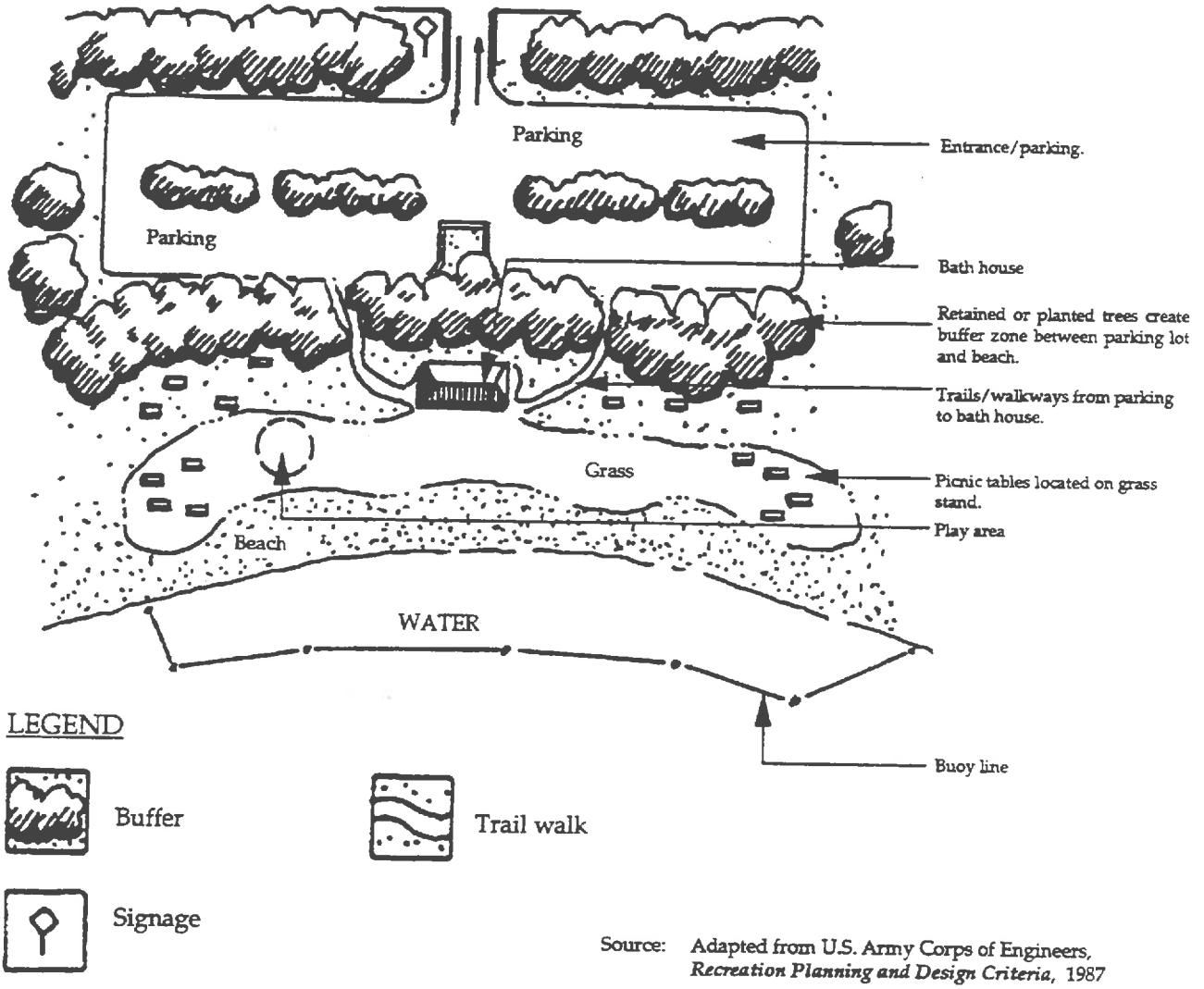
2. Swimming access, including beaches and designated areas appropriate for swimming;

3. Fishing access, including piers, bank fishing, and parking adjacent to tidal waters;

4. Natural area access, including wildlife management areas, natural area preserves, wildlife observation areas, nature trails, and educational facilities contiguous to tidal waters. [96]

The general discussion of public and private access in this section includes the activities just outlined as well as other water-related activities such as picnicking, camping, hiking, and hunting. Boat-related facilities and activities are treated in greater detail as such facilities potentially have a greater impact on water quality and they are frequently a major element in access programs.

BEACH/SWIMMING ACCESS SCHEMATIC PLAN *FIGURE 6-24*



Source: Adapted from U.S. Army Corps of Engineers, *Recreation Planning and Design Criteria*, 1987

sion analyzed this issue and concluded that although the impact from individual boats may be negligible, the **cumulative** impact in many cases may generate significant localized water quality problems. [100]

Siting Marina Facilities

In 1988, the Virginia Marine Resources Commission (VMRC) issued its *Criteria for the Siting of Marinas and Community Facilities for Boat Mooring*.[101] The *Siting Criteria* serve as guidelines VMRC uses to evaluate the location and design of proposed marinas and boat docking facilities.

The *Siting Criteria* are divided into two parts. The General Siting Criteria address the siting of boat-related facilities relative to sensitive environmental features and marine resources. The Specific Siting Guidelines focus on project design in order to minimize any adverse environmental impacts. The *Siting Criteria* are summarized in checklist form for use in evaluating permit applications (see Table 6-7).

The *Siting Criteria* provides VMRC a technical basis to evaluate potential environmental impacts of development proposals. However, the *Siting Criteria* are only **advisory** and applied on a case-by-case basis. Thus, VMRC is unable to make regional or long-term planning decisions about the suitability of certain areas for the development of water-dependent facilities. By integrating the *Siting Criteria* into a planning process, local governments will be able to **proactively** identify the most suitable locations for boating facilities.

Relationship of Land Use to Commercial and Recreational Fisheries

The Bay has always been a rich source of seafood and shellfish. However, during the past decade, commercial shellfish populations have been severely decimated by disease and pollution. Many large areas, such as entire rivers and bays, have had their harvesting condemned. Whether state efforts and initiatives to improve overall water quality in the Bay will be adequate and sufficiently timely to allow for the wholesale regeneration of these shellfish beds remains to be determined by research.

Aquaculture is an increasingly important coastal-dependent use which produces food, enhances fisheries stocks, and contributes to state and local economies. Clean waters are essential for aquaculture operations. Level of nitrogen, dissolved oxygen, salinity, changes from fresh water runoff, turbidity, temperature, and fecal coliform bacteria levels are water quality indicators which will dictate the suitability of an area for aquaculture production. The long-term viability of aquaculture sites will depend on local policy addressing the use and development of adjacent land.

Recreational fishing was identified in the ***1989 Virginia Outdoors Plan*** as one of the top ten ranking recreational demands, with 27 percent of the state's population participating. Though existing facilities for fishing are adequate to meet future demand, the Plan recommends that new opportunities for fishing be developed, and existing single purpose facilities, such as wharfs and docks, be expanded to accommodate additional low-intensity recreational fishing opportunities.

Local policies can provide opportunities for aquacultural and other uses such as commercial fishing, recreational boating, and shoreline land use in a manner which minimizes the conflicts between these uses and protects water quality.

Data Collection and Analysis

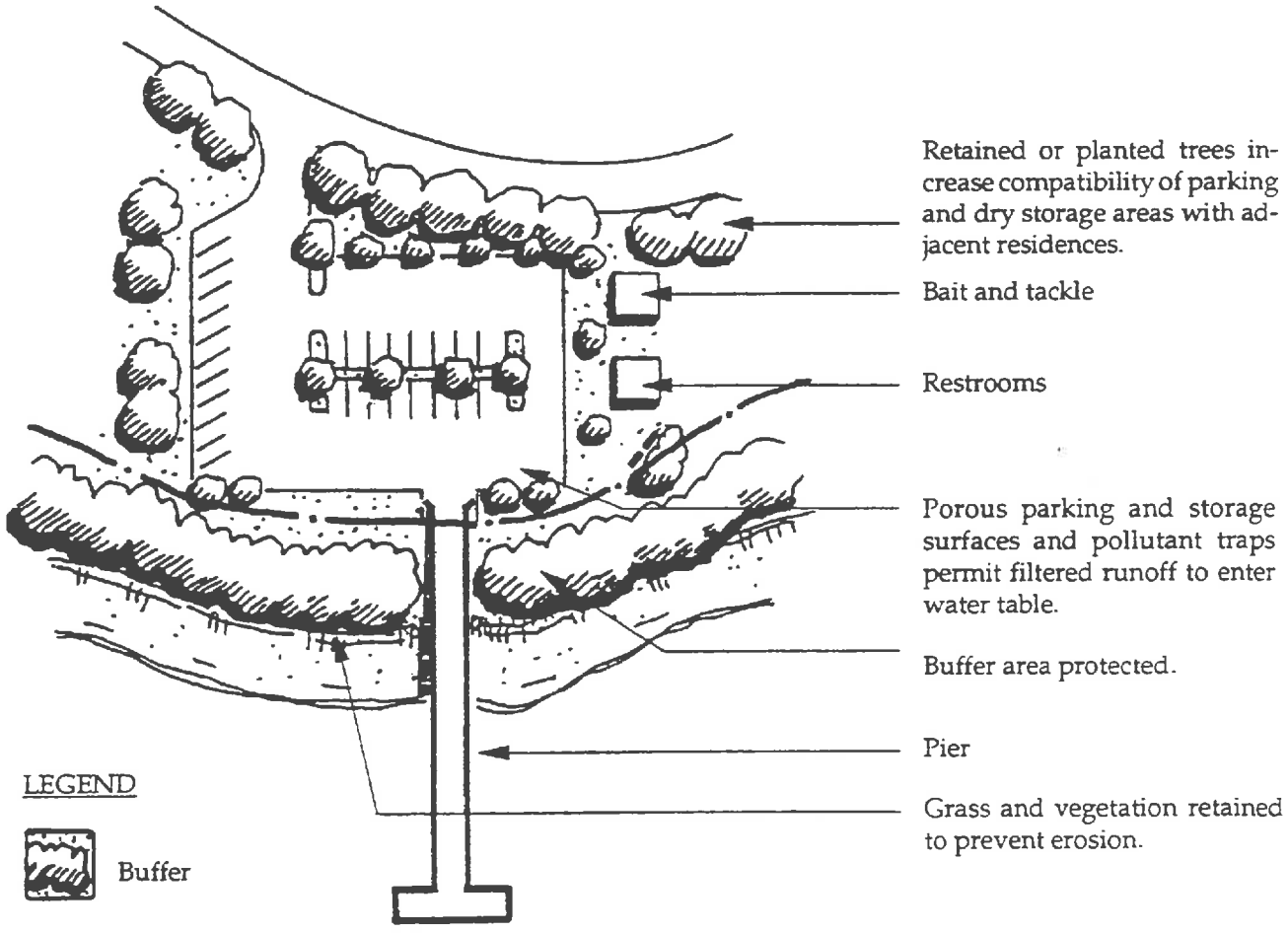
Data necessary to assess access opportunities and plan to meet future demand can augment existing information on local land use and development trends and the local environmental resources inventory. Information collected and analyzed may be used to determine existing and future demand and the general vicinity for access opportunities.

STEP ONE

Inventory environmentally sensitive areas.

The environmental inventory used in the designation of Chesapeake Bay Preservation Areas will serve as the basis for this task. Additional data on marine resources and habitats will be necessary in order to establish a more comprehensive information base for water access planning.

Pier and Bank Fishing Access Schematic Plan — *Figure 6-25*



Source: Adapted from U.S. Army Corps of Engineers, *Recreation Planning and Design Criteria*, 1987

STEP THREE

Inventory existing access sites.

Existing public and private access facilities need to be identified and mapped. The *Chesapeake Bay Area Public Access Plan* (1990) is a good resource in undertaking this task. [105] The document contains detailed information on public and private access sites in map format. Augmenting information from this resource with local data on other water access to smaller creeks, upland streams, and reservoirs is desirable. All of these sites should be delineated on the inventory map.

STEP FOUR

Evaluated existing and future demand.

Current access facilities and services should be compared to the existing and projected demand for access. Demand can be determined using the "National Recreation and Community Facilities Standards" provided in Appendix G. These national standards are provided for assessing unmet demand based on a locality's demographics and the adequacy of available services. This unmet community demand may reinforce the need for additional access and recreation facilities. Coastal localities, in particular, should distinguish between seasonal or tourist-related demand. A summary of the needs assessment should be prepared.

It will be important to assess demand in terms of the different access types to ensure a comprehensive approach in securing access opportunities. Moreover, a good "fit" between the intensity of a proposed access facility and the land/water capacity is crucial for protecting water quality.

STEP FIVE

Examine existing and proposed land use.

An examination of existing land use patterns will be an important aspect of determining demand, both existing and projected. Planning for access in relation to anticipated growth areas ensures that access opportunities are proximate to population concentrations. This not only enhances access opportunities to more people but diminishes the burden on transportation systems and provides pedestrian circulation between residential and recreational areas.

STEP SIX

Analyze data and develop planning factors map.

A thorough analysis of the data outlined in Steps One through Five can be facilitated through the preparation of a planning factors map. The collection and preliminary analysis of background information will allow an identification of key planning issues and factors. Understanding demand and supply and the carrying capacity of land and water areas will provide a sound basis for planning and policy decisions for the provision of access while ensuring water quality protection.

Through an analysis of data resources and the planning factors map, it will be possible to identify areas appropriate for the different types and intensities of access. VMRC's Siting Criteria will be a helpful tool in developing planning factors associated with the development of marinas and community docking facilities. Local goals of enhancing access to Bay waters may conflict with water quality protection goals if the location of ac-

needs and issues. For water bodies bordered by two or more jurisidictions, the compatibility of local plans will be important.

STEP EIGHT

Evaluate inventory of potential access sites.

Potential new public access areas should be evaluated using locally developed criteria. The following criteria are recommended for use in an initial site selection process, though these should be modified as necessary to reflect local need and demand. The criteria or elements within a single criterion could be weighted to reflect the relative importance of the different criteria to one another.

1. Desirability of the site for public access. Desirability of a site for public access includes consideration of its (i) potential for recreational opportunities; (ii) uniqueness and variety; (iii) scenic quality; (iv) size and opportunity for expansion; (v) accessibility; and (vi) ability to walk from the site to adjacent shoreline points of interest.

Potential sites that provide an unspoiled, highly scenic shoreline suitable for a wide variety of low-intensity recreational uses such as picnicking, swimming, fishing, viewing, and walking would be desirable and ranked high. Assessing potential sites for their accessibilty to existing public roads, available space and the opportunity each site presents for possible expansion, and opportunities to link the site with adjacent shoreline areas of interest provides other important criteria in ranking site desirabilty.

2. Physical characteristics of a site. Physical characteristics of a site which influence its suitability for public access would include topography, geologic features, capacity to sustain proposed use, and presence of fragile environmental resources, including threatened or endangered species. Hazards, significant shoreline erosion, and potential impact on water quality are other factors which would be important in a selection process.

3. Availability of access nearby. Another factor to consider in determining the appropriateness of potential access areas is the proximity of the site to existing access areas. A site may be ranked high in terms of its desirability or physical characteristics but if adequate access exists nearby, the site might not repesent a good fit to public need. However, depending on the size and type of access desired, the site together with additional adjacent property may offer an excellent opportunity for expansion of an existing public access area.

4. Adjacent land uses. The relationship between the potential access site and adjacent land uses will affect the suitability of the site for public use. Sites where users might encounter heavy industrial traffic or other potential safety hazards would clearly be less suitable. The privacy of adjacent residential property owners should be a concern with the development of public access facilities. A good "fit" between the type of access area and the surrounding land use will be an important objective. Anticipated conflicts between public use and adjacent private use might be mitigated through additional setbacks, screening, and/or limitations on the number of users.

5. Other factors. Other factors associated with ownership, the willingness of the seller, cost, proximity to service area, and/or access potential in relation to access demand will vary in importance from locality to locality.

Appropriate Density for Docks and Piers

Local governments should consider whether it may be more appropriate in particular areas to emphasize community facilities over individual docks. In evaluating or establishing local policy, it is important to consider both the economic and water quality impacts of each approach, as well as riparian rights of property owners. While it may be argued that individual docks disperse and, therefore, dilute pollutants from boat-related activities, it is more likely that concentrating activities at community facilities will make management of pollution sources easier. For example, there would be opportunities for sewage pump-out at a community docking facility that would not be feasible at an individual dock.

Some localities have chosen to encourage residential development along waterfront areas in order to build local tax bases. Yet, this development puts additional pressure on land prices and small-scale commercial fishing operations. Because most waterfront developments offer individual boating capabilities for each property, the attendant high density of docks and piers may result in significant water quality impacts.

Another consideration in determining dock and pier densities is the visual character of a predominantly natural area. Numerous facilities may diminish visual amenities, which could result in a decline in property value.

The ideal way to determine appropriate densities for docks and piers is to assess the carrying capacity of each creek to support docking facilities, rather than to allow density to be demand-driven. Factors which affect the carrying capacity of water are the volume of water, its flushing characteristics, and tidal action. Although carrying capacity of water bodies is a difficult analysis to conduct, ultimately a creek-by-creek analysis is the best way to determine appropriate densities for docks and piers.

Policy should be developed to balance competing demands in waterfront areas. The way in which land is subdivided may be an important consideration: should shoreline areas be held in common ownership to promote passive recreational access and enhance protection of buffer areas? A shoreline segmented by numerous small parcels will make management of the land/water zone more difficult. A locality might emphasize development strategies that encourage clustering houses around a central access area. Community dock facilities might be required in lieu of individual docks. Strict limits could be placed on the number of slips available at the docking facilities.

Private Access to Waterfront Areas and Effect on Water Quality

Access policies should be integrally related to local park and recreation policies and programs, and access opportunities may be expanded depending on how much shoreline is available in the jurisdiction. Local policies on access to waterfront areas, however, should also seek to balance public and private interests with water resource protection goals.

In addition to boat-related activities, other types of access opportunities should be considered in formulating local access policy. For example, passive recreational activities and facilities such as picnicking, wildlife observation, and hiking and biking trails are

generally suitable in Resource Protection Areas, including buffer areas. Local governments should consider meeting the broad range of recreational demand in their policy framework.

General Policy Considerations

Local policy on access should ensure that boat-related and other water-dependent access facilities are sited and designed consistently with the performance criteria in Part IV of the Regulations. The criteria should be considered in determining the location, type, and intensity of new facilities. In general, access desired in sensitive areas should be low impact -- local policies should be developed which will ensure a long-term orientation toward passive uses in such areas.

Larger public and private marinas will absorb some of the local demand for boat-related facilities, and some localities may wish to consider larger facilities as a component of both their water protection and economic development strategies. However, strict health and environmental controls must be scrupulously enforced to safeguard marine resources and local quality of life. Moreover, costs related to sewage treatment, public safety, and enforcement associated with this type of development must also be considered. These significant costs, along with natural resource considerations, provide substantial justification for the locality to play a more proactive role in planning the location and timing of marina construction. Considering these factors during a comprehensive planning process allows local governments to determine where and when large marina facilities are appropriate.

Another policy issue to be addressed in a planning process is improved coordination among the levels of government with oversight in the development of access facilities. Since federal (e.g., U. S. Army Corps of Engineers, Environmental Protection Agency) and state (e.g., VMRC) officials are frequently involved in local projects, local policy should encourage improved coordination among all three levels of government. Moreover, an element of local policy should ensure opportunities for the input and expertise of state and federal agencies during the planning and development process.

Other policies directed at development of public and private access facilities should relate to the physical constraints of specific locations. The size of the facility should be based on carrying capacity, recharge capacity, and other environmental constraints, regardless of the size of adjacent residential development. The size of the facility and the intensity of related uses can also be conditioned by the service capacity of supporting infrastructure. Local policies might require that only areas with an excess capacity to absorb boat-related activity may be considered for development and that development size be limited to the carrying capacity of the water body.

Mapping

The comprehensive plan map should be amended to reflect the location of major boat-related facilities and other access sites. Potential sites may be indicated after an analysis of areas deemed appropriate in the planning factors summary. Depicting these sites on the plan map will be useful for evaluating rezoning proposals.

docks and piers through land use controls. Although local government regulation of boaters is primarily limited to indirect control through marina siting guidelines, waterfront land use controls, and the use of "No Wake" signs, significant opportunities exist to control boat pollution in a manner which achieves water quality protection and other community goals alike.

Private and Community Piers

Zoning and subdivision ordinances can have a significant impact on the density of private and community piers, and therefore, on water pollution. Two primary means of implementing density controls are community mooring facilities and minimum shoreline width requirements.

Water quality protection and site design flexibility can be increased with community access facilities and waterfront open space. Waterfront residential subdivisions should be designed to provide water access to all property owners, including those without waterfront property. Community mooring facilities should be encouraged, provided the location is suitable and water quality impacts can be mitigated. If community access is secured in a subdivision, the rights of riparian property owners to install docks or piers should be limited. This can be accomplished through a number of methods:

- Clustering lots away from the waterfront;
- Establishing areas held in common as community open space along the entire waterfront area;
- Retaining the riparian rights to the land when selling waterfront lots;
- Requiring covenants or deed restrictions which restrict riparian rights.

In a planned unit development or PUD, development is focused in areas most suitable and with few physical constraints. These areas tend to be away from the waterfront. This provides the opportunity to retain the waterfront area in common open space. All property owners would then have equal rights to access the waterfront, and benefit from community facilities.

In traditional subdivisions, retaining the area adjacent to the waterfront in community open space would also facilitate well-managed community access and limit unplanned individual access. The area adjacent to the waterfront should be of a size large enough to provide design flexibility for construction of trails and community access facilities. Notably, placing the Resource Protection Area in common ownership would enhance protection of sensitive resources and the buffer area.

Riparian rights of property owners can be modified with covenants which specify that no private piers may be constructed in the subdivision. This is the least effective method of controlling private pier development since local governments have little ability to enforce a subdivision's covenants. Also, covenants could be changed at any time by the homeowners association or other entity with enforcement responsibility.

Local governments can encourage or require the use of one or more of these methods through their zoning and subdivision ordinances. Both zoning and subdivision ordinances can promote the use of cluster housing and PUDs. This can be done by

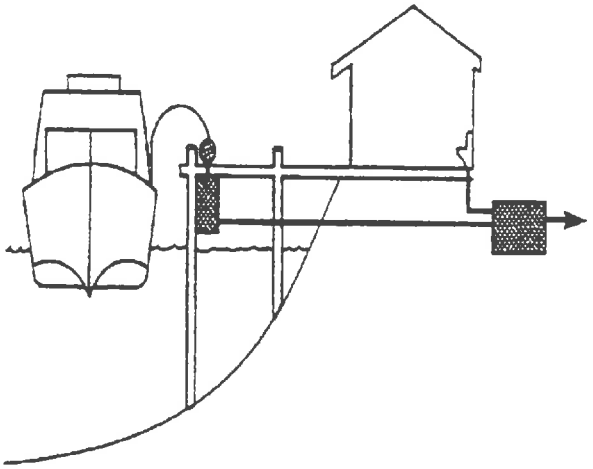
Marinas

Controlling the density of marinas is best approached by considering the natural physical constraints of the shoreline and aquatic resources. The overlay technique mentioned previously will identify areas where demand is high, as well as areas which are most appropriate from a water quality standpoint.

For example, land abutting small and shallow embayments should not be zoned to permit marinas because the water will not have the flushing capability to remove spilled oil, diesel, gasoline, antifeeze, and contaminants. Areas with high energy shorelines, submerged aquatic vegetation, or valuable wetlands are likewise unsuitable for marina development. By analyzing physical constraints in context with available infrastructure and demand, localities should be able to identify those areas best suited for marina development.

This approach has many benefits. It is futile and counter-productive to zone an area for marina development if the site will not pass muster with reviewing agencies. Other, more suitable areas could have been developed in the interim, costing the locality both in terms of tax base and community access to the water. Further, identifying marina development areas will allow the locality to plan for needed extensions of infrastructure and avoid problems associated with the disposal of marine toilet wastes into septic systems.[109] In addition, this approach allows density to be controlled by the carrying capacity of the natural environment itself, and helps to promote recreational boating by establishing a level of use which the environment can support.

BOAT SEPTAGE PUMP-OUT *FIGURE 6-28*



Source: State Department of Health, ***Commonwealth of Virginia Sanitary Regulations for Marinas and Boat Moorings***

of proposed redevelopment. For example, redevelopment of an old warehousing district into a mixed-use project may incorporate revegetation of portions of the development site. Surface parking areas can be consolidated into structured parking, breaking up expanses of impervious cover. Careful revegetation measures can be designed to improve water quality while providing important amenities to both residents and shoppers.

Waterfront revitalization efforts in particular present a clear opportunity to integrate water quality protection measures. Harbors or other waterfront areas that have been allowed to decay through neglect and disuse are often prime candidates for revitalization plans. Rotting piers, leaking underground storage tanks, and antiquated sewer lines are some of the existing conditions that may contribute to water quality degradation. Rejuvenation of older waterfront areas is often viewed as a major economic booster, potentially creating hundreds of jobs and housing, even for smaller urban centers.[112] Correcting water quality problems and upgrading dilapidated facilities should be a major thrust of local water quality improvement strategies and a significant element of any revitalization program.

Ideally, local governments should develop a set of policies for each redevelopment area with similar water quality problems. These policies should reflect area characteristics and should integrate general redevelopment policies and water quality improvement strategies. An important consideration will be the development of policies to establish the buffer area in IDAs over time, as stipulated in § 4.3.B.3 of the Regulations. Establishing the buffer area and encouraging buildings and other improvements to relocate back from the water's edge may not be possible for all segments of the shoreline. However, this can be achieved **incrementally as areas redevelop**. Fulfilling such objectives may seem unlikely today, but with a strong policy framework in the local plan, these objectives become more realistic within a typical 15-20 year planning period (see Figures 6-29 through 6-31).

Data Collection and Analysis

STEP ONE

Identify existing and potential redevelopment areas.

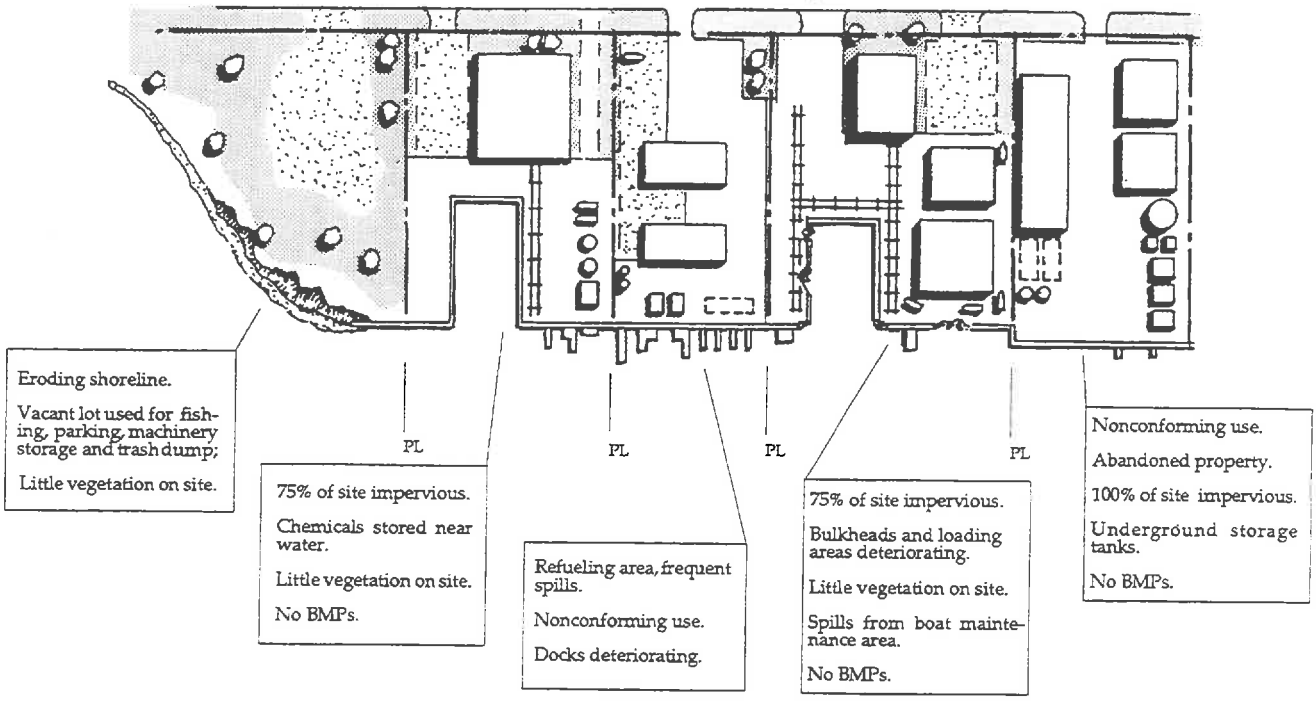
Local governments are encouraged to develop a comprehensive water quality strategy for all redevelopment areas whether within IDAs or not. Developed communities generally identify and develop goals and policies in a comprehensive plan for areas within the locality experiencing decline. Redevelopment areas can be identified from a general study of existing conditions. Data collection and analysis efforts should be coordinated with economic development staff and the local housing authority, where applicable.

STEP TWO

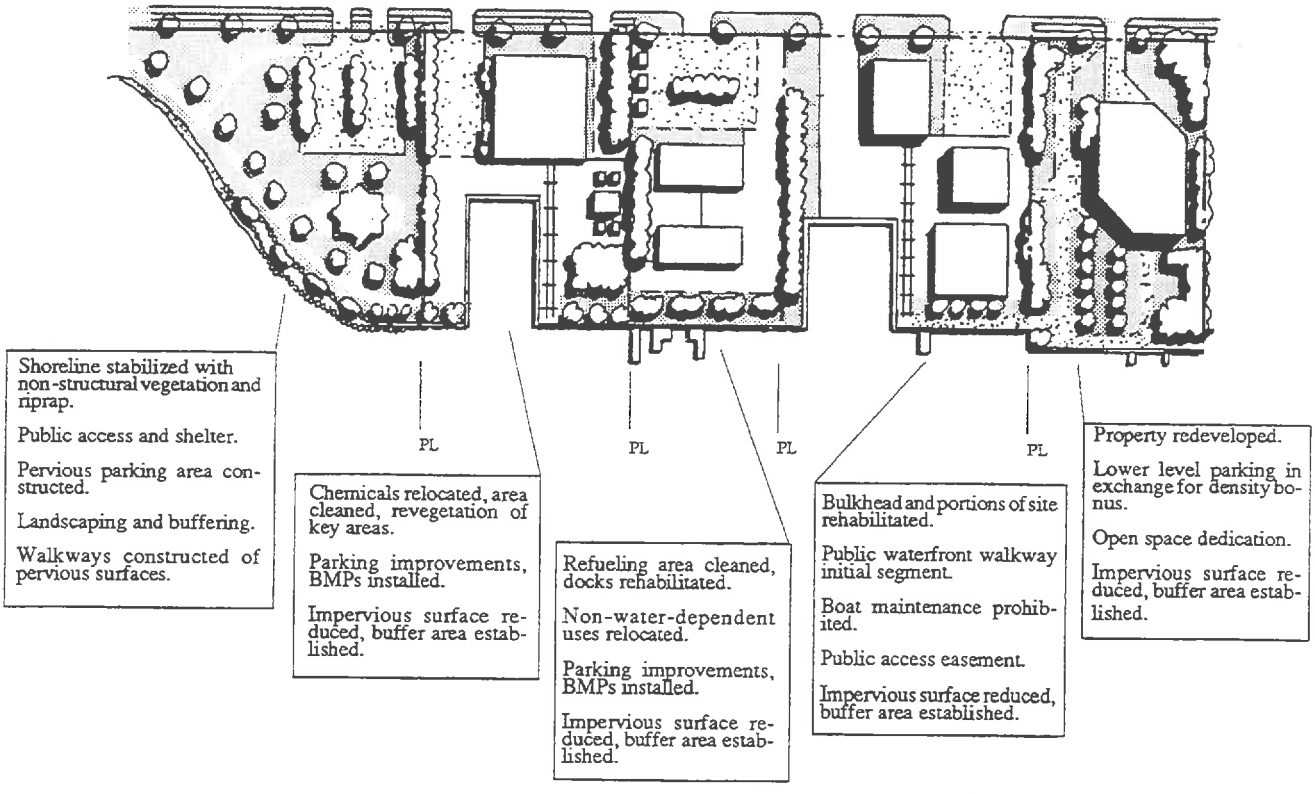
Examine existing conditions within redevelopment areas.

Characterizing the pattern of existing development within IDAs will be an important step in developing a water quality improvement strategy. Factors important to this examination include the general condition and age of structures, the amount of

IDA Example - Present Conditions — *Figure 6-29*



IDA Example - Conditions in 5 to 10 Years — *Figure 6-30*



be reexamined to determine the best location and configuration for industrial development.

Plan policies should also recognize needs and priorities and the historic character of redevelopment areas, including individual neighborhoods, while reflecting the waterfront environment and reinforcing water quality objectives. The intensity of water-dependent uses, the extent of open space and access, public amenities, building orientation, height, and massing are all components of an overall revitalization plan. Each of these components can be in harmony with or work against water quality protection goals and objectives.

Redevelopment and Public Access

The Regulations identify public access to waterfront areas and the effect on water quality as one of the issues to be addressed in the local comprehensive plan. Revitalization of urban waterfronts often involves an expansion of public access opportunities. Policies for redevelopment of intensely developed areas should complement local public access objectives. The incorporation of policies that enhance public access to municipal waterfront areas can be a central and important element of any local water quality improvement strategy. Deteriorated waterfront areas characterized by dilapidated piers and abandoned structures inhibit public access to urban waterways. These areas may no longer be suitable for today's maritime economy but a broad array of other water-dependent uses, such as commercial boating activities, water-taxi facilities, and public landings, may be viable.

Mapping

Local IDA designations will be depicted on the jurisdiction's Chesapeake Bay Preservation Area Map. A reduction of this map is recommended to be included in the plan. As an alternative, local governments may wish to amend the local land use map with a Preservation Area overlay including the depiction of IDAs. General redevelopment areas should also be identified on the general land use plan. Local governments that conduct a planning process for distinct planning areas or sectors should consider delineating individual redevelopment areas within IDAs in sector plans.

Implementation

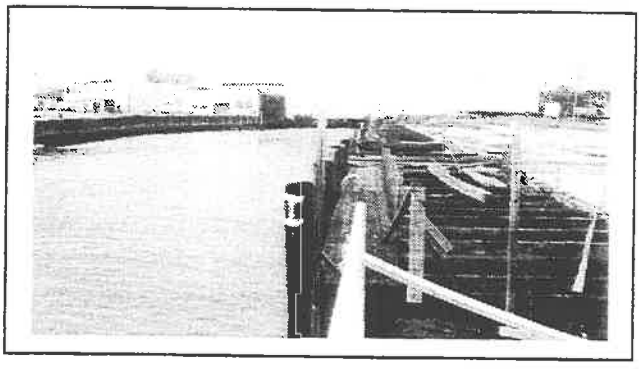
Strategies for the establishment of the buffer area in IDAs over time and for the protection and improvement of water quality should be developed in the plan. Using the information and mapping from Step Five, local governments may differentiate redevelopment areas based on the classification system and develop categories for IDAs and redevelopment areas. These categories should be focused on the character of the area and revitalization proposals, water quality protection strategies, and the ability to establish the buffer area over time. Special zoning regulations could be adopted which address the establishment of the buffer area as land within IDAs redevelops. Standards for buffer areas would vary within different IDA categories.

IDA Subcategories

After the completion of Step Five, local governments may identify different classifications for redevelopment areas and consider "customizing" IDAs to more accurately reflect the existing development patterns along the shoreline.[116] More specific standards for implementing the buffer area and other performance criteria could be instituted within different classifications. The local Chesapeake Bay Preservation Areas map should be amended to include the different classifications of IDAs, if this approach is employed. Such a classification system could include Industrial IDAs and Commercial/Residential IDAs as discussed below.

INDUSTRIAL IDAs

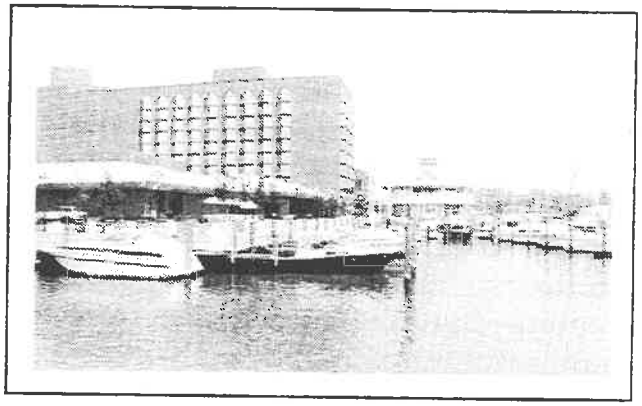
These areas would be characterized as working waterfronts by their intensive industrial activity. Working waterfronts may have limited ability for the creation of open space or establishment of the buffer area because of the necessity for access to the water, the amount impervious surface, and the lack of natural shoreline. Policies tailored to the unique character of these areas will recognize the impracticability of implementing buffer area and rely on other water quality strategies more effective for such uses. Intense industrial areas can be treated differently than other redevelopment areas which are no longer viable working waterfront areas.



Industrial intensely developed area.

COMMERCIAL/RESIDENTIAL IDAs

These areas would be characterized by less intense uses such as commercial, residential, or office areas and may include infill sites. These areas will likely provide greater latitude in establishing the buffer area since access to waterways is not paramount to their operation. Some of these areas may already have a limited natural buffer area. Implementation of on-site structural stormwater



Commercial/residential intensely developed area.

Best Management Practices could be more easily applied in areas that have less impervious surface. Policies tailored to these areas will recognize the ability of implementing the buffer area and other revegetation strategies could focus on the aesthetic appeal of natural areas. Establishment of a buffer area could enhance the attractiveness of some redevelopment projects, especially those that are oriented toward people. Localities throughout the United States have discovered the potential for profitable and popular urban waterfronts through the redevelopment of existing impervious areas.

Many urban communities across the United States have incorporated the preservation and restoration of shoreline resources into overall shoreline revitalization plans. Local governments could institute a revolving loan fund to assist developers in meeting the cost of installing water quality BMPs for redevelopment projects. This fund could also be used in conjunction with an incentive program for buffer establishment and revegetation, the provision of structured parking areas, the replacement of antiquated utility systems, and the overall "greening" of redevelopment areas as a marketing mechanism to attract investors. Success stories such as San Antonio's River Walk point to the possibility of revitalized redevelopment areas which address environmental issues in a mutually beneficial way.

As an alternative to open space requirements, a locality could set maximum impervious surface thresholds. Under such a scenario, local governments could retain the intensity of development while decreasing the permitted lot coverage for each project. Methods of achieving a reduced lot coverage may include the construction of structured parking areas in IDAs and prohibition of additional surface parking areas. This approach would enable greater development intensity on a site while providing more area for revegetation.

Source Control Program

Conventional surface stormwater management techniques designed to achieve the "no net increase" standard for stormwater pollutants in the Regulations may be difficult to implement in highly urbanized areas even as these areas redevelop. Revitalization efforts may propose to increase a site's development intensity, further limiting design flexibility, and sub-surface conditions may preclude certain structural BMP options altogether. Other effective Best Management Practices can be implemented, however, to improve the quality of stormwater runoff consistent with water quality objectives in the Act and Regulations.

NOTE: The Department is funding a Northern Virginia Planning District Commission project to conduct an assessment of BMPs for the "ultra-urban environment." This study will examine specific design modifications associated with the use of underground storage tanks and cistern stormwater collection and recycling. The assessment will be directed at evaluating actual long-term efficiencies and specific limitations on the use of these BMPs as well as maintenance requirements and costs. The Department expects the results of this study to expand not only the knowledge base in developing an effective source control program but also the array of available options for meeting stormwater quality performance standards.

Source control measures can be effective in protecting receiving waters from oil and grease in urban stormwater runoff. A local water quality improvement strategy for redevelopment areas could implement innovative measures such as wet vacuum street sweeping. Another important aspect of such a strategy might be as simple as improved litter control, including the provision of new trash receptacles and sidewalk sweeping. Underground storage facilities are another BMP that shows promise for use in urbanized centers where available land area is severely limited.

CONSERVATION AND DEVELOPMENT OPPORTUNITIES FOR WATER QUALITY PROTECTION

Community values can be preserved and citizen-identified goals can be achieved through creative land use and development strategies that may also further the objectives of the Chesapeake Bay Preservation Act. Open space subdivision or cluster development, planned unit development, performance-based zoning and site planning, and greenways are all examples of innovative development and conservation tools with the common thread of preserving local character and protecting a community's natural and cultural resources. This section explores a number of creative approaches that may represent opportunities for implementing community objectives identified in a comprehensive planning process while enhancing and reinforcing the local Preservation Act program.

Open Space Preservation

Despite the transience of contemporary life, the visible landscape remains an important component in the way we define "community." A region's character and sense of place are important contributors to the attraction it holds to new residents and business. "Quality of life" sustains as much significance to economic development as it does to urban design. Surveys have shown that open space systems and the preservation of natural areas are important factors in establishing a high quality of life and attracting new business and industry.

Local governments are increasingly concerned about the need to preserve open space as the supply of undeveloped land diminishes. Local objectives for preserving open space can vary -- to provide outdoor recreation and public use areas like beaches, trails, and riverfront lands; to preserve the rural, open character of the community and prime agricultural land, and guide the location and rate of development; and to preserve important environmental resources like wetlands, wildlife habitat, scenic areas, and aquifer recharge areas.

Land development and conservation strategies for protecting open space are numerous. Measures that work for one locality may not necessarily be appropriate for another. Therefore, it is important to identify local open space objectives to ensure the strategy or combination of strategies is effective. For localities complying with the Chesapeake Bay Preservation Act, a primary objective for open space preservation should be the protection of water quality. Opportunities for local governments that further implementation of the Act and Regulations can also address other important community needs and objectives.

Designing a Continuous Open Space System

Some community visionaries have been motivated by the desire to walk or ride a bicycle from one corner of a local jurisdiction to the opposite corner without impediment.[118] These individuals have reasoned that such a "continuous" pathway system would expand recreational opportunity while enhancing public safety. The internal pedestrian paths and bikeways within planned communities are an example of such an open space system on a micro scale. Localities interested in applying this concept on a jurisdiction-wide or regional scale see opportuni-

and private. Ownership is an important factor in selecting local strategies appropriate for implementing an open space system.

RPA and Greenway Corridors

The RPA skeleton can first be enhanced or augmented by additional linear open space configurations, such as conservation easements along scenic tributaries, abandoned railroad rights-of-way, and linear parks, trails, parkways and bikeways (see Figure 6-33). This evokes the concept of greenways planning. Greenways are corridors of private and public lands providing access to open spaces and linking population centers with recreation areas. In addition to utilizing watercourses (streams and rivers) and railroad rights-of-way, a greenways network can include floodplains, scenic byways, forests, farms, and utility rights-of-way. Greenway programs can be enhanced through regional efforts. Examples in Virginia include the Virginia Creeper in Washington County and the Washington and Old Dominion Railroad Regional Park Trail extending from Alexandria west to Purcellville.[119]

NOTE: The *1988 Palisades Conservation Plan* developed by the Regional Plan Association and the Trust for Public Land is a greenway plan for 18 miles of the New Jersey shore. The Plan involves both adoption of new land use regulations and strategic property acquisition. The Plan concept establishes a public/private greenway that "connects, both visually and physically, the new and existing parks, trails and roadways, cultural attractions, natural resources, and significant viewpoints." [120]

Scenic Rivers

Wild and scenic waterways are an important linear element to the landscape. Riparian areas retained in their natural state protect water quality and preserve the scenic qualities of the watercourse.[121] Low impact facilities like picnic areas, pedestrian paths, and bikeways provide access and recreational opportunities which complement resource protection objectives. Allowing multiple uses enhances existing corridors and generates interest in creating new links to the open space system over time.

Wildlife Corridors

The fragmentation of forests reduces and alters habitat, resulting in significant species loss. Preserving environmentally sensitive areas and open space in the form of riparian forests or wildlife corridors will establish significant habitat areas and a safe passageway for wildlife. Wildlife corridors can link with nodes of open space or woodland to provide a spatial distribution adequate to support the diversity of plant and wildlife species.

Connecting Isolated Nodes of Open Space

By using the RPA as a means of linking "nodes" of open space, the system can ultimately expand to eventually connect a full range of open space types to meet local preservation objectives. For example, nodes of open space can include recreational areas like parks and playgrounds, planned communities with their internal systems of pathways, and public or semi-public access like boat landings and marinas.

Recreational Areas and Parks

A first priority in designing a local open space system would be to connect public recreational areas. Linking parks -- federal, state, and local -- playgrounds, wildlife management areas, and public boating access areas by designated RPA corridors would enhance resource protection while expanding both passive and active recreational opportunities and public use of these areas (see Figure 6-34).

Farmland and Woodlands

Additional expansions of the open space system could be realized by connecting farmland and existing wooded areas. The preservation of farmland helps protect rural character and enhances communty open space.

Woodlands are important in moderating climatic effects, reducing impacts caused by flooding and high winds, and protecting watersheds from siltation and erosion as a result of heavy runoff. Woodlands buffer incompatible land uses, minimize noise, and absorb air pollutants. They add value to adjacent residential areas and offer recreation and hunting opportunities. The environmental diversity of woodlands is an essential resource in protecting wildlife. Woodlands should be a major component of a comprehensive open space system. Wooded stream corridors linking nodes of woodlands such as state forests, parks, or natural areas will extend the network of open space and provide areas adequate to sustain significant wildlife populations.

Residential Open Spaces

The internal open space of planned communities or even office and industrial parks can be designed to link with the larger open space system. As new residential projects are initiated, they can be designed to connect to existing or proposed parks or other elements in the community open space system (see Figure 6-35). The design of the residential project should ensure that RPA corridors are protected and incorporated as part of the local open space system, and individual lots are configured so that residents' privacy is adequately safeguarded.

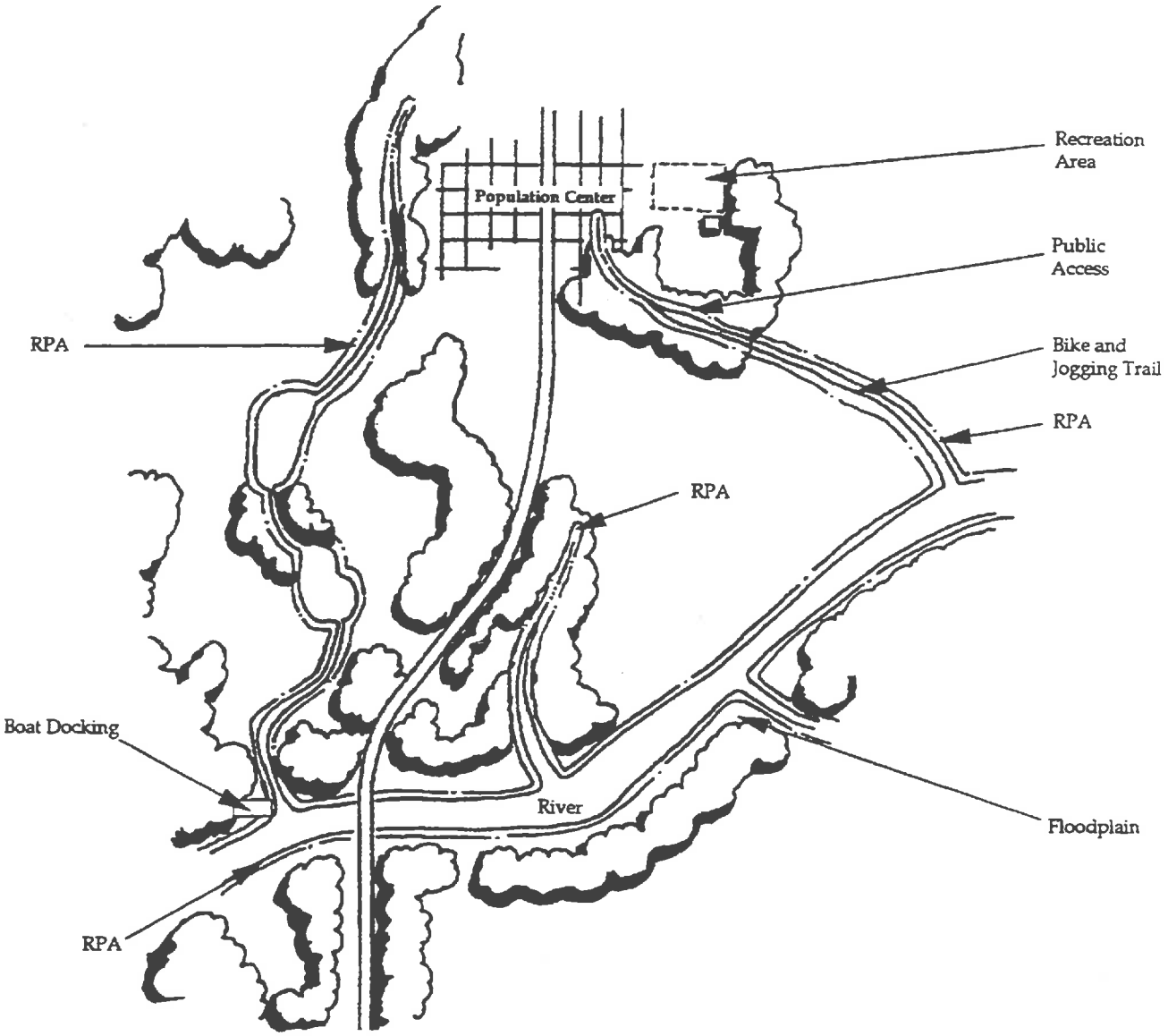
Implementation Strategies

As previously discussed, conservation and development strategies to preserve open space and protect a community's environmental and cultural resources can also be effective in protecting water quality. All of these tools can enhance implementation of local Chesapeake Bay Preservation Act programs, but some are more effective than others. Employing strategies with the greatest water quality potential enables a more comprehensive and cost-effective approach to achieve community goals.

Implementing an Open Space or Greenways System

In the Commonwealth, the Department of Conservation and Recreation (DCR) is promoting the growth and expansion of greenways and trails throughout the state on both public and private lands. A variety of programs will facilitate a local process of

EXAMPLE OF GREENWAYS AND LINKAGES *FIGURE 6-34*



GREENWAY: Locality establishes greenway network based on RPA and linkages to other natural features and public access and recreational sites.

Recreation Nodes: To include parks, boat docking, public landings.

Bike and Jogging Trails: Developed within riparian corridors to link population centers, recreation facilities, and natural resource areas.

camping areas, picnic facilities, trails, boating and fishing facilities, canoeing, and parking areas.

Once the decision has been made to initiate the planning process, data must be collected and analyzed. As for any plan development, planning for greenways must be based on objective data about the landscape. The decision to create a system of greenways should be based on evaluation of data relative to demographic and development trends, recreational demand, sensitive land features, and existing and projected land use patterns. Locally designated Resource Protection Areas form natural greenways in the landscape. Connecting RPAs to other open space or recreational areas within a jurisdiction and among neighboring localities is a way of designing a greenway network. Consideration of all related programs and activities in a region should be an important part of the greenway planning process. The record in other states has shown that cooperation among adjacent localities is important in creating extensive greenways.[123]

Local Land Use Regulations

Implementation of the general performance criteria in the Regulations can also meet local objectives relative to quality development, recreational opportunity, and community character. For example, development strategies that recognize and incorporate a site's natural features into the overall design of a project minimize land disturbance (§ 4.2.1). Design strategies that cluster buildings reduce the area needed for roads and utilities. While keeping costs down, clustering reduces the area of impervious surface (§ 4.2.5). Tree preservation and landscaping ordinances provide buffering between incompatible land uses and preserve community character while preserving indigenous vegetation consistent with the Regulations (§ 4.2.2).

Most local planners are familiar with such conservation and development strategies and many examples of local implementation of these tools exist. Where localities have already implemented open space standards, landscaping ordinances, and other strategies, **reexamination may reveal additional ways to maximize water quality protection.** In many cases, the concept may be the same but the effect may have little or no impact on water quality protection. Piggybacking water quality goals with other community objectives establishes a more comprehensive, integrated implementation strategy which will prove more cost-effective and successful both in the near and long term. The purpose of the following discussion is to examine some of these strategies based on their merits for water quality protection.

Open Space Subdivision or Cluster Development

Open space subdivision or cluster housing is a cost-effective, affordable alternative to conventional residential development. By clustering development on less sensitive portions of a site, farmland and scenic open space can be preserved while maintaining the same overall density of development. Reduced lot sizes and closer grouping of structures is exchanged for a dedication of useable open space. This type of residential development reduces site development and construction costs by reducing utility and infrastructure requirements, promoting shared access, and conserving land and energy.[124]

During the past several years, a number of cities and towns have undertaken ambitious tree planting and maintenance programs by enacting tree and landscaping ordinances. Landscaping ordinances require developers and property owners to develop landscaping plans for their projects. Most ordinances establish standards for location, quantity, sizing, spacing, buffering and screening. Some ordinances list plant species recommended for specific locales, but many fail to do this well. However, few landscaping ordinances directly consider the relationship between plant communities and local hydrology.

Local governments interested in developing a tree preservation and landscaping ordinance will benefit in seeking assistance from landscape architects, arborists, extension service agents, foresters, and other professionals. A committee comprised of citizens and landscape professionals can define community issues, build consensus, and steer development of the local ordinance. With this expertise, a list of appropriate species can be developed. A list of plants not recommended for use should also be included in a local ordinance.[128]

Local landscaping ordinances should reflect the interests, concerns, and values of the community. In designing a local landscaping ordinance, differences in communities can vary in four important ways:

- physical environment;
- community values and interests;
- the legal framework of the community; and
- the political/economic climate.[129]

Consideration of these four factors will assure a well-designed landscaping ordinance better suited for acceptance, adoption and compliance.

Landscaping ordinances set minimum standards for landscaping and screening and help a community better manage and conserve resources. Many landscaping ordinances require street tree plantings, shading of parking areas, and vegetated buffers between adjacent uses. Some localities, mostly in the Southwest, are encouraging a shift in landscaping practices from water intensive vegetation towards water conserving, drought-tolerant landscaping. Even modest measures, such as encouraging landscaping ground covers that require less maintenance and conserve energy, can reduce overall public and private costs. Though Tidewater and the East coast are generally considered "water-rich," water conservation measures employed painlessly year round maintain healthy growing conditions and help to avoid bans on water use during periods of drought.

To enhance water quality protection, local landscaping ordinances should limit ornamentals and other exotic species, instead encouraging planting schemes that rely on indigenous species. Indigenous vegetation is well-suited to the area's climate and is more resistant to disease. Many landscaping ordinances require on-site irrigation systems. Integrating landscaping requirements with stormwater management performance standards can secure an on-site water supply and meet all of a project's irrigation needs.[130] Ordinances which require the use of cisterns or other water-harvesting techniques, require the preservation of existing specimen vegetation, and discourage the use of exotic species that require greater maintenance and water will protect water quality and conserve water consistent with the Act and Regulations.

Wildlife Habitat Protection Corridors

Water quality and wildlife habitat are closely interrelated. Most aquatic organisms are directly dependent upon high quality waters for their survival or commercial value. In addition, some of the most important habitat for terrestrial species is found at the interface of land and water. The vast majority of Virginia's threatened and endangered wildlife species are located in the forested wetlands, tidal marshes, and shoreline areas of the Tidewater region.[131] These same land features are the most important for the filtering of nonpoint source pollutants and have been identified as components of Resource Protection Areas designations under the Regulations. From a comprehensive planning perspective, determining the locations and types of wildlife habitat within the locality should be an important exercise in planning for open space and water quality protection.

Perhaps the greatest impact of land development activities on wildlife and species diversity is the fragmentation of habitat into small or isolated "islands." Two problems result from habitat fragmentation. First, fragmentation leads to the loss of large, wide-ranging or ecologically specialized species that cannot survive in protected lands of inadequate size or areas subject to high levels of human disturbance. Second, it often contributes to the progressively increasing domination of remaining habitat fragments by opportunistic and exotic species that are characteristic of humanized landscapes.[132]

While the loss of habitat due to the development of large contiguous parcels of open space has been noted in planning literature, the contribution of land disturbing activities to the introduction of invasive species, and the subsequent loss of native vegetation has not received sufficient attention. Examples of this phenomenon can be found in two species of marsh vegetation, *Hydrilla* and *Phragmytes*. These species invade wetlands when soil is exposed during land disturbing activities. Such activities include residential, commercial, and industrial development; the construction of piers, docks, boat houses, and shore stabilization structures; and the building of stationary duck blinds.

Once an invasive species has taken root in an area, it is likely to spread and become the dominant species in the marsh. This has the effect of crowding out the natural diversity of a marsh (particularly tidal freshwater marshes), and can lead to the extirpation of rare and endangered plants. The decreasing diversity has an adverse impact on waterfowl. This is especially acute when a colony of *Phragmytes* invades a marsh, since this plant does not provide food for waterfowl.

Habitat Protection Planning

The first step in establishing a local habitat protection program is an inventory of habitat resources. The following outlines the inventory process:

(1) Identify habitats and their relative values;
(2) Identify species supported, including threatened and endangered species;
(3) Identify areas of important wildlife plant food;
(4) Analyze adjacent land uses;
(5) Develop continuous open space/wildlife corridor systems.

The first three steps involve identification of species and habitat using specific data resources. The Virginia Department of Con-

VIRGINIA'S NATURAL HERITAGE PROGRAM

The Department of Conservation and Recreation, through its Division of Natural Heritage, is the Commonwealth's principal manager of data on natural heritage resources, defined by the Virginia Natural Area Preserves Act (§ 10.1-209 et seq.) as unique and exemplary natural communities; habitats for rare, threatened and endangered species; and other significant biological and geological features. The Division's Natural Heritage Information Management Section maintains data in an integrated system of computer databases, maps and supporting manual files that are continually updated. Each natural heritage resource is assigned a ranking which reflects its rarity both within Virginia and around the globe. Ranking and data management procedures utilized by the Division are identical to those used by the natural heritage network, operating in all 50 states, Canada, and several Latin American and Caribbean countries. A locality can obtain a summary of data for its jurisdiction, including the legal status of rare species by writing to the Division (see Appendix A).

Under the Natural Area Preserves Act, the Division is responsible for conducting statewide inventories for natural heritage resources. The Division has also conducted a Natural Areas Inventory Program since 1989. Under this program, one or more localities contract with the Division to perform a systematic inventory of natural heritage resources. Funding has come through private and public sources, including coastal zone management funds. These inventories include a thorough review of the natural heritage maps and databases, museum collections, and other existing information; interviews with knowledgeable individuals; analysis of maps and aerial photographs; aerial reconnaissance; and field surveys. The final report includes lists and maps of natural heritage resources, protection boundaries for the most significant sites, and protection recommendations developed in cooperation with local officials. Natural heritage staff scientists provide technical assistance regarding the biology, status, or identity of natural heritage resources.

The Division has contracted to conduct inventories in Loudoun County, the City of Virginia Beach, James City County, York County, and the City of Williamsburg. The last three localities contracted with the Division jointly. This inventory is in its third, and final, year. Of roughly 90 potential natural areas identified at the start of this inventory, some two dozen have proven to support natural heritage resources. Protection recommendations for these sites and maps showing their ecological boundaries will be included in the final report.

The Division also includes a Natural Area Conservation Section that oversees the Virginia Natural Area Preserves System. Dedicating a site as a natural area preserve protects it in perpetuity. Any site supporting natural heritage resources can be dedicated, whether it is owned by the state, a locality, or a private individual. Other protection tools authorized by Virginia's Natural Area Preserves Act include conservation easements and natural area registry with the Department. The Natural Area Conservation Program staff can provide localities with general information and guidance on natural area protection and management.

EXAMPLES OF LOCAL HABITAT PROTECTION PLANNING

Fairfax County: The most successful efforts to create habitat corridors have reserved riparian habitat areas during the planning and development process. Fairfax County has incorporated this concept into its comprehensive plan through the establishment of Environmental Quality Corridors (EQCs). Corridors are delineated on two levels: sensitive lands EQCs and resource protection EQCs (see page IV-62).

The County has also undertaken the development of a computerized Ecological Resources Inventory. This effort identifies major natural vegetation communities within the County using recent aerial photography. Data from BOVA and the Natural Heritage Program was integrated into the database and areas were field surveyed to verify the photo-interpreted data and collect more specific information about species composition and relative value. The inventory is designed so that information from field observations can continually update and expand the database. The inventory will provide an important tool for County staff in completing impact assessments for development proposals. Information from the inventory has identified ecologically valuable properties which the Park Authority used in prioritizing parkland acquisitions.

Virginia Beach: The City of Virginia Beach is using the assistance of the Natural Heritage Program to digitize and incorporate the habitat inventory as an information layer in its land use planning database. The planning department will propose incorporating this information into their decision making process.

Northampton County: The County of Northampton has utilized wildlife and habitat information in the development of its land use plan. The Northampton County Board of Supervisors adopted policies to protect the flyway corridor used by migratory birds traversing the County. The Nature Conservancy's Virginia Coast Reserve contributed in collecting information and providing technical assistance based on Natural Heritage information.

Conservation Easements

The Virginia Outdoors Plan characterizes the use of conservation easements for water quality and resource protection as having "vast, untapped potential."[137] Local governments and other public bodies have had the authority to secure conservation easements since the Open-Space Land Act was enacted by the General Assembly in 1966.[138]

A conservation easement is a signed legal document which transfers some of the landowner's rights to another party, usually called a holder. The landowner retains ownership and use of the property, subject only to the restrictions mutually agreed to by the parties. The extent of restrictions depends to a great extent on the intent and desire of the landowner.

Conservation easements have typically been used to preserve open space, protect habitat and historic properties, or provide buffer zones between those resources and more intensive development. In addition, the Open-Space Land Act provides local governments with the authority to acquire easements over tidal wetlands. However, per-

ENDNOTES

[1] Code of Virginia §§ 10.1-2100 (Repl. Vol. 1989) (emphasis added).

[2] Chesapeake Bay Local Assistance Department, ***Discussion of Economic and Social Impacts of Proposed Regulations*** (Richmond, Va.: Chesapeake Bay Local Assistance Department, 1989).

[3] Virginia Department of Tourism, ***1987 Travel in Virginia - An Economic Report*** (Ricmond, Va.: Division of Tourism), 5-7; Smith, Demer, and Norman Market Research, Executive Summary, in Economic and Fiscal Impact Analysis of the Chesapeake Bay Preservation Act on Tidewater Virginia Localities (Hampton, Va.: SDN Market Research, 1989), 2.

[4] Virginia Department of Conservation and Recreation, ***The 1898 Virginia Outdoor Plan*** (Richmond, Va.: Division of Planning and Recreation, 1989), 285.

[5] Ibid.

[6] Ibid.

[7] University of Virginia, ***Virginia Statistical Abstract - 1987 Edition*** (Charlottesville, Va.: Center for Public Service, 1987), 183.

[8] Sportfishing Institute, ***Economic Impact of Sportfishing in the State of Virginia*** (Washington D.C.: Sportfishing Institute, 1989). Total economic impact of a given activity includes secondary impacts. For example, a tackle shop and wages paid to its employees are primary economic impacts of recreational fishing. The dollars those employees spend in the local economy create secondary impacts, such as employment for workers in a local grocery. Economic developers recognize this "multiplier effect" when targeting industries for recruitment.

[9] Code of Virginia §§ 15.1-446.1 to 457.

[10] Code of Virginia § 15.1-446.1.

[11] Code of Virginia § 15.1-454.

[12] 1988 Virginia Acts of Assembly, Chapter 438. (Codified at Code of Virginia § 15.1-447(1)(a)).

[13] Code of Virginia § 10.1-2109.B.

[14] E. Yokley, ***Zoning Law and Practice***, vol. 1, § 5.2 (Charlottesville, Va.: Michie Company, 1978). For an interesting discussion of the relationship of comprehensive plans to zoning and subdivision ordinances, see also Mandelker, "The Role of the Local Comprehensive Plan in Land Use Regulation," ***Michigan Law Review***, vol. 74, p. 899 (1976); Haar, "In Accordance With a Comprehensive Plan," ***Harvard Law Review***, vol. 68, p. 1154 (1955).

[28] Virginia Department of Health, ***Sewage Handling and Disposal Regulations*** (Richmond, Va.: Department of Health), parts III, IV.

[29] Bruce Hendler, ***Caring for the Land: Environmental Principles for Site Design and Review***, Planning Advisory Service Report Number 263 (Chicago: American Society of Planning Officials, 1970).

[30] U.S. Department of Agriculture, Soil Conservation Service, ***Field Office Technical Guide*** (Washington, D.C.: Soil Conservation Service).

[31] Ibid.

[32] Satellite imagery is generally available from two sources in the United States: the EOSAT Company in Lanham, Maryland (800- 344-9933) and the SPOT Image Corporation in Reston, Virginia (703-620-2200). Additionally, use of satellite imagery for natural resource applications is being evaluated by the Virginia Remote Sensing Study at the College of William and Mary (804- 221-3463).

[33] William Toner, "Environmental Land Use Planning," in Frank S. So and Judith Getzels, eds., ***The Practice of Local Government Planning*** (Washington, D.C.: International City Management Association, 1988), 117-138.

[34] Devon M. Schneider et al., ***The Carrying Capacity Concept as a Planning Tool***, Planning Advisory Service Report Number 338 (Chicago: American Planning Association, 1978).

[35] Virginia Department of Conservation and Recreation, ***The Floodplain Management Plan for the Commonwealth of Virginia.***

[36] ***Report of the Task Force on Septic Regulations*** (Charlottesville, Va.: Institute for Environmental Negotiation, 1991).

[37] Several Virginia localities already employ increased vertical separation requirements, ranging from 18" (Chesterfield, Clarke, Culpepper, Fauquier, and Poquoson) to 24" (Loudon).

[38] Virginia Polytechnic Institute and State University, ***Protecting Virginia's Groundwater: A Handbook for Local Government Officials,*** by Margaret Hrezo and Pat Nickinson (Blacksburg Va.: Virginia Water Resources Research Center, 1986).

[39] Virginia State Water Control Board, Ground Water Protection Steering Committee, ***A Ground water Protection Strategy for Virginia*** (Richmond, Va.: State Water Control Board, 1987), vi.

[40] Virginia Polytechnic Institute and State University, ***A Groundwater Primer for Virginians***, by Torsten Sponenberg and Jacob Kahn (Blacksburg Va.: Virginia Water Resources Research Center, 1984).

[50] Virginia State Water Control Board, Groundwater Protection Steering Committee, ***Virginia Groundwater Management Handbook: State Agency Programs for Groundwater Protection*** (Richmond, Va.: State Water Control Board, 1988), 2-19.

[51] Virginia State Water Control Board, ***Virginia Water Quality Assessment, 1990 305(b) Report to EPA and Congress***, Information Bulletin 579 (Richmond, Va.: State Water Control Board, 1990).

[52] Robert Taylor, Division of Water Supply Engineering, Virginia Department of Health, telephone interview by Raymond Utz, Senior Environmental Planner, Chesapeake Bay Local Assistance Department, 20 June 1991.

[53] Virginia State Water Control Board, ***Virginia Groundwater Management Handbook: State Agency Programs for Groundwater Protection***, 2-3.

[54] Ibid., 2-3 and 2-16.

[55] Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, ***Virginia Nonpoint Source Pollution Assessment Report*** (Richmond, Va.: Division of Soil and Water Conservation, 1989).

[56] Ibid.

[57] Virginia State Water Control Board, ***A Groundwater Protection Strategy for Virginia***, 23.

[58] Russel P. Ellison, Division of Groundwater Programs, Virginia State Water Control Board, telephone interview by Raymond Utz, Senior Environmental Planner, Chesapeake Bay Local Assistance Department, 18 June 1991.

[59] Virginia State Water Control Board, ***Virginia Groundwater Management Handbook: State Agency Programs for Groundwater Protection***, 2-17.

[60] Ellison, telephone interview, 18 June, 1991.

[61] Virginia State Water Control Board, ***Virginia Groundwater Management Handbook: State Agency Programs for Groundwater Protection***, 4-20 and 4-21.

[62] Paula Ripley, ed., ***Economic Implications of Groundwater Contamination to Companies and Cities*** (Navarre, Mn.: Freshwater Foundation), 6.

[63] Martin Jaffe and Frank DiNovo, ***Local Groundwater Protection***, 76.

[64] Ibid., 77.

[74] Localities which have open space requirements include Fauquier County and Fairfax County.

[75] Virginia State Water Control Board, ***Virginia Groundwater Management Handbook: State Agency Programs for Groundwater Protection,*** 4-20 and 4-21.

[76] ***Report of the Task Force on Septic Regulations*** (Charlottesville, Va.: Institute for Environmental Negotiation, 1991).

[77] Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, ***Sediment and Nutrient Contributions of Selected Eroding Banks of the Chesapeake Bay Estuarine System,*** by Nancy A. Ibison, Chris W. Frye, Jack E. Frye, Carlton Lee Hill, and Ned H. Burger, (Richmond, Va.: Shoreline Programs Bureau, 1991).

[78] Ibid.

[79] U.S. Army Corps of Engineers, ***Chesapeake Bay Shoreline Erosion Study: Feasibility Report*** (Baltimore, Md.: Baltimore District, Corps of Engineers, October 1990), unnumbered page.

[80] Scott Hardaway and Gary Anderson, ***Shoreline Erosion in Virginia*** (Gloucester Point, Va.: Virginia Institute of Marine Science, 1980), 5.

[81] Robert Byrne and Gary Anderson, "Shoreline Erosion in Tidewater Virginia," in ***Applied Marine Science and Ocean Engineering No. 111*** (Gloucester Point, Va.: Virginia Institute of Marine Science, 1977), 3.

[82] Hardaway, ***Shoreline Erosion in Virginia,*** 3, 4.

[83] Lee Hill, Shoreline Erosion Advisory Service, telephone interview by Sandra Benson, Information Officer, Chesapeake Bay Local Assistance Department, 6 May, 1991.

[84] Hardaway, ***Shoreline Erosion in Virginia,*** 3.

[85] Ibid., 5.

[86] Larry G. Ward and others, ***Living with Chesapeake Bay and Virginia's Ocean Shores*** sponsored by the National Audubon Society, (Durham, Nc.: Duke University Press, 1989), 52.

[87] Ibid., 63.

[88] Shoaling refers to the deposition of sand in an area which affects depth of water and may endanger surface navigation.

[89] Ward, ***Living with Chesapeake Bay and Virginia's Ocean Shores,*** 68.

[102] These maps are available through Virginia's Marine Resources Commission
2600 Washington Avenue
P.O. Box 756
Newport News, Va. 23607
(804) 247-2200

[103] Robert J. Orth and others, ***Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Tributaries and Chincoteague Bay 1987*** (Gloucester Point, Va.: Virginia Institute of Marine Science, 1988), 88.

[104] The Virginia Chesapeake Bay Local Assistance Department is investigating opportunities to provide this resource to local governments free of charge.

[105] Virginia Department of Conservation and Recreation, ***Chesapeake Bay Area Public Access Plan***, 1990.

[106] Chesapeake Executive Council, ***The 1987 Chesapeake Bay Agreement*** (Chesapeake Executive Council, 1987), 5.

[107] Virginia Department of Conservation and Recreation, ***The 1989 Virginia Outdoors Plan***.

[108] Richmond County, ***Subdivision Regulations for Richmond County, Virginia*** (Richmond County, Va.: August 10, 1989), IV-15.

[109] Marine sanitation devices often use additives such as zinc, quaternary ammonium, and formaldehyde, which can kill beneficial organisms in septic drainfields, see "Recreational Boat Pollution and the Chesapeake Bay," Report to the Chesapeake Executive Council, January 8, 1991.

[110] Chesapeake Bay Local Assistance Department, ***Local Assistance Manual: Appendix C Guidance Calculation Procedure*** (Richmond, Va.: Chesapeake Bay Local Assistance Department, 1990), C-10.

[111] See Commonwealth of Virginia, Council on the Environment, ***Case Studies in the Application of Best Management Practices to Meet the Requirements of Virginia's Chesapeake Bay Preservation Act*** (Richmond, Va.:Council on the Environment, 1990).

[112] See Jim Schwab, "Riverfront Gamblers," ***Planning*** (September 1989), 15-18.

[113] See Boston Redevelopment Authority, ***City of Boston Municipal Harbor Plan***(Boston, Ma.:Boston Redevelopment Authority, 1990), 42-44.

[114] Ibid., 8.

bridge, Ma.: Lincoln Institute of Land Policy and the Environmental Law Foundation, 1988), 32.

[126] Ibid., 37.

[127] With the increasing interest in golf, golf course facilities are frequently integrated as a component of residential community development projects. Although golf courses provide open space, their construction and operation may severely degrade water quality and adversely impact environmentally sensitive resources. See Richard D. Klein, ***Protecting the Aquatic Environment from the Effects of Golf Courses*** (Maryland Line, Md.: Community and Environmental Defense Associates, 1990).

[128] Wendelyn A. Martz with Marya Morris, ***Preparing a Landscaping Ordinance***, Planning Advisory Service Report Number 431 (Chicago: American Planning Association, 1990), 3.

[129] Ibid., 3-5.

[130] See Bruce Ferguson and Thomas N. Debo, ***On-Site Stormwater Management: Applications for Landscape and Engineering***, 2d ed. (New York: Van Nostrand Reinhold, 1990), 153-174, for a discussion on water harvesting design. The authors cite a number of examples where stormwater runoff is collected and successfully used for landscape irrigation.

[131] See Gay Mackintosh, ed., ***In Defense of Wildlife: Preserving Communities and Corridors*** (Washington, D.C.: Defenders of Wildlife, 1989).

[132] Ibid.

[133] Lowell W. Adams and Louise E. Dove, ***Wildlife Reserves and Corridors in the Urban Environment: A Guide to Ecological Landscape Planning and Resource Conservation*** (Columbia, Md.: National Institute for Urban Wildlife, 1989), 27.

[134] Ibid., 29.

[135] Ibid., 29.

[136] Ibid.

[137] Department of Conservation and Recreation, ***The 1989 Virginia Outdoors Plan***, 122.

[138] Code of Virginia §§ 10.1-1700 to 1705.

[139] Code of Virginia §§ 10.1-1009 to 1016.

[140] Code of Virginia §§ 10.1-1800 to 1804.