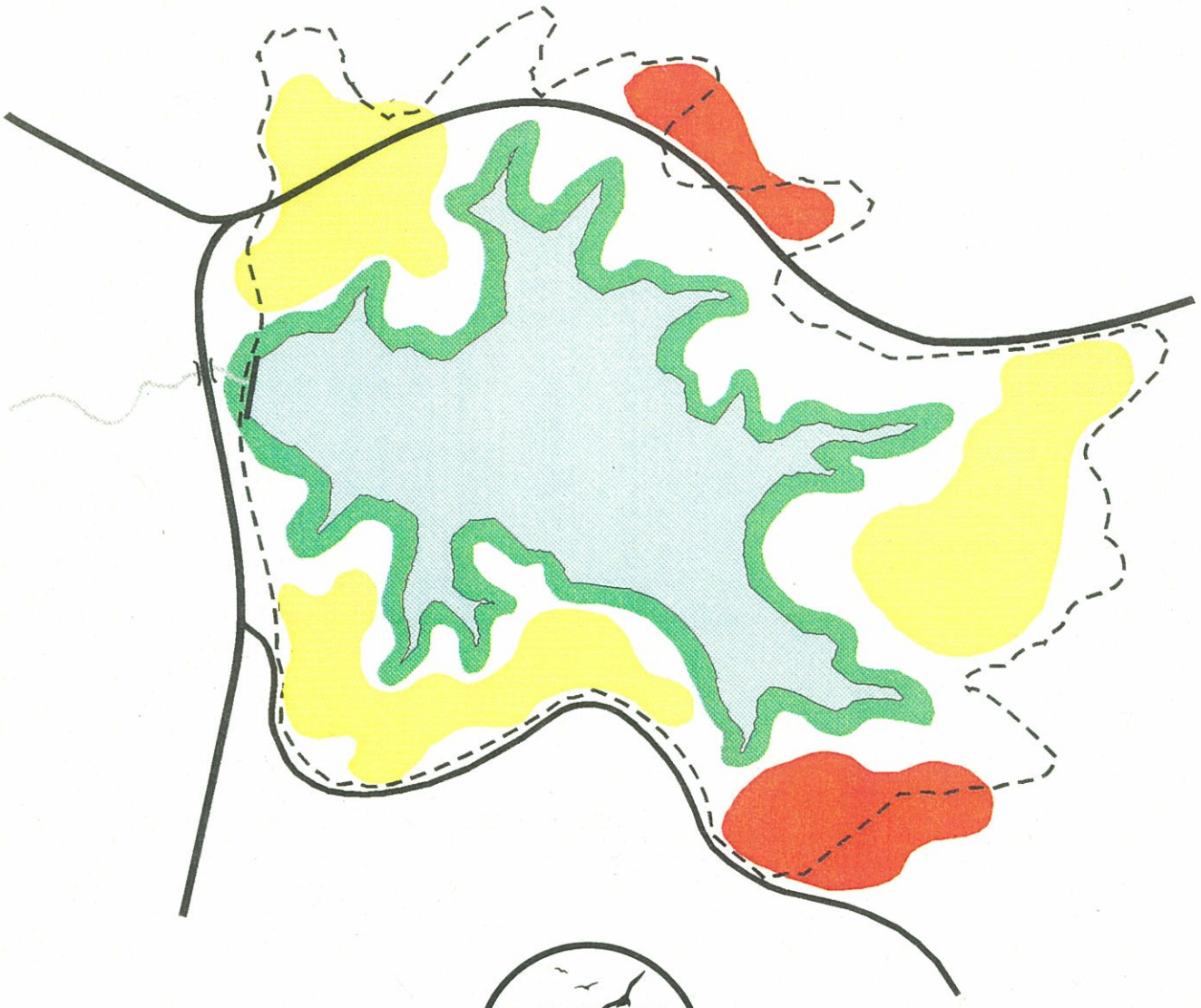
WATER SUPPLY WATERSHED MANAGEMENT IN HAMPTON ROADS



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PLANNING DISTRICT COMMISSION

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WATER SUPPLY WATERSHED MANAGEMENT IN HAMPTON ROADS

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Prepared by the staff of the
Hampton Roads Planning District Commission
in Cooperation with Staff from the Cities and Counties
of Hampton Roads

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INTRODUCTION

Water Supply Watershed Management in Hampton Roads was developed by the Hampton Roads Planning District Commission (HRPDC) staff in cooperation with the HRPDC Directors of Utilities Committee. The report is intended to provide water supply watershed management guidance to a broad audience. The target audience includes residents, business owners, developers, elected officials, city and county staff members and all others who are concerned with the proper management of the water supply watersheds in Hampton Roads. Due to the broad range of issues involved in watershed management and the diverse educational and professional backgrounds of the target audience, it is impossible to cover all pertinent topics in a single document. However, the report does provide a starting point for those wishing to learn about watershed management issues and options.

The report is divided into eight sections; an executive summary and seven subsequent chapters. The executive summary contains an overview of the Water Supply Watershed Management Principles developed by the Planning and Utility Directors of the region's localities. In addition, the executive summary contains the findings and recommendations from the final chapter of the Report. Chapter One contains an introduction to the Watershed Management Process and a discussion of the multidisciplinary nature of watershed management. The U.S. Environmental Protection Agency's Watershed Protection Approach is used as a framework for the discussion in Chapter One. Chapter Two presents an analysis of federal laws that have a significant impact on water supply watershed management. Chapter Three presents an analysis of Virginia state law in the context of watershed management. Chapter Four contains a description of local watershed management initiatives in Hampton Roads. Chapter Five contains an investigation of the technical aspects of watershed management. Chapter Six contains case studies of watershed management initiatives in three different regions; the Occoquan Watershed in Northern Virginia, the Tar and Neuse Watersheds in the Raleigh/Durham, North Carolina area and the Catskill/Delaware and East of Hudson Watersheds in New York State. Finally, Chapter Seven contains conclusions and recommendations.

It is important to understand that this Watershed Management report is an integral part of a regional effort to foster interjurisdictional cooperation on watershed management issues. A key step in this effort was the development of a set of Water Supply Watershed Management Principles by the Planning and Utility Directors of the region's fifteen member localities. It is hoped that the development of the Principles and this report will be part of an ongoing regional program that improves both the understanding and the implementation of water supply watershed management measures in Hampton Roads.

WATERSHED MANAGEMENT PRINCIPLES

In June of 1996, the HRPDC staff was requested by the Chief Administrative Officers of the region's localities to facilitate a process by which the Planning and Utility

Directors of the 15 member localities developed a set of water supply watershed management principles. To accomplish this task the group met a total of four times in the period from July through September of 1996 to discuss watershed management issues, activities and concerns. Based on these discussions, the HRPDC prepared a draft for consideration. The committee reviewed the draft and modified it to more closely reflect local needs and concerns. Consensus was reached on all components of the draft. Compensation issues were identified and the committee consensus was that resolution of these issues should occur during negotiations between individual purveyor and host communities. The committee believes that the Principles provide a framework to guide future watershed management decisions. It should be noted that while the bulk of the recommendations in the Interjurisdictional Cooperation section pertain to the interaction of host and purveyor communities, the remaining principles are applicable to all water supply watershed management efforts in the planning district. The following sections, titled "Definitions" and "The Principles", contain the actual text of the Principles.

Definitions

Host community: A locality that has all or part of the raw water supply of another jurisdiction within its boundaries. The raw water supply can include all or part of a water supply river or reservoir as well as all or part of its accompanying watershed.

Purveyor community: A locality that supplies finished or raw drinking water to the citizens of some portion of the Hampton Roads Planning District, and, in the context of these Watershed Principles, has all or part of its raw water supply in another jurisdiction.

The Principles

The future of Hampton Roads is dependent upon the quality and quantity of the region's water supply. While many factors affect the quality of our raw water supplies, the type and distribution of land uses in the watersheds of our water supply rivers and reservoirs are key issues. Continued population growth and development will both increase water demand and alter the land use patterns in the water supply watersheds. Intelligent watershed management will be necessary to protect our water supplies. In the context of this document, watershed planning is defined as the process of determining the most cost effective and environmentally sound methods of managing land uses within a watershed to protect water supplies. Watershed management is defined as the implementation of watershed plans and all other actions targeted at protecting water supplies through maintenance of the watershed.

A proactive approach to watershed management can yield many benefits. Correcting water quality problems associated with established land use patterns can be difficult and expensive. In addition, proper management of land uses can help avoid health risks associated with waterborne

pathogens and other forms of contamination. Proactive watershed management can both protect water supplies and provide a healthy and aesthetically pleasing environment for residents and businesses of the watershed. A properly maintained reservoir can provide potable water, recreational amenities, wildlife habitat, amenities for development, and economic benefits. Proactive planning can also lead to lower life cycle costs in finished water production and BMP maintenance.

Complex interjurisdictional relationships are a hallmark of the water supply systems in Hampton Roads. These Watershed Management Principles have been established to provide a common point of reference for localities seeking to cooperate in watershed management efforts. All efforts in this arena should target maximum long term benefits for the host localities, the residents of the water supply watersheds, the water purveyors, and citizens of the region at large. Many of the Watershed Management Principles are also applicable to localities with self contained water supply systems.

Interjurisdictional Cooperation

Maintenance of a high quality and ample water supply is a responsibility shared by all localities in Hampton Roads.

Open communication and cooperation are essential to any intergovernmental efforts to manage watersheds to protect water supplies.

All watershed management principles that are accepted as regional standards must be approved by both host and purveyor communities.

Watershed planning and management should be a cooperative venture between host and purveyor communities. Cooperative planning and management efforts should involve an equitable sharing of resources between host and purveyor based on costs incurred and benefits derived by each community. In addition, the financial resources of each community should be taken into consideration in the negotiation of cost share agreements.

Host communities will maintain the fundamental authority for planning, zoning, and other forms of development control within their jurisdictions.

Host and purveyor communities should endeavor to provide a uniform set of regulations for water supply watershed management, thus avoiding a situation in which citizens must deal with differing regulations on host and purveyor land holdings.

A communication network between host and purveyor communities should be established to expedite response to citizen concerns and to improve

communication between the host and purveyor communities on watershed management issues.

Through cooperative and proactive watershed planning, host and purveyor communities should strive to avoid situations requiring the use of the purveyor's extrajurisdictional watershed management authority to address water quality problems.

Public Involvement

The citizens of the host community and, in particular, the residents and businesses of the watershed in question should be encouraged to participate in watershed planning and watershed management efforts. Appropriate opportunities for public involvement should be provided.

Public education is a critical component of watershed management. Host and purveyor communities should share responsibility for this education.

Watershed Planning and Management Issues

Hampton Roads has a finite raw water supply, and the development of additional reservoirs is an extremely difficult and costly undertaking. It is essential that new and existing reservoirs and the accompanying watersheds be maintained as healthy, viable systems.

Hampton Roads communities should coordinate their research into watershed management techniques with the goal of developing an improved scientific understanding of watershed management issues. Watershed planning and management should be based on the best available scientific information.

Future economic development in Hampton Roads is dependent on an ample water supply. Economic development projects in water supply watersheds should be designed to maintain or enhance raw water quality.

Hazardous material facility siting and hazardous material transportation pose significant threats to the water supplies. A consistent regional policy on the location and management of such facilities and the transport of hazardous materials in water supply watersheds should be developed. The coordination between hazardous material emergency response teams and water purveyors should be improved.

Long term maintenance of stormwater BMPs is a problem throughout the region. Coordinated solutions, including the implementation of regional BMPs and development of funding mechanisms, should be explored.

The siting and management of public sanitary sewer systems in water supply watersheds should be addressed cooperatively by host and purveyor communities and the Hampton Roads Sanitation District.

Organisms of concern, e.g. *Giardia, Cryptosporidium, E. Coli* and others, which may be found in water are typically associated with land use activities in the tributary watershed. As scientific understanding of management practices for dealing with these problems improves, the region's local governments should act as a region to protect the water supplies from these threats.

FINDINGS AND RECOMMENDATIONS

The following are the key findings of the research documented in Water Supply Watershed Management in Hampton Roads.

- **Effective water supply watershed management must address the watersheds in question as whole, integrated systems.** All aspects of watershed management benefit from a holistic approach to data collection, planning and implementation. Fragmentation of a watershed leads to a skewed understanding of its functioning and yields less than optimum solutions to management problems. To achieve maximum effectiveness all aspects of watershed management, including, but not limited to data collection and analysis, identification of point and non-point pollution sources, BMP system engineering and maintenance, land use planning, hazardous material handling and stakeholder involvement must address watersheds as integrated units.

- **The USEPA is using the Watershed Protection Approach as an organizational paradigm for both Clean Water Act and Safe Drinking Water Act programs.** The EPA continues to organize Federal water quality programs based on the Watershed Protection Approach. In addition, EPA is urging states to adopt a similar approach in their water quality programs. This trend has the potential to improve integration of diverse research and management activities occurring at the federal, state and local levels.

- **Regional cooperation in water supply watershed management is essential.** An inherent difficulty in watershed management is caused by the fact that watershed boundaries seldom follow political boundaries. Given the complex interrelationships between host and purveyor communities and the number of water supply watersheds that cross jurisdictional boundaries in Hampton Roads, it is essential that the localities of the region work together to insure proper watershed management.

- **Water supply watershed management programs must be tailored to individual watersheds.** Many variables come into play in determining the

content of a management program, but the degree of development in the watershed in question is among the most critical factors. In the rural watersheds in Hampton Roads development controls are key. Comprehensive plans, land use plans, zoning ordinances and subdivision ordinances all play a critical factor in determining future land use patterns. In more urbanized watersheds, stakeholder education and implementation and maintenance of BMPs are the more critical factors.

- **Watershed planning and management actions that precede the development of serious watershed problems are more cost effective and beneficial than efforts made to correct problems after they occur.** Once detrimental land use patterns have been established in a watershed they are nearly impossible to modify. Management practices in this type of scenario are often limited to treating the symptoms rather than the cause of the problems.

- **Maintenance of forested open space in water supply watersheds is one of the most effective methods of water quality protection.** Forested open space provides many benefits including limiting nonpoint source pollution, limiting runoff rates, limiting erosion, maintaining natural water temperature gradients and facilitating ground water recharge. In addition, forested open space requires little maintenance to provide these benefits to a watershed. (However, it should be noted that some localities in Hampton Roads are experiencing problems with deer and beaver overpopulation in forested areas.) In comparison, structural BMPs such as detention ponds are expensive to construct and become ineffective over time if not properly maintained. Many variables impact the effectiveness of forested open space, including the location of the open space in the watershed and the type of vegetation it contains.

- **Stream buffers are an effective tool for water quality protection.** In the absence of larger tracts of forested land, forested stream and reservoir buffers are proven to provide several water quality benefits. A properly designed buffer system acts to slow and diffuse runoff, thereby reducing the adverse impacts of nonpoint source pollution. The width and constitution of the buffer system must be determined based on a host of factors including surrounding land uses, slope and soil type.

- **Regional stormwater BMPs are more cost effective than onsite systems, but must be carefully engineered to avoid adverse environmental impacts.** Proper engineering of regional BMP systems becomes more difficult as the degree of urbanization in a watershed increases. Runoff rates increase rapidly as the percentage of impervious surface in a watershed goes up. In this type of environment it becomes difficult to maintain normal water temperature gradients and to limit transport of pollutants into receiving waters. Analysis of the watershed in question as

an integrated unit is essential. Development of an integrated BMP system that incorporates both regional and onsite systems is often necessary to prevent adverse water quality impacts across a broad range of storm sizes.

- **Use of sound environmental and urban design principles in developing areas is essential to maintaining high quality water supplies.** The degree of development and the percentage of impervious surface in a water supply watershed are obviously critical factors. However, the location of the impervious surface, the location and structure of buffer areas, and the details of site design also play a significant role in protecting water quality. All efforts should be made to employ sound environmental and urban design principles in developing watersheds.

- **Agricultural and silvicultural operations in water supply watersheds should employ Best Management Practices that are sufficient to protect water supplies.** Several components of agricultural operations are potentially detrimental to public water supplies, including management of animal waste and application of fertilizers and insecticides. Sufficient buffer areas and other BMPs should be utilized to protect water supplies.

- **There are a number of institutional models for cooperative regional watershed management to protect water supplies.** They range widely in cost and policy level involvement. At one extreme is New York City, where the watershed management program involves a myriad of interjurisdictional agreements and a cost in excess of $1.5 billion. Others, such as the Occoquan Basin, focus on scientific research and technical recommendations to several local governing bodes. Recommendations are provided to a Technical Advisory Committee, comprised of local government staff supported by the scientific community. Finally, the Upper Neuse Association in North Carolina involves both a Technical Advisory Committee and a policy level association of elected officials in the Basin.

Recommendations

1) **The localities in the region should continue efforts to build a framework for interjurisdictional cooperation on water supply watershed management:** The Water Supply Watershed Management Principles developed by the planning and utility directors of the region's localities establish a foundation for regional cooperation on watershed management issues. Deriving full benefit from the Principles will require the following actions:

   - The Principles should be utilized when localities make decisions on watershed development and management.

   - The existing Principles identify several areas in which development of regional standards and guidance is needed. The localities of the region

should continue to work toward the development of the needed standards and guidance.

- Individual host and purveyor communities should develop specific agreements on the sharing of financial and technical resources needed to facilitate watershed management efforts. These agreements should be based on the Watershed Management Principles

- The existing Principles should be revised as necessary to incorporate emerging regional water supply watershed management issues.

- The localities of the region should continue to work together toward the development of an improved scientific understanding of water supply watershed management problems and solutions.

2) **A regional educational program focused on water supply watershed management issues should be designed and implemented.** A comprehensive watershed management program must include a strong educational element. A successful education program must involve a broad cross-section of participants and provide incentives for their participation. The localities of the region should work together to develop a water supply watershed education program with a regional focus. The following audiences should be targeted:

- **Watershed Residents:** Effective watershed management must include education of residents located in water supply watersheds. Incentive programs to encourage the participation of this group should be explored.

- **Development Community:** Design and technical assistance should be offered to the development community as a method of both educating developers on watershed management and minimizing the adverse impact of new development on water quality.

- **Industrial, Commercial and Business Community:** It is essential that members of the industrial, commercial and business community be aware of their proximity to water supply watersheds, the impact of their operations on water quality and Best Management Practices that can be employed to protect water quality.

- **Elected Officials and Local Staff:** Educational efforts for this audience should include information on the long term financial benefits of effective watershed management, the cumulative impacts of development, alternative development controls and the benefits of integration of watershed management efforts among different departments of local government.

- **Other Agencies:** Agencies, including but not limited to, the Virginia Departments of Transportation, Environmental Quality, Health and

Conservation and Recreation, the United States Military, the Corps of Engineers, the United States Fish and Wildlife Service and others as appropriate, should be included in educational efforts.

3) **An enhanced set of regional water supply watershed management tools should be developed and made available to all localities in the Planning District.** Several tools are needed to support regional watershed management. While many data sets and planning tools exist in each of the localities in the Planning District, few of them are suitable for managing watersheds that cross jurisdictional boundaries. It is essential that each locality that contains part of a water supply watershed has the data and tools necessary to assess the cumulative impact of development in the entire watershed. The following steps are intended to create a suitable set of watershed management tools.

- **Evaluation of Existing Data:** The first step in this process involves the evaluation of existing data on the water supply watersheds in Hampton Roads. Water quality trends, land use trends, data on natural systems, BMP inventories and other significant information should be assembled and evaluated for possible inclusion in a regional data base.

- **Research:** Significant information gaps identified in step one should be addressed through research and analysis of the region's water supply watersheds. Individual watershed studies should be structured to add to a cumulative regional data base and, where possible, add to the understanding of processes impacting watershed management across the region.

- **Regional GIS:** A regional Geographic Information System is an essential tool for both archival research and analysis of information pertaining to water supply watershed management. A regional system would provide a platform for organization, display and analysis of data pertaining to multi-jurisdictional watersheds. A regional GIS would be valuable in determining the cumulative impacts of land uses in the watersheds. In addition, such a system could be used to design regional stormwater BMPs, and as part of a software system to perform hydrologic and water quality modeling. The existing Regional GIS Users Group should be involved in the development of a system that supports water supply watershed management.

4) **The localities of the region should formally establish an institutional structure for interjurisdictional cooperation on water supply watershed management.** To continue the interjurisdictional dialogue and guide the development of the educational programs and analytical tools necessary to support cooperative water supply watershed management, a Technical Advisory Committee, comprised of the region's Directors of Utilities and Planning Directors Committees should be established. The HRPDC should provide staff support for the TAC and the programs. (This action would formalize the existing roles of the HRPDC Directors of Utilities and Directors of Planning Committees in water supply watershed management.) The localities should explore, through the HRPDC, the

establishment of a regional policy mechanism for water supply watershed management, which may include local elected officials or their representatives.

5) **The localities of the region should develop an enhanced watershed inspection and maintenance program.** Without rigorous inspection and maintenance it is difficult to realize the full benefit of a watershed management program. In particular, inspection and maintenance of stormwater BMPs is critical to their proper functioning. Opportunities for regional cooperation in this area should be investigated.

6) **The localities of the region should remain involved in the State's efforts to develop a source water protection program.** As the State of Virginia continues the development of a source water protection program, it is important that the localities of Hampton Roads remain engaged in the process to ensure that the State program meets the needs of the region.

CHAPTER 1

THE WATER SUPPLY WATERSHED MANAGEMENT PROCESS

THE WATERSHED MANAGEMENT PROCESS

Water supply watershed management is by its very nature is a multi-disciplinary and holistic endeavor. The interaction of complex natural and man-made systems determines the quality of raw drinking water supplies. The challenge of watershed management is the identification of the critical variables in these systems, and the subsequent development of cost-effective and environmentally sound solutions to current or potential watershed problems.

Many factors come into play in watershed management, including the state of existing natural systems, land use patterns, and development trends. The water supply watersheds in the Hampton Roads Planning District vary in character from rural to urban. The management techniques needed depend largely on the existing and projected land use. In rural watersheds the key issues include dealing with the impacts of agricultural, forestal, and low density residential uses, while future planning must consider the possibility of rapid urbanization. In urban watersheds the critical problems include high runoff rates and pollutant loading associated with a high percentage of impervious surface and the adverse impacts of a variety of residential, commercial and industrial land uses.

The Watershed Management Process outlined in this chapter is based on the U.S. Environmental Protection Agency's (USEPA) Watershed Protection Approach (WPA). The USEPA is focusing on the WPA as a method of organizing implementation and administration of existing water quality programs. The WPA is intended to be a methodology for integration of the many individual programs that have evolved to implement the goals of the Clean Water Act and the Safe Drinking Water Act. The WPA is based on the following guiding principles:

> "Partnerships - Those people most affected by management decisions are involved throughout and shape key decisions.
>
> Geographic Focus - Activities are directed within specific geographic areas, typically the areas that drain to surface water bodies or that recharge or overlay ground waters or a combination of both.
>
> Management Techniques based on Sound Science and Data - Collectively, watershed stakeholders employ sound scientific data, tools, and techniques in an iterative decision making process (USEPA, 1996)."

The WPA appears destined to become an organizational theme for the implementation of both the Safe Drinking Water Act and the Clean Water Act. The Watershed Management Process (WMP) presented in the following section incorporates the WPA into a more detailed seven step process that is suitable for application to the water supply watersheds in Hampton Roads. The Watershed Management Process will be used as a framework for discussion and analysis in subsequent sections of the report.

STEP I: IDENTIFICATION AND INVOLVEMENT OF STAKEHOLDERS

A key first step in a successful watershed management initiative is the identification and involvement of stakeholders. The EPA defines the stakeholders as individuals and organizations that have an interest in identifying and solving water quality problems and in monitoring the effectiveness of these solutions over time. The stakeholders for any watershed project could include city and county governments, planning district commissions, water suppliers, state agencies, local soil and water conservation districts, individual citizens, local industries, citizen action groups, academics, and science and engineering specialists.

Early involvement of stakeholders helps to build consensus and good working relationships among all parties that will be affected. Stakeholder involvement also provides valuable insight and information from those who are most familiar with a particular watershed; both opportunities and problems can be identified early in the watershed management process. Identification and involvement of stakeholders is an activity that must continue over the life of the watershed management process. As progress is made through the following steps new stakeholders will be identified and should be involved in the process.

STEP II: WATERSHED DELINEATION

The second step in the development of a watershed management plan is the identification of the specific geographic area of interest. A watershed is defined as the area of land drained by a particular water body. Watersheds are hierarchical, with the largest being the watersheds of the major oceans of the world and the smallest subdivisions being the watersheds of headwater streams. For example, the watershed of the Chesapeake Bay can be subdivided into the watersheds of tributaries like the James, York, and Potomac Rivers. These watersheds can in turn be subdivided into the watersheds of smaller tributaries such as the Elizabeth and Chickahominy Rivers. The process of subdivision ends with the delineation of the watersheds of individual headwater streams. As the delineation process proceeds from major water bodies to headwater streams the size of the watershed becomes markedly smaller.

For water supply reservoirs, the area of interest will typically include the watershed of the reservoir and all of its tributary streams. If a water supply river is under consideration, the area of interest will probably include only a subset of the watershed, with distance from the water withdrawal point and pollution potential being two of the critical factors in determining the area that must be studied.

STEP III: IDENTIFICATION AND ANALYSIS OF NATURAL FEATURES

The third step in the process is the identification and analysis of significant natural features. To some extent, the natural features of interest will depend on the specific goals of the watershed management plan and the specific problems being addressed by the watershed management effort. In most cases significant natural features will include, but

are not limited to, existing water quality, quantification of the amount of water moving through the reservoir, determination of water movement pathways including the interconnection of the ground water system with the surface water system, geological features, flora, fauna, topography, and weather patterns. Analysis of this information will yield an improved understanding of pollution transport, natural pollutant background levels, and suitability of the watershed for particular land uses.

STEP IV: ANALYSIS OF THE IMPACTS OF EXISTING LAND USES

Step four is an assessment of existing land uses and their impacts on the watershed. This is a multifaceted project that includes the categorization of land uses, determination of land area for each use, determination of the average degree of imperviousness of each use, identification of pollution sources (both point and non-point), mapping of septic tanks and underground storage tanks, and identification of existing stormwater facilities.

STEP V: ASSESSMENT OF THE REGULATORY FRAMEWORK

The next phase is an analysis of the existing local, state and federal regulatory framework. Local elements such as the comprehensive plan, zoning, watershed overlay districts and subdivision regulations must be evaluated to determine the ability of the local government and other governmental agencies to manage development in the watershed in question. This analysis may identify deficiencies in the existing regulatory framework.

STEP VI: ANALYSIS OF DEVELOPMENT TRENDS

In step six development and demographic trends in the watershed are analyzed to create projections of future growth and development. This information, coupled with the physical and regulatory constraints determined in the previous steps, will yield a picture of the type of development that is economically viable, and where and when it is likely to occur.

STEP VII: DEVELOPMENT OF A WATERSHED MANAGEMENT PLAN

At this point it is possible to assemble a watershed management plan. The previous steps will yield a clear picture of development pressures and limitations, pollution sources, pollutant transport, water quality and land use trends. The content of the management plan will be determined by a combination of these factors and the political and social environment. Involvement of a broad spectrum of stakeholders will be necessary to produce a management plan that can be implemented. Consensus building and compromise will be necessary to develop a plan that is viable and meets the needs of all of the stakeholders.

STEP VIII: IMPLEMENTATION

All of the previous steps will do little to protect water supplies if the watershed management plan is not implemented. Successful implementation of a watershed management plan will require continued involvement and education of a broad spectrum of stakeholders. Whereas steps two through six are largely a research project; steps one, seven and eight are dependent on political leaders, citizens, land owners, business owners and governmental staff working together to develop and implement a set of realistic procedures to protect water quality.

THE WATERSHED MANAGEMENT PROCESS AS A MULTI-DISCIPLINARY ENDEAVOR

Successful implementation of the Watershed Management Process (WMP) requires the involvement of a broad spectrum of professionals. For drinking water supplies, it is clearly the water supply utility that should be in the lead in initiating a source water protection plan for its system. The water supply utility has the responsibility to provide its customers with water that is safe to drink. But unlike a water system upgrade where in-house experts or consultants develop an engineered solution to a treatment or distribution problem, effective source water protection requires the coordination and cooperation of local planning, public works and engineering departments, as well as support by the governing bodies and various other stakeholders to be successful. Specialists, such as environmental scientist, computer scientists, social scientists, geologists, architects, and economist may be brought into the process as needed. The WMP provides a model to bring the stakeholders together and move beyond the traditional engineering approach to problem solving. The following sections explore the technical details of the Watershed Management Process and the roles of public utilities and planning professionals in this process. This discussion is not intended to minimize the roles of other stakeholders but is intended to shed light on the roles of the professionals most closely involved in the source water protection initiative.

THE PLANNING PROFESSIONAL AND THE WATERSHED MANAGEMENT PROCESS

Involvement of local and regional planning staff in the Watershed Management Process is essential. Planning departments have four primary resources to offer. First, planning offices are typically repositories for a variety of data pertaining to the localities they serve. Examples of the types of information typically available include demographic data, economic data, land use/land cover data, transportation infrastructure data, utility infrastructure data, natural systems data and lists of community groups and neighborhood associations. Second, planning departments are typically involved in analysis on a variety of topics including demographic trends, land use trends and economic development. Third, city and county planners are typically responsible for maintenance and administration of comprehensive plans, land use plans and zoning ordinances. These tools have a significant bearing on future development patterns. Finally, planning departments house a great deal of expertise and local knowledge on the social and political environments in which they operate. This information is particularly valuable in the context of fostering stakeholder involvement in the Watershed Management Process.

Several aspects of the Watershed Management Process draw on skills and resources available in local and regional planning offices. In particular, Step I: Identification and Involvement of Stakeholders, Step III: Identification and Analysis of Natural Features, Step IV: Analysis of the Impacts of Existing Land Uses, Step V: Assessment of the Regulatory Framework and Step VI: Analysis of Development Trends are tasks that planners are typically trained for and experienced in.

Identification and Involvement of Stakeholders (Step I)

Most planning offices have extensive experience in the identification and involvement of stakeholders in dialogue to establish public policy. Survey data and reports may be available that answer questions pertinent to a watershed management initiative. Planning departments may have established methodologies for identifying a representative sample of stakeholders that are applicable to a watershed management initiative. In addition, a planning department may have established procedures for running public meetings that could be adopted for a watershed management initiative.

Identification and Analysis of Natural Features (Step III)

The skills necessary for Step III, Identification and Analysis of Natural Features, will be possessed by some planning departments and not by others. The ability to contribute to this task is largely dependant on the size and diversity of the planning office in question. Landscape architects and environmental planners will likely possess the requisite skills while planners trained in urban planning or public administration may not.

Analysis of the Impacts of Existing Land Uses (Step IV)

The bulk of the information necessary for Step IV, Analysis of the Impacts of Existing Land Uses, should be available through local planning offices. Planning departments are typically responsible for tracking land areas associated with various uses. Other information required for this step, such as an inventory of existing storm water facilities, may be available through local engineering or public works departments.

Assessment of the Regulatory Framework (Step V)

Assessment of the regulatory framework in the context of a watershed management effort may differ sightly from the type of analysis typically performed in a planning office. However, any attempt to examine build-out conditions under differing development control scenarios could be adapted to a particular watershed and would provide an extremely valuable starting point for understanding the impact of development controls on a specific watershed.

Analysis of Development Trends (Step IV)

Finally, analysis of development trends is a process that is essential to any local government. This expertise may reside in the planning department, the economic development department, or both. In summary, the bulk of the analysis, or at least the raw materials for the analysis, should be available through the planning offices of the localities in the watershed in question.

THE PUBLIC UTILITY PROFESSIONAL AND THE WATERSHED MANAGEMENT PROCESS

In the Hampton Roads area, it is recognized that the engineering and service operations related to watershed protection vary in some degree in organization and function from jurisdiction to jurisdiction. For this reason, the term "public utilities" will be used to generically refer to all engineering and service operations involved in water supply, stormwater or wastewater.

Involvement of the public utilities staff impacted by the watershed management initiative is essential. The public utilities within a watershed have varying responsibilities for managing and protecting water quality based on the function they serve and the regulatory process for which the services must comply. Therefore, each public utility has developed varying technical expertise in water quality protection that can be transferred, at least in part, to source water watershed management. The public utility professional can also include the consultant involved in a range of public utility related functions.

The major role of the public utility professional in the Watershed Management Process is to provide the engineering and science required to develop a sound watershed management plan. Although engineering and science principals may play some part in all phases of the Watershed Management Process, Step II: Watershed Delineation, Step III: Identification and Analysis of Natural Features, and Step IV: Analysis of the Impacts of Existing Land Uses can draw heavily on the expertise of the public utility professional.

Source Water Area Delineation (Step II)

The purpose of delineating the source water protection area of the watershed is to provide a reasonable boundary that will facilitate contamination source inventories and susceptibility analyses. The source water area delineation should be tailored to the specific needs of the drinking water source. It should be based on hydrologic information that will lead to effective source water protection efforts. The delineation should also include a preliminary identification of problem areas or potential stressors to the water system as well as identifying critical areas sensitive to preserving drinking water quality.

The most common method of delineating a source water area is based on a topographic boundary. A topographic boundary of a watershed is the perimeter of the catchment area of a water system. For an entire river system the boundary would be the watershed divide. For a reservoir or a water supply intake on a river the topographic boundary would be the area of the catchment that contributes surface flow of water into the river system up slope of the reservoir dam or the intake. It is referred to as a watershed-area. For a well field, it would be the catchment area contributing recharge to the source water aquifer and can be referred to as the wellhead recharge area.

Probably, the most common tool used to delineate the topographic boundary of the source water area is the United States Geologic Survey (USGS) Quadrangle Maps at 1:24,000 scale. These maps are generally available, inexpensive, and are at a scale suitable for most topographic boundary delineations of public source water areas. Most

of the USGS quadrangle maps are now available in a digital format for geographic information systems (GIS) applications. The digital format can be used as the base map for GIS. An example of a GIS application by a public utility is given in Chapter 5. The Department of Environmental Quality and the Department of Conservation and Recreation have delineated Virginia's watersheds for various regulatory programs. In some cases, the existing watershed delineation may be suitable for source water area delineation.

Identification of Natural Features: (Step III)

One of the major technical issues for source water protection is developing an understanding of the intricacies of the watershed. Upon completion of the delineation, the significant natural features within the source water area should be identified and evaluated. To some extent the natural features of interest will depend on the specific problems being addressed by the source water protection effort and the specific goals of the watershed management plan. The natural features of the watershed can be classified into two major groupings; physical and ecological characteristics.

Physical Characteristics of the Watershed

The physical characteristics of the watershed are those features that deal primarily with nonliving material and for the purposes of this discussion will pertain to those elements that affect the movement of water within the watershed. The physical characteristics include both the geomorphology of the watershed and aquatic features. The following sections provide a brief description of some of the features that may be significant in assessing source water protection.

Surface Drainage Patterns

It is important to understand the drainage pattern of the watershed since surface flow is the major transport pathway mechanism for stormwater related pollutants. For estimating the rate of flow through a drainage area, the effective slope of the drainage pattern should also be evaluated. The major flow patterns and an estimate of the slope can generally be mapped from USGS Topographic Quadrangle Maps. In areas where topographic relief is relatively flat, maps with a finer resolution may be required to properly characterize the flow of surface water. Field mapping may also be required to improve the detail of the drainage pattern in some areas.

Soil Properties

The characteristics of the soil are important for estimating the infiltration rate of precipitation and the potential for erosion if the hydrology is altered. Soil surveys conducted by the Natural Resource Conservation Service provide useful information regarding soil properties. The soil surveys include useful information such as soil location, classification, potential development usage, relative slope and drainage, septic suitability, and relative infiltration rates. Field mapping and testing may be required to improve the level of detail in some areas of the watershed.

Ground Water Flow

In some areas, ground water flow may be a significant transport mechanism for moving pollutants into source water. To identify these areas it is necessary to evaluate the surface water and ground water interaction. The first step in this evaluation is identification of those areas within the source water area from which ground water discharges into the surface water system. This can be accomplished by field mapping the location of springs and seeps and the portion of rivers for which ground water provides the baseflow. After mapping these features, the USGS Quadrangles can be used to help identify ground water recharge areas that supply ground water to these features. The time-of-travel or the rate of movement of the ground water from the recharge area to the discharge area can be estimated by various dating methods and tracer studies.

Meteorological Data

Precipitation

The historic trends of precipitation can be useful in predicting the water budget for the source water area and assessing the surface flow contribution to the water system from various drainage areas. Over a large source water area, the distribution of precipitation may be significantly different from one area of the watershed to another. For a case in point, it can be important to know the historic distribution of rainfall in order to estimate the relative contribution of surface flow to the water system between various drainage areas. Rainfall data can be collected from the National Weather Service, local airports, many universities, military airports, and agricultural extension offices. The Soil Survey also will have some limited average regional rainfall data as well.

Evaporation

For the purposes of source water assessments, the public utility is probably most interested in the potential evaporation of water from reservoirs. Potential evaporation is defined as the quantity of water evaporated per unit area, per unit time from an idealized, extensive, free water surface under existing atmospheric conditions (Shuttleworth, 1993). Evaporation can be result in a significant loss of water from a reservoir. The national average for evaporative loss is around 70% of the precipitation (Shuttleworth, 1993). The National Weather Service maintains evaporation loss records across the nation. Evaporation from open water can also be estimated empirically based on several variables including, temperature, elevation, average vapor pressure, wind speed, relative humidity, and solar energy. The Handbook of Hydrology (Maidment, 1993) is one of several books that provides empirical methods for estimating evaporative losses.

Fluvial Characteristics

It may be advantages to assess the characteristics of the river or stream system within a source water area. The stages of the river are important factors to consider when assessing the potential for a water system to handle a waste load. The 7 year (Q7) and 10 year (Q10) low river flow are used in determining mixing of the pollutant load to a receiving stream. These values could also be used to help rank the vulnerability of the source water in a susceptibility analysis. Records of historic flow and river stages for many river systems in Virginia are maintained by the USGS and published yearly in the Water Resource Data Water Year reports.

Reservoir Characteristics

The physical configuration of the reservoir plays an important role in the geochemical processes that take place in an open body of water. The water in shallow reservoirs tends to have seasonal temperature fluctuations that are greater than deeper reservoirs; warmer in the Summer and colder in the Winter. As a result of the warmer Summer temperatures, the shallow reservoir tends to be more susceptible to algae blooms.

Water Quality Parameters

Water quality parameters are often referred to by the USGS as physical parameters of water and are those features that govern the chemical reactions and transformations of pollutants in the natural system. Collectively they are measures of the geochemical state of the natural water. The analysis of most of these parameters can be performed in the field at a relatively low cost. In any water quality study, each water quality parameter tested can be used to tell a small part of the water quality story. By combining the parts, a better understanding of the water quality and its ability to resist chemical changes can be developed. The following are basic descriptions of the most common water quality parameters:

Alkalinity

Alkalinity is a measure of the capacity for water to neutralize (buffer) acid or reset the changes in pH. Alkalinity is a measure of the concentration of bicarbonate (HCO_3^2) carbonate (CO_3^2), and hydroxide (OH). It is expressed as milligrams per liter (mg/l) of calcium carbonate ($CaCO_3$). In general, water with a low alkalinity is more susceptible to changes resulting from acidification and water with a high alkalinity (>100 mg/l) is less sensitive to acidification (Weigmann et.al., 1993) The measurement of alkalinity is required for chemical equilibrium calculations related to carbonate systems.

Color and Odor

Although water color and odor do not have direct chemical significance, they are qualitative indicators of water quality. Both color and odor are related to

organic content of the water. From a drinking water standpoint, the color and odor can be a nuisance treatment problem. In the case of "true color" water, or colored water due to dissolved constituents, treatment can be a costly problem. "Apparent color" is due to turbidity or suspended particles and can be treated easily by filtration.

Hardness

Total hardness of water is a measure of its mineral content, expressed as mg/l equivalents of $CaCO_3$. Water referred to as hard has a high dissolved mineral content and water referred to as soft has a low mineral content. Hard water, due to the higher dissolved mineral content, has a lower capacity for accepting additional dissolved ions than soft water. From a water supply standpoint, hard water results in mineral deposit in pipes and on screens reducing the efficiency of the water system.

Specific Conductance

Specific conductance measures the ability of the water to conduct electricity. It is defined as the electrical conductance of a cubic centimeter of any substance compared with the conductance of the same volume of pure water (Driscoll, 1984). Values for specific conductance in water are reported in microseimens per second (µS/sec) or micromhos (µmhos). Chemically pure water has a very low conductance and it only takes a minute amount of a dissolved mineral (salt) to increase the conductance. Specific conductance has a strong linear correlation to total dissolved solids (TDS). Increases in specific conductance generally infer increases in TDS. Specific conductance also reflects the activity of the electrically charged ions such as sodium and calcium. As a result the higher the specific conductance the greater the potential for the water to be corrosive to iron and steel.

pH

pH is the measure of hydrogen-ion activity, which contributes to the chemical aggressiveness of water. Low pH represents high hydrogen activity resulting in acidic conditions. High pH represents low hydrogen activity resulting in basic or caustic conditions. A pH of 7 is considered neutral; neither basic or acidic. The hydrogen-ion activity is measured on a logarithmic scale, therefore, a pH of 9 is ten times more basic than a pH of 8. Hydrogen-ion activity in natural waters is controlled by the interactions of various chemical compounds that either produce or consume hydrogen ions. The measurement of pH is a useful parameter in evaluating the geochemical environment of natural waters and is required to determine the oxidation and reduction potential of minerals. From a water supply standpoint, the effectiveness of many of the chemical treatment processes, such as alum to promote coagulation, are related to the pH of the raw water.

Total Dissolved Oxygen

Total dissolved oxygen (DO) is an indicator of the oxidation-reduction state of a water body and is generally reported in milligrams per liter (mg/l). Low DO values indicate a reduced or an oxygen deficient environment and high DO values indicate oxidized conditions or an oxygen abundant environment. In an oxygen rich water, minerals such as iron tend to rust or oxidize. The potential for a body of water to hold oxygen in the dissolved state is related to the temperature of the water. For a natural body of water, the highest concentrations of DO occur during the winter months when the water is the coldest and the lowest during the summer months when the water is the warmest, all other things being equal. The life cycle of the aquatic vegetation can influence the seasonal variations in oxygen. Vital aquatic plants consume carbon dioxide and produce oxygen. Dead aquatic plants and plant litter consume oxygen and produce carbon dioxide in the natural process of decay. Under natural conditions, the aquatic plant population tends to flourish during the warmer months and decline during the colder months. Therefore, during the warmer months, when the aquatic plant population is the strongest, oxygen produced by the plants can help to counteract loss of DO from the water due to warmer conditions. During the colder months, as the plant population declines and the debris settles to the bottom, oxygen consumed by the process of decay lowers to some degree the DO content of the water. A problem occurs when the vegetative life cycle becomes unbalanced. The population of aquatic vegetation and algae is not only controlled by water temperature and DO but also by the availability of nutrients. In cases where nutrients are over abundant during the warmer months, the population of aquatic plants and algae can exceed the carrying capacity of the water system to support life. Algae will bloom excessively in response to abundant nutrients. The algae blooms can reduce the amount of light reaching submerged aquatic vegetation (SAV), resulting in a decline in SAV population. As the excess nutrients are consumed, the algae bloom will eventually decline. The organic debris from the algae will settle to the bottom with the SAV debris and will decay. Since the process of decay consumes oxygen, the water system may become oxygen deficient and fish and other aquatic species may die.

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of the concentration of all dissolved material in the water. The dissolved material generally consists of mineral constituents (salts) dissolved from rocks and soils, but it may also include to some degree dissolved organic matter (Smith, 1982). Measurements of dissolved solids can be used to classify water as saline or fresh. Fresh water has a TDS generally lower than 1000 mg/l and saline water has a TDS concentration of greater than 1000 mg/l (Focazio et. al., 1993). Unlike the other parameters mentioned, TDS requires laboratory procedures for analysis.

Temperature

Temperature is a measurement of the degree of heat based on a standard scale (Webster, 1966). The temperature of shallow ground water in Hampton Roads shows minor seasonal fluctuations ranging from approximately 21° to 27° Celsius (C) whereas the temperature of surface water in the area shows significantly greater seasonal fluctuations ranging from 2° to 35° C depending upon the depth and flow rate of the surface water (HRPDC, 1995). Changes in temperature can be the catalyst to increase or decrease the chemical activity of natural waters. The amount of dissolved oxygen or minerals in water is dependent to some degree on the temperature of the water. As an example, the concentration of dissolved oxygen is lower during mid-summer than during mid-winter if all other things are equal.

Turbidity

Turbidity is a measurement of the clarity of water and, more importantly for source water supply, is a measure of potential sediment load to a receiving stream. The higher the turbidity, the more cloudy the water and the more suspended material in the water. Turbidity is attributable to material suspended in the water such as fine organic matter, clay, silt, and fine sand particles (Weigmann et. al., 1993). From a water supply standpoint, turbidity in the raw water affects the efficiency of the filters in the treatment system. Too much turbidity can result in premature clogging of the filters whereas too little can reduce the over all ability of a sand filter to trap particles.

The ability of the water to hold these particles in suspension is a function of the size and shape of the particles and the rate of movement of the water. Fast flowing water has the ability to carry larger particles in suspension than slow moving water. Another test used to determine the potential sediment load of a water body is total suspended solids (TSS). This is a direct measurement of all suspended solids in a water sample. A quick method of determining TSS is to collect one liter of water in a graduated cone (Imhoff cone) and allow the sediment to settle to the bottom. TSS is generally measured in milligrams per liter.

Ecological Characteristics of the Watershed

The ecological characteristics of a watershed involve both terrestrial and aquatic environments. An assessment of the ecology for the purposes of watershed protection provides an explanation of the interaction of the elements of the ecosystem within the watershed and how this interaction affects water quality. The ecosystem of concern includes the plants, animals, and microbial population of the watershed. The following provides a description of the interactions and impacts of various ecological elements that may be significant in assessing source water protection.

Vegetative Buffers

The term "vegetative buffer" refers to the terrestrial vegetative growth in the riparian area of the watershed. It may be important to inventory and assess the vegetative buffers that provide water quality protection to the source water area. Vegetative buffers may be composed of grasses or forests. The natural vegetative buffers reduce the potential for stream bank and sheetflow erosion. High sheetflow erosion results in surface waters that have a higher turbidity and suspended sediment load. Not only do the root systems and the ground cover associated with vegetative buffers provide erosion control, but they also help to reduce the potential for nutrients and other stormwater related contaminants from entering the source water. The forest canopy provides shade in the summer which helps to keep the water cool. It is important for the surface water to remain cool in the summer. As surface water temperature increases the solubility of the major ions increases and the dissolved oxygen tends to decrease.

Wetlands

In source water areas, the major vegetation of wetlands can be forest or grasses. In general, wetlands are found in lowlands of the watershed in areas where the ground water is discharging to the surface. They are commonly found near the confluences of feeder streams and the river mainstream. The ecological importance of wetlands to source water protection is the ability of wetlands to filter stormwater contaminants. These contaminants include nutrients, inorganic compounds, organic compounds, and sediments.

Aquatic Vegetation

Aquatic vegetation grows in areas permanently inundated with water. They are free floating, submerged or have their leaves floating at the surface with the stems rooted in the substrate (Tiner, 1993). For the purpose of watershed management, the aquatic vegetation of greatest interest is the submerged aquatic vegetation (SAV). Monitoring the distribution of SAV can be used to indicate the overall health of the water system. For example, the Virginia Institute of Marine Science has conducted several SAV distribution projects for the Chesapeake Bay Watershed (VIMS, 1995) to be used to help assess the health of the Bay. Aerial photographs, along with quality assurance measures and ground truthing, are used to assess the distribution of select SAV populations. If the population of SAV in a river segment decreases with time then the river segment is experiencing a detrimental stress. It could possibly be due to insufficient nutrients or an increase in sediments or toxics. In some cases, loss of SAV may be due to an excess in nutrients that results in an algae bloom that reduces the amount of light needed for the SAVs to grow. The other extreme is when the SAV

population explodes, the river segment is probably experiencing an increase in nutrients that may lead to other water quality problems such as an algae bloom. If the SAV population remains relatively strong and constant, the water quality in the river segment is probably good and if some growth is experienced, the water quality may be improving. This type of monitoring can be performed for a freshwater system and requires training in SAV taxonomic recognition.

Macroinvertebrates

Stream water quality can be evaluated through the collection and analysis of key indicator species of aquatic insects and other macroinvertebrate life forms. There are literally thousands of different species of macroinvertebrates found in Virginia's rivers and streams. Each taxonomic grouping has specific water quality requirements that a stream must have in order for its members to survive. The quality of the water for the stream can be evaluated by determining what species inhabit a stream. Changes in water quality in stream segments can also be evaluated in comparison to overall stream quality (Izaak Walton League, 1996). By selecting key indicator species with differing sensitivities to pollution a quantitative water quality assessment can be performed. Typical key indicators species are divided into three groups; pollution sensitive (i.e. Caddisfly and Mayfly larvae), pollution intermediate (i.e. Damselfly Nymphs, Crayfish, and clams) and pollution tolerant (i.e. aquatic worms, Pouch snails and Black Fly larvae) (KyNREP, 1997). By analyzing the diversity, the percentage, the number per unit area, and the relative pollution tolerance the various problems associated with water quality can be determined. For example, enrichment of organic pollutants, such as fertilizer or domestic waste, will result in low species diversity with the highest percentage of organisms in taxonomic groups that feed directly on organic material. This method can be used to determine the impacts of altered hydrology (i.e. increased runoff, temperature extremes, or increased sediment load) on a stream system and to some degree the toxic impacts from chemical pollutants (i.e. chlorine, acids, metals, etc...). Although the quantitative analysis requires the expertise of a trained scientist to collect and properly identify organisms to the species level, several state and nonprofit organization have trained citizens groups and high school students to identify pronounced stream quality problems as well as to gather information that can be useful in the long term monitoring of the stream quality (i.e. Izaak Walton League, Alliance for the Chesapeake Bay, River Network, Kentucky Water Watch).

Analysis of Natural Features

Concurrent with identifying the natural features of the watershed, the utility professional can begin to formulate a conceptual model of the source water area to be protected. As information is gathered critical areas can be identified. Critical

areas can be defined as areas sensitive to water quality changes from a drinking water standpoint as well as from an ecological standpoint. The most obvious critical area is a raw water intake. A less obvious critical area may be a wetland area upstream from the intake that provides a significant reduction in nutrient pollution from stormwater runoff.

Based on the natural features, the watershed can be further delineated into zones requiring various levels of protection in order to concentrate source water protection activities in those areas needing the most attention. The number of zones and the criteria for establishing the zones will vary depending on the specific needs for source water protection for any given area. One example of zones that may be used to divide the watershed is as follows:

Delineated Zones		Description
Zone 1	Critical Area	The most sensitive areas. Requiring the highest level of protective measures to insure safe drinking water
Zone 2	Moderate Area	Area requiring some level of protective measures to insure safe drinking water
Zone 3	Marginal Area	Area requiring little to no protective measures to insure safe drinking water

The principal of using zones for protecting ground water supplies and in making land use decisions is heavily documented in the EPA wellhead protection program. As one example, Florida uses zones to protect the recharge and wellhead areas throughout the state. Maps illustrating the boundaries of the zones are used as overlays to land use maps to insure that activities planned in the protection areas are sensitive to the needs of the source water. Facilities located in protected areas that may pose a threat to source water are required to take extra measures to reduce the threat.

The next step in analyzing the natural features involves developing hydrologic models to evaluate current and future impacts to the watershed. There are numerous models available and several that use a GIS platform. The advantage of modeling using a GIS platform is that all the data pertinent to the model can be graphically coded and tied into land use patterns and functions. The GIS may also serve other management purposes within the local government and the water utility. Further discussion on the utility of GIS and hydrologic modeling in watershed protection can be found in Chapter 5.

Analysis of the Impacts of Existing Land Uses

The primary causes of deterioration of surface water quality are land use related; municipal and domestic wastewater, industrial and agricultural waste, solid and semi-solid refuse, and nonpoint source pollution. There should be an ongoing

program for the planners, engineers, and scientists to evaluate and monitor the relationship between existing land use in and around the watershed and source water quality. This is paramount for effective watershed protection.

The analysis of existing land uses and their impacts on the watershed is a multifaceted project that includes the categorization of land uses, inventory of pollution sources and the identification of existing stormwater facilities.

Land Use Inventory

The first step in formulating an understanding of the land use impacts on water quality is to categorize and determine the extent of the various land uses in a watershed. This requires an inventory of the activities that may be associated with a particular land use and the density of that activity. The level of detail for the land use inventory should start with basic land use classification. For commercial and industrial properties, there may come a point at which the inventory may need to be more thorough. For example, in the critical area (Zone 1) of the watershed, the industrial land uses may be inventoried to the type of activity of each industry by the Standard Industrial Classification (SIC) code or some other established industrial coding. The purpose of such a detailed inventory would not only be to identify potential pollution threats to the water system but also to enable the watershed management team to assess individual threats. On the other hand, in the marginal areas (Zone 3) of the watershed, it may only be necessary to address industrial land uses in general terms such as light and heavy industry.

In conjunction with determining land use, the average degree of imperviousness associated with the land use should also be assessed. The degree of imperviousness refers to the amount of property at a site that does not allow infiltration of stormwater into the subsurface. This would include the foot print of any buildings on the property, the roads and parking lots and any other structure that is impervious. The average degree of imperviousness is a critical component for estimating the volume of stormwater runoff from a particular land use, which in turn is used to assess the impacts of NPS pollutants on the source water system. In the Hampton Roads area, the engineering or public works departments have already assessed the average degree of imperviousness of various land uses.

Stormwater Facilities Inventory

Existing stormwater facilities and stormwater discharges within the water supply watershed should be identified. It would be helpful to geographically represent the location of each stormwater facility and discharge point on a geographical information system (GIS) to analyze the distribution of the stormwater pollution controls already in place as well as the discharges without pollution control. This inventory can be used when assessing the

need for additional pollution control measures that may be required within the water supply watershed to protect water quality.

Pollution Source Inventory

Identifying and assessing sources of potential pollution are, of course, key components of any watershed protection strategy whether it be the CWA Watershed Protection Approach, the SDWA Source Water Protection Program, or a citizens group effort to protect surface water resources. It is useful to have an understanding of the categories of pollutants that may be present in the watershed prior to identifying potential sources. The most common pollutants discussed in terms of water quality are the nutrients, sediments (suspended solids), toxic chemicals (organic and inorganic) and microorganisms. The following presents a brief introduction to the most common categories plus several other categories of pollutants that may be of concern in source water protection:

Common Pollutants

Nutrients

The carbon, phosphorous, and nitrogen cycle is probably the most important biochemical influence on water quality. Nitrogen and phosphorous are generally regarded as the primary nutrients responsible for phytoplankton, productivity in natural surface waters. Phosphorous is generally the "limiting nutrient" controlling the productivity of phytoplankton and aquatic vegetation in fresh water. The balance of the cycle is important in maintaining the health of the water system whether from an ecological standpoint or a source water protection standpoint. If phosphorous is abundant, phytoplankton and vegetation will flourish; and if extremely abundant, algal blooms or eutrophication will occur. On the other hand, if phosphorous is deficient, productivity of the phytoplankton and other vegetation will be low (oligitrophic). Typically in natural lakes there is a surplus in the amount of nitrogen required to support phytoplankton and aquatic vegetation. Therefore, an increase in nitrogen without an increase in phosphorous will generally not stimulate further growth.

The source of nitrogen and phosphorus in ground water can generally be attributed to nitrogen loading from septic systems and infiltration of nutrients from fertilizer applications in agricultural and residential areas. The source of nitrogen and phosphorus in stormwater is from improper application of fertilizers in rural and urban areas and in some cases, industrial wastes.

Toxic Chemicals

Both inorganic and organic chemicals can be lumped into the category of "toxic chemicals." Toxic chemicals are considered hazardous to the health

of humans, animals and the aquatic life. Exposure to such wastes can occur through ingestion, respiration or epidermal contact. The toxic organic compounds are comprised of synthetic and volatile organic chemicals including pesticides, herbicides, solvents, wood preservatives, and hydrocarbons to name a few. The toxic inorganic compounds include heavy metals such as lead, chromium, and mercury, as well as various salts. Accidental or intermittent discharges of certain toxic chemicals may go unnoticed. Not only does the biological system of the stream suffer as a result, but the water purveyor may also experience treatment problems. For example, complex inorganic phosphates, such as P_2O_5, at levels as low as 0.5 parts per million, may interfere with normal coagulation and sedimentation processes (Nemerow, 1991). The water purveyor may be able to adjust for this inconvenience by increasing the coagulant dosages and/or the settling time. As a second example, phenols react with chlorine even in small quantities, and as a result the treated drinking water can have a noticeable medicinal taste. Phenols are mainly used in integrated steel mills, synthetic textile mills and in resin manufacturing (Nemerow, 1991).

Microbiological Organisms

The microorganisms significant to source water quality include viruses, bacteria, fungi, algae and protozoa. Microorganisms are present in all surface waters and if found in ground water are generally low in concentration (McCutcheon et. al., 1993). For the record period 1993-1994, nine states reported ten outbreaks of gastroenteritis associated with recreational water which affected an estimated 1,437 people. Of these ten outbreaks, three were caused by protozoan parasites (*Cryptosporidium* or *Giardia*) and four were caused by bacterial pathogens (Shigella sonnei, Shigella flexneri, or *Escherichia coli* 0157:H7) (Kramer et. al., 1996). The remaining three cases were from either community or private swimming pools.

For the same 1993-1994 record period, twenty-two outbreaks caused by microorganisms were reported in water intended for drinking. Protozoan parasites were the most frequently identified etiologic agents (Giardia lambilia, Crypotsporidium, or undefined) (Kramer et.al. 1996). Standard Methods for the Examination of Water and Waste Water (Standard Methods) includes a number of tests for microorganism. The EPA is currently evaluating methods for accurately and consistently identifying *Cryptosporidium.*

Suspended Solids

Suspended solids are those particles in the water column of the stream that may settle to the bottom. Suspended solids composed mostly of organic material will eventually decompose. If there is an excess of this organic particulate matter, decomposition will result in the depletion of oxygen in the

water body and possibly foul odors. Suspended solids composed of mostly inorganic inert material such as sand and silt may cover vegetation and benthic organisms in the water system. From a water supply standpoint, both the inorganic and organic suspended solids may result in turbidity problems. Some turbidity in the raw water is good but too much or too little can present filtration problems.

Inorganic Salts

Inorganic salts are present in most industrial and agricultural wastes as well as in natural waters. It is the inorganic salts that make water "hard" and a stream undesirable for industrial, municipal and agricultural uses (Nemerow, 1991). Hard water results in scales or deposits on water distribution pipes, which in turn increase the resistance to flow and lower the overall capacity of the lines. Hard water can be treated or softened either at the public water treatment plant or at the faucet in a home treatment system.

Color

Color is a visible pollution. Slaughter houses, textile mills, plating mills, and various other industrial processes can contain color in their waste stream. Also the natural decay of leaf litter and other organic debris can color the water. The tannic water associated with natural swamps is brown in color. Regardless of the source, water purveyors have great difficulty in removing true color from the raw water.

Acids and/or Alkalis

Acids and alkalis are discharged by chemical and other industrial processes. Water treatment plants using alum as a coagulant often find that a change in pH as a result of a shock load of acid or alkali interferes with flocculation (Nemerow, 1991). For natural systems, changes in the natural pH can result in fish kills, and make the river unsuitable for recreational boating and swimming.

Floating Solids and Liquids

Floating solids and liquids refer to oils, greases, and other materials which float on the surface. They not only make the water system unsightly but if prevalent, obstruct light penetration reducing SAV growth. From a water treatment standpoint, oil and greases will coat sand filters with a persistent film imparting tastes and odors to the finished water (Nemerow, 1991).

Potential Pollutant Sources

Inventorying potential pollution sources may seem like an arduous task at best. To what detail must the inventory be? The answer to this question is

watershed specific. The water resource professional and the team working on the Watershed Management Process may need to set guidelines up front on what constitutes a sufficient inventory. In the near future, the Virginia Department of Health may provide some guidelines in the State Source Water Protection Program as to the kinds of sources that may be critical in source water protection. Until further guidance is available, there are numerous public data bases that may be helpful in quickly screening the registered industrial and commercial activities within the watershed. A review of publicly-accessible databases and files from federal, state, and local environmental regulatory agencies can be conducted to identify use, generation, storage, treatment or disposal of hazardous materials and chemicals, or incidents of release of such materials that may affect the source water watershed.

Electronic Public Data Bases

With the advent of the Internet and the Community Right to Know initiatives and regulations of the Federal Government, many of the electronic public data basis are available through home pages of sponsoring agencies. The EPA maintains links to various sources of public data. Many of the sources either allow the user to geographically depict the data on an online GIS or the data can be downloaded in a GIS format. There are also computer programs available on CD rom, such as the EPA Landview II, that provide the necessary software and many of the public databases to quickly inventory and geographically represent potential pollution sources within a watershed.

The federal public databases include the following:

National Priorities List (NPL) report - Also known as the Superfund list, it is an EPA listing of uncontrolled or abandoned hazardous waste sites. These sites are targeted for possible long-term remedial action under the Superfund Act.

Resource Conservation and Recovery Information System - Treatment, Storage, and Disposal Facilities (RCRIS_TS) - The RCRIS_TS report contains information pertaining to facilities that either treat, store, or dispose of hazardous waste.

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) - This is a compilation of known or suspected uncontrolled or abandoned hazardous waste sites. These sites have either been investigated or are currently under investigation by the U.S. Environmental Protection Agency (EPA) for the release or threatened release of hazardous substances.

Resource Conservation and Recovery Information System - Large Quantity Generators (RCRIS_LG) - This report contains information pertaining to facilities that either generate more than 1000 kilograms (kg) of hazardous waste per month or meet other applicable requirements of the Resource Recovery and Conservation Act (RCRA).

Resource Conservation and Recovery Information System - Small Quantity Generators (RCRIS_SG) - This report contains information pertaining to facilities that either generate between 100 kg and 1000 kg of hazardous waste per month or meet other applicable requirements of RCRA. The RCRA Administrative Action Tracking System (RAATS) is included in the RCRIS_SG report.

Civil Enforcement Docket (DOCKET) system - DOCKET is the U.S. EPA's system for tracking civil judicial cases filed on the agency's behalf by the U.S. Department of Justice.

Hazardous Materials Incident Reporting System (HMIRS) - HMIRS contains information pertaining to all hazardous materials spills that have been reported to the U.S. Department of Transportation.

Permit Compliance System (PCS) - The PCS report contains information pertaining to facilities that have been issued permits for the routine discharge of waste water or hazardous waste into either an injection well or surface water.

Toxic Release Inventory System (TRIS) of 1992 - The TRIS contains information on the industrial release and/or transfer of toxic chemicals as reportable under Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (SARA Title III).

Emergency Response Notification System (ERNS) - ERNS is used to store information on the sudden and/or accidental release of hazardous substances, including petroleum, into the environment. The ERNS report system contains preliminary information on specific releases, including the spill location, the substance released, and the responsible party.

Facility Index System (FINDS) - FINDS is an inventory of all facilities that are regulated or tracked by the U.S. EPA. These facilities are assigned an identification number that serves as a cross-reference for other databases in the EPA's program system.

Open Dumps Report (OPENDUMP) - OPENDUMP is a report of facilities where solid waste is disposed of which fail to meet the criteria promulgated under Section 4004 for sanitary landfills.

Nuclear Power Facilities (NUCLEAR) - NUCLEAR is a comprehensive listing of all licensed and active nuclear power plants in the United States.

The Commonwealth of Virginia records include the following:

Virginia Leaking Underground Storage Tank (LUST) - LUST contains summary information pertaining to all reported leaking USTs located in the Commonwealth of Virginia. The information contained in this database is a combination of all LUST lists maintained at the state and regional levels.

Virginia Solid Waste Facility (SWF) List - The SWF list contains summary information pertaining to all permitted solid waste landfills operating in the Commonwealth of Virginia.

Virginia Underground Storage Tank (UST) - The UST report is a comprehensive listing of all registered USTs located in the Commonwealth of Virginia.

Other Data Sources

The public data bases do not include all potential threats to the river source water system. The following list include other data sources that should be considered:

Sanitary Survey - An inventory of all septic tank systems and municipal sewage lines and pump stations to assess the susceptibility of source water area to sewage related wastes. Many of the local planning departments in Hampton Roads have at least a partial inventory of septic systems as part of the Chesapeake Bay Act septic system pump out program.

Well Head Survey - Although a well is not directly a potential source of pollution, it may be important to identify private and public wells to determine the potential of the wells to be conduits for pollution to enter the ground water system and eventually the surface water system. The Virginia Department of Health and the Department of Environmental Quality maintain records regarding well location and use. It should be noted that neither set of records is complete.

Residential USTs Survey - Residential underground storage tanks (USTs) for heating oil are not regulated but may pose a threat to a source water area.

Pesticide Use Survey - Use of pesticides in agricultural areas is registered with the Department of Conservation and Recreation.

Pesticide application rates may be useful in assess the susceptibility of the source water area to pesticide contaminants.

Hazardous Materials and Wastes Transportation Routes Survey - A survey of rail and road use for hazardous waste and hazardous material transportation may be useful in assessing the susceptibility of source water area to accidental spills. For areas identified as problematic, emergency response contingencies to protect the water resources can be developed and additional spill control measures can be implemented.

The Watershed Management Plan

It is critical that the utility professional be involved in the development of the watershed management plan. The utility professional, the planning professional and other stakeholders synthesize and combine the pertinent information to identify and prioritize options for watershed management. The utility professional brings to the table the technical background for identifying and determining the feasibility of appropriate pollution control alternatives and engineered solutions to resolve problem areas within the watershed. Working alongside the planning professionals, they can help to develop the design options for regional stormwater management facilities, urban retrofits, buffers, or other suitable options .

Implementation

The utility professional is instrumental in implementing many aspects of the watershed management plan. Some of the key technical elements of the watershed management plan are as follows:

Water Quality Monitoring - Water Quality is monitored to determine the effectiveness of the watershed management program. Statistical analysis should be performed on the data on a regular basis. Trend analysis for change over time and change over distance (spatial) can be used to assess the changes in water quality and help to identify problem areas within the watershed.

Hydrologic Modeling - Hydrologic modeling may be necessary to effectively predict and assess the quality of source water. A model should be selected based on its compatibility with the concerns identified for the source water area. Hydrologic models are used to determine likely contaminant transport pathways, to estimate inflow and outflow of water in the system, and to predict the impacts of future land use on water quality, as well as to estimate the sensitivity of the source water area to accidental releases of contaminants from existing land uses.

Regional BMP Maintenance -The utility professional may be required to maintain the performance of the regional stormwater facilities and, in some instances, to maintain smaller facilities.

Education - The utility professional may be involved in educating the public, local government officials, and the business community on water quality issues, stormwater best management practices, and watershed management.

Technical Assistance - The utility professional may be called upon to provide technical assistance to the business community on stormwater best management practices.

CHAPTER 2

FEDERAL LAW
IN THE CONTEXT OF
WATER SUPPLY WATERSHED MANAGEMENT

THE FEDERAL CLEAN WATER ACT

INTRODUCTION AND HISTORY

In 1972 Congress passed the Federal Water Pollution Control Act. The primary goals of the Act were the restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters. The Act outlined a national water quality management plan in which the federal government led the pollution control effort with assistance from the states. As a result of the Act USEPA was required to set water quality standards, establish technology-based effluent limits, and develop the National Pollutant Discharge Elimination System (Camp, Dresser and McKee Inc., 1989).

Congress passed the first major amendments to the Federal Water Pollution Control Act in 1977. These amendments are known as the Clean Water Act (CWA) of 1977. The CWA increased federal funding to $24.5 billion through 1981 and increased the federal funding share to 85% for water quality projects using innovative and alternative technologies (Camp, Dresser and McKee Inc., 1989).

In 1987 the CWA was amended. The amendments transferred operation of the entire pollution control program to the states and phased out the federal construction grants program, replacing it with State Revolving Funds. The 1987 amendments resulted in stormwater management regulations that require permits for municipal storm sewer systems serving populations of 100,000 or more.

The 104th Congress attempted to pass a comprehensive reauthorization of the CWA. House Resolution 961 passed the House of Representatives in May of 1995. Following this the Senate held only one hearing on the CWA, ending any chances for completion of the reauthorization during the 104th Congress. The 105th Congress has not yet addressed reauthorization of the CWA (WEF, 1997).

The CWA and its associated regulations have spawned a large number of programs that impact water quality in the United States. While many of these programs impact the quality of drinking water supplies, few are targeted directly at drinking water protection. The following sections cover three topics related to the CWA that are pertinent to water supply watershed management initiatives in Hampton Roads; the NPDES MS4 program, the requirements under Section 319 of the CWA for Virginia to assess nonpoint source pollution and attempts to resolve conflicts between stormwater management and wetland protection programs under the CWA.

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM

Section 402(p) of the Clean Water Act requires that localities with a population over 100,000 obtain a National Pollution Discharge Elimination System (NPDES) permit for discharges from municipal separate storm sewer systems (MS4). Within the Hampton Roads Planning District the cities of Chesapeake, Hampton, Norfolk, Portsmouth and Virginia Beach must comply with the program requirements. The requirements for the permit application are extensive. Applicants must both evaluate the existing state of the

MS4 and propose a management plan to reduce water pollution from the system to the maximum extent practicable. To achieve these goals the applicant must identify significant sources of pollutants, characterize the pollutants, estimate changes in pollutant loading associated with population growth and development, assess the impact of storm sewer discharges on the quality of receiving waters, propose controls to reduce pollutants, estimate the reduction in pollutant discharges, outline a plan for source controls and improved best management practices and evaluate the actual improvement in water quality resulting from the implementation of the controls and BMPs (USEPA, 1996).

In order to meet the permit requirements participating localities must engage in a broad range of activities including monitoring of selected stormwater outfalls, modeling of watersheds to determine estimated annual pollutant loads and event mean concentrations and development of pollution prevention plans.

While not targeted specifically at protecting drinking water supplies, the NPDES MS4 program is a significant tool for source water protection. The data collection, modeling and analysis components of the program provide an important base of information for water supply watershed management programs. The requirements for the creation of a nonpoint source pollution control program cause participating localities to perform an inventory of existing initiatives and analyze overlaps and deficiencies. Finally, the MS4 program requires that specific actions, identified through the preceding steps, be taken to protect the purity of receiving waters.

SECTION 319 OF THE CLEAN WATER ACT

Section 319 of the Clean Water Act requires that Virginia periodically assess the impact of nonpoint source pollution on State waters. The assessment is performed by the Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation. The assessment report draws on information from several agencies, including the Virginia Department of Environmental Quality, the Virginia Department of Forestry, the Virginia Department of Mines, Minerals and Energy, the USDA Natural Resources Conservation Service and local Soil and Water Conservation Districts. The report is prepared on a watershed basis. It includes comparative information about Virginia's watersheds based on various rating criteria. The rating criteria are largely based on two types of information, land use data and water quality data. The assessment report provides a general guide to the impact of nonpoint source pollution for watershed managers.

CONFLICTS BETWEEN STORMWATER MANAGEMENT AND WETLAND PROTECTION PROGRAMS UNDER THE CWA

Several conflicts exist between stormwater and wetland protection programs intended to meet the mandates of the Clean Water Act. The need to effectively manage stormwater quality and quantity while protecting the chemical, physical and biological integrity of our aquatic resources has created problems in the siting, construction and maintenance of regional stormwater BMPs (Malcolm). In August of 1992 a Stormwater/Wetlands Workgroup was formed to develop a consensus on stormwater

management and wetlands protection strategies for the Mid-Atlantic region. The following agencies participated:

Federal Agencies

U.S. Environmental Protection Agency, Region III
U.S. Fish and Wildlife Service, Region V, Ecological Services Field Offices
Chesapeake Bay, Pennsylvania, Virginia
U.S. Army Corps of Engineers,
Baltimore, Norfolk, Philadelphia Districts

State and District Agencies

Maryland
Department of the Environment, Water Management Administration
Delaware Department of Natural Resources
Division of Soil and Water Conservation
Division of Water Resources
Pennsylvania
Department of Environment Resources:
Bureau of Dams, Waterways and Wetlands
Bureau of Land and Water Conservation
Pennsylvania Fish and Boat Commission
Virginia
Department of Conservation and Recreation, Division of Soil and Water Conservation
Chesapeake Bay Local Assistance Department
Washington Metropolitan Council of Governments

The Workgroup focused on two primary areas, maintenance of stormwater management facilities and the placement of stormwater management facilities in urban and degraded non-tidal wetlands and streams. The goal of the Workgroup was the creation of a framework for balancing stormwater management and wetland protection objectives. The recommendations of the Workgroup are in a draft state and have not yet been approved by the participating agencies.

Maintenance of Stormwater Management Facilities

Stormwater management facilities located in upland areas may gradually acquire some characteristics of natural wetlands. In addition, some facilities utilize constructed wetlands to enhance stormwater quality and quantity control. Once established these facilities require regular maintenance to prevent degradation of their stormwater control functions. Concern has been raised as to whether the wetlands characteristic of these facilities will trigger the need to obtain wetland permits before performing maintenance on the facilities. The recommendation of the Workgroup is that these facilities should not be subject to the provisions of Sections 401 and 404 of the Clean Water Act (USEPA, 1996).

Stormwater Management Facilities in Urban and Degraded Non-tidal Wetlands and/or Streams

Urbanization and the associated increases in impervious surface area can cause extensive degradation to receiving streams and wetlands. The increase in stormwater volume and associated pollutant transport can diminish the value of these components of the aquatic ecosystem for flood retention, water quality improvement, sediment accretion, food chain support, and as wildlife habitat. The Workgroup recommends that the protection and restoration of streams and wetlands should be a primary component of all stormwater management projects. The alteration, impoundment, or other utilization of natural stream or non-tidal wetland systems for stormwater treatment and management may be considered only in those areas that are urbanized and degraded to a point that proper stormwater management can enhance the overall quality of the natural system. Specifically, the Workgroup recommends the following:

> "In those instances where a stream or a non-tidal wetland has been extensively degraded by the adverse impacts of urban development and uncontrolled stormwater runoff and no practicable or effective on-site control can be employed, development of stormwater quantity and/or quality control facilities within a stream or non-tidal wetland may be appropriate and even necessary for the integrity of the entire watershed. If no feasible alternatives exist, these projects may be deemed to be in compliance with the 404(b)(1) guidelines (USEPA, 1996)."

The Workgroup goes on to state that a non-tidal wetland or stream must meet the following criteria to be considered as extensively degraded:

- More than 20% of the contributing watershed must be covered in impervious surface,
- A wetland community must be predominantly monotypic and be dominated by exotic or invasive species,
- A bioassessment of a stream reach shows it to be a non-supporting habitat, a severely impaired benthic macroinvertebrate community and has little or no potential to be restored,
- The stream system does not support or contribute to a cold water or anadromous fishery or other high quality fisheries,
- The wetland or stream system does not support or contribute to federal or United States listed threatened or endangered species (USEPA, 1996).

While the recommendations are only in a draft state, they highlight two potential problem areas with stormwater BMPs. The way in which these issues are resolved will have a significant bearing on stormwater BMP design and implementation.

FARM BILL REAUTHORIZATION

The 104th Congress passed and the President signed a comprehensive Farm Bill reauthorization. The reauthorization contains several provisions that have the potential to impact water supply watershed management. The Conservation Reserve Program has been renewed providing 1.5 billion dollars to be spent on rental payments to farmers who idle environmentally sensitive lands. In addition, a number of small technical programs have been combined to form the Environmental Quality Incentives Program (EQIP). $200 million will be available in each of the next seven years under EQIP for structural and non-structural BMPs that improve water quality and reduce erosion. Examples of BMPs that could receive funding under this program include filter strips and animal waste management systems. In total, the Farm Bill provides over $2 billion annually to protect and improve environmental quality. Most of the new spending is mandatory, making the Farm Bill a significant federal mechanism to address nonpoint source pollution (Water Environment Federation, 1997).

SAFE DRINKING WATER ACT

Title XIV of the Public Health Service Act, which is commonly known as the Safe Drinking Water Act (SDWA), was passed by Congress in 1974. The SDWA was amended both in 1986 and 1996. The 1996 amendments were developed with significant contribution from both water suppliers and state and local officials. The 1996 amendments embody a partnership approach that includes new federal funds to aid water utilities in complying with the law.

Historically, the SDWA has focused on the processing of raw water rather than source water protection. However, the 1996 amendments contain provisions that have the potential to impact source water protection in Hampton Roads. The following sections describe those sections of the 1996 amendments that have the potential to affect water supply watershed management.

SOURCE WATER PROTECTION

The 1996 amendments to the SDWA require states to implement EPA-approved programs to assess threats to surface water supplies. The following is an outline of the provisions for source water protection:

- EPA will publish a guidance document on source water protection by August 6, 1997. (A draft guidance document is currently available.)

- States will have 18 months following the issuance of the guidance document to submit source water protection program plans to EPA. The following text from the 1996 amendments outlines the basic requirements for the protection programs:

  (A) delineate the boundaries of the assessment areas from which one or more public water systems in the State receive supplies of drinking water, using all reasonably available hydrogeologic information on the sources of the supply of drinking water in the State and the water flow, recharge, and discharge and any other reliable information as the State deems necessary to adequately determine such areas; and

  (B) identify for contaminants regulated under this title for which monitoring is required under this title (or any unregulated contaminants selected by the State, in its discretion, which the State, for the purposes of this subsection, has determined may present a threat to public health), to the extent practical, the origins within each delineated area of such contaminants to determine the susceptibility of the public water systems in the delineated area to such contaminants (United States Congress, 1996).

The assessments may make use of existing documentation of watershed boundaries and contaminant sources. A State may use up to 10% of its Drinking Water State Revolving Fund allotment in both FY 1996 and 1997 to delineate and assess source water protection areas. States must submit their program to EPA no later than 18 months after EPA publishes guidance.

Information Collection Rule

The final Information Collection Rule (ICR) was published in the Federal Register on May 14,1996. A high priority health risk concern in the regulation of drinking water is the risk-risk trade off between the control of microbiological contamination (bacteria, viruses and protozoa) and disinfection byproducts. This risk-risk tradeoff arises because typically the least expensive way for a public water system to increase microbial control is to increase disinfection (which generally increases byproduct formation) and the easiest way to reduce byproducts is to decrease disinfection (which generally increases microbial risk). Microbiological contamination often causes flu-like symptoms, but can also cause serious diseases such as hepatitis, giardiasis, cryptosporidiosis, and Legionnaire's Disease. Disinfection byproducts may pose the risk of cancer and developmental effects (USEPA).

In 1992, EPA entered into a Regulatory Negotiation to address this tradeoff. Regulatory Negotiation is a process whereby the Agency acts on an equal basis with outside parties to reach consensus on the content of a proposed rule. If the group reaches consensus, the Agency commits to propose the rule with the agreed upon content. In 1993 negotiators reached consensus on a three part regulatory approach:

1. Interim rules were developed to reduce levels of disinfection byproducts without causing major industry shifts to alternative disinfectants (such as ozone and chlorine dioxide) until the risks from those alternatives are more clearly understood. Interim rules were also developed to modify the current regulation on microbial contamination to ensure a uniform level of protection, regardless of the quality of the water used as a drinking water source (the current rule requires a uniform level of contaminant reduction for all public water systems, regardless of the quality of the water used as a drinking water source).

2. An intensive data collection and research effort was initiated to learn more about the occurrence of microbial contamination and disinfection byproducts, the health risks posed, appropriate analytical methods, and effective forms of treatment.

3. Longer term rules will be developed as needed based on the analysis and research.

The ICR does not have any immediate ramifications for watershed management, but one possible approach to dealing with the trade off between the threats of microbial contamination and disinfectant byproducts is the use of watershed management as a tool for reduction of the risk of microbial contamination. This will largely be dependent on the

results of the research performed in step two and the development of rules under step three.

Filtration Avoidance

The criteria for filtration avoidance under the SDWA have major watershed management implications. However, these criteria do not currently apply to any of the water purveyors in Hampton Roads.

CHAPTER 3

VIRGINIA STATE LAW
IN THE CONTEXT OF
WATER SUPPLY WATERSHED MANAGEMENT

VIRGINIA STATE CODE AND WATER SUPPLY WATERSHED MANAGEMENT

THE 1997 GENERAL ASSEMBLY SESSION

The 1997 session of the Virginia General Assembly produced several additions and alterations to the Virginia Code that have the potential to impact water supply watershed management in Hampton Roads. The following is a synopsis of the pertinent sections of the Code that were impacted by the 1997 Assembly session.

15.1-1240, 15.1-1241, 15.1-1250, 15.1-1252, 15.1-1258, 15.1-1259, 15.1-1260 and 15.1-1268 amended. Water and Sewer Authorities Act

These amendments allow water and sewer authorities to own and operate stormwater control systems. In the context of this Act the term "stormwater control system" is defined as a structural system of any type that is designed to manage the runoff from land development projects or natural systems designated for such purposes including, without limitation, retention basins, ponds, wetlands, sewers, conduits, pipelines, pumping and ventilating stations, and other plants, structures, and real and personal property used for support of the system.

9-6.14:4.1, 28.2-103 and 28.2-1207 amended; 62.1-44.15:5.1 added. Water Quality Improvement General Permits

These modifications require that the State Water Control Board and the Virginia Marine Resources Commission develop a unified and expedited permit process for certain water quality improvement activities. Examples of types of projects covered under the unified permit include bioengineered streambank stabilization and livestock stream crossings. The general permit must be promulgated by July 1,1998.

10.1-1186.1, 62.1-44.17:2, 62.144.17:3 added. Reduction and Reporting of Toxics in State Waters

As a result of House Bill 2246 three new sections were added to the Virginia Code dealing with reduction and reporting of toxic substances in state waters. Section 10.1-1186.1 requires DEQ to continue to publish in March of each year a document known as "Virginia Toxic Release Inventory." The report is to be organized by chemical, facility, facility location and standard industrial classification code. The report will be distributed to newspaper publishers and radio and television broadcasters for publication. The report is to contain information collected for the most recent calendar year. Section 62.1-44.17:2 contains the definitions of the words toxicity and toxics. Finally, section 62.1-44.17:3 outlines the requirements for an annual report on reduction of toxics in state waters. The State Water Control Board is required to conduct ongoing assessments of the levels of toxics in Virginia's waters and develop and implement a plan for the reduction of toxics in Virginia's waters.

62.1-44.19:4 through 62.1-44.19:8 Water Quality Monitoring, Information and Restoration Act: Chapter 3.1 of Title 62.1 sets forth requirements for the following: water quality monitoring and reporting, the content of the 303(d) and 305(b) reports, notification of the public of toxic impaired waters and plans to address impaired waters. The 303(d) and 305(b) reports are required to (i) provide an accurate and comprehensive assessment of the quality of state surface waters; (ii) identify trends in water quality for specific and easily identifiable geographically defined water segments; (iii) provide a basis for developing initiatives and programs to address current and potential water quality impairment; (iv) be consistent and comparable documents; (v) contain accurate and comparable data that is representative of the state as a whole. The section of the Chapter dealing with plans to address impaired waters calls on the State Water Control Board to develop and implement a plan to achieve fully supporting status for impaired waters, except when the impairment is established as naturally occurring. Water quality standards will be adjusted based on the use of the water body in question, with more stringent standards applied as necessary to protect public health, aquatic life or drinking water supplies.

10.1-2117 through 10.1-2134 added. Virginia Water Quality Improvement Act of 1997

The Virginia Water Quality Improvement Act of 1997 adds a new chapter, 21.1, to Title 10.1 of the Virginia Code. The focus of the new chapter is the restoration of the quality of state waters and the protection of state waters from future degradation. To achieve these goals a fund is established to provide financial assistance to local governments and individuals for point source and nonpoint source pollution control programs. One of the stated goals for the nonpoint source pollution control program is the protection of public drinking water supplies. A key focus of the entire Act is fulfilling Virginia's commitments for nutrient reduction under the Chesapeake Bay Agreement and the Tributary Strategies program. However, the Act stipulates that fifty percent of the nonpoint grant funding be distributed to areas of Virginia not covered by the tributary plans.

62.1-233, 62.1-234 and 62.1-237 through 62.1-239.1 amended. Drinking Water Fund

Authorizes owners of drinking water systems, whether they are local governments, individuals, partnerships or corporations, access to funds in the Virginia Water Supply Revolving Fund. Previous to this change only local governments were eligible to receive these funds.

2.1-51.12:2 amended. Tributary Plan Development and Implementation

This amendment extends by six months the deadline for the tributary plans for the York and James River Basins. The new deadline is July 1, 1998.

OTHER ELEMENTS OF THE VIRGINIA CODE THAT IMPACT WATER SUPPLY WATERSHED MANAGEMENT

In Virginia, localities have only those powers that have been specifically granted to them by the General Assembly through the Virginia State Code or individual Charters. There is a significant variation in the powers granted to different localities through their charters, particularly in the realm of extrajurisdictional authority for watershed management. In general, however, there is a great deal of similarity in the tools available to each locality for watershed protection. The following are sections of the Virginia Code that impact water supply watershed management.

15.1-489: Purpose of zoning ordinances: "Among the purposes of zoning is the creation of reasonable provisions, not inconsistent with applicable State water quality standards, to protect surface water and groundwater..." (Virginia Beach, 1992)

15.1-446.1: Comprehensive plan to be prepared and adopted; scope and purpose: This section of the Code outlines the purpose and content of local comprehensive plans. The stated purpose of a comprehensive plan is "guiding and accomplishing a coordinated, adjusted and harmonious development of the territory which will, in accordance with present and probable future needs and resources best promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants". 15.1-447 outlines surveys and studies to be made in preparation of a comprehensive plan. This section calls for natural resources, groundwater, surface water and geologic features to be included in the studies.

15.1-491: Permitted provisions in ordinances; amendments: This section of the Code authorizes localities to require "submission and approval of a plan of development prior to the issuance of building permits to assure compliance with regulations contained in such zoning ordinance." (Virginia Beach, 1992)

15.1-854: Water Supplies: "A municipal corporation may regulate and inspect public and private water supplies and the production, preparation, transmission and distribution of water, and the sanitation of establishments, systems, facilities and equipment in or by means of which water is produced, prepared, transmitted and distributed; may adopt such regulations as are deemed necessary to prevent the pollution of such water supplies; and without liability to the owner thereof may prevent the transmission or distribution of water when found to be polluted, adulterated, impure or dangerous."

10.1 - 560 through 571: Erosion and Sediment Control: This section of the Code defines requirements for the submission of an erosion and sediment control plan for most land disturbing activities.

10.1-603.1 through 603.15: Stormwater Management Act

10.1-603.3: Minimum contents of a local stormwater ordinance:

"1. Consistency with regulations promulgated in accordance with provisions of this article;
2. Provisions for long-term responsibility for and maintenance of stormwater management control devices and other techniques specified to manage the quality and quantity of runoff; and
3. Provisions for the integration of locally adopted stormwater management programs with local erosion and sediment control, flood insurance, flood plain management and other programs requiring compliance prior to authorizing construction in order to make the submission and approval of plans, issuance of permits, payment of fees, and coordination of inspection and enforcement activities more convenient and efficient both for the local governments and those responsible for compliance with the programs."

10.1-603.4: Development of regulations: This section of the Code provides guidance for the quality and quantity of stormwater from developed areas.

10.1-603.7: Authorization for more stringent regulations: "Localities are authorized to adopt more stringent stormwater management regulations than those necessary to ensure compliance with the Board's minimum regulations, with the exception of regulations related to plan approval, provided that the more stringent regulations are based upon the findings of local comprehensive watershed management studies and that prior to adopting more stringent regulations a public hearing is held after giving due notice."

62.1-44.2: State Water Control Law: "purpose (1) protect existing high quality state waters and restore all other state waters to such condition of quality that any such waters will permit all reasonable public uses and will support the propagation and growth of all aquatic life, including game fish, which might reasonably be expected to inhabit them, (2) safeguard the clean waters of the Commonwealth from pollution, (3) prevent any increase in pollution, (4) reduce existing pollution, and (5) promote water resource conservation, management and distribution, and encourage water consumption reduction in order to provide for the health, safety, and welfare of the present and future citizens of the Commonwealth."

10.1, Chapter 11.1 Department of Environmental Quality, Article 3 Watershed Planning and Permitting, Promotion and Coordination

Section 10.1-1193: Calls on DEQ and the Watershed Planning and Permitting Coordination Task Force to coordinate watershed-level activities conducted by State and local agencies and authorities and to foster the development of watershed planning by localities. Assigned duties include

acquiring and maintaining information on watershed planning, research on watershed planning, provision of technical assistance to local officials, developing recommendations for needed regulatory and legislative changes to assist local governments in developing and implementing watershed planning, and developing recommendations on watershed permitting.

10.1-1194: This section identifies the members of the Watershed Planning and Permitting Coordination Task Force as the Directors of DEQ, DCR, Forestry, Mines, Minerals and Energy, CBLAD, and Agriculture. The Task Force is called upon to meet at least quarterly and report to the Governor and General Assembly.

10.1-1196: Guiding definition and principles - Definition of watershed planning: "the process of studying the environmental and land use features of a watershed to identify those areas that should be protected and preserved, measures to be utilized to protect such areas, and the character of development in order to avoid and minimize disruption of natural systems. Its focus is not on directing development to particular parcels of land but rather to identify critical resources, and measures to protect those resources, so that development, when it does occur, will not negatively impact water resources. In so doing watershed planning uses and protects ecological processes to lessen the need for structural control methods that require capital costs and maintenance. By including consideration of a watershed and its characteristics, cumulative impacts and interjursdictional issues are more effectively managed than when solely relying on single-site permit approaches. Watershed planning can be an important tool for maintaining environmental integrity, economic development and watershed permitting." "Watershed Principles: Stream systems tend to reflect the character of the watershed they drain. Unchecked physical conversion in a watershed accompanying urbanization leads to degraded streams and wetlands. As urbanization continues to spread across the state, natural vegetation, slope and water retention characteristics are replaced by impervious surfaces disrupting the dynamic balance of the natural hydrologic cycle. Poorly planned development can increase peak storm flows and runoff volume, lower water quality and aesthetics, and cause flooding and degradation of downstream communities and ecosystems."

3.1 - 249.27 through 249.78: Virginia Pesticide Control Act: This section of the Code contains certification requirements for commercial and private applicators of pesticides classified for restricted use under the Federal Insecticide, Fungicide, and Rodenticide Act. The Act also requires the registration of any pesticide manufactured, distributed, sold or used within the Commonwealth of Virginia.

3.1-74 through 3.1-106: Virginia Fertilizer Law: This law regulates the manufacture and sale of fertilizer within Virginia but does not regulate applicators of fertilizers.

As is evident from the preceding list, localities in Virginia have a wealth of watershed management tools at their disposal. If the political will is present, it is possible for a locality to build a comprehensive regulatory structure to deal with water supply watershed management. Unfortunately, development of an appropriate regulatory structure is only one facet of an effective watershed management program. Funding for implementation, inspection and maintenance of BMPs is often difficult for localities to obtain. In addition, other factors such as stakeholder involvement and education influence the overall effectiveness of a watershed management program.

CHESAPEAKE BAY PRESERVATION ACT

OVERVIEW OF THE BAY ACT

The Chesapeake Bay Preservation Act (CBPA) is located in sections 10.1-2100 through 10.1-2115 of the Virginia Code. The main headings of Chapter 2100 establish the Chesapeake Bay Local Assistance Board, outline the powers of the Board, establish the Local Assistance Department and define the role of local governments in implementing the program. The language of section 10.1-2100 of the Act requires local governments in Tidewater to "incorporate general water quality protection measures into their comprehensive plans, zoning ordinances, and subdivision ordinances." This section goes on to state that localities in Tidewater must establish programs that define and protect lands which, if improperly developed, may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries. Section 10.1-2102 defines the Chesapeake Bay Local Assistance Board and section 10.1-2103 outlines the powers and duties of the Board. The Board consists of nine Tidewater residents that have interest and experience in local government, business, land development, agriculture, forestry, and the protection of water quality. The Board is the body responsible for promulgation of the regulations that implement the Bay Act. Section 10.1-2105 defines the general powers of the Chesapeake Bay Local Assistance Department. The Department provides technical support to both the Board and local governments charged with implementing the Act. Section 10.1-2107 outlines the Board's responsibility to develop criteria for use by local governments to determine the ecological and geographic extent of Chesapeake Bay Preservation Areas. The Board is also responsible for the development of criteria for the granting, denying, or modifying requests to rezone, subdivide, or to use and develop land in those areas. Section 10.1-2108 authorizes local governments to exercise their police and zoning powers to protect the quality of state waters consistent with the provisions of the Act. Section 10.1-2110 permits local governments outside of Tidewater Virginia to adopt the provisions of the Act to protect the quality of state waters. State waters are defined in chapter 21 as including all waters on the surface or under the ground, wholly or partially within or bordering the Commonwealth. Thus, if so desired, the CBPA could be applied to any water supply watershed in the State. However, it should be noted that it is not required that waters that are hydrologically isolated from the Chesapeake Bay be covered by local programs adopted pursuant to the Act.

OVERVIEW OF THE CBPA REGULATIONS

The CBPA Regulations are divided into six sections. Section 1 contains the introduction, section 2 outlines local government requirements, section 3 describes Chesapeake Bay Preservation Area criteria, section 4 covers land use and development performance requirements, section 5 deals with implementation, assistance, and determination of consistency and section 6 describes enforcement. The CBPA Regulations are currently being reviewed and will likely be revised in the near future.

Part 1: Introduction

Section 1.3 of the introduction covers the purpose of the Regulations. The focus of the regulations is on the protection and improvement of water quality of the Chesapeake Bay, its tributaries, and other state waters by minimizing the effects of human activity upon these waters.

Part 2: Local Government Programs

Section 2.1 states that local Bay Act 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 will support the propagation and growth of all aquatic life, including gamefish, which might reasonably be expected to inhabit them; (ii) safeguarding the clean waters of the Commonwealth from pollution; (iii) prevention of any increase in pollution; (iv) reduction of existing pollution; and (v) promotion of water resource conservation in order to provide for the health, safety and welfare of the present and future citizens of the Commonwealth." This framework provides a great deal of latitude and is broad enough to include many elements of water supply watershed management. Section 2.2 outlines the required elements of local programs. Local programs must include a map delineating Bay Preservation Areas, performance criteria, comprehensive plan elements dealing with the Bay Act, zoning ordinance elements that protect the quality of state waters in Bay Preservation Areas, subdivision ordinance elements that protect the quality of state waters in Bay Preservation Areas, a sufficient erosion and sediment control ordinance and development review process that assures the protection of water quality. Given this program outline it is certainly possible for a locality to exercise a great deal of control over the development process in water supply watersheds.

Part 3: Chesapeake Bay Preservation Area Designation Criteria

Part III of the Regulations deals with the designation criteria for Chesapeake Bay Preservation Areas. Two types of Preservation Areas are defined, Resource Protection Areas (RPA) and Resource Management Areas (RMA). A third category, Intensely Developed Areas (IDA) can be defined as an overlay to other preservation areas.

RPAs are defined as sensitive lands at or near the shoreline that have an intrinsic water quality value due either to the ecological and biological processes they perform or to the fact that they are sensitive to impacts which may cause significant degradation to the quality of state waters. In their natural condition, these lands provide for the removal, reduction or assimilation of sediments, nutrients and potentially harmful or toxic substances in run-off entering the bay and its tributaries, and minimize the adverse effects of human activities on state waters and aquatic resources (Commonwealth of Virginia, 1991).

Resource Protection Areas must include the following natural features:

1. Tidal wetlands;

2. Nontidal wetlands connected by surface flow and contiguous to tidal wetlands or tributary streams;

3. Tidal shores;

4. Such other lands under the provisions of subsection A of 9VAC10-20-80 necessary to protect the quality of state waters;

5. A buffer area not less than 100 feet in width located adjacent to and landward of the components listed in subdivisions 1 through 4 above, and along both sides of any tributary stream (VCBLAD, 1997).

Resource Management Areas are defined as land types that have the potential for causing significant water quality degradation if improperly used or developed (Commonwealth of Virginia, 1991). The following section specifies the components of the RMAs.

1. Resource Management Areas shall include land types that, if improperly used or developed, have a potential for causing significant water quality degradation or for diminishing the functional value of the Resource Protection Area.

2. A Resource Management Area shall be provided contiguous to the entire inland boundary of the Resource Protection Area. The following land categories shall be considered for inclusion in the Resource Management Area:

   A. Flood plains;

   B. Highly erodible soils, including steep slopes;

   C. Highly permeable soils;

   D. Nontidal wetlands not included in the Resource Protection Area;

   E. Such other lands under the provisions of subsection A of 9VAC10-20-90 necessary to protect the quality of state waters.

3. Resource Management Areas shall encompass a land area large enough to provide significant water quality protection through the employment of the criteria in Part IV and the requirements in Parts II and V (VCBLAD, 1997).

At their option, local governments may designate Intensely Developed Areas as an overlay of Chesapeake Bay Preservation Areas within their jurisdictions. Intensely Developed Areas are redevelopment areas in which development is concentrated as of the

local program adoption date. Areas so designated must comply with the performance criteria for redevelopment in Part IV. Local governments exercising this option must examine the pattern of residential, commercial, industrial and institutional development within Chesapeake Bay Preservation Areas. Areas of existing development and infill sites where little of the natural environment remains may be designated as Intensely Developed Areas provided at least one of the following conditions exists:

1. Development has severely altered the natural state of the area such that it has more than 50% impervious surface;

2. Public sewer and water is constructed and currently serves the area by the effective date. This condition does not include areas planned for public sewer and water;

3. Housing density is equal to or greater than four dwelling units per acre (VCBLAD, 1997).

Part 4: Land Use and Development Performance Criteria

The performance criteria are divided into two categories, general performance criteria and Resource Protection Area criteria. The general performance criteria apply to all RMAs and the Resource Protection Area criteria are specific to the RPAs. The general performance criteria cover a broad range of topics including minimizing disturbed land area during development, preservation of indigenous vegetation, maintenance of BMPs, the requirement for a development review process, minimization of impervious surface, employment of erosion and sediment control measures, the requirement for reserve drain fields for on-site sewage treatment and stormwater management standards. While presently different than the DCR stormwater criteria, regulatory revisions presently proposed by the two agencies will bring the Bay Act and DCR stormwater criteria into conformity. Agricultural activities are required to have a soil and water conservation plan based upon the Field Office Technical Guide of the U.S. Department of Agriculture. Silvicultural activities are exempt from the Regulations provided that the silvicultural activities adhere to water quality protection procedures prescribed by the Department of Forestry in its "Best Management Practices Handbook for Forestry Operations."

The performance criteria for RPAs are much more restrictive than the general performance criteria. Only two categories of development are allowed, water dependent facilities and redevelopment of existing facilities.

Part 5: Implementation, Assistance and Determination of Consistency

Part V describes the required parts of the local programs. Required elements include amendments to comprehensive plans, zoning ordinances and subdivision ordinances that target water quality protection. In addition, local governments must incorporate elements in their development review process that insure the protection of water quality.

Part 6: Enforcement

The Bay Act requires that the Board ensure that local governments comply with the Act and regulations and that their comprehensive plans, zoning ordinances and subdivision ordinances are in accordance with the Act. To satisfy these requirements, the Board has adopted this chapter and will monitor each local government's compliance with the Act and this chapter.

EVALUATION OF THE CHESAPEAKE BAY PRESERVATION ACT AS A WATER SUPPLY WATERSHED MANAGEMENT TOOL

The CBPA contains many of the tools needed to effectively manage a water supply watershed. Local governments have been granted the power to apply the Act to any of the "state waters" in Virginia. Localities have also been granted the authority to exercise their police and zoning powers to protect the quality of state waters. The performance criteria of the Act address many, but not all, of the critical water quality issues associated with development practices. Unfortunately, the overlap between the set of water quality issues critical to the Bay and those critical to surface water supplies is not complete. The Bay Act is silent on the storage and transport of hazardous materials, contains no reference to the control of organisms such as Giardia and Cryptospordium, and provides only limited control over agricultural and silvicultural activities. Despite these shortcomings, the Bay Act is the single most complete watershed management tool available to localities in Virginia. Used in conjunction with other local ordinances designed to address its deficiencies the Act can be a valuable component of a water supply watershed management program.

Another significant feature of the Act is the degree of flexibility that local governments are granted both in drafting local programs and implementing them. The effectiveness of the Act as a water supply watershed management tool is largely dependent on the way in which the program is administered in a given locality. The Act gives localities the opportunity to require significant focus on water quality issues throughout the development cycle. The vigor with which localities pursue adherence to high water quality standards in the development process ultimately determines the degree of water quality protection that the Act provides.

THE VIRGINIA STORMWATER MANAGEMENT PROGRAM

The Virginia Department of Conservation and Recreation (DCR) has been charged with consolidating the Virginia stormwater management program. Currently the regulations associated with four state laws impact stormwater management; the Virginia Stormwater Management Regulations, the Virginia Erosion and Sediment Control Regulations, the Virginia Pollutant Discharge Elimination System Regulations, and Virginia Chesapeake Bay Preservation Area Designation and Management Regulations.

DCR is moving towards a segmented program that offers localities the option of adopting different subsets of the regulations rather than an all or nothing approach. The stormwater management evaluation design criteria may also change to place more emphasis on low return period events such as the one-year storm. The revised regulations will promote consistency among local governments, state agencies and federal agencies in developing technical criteria and administrative procedures for stormwater management (Espey, Huston and Associates, Inc.,1997).

DCR is considering a Cafeteria style menu approach for local stormwater management programs. Under this approach localities could customize their stormwater programs, rather than being forced to adhere to the existing all or nothing approach. The cafeteria approach would likely apply only to sections 2.3: Water Quality, 2.4: Stream Channel Erosion and 2.6: Regional Stormwater Management Plans. Section 2.5: Flooding will still be required for all local programs. Adoption of a stormwater management program would remain optional for localities.

CHAPTER 4

WATERSHED MANAGEMENT INITIATIVES IN THE HAMPTON ROADS AREA

WATERSHED MANAGEMENT INITIATIVES IN THE HAMPTON ROADS AREA

Water supply watershed management in the cities and counties of the Hampton Roads area is accomplished through a variety of means. In some cases, regulations and management programs are specifically focused on protecting drinking water supplies. In other cases regulations and programs that have a different primary focus have secondary impacts on water supply watershed management. This chapter provides information on the location of the water supply reservoirs and rivers in the Hampton Roads Area, a description of existing land use patterns in the water supply watersheds, and a description of the watershed management initiatives in each of the localities in the Hampton Roads area that contain a water supply watershed. New Kent County, which is outside of the Hampton Roads area, is included due to its proximity to the Chickahominy River and the Diascund Creek Reservoir.

WATER SUPPLY WATERSHED LOCATION AND DEGREE OF URBANIZATION

There is a great deal of diversity in the watershed management initiatives utilized within the Hampton Roads area. Several factors come into play in this variation, including the political, social and financial histories of the localities, development pressures, and the degree of urbanization in the watersheds. The water supply watersheds in Hampton Roads range from highly urbanized to relatively undeveloped. The tools and techniques appropriate for a specific watershed will to a large extent be influenced by the degree of urbanization. Development controls such as zoning and subdivision ordinances have a significant influence on the evolution of developing watersheds, while maintenance of stormwater BMP systems and public education programs are more pertinent in highly developed watersheds. The following table describes the location of the various water supply watersheds in Hampton Roads and their relative degree of urbanization. The degree of urbanization is categorized as either vary low, low, medium or high.

TABLE 4-1
WATER SUPPLY WATERSHED LOCATION
AND DEGREE OF URBANIZATION

Host Locality	Purveyor and Water Body	Watershed Location and Degree of Urbanization
Gloucester County	Gloucester County: Beaver Dam Reservoir	Center of the County. Urbanization: Low

TABLE 4-1
WATER SUPPLY WATERSHED LOCATION
AND DEGREE OF URBANIZATION

Host Locality	Purveyor and Water Body	Watershed Location and Degree of Urbanization
New Kent County	Newport News: Chickahominy River, Diascund Creek Reservoir	**Chickahominy River:** Southern 2/3 of the County. Urbanization: Low **Diascund Reservoir:** Southeast corner of the County. Urbanization: Low
James City County	Newport News: Little Creek, Diascund Creek and Skiffe's Creek Reservoirs	**Diascund Creek:** Small section in the extreme northwest corner of the County. Urbanization: Low **Little Creek:** Northwest corner, south of the Diascund watershed. Urbanization: Medium, Residential **Skiffe's Creek:** South end of the County. Watershed is split with Newport News and York County. Urbanization: High, Industrial Park
York County	Newport News: Lee Hall, Harwood's Mill, Skiffe's Creek Reservoirs Williamsburg: Waller Mill Reservoir U.S. Military: Jones Pond and Big Bethel Reservoirs	**Waller Mill:** North end of the County. A small portion of the watershed extends into Williamsburg. Urbanization: Medium, Residential, Commercial **Jones Pond:** North end of the County, south of Waller Mill. (Located on U.S. Naval Weapons Station-Yorktown) Urbanization: Medium, Commerce Park, Military Base **Big Bethel:** South end of the County. The reservoir straddles the borders of York County, Hampton and Newport News. Urbanization: High, Residential **Lee Hall:** A small portion of the reservoir and watershed are located adjacent to the Newport News border, approximately centered north/south in the County. Urbanization: Low, Golf Course **Harwood's Mill:** South end of the County. A small portion of the watershed extends into Newport News. Urbanization: Medium, Airport, Residential **Skiffe's Creek:** A small portion of the watershed extends into the U.S. Naval Weapons Station-Yorktown.

TABLE 4-1
WATER SUPPLY WATERSHED LOCATION
AND DEGREE OF URBANIZATION

Host Locality	Purveyor and Water Body	Watershed Location and Degree of Urbanization
Williamsburg	Williamsburg: Waller Mill Reservoir	A small portion of the watershed extends from York County into Williamsburg. Urbanization: Medium
Newport News	Newport News: Lee Hall, Skiffe's Creek and Harwood's Mill Reservoirs U.S. Military: Big Bethel Reservoir	**Skiffe's Creek:** North end of the City. Urbanization: Medium, Residential **Lee Hall:** Northeast corner of the City, south of Skiffe's Creek. Urbanization: Low, Residential, Parks, Several Major Roads. **Harwood's Mill:** A small portion of the watershed extends into the City adjacent to the airport. Urbanization: Medium, Airport, Residential **Big Bethel:** Southeastern corner of the City. Urbanization: High, Residential
Hampton	U.S. Military: Big Bethel Reservoir	Northwest corner of the City. Urbanization: High, Residential, Landfill.
Virginia Beach	Norfolk: Lakes Smith, Lawson and Stumpy, Little Creek Reservoirs Chesapeake: Northwest River	**Lakes Smith, Lawson and Little Creek Reservoir:** Northwest corner of Virginia Beach. The watershed for the in-town lake complex extends into the northeast corner of Norfolk. Urbanization: High, Residential, Amphibious Base. **Stumpy Lake:** Adjacent to the western border of Virginia Beach, south of and separate from the in town lake complex. Watershed extends into Chesapeake. Urbanization: Medium, Residential, Golf Course **Northwest River:** A small portion of the watershed extends into southwestern Virginia Beach. Urbanization: Very Low, Agriculture.
Norfolk	Norfolk: Lakes Whitehurst, Wright and Taylor	Northeast corner of the City. Urbanization: High, Residential, Golf Course, Airport.

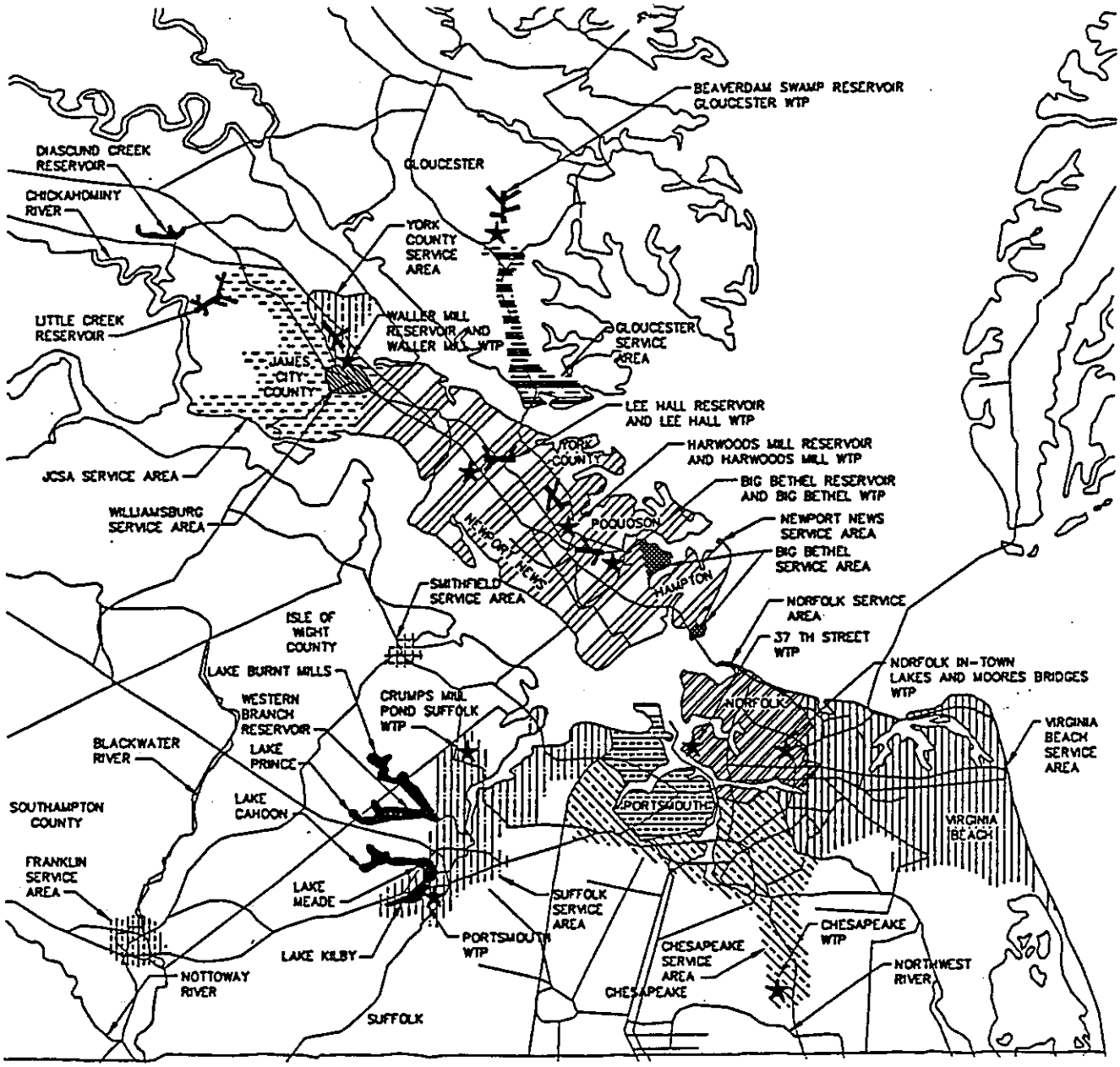
TABLE 4-1
WATER SUPPLY WATERSHED LOCATION
AND DEGREE OF URBANIZATION

Host Locality	Purveyor and Water Body	Watershed Location and Degree of Urbanization
Chesapeake	Chesapeake: Northwest River Norfolk: Stumpy Lake	**Northwest River:** Southern third of the City of Chesapeake. Urbanization: Very Low, Agriculture. **Stumpy Lake:** Eastern edge of City. Urbanization: Low, golf course.
Suffolk	Suffolk: Lone Star (a series of small lakes in Lone Star Park) and Crumps Mill Pond. Norfolk: Lakes Burnt Mills, Prince and Western Branch Reservoir. Portsmouth: Cahoon, Meade, Kilby and Speight's Run.	**Suffolk's Lakes:** Northwest corner of the City. A small portion of the watershed extends into Isle of Wight. Urbanization: Low, Residential, Agriculture, Park, Superfund site in Crump's Mill Pond Watershed. **Norfolk's Lakes:** Northwest corner of the City, south of the Lone Star Lake Complex. Urbanization: Low, Residential, Agriculture. **Portsmouth's Lakes:** Center of the City. Urbanization: Medium, Residential, Golf Course, Agriculture.
Isle of Wight County	Suffolk: Crump's Mill Pond Norfolk: Lakes Burnt Mills and Prince, Blackwater River Portsmouth: Lake Cahoon	**Crump's Mill Pond:** An extremely small portion of the watershed extends into the northeastern corner of Isle of Wight County. **Norfolk's Lakes:** Adjacent to the Suffolk border, approximately centered north/south. Urbanization: Low. **Blackwater River**: Western border of the County. Urbanization: Low. **Lake Cahoon:** A small portion of the watershed extends into the eastern portion of the County.

TABLE 4-1
WATER SUPPLY WATERSHED LOCATION
AND DEGREE OF URBANIZATION

Host Locality	Purveyor and Water Body	Watershed Location and Degree of Urbanization
Southampton County	Norfolk: Blackwater and Nottoway Rivers	**Blackwater River:** Forms the eastern border of the County. The bulk of the northeast quarter of the County drains to the Blackwater. Urbanization: Low. **Nottoway River:** Center section of the County. Urbanization: Low.

REGIONAL PUBLIC WATER SYSTEMS

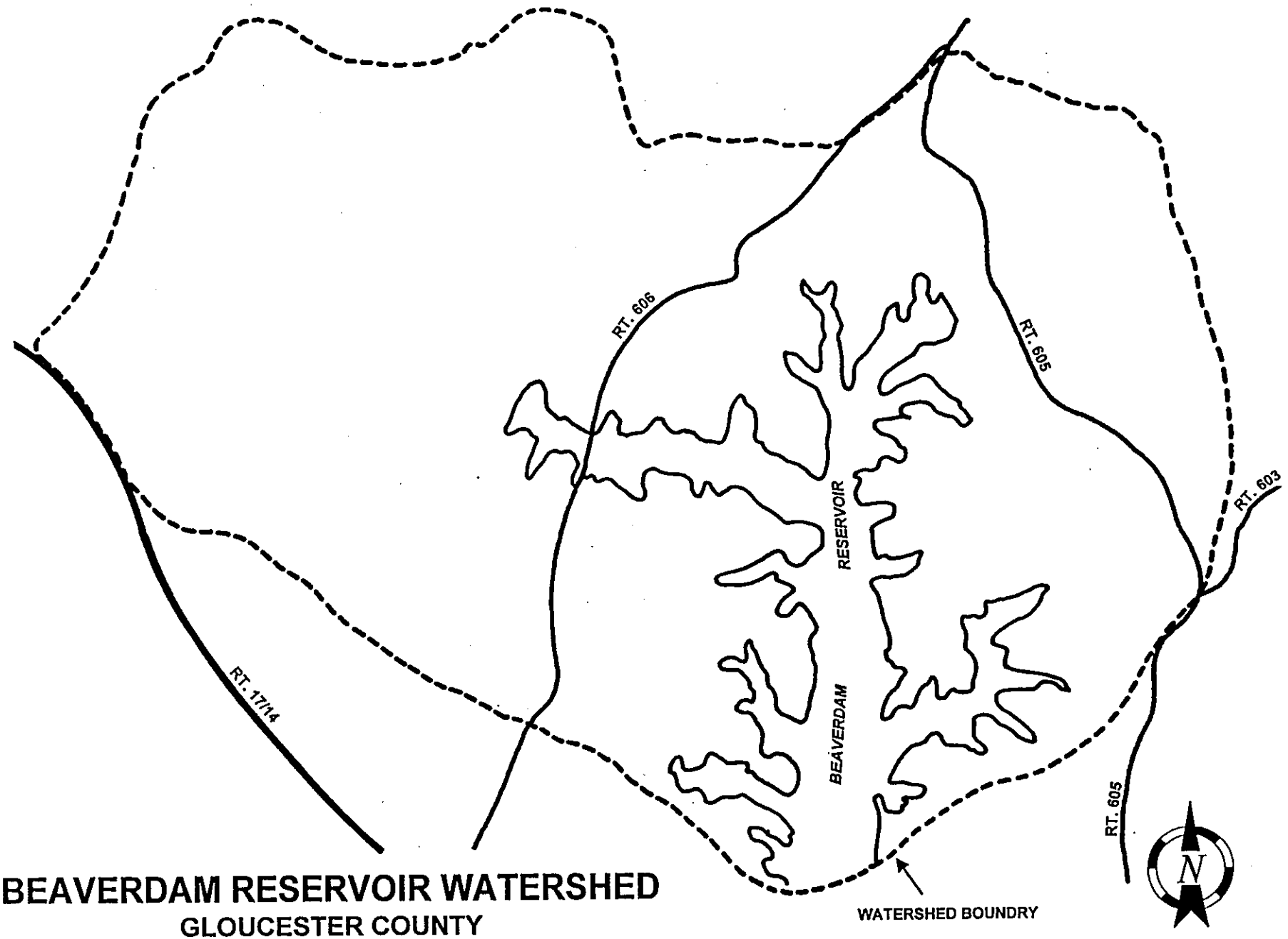


SERVICE AREA LEGEND

SCALE: 1" = 8 MILES APPROX

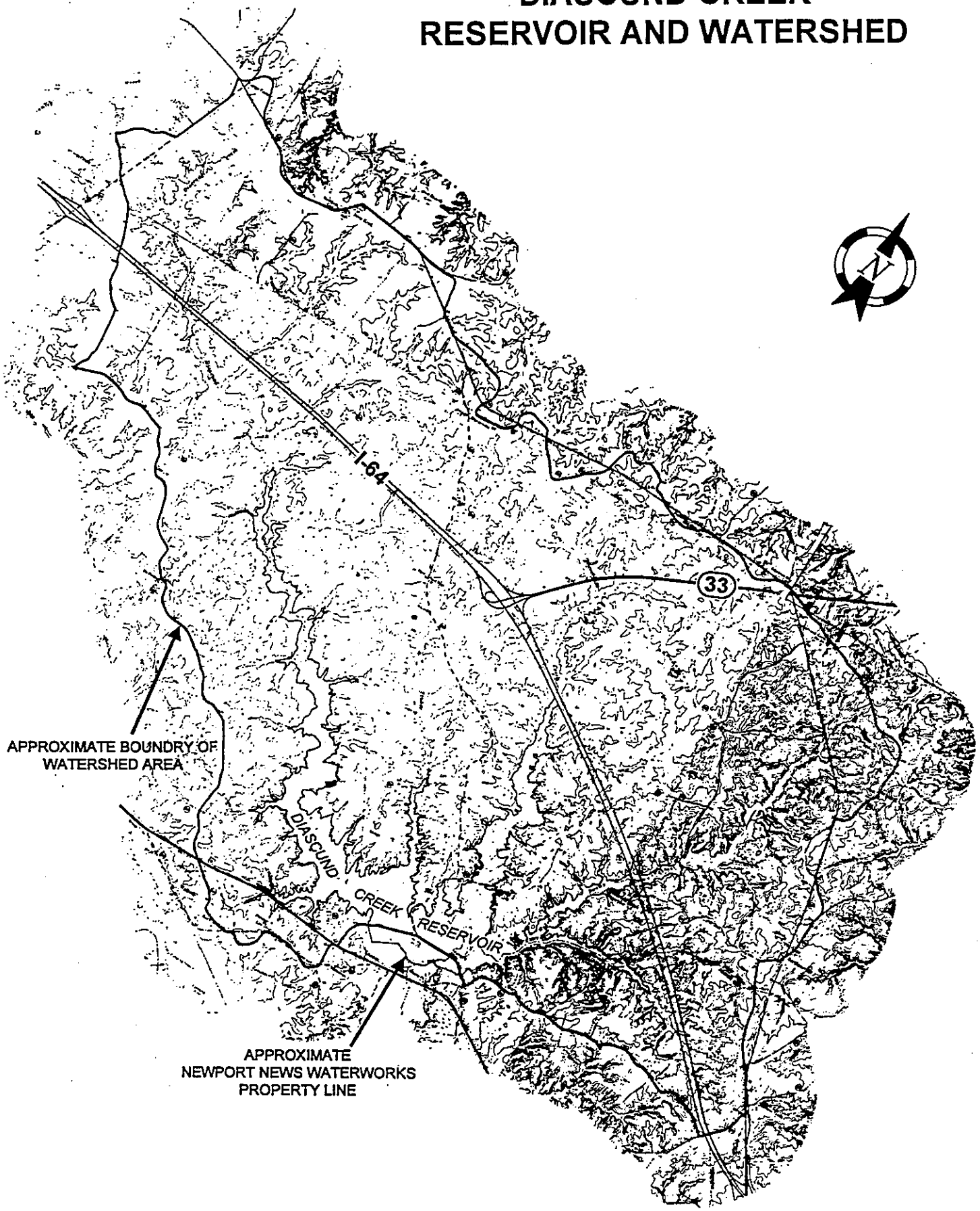
- GLOUCESTER
- JCSA
- YORK COUNTY
- WILLIAMSBURG
- NEWPORT NEWS
- BIG BETHEL
- SMITHFIELD
- FRANKLIN
- SUFFOLK
- PORTSMOUTH
- NORFOLK
- CHESAPEAKE
- VIRGINIA BEACH

N

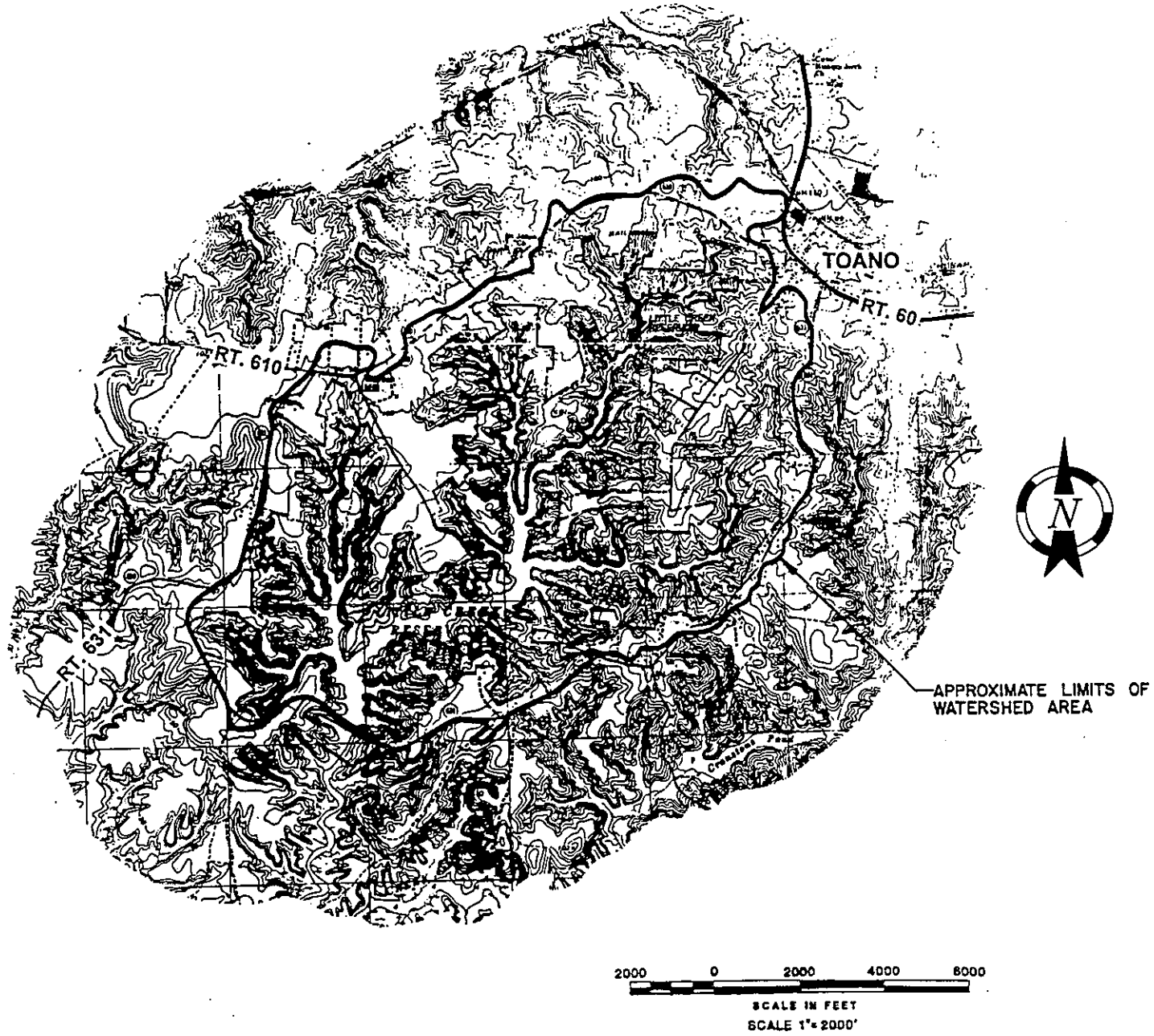


BEAVERDAM RESERVOIR WATERSHED
GLOUCESTER COUNTY

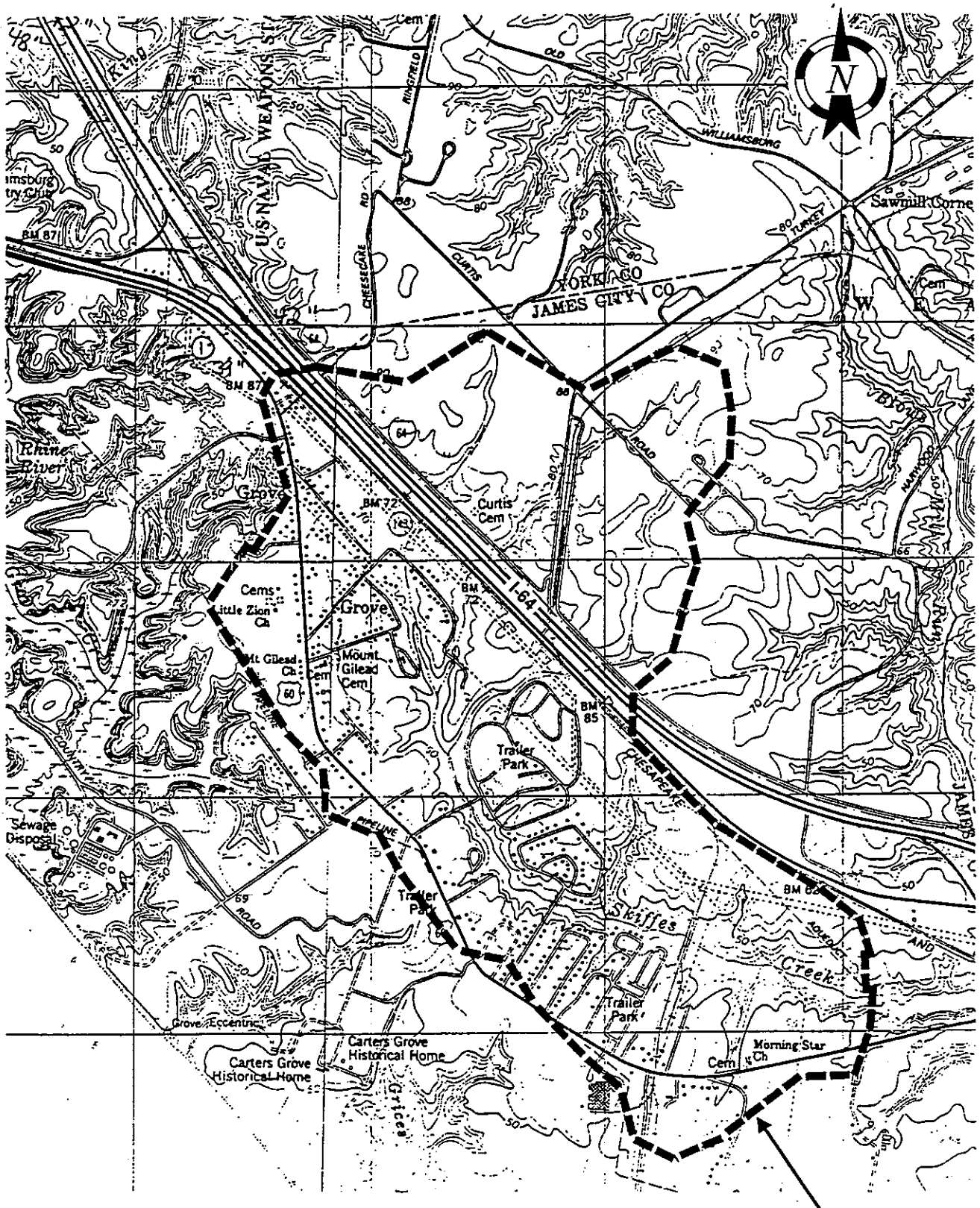
DIASCUND CREEK RESERVOIR AND WATERSHED



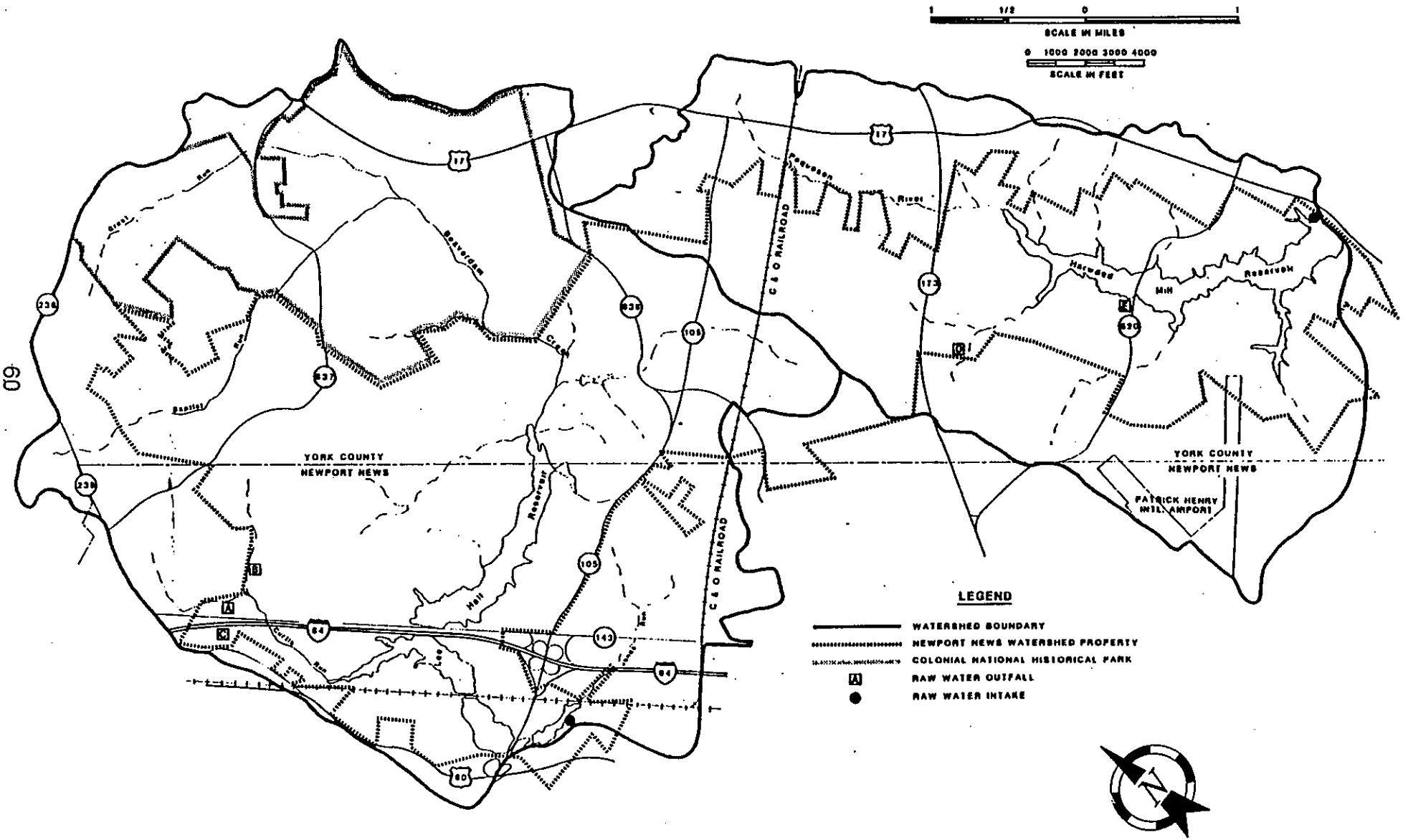
LITTLE CREEK
RESERVOIR AND WATERSHED



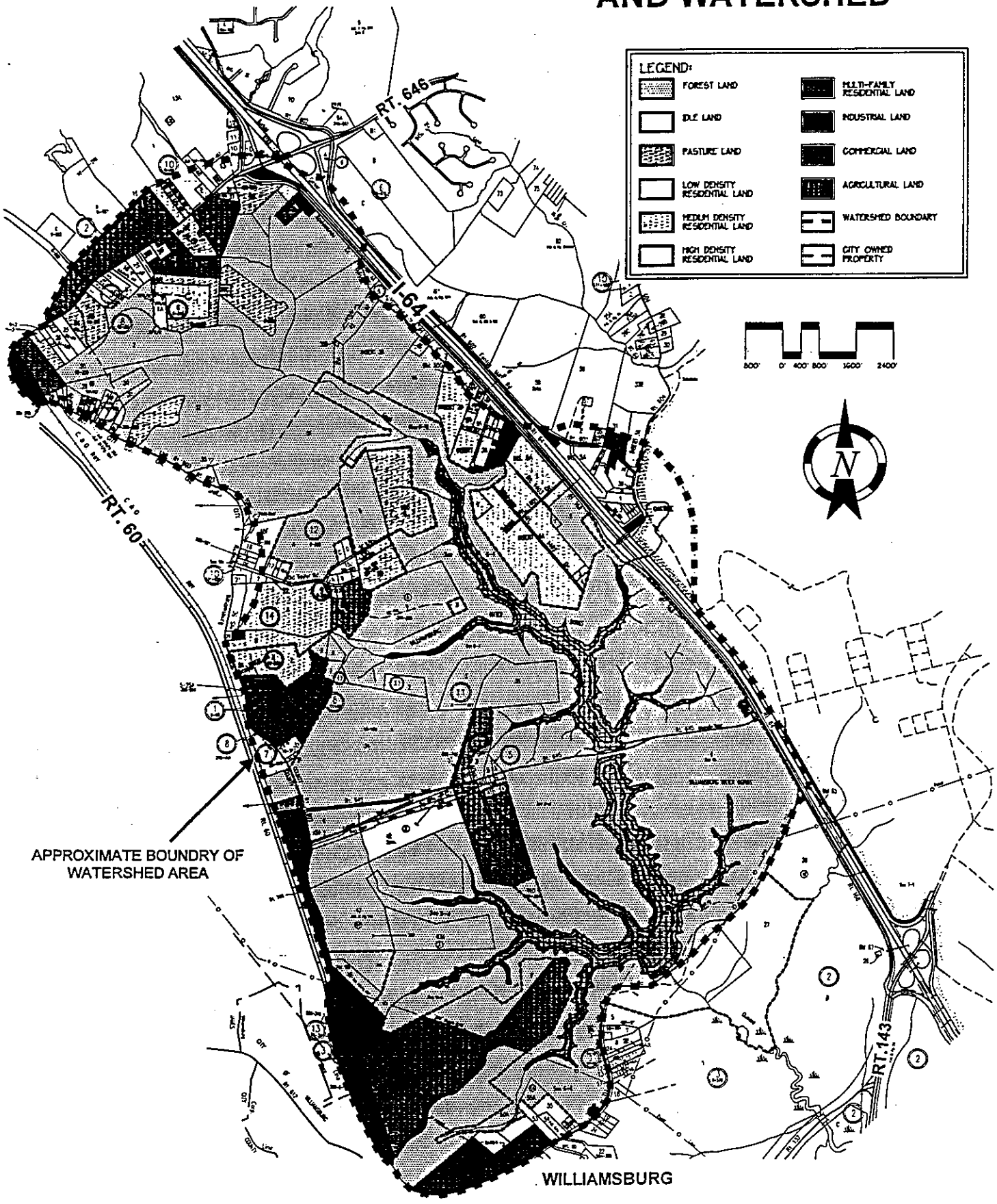
SKIFFE'S CREEK
RESERVOIR AND WATERSHED



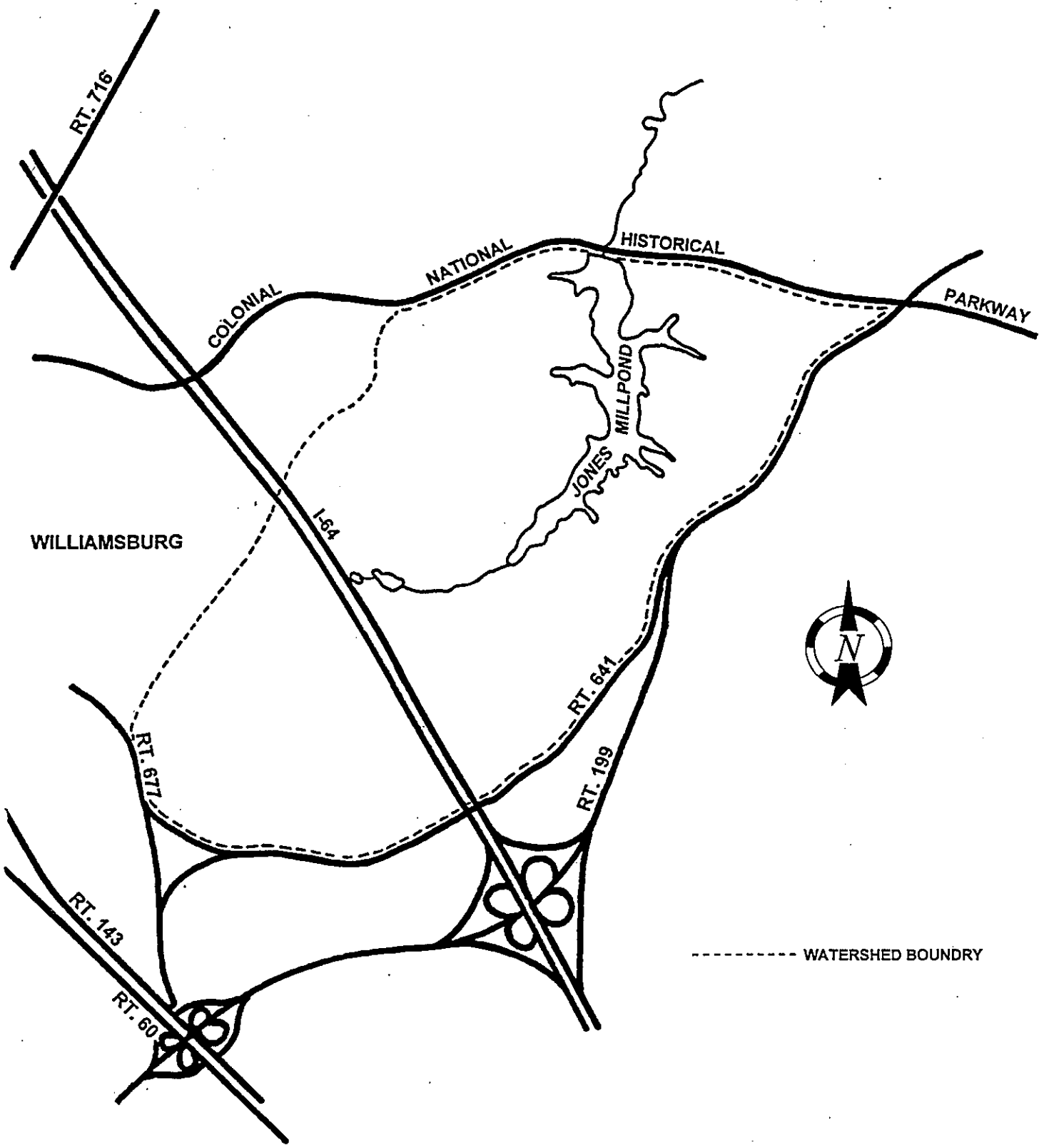
LEE HALL AND HARWOOD'S MILL RESERVOIR AND WATERSHEDS



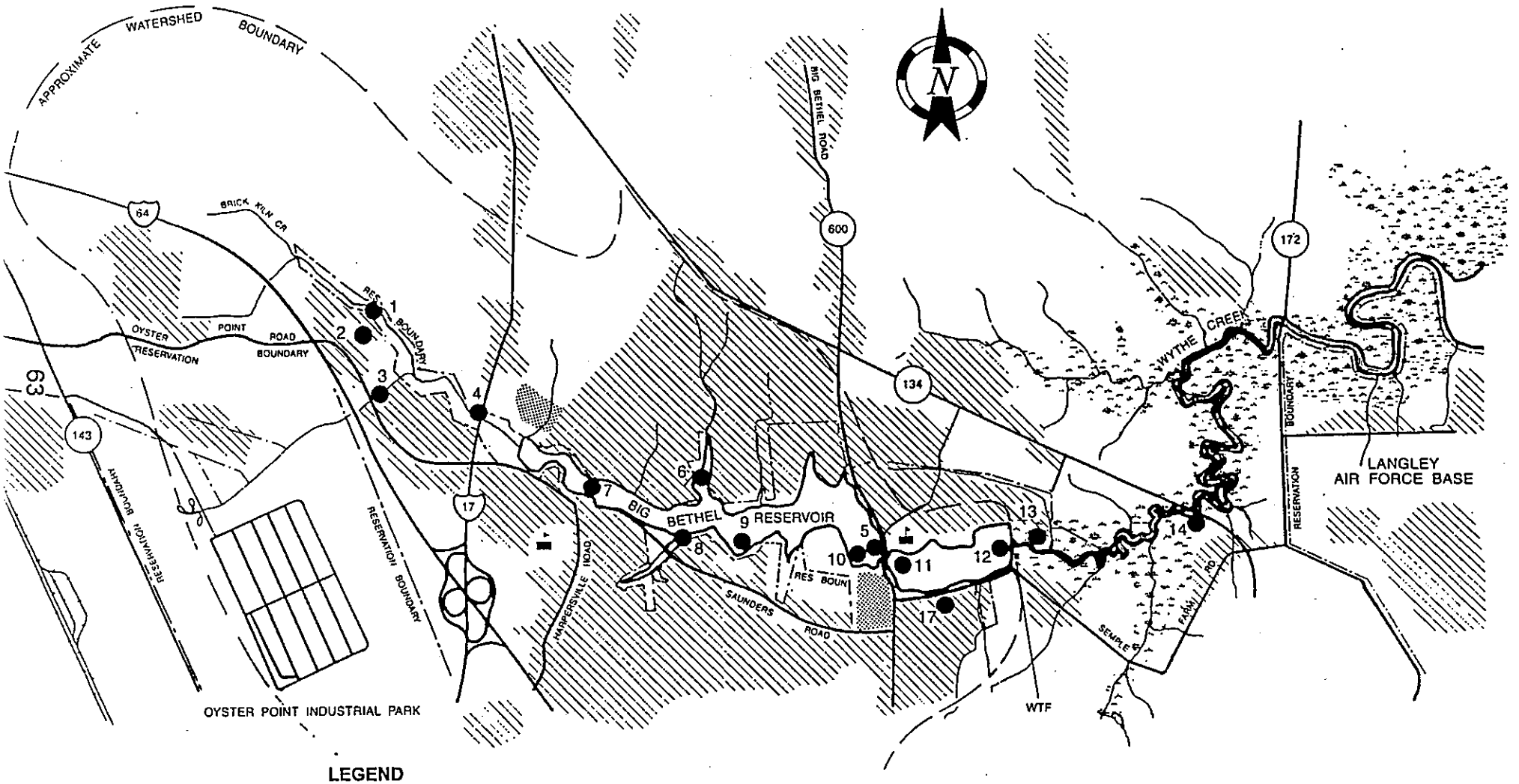
WALLER MILL RESERVOIR AND WATERSHED



JONES POND
RESERVOIR AND WATERSHED



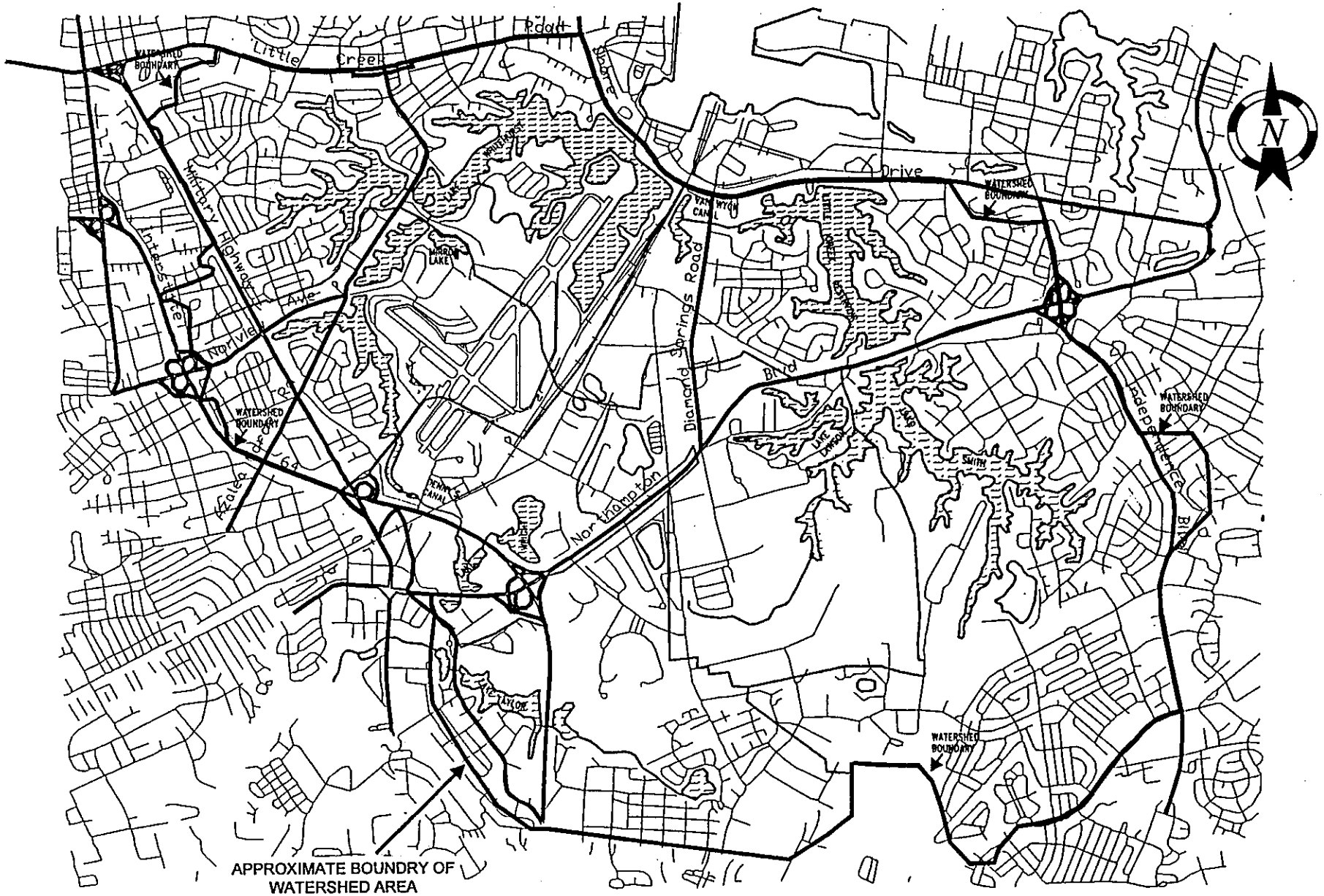
BIG BETHEL
RESERVOIR AND WATERSHED



LEGEND

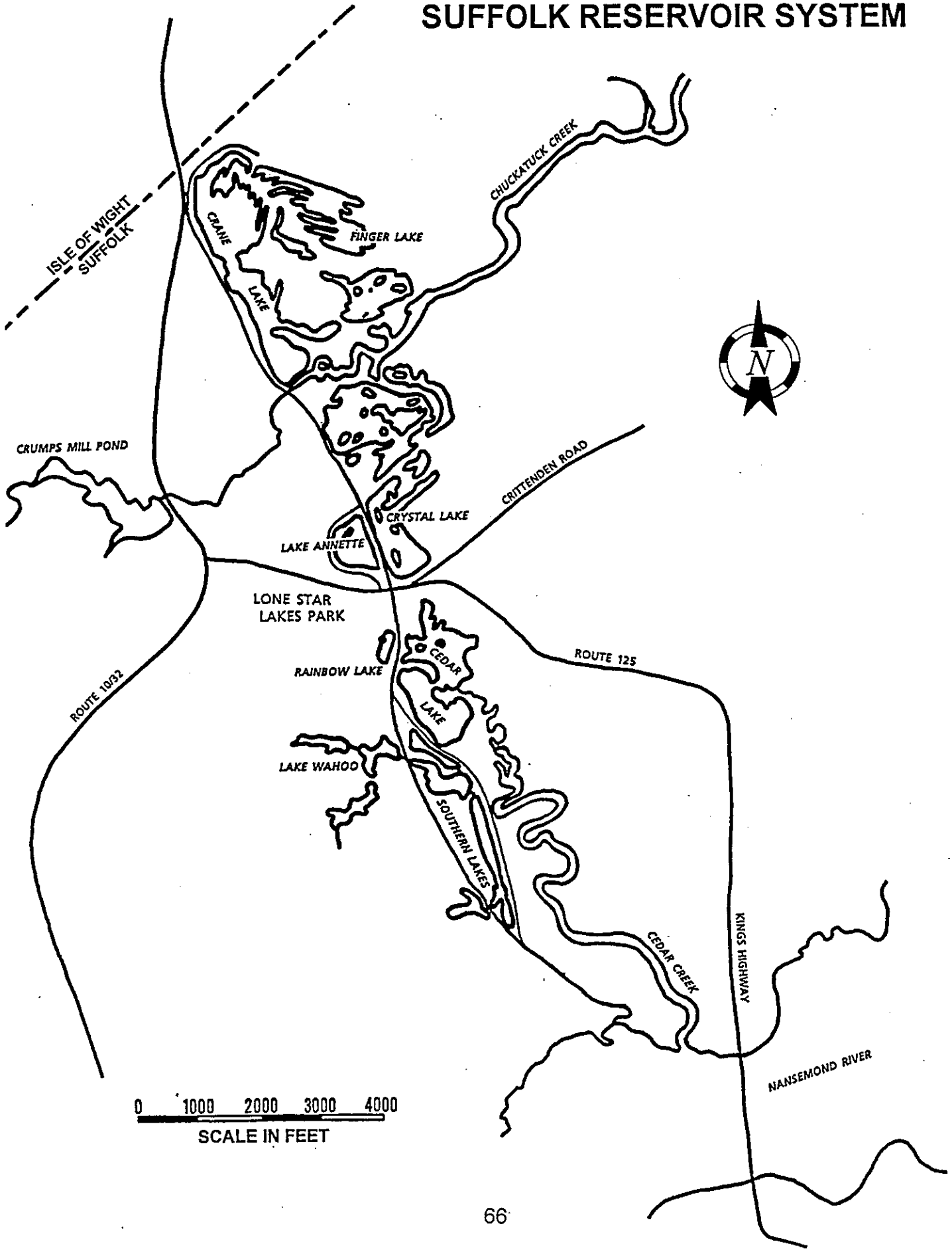
- RESIDENTIAL AREAS
- AGRICULTURAL / CLEARED
- SAMPLE POINT LOCATIONS

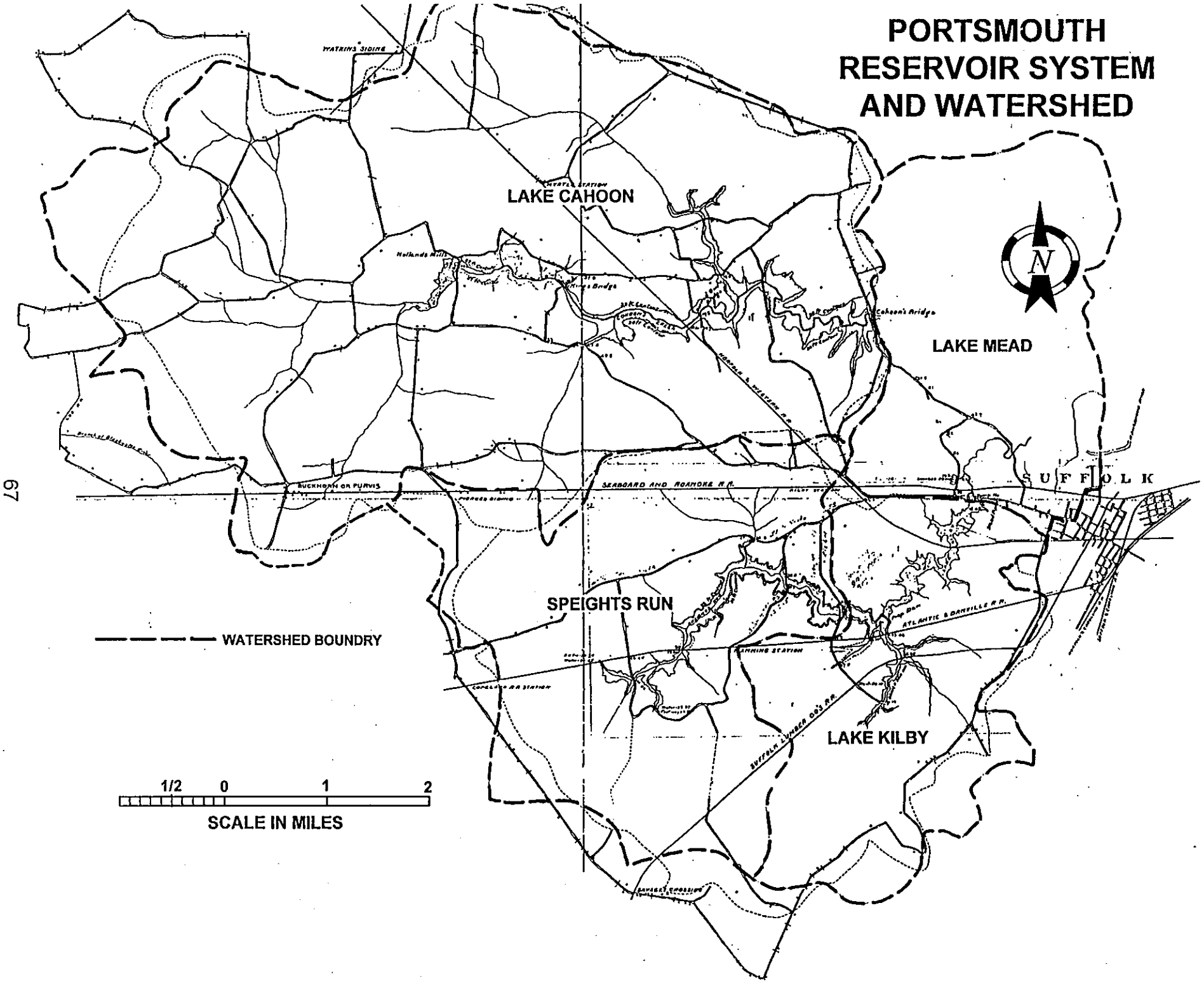
EASTERN IN-TOWN
LAKES AND WATERSHED
NORFOLK SYSTEM



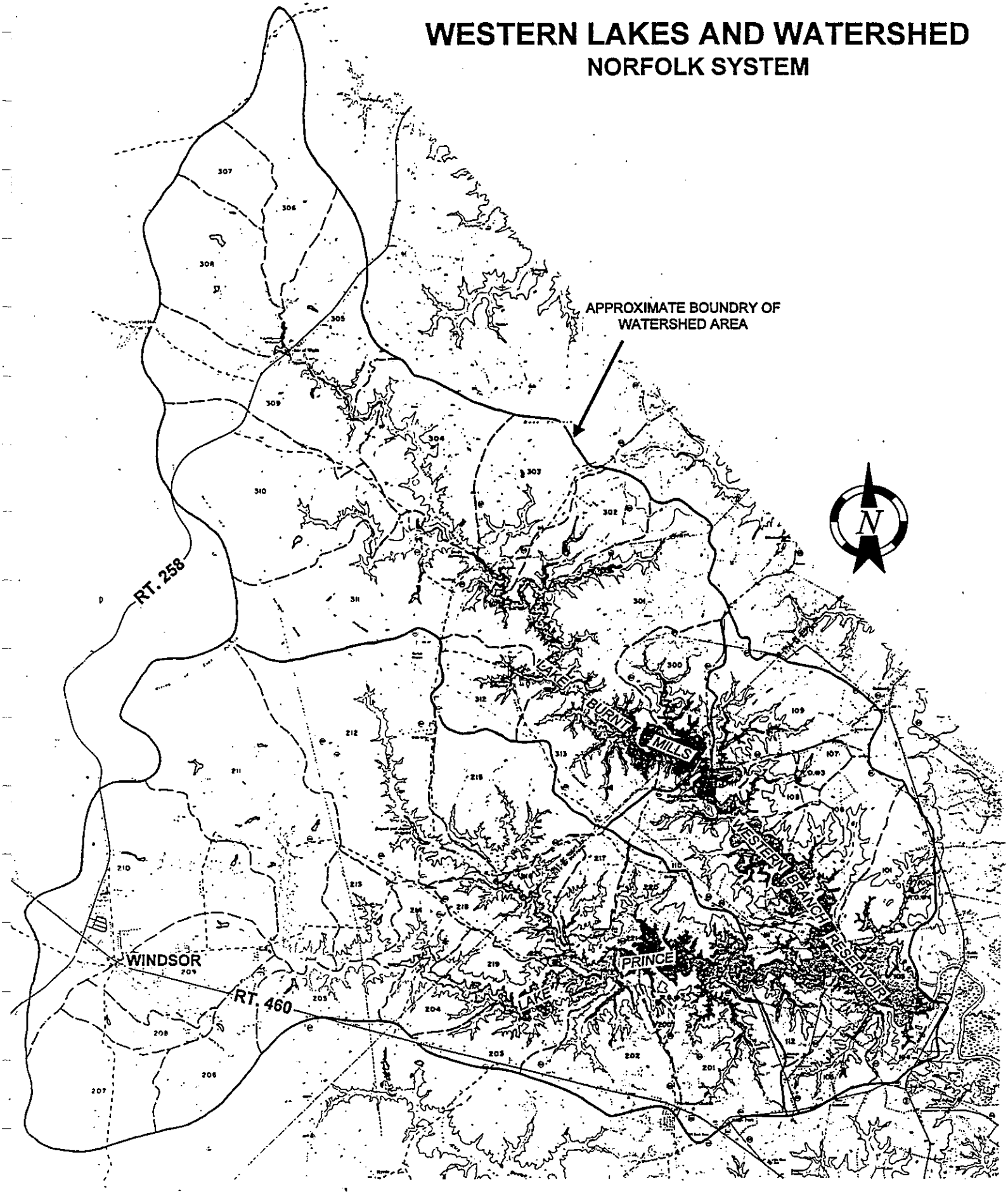
STUMPY LAKE WATERSHED

SUFFOLK RESERVOIR SYSTEM




PORTSMOUTH
RESERVOIR SYSTEM
AND WATERSHED
LAKE CAHOON
LAKE MEAD
SPEIGHTS RUN
LAKE KILBY
SUFFOLK
N
WATERSHED BOUNDRY
1/2 0 1 2
SCALE IN MILES

WESTERN LAKES AND WATERSHED
NORFOLK SYSTEM



COMMON ELEMENTS IN LOCAL WATERSHED MANAGEMENT PROGRAMS

Several common elements exist in local water supply watershed management programs. The Chesapeake Bay Preservation Act is applied to water supply watersheds in several Hampton Roads localities. In six localities, the NPDES Municipal Separate Storm Sewer System program has a major impact on watershed management. Two localities have ordinances which are specifically focused on protecting water supply watersheds. The following tables summarize several of the common components of water supply watershed management programs in Hampton Roads. The first table lists those localities that apply the Chesapeake Bay Preservation Act to water supply watersheds and those localities that have an NPDES MS4 program.

TABLE 4-2
HOST LOCALITIES THAT APPLY THE CHESAPEAKE BAY PRESERVATION ACT TO THEIR WATER SUPPLY WATERSHEDS AND LOCALITIES WITH NPDES MS4 PROGRAMS

Host Locality	Water Bodies	Bay Act Applied to Water Supply Watersheds?	Locality has NPDES MS4 Program?
Gloucester County	Beaver Dam Reservoir	Yes	No
New Kent County	Diascund Creek Reservoir, Chickahominy River	Yes	No
James City County	Little Creek, Diascund Creek and Skiffe's Creek Reservoirs	Yes	No
York County	Lee Hall, Harwood's Mill, Skiffe's Creek Reservoirs. Waller Mill Reservoir. Jones Pond and Big Bethel Reservoirs	No	No
Williamsburg	Waller Mill Reservoir	No	No
Newport News	Lee Hall, Skiffe's Creek, Harwood's Mill Reservoirs. Big Bethel Reservoir.	Yes, but only for the Big Bethel Reservoir.	Yes
Hampton	Big Bethel Reservoir	No	Yes

TABLE 4-2
HOST LOCALITIES THAT APPLY THE CHESAPEAKE BAY PRESERVATION ACT TO THEIR WATER SUPPLY WATERSHEDS AND LOCALITIES WITH NPDES MS4 PROGRAMS

Host Locality	Water Bodies	Bay Act Applied to Water Supply Watersheds?	Locality has NPDES MS4 Program?
Virginia Beach	Lakes Smith, Lawson and Stumpy. Little Creek Reservoir. Northwest River	Yes, but only for Lake Smith, Lake Lawson and Little Creek Reservoir. (RMA only)	Yes
Norfolk	Lakes Whitehurst, Wright and Taylor	No	Yes
Chesapeake	Northwest River, Stumpy Lake	No	Yes
Suffolk	Lone Star Lakes and Crumps Mill Pond. Lakes Burnt Mills, Prince and Western Branch Reservoir. Lakes Cahoon, Meade, Kilby and Speight's Run.	Yes	No
Isle of Wight County	Lakes Burnt Mills and Prince. Lake Cahoon. Crump's Mill Pond. Blackwater River	Yes for all water supply watersheds except the Blackwater River.	No
Southampton County	Blackwater and Nottoway Rivers	No	No

Table 4-3 shows which localities have ordinances that are specifically targeted on water supply watershed management.

TABLE 4-3
HOST LOCALITIES WITH SPECIFIC WATER SUPPLY WATERSHED PROTECTION ORDINANCES

Locality	Water Bodies	Regulation
Gloucester County	Beaver Dam Reservoir	None
New Kent County	Diascund Creek Reservoir, Chickahominy River	None (Agreement in place with Newport News Waterworks to develop a reservoir protection ordinance.)
James City County	Little Creek, Diascund Creek and Skiffe's Creek Reservoirs	None (Agreement in place with Newport News Waterworks to develop a reservoir protection ordinance.)
York County	Lee Hall, Harwood's Mill, Skiffe's Creek Reservoirs. Waller Mill Reservoir. Jones Pond and Big Bethel Reservoirs	Watershed Management and Protection Area Overlay District: Sec. 24. 1-376
Williamsburg	Waller Mill Reservoir	None
Newport News	Lee Hall, Skiffe's Creek, Harwood's Mill Reservoirs.	Water Supply Reservoir Protection Ordinance: Chapter 42, Article IV, Sect. 42-71 to 42-74.
Hampton	Big Bethel Reservoir	None
Virginia Beach	Lakes Smith, Lawson and Stumpy. Little Creek Reservoir. Northwest River	None
Norfolk	Lakes Whitehurst, Wright and Taylor	None
Chesapeake	Northwest River, Stumpy Lake	None

TABLE 4-3
HOST LOCALITIES WITH SPECIFIC WATER SUPPLY WATERSHED PROTECTION ORDINANCES

Locality	Water Bodies	Regulation
Suffolk	Lone Star Lakes and Crumps Mill Pond. Lakes Burnt Mills, Prince and Western Branch Reservoir. Lakes Cahoon, Meade, Kilby and Speight's Run.	None
Isle of Wight County	Lakes Burnt Mills and Prince. Lake Cahoon. Crump's Mill Pond. Blackwater River	None
Southampton County	Blackwater and Nottoway Rivers	None

CITY OF CHESAPEAKE

INTRODUCTION

The Northwest River is the primary drinking water supply for the City of Chesapeake. The River is located in the southeastern corner of the City, and its watershed occupies approximately one-quarter of the land area in the City. The watershed extends west to Route 17 and approximately eight miles north from the North Carolina border. A small portion of the watershed extends into Virginia Beach. The River flows into North Carolina and eventually connects to Currituck Sound. The River is primarily influenced by wind tides rather than lunar tides.

Land uses in the Northwest River Watershed are predominantly rural residential and agricultural. Extensive wetlands surround the River. The City of Chesapeake continues to grow at a rapid rate and new residential and commercial development have the potential to significantly alter land use patterns in the watershed in the future.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

The Southern Watershed Area Management Program

The Southern Watershed Area Management Program (SWAMP) is a joint project of the Cities of Chesapeake and Virginia Beach, coordinated by the Hampton Roads Planning District Commission and funded by the Virginia Coastal Resources Management Program. The Program's purpose is to develop a coordinated management plan for the Southern Watershed Area (SWA) which includes the watersheds of Back Bay, the Northwest River and the North Landing River. The project has proceeded in three phases. Phase I of the project focused on creating a framework for the two cities to work together. This was accomplished through the creation of a mission statement, a set of goals and objectives for management of the SWA and a Memorandum of Agreement that was signed in the Fall of 1995. The mission statement is as follows:

> Natural Resources, Sensitive Lands, and Water Supplies of The Southern Watersheds of Virginia Beach and Chesapeake Should Be Protected and Enhanced.

The goals are as follows:

Goal 1: Water Quality Should Be Protected and Enhanced for Water Supplies and Natural Resources Conservation.

Goal 2: Preserve Open Lands to Help Protect and Enhance Water Quality.

Goal 3: Ensure Compatibility of Recreational Activities and Commerce with Natural Resource Protection.

Goal 4: The Character of the Southern Watershed Should Remain Rural While Providing for Rural Residential Development.

Goal 5: Agricultural and Forestal Activities in the Southern Watershed Should Be Sustained and Encouraged.

Each of the goals has an associated set of objectives. Specific objectives include the following:

- Protection of water quality for water supply of the Northwest River Treatment Plant.
- Preservation of critical edge habitat areas, marshes and swamps by application of preservation zoning, conservation easements and any other appropriate development incentives.
- Promotion and encouragement of the preservation of agricultural and forestal lands.

In addition to the mission statement and the goals and objectives, a Memorandum of Agreement (MOA) was signed by Chesapeake and Virginia Beach. The MOA formalizes criteria for exchange of information on development projects in the SWA. In addition, the MOA states that the two cities will support the previously mentioned goals and objectives for the SWA.

In Phase II progress was made in several different areas including the completion of a survey of agencies working in the SWA, the creation of a Water Quality Task Force and efforts to implement the goals and objectives established in Phase I. In addition, the foundation for Phase III of the project was established.

Funding has been obtained to implement a Special Area Management Plan (SAMP) for the SWA in fiscal year 1996. In addition, the 1997 Coastal Zone Management Strategy for Virginia requests additional funding for fiscal years 1997 through 1999 to continue the SAMP. The SAMP is intended to foster the development of new enforceable policies for the protection of the natural resources in the SWA. Focusing on locally defined needs and opportunities, it will build on the accomplishments of SWAMP and bring a broad cross-section of stakeholders into the planning process. The first year of the SAMP will include the following tasks.

Water Quality Data Analysis: The Water Quality Task Force determined a need for detailed analysis of existing water quality data for the SWA. This task involves the following steps: 1) examination of the data, 2) identification of the proper method of statistical analysis, 3) the actual analysis, and 4) development of a report documenting the results of the analysis. The goals of this task are to better understand water quality trends and to assess the configuration of the monitoring network. The need for additional, highly focused water quality studies may be identified. The Applied Marine Research Laboratory at Old Dominion University has been hired to accomplishment the first phase of this task.

Watershed Stakeholder Workshop: A workshop will be held to establish a shared vision for sustainable economic development and natural resource preservation for the Southern Watershed Area. A broad spectrum of stakeholders will be involved, including local citizens, business owners, local elected officials, environmental groups, and staff of local government. A survey will be performed preceding the workshop to solicit the views of stakeholders on the current and future state of the watershed.

Stakeholder Involvement: A Festival will be held to promote public awareness of the natural resources in the SWA. The Festival will emphasize several themes including the economic benefit of protecting the natural resources in the SWA, recreational opportunities, and education on the detrimental effects of inappropriate land use and development patterns.

Analysis of Development Controls: Zoning codes, subdivision ordinances, site plan regulations, and related land use and environmental management regulations will be critical factors in determining the type of development that takes place in the SWA. Case studies will be used to identify tools that are available to protect water quality and critical habitat.

Research on Options for Sustainable Economic Development: Demonstration of the economic value of the unique natural features of the SWA is a critical factor in their preservation. Several options for sustainable economic development will be examined including nature tourism, agricultural tourism, and sustainable agriculture.

NPDES MS4 Program

The National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) program is intended to foster the evaluation and reduction of non-point source water pollution. While the MS4 program is not specifically focused on water supply watershed management it will have a significant impact on the Northwest River watershed as new development occurs. A general discussion of the MS4 program is contained in the section of this Manual dealing with federal regulations.

The section of the MS4 program that is likely to have the most significant impact on the Northwest River watershed is the Management Program for Commercial and Residential Areas. While the bulk of the Northwest River watershed is currently rural and agricultural, new commercial and residential development is likely to occur in the near future. Section 9.1 of the Permit Application is strongly biased towards the use of structural controls stating that "new structural controls are the most appropriate control measure for new development sites" (Camp: 9-1). This section does mention nonstructural controls, but only in the context of managing areas with existing commercial and residential development. Section 9.3 of the Application outlines the Comprehensive Master Plan for Areas of New Development. This section references elements of the Comprehensive Plan, the Subdivision Ordinance, the Chesapeake Bay Preservation Area Overlay District, the Erosion and Sediment Control Ordinance and the Public Facilities Manual that impact stormwater management. In addition this section describes a proposed new stormwater management ordinance. The Model Stormwater Management Ordinance for Localities

prepared by the Virginia Department of Conservation and Recreation will be used as a reference. The City plans to adopt the new ordinance by December of 1997. Section 9.3.5 describes the consolidation of design guidelines for structural BMPs. The intent is to consolidate the design guidelines for structural BMPs required by different City ordinances into the Public Facilities Manual.

Comprehensive Plan

The City of Chesapeake is in the process of developing a new Comprehensive Plan. The City is subdivided into several planning areas and each of the area plans are being developed in series. The South and West Area Plan covers most of the SWA. The land use plan map will be revised as part of this process.

The City's current Comprehensive Plan addresses a number of environmental issues including water quality. Objectives for water resources include protection of the chemical, biological and aesthetic quality of the Northwest River.

Zoning

The Zoning Ordinance establishes Conservation Districts to preserve and protect unique natural water, forest and other open space areas which could not be replaced if misused or destroyed. Land cover types within Conservation Districts may include open spaces, wetlands, hardwood swamps, flood plains, watersheds, water supplies and those areas providing habitat for fish and wildlife.

The Zoning Ordinance also contains provisions for residential cluster development. These provisions include grouping of residential uses and structures together such that lot sizes, setbacks, and other dimensions are less than those normally imposed under the applicable zoning district. The overall density of development remains the same as that permitted under conventional zoning and subdivision regulations. The undeveloped land preserved by clustering is set aside as permanent open space. The stated goals for cluster developments include preserving green space, maintaining tree cover, protecting scenic vistas and natural drainage ways or other irreplaceable and/or significant natural features. It is required that significant natural features be included in the permanent open space system.

GLOUCESTER COUNTY

INTRODUCTION

Gloucester County is one of the few jurisdictions in the planning district with a totally self-contained water supply. The Beaverdam Reservoir is located in the center of the County in the Ware River watershed. The Gloucester County Land Use Plan shows the bulk of the water supply watershed designated as a rural countryside district. A small portion of the watershed is designated as "village" and is in the County's development district. The tributary streams to the reservoir are buffered by a resource conservation district. The County owns a buffer that surrounds the entire reservoir. The buffer varies from 50 to 200 feet in width and is predominantly forested.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Comprehensive Plan

The September 1991 Gloucester County Comprehensive Plan outlines a growth management strategy described as "contained growth" (Gloucester County (b), 1991). The goal of this strategy is to concentrate new development in the south central area of the County. This strategy will focus the bulk of new development downstream of the reservoir.

Section 8 of the Comprehensive Plan deals with natural resource protection. This section contains several implementation recommendations that will potentially contribute to watershed management. Recommendation 2 deals with performance standards and states the following, "New environmentally sensitive development regulations are needed which recognize and protect natural site functions. Environmentally sensitive features such as wetlands and critical plant and wildlife habitats should be explicitly protected and buffered from development activities." Other recommendations include increased use of clustering, no net change in runoff allowed at development sites, vegetation retention/replacement, and enforcement of runoff controls around Beaverdam Reservoir (Gloucester County (b), 1991).

Chesapeake Bay Preservation Ordinance

The Chesapeake Bay Preservation Ordinance is the primary watershed protection measure in Gloucester County. The entire County is designated as a Resource Management Area (RMA). The performance criteria in the RMA include prevention of a net increase in nonpoint source pollution from new development, achievement of a 10 percent reduction in nonpoint source pollution from redevelopment, and achievement of a 40 percent reduction in nonpoint source pollution from agricultural and silvicultural uses (Gloucester County (a), 1991).

General Performance Standards for the RMA include the following:

- Minimize land disturbance, preserve indigenous vegetation, minimize impervious cover, comply with the Erosion and Sediment control ordinance for land

disturbing activities exceeding 2,500 square feet, a five year pump out requirement for septic systems and a reserve drainfield requirement.

- New development: The post-development pollution runoff load shall not exceed predevelopment conditions (assumed 0.45 lbs. per acre per year).
- Redevelopment: 10% reduction in nonpoint source pollution load.
- Wetlands permits needed prior to grading.
- Agricultural operations: Soil and water conservation plan based on Field Office Technical Guide of the U. S. Department of Agriculture Soil Conservation Service. Required by 1995 (Gloucester County (a), 1991).

A plan of development is required for any development or redevelopment exceeding 2,500 square feet. Required elements include a site plan, environmental inventory, a clearing plan showing trees to be preserved, a stormwater management plan, an erosion and sediment control plan, and a landscaping plan (Gloucester County (a), 1991).

The stormwater management plan requires structural and/or nonstructural BMPs for developments with impervious cover exceeding sixteen percent of site area and for subdivisions with lots of less than two acres. The plan is required to include the location and design of stormwater control devices and BMPs, procedures for implementing nonstructural stormwater control practices, pre and post development nonpoint source pollutant loadings with supporting documentation of all utilized coefficients and calculations. The plan must also include a long-term schedule for inspection and maintenance of stormwater management facilities that includes all maintenance requirements and persons responsible for performing maintenance (Gloucester County (a), 1991).

CITY OF HAMPTON

INTRODUCTION

The Big Bethel Reservoir is located at the northwest corner of the City of Hampton. The watershed is split between Hampton, Newport News and York County. Approximately one-fourth of the watershed lies in Hampton. Land uses in the watershed are predominantly residential. The Williams Pit Landfill is located in the southern portion of the watershed.

The northeast corner of the City is identified in the Hampton Comprehensive Plan as Planning Area Five. The land use plan for Area Five features low density residential uses in the bulk of the Big Bethel watershed. An area adjacent to Big Bethel road is designated for residential transitional use. According to the comprehensive plan Area Five is the least developed section of Hampton and will become a major growth area (City of Hampton, 1991). The chapter of the Comprehensive Plan dealing with environmental issues discusses the environmental constraints on development in Area Five. The land between Big Bethel Road and Magruder Boulevard may contain significant nontidal wetlands. Due to the fact that these areas drain to Back River they may be considered Resource Protection Areas under the Chesapeake Bay Preservation Act. If delineation proves this to be the case there would be a two fold impact on the portion of the Big Bethel watershed in Area Five. First, the status of the wetlands under the Bay Act will limit development. Secondly, any development that does take place adjacent to the wetlands will be subject to more stringent performance criteria than would otherwise be required (City of Hampton, 1991) . The environmental chapter of the Plan goes on to recommend the establishment of a reservoir protection ordinance or zoning district to address the issues of appropriate land uses and development standards to protect reservoir water quality (City of Hampton, 1991).

STORMWATER MANAGEMENT

Chapter 33.1 of the Hampton City Code deals with stormwater management. Many of the requirements of the Chesapeake Bay Preservation Act are imbedded in this section of the code. However, this ordinance is limited as a tool for water supply watershed management because the Big Bethel watershed is not currently in a Preservation Area. For example, the requirements for a water quality impact assessment and the stormwater management performance standards only apply to the Bay Preservation Areas.

NPDES MS4 PROGRAM

The National Pollution Discharge Elimination System Municipal Separate Storm Sewer System (NPDES MS4) stormwater management program is a dominant feature of the water supply watershed management efforts in Hampton. This program has served to organize and strengthen preexisting efforts to manage nonpoint source pollution. According to the executive summary contained in Part Two of the Hampton NPDES MS4 permit application, Hampton's municipal stormwater program is required to address runoff from commercial and residential areas, illicit discharges and improper disposal to the storm

sewer system, runoff from waste disposal and select industrial facilities and runoff from construction sites (City of Hampton, 1993). The summary goes on to state that Hampton's four major priorities for the stormwater management program are improving drainage in residential areas, improving maintenance of the storm drainage system, establishing area-wide storm drainage basins and developing public education programs (City of Hampton, 1993).

A significant facet of Hampton's NPDES MS4 program is the creation of a storm water quality management plan. Several aspects of Hampton's plan have positive ramifications for protection of water quality in the Big Bethel reservoir. In particular, the BMP maintenance, storm sewer system maintenance and education provisions will benefit water supply watershed management. The education and information component calls for the Department of Public Works to coordinate seminars for city employees, contractors, landscapers, and the general public which will explain the purpose and operation of BMP facilities. The seminars will emphasize the maintenance and inspection of BMPs and proper record keeping.

VPDES MS4 FY96 Annual Report

The FY 96 Annual Report contains information on accomplishments made under the VPDES MS4 program in Hampton. While the majority of these activities apply to the entire city, they impact the management of nonpoint source pollution in the Big Bethel watershed. The following are a some of the highlights from the 1996 report.

- Data on all stormwater BMPs installed in the City has been collected and is being entered into a master database using HRPDC's BMP Maintenance Tracking Program. BMP maintenance inspections are performed in January, February and March currently under a manual scheduling system. Upon completion of the database, scheduling will be done electronically.

- Public Works Engineering has begun development of a Stormwater Master Plan by updating the storm system maps for the City and is now putting them into their GIS system for future use and analysis. Major and sub-basin boundaries have been identified and are also being added to the GIS system. The basin areas and drainage system plans will be used along with land use layers, topography and vacant parcel information to identify potential sites for regional BMPs. The digitizing of this information should be completed by the end of FY 96 and a watershed analysis and project identification will begin. This plan will be developed into a formal Stormwater Master Plan and become the basis for future capital project undertakings.

- With an investment in additional equipment and manpower, improved storm sewer system maintenance has been very successful in keeping large volumes of sediments from reaching outfalls. Increased maintenance promises to be a major part of the program for the next several years. Street sweeping reaches a large number of neighborhoods but can be further increased in scope and frequency. Under the stormwater program, the City expanded its original

program of drainage maintenance to include catch basin sediment removal, street side and rear ditch cleaning and outfall repair. Additional crews and two vacuum trucks were added to increase maintenance activities to reduce the amount of sediment and debris entering the drainage system. In FY 96, 69% of all drainage structures were cleaned and checked; 43% of front yard and 50% of rear yard ditches were cleaned and 12.8% of the storm sewer system piping was cleaned.

- The first regional stormwater BMPs are in design and additional sites are being considered. The completion of storm sewer system and drainage basin/watershed mapping in the City's GIS will greatly assist the Engineering staff in identifying sites with the most water quality benefits. Plans call for at least one major basin to be built each year in the stormwater program's capital improvements program (City of Hampton, 1996).

Education/Outreach: VPDES MS4 Permit Annual Report states that the facet of the stormwater program with the greatest potential for positively impacting water quality is public education and awareness. The City has continued to expand its educational programs since the initial Stormwater Utility implementation efforts. The City hired an environmental relations manager in 1993 to develop public education activities. Since that time, the office has grown to include more staff, including volunteers. A communication plan identified target audiences and developed the communication tools need to reach them. These efforts have included video production, advertising, community cleanups, signage, publications, speaking engagements, exhibits, workshops, environmental tours, surveys, focus groups, promotional items, a stormwater hotline, in-house training, correspondence, mapping areas plagued by illegal dumping, work with schools, and grant-writing to support environmental education.

To assess public awareness of stormwater management, 3 environmental surveys were completed over a 3-year period. Results indicated a lack of understanding about the connection between storm drains and local waterways. Several efforts were implemented to boost public understanding. A list of efforts is found in 1996 Annual Report.

Several efforts have been aimed at educating contractors, developers and land managers about erosion and sediment controls and land management practices that will improve water quality. Initiatives include a video, brochures, mailings to lawn companies on illegal dumping of yard wastes and two conferences aimed at land managers held in 1995 and 1996.

A series of meetings were held to update front line city staff who handle stormwater calls. A question and answer booklet was prepared for use by the staff. With educational efforts to increase awareness of stormwater's impact on the Chesapeake Bay, public acceptance of the stormwater program is growing. Public participation in waterway cleanups and reporting of illegal dumping are making a difference in some waterways in the City.

A major aspect of the program has been cultivation of relationships and establishment of partnerships among different agencies. Links have been created with the Elizabeth River Project, Hampton Clean Community Commission, Sandy Bottom Nature Park, Norfolk Environmental Commission, the Extension Office, Center for Marine Conservation, the Virginia Marine Resources Commission, Hampton Roads Planning District Commission, the Hampton Planning Department, Chesapeake Bay Foundation and others.

Planned Activities: For fiscal year 1998 and beyond, the Annual Report states that under the terms of the 5-year MS4 permit, the City must reduce pollution of stormwater to the "maximum extent practicable (City of Hampton, 1996)." While there is no clearly defined target for what this means, the current permit requires expansion of existing efforts. Program activities in the coming years are likely to include more frequent street sweeping, more frequent cleaning of catch basins and open ditches, and inspection of sites to detect illicit discharges. Also, capital projects, such as roadside ditch piping and stormwater basins, will increase in quantity and cost. Funding for any new or expanded stormwater programs will likely come from the stormwater utility fee, as no federal or state funding is anticipated.

ISLE OF WIGHT COUNTY

INTRODUCTION

Isle of Wight County is divided into two main watersheds. The eastern half of the County drains to the James River and the western half drains to the Blackwater River. Two of the reservoirs in Norfolk's water supply system, Lakes Prince and Burnt Mills, abut the eastern border of the County. The Blackwater River forms the western boundary of the County. Norfolk withdrawals water from the Blackwater approximately 10 miles upstream from Franklin. Thus, a large portion of Isle of Wight drains to the raw water supply for the Norfolk utility. A small portion of the County drains to Lake Cohoon in Suffolk. Lake Cohoon is part of the Portsmouth Utility Department's reservoir system.

The bulk of the land draining to the three reservoirs and the Blackwater River is rural. The main land uses are agricultural, silvicultural, and residential. The majority of the land in the water supply watersheds is zoned A-1, agricultural. The main exception to this is the area surrounding the Town of Windsor, which has been designated as a Development Service District in the 1990 Comprehensive Plan. This designation coincides with major transportation corridors and future sanitary sewer service areas. The intent expressed in the Comprehensive Plan is to focus residential and commercial growth in the Development Service Districts.

Isle of Wight County is beginning to experience an increase in development pressure. According to the Comprehensive Plan the bulk of the development in recent years has been residential and this trend is expected to continue in the coming years. The majority of the new residential development is projected to occur in the northern third of the County, primarily due to this area's proximity and accessibility to employment centers on the Peninsula and in northern Suffolk (Isle of Wight County (a), 1991). However, two factors will encourage development in the watersheds of Lakes Burnt Mills and Prince. The first is the desire of developers to use the proximity to the Lakes as a marketing tool for new homes. As in other parts of Hampton Roads, water view property is highly valued by both developers and home buyers. The second factor is the planned provision of water and sewer services to the Windsor area. This will likely spark both residential and commercial development. The Comprehensive Plan states that the number of building permits for commercial development has been steadily increasing in recent years. In addition, the Plan states that "east and west of Windsor, along the Route 460 and rail corridor, large tracts of land are available for future industrial growth (Isle of Wight County, 1991)."

The portion of the Blackwater River watershed that is upstream of Norfolk's intake will probably remain rural in the near future. Little development is currently taking place in that area. According to the Comprehensive Plan, there is a large area zoned for industrial use along Route 58 and the rail lines in the vicinity of Union Camp, but that area is south of Norfolk's intake.

Soils and wetlands are limiting factors for future development in Isle of Wight. According to the Chesapeake Bay Preservation Area Program Supplement to the Comprehensive Plan, the majority of the soil types in the County are generally ill-suited for

utilization of on-site septic systems, presently the standard method for wastewater treatment in the County. In addition to this limitation, "Approximately forty percent of the undeveloped land in Isle of Wight is wetlands, both tidal and non-tidal. Although scattered throughout the County, these wetlands typically lie adjacent to shorelines and waterways (Isle of Wight County, 1995)." These two factors will limit the density and location of future development.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Comprehensive Plan and Land Use Plan

A major component of the Isle of Wight Comprehensive Plan is the Growth Management Plan. The Growth Management Plan attempts to limit sprawling development patterns through the focusing of growth in three Development Service Districts (DSD). The DSDs are expected to be the principal residential, commercial and employment centers of the County. The largest DSD is adjacent to Smithfield in the northeast corner of the County. The second DSD surrounds the Town of Windsor, extending east to the Suffolk border. This DSD includes part of the Lake Prince and Lake Cohoon watersheds. The third DSD is located in the southern tip of the County, adjacent to Franklin. It is entirely in the in the Blackwater River watershed, but is downstream of Norfolk's raw water intake.

The County intends to use the provision of utility infrastructure as a tool to guide new development into the DSDs. In the Northeast Development Service District, a sewer line from the HRSD Nansemond treatment plant in Suffolk extends to Smithfield. Developers are responsible for the addition of collection systems for new construction projects. The County will eventually add collection systems for existing residents. In the Central Development Service District, a connection to the Nansemond treatment plant became operational in June of 1997. A force main will follow Rt. 460 to Windsor from Suffolk. Isle of Wight is designing a collection system that will take some of the existing package systems off-line. Zuni, in Isle of Wight, and Ivor, in Southampton County, may eventually be connected. According to Bryan David, the former Isle of Wight Director of Planning and Community Development, the proposal for connection of the Southern Development Service District to the Nansemond Treatment Plant outlined in the Comprehensive Plan is not feasible. The Franklin sewer system may be expanded to serve this DSD (David, 1996).

Zoning Code

The zoning in Isle of Wight County basically follows the Land Use Concept Plan (Map #2-1) in the Comprehensive Plan. The bulk of the area shown as Rural/Agricultural Conservation District on that map is zoned A-1. Areas of transition between urban and rural land uses are typically zoned A-2. Thus the bulk of the land in the water supply watersheds is zoned either A-1 or A-2. The main exception to this pattern is Windsor and the surrounding development service area. This area is zoned for higher densities and a mixture of land uses (Welton, 1996).

Existing Zoning Code

The existing Zoning Code defines zoning category A-2 as being established for the purpose of facilitating existing and future farming operations, conservation of water and other natural resources, reducing soil erosion, protecting watersheds and reducing hazards from flood and fire. Uses not consistent with the existing character of the A-2 district are not permitted. The County intends to control new development in A-2 areas by limiting the type and number of upzonings.

Draft Zoning Code

Isle of Wight County is in the process of adopting a new Zoning Code. The following analysis in this section is based on the 1995 draft of the proposed code revision.

Configuration of Open Space

The configuration of open space is a critical factor in the control of stormwater runoff. The design and placement of vegetated surfaces can dramatically affect the runoff rates, pollutant content and flow type. Several provisions of the draft zoning code affect the configuration of open space. In particular, Floodplain Management Districts and Planned Development Districts have specific requirements for open space. Section 3402, Item B of the zoning code restricts certain uses, activities, and development from locating within districts subject to flooding (Isle of Wight County, 1995). Section 3500 states that Planned Development Districts are intended to encourage innovative and creative design of residential, commercial and industrial development projects. In addition, these districts are intended to facilitate the use of the most advantageous construction techniques and to maximize the conservation and efficient use of open space and natural features (Isle of Wight County, 1995). The bulk of the specific language dealing with the configuration of open space focuses on recreational space rather than resource conservation. A design professional working in a planned development district has a great deal of latitude and could use the provisions in this section to produce a project that does a good or poor job of watershed protection.

Another critical feature in minimizing impervious surface is the preservation of vegetation. In the new Zoning Code, Isle of Wight has included several provisions for landscaping in new developments. Part 3 of the Code deals with landscaping of parking facilities. Section 7302-E provides for the preservation of significant natural vegetation when parking facilities are constructed. Section 7032-F provides for the preservation of trees when pedestrian and bike paths are constructed. Section 7303-E provides minimum tree requirements for interior landscaping of parking lots.

Reduction of Impervious Surface

Shared use of parking facilities is one of the most effective ways to reduce impervious surface in a water supply watershed. Section 7207 of the draft zoning code addresses the joint use of required parking spaces. Joint parking areas for non-residential uses are permitted subject to the following restrictions:

"1. The operations sharing the joint use of parking areas shall not be open for business or used during the same principal operating hours, and

2. The parties concerned with such joint use are subject to a written joint use agreement as determined by the Zoning Administrator (Isle of Wight County, 1995)."

In addition, the Highway Corridor Overlay Zone contains tree protection and landscaping requirements, although these measures are targeted more at aesthetic concerns then watershed protection.

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act applies to the entire James River Watershed in Isle of Wight County with the entire watershed designated as a Chesapeake Bay Preservation Area. A 100 foot buffer area surrounding all of the Norfolk and Portsmouth Reservoir system is designated as a Resource Protection Area. The bulk of the remainder of the James River watershed is designated as a Resource Management Area.

Development Restrictions

Agricultural, silvicultural and developmental activities are permitted in the RMAs in accordance with the Isle of Wright County Chesapeake Bay Preservation Area Program. For development exceeding a disturbed land area of 2,500 square feet, a development review is required. On-site sewage treatment systems are required to have a reserve drain field and be pumped out every five years. Stormwater management practices are divided into two categories, redevelopment and new development. In general, redevelopment proposals are required to demonstrate a 10 percent reduction of pollutant loadings. If a redevelopment site is currently developed in impervious surfaces, restoring a minimum of 20 percent of the site to vegetated open space will be considered to meet the 10 percent reduction criteria. The requirement for new development is that stormwater management measures limit pollutant loadings to .45 pounds or less of phosphorus per acre per year. According to the text of the ordinance this is equivalent to 16% impervious surface in average land cover conditions in Tidewater, Virginia. Vegetative shoreline erosion control measures are required where appropriate to minimize erosion. Finally, land upon which agricultural activities are being conducted must have a soil and water conservation plan (Isle of Wight County, 1990).

Resource Protection Areas

Only two categories of development are allowed in Resource Protection Area, water dependent facilities and redevelopment projects. In either case a Water Quality Impact Assessment must be performed before the project is begun (Isle of Wight County, 1990).

Resource Management Areas

Permitted uses and density are determined by the underlying zoning in RMAs. Site development performance standards include limitation of land disturbance to the area necessary for the desired use, limitation of the construction footprint to 60 percent or less of the total site, preservation of indigenous vegetation and minimization of impervious cover (Isle of Wight County, 1990).

Isle of Wight Subdivision Ordinance

While most of the Subdivision Ordinance is silent on the issue of watershed protection, there are a few significant provisions. Section 4-8 of the Ordinance states that the subdivision of lots in Chesapeake Bay Preservation Areas must comply with the requirements of the Chesapeake Bay Preservation Ordinance. Section 4-3 prohibits land that is subject to flooding from being developed. Section 3-8 requires that subdivisions of three or more lots must be in R-1, R-2, R-A (Residential Rural), or R-MH (Residential Mobile Home) zones. This is significant given that the majority of the land in water supply watersheds in the County is zoned A-1 or A-2.

JAMES CITY COUNTY

INTRODUCTION

James City County is tributary to three of the reservoirs in the Newport News Waterworks system. The Diascund Creek Reservoir is located in the north end of the County on the border with New Kent County. Both the reservoir and its watershed are split between the two counties. The Little Creek Reservoir is located in the north-central section of James City County. Both the reservoir and its watershed are contained within the County boundaries. The Skiffe's Creek Reservoir is located in the south end of the County, adjacent to the border with Newport News. The watershed is split between Newport News and James City County.

LAND USE

Land uses in the three water supply watersheds are quite varied. The Diascund Creek watershed features a mixture of low density residential and mixed use. The Little Creek watershed is comprised of a mixture of rural lands and low density residential uses. The Skiffe's Creek watershed contains a combination of general industrial, conservation, low and medium density residential and mixed use areas. In addition, the U.S. Naval Weapons Station-Yorktown occupies a small part of the watershed.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Chesapeake Bay Preservation Act

All of James City County is designated as a Chesapeake Bay Preservation Area. Performance standards in the Resource Management Areas include minimizing land disturbance for new development, preservation of indigenous vegetation, minimizing impervious cover, requirements for reserve sewage disposal capacity and limitations on pollution from stormwater runoff for new development and redevelopment. The more restrictive development criteria associated with Resource Protection Area criteria do not apply to the three reservoirs. Permitted uses and lot sizes in the water supply watersheds are determined by the underlying zoning.

All development or redevelopment exceeding 2,500 square feet of land disturbance is subject to a plan of development review process, including approval of a site plan in accordance with the provisions of the Zoning ordinance or a subdivision plan in accordance with the Subdivision Ordinance. Plans of development or water quality impact statements are not required for agricultural lands.

Comprehensive Plan

The 1997 revision to the Comprehensive Plan calls for the creation of a reservoir protection overlay district to provide additional protection for the Diascund, Little Creek and Skiffe's Creek reservoirs. An agreement has been negotiated with Newport News Waterworks on the creation of the overlay district.

NEW KENT COUNTY

INTRODUCTION

Two of the raw water supplies for the Newport News Water Utility border New Kent County. The Diascund Creek Reservoir is located on the border between New Kent and James City Counties, in the southeastern corner of New Kent. New Kent County contains approximately one-half of the Diascund Creek Reservoir watershed. The Chickahominy River flows along the southern border of the County, separating New Kent from Charles City County. Approximately two-thirds of the land in New Kent is in the Chickahominy watershed.

LAND USE

New Kent County is dominated by rural land uses. Silvicultural and agricultural operations occupy the bulk of the land in the water supply watersheds. The land in the Diascund watershed is zoned for agricultural uses. The Diascund watershed contains some large lot residential development, several small farms and no large livestock operations. A proposed development project may bring 8500 new dwelling units on 5500 acres to the Watershed. The Chickahominy River watershed contains a variety of land uses. A small industrial facility, a transfer station owned by Tarmac, is located adjacent to the River in the western part of the County. The land adjacent to the River in the eastern part of the County is occupied by residential uses, two campgrounds and conservation areas.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act applies to both the Diascund and Chickahominy watersheds. Both watersheds are designated as Resource Management Areas (RMA). A 100 foot buffer adjacent to both the river and the reservoir is designated as a Resource Protection Area. Performance standards in the RMA include minimizing land disturbance for new development, preservation of indigenous vegetation, minimizing impervious cover, requirements for reserve sewage disposal capacity and limitations on pollution from stormwater runoff to pre-development levels for new development and redevelopment.

New Kent - Newport News Water Agreement

New Kent County and Newport News entered into an agreement in 1993 on several water supply issues. One of the topics covered in the agreement is watershed protection for the Diascund Creek Reservoir. The County agreed to implement a watershed protection program similar to that adopted by Newport News in 1987. Elements of the proposed program include establishment of a watershed protection district, establishment of buffer zones, requirements for runoff control permits, requirements for use of BMPs for new development, establishment of spill containment measures, strict controls on land

disturbing activities on steep slopes and a requirement for a 100-foot setback for construction beyond the Newport News property boundary.

The Wetlands Landscape Analysis Project: Chickahominy River Watershed Model

This project is a cooperative public-private effort that was initiated by the US Fish and Wildlife Service (USFWS) to develop and test a proactive approach to managing cumulative impacts on the Chickahominy River watershed. The study area for the project extends from Hanover County to James City County. The project is currently supported by a Technical Committee and the Chickahominy Watershed Alliance. The Technical Committee is coordinated by the USFWS and includes members from the Virginia Commonwealth University, the Virginia Institute of Marine Science, William and Mary, the University of Richmond, the Virginia Natural Heritage Program, the U.S. Geological Survey and the Virginia Department of Game and Inland Fisheries. The goals of the Technical Committee include documenting the relationships between hydrology, water chemistry, and biotic diversity. This information will be used to analyze the impact of human-induced changes over time. A Geographic Information System will be used as a platform for this analysis.

The Chickahominy Watershed Alliance is composed of diverse group of watershed residents. It is the intention of the Alliance to utilize the information produced by the Technical Committee to promote conservation and stewardship of the natural resources in the watershed. The Alliance organizes educational events and field days to inform other watershed residents about the watershed project and conservation activities.

CITY OF NEWPORT NEWS

INTRODUCTION

Newport News Waterworks draws raw water from the Chickahominy River and directs it to a series of reservoirs that include Diascund, Little Creek, Skiffe's Creek, Lee Hall and Harwood's Mill. Two of the reservoirs, Skiffe's Creek and Lee Hall, lie partially within the boundaries of the City of Newport News. The remaining reservoirs lie in other jurisdictions. The Skiffe's Creek reservoir straddles the border between Newport News and James City County at the north end of the City. The bulk of the Lee Hall reservoir and its watershed lies in the north end of the City, adjacent to the border with York County. A small portion of the watershed of the Harwood's Mill reservoir abuts the eastern border of the City adjacent to the Newport News/ Williamsburg International Airport. Treatment plants at Lee Hall and Harwood's Mill deliver finished water to citizens of Newport News, Hampton, Poquoson, York County and part of James City County. Newport News Waterworks provides a backup supply of raw water to Williamsburg. In addition, a small portion of the Big Bethel reservoir, which is owned by the U.S. Army, lies within the City. The Big Bethel reservoir is located at the intersection of the boundaries of Newport News, Hampton and York County in the southeastern corner of Newport News.

According to the City's current estimates approximately 90.2 percent of the land in the City is developed. The existing land use patterns in the water supply watersheds are as follows. The Skiffe's Creek watershed is mixed use with community facilities, low and medium density residential and some vacant land. The Lee Hall reservoir watershed is mostly park land with some low and medium density residential and a small amount of vacant land. According to the Lee Hall Area Plan, which was adopted by the City in January of 1997, land use percentages for the portions of the Skiffe's Creek and Lee Hall watersheds within Newport News are as follows: residential: 7.6%, commercial: 0.4%, Industrial: 7.1%, parks and open space: 45.5 %, streets and rights-of-way: 12.2% and vacant: 23.9%. The portion of the Harwood's Mill reservoir watershed in Newport News is dominated by the Newport News/Williamsburg International Airport. The Big Bethel reservoir watershed features medium density residential, retail and community facility uses. Two stormwater diversion projects have been implemented to protect drinking water supplies in Newport News. The Jones Run Diversion transfers stormwater from the Jones Run Drainage Area to the headwaters of the Warwick River, circumventing the Lee Hall Reservoir. The Route 17 Diversion transfers stormwater from the Route 17 transportation corridor to the headwaters of the Poquoson River, circumventing the Harwood's Mill Reservoir.

The land use plan for the City depicts the following uses for vacant land in the water supply watersheds. Designated uses for the vacant land in the Skiffe's Creek reservoir watershed include a natural area buffer around the reservoir and additional industrial use areas. The land use plan for the Lee Hall area projects that most of the new development will occur in office, commercial, industrial and community facility land uses. The Harwood's Mill watershed shows no change. In the Big Bethel watershed vacant land is designated as a natural area buffer surrounding a portion of the reservoir.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Reservoir Protection Ordinance

Newport News is one of the few localities in the Planning District that has an ordinance specifically designed to protect drinking water supplies through watershed management. The Reservoir Protection Ordinance limits land uses, establishes a buffer area and outlines requirements for a runoff control permit.

The Reservoir Protection Ordinance begins with the following statement of purpose:

> "*Purpose and intent*" The purpose of this article is to protect against and minimize the pollution and degradation of the drinking water supply impoundments in the City of Newport News resulting from land development in the respective watersheds thereof. To accomplish this purpose this article provides for:
>
> 1. The creation of the reservoir protection area;
>
> 2. Modifications to the use and dimensional regulations within the area; and
>
> 3. The requirement of a runoff control permit for all development within the area (City of Newport News, 1997).

Reservoir protection areas

The provisions of the Ordinance apply to the watersheds of the Skiffe's Creek, Lee Hall and Harwood's Mill reservoirs. In cases where the watersheds extend beyond the boundaries of Newport News, the Ordinance applies only to the portion of the watersheds within the city boundaries. The Newport News Department of Engineering maintains maps showing the watershed boundaries.

Runoff control permits

A runoff control permit is required for most forms of development in the water supply watersheds. Exceptions are granted for the installation or repair of small water supply systems, the interior repair of existing structures and developments for which plans have already been submitted and approved prior to the date of the adoption of the Reservoir Protection Ordinance. The following conditions apply to the permits:

> The application for the permit must include a runoff control plan prepared by a registered professional engineer with specifications for the temporary and permanent control of surface water runoff .
>
> The Newport News Runoff Control Official will review the plan to ensure that the quality and quantity of surface water runoff will not be detrimental to the water

quality of the impoundment. The plans should provide for a diversion/retention system which is equally or more effective as the wet ponds outlined in the City of Newport News "Design Criteria Manual" in containing and removing potential pollutants. Plans should also provide for the containment of a spill of any materials stored on the property.

A bond is required to insure that the runoff controls specified in the permit are completed in a timely fashion.

The maintenance, repair and replacement of any temporary or permanent runoff control measures is the responsibility of the property owner.

Septic Tanks and Drain Fields

The general policy of the Newport News City Council is to discourage the installation of new septic tanks and drainage fields in reservoir protection areas. For lots of record existing as of the date of passage of the Reservoir Protection Ordinance new septic tanks and drainage fields may be installed given that the system does not encroach on the buffer zone and health department approval is obtained. Septic systems are allowed on new lots given that they meet the above criteria and the lots are at least one acre in size. Properties in which septic systems are installed pursuant to this section must connect to the Newport News public sewer system when such a connection is "reasonably available".

Prohibited Uses

Several land uses are prohibited within the reservoir protection areas. The prohibited uses include the manufacture, bulk storage and distribution of petroleum, chemical, or asphalt products, or any materials hazardous to a water supply. Within buffer zones septic tanks, drain fields, trash containers, dumpsters, feed lots, livestock impoundments and fuel storage in excess of fifty gallons are prohibited. Sewage pumping stations and sewage lines are prohibited unless they meet the standards set forth in the City Design Criteria Manual-Standards and Specifications.

Buffer Zones

Development is prohibited within two hundred feet from the center of any perennial stream, within two hundred feet of the edge of any city reservoir or within one hundred feet from the center of any intermittent stream. Crossing of perennial or intermittent streams by roads and utilities are allowed only when necessary for the development of the site or to meet city regulations. The crossings must be located to minimize adverse water quality impacts as determined by the Department of Public Utilities. Buffer width can be reduced to no less than fifty feet when it can be proven to the satisfaction of the runoff control official that a combination of the reduced buffer and best management practices yield the same water quality protection as the full buffer. In cases of significant hardship, the buffer width on a single parcel can be reduced to no less than twenty five feet to allow the construction of one detached single family structure.

Reservoir Protection Appeals Committee

An appeals committee is established to review decisions of the runoff control officials when appealed by runoff control permit applicants. In addition, the committee will advise the City Council on property acquisition for reservoir protection.

Review Standards

The runoff control official is responsible for the development of guidelines for the calculation of pre- and post-development runoff flow rate and characteristics. In addition, the guidelines will identify acceptable measures for runoff control. The guidelines will be submitted to Council for approval.

Inspections and Enforcement

The runoff control official and his designated agents shall have the right to enter property subject to this article at all reasonable times for the purpose of monitoring surface water runoff and making inspections relating to compliance with the provisions of the Runoff Control Ordinance. Runoff control permits may be revoked for noncompliance. Violation of the conditions of a permit are punishable by a fine of not less than $100 and not more than $500 per day.

Overlap with Other Programs

Development projects in the water supply watersheds are subject to compliance with stormwater management regulations and development proposals are reviewed by both Waterworks and the Newport News Engineering Department. There is no overlap between Chesapeake Bay Protection Areas and Reservoir Protection Areas in Newport News.

NPDES MS4 Stormwater Program

The City of Newport News Stormwater Management Program includes several elements that impact water supply watershed management. The Stormwater Management Program addresses maintenance, engineering, and inspection of stormwater management infrastructure, planning functions, public education, development of new regulations to control pollutants and various stormwater management feasibility studies.

Other Watershed Management Efforts

Spill Response Program: The Newport News Fire Department has established a hazardous materials response policy. The Hazmat Team provides on-site response to hazardous materials releases in the City and region. In addition, the Newport News Public Works Department assists in spill containment and maintains an emergency number that can be used to receive calls related to spills. Information is relayed to the Communications and Emergency Services Department.

Public Information Programs: Newport News has a public information program designed to provide information on water quality protection through its Public Information Office. The goals of the program include educating the public on what stormwater management is, how pollutants enter stormwater, how to properly dispose of hazardous products, how to report illicit discharges, and the benefits of proper water quality management. Information is disseminated through cable television programs, newspaper advertisements, storm drain stenciling and poster contests in public schools. In addition, Newport News Waterworks also runs a public information program.

Insecticide Application: Waterworks has initiated a system to limit the application of insecticides by the Virginia Department of Transportation in water supply watersheds. Red and green markers are used on Interstate 64 to mark the edge of the watersheds. Workers applying insecticide stop application when a red marker is reached and begin again when a green marker is reached.

CITY OF NORFOLK

INTRODUCTION

The reservoir system owned by the City of Norfolk consists primarily of two groups of lakes. The first group, the In-Town Lakes, are located in Norfolk and Virginia Beach. The second group, the Western Lakes, are located in Suffolk and Isle of Wight County. The total area of the watershed of the In-Town system is approximately 11.8 square miles. Two of the reservoirs in the In-Town System are located in Norfolk. Lake Wright and Lake Whitehurst are both located in the northeastern corner of the City adjacent to the Virginia Beach border. The watersheds of Lake Wright and Lake Whitehurst are split between Virginia Beach and Norfolk.

LAND USE PATTERNS

The bulk of the land in the water supply watersheds in Norfolk is developed. Land use categories represented in the watersheds include residential, commercial, industrial, institutional and recreational. Specific facilities located in the watersheds includes the Norfolk International Airport, Little Creek Amphibious Base, Lake Taylor High School and Middle School, Lake Taylor Hospital and the Lake Wright golf course.

WATER QUALITY ISSUES

Water-quality problems in the In-Town Lakes are primarily the result of high phosphorus concentrations. Stormwater runoff is the major source of phosphorus loading. The nutrient loading causes the reservoirs to fluctuate between eutrophic and hypereutrophic conditions, as measured according to Carlson's trophic state index. Water-quality problems in eutrophic reservoirs include algal blooms throughout the growing season; taste and odor problems from the excessive algae growth, and fish kills from periods of low dissolved oxygen. Eutrophication can result in loss of reservoir volume, increased trihalomethane (THM) precursors, and increased treatment costs to control taste and odor problems. (Hauger, et al, 1996). Norfolk is currently using duck weed harvesting equipment in two of the lakes to remove excess vegetation that has resulted from the eutrophication. The harvesting has been undertaken in response to requests by local residents.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

NPDES MS4 Program

The National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) program is intended to foster evaluation and reduction of non-point source water pollution. (A general discussion of the MS4 program is contained in the section of this report dealing with Clean Water Act.) Norfolk's NPDES program applies to the entire City and is a significant factor in water supply watershed management. The program serves to coordinate existing water quality protection programs and has fostered several new initiatives including modeling and monitoring of the City's watersheds. Under

the NPDES MS4 program, Norfolk is required to reduce the discharge of pollutants from the municipal storm sewer system to the maximum extent practicable using management practices, control techniques and systems, and design and engineering methods. Additionally, Norfolk must adhere to applicable state programs, including the Erosion and Sedimentation Control Law and Wetlands Use and Development Regulations. The activities contributing to the improvement of stormwater quality are housed in several departments throughout the City. The collective efforts of these departments constitute Norfolk's Storm Water Quality Management Program (City of Norfolk, 1992).

Characterization Data

The NPDES MS4 program requires Norfolk to perform water quality monitoring and watershed modeling to determine the quantity and quality of stormwater runoff in the City.

Water Quality Monitoring

Two of the automated stormwater samplers required by the program are located in the watershed of the In-Town Lakes. Sampling site MS-8 is located on Lake Wright and MS-9 is located on Lake Whitehurst. The monitoring program includes testing for a broad range of pollutants. Three sets of samples were collected prior to the submission of Part Two of the permit application in November of 1992. Four storms per year will be measured during the five year period following the issuance of the permit. The results from the monitoring program will be used to both identify non-point pollution sources and calibrate the watershed model.

Watershed Modeling

The stormwater quality model P8 was used to estimate annual pollutant loads and event mean concentrations for discharges from the Norfolk outfalls. According to the permit application the computer model computes pollutant loads and concentrations by using simulated runoff volumes for both pervious and impervious areas (City of Norfolk, 1992). Sixteen subwatersheds were delineated and digitized to support the modeling effort. The land use composition of each watershed was identified and used as an input to the model.

Norfolk's Storm Water Quality Management Program

Norfolk's Storm Water Quality Management Program, as described in Part II of the NPDES MS4 Permit Application, consists of elements that address runoff from commercial and residential areas, non-stormwater discharges, runoff from industrial facilities and runoff from construction sites.

City Charter and Code

Many sections of the Norfolk Charter and Code impact the management of water supply watersheds. The following section lists several of the key provisions.

Water Supply/Watershed Management

The Charter of the City of Norfolk and Section 46-28 of the Code of the City of Norfolk, Virginia, 1979, specifically authorize the City to control, regulate, and enforce provisions to protect the water supply and watersheds of the City.

Section 2 of the Charter references the general powers of the City. The following section outlines the City's watershed management authority.

> "...to make reasonable rules and regulations for promoting the purity of its said water supply and for protecting the same from pollution; and for this purpose to exercise full police powers and sanitary patrol over all lands comprised within the limits of the watershed tributary to any such water supply wherever such lands may be located in this state; to impose and enforce adequate penalties for the violation of any such rules and regulations; and to prevent by injunction any pollution or threatened pollution of such water supply and any and all acts likely to impair the purity thereof;..." (City of Norfolk)

Section 46-28 of the City Code references specific regulations for protection of the water supply and watershed areas.

> **Sec. 46-28. Pollution of water supply generally; protection of watershed.**
> (a) No person shall put any filth, animal or vegetable matter, chips, shavings or any other substance on the waterworks property, or do any injury thereto, or in any manner pollute the water supply of the City.
>
> (b) It shall be unlawful for any person to defile or render impure, turbid or offensive the water used for the supply of the inhabitants of the city, or to endanger the purity thereof by the following means, or any of them: By constructing or maintaining any privy vault, cesspool, septic tank or any contrivance for the elimination or destruction of human waste, within those portions of the watershed of the City contiguous to the intake of the city's water supply, as hereinafter described, or by placing any foul or putrescible substance, whether solid or liquid, and whether the same be buried or not, within the limits of the portion of the watershed so described.

Chesapeake Bay Preservation Act

In Norfolk, the Bay Act does not apply to the watersheds of drinking water reservoirs. The Chesapeake Bay Preservation Area Development Handbook for Norfolk states that properties adjacent to nontidal bodies of water, such as drinking water reservoirs and other lakes or impoundments, are not affected by the CPBA regulations. (City of Norfolk, 1991). The City is currently considering a proposal to identify the water supply watersheds as Chesapeake Bay Preservation Areas.

SOUTHAMPTON COUNTY

INTRODUCTION

Southampton County contains a portion of both of the watersheds of two of the water supply rivers for the Norfolk utility. The Blackwater River forms the eastern boundary of the County. The Nottoway River flows through the center of the County. The withdrawal point in the Blackwater River is upstream of Franklin. The withdrawal point on the Nottoway River is upstream of Courtland. Thus, most of the northeast portion of the County is in a water supply watershed.

LAND USE

The bulk of land in the water supply watersheds is agricultural, forestal and rural residential. The Town of Ivor is located in the northeast corner of the County. Land use patterns in the County have changed little over the last forty years except for residential and commercial growth around Franklin and Courtland (Southampton County, 1989). The bulk of the agricultural land in the County is devoted to crop production, although there are several livestock operations including Smithfield-Carroll Foods, an extensive hog raising operation in the northern part of the County near Dory.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Comprehensive Plan

The Land Use Plan Map contained in the 1989 Comprehensive Plan identifies the area surrounding Ivor as a residential development area and a major commercial center. In addition, a commercial/industrial corridor is identified adjacent to Route 460 where it passes through Ivor.

Agricultural Management

The Natural Resource Conservation Service (NRCS) is involved in several cost share programs that impact stormwater runoff from agricultural lands in Southampton County. The programs include establishment of buffer areas around waterways, installation of erosion control structures and control of livestock waste. In addition, the NRCS is starting an environmental incentive program that will involve assessment of agricultural operations in the County that adversely impact water quality and development of a plan to deal with the problems. Federal cost share money will be made available based on that plan.

The Agricultural Extension Office in Southampton County is involved in education of farmers on a number of topics that impact water quality, including proper application of pesticides and herbicides. Farmers are advised on testing methods to determine the need for application of these chemicals.

Large livestock operations are subject to permits administered by the Virginia Department of Environmental Quality. The permits require particular management practices based on the size and location of the operations.

CITY OF SUFFOLK

INTRODUCTION

The City of Suffolk is divided into two main watersheds. The northern section of the City drains to the lower James River, while the southern section of the City drains to the Chowan River. Suffolk is a host community for the reservoirs of both Norfolk and Portsmouth. In addition, Suffolk maintains a grouping of small reservoirs for its own water supply. All of the reservoirs lie in the James River Watershed. Portsmouth's reservoirs, Lakes Cohoon, Kilby and Meade and Speight's Run are located in the center of Suffolk adjacent to the urban core of the City. Norfolk's Lake Prince, Lake Burnt Mills and the Western Branch Reservoir are located in the northwest corner of the City. The lakes abut the western border of the City and the watersheds of the reservoirs extend into Isle of Wight County. The lakes that provide Suffolk's drinking water are located in the extreme northwest corner of the City. This reservoir system consists of ten lakes. Nine of the lakes are located in Lone Star Lakes Park. Crumps Mill Pond, the tenth lake, is located just west of the park (SVPDC, 1988).

Suffolk is experiencing a dramatic increase in development pressure. The number of residential building permits issued between 1993 and 1995 increased 77 percent from 501 to 806 (HRPDC(a), 1996). Driving the development rate increase is a rapidly growing population that is projected to double from 55,000 to 110,000 by 2018 (HRPDC(b), 1996).

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act (CBPA) is the primary tool for water supply watershed protection in Suffolk. The CBPA is implemented as an overlay district in the Suffolk Zoning Ordinance. The entire portion of the City that is in the Bay watershed is designated as a Resource Management Area (RMA). In addition, a 100 foot buffer surrounding the water supply reservoirs is designated as a Resource Protection Area (RPA).

Development Standards in RMAs

Permitted uses in RMAs in Suffolk are guided by the underlying zoning. Performance standards for site development include the following:

- All development exceeding a disturbed land area of 2,500 square feet shall be accomplished through a development review and comply with the Suffolk Erosion and Sediment Control Ordinance.
- Septic systems must be pumped out every five years.
- Development and redevelopment are subject to significant stormwater management standards.

- Land disturbance shall be limited to the area necessary for the desired use.
- Indigenous vegetation shall be preserved to the maximum extent possible.
- Impervious cover shall be minimized (City of Suffolk, 1995).

Development Standards in RPAs

Development Standards in RPAs are significantly more restrictive than those in RMAs. The only permitted uses are water dependent facilities and redevelopment of a site. Density of redevelopment is controlled by the underlying zoning. A 100 foot buffer is required (which can be reduced to 50 feet with appropriate best management practices) surrounding the water supply reservoirs. Within the buffer area natural vegetation must be maintained. In agricultural lands a 50 foot buffer is required (City of Suffolk, 1995).

Nansemond/Chuckatuck Rural Clean Water Project

The Nansemond/Chuckatuck Rural Clean Water Project was a ten year effort focused on implementation of agricultural Best Management Practices (BMPs) and monitoring of water quality to determine the effectiveness of the BMPs. The study area included approximately 114,000 acres of the Nansemond/Chuckatuck basin in Suffolk and approximately 48,000 acres in Isle of Wight County. The project took place during the period from 1981 through 1989. According to Paul Fisher, Suffolk's Planning Director, approximately two million dollars was invested in BMPs. Animal waste containment and efforts to keep animals out of the reservoirs were among the most effective initiatives.

Comprehensive Plan

Chapter four of the Suffolk Comprehensive Plan contains the General Plan Standards. The Environmental Standards section of chapter four contains a set of minimum standards for water supply watershed management. These standards include recommendations for the establishment of Watershed Management Areas along each water supply impoundment and its tributaries. These Management Areas are intended to contain "filter strips", areas of perennial vegetation that act to filter sediment from runoff (City of Suffolk (b), 1989). In addition, the standards state that all development and land disturbing activities which occur adjacent to or in water impoundment areas should be restricted to the minimum area required for the proposed development (City of Suffolk, 1989). The standards also call for revegetation of denuded areas, implementation of BMPs by farmers, periodic monitoring of water quality in impoundments, and restriction of residential development in Watershed Management Areas not served by central sewer systems to a minimum lot size of one acre (City of Suffolk, 1989). The Suffolk Comprehensive Plan is currently under revision.

Land Use Plan

The City of Suffolk developed a detailed Land Use Plan Map as part of the 2005 General Plan. The map is intended to provide a general picture of future development patterns in the City. The land use projections are based on several factors including the underlying zoning in the City and planned utility provision. Several Urban Development Areas (UDA) are identified on the map. The General Plan states that urban development should be directed into the UDAs to promote compact development and to prevent urban sprawl (Suffolk (b), 1989). Due to their proximity to the urban core of Suffolk, the watersheds of the Portsmouth reservoir system contain more medium and high density uses than either the Norfolk or Suffolk reservoir systems. A large portion of the Portsmouth reservoir system is located within the largest and most dense UDA in Suffolk. Within the UDA the designated land uses include high density, medium density, low density and rural residential, high and medium intensity industrial, office, high intensity commercial and a variety of publicly held lands. The portion of the watershed outside of the UDA is designated for agricultural, forestal and residential uses. Of the three reservoir systems located in Suffolk, the watershed for the Portsmouth system contains the widest variety of land uses. Norfolk's reservoir system is located almost totally outside of the urban development areas with the bulk of its watershed projected for rural residential and agricultural uses. In addition, several large land areas adjacent to the reservoirs are designated for public use. The bulk of Suffolk's reservoir system is located within an urban development area. Designated land uses include low density and rural residential, medium density commercial and public land.

VIRGINIA BEACH

INTRODUCTION

The City of Virginia Beach has two water supply watershed areas. Part of Norfolk's In-town Lake System is located in the northwest corner of the City and Stumpy Lake, also part of the Norfolk system, is located on the western border of the City. The portion of the In-town Lake System located in Virginia Beach includes Lake Smith, Lake Lawson, and Little Creek Reservoir. The watershed of the In-town Lake System is split between Norfolk and Virginia Beach. Stumpy Lake is located near the intersection of Lynnhaven Parkway and Indian River Road. The bulk of the lake and its watershed are located in Virginia Beach, with a small fraction located in the City of Chesapeake.

LAND USE

In-town Lakes: The portion of the In-town Lakes watershed in Virginia Beach is highly developed. Land uses are predominantly residential, but also include industrial, military, recreational and institutional uses. Major features in the watershed include the U.S. Naval Amphibious Base-Little Creek, the Cypress Point Country Club, the Virginia Tech Agricultural Experimental Research Center, the Airport Industrial Park and Bayside High School. Some new residential development is taking place around lakes Smith and Lawson.

Stumpy Lake: Stumpy Lake is surrounded by lands owned by the City of Norfolk and used in part for the Stumpy Lake Golf Course. The area north and east of the Lake is predominantly residential.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act (CBPA) is one of the primary tools for water supply watershed protection in Virginia Beach. The CBPA applies to the entire Chesapeake Bay watershed and therefore impacts the management of the watersheds of the In-town Lakes. The entire portion of the City that is in the Bay watershed is designated as a Resource Management Area (RMA). The Resource Protection Area designation does not apply to the In-town Lakes.

Development Standards in RMAs

Permitted uses in RMAs in Virginia Beach are guided by the underlying zoning. Performance standards for site development include the following:

- Land disturbance shall be limited to the area necessary for the desired use.
- Indigenous vegetation shall be preserved to the maximum extent possible.
- Impervious cover shall be minimized.

- All development exceeding a disturbed land area of 2,500 square feet shall be accomplished through a development review and comply with the erosion and sediment control provisions.
- Septic systems must be pumped out every five years.
- Stormwater runoff in new development shall not exceed predevelopment loadings and runoff in redeveloped areas shall be reduced by 10 percent (City of Virginia Beach, 1988).

Southern Watershed Management Ordinance

The Southern Watersheds Management Ordinance applies to the Back Bay, North Landing and Northwest River watersheds in Virginia Beach. Stumpy Lake is in the Southern Watershed Area. The objective of the ordinance is to protect, enhance and restore the quality of the waters within the Southern Watershed Area. Performance standards for development include adherence to erosion and sediment control requirements, reserve drainfield requirements, prohibition of development within 50 feet of any shoreline or specified wetlands and requirements for matching of pre and post development runoff conditions.

Development of any land within the Southern Watersheds, except single-family dwellings and duplexes that are not part of a subdivision, requires submission of a Southern Watersheds Management Plan. The plan must contain the existing environmental and hydrologic conditions of the site and receiving waters. Specific information includes the direction, flow rate and volume of stormwater runoff under existing conditions, a description of all watercourses on the site, location of floodplains, identification of vegetation, the topography of the site and soil types. Proposed alterations of any site adjacent to a shoreline require a description of changes to topography resulting from development, areas where vegetation will be cleared or killed, areas to be covered with impervious surface, size and location of proposed buildings and predicted impacts on water quality. In addition, a plan for control of stormwater runoff must be submitted along with a plan for BMP maintenance.

Provisions under the ordinance for agricultural operations consist of encouragement of voluntary measures including participation in demonstration and education projects, cost-share incentives and technical assistance programs.

The Lake Smith/Lake Lawson Watershed Initiative:

The Lake Smith/Lake Lawson Watershed Initiative was created to increase public awareness of water supply watershed management issues and foster public involvement in watershed management initiatives. It is a joint effort of the following agencies:

City of Norfolk:	Department of Utilities
	Bureau of Environmental Services
City of Virginia Beach	Department of Public Works
	Environmental Management Center
	Cooperative Extension
Natural Resources Conservation Service	
Virginia Dare Soil and Water Conservation District	

The initiative was formed in 1995 based on meetings held between several agencies to discuss shared goals for protection of Lakes Smith and Lawson. A local steering committee was formed to guide the Initiative. The steering committee is composed of watershed residents and agency representatives. Monthly meetings of the steering committee are held to plan educational programs and disseminate information on watershed protection. The mission statement for the Initiative is "To promote and improve water quality and conservation through education and example" (Rosenthal (a), 1996). The initiative has fostered the following activities:

Field Day: This event was held at in the Spring of 1996 and featured educational exhibits by the Virginia Department of Game and Inland Fisheries, Virginia Beach Cooperative Extension, Virginia Dare Soil and Water Conservation District, Southeastern Public Service Authority and various departments from the City of Norfolk.

Fact Sheet: Covers topics such as proper lawn care, proper use of fertilizer, non-point source pollution and watershed protection. The fact sheet has been distributed to all residents of the watershed.

Water Quality Monitoring Program: A science teacher at Bayside High School is leading a water quality monitoring program. Students are involved in collecting and analyzing samples from several sites in the watershed. Information gathered during the five year program will be added to the existing data base maintained by Norfolk Utilities.

The Watershed Initiative has met with mixed results. According to Norfolk reservoir manager Mr. David Rosenthal, one of the agency coordinators of the Initiative, the main problem with the Lake Smith/Lake Lawson Initiative has been a lack of public buy-in. Agency staff has been responsible for much of the activity that has taken place. Mr. Rosenthal feels that the majority of residents and businesses in the watershed are still relatively uninformed about watershed management issues (Rosenthal (b), 1996). On the positive side a local nursery has run educational programs in the watershed and Virginia Beach Public Works traffic will post signs marking the edge of the watershed. If the

Initiative takes off and a higher level of public involvement is achieved then the program may be expanded to include the Little Creek reservoir.

The Southern Watershed Area Management Program

The Southern Watershed Area Management Program (SWAMP) is a joint project of the Cities of Chesapeake and Virginia Beach, coordinated by the Hampton Roads Planning District Commission and funded in part by the Virginia Coastal Resources Management Program. SWAMP is described in the section of this chapter that deals with the City of Chesapeake.

WILLIAMSBURG

INTRODUCTION

The Waller Mill Reservoir, which is located in York County, is the primary water supply for the City of Williamsburg. The bulk of the watershed is in York County. The City of Williamsburg owns approximately one-half of the land in the watershed. The Williamsburg land holdings are predominantly forested and are maintained for watershed protection. In addition, York County has a watershed protection program that applies to its land holdings in the watershed. That program is described in the York County chapter. A very small portion of the watershed extends from York County into the northwest tip of Williamsburg. Land uses in this area of the City are predominantly residential and commercial.

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

Comprehensive Plan

The Land Use Plan Map in the 1989 Comprehensive Plan designates the small fraction of the Waller Mill watershed that extends into Williamsburg for general commercial and low density residential uses.

Stormwater Management Plan

Williamsburg's stormwater management plan includes the development of regional stormwater BMP's and maintenance of vegetation in stream valleys and sensitive environmental areas that trap and filter runoff. The Comprehensive Plan calls for the creation of an overlay district that would strongly discourage development of such areas and require a special permit for removal of vegetation or filling of ravines in sensitive areas (City of Williamsburg, 1989).

Chesapeake Bay Preservation Act

The City's Chesapeake Bay Program does not apply to the Waller Mill watershed.

YORK COUNTY

INTRODUCTION

York County is divided into three main watersheds, the northern section of the County drains to the York River, the southern section of the County drains to the Poquoson River and the Chesapeake Bay and the western edge of the County drains to the James River. York County contains all or part of five different water supply reservoirs.

The Waller Mill Reservoir and Jones Pond are located in the York River watershed. The Waller Mill Reservoir is in the northwest corner of the County and the entire reservoir and the bulk of its watershed are within the County boundary. The reservoir is part of the Williamsburg waterworks system. Jones Pond lies to the southeast of Waller Mill in the northern section of the County. Its entire watershed is within the County boundary. The reservoir belongs to the U.S. Navy.

The Lee Hall Reservoir is located in the James River watershed. The bulk of the Lee Hall reservoir lies in Newport News with a small portion of both the reservoir and its watershed extending into the west central portion of York County. The Lee Hall reservoir is part of the Newport News Waterworks system.

The Harwood's Mill and Big Bethel reservoirs are located in the south end of the County in the Chesapeake Bay watershed. All of the Harwood's Mill reservoir and the bulk of its watershed lie within the County boundaries. The Harwood's Mill reservoir is part of the Newport News Waterworks system. The Big Bethel Reservoir is located at the extreme southern tip of the County. It straddles the border with Hampton and Newport News, with its watershed extending into the three localities. The reservoir is owned by the U.S. Army.

LAND USE

Approximately 36% of the total land area in York County is owned by the federal government. These land holdings include military installations and a national park. The cities of Newport News and Williamsburg each own reservoirs and watershed property in the County. These holdings account for another 10% of the land area in York County. Thus, almost half of the land in the County is held by other governmental entities. The bulk of the land owned by the federal government is concentrated in a linear area that extends from the northeast corner of the County to the southwest. The land that is available to the County for future development is concentrated in the northern and southern ends of the County.

The land use chapter of the York County Comprehensive Plan analyzes existing land uses, environmental constraints, and land use plan designations for each of 36 planning areas in the County. The following section provides a synopsis of that information for the planning areas in water supply watersheds.

Waller Mill Reservoir

Planning Areas 33, 34 and 35: Planning Area 33 surrounds the Waller Mill Reservoir. Planning Areas 34 and 35 are located to the northeast of Area 33. Together they occupy a large portion of the Waller Mill reservoir watershed. Existing land uses in the three Areas include large lot residential, limited industrial, automotive and service uses. Public sewer services are not currently available in any of the three Areas. Environmental constraints on future development include steep slopes, severe erosion potential and proximity to the reservoir. The land use plan designations for these areas include low density residential, office, limited industrial, economic opportunity, resource management and conservation (York County, 1993). The City of Williamsburg owns approximately one-half of the land in the watershed which it maintains both as a park with camping areas and as idle land for watershed protection.

Jones Pond

The Jones Pond Reservoir is located on the U.S. Naval Weapons Station-Yorktown and is therefore not in a planning area.

Lee Hall Reservoir

The Lee Hall Reservoir watershed is located in Colonial National Historical Park and is therefore not in a planning area.

Harwood's Mill Reservoir

Planning Areas 6 and 7: Planning Area 6 surrounds the Harwood's Mill Reservoir. Planning Area 7 is located to the northwest of Area 6 and is bounded by Fort Eustis Boulevard to the north and Route 17 to the east. Together the two planning areas occupy a substantial portion of the Harwood's Mill watershed. A large portion of both planning areas is owned by Newport News and is maintained in a natural state. One of the runways of the Newport News/Williamsburg International Airport extends into Area 6, with the associated Airport land holdings extending to the edge of the reservoir. Proposed land uses for Area 6 include single and multi-family residential, general commercial, limited industrial and conservation. Proposed land uses in Area 7 include medium and high density single-family residential, office, commercial, limited industrial and conservation. Water and sewer services are currently available to only a portion of each Area. Future development will be tied to the provision of these services (York County, 1993).

Big Bethel Reservoir

Planning Area 3, Bethel: The Bethel Planning Area is bordered by the Big Bethel reservoir to the south and Victory Boulevard to the north. Existing land uses include apartments, small lot single-family homes, commercial development, military housing, a borrow pit that is being reclaimed and two elementary schools. Environmental constraints on future development include the 100-year floodplain, hydric and poorly drained soils, wetlands, and the location of this planning area in the Big Bethel watershed. Public water

and sewer are available in this section of the County. Projected land uses include high density single family residential, multi-family residential, general commercial, resource management and conservation (York County, 1993).

WATERSHED MANAGEMENT TOOLS AND INITIATIVES

York County Zoning Code

Watershed Management and Protection Area Overlay District

York County is one of only two localities in the Planning District with an ordinance that is specifically targeted at water supply watershed management. The purpose of the ordinance is summarized in the Statement of Intent:

> "*Statement of intent.* In accordance with the objectives of the comprehensive plan, the Watershed Management and Protection Area Overlay regulations are intended to ensure the protection of watersheds surrounding current or potential public water supply reservoirs. The establishment of these regulations is intended to prevent the causes of degradation of the water supply reservoir as a result of the operation or the accidental malfunctioning of the use of land or its appurtenances within the drainage area of such water sources (York County, 1995)."

The watershed management and protection area overlay district applies to three sections of York County. In the northwestern corner of the County a large land area surrounding the Waller Mill Reservoir is included. In the central section of the County the land area surrounding Jones Pond is included. In the southern half of the County a large swath adjacent to the western border that separates York County and City of Newport News is included. This section includes a small portion of the watershed of the Lee Hall Reservoir and the Harwood's Mill watershed.

The essential provisions of the ordinance include a limitation on allowable land uses in the overlay zones, requirements for a 200 foot buffer along the edge of tributary streams and reservoirs, requirements for an impact study for most forms of development and requirements for performance assurances to guarantee that all runoff controls and reservoir protection measures called for in the impact study are properly constructed, operated and maintained.

Limitation of Land Uses

Several land uses are specifically prohibited within the overlay areas. These uses include the storage or production of hazardous wastes as defined in either the Superfund Amendments and Reauthorization Act of 1986 or the Identification and Listing of Hazardous Wastes, 40 C.R.F. 281 (1987). Also prohibited is the land application of industrial wastes.

In addition to the restrictions that apply to the entire overlay area, a separate set of land use restrictions applies to the buffer strips and all lands within 500 feet of the buffer strips. These restrictions prevent septic tanks and drainfields, feed lots and other livestock impoundments, trash containers and dumpsters, fuel storage in excess of fifty gallons and sanitary landfills. In addition, activities involving the manufacture, bulk storage or distribution of petroleum, chemical or asphalt products or any materials hazardous to a water supply are restricted. Hazardous materials are identified by the definition provided in *Hazardous Materials Spills Emergency Handbook,* American Waterworks Association, 1975, and include the following general classes of materials:

oil and oil products;
radioactive materials;
any material transported in large commercial quantities which is a very soluble acid or base, causes abnormal growth of an organ or organism, or is highly biodegradable, exerting a severe oxygen demand;
biologically accumulative poisons;
active ingredients of poisons that are or were ever registered in accordance with the provisions of the Federal Insecticide, Fungicide and Rodenticide Act;
substances highly lethal to mammalian or aquatic life.

The restriction on toxic substances and associated land uses in the overlay zone is a significant difference between this ordinance and the Chesapeake Bay Preservation Act. Several localities in the Planning District use the Bay Act as a tool for water supply watershed management.

Impact Study Requirements

All development proposals, except the construction of an individual single-family home, in watershed management areas must be accompanied by an impact study. The impact study is to be performed or reviewed by a registered professional engineer who shall certify that the study has been conducted in accordance with good engineering practices. The study must include the following elements:

a. Description of the proposed project including location and extent of impervious surfaces; on-site processes and storage of materials; anticipated use of the land and buildings; description of the site including topographic, hydrologic, and vegetative features.

b. Characteristics of natural runoff on the site and projected runoff with the proposed project, including its rate and chemical composition including phosphorus concentration, nitrogen concentration, suspended solids, and other chemical characteristics as deemed necessary by the zoning administrator to make an adequate assessment of water quality.

c. Measures proposed to be employed to reduce the rate of runoff and pollutant loading of runoff from the project area, both during construction and after.

d. Proposed runoff control and reservoir protection measures for the project and performance criteria proposed to assure an acceptable level and rate of runoff quality. Such measures shall be consistent with acceptable best management practices and shall be designed with the objective of ensuring that the rate of surface water runoff does not exceed pre-development conditions and that the quality of such runoff will not be less than pre-development conditions. Special emphasis is placed on limiting encroachment of development into buffer areas.

e. Proposed methods for complete containment of a spill or leaching of any materials stored on the property which would or could cause contamination of drinking water sources.

f. Where the developer of property which is subject to the terms of this overlay district desires to utilize existing or planned off-site stormwater quality management facilities, the developer shall provide a written certification to the zoning administrator that the owner of the off-site facilities will accept the runoff and be responsible for its treatment to a level acceptable to the County and consistent with the watershed management requirements (York County, 1995).

Buffer Area Requirements

A two hundred foot wide buffer strip shall be maintained along the edge of any tributary stream or reservoir. The buffer strip must be maintained in a natural state or planted with an erosion resistant vegetative cover. Provisions are given for reduction of the of the buffer to an absolute minimum of fifty feet with additional erosion and runoff control measures. Development must be located outside the buffer area with the exception of development of facilities by a public water supplier or roads, main-line utilities, or stormwater management structures. In the latter three cases a set of requirements intended to minimize water quality impacts must be met.

Performance assurances shall be provided for permitted non-residential uses within the WMP areas. The assurances are intended to guarantee that all runoff control and reservoir protection measures proposed in the impact study shall be constructed, operated and maintained so as to meet the performance criteria set forth in the study.

Landscaping Requirements in the Zoning Code

The York County Zoning Code contains several landscaping provisions that are potentially beneficial to watershed management efforts. The statement of intent for landscaping regulations is as follows.

> "To establish minimum standards for the design of landscapes in development areas and practices for the preservation of trees in order to better control soil erosion and the transport of sediment, protect and improve

the quality of surface and groundwater, screen noise and dust, and preserve, protect and enhance the natural environment (York County, 1995)."

The Zoning Code goes on to state the following.

"In preparing landscape plans the following factors shall be considered:

(1) Trees, shrubs, groundcovers and other landscaping shall be located to utilize effectively the natural capacities of plant materials to intercept and absorb airborne and runoff related pollutants and to reduce runoff volume, velocity and peak flow increases caused by development (York County, 1995)."

These landscaping requirements are another important element in York County's watershed management efforts.

Planned Development Districts

Planned Development Districts are another tool that can be applied in York County to protect water supplies. The Zoning Code states the following.

"The purpose of the planned development district established by this chapter is to encourage a more efficient use of land and public services by allowing a more flexible means of development than is otherwise possible under typical lot-by-lot or cluster zoning restrictions. Further, this district provides opportunities for development which reduces land consumption, reduces the amount of land devoted to streets and other impervious surfaces, provides increased amounts of open space and recreational amenities, and encourages creativity and innovation in design, all of which could serve to enhance the quality of life and to reduce the tax burden on the citizens of the county (York County, 1995)."

The Zoning Code goes on to state that a minimum of twenty-five percent of the total residential area and twenty percent of the total non-residential area of any PD development shall be reserved as open space designed and improved or maintained for use by those who live or work within the development (York County, 1995). The common open space must be designed to facilitate its use, ensure continuity of design, and preserve sensitive environmental features.

Stormwater Management

The York County Comprehensive Stormwater Management Plan has been under development for several years. The County received seed funding from the Virginia Coastal Resource Management Program to begin development of a Comprehensive Stormwater Management Plan, and additional funding from the Chesapeake Bay Local Assistance Department to conduct water quality analysis for all drainage sub-basins for inclusion in the Plan. The County supplied funding for completion of the Plan, which was

finished in 1996. The County has been subdivided into 49 drainage basins and the basin boundaries were digitized for use on the County's geographic information system. Optimum solutions for each sub-basin were modeled and basin improvement plans prepared. Under the Plan, stormwater BMPs are installed and maintained either by developers or homeowner associations; the County advises on maintenance but does not operate or maintain the facilities.

CHAPTER 5

WATERSHED MANAGEMENT TECHNIQUES

WATERSHED MANAGEMENT TECHNIQUES

The methods used to achieve watershed protection goals may include the use of both deterministic and application tools. Deterministic tools provide the decision maker with sufficient information to make decisions regarding the management of complex systems. Application tools, in the context of watershed management, are the pollution control techniques that can be used to achieve the goals of watershed protection.

DETERMINISTIC TOOLS

The current state-of-the-art management method for water resources is the Decision Support Systems (DSS). DSS has evolved to supersede "Management Information Systems" (MIS). DSS is an advisory system for management that involves a conglomeration of data bases, computer simulations and optimizations, graphical interfaces, and mapping tools. In theory, the use of a DSS is a straight forward process: data is collected; analyses are performed; and options and consequences are identified and evaluated. And finally, a management decision is made (Grigg, 1995). In reality, the flow of the DSS process may have many loops or repetitive steps before the management decisions can be made. Most problems involve the four basic principles of systems analysis which are state variables, decision variables, inputs, and outputs (Grigg, 1995). The "state variables" are those that characterize the status of a system at any given time. An example is the land use around a reservoir or the stage of a river. The "decision variables" are those that can be controlled. For example the pumping rate from a well or from an intake in a river. The "inputs" refer to the data or parameters that are externally applied to the system such as historical river stages and rainfall histograms or existing infrastructure, available funds, and even political opinion. The "outputs" refer to the consequence of the decisions such as safe yield estimates and stormwater management scenarios. The major components that are time intensive in management and application in the DSS are the data bases, the models, and the graphical interface. It is very important for the data, the models and the graphical interface to be compatible with each other. The Geographical Information System (GIS) is a powerful tool that combines data management with a graphical/mapping interface. Developers of hydrologic computer models are also moving toward interfacing the computer simulation and optimization programs to access data in a GIS platform.

Geographic Information Systems

Geographic Information Systems (GIS) are a state-of-the-art technology for data management and decision support. The technology consists of computer hardware and software that simultaneously manipulates both geographic and associated tabular databases.

Throughout the world, local governments are using GIS to support all aspects of water resource planning and management. GIS can be interfaced with various computer programs to model and analyze the hydrology of the watershed and distribution systems for stormwater runoff, drinking water and wastewater. GIS can also be used to assess trends in water quality and can be used to geographically depict current and future land

uses and their impacts on raw water quality. The use of GIS in watershed management is limited only by the availability of information, staff time, and budget. GIS is not, however, the panacea for all water resource planning issues. Many local governments have been reluctant to move toward GIS because of the initial set up costs and the cost associated with collecting and digitizing or purchasing the data needed to perform complex analyses. Like any computer program used to assess complex spatial and temporal data, its results are based on various user defined assumptions, data limitations, and user interpretation. Therefore, it is critically important that the users of GIS and modeling software be aware of the limitations of these systems to accurately predict future conditions.

GIS in Hampton Roads

The localities in the Hampton Roads Planning District utilize a variety of different types of Geographic Information Systems (GIS). The systems vary in terms of hardware, system software, application software and types of coverages and attribute data included. Many of the systems are still evolving and a few are still in the initial planning phases. The most prevalent hardware/software combination is a UNIX workstation running ESRI's ARC/INFO software. Other combinations include PCs running the Windows/NT version of ARC/INFO, PCs running the INTERGRAPH MICROSTATION software and personal computers running AUTOCAD with the AUTOCAD Data Extension software. The following is a synopsis of the type of system utilized in each locality in the Planning District.

Chesapeake

Chesapeake is in the process of developing a workstation ARC/INFO based GIS system. The system is being developed by planning area, with Western Branch and Deep Creek being developed first. Coverages being developed include census tracts, transportation zones, street center lines, zoning, parcel boundaries, drainage basins and topography. Digital orthophotographs of the entire city are currently loaded on the GIS. Future plans include use of ArcView on desktop personal computers to provide GIS access for city staff.

Franklin

Franklin currently uses AUTOCAD to maintain information on the city's utility infrastructure.

Gloucester County

Gloucester County is currently developing a PC based system utilizing AUTOCAD and the AUTOCAD Data Extension software. The CAD system currently includes a set of planimetric maps for the entire County. Also in development are coverages that include tax maps, zoning and utilities infrastructure.

Hampton

Hampton is using workstation ARC/INFO. The city was flown in 1995. Coverages include digital orthophotographs, planimetric maps, tax maps, Chesapeake Bay Preservation Area boundaries and zoning.

Isle of Wight County

Isle of Wight County is in the process of developing a new GIS. The system is PC based and runs the Windows/NT version of ARC/INFO. The current system includes the street network and addresses and will be used to augment the existing E911 system. The next phase will include zoning and tax map coverages. Future plans include having flood maps digitized. National Wetlands Inventory information will also be incorporated. Long range plans include implementation of a county-wide network to support desktop systems running ArcView.

James City County

James City County has an ARC/INFO based GIS that includes tax maps, road network, water features, topography and zoning.

Newport News

The Newport News GIS has been under development since 1990. The GIS consists of IBM RS6000 and SGI workstations running workstation ARC/INFO and personal commuters running ArcView. Newport News has two separate initiatives under way, one focused on the City and a second focused on the service area for Newport News Waterworks. The Citywide GIS includes the following coverages: parcel maps, zoning, land use plan, fire districts, police districts, orthophotographs, FEMA flood maps, Chesapeake Bay Preservation Areas and reservoir protection area. Planimetric maps are under development and will include topography, building footprints and roads. The Waterworks GIS includes information from the following geographic areas: all of the cities of Hampton, Newport News, Poquoson and parts of York and James City Counties. The primary use of the Waterworks GIS is documentation and maintenance of utility infrastructure (pipes, valves, hydrants, etc.). The Waterworks GIS includes both land use and topographic information. Future plans include the addition of watershed boundaries and other natural features to the Waterworks GIS. The addition of these features will improve the usefulness of the system for watershed management.

Norfolk

The Norfolk GIS utilizes workstation ARC/INFO and PCs running ArcView. The City was flown in the winter of 1995. These images will be digitized for inclusion in the GIS. The watersheds of the Western Lakes have been flown, but these images are not orthophotographs and are, therefore, not suitable for inclusion in the GIS.

Poquoson

Poquoson does not currently have a GIS.

Portsmouth

Portsmouth is in the process of developing a GIS utilizing workstation ARC/INFO. The focus is on the area within the City boundaries. In addition, a 58 square mile area encompassing the watersheds of Portsmouth's extrajurisdictional reservoirs has been flown. Both visible spectrum and infrared photos were taken. The images are orthophotographs but they have not yet been digitized.

Southampton County

Southampton County is using AUTOCAD with the AUTOCAD Data Extension software. Coverages include tax maps and planimetric maps.

Suffolk

Suffolk currently has a PC Atlas based system that includes Chesapeake Bay Preservation Areas, major roads and water and sewer utility infrastructure. A more comprehensive system is in the planning phase.

Virginia Beach

Virginia Beach has information in ARC/INFO, AUTOCAD and INTERGRAPH MICROSTATION formats. A broad range of information has been digitized including utilities infrastructure, natural features, tax maps and drainage basins.

Williamsburg

Williamsburg currently has a CAD system that utilizes AUTOCAD. Coverages include new planimetric maps and orthophotographs.

York County

York County is currently using workstation ARC/INFO. Coverages include soils, flood plains, steep slopes, tax maps, zoning, topography, planimetric maps and drainage basins.

Hampton Roads Planning District Commission

The HRPDC has a SUN Workstation running ARC/INFO and networked PCs running ArcView. Available coverages include TIGER, National Wetlands Inventory, Digital Line Graphs and SPOT imagery. USDA Soils maps and FEMA flood maps are available for some localities in the Planning District. The HRPDC is in the process of updating the attribute data associated with the TIGER files.

Virginia Department of Transportation

The Virginia Department of Transportation (VDOT) is in the process of developing a statewide GIS to support development and maintenance of the State's transportation infrastructure. The cartography group within VDOT is developing a coverage featuring the road network at a 1:24,000 scale. The INTERGRAPH MICROSTATION GIS software is being used for the project. It is possible that features other than the road network will be included in the VDOT GIS, but no firm decision has been made.

Virginia Department of Conservation and Recreation

The Virginia Department of Conservation and Recreation has several sets of information available including the VIRGIS data, watershed boundaries associated with Virginia's Hydrologic Unit Codes (HUC) and Landsat data. The VIRGIS project was intended to evaluate agricultural nonpoint source pollution. For that reason no coverages exist for the dominantly urban localities in the Hampton Roads Planning District (Norfolk, Portsmouth, Hampton, Newport News and Poquoson). For several localities all of the coverages are available. The full set of coverages includes the following: agricultural land use, elevation, slope, erosion index, soils, water quality index, water features and delivery ratio. This full set of coverages is available for York County, James City County, Isle of Wight County and Suffolk. Land use, soils and wetlands data are available for Chesapeake and Virginia Beach. All coverages but soils are available for Southampton County. The VIRGIS data are available from the Virginia Department of Conservation and Recreation in both raster and vector formats.

United States Geological Survey

The USGS has several GIS coverages available, including Digital Line Graph data, which contain topographic and planimetric map features and Digital Elevation Models.

Application of GIS as a Tool for Watershed Management

Geographic Information Systems have the potential to be powerful tools for watershed management in Hampton Roads. Newport News Waterworks appears to be in the lead in terms of integrating information from several localities into a single system. However, the range of information in their system is oriented more toward managing the distribution system than for watershed management. This will likely change in the future as more natural resource information and watershed boundaries are added to the system. A first step in determining the potential for integration of local GIS into a regional system suitable for use in watershed management would be a detailed technical analysis of the coverages and attribute data contained in each local system. Only then would it be possible to determine which geographic areas have suitable information available and where gaps exist. Such an analysis would also identify compatibility problems between individual local GIS.

Several allied technologies are available to augment the watershed management capabilities of GIS. Remote sensing is improving rapidly as a tool for regional environmental analysis. Increased resolution combined with new techniques for image analysis will yield improved ability to differentiate between land uses and assess nonpoint pollution potential. GIS can also be used in conjunction with computer models both as a means of data input and as a tool for displaying the results of the analysis.

GIS Case Study: The Massachusetts Water Resources Authority

The Massachusetts Water Resources Authority (MWRA) provides over 2.5 million people in 60 communities in the Greater Boston area with wholesale water and wastewater services. The MWRA is responsible for the protection and maintenance of over 800 square miles of watershed and over 780 miles of large diameter pipe, dozens of pumping stations and several treatment plants. In 1989, the MWRA began developing a GIS to support management and planning needs. The program grew from a tool used to support general planning applications to a Decision Support System (DSS) that is suitable for automated mapping, hydraulic modeling, site specific analysis, maintenance and facilities management.

Source Water Watershed Protection

MWRA's first application of GIS involved watershed and wellhead protection. The agency developed a watershed protection program as part of a long-range water supply study to maintain the water quality of the Quabbin and Washusett reservoirs and the supplemental source water of its member localities. The regional water supply protection study commissioned by MWRA included delineating areas to be protected and identifying potential hazards in the area that could have adverse impacts on water quality. GIS was used to manage and analyze the extensive data collected for the 800 square miles of watershed, as well as to delineate the boundaries of the watershed and the critical areas needing protection. After protection areas or zones were identified, the potential sources of contamination were identified and mapped. GIS was used to manage a relational database and spatial overlays by which the sources for potential contamination were ranked according to the potential detrimental impact to drinking water resources. The data base generated for source water protection has been used repeatedly by member localities as they continue to protect their water resources.

Sewage Analysis and Management System

MWRA's second application of GIS was for the Sewage Analysis and Management System (SAMS). The MWRA's sewerage division wanted to update existing linen maps and conduct an extensive hydraulic study of their system. Based on the capital investments of the regional water supply protection project, the sewerage division developed a GIS application that not only would be useful in the SAMS but also could be used by the member localities. A region wide base map was generated from a 1:24,000 digital line graphs (DLG) road coverage and was enhanced to a scale that approximates 1:400. The project team developed several

new layers and applications to enable automated mapping of the sewerage facilities, hydraulic modeling of the sewerage system, as well as to help plan and design future facilities. The sewerage division also scanned all of the documents and images pertaining to the sewerage system so that an MWRA or member locality user can now retrieve physical information about a specific pipe or pump facility including the original design and record drawings based on its location relative to a road.

Water System Schematics and Other Projects

The MWRA has developed GIS applications to consolidate the water distribution facility data and source documents into a usable set of tables and digital maps. The geocoded data allows MWRA users to access the records and related data of every valve, pipe, pump, meter and fitting in the distribution system. The MWRA has linked the GIS to several real-time data bases. For example, it can be used not only to quickly locate a mainline valve of a given distribution branch but also to visualize the real-time status of the mainline valve. If a mainline valve becomes inoperable or is opened or closed, the GIS will automatically change the status of the valve according to a color code alerting the users of the change.

The MWRA has also completed a GIS application which consolidates over 100 years of geologic data into a relational data base that is geocoded and mapped. By having the exploratory boring locations spatially represented on a digital map and linked to the relational tables of data, the MWRA can better coordinate and control the cost of current and future exploration projects.

Conclusion

The MWRA has developed extensive GIS capabilities over the last eight years. The program started with a specific and fairly small application and through various projects and needs integrated the GIS into the management and decision making process of the MWRA. The base maps and many of the layers developed by the MWRA can be used by the member localities not only to help protect the water resource but also in other general planning applications. (ESRI, 1996)

Hydraulic Computer Modeling

The basic purpose of computer modeling in watershed protection is to simulate the influence of various stressors on the watershed. Numerous hydraulic models have been developed and used by water resource professionals across the nation and the world for many years. Development of new models and modifications and improvements to existing models are ongoing endeavors for hydrologists and programmers. A well designed and validated model can be extremely useful in predicting the reaction of a complicated natural system to an environmental stress. Computer models can be used to estimate or predict critical reservoir levels based on the trends in historical weather and water usage. They can be used to predict the impacts of municipal pumping or discharge to water systems as well as to predict the impacts of land use and imperviousness on surface water quality and

quantity. As can be seen from this description, the uses of computer models are as varied as the needs and new modeling applications for water resources are continuously being developed.

In general, a computer model answers questions that would be impractical to answer through field measurements and observation alone. The following are some rules that are helpful in understanding the application of any computer model (Nix, 1996):

- The results of a computer simulation are only as good as the input data.
- The results of a computer simulation will not be entirely accurate because every model is based on basic assumptions about complex systems.
- The numbers produced by a computer model are no more accurate than hand calculations, they are simply produced faster and, if programed properly, without human error.
- All models have limitations; sometimes the limitation are not recognized until the results of simulation are tested (even after validation is completed).
- Models are just tools and are not a substitute for sound judgement and analysis.

A model should be selected based on what the model is expected to accomplish. A simple model may be appropriate if all that is needed is a rough estimate. A more complex model may be needed to answer a design question. Cost-benefit analysis is one way to determine the level of effort that is appropriate. The cost for setting up the data, as well as running and validating the model should be commensurate with the costs associated with the consequences of the pending decision. Table 5-1 lists the most commonly used models by application categories.

Table 5-1
A Selection of a Few Commonly Used Hydrologic Models

Name	Author	Description
DR3M (Distributed Routing Rainfall-Runoff Model)	U.S. Geological Survey	A simulation distributed parameter model for urban rainfall-runoff applications. Soil moisture routine allows for quasi-continuous simulation.
HEC-1	U.S. Army Corps of Engineers	Programs for flood hydrograph computations, water surface profile computations, reservoir system analysis, monthly streamflow synthesis, and reservoir system operation for flood control.
HSP (Hydrocomp Simulation Program)	Hydrocomp, Inc.	Incorporates hydraulic reservoir routing and kinematic-wave channel techniques.
ILLUDAS (Illinois Urban Drainage Area Simulator)	Illinois EPA	Incorporates directly connected paved area technique but also recognizes and incorporates runoff from grassed and non-connected paved areas.

Table 5-1
A Selection of a Few Commonly Used Hydrologic Models

Name	Author	Description
STORM	U.S. Army Corps of Engineers	Models quality and quantity of urban runoff.
SWMM (Storm Water Management Model)	U.S. EPA	Simulates runoff of a drainage basin for any prescribed rainfall pattern by breaking up the watershed into a finite number of smaller units that can be described by their hydraulic properties.
SWM-IV / HSPF (Stanford Watershed Model IV)	Crawford and Linsley	Simulates portions of the hydrologic cycle for an entire watershed.
SCS TP149	U.S. Soil and Conservation Service	Estimates peak flow rates from small (5-2000 acres) agricultural watersheds. Consists of 42 charts from which the peak discharge of a 24 hour rainfall can be determined.
SCS TR55	U.S. Soil and Conservation Service	Estimates runoff volume and peak rates of discharge from urban areas.
TWM (Texas Watershed Model)	Claborn and Moore, University of Texas	Modified the SWM-IV model by changing the model time steps and input data.
USDAHL	Not Available	Uses continuous simulation approach and incorporates the effects of soil types, vegetation, pavements, and farming practices on infiltration and overland flow

Source: Modified from Nix, 1996.

Factors to consider when choosing a model include the:

- availability of suitable hardware;
- availability of trained personnel;
- long-term commitment to the model (Is it a model that may be used in other applications or for other projects?);
- in-house model experience; and
- acceptance and support of the model (Staying with mainline models is safest from a credibility standpoint.).

POLLUTION CONTROL TECHNIQUES

The pollution control techniques discussed in this section are focused on the control of rural and urban nonpoint source (NPS) pollutants. The EPA has estimated that NPS pollution is the single largest cause of water quality problems in the United States (Anbold

and Beristain 1996). NPS pollution is the term that applies to runoff of polluted water into rivers and reservoirs. It is water flowing over the land that picks up and carries with it pollutants, such as, oil and grease, fertilizer and pesticides, silt and sand from poorly vegetated areas and construction sites, or even pathogens from animal wastes. It can be generated during rain events, lawn watering, car washing, agricultural irrigation, or any other time water is applied to and flows across the land surface.

Nonpoint Source Pollution

The contaminants of concern resulting from NPS pollution can be classified as nutrients, microbes, sediments and toxins. The following provides a brief introductory discussion of the classification of potential NPS pollutants. Additional information is also provided in Chapter 1.

Nutrients

Nutrients are compounds that stimulate biological growth. All living organisms need nutrients to survive. A problem occurs when nutrients are available in excess quantities. Excessive nitrogen in drinking water, for example, can cause health problems like blue baby syndrome (Arnold and Beristain, 1996). Likewise, an excess of fertilizer applied to yards and crops provides excess nutrients to a raw water supply. The nutrients of greatest concern are nitrogen and phosphorous. Excessive nutrients cause the water system to become eutrophic. or oxygen depleted, resulting in algae blooms. A more detailed description of eutrophication and nutrient pollutants is provided in Chapter 1.

Microorganisms

Harmful microorganisms such as *Giardia*, *Cryptosporidium*, and coliform can present a public health risk if present in a water supply system in sufficient quantities. The sources of these microbes are animal and human feces. The contribution of these disease-causing microbes to the surface water system is typically greatest during the "first flush" of a storm event. Ingestion of these microorganisms may result in gastrointestinal "flu" like symptoms. In recreational surface waters, ingestion could result from casual contact while swimming or playing. For drinking water supplies, typical water treatment of filtration and disinfection will take care of most microbes; the major exception being *Cryptosporidium*. The *Cryptosporidium* oocyst is much smaller and is much more resistant to filtration and disinfection practices than other common harmful microbes. Young children and people with lowered immune systems such as AIDS patients and the elderly are most susceptible to waterborne microbial diseases.

Sediments

Sediments include mineral (i.e. sand and silt) and organic material (i.e. leaf detritus) that is suspended and transported in the water system. An increase in sediment load to a water system can alter the habitat. The sources of the sediment

include uncontrolled construction sites, poorly vegetated residential yards and gardens and poor agricultural tillage practices. Submerged vegetation and filter feeders can literally be choked, thereby reducing the natural effectiveness of the water system to remove other pollutants. The channel morphology can change as well as the texture of the water system floor. Of particular concern to the drinking water purveyor is the increase in turbidity for the raw water and the increased potential for harmful microbes in the raw water.

Toxins

Toxins introduced to the water system via NPS pollution include herbicides, pesticides, oils and greases, solvents, and metals. These pollutants are of particular concern due to their potential for both habitat degradation and contamination of raw water supplies. Costs associated with treating water containing toxins are much greater than costs associated with pollution control. Runoff from highways, roads, parking lots and industrial facilities often contains solvents, oils and greases, as well as many heavy metals. Runoff from urban and agricultural areas may contain pesticides and herbicides. Treating water containing toxins is costly and can result in eventual abandonment of a drinking water supply.

Pollution Control

Sources of NPS pollution can be associated with two major land use categories - rural and urban. Although the contaminants entering the water system can be the same for both land use categories, the dynamics of the sources of those contaminants and the controls used to protect the watershed are different enough to merit separate discussions.

Rural NPS Pollution

In rural areas, nonpoint pollution sources can be further subdivided based on association with agricultural and silvicultural land uses. Agricultural land uses include both farming and livestock practices. Silvicultural land uses include tree farming and logging practices. In both cases, the primary reason for NPS pollution can be attributed to poor management practices.

Agriculture

For agriculture, the NPS pollutants of concern include sediments, nutrients, pesticides, and microorganisms. Virtually all agricultural NPS pollution problems can be linked to poor management practices. The following are some of the potential pollution sources and their associated management failures:

- Sediment from poor tillage practices,
- Nitrates and phosphates from poorly managed application of fertilizers,
- Herbicides/Pesticides from poorly managed pest control practices,
- High biological oxygen demand (BOD) and ammonia from uncontrolled runoff at feed lots,

- Microorganisms such as *Cryptosporidium*, *Giardia*, *e-coli* from uncontrolled runoff from feed lots and poorly functioning septic systems, and
- Viruses such as hepatitis-b and typhoid, and dysentery from poorly functioning septic systems.

Much work has been done in rural areas to help control NPS pollution. The Department of Agriculture, the Environmental Protection Agency, the Natural Resources Conservation Service, Extension Service and other federal and state agencies have made much progress through voluntary and regulatory control efforts to reduce the amount of NPS from agricultural sources. Some typical control measures are as follows:

- Minimal and no tillage practices which are less labor intensive than traditional tillage practices; reduce soil loss, and reduce costs associated with soil augmentation;
- Animal waste containment and land application of animal waste which reduces the amount of pollutants from uncontrolled runoff from livestock practices;
- Livestock watering areas instead of uncontrolled stream watering reduces the stream degradation from animal wastes;
- Pesticide and fertilizer application pollution prevention education provides cost saving incentives for farmers through reduction;
- Create or preserve marshlands and wetlands which are useful in intercepting NPS pollutants; and
- Vegetative buffers or setbacks which also are useful in preventing NPS pollutants from entering nearby surface water.

Silviculture

For silvicultural activities the potential NPS pollutants of concern include sediments, nutrients, and microorganisms. As is the case with agricultural activities, the majority of silvicultural NPS pollution problems can be linked to poor management practices. The following are some of the potential pollution sources and their associated management failures:

- Soil loss from poor timbering practices;
- Nitrate and phosphate contribution from application of fertilizers and in some cases the application of municipal wastewater sludge on tree farms; and
- Microorganisms such as *Cryptosporidium, giardia*, and *e-coli* from uncontrolled deer and other mammalian populations.

The Department of Interior, the Environmental Protection Agency, the Forestry Service, the Natural Resources Conservation Service, the Fish and Wildlife Service and other federal and state agencies have made progress through voluntary and regulatory control efforts to reduce the amount of NPS from silvicultural practices. Some typical control measures are as follows:

- Alternative timbering practices such as selective tree cutting rather than clear cutting forested areas;
- Pesticide and fertilizer application pollution prevention education provides cost saving incentives for loggers;
- Create or preserve marshlands and wetlands which are useful in intercepting NPS pollutants; and
- Forested buffers or setbacks which also are useful in preventing NPS pollutants from entering nearby surface water; and
- Enforcement of appropriate erosion control measures.

Urban NPS Pollution

In urban areas, the potential pollutants of concerns include sediment, nutrients, toxics, and microrganisms. The sources of these contaminants vary to some degree but all generally attributable to outdated designs and/or poor management practices. The following are some of the sources of NPS pollutants in urban areas:

- Sediment from poor sediment and erosion control measures,
- Nitrates and phosphates from poorly managed application of fertilizer in residential and commercial areas,
- Toxics such as lead, chromium, nickel and ethylene glycol (antifreeze) from parking lots, driveways and highways,
- Petroleum hydrocarbons from parking lots, driveways and highways,
- Toxics such as lead, chromium, and nickel from industrial air emission and accidental releases of waste and product,
- Microorganism such as *Cryptosporidium, Giardia*, and *e-coli* from municipal sewerage overflows, poorly managed septic systems and pet waste, and
- Viruses such as hepatitis–b and dysentery from sewerage overflows and poorly functioning septic tanks.

In determining suitable control measures, the urban setting can be further divided into existing and developing areas. In rapidly growing urban areas, it may be the most cost-effective strategy, both financially and environmentally, to focus on control strategies for the new development instead of focusing on retrofitting existing areas. Regardless of the focus, the selection of suitable urban control technologies requires an understanding of the size and distribution of the storm events. From a pollution standpoint, the impacts from smaller storm events are generally greater than for larger less frequent storm events (Moffa, 1996). This is contrary to the more traditional philosophy of storm water management for flood control. In many parts of the United States, 85% percent of all the storm events result in less than 0.6 inches of rain in depth but can generate about 70% of the total annual storm water runoff (Moffa, 1996). Traditional stormwater control is

concerned with peak flow rates from relatively infrequent large storm events and the conveyance of the peak runoff. Therefore, criteria used to establish stormwater flood control measures may not be adequate in determining pollution control measures for smaller storm events in urban areas. The following section describes the typical tools used in urban areas to reduce and control NPS pollution.

Urban NPS Pollution Control

Numerous authors have tried to divide non-point source pollution controls into two basic categories: "structural", such as detention facilities, and "non-structural", such as regulatory processes. Unfortunately, there are inconsistencies between authors on what constitutes structural and non-structural controls. The use of the terms also tend toward an interpretation that structural and nonstructural methods are separate approaches to watershed management. All the tools used to control NPS pollution (regardless of whether they may be considered structural or non structural) should be presented collectively so that the best set of management practices to achieve the watershed goal can be developed from a full suite of potential solutions or tools.

The tools available to achieve effective stormwater management can be divided into five categories: public policy, education, source control of pollutants, attenuation and infiltration of flow, and source treatment. The purpose of this section is to introduce the reader to basic concepts and tools used to control NPS pollution rather than to provide engineering details of the technologies or summaries of the public policies used in the recent years to control NPS pollution. For those requiring more detailed information, Table 5-2 provides a list of documents available that describe the engineering detail.

TABLE 5-2
Reference List : Stormwater Best Management Practices

Document Title	Author or Editor	BMPs Included	Information Available
Best Management Practices Design Guidance Manual for Hampton Roads, 1991	Hampton Roads Planning District Commission	Biofiltration Vegetative Infiltration Storage Water Quality inlets Dry well Porous pavement Grid/modular pavement Grit-oil separator	General description Design Use limitations Maintenance Examples Cost Life expectancy

TABLE 5-2
Reference List : Stormwater Best Management Practices

Document Title	Author or Editor	BMPs Included	Information Available
Coastal Nonpoint Source Control Program: Management Measures and Guidance, 1993	U.S. EPA and NOAA	Housekeeping Infiltration Vegetative Quality inlets Filtration	General description Effectiveness Design Use limitations Maintenance Cost Examples
Control and Treatment of Combined Sewer Overflows, 1993	Moffa	Source Control Collection system Storage Treatment	General description Design Maintenance Use limitations
Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, 1987	Schueler	Detention Infiltration Vegetative Filtration Quality inlets	General description Effectiveness Design Use limitations Maintenance Cost Examples
Decision Maker's Storm Water Handbook: A Primer, 1992	Phillips-U.S. EPA Region V	Housekeeping Detention Infiltration Vegetative Quality inlets Filtration	General description Effectiveness Design Use limitations Maintenance Examples
Nonstructural Urban BMP Handbook: A Guide to Nonpoint Source Pollution Prevention and Control Through Nonstructural Measures, 1996	Northern Virginia Planning District Commission	Vegetative Public education Land use management Street sweeping	General description Effectiveness Design Use limitations Maintenance
Protecting Water Quality in Urban Areas, 1989	MPCA	Housekeeping Detention Infiltration Vegetative Water quality inlets	General description Effectiveness Use limitations Maintenance Cost Examples
Stormwater Management, 1992	Wanielista and Yousef	Water quality inlets Infiltration Detention	General description Effectiveness Cost Examples

TABLE 5-2
Reference List : Stormwater Best Management Practices

Document Title	Author or Editor	BMPs Included	Information Available
The Florida Development Manual: A Guide to Sound Land and Water Management, 1992	Livingston et. al.	Housekeeping Infiltration Vegetative Water quality inlets	General description Effectiveness Design Use limitations Maintenance Cost Examples
Urban Targeting and Urban BMP Selection, 1990	Woodward-Clyde	Housekeeping Detention Infiltration Vegetative	General description Effectiveness Design Use limitations
Vegetative Practices Guide for Nonpoint Source Pollution Management, 1992	Hampton Roads Planning District Commission	Landscaping Integrated pest management vegetative	General description Design Use limitations Maintenance Plant lists
Stormwater: Best Management Practices and Detention for Water Quality, Drainage, and CSO Management, 1993	Urbonas and Stahre	Storage Source control Detention Treatment Water quality inlets	General description Effectiveness Design Use limitations
Integrated Stormwater Management, 1993	Field, O'Shea, and Chin	Detention Management Vegetative Infiltration Flood Control Reclamation Collection system	General description Effectiveness Design Use limitations

Public Policy

Public policy on land use and resource management is an important element of nonpoint source pollution control. A local government can control nonpoint source pollution through the use of land use regulations, comprehensive stormwater regulations, and land acquisition.

Land Use Regulations

A local government can limit the adverse impacts of undesirable development and management practices in areas critical to watershed protection using zoning, including overlay districts, site plan reviews and subdivision regulations and

ordinances. This could include such provisions as natural resource protection areas, specified buffers and setbacks from water ways, wetlands preservation ordinances and so forth. An overview of the existing regulations and codes used by the local governments in the Hampton Roads area that can be used as tools for watershed protection and urban non-point source control are provided in Chapter 4.

Site Plan Review Process

Another opportunity for the local government to control stormwater impacts to local receiving streams is through the site plan review process. Typically, the engineering consultant for a developer is responsible for developing the initial BMP plan for a proposed development. The planner reviews the site plan to ensure that it conforms with the local policies and design standards as well as the comprehensive plan for the locality. During the site plan review process, one of the tasks of the planner and the engineer is to identify the ultimate objective for managing NPS runoff from the site. Items considered in the review process that relate to NPS pollution include the foot print of the building, the amount and type of impervious surfaces, the type and thickness of stream buffers, the amount and type of vegetative cover, and the preservation of critical environmental features. At a minimum, the planner and the consulting engineer jointly develop a site specific plan to control NPS pollution that: (Schueler, 1987):

- maintains, within reason, the downstream hydrological conditions prior to construction;
- is appropriate for the site;
- is consistent in cost and effectiveness to other control options;
- can be maintained reasonably in comparison to other control options;
- has a neutral impact on human health and the environment; and removes a reasonable level of most urban pollutants.

The effectiveness of the review process in controlling NPS pollution is related to the strength of the locality's stormwater management regulations and site plan ordinance. Unfortunately some stormwater management regulations are not based on a holistic approach to watershed protection or management from a water quality standpoint. Also, planners often are forced to react to new development proposals without the benefit of a long range watershed protection plan based on sound science and community support. This piecemeal approach can lead to BMP design and siting that is very site specific and not effective at meeting watershed protection goals. According to the Water Environment Federation and the American Society of Civil Engineers (WEF/ASCE, 1992), a piecemeal approach results in only a partial resolution of major flooding problems and creates new down stream flooding problems. Likewise, improperly located detention basins may actually increase peak flows rather than reduce them. The WEF and ASCE also indicate that the costs of uncoordinated pollution control solutions are likely to be much greater than the overall costs incurred when adequate management programs have been developed and implemented.

Comprehensive storm runoff control plans and regulations

From a local government perspective, the best approach for controlling the pollution from non-point sources is through a comprehensive or integrated stormwater management plan (WEF/ASCE 1992). Planning approaches found in the literature to develop effective stormwater management strategies, both in cost and pollution control are summarized below (Moffa, 1996; Walesh, 1989; USEPA, 1991a, USEPA 1991b, Grigg, 1996):

- Delineate the boundary for stormwater contribution to a given area
- Identify and analyze the natural features and the existing land use
  - Determine the existing conditions
  - Set specific goals for areas within the watershed
  - Collect and analyze data
  - Refine area specific goals
- Develop a management plan
  - Assess and rank problems
  - Screen control options
  - Select control options and treatment technologies
- Implement the management plan
- Monitor and re-evaluate

According to the Water Environment Federation and the American Society of Civil Engineers, the engineers and planners should draw on the resources of combined efforts of large and diverse group of specialists and interest groups in the planning and designing process to develop technically sound drainage projects that will be supported by the community. NPS pollution controls such as regional BMPs can be both attractive and functional, providing recreational opportunities as well stormwater control. The designer of stormwater BMPs must be creative in adapting the preceding principles to a specific watershed. Rigid adherence to particular standards may prove to be undesirable and unwise (WEF/ASCE, 1992).

Land Acquisition

Local governments may choose to purchase land adjacent to waterways and drinking water reservoirs. By purchasing riparian land around a reservoir or other portion of the water system, a local government can control the land use activities. In some cases, the purchase may be a conservation easement or right-of-way which could allow for a permanent vegetative buffer between the water system and nearby development. In other cases, entire parcels may be purchased. Economically land acquisition may be the most difficult nonstructural option to pursue.

Public Education

There are various ways to approach watershed protection education. The major objective of watershed protection education is to encourage the public to adopt daily

practices that are not harmful to water quality. Through educational programs, the public can become aware of long standing practices that have been harmful to the environment; change those practices, and consequently develop new traditions that are sensitive to preserving water quality. Numerous resources are available to help meet the educational objectives of watershed protection. Professional organizations such as American Water Works Association, the American Society of Civil Engineers, and the Water Environment Federation, have brochures and literature for watershed related education. Nonprofit organizations such as the National Small Flows Clearing House and the Groundwater Foundation also have a selection of education materials and programs to address various watershed issues. There are several grassroots not-for-profit organizations (NPO) as well as governmental agencies actively providing various levels of watershed protection education in Hampton Roads. Table 5-3 provides a list of organizations and programs whose mission includes public education on water quality issues.

Table 5-3
Nonprofit Organizations Involved in Watershed Education

Organization	Mission
Alliance for the Chesapeake Bay P.O. Box 1981 Richmond, VA 23218	Build, maintain, and serve the partnership among the general public, the private sector, and government that is essential for establishing and sustaining policy, programs and the political will to preserve and restore the resources of the Chesapeake Bay.
Atlantic Coast Conservation Association of Virginia P.O. Box 68423 Virginia Beach, VA 23455	Not Available
Biohabitats of Virginia, Inc. P.O. Box 29540 Richmond, VA 23242	Foster ecological stewardship and sustainability by providing ecological habitat protection and restoration services.
Center for Marine Conservation Chesapeake Bay Field Office 306-A Buckroe Ave. Hampton, VA 23664	Dedicated to protecting marine wildlife and conserving coastal and ocean resources.
Chesapeake Bay Foundation 1001 E. Main Street, Suite 815 Richmond, VA 23219	Working to "Save the Bay" by protecting and restoring the water quality and living resources of the Chesapeake.
Chesapeake Bay Group, Virginia Chapter, Sierra Club P.O. Box 3414 Norfolk, VA 23514-3414	To preserve, protect, and enjoy the wild places of the earth.

Table 5-3 Nonprofit Organizations Involved in Watershed Education	
Organization	**Mission**
Coastal Canoeists P.O. Box 566 Richmond, VA 23204	Preservation and enjoyment of wilderness waterways and to promote the general health and welfare of the community through the sport of paddling.
Elizabeth River Project 100 West Plume St., Suite 220 Norfolk, VA 23510	To form a partnership among diverse community interests to raise appreciation of the economic, ecological, and recreational importance of the river; and to restore the Elizabeth River system to the highest practical level of environmental quality.
North Landing River and Its Tributaries P.O. Box 61888 Virginia Beach, VA 23462	Not Available
Southeastern Association for Virginia's Environment (SAVE) P.O. Box 6133 Virginia Beach, VA 23456	Dedicated to the preservation and protection of the total environment of the southeastern region of Virginia.
Southern Environmental Law Center 201 W. Main St., #14 Charlottesville, VA 22902	To help preserve and protect the rivers, other waterways, and wetlands in the Southeast. Also, to protect human health from adverse impacts of water pollution.
Virginia Conservation Network 1001 E. Broad Street, Suite 411 Richmond, VA 23219	To bring together Virginia conservation and environmental organizations to monitor and disseminate information on state legislative and regulatory activities, achieve consensus among member organizations on select issues, and facilitate and coordinate collaborative activities of member organizations.
Virginia Lakes Association 24400 Pine Tree Lane Carrollton, VA 23314	To clean the lakes and waters of Virginia and to maintain good water distribution.

Source: Virginia Department of Environmental Quality, 1997.

The major audiences targeted for watershed education can be categorized as watershed residents, commercial businesses, industry, local government, and the development community. These categories are defined based on unique practices and educational needs.

Watershed Residents

For educating watershed residents, there are two schools of thought; a long range objective and a short range objective (Moffa, 1996). The long range objective is to change those traditions entrenched into today's society that are harmful to water quality into traditions used by generations to come that are more protective of water resources. The long range objective can be accomplished through programs targeted at the younger members of a community. Primary and secondary educational institutions have been the target for various educational programs ranging from environmental awareness such as recycling, to drug prevention ("just say no"), and crime prevention ("Take a Bite Out of Crime"). Many school systems already have strong environmental programs and in some of the secondary schools across the nation, the students are already involved in watershed monitoring. The rewards of youth targeted educational programs not only come in the future as the children become community leaders who have been taught the importance of watershed protection but also in the near term. Children are a valuable educational source to their parents.

The short range objective is to improve water quality now and generally involves educational programs targeted at homeowners. The programs aim at changing homeowner practices that are harmful to the watershed. Some of the more obvious harmful homeowner practices include excessive fertilizer and pesticide use and improper disposal of automobile oil and household chemicals. Some of the less obvious harmful practices include reduction of pervious surfaces, landscaping that promotes quick runoff and using ornamental plants that are not water efficient or drought resistant. Educational activities include workshops, newsletters, community meetings and awareness programs, newspaper articles, brochures, online Internet resources, video and local news coverage.

Commercial Businesses

The objective of educating businesses is to encourage owners and employees to act responsibly in their community and to advise them of their responsibilities under local and state codes. For the commercial sector, a different forum for education is required. Some of the approaches that can be used include direct contact between the watershed protection specialist and the owners to convey concerns about watershed protection, press releases and news letters aimed at watershed initiatives and recognizing those businesses that are acting responsibly in the community. Press and media recognition of businesses in violation of NPS regulations can also provide valuable education as well as incentive to local businesses. Working with businesses to reduce the potential for violations through pollution prevention initiatives is also a very effective method of educating.

Industry

The objective of educating industries is similar to that of general commercial businesses. In both cases the goal is to encourage owners, managers, and

employees to act responsibly in their community. Educational approaches for industry may include cooperative educational programs with industrial associations, consultants, direct contact with the environmental or operational managers at the facility, as well as those mentioned in the section for commercial businesses above.

Local Government

The local government audience includes the local elected officials and the governmental staff. The objective of educating the elected officials is to encourage their support to make policy decisions that are protective of the water supply watershed. Without the support of the local elected officials, the watershed protection efforts will never move forward through policy decisions. It is imperative for a watershed protection plan to include endorsement and support by the local elected officials. The education process for local elected officials also involves education of the local government staff. Education efforts for this audience should include information on the long term financial benefits of effective watershed management, cumulative impacts of development, alternative approaches to development controls and the benefits of integration of watershed management efforts among different departments of local government.

Development Community

The objective of an educational program for the development community is to encourage development practices that are sensitive to water quality and the environment. The program should focus on design and technical assistance, as well as provide general background on the issues. This type of forum allows for the presentation of alternative approaches to developing the watershed that are cost-effective as well as protective of the water quality.

Source Control of Pollutants

Generally, source control techniques can categorized as "good housekeeping" practices. Some examples are provided in the following list:

- Controlled Construction Activities
- Street Sweeping
- Solid Waste Management
- Animal Waste Removal
- Fertilizers/Pesticides/Herbicides Use Reduction
- Roadway Sanding and Salting Use Reduction
- Hazardous Material and Chemical Use Substitution

Existing Drainage System Pollution Control

Control practices that can be applied to the drainage system are relatively limited, especially for existing systems and involve the following items:

Removal of illicit or inappropriate cross-connections

Illicit or inappropriate cross connections refer to sewage and/or industrial wastewater discharges into stormwater drainage systems. Illicit cross connections can be a major source of pollution of the water system in some areas. A survey or an inspection program for illicit and inappropriate cross connections can be time consuming but may be a very cost effective approach for reducing pollution from urban stormwater discharges. In the event that illicit cross connections are found, the generator of the effluent may be held liable not only for the cost of correcting the connection but also for environmental degradation associated with the illegal discharge.

Catchbasin cleaning

Catchbasin cleaning is a "good housekeeping" practice for existing catchment structures such as oil/water separators, grit basins, detention ponds, wet ponds, and retention ponds. In order to sustain catch basin performance, it is important to maintain a regular cleaning schedule at a frequency such that sediment buildup is limited to 40-50% of the sump capacity (USEPA, 1977).

Flow Attenuation

Flow attenuation refers to methods for reducing the rate and quantity of stormwater runoff into water supply watersheds. These methods vary from relatively nonintrusive technology such as vegetative practices to hard constructed technologies such as detention basins and in-line/offline storage.

Vegetative Practices

An important technique for reducing the introduction of pollutants into receiving streams is to increase the attenuation and infiltration of stormwater. Traditionally, this idea has been a cornerstone of stormwater management involving facilities such as detention ponds and infiltration trenches. This is also the premise behind techniques referred to as "vegetative practices." Vegetative practices promote biofiltration and bioretention. Vegetation results in biofiltration when the density of vegetation is sufficient to filter pollutants, such as sediments, effectively from runoff after a storm event. Bioretention refers to the ability of the vegetation to retain or attenuate the pollutants in stormwater runoff as well as to reduce the amount of surface flow. More information regarding the use of vegetation as a best management practice can be found in the Vegetative Practice Guide for Nonpoint Source Pollution Management (HRPDC, 1992). Various techniques used in vegetative practices include the following:

Grassed Swales

Grassed swales are typically used in low density areas as an alternative to curb and gutter drainage systems. The pollutants are filtered out by the grass and subsoil.

Check Dams may be used to temporarily pond the runoff, allowing infiltration over a period of time. Swales cannot, however, accommodate major runoff events.

Vegetative Filter Strips/Buffer Zones

Vegetative filter strips are similar to grassed swales except that they are wider. They should be at least 20 feet wide and not be used on slopes greater than 15 percent (HRPDC, 1992). Filter strips are usually vegetated and are best suited to accept evenly distributed sheet flow. Filter strips are often used as a riparian buffer. There are benefits including aesthetics, wildlife habitat and noise screening.

Stormwater Wetlands

Natural wetlands have been recognized for their ability to filter sediment and attenuate contaminants in a water system. As a result engineered wetlands are receiving much attention as an attractive system for removing pollutants from stormwater runoff. A stormwater wetland is a shallow pool that was designed to provide the growing conditions suitable for wetland vegetation. These stormwater wetlands are designed to remove pollutants from surface runoff through uptake by the vegetation and retention and settling.

Riparian Buffers

The purpose of a buffer is to provide a vegetated area along perennial streams through which stormwater runoff is intercepted. Sheet flow from stormwater runoff is filtered by the vegetation and the flow is diffused resulting in greater infiltration into the soil. The roots can remove pollutants from the surface water as it infiltrates into the groundwater. In many, if not all developed urban areas, the natural riparian buffer has either been removed or greatly altered. Restoration of the riparian buffer includes programs such as urban reforestation and riparian buffer restoration. Both types of programs emphasize restoring vegetation along the streams and rivers to improve water quality.

Rain Gardens

Rain Gardens are vegetative areas designed in low lying areas for the purpose of filtering and removing pollutants from stormwater. In Maryland, the Prince Georges County Department of Environmental Resources (DER, 1997) has done much to promote the use of rain gardens. The soils of a rain garden generally consist of a sand bed, an organic rich soil, and a mulch layer at the top. The sand layer provides drainage for the organic soil and acts as an additional filter for stormwater water runoff. The organic rich soils provide the nutrients needed by the plants to thrive and the organic mulch layer also provides a filtering mechanism but more importantly acts as a moisture barrier to prevent the organic rich soil from drying out between rain events.

Detention Basins

Detention basins are more widely used for urban stormwater management than any other form of stormwater control. They were originally implemented for flood control or peak flow attenuation of major storm events. It was not until the late 1980s that detention would be used for the purpose of water quality control of stormwater runoff (Urbanos and Stahre, 1993). The relationship of the design to pollution removal efficiencies is not well developed but there is enough empirical evidence from existing facilities to develop sound guidelines to design a facility to control stormwater runoff quality. Two basic type of detention basins used for water quality are extended-detention (dry) basins and wet (retention) ponds

Extended-Detention (Dry) Basins

Dry basins are facilities that empty completely between storms. These are the most common type of attenuation facility used in the United States, Canada, Australia and possibly other countries (Urbanos and Stahre, 1993). Those designed to detain peak flows generally empty in less than 6 hours and pollution removal is virtually nonexistent. According to laboratory tests, 80% of pollutants associated with suspended solids are attached to the fine silts and clay particles (Urbanos and Stahre, 1993). The fine silts and clays are smaller than 6 microns in size and the clay particles are flat and elongated. As a result of the size and shape of these particles, the amount of time required to remove them from stormwater runoff exceeds the 6 hour detention time of peak flow facilities. In order to adequately address pollutant removal, the extended detention basin should be designed to empty within 24 to 60 hours even for the smallest rain events (Urbanos and Stahre, 1993).

Wet Ponds

Wet ponds also referred to as "retention basins" are basins with a permanent pool of water and sufficient additional capacity above the pool for temporary storage of stormwater runoff. They are designed with outlet structures to release the runoff that accumulates above the pool level over some specified period of time. Wet ponds are often used in residential developments. They can be designed so they are aesthetically pleasing and are an attractive asset to a development if designed, constructed and maintained properly. The wet pond can be effective in removal of pollutants from stormwater through sedimentation and bioretention. Theoretically, the water existing in the pond is replaced by incoming stormwater runoff. Therefore, the suspended sediments have time to settle to the bottom and the aquatic vegetation and algae in the basin have time to remove significant quantities of inorganic and organic pollutants.

In-line storage

In-line storage refers to using the storage capacity of the various components of a drainage system to retain stormwater run-off. The storage can be provided by using

tanks, basins, tunnels, or surface ponds which are connected in-line to the conveyance network. In-line storage systems are not likely to be effective for the treatment of pollutants, but they do provide flow attenuation. They should be designed to be self-cleaning so there would be no sediment catchment in the network. To be effective in pollutant removal an in-line storage system must be coupled with end of the pipe treatment.

In-line storage benefits the receiving stream by reducing the peak flow and equalizing the loading to be assimilated by the receiving water. Storage in-line can be maintained by either fixed or adjustable controls that restrict the flow. Fixed controls offer less maintenance cost but also less control. Some fixed controls include weirs. Adjustable controls require more maintenance but can be used to optimize the in-line storage. Adjustable controls also offer the advantage of being connected to real time control (RTC) systems which can be controlled by a computer system that can adjust the controls to release or hold back water to maximize the storage capacity of the system. RTC systems have been installed for the control of combined sewer overflows (CSO). Several publications are available on CSO control that provides more information regarding adjustable flow controls (Urbanos and Stahre, 1993, USEPA, 1970 and APWA, 1970).

Off-line storage

Off-line storage refers to storage that is diverted from the drainage system when a certain flow rate is exceeded. The diverted water is stored until sufficient capacity is available downstream. Off-line storage facilities can be comprised of basins, ponds, and tanks. If gravity filling and emptying are not possible, pumping will be required. The advantage of such systems is similar to in-line storage in that they can be used to reduce the impact of the peak flows to the receiving waters. Off-line storage is not likely to be effective for treatment of pollutants but does provide flow attenuation. If tanks are used they should be designed to be self-cleaning so there is no effective sediment catchment. To be effective in pollutant removal off-line storage systems should be coupled with end of the pipe treatment.

Diversion

In some cases it may be necessary to divert stormwater runoff into another drainage basin. Land use activities in the watershed in question may not be compatible with maintaining a safe water drinking water supply. The City of Newport News has identified one diversion area around the Lee Hall reservoir and three diversion areas around the Harwoods Mill reservoir system (CDM, 1986). These areas were selected for diversion on the basis of either existing or predicted intense urban development which could produce relatively high pollutant loads of metals and nutrients from stormwater runoff. Three of the diversion areas reduce the stormwater runoff discharges into the reservoir near the water supply intakes.

Infiltration Practices

Infiltration practices divert the natural flow of stormwater at the land surface into the ground water flow system. In essence, infiltration practices use the natural soils at a site to diffuse and filter stormwater runoff. These methods rely on suitable permeability of the soil and adequate depth to the water table to be effective. Infiltration practices should only be used in areas where the water table is low, soils have a suitable permeability, and pollutants from stormwater will not be a threat to a viable ground water resource. From a water budget standpoint, infiltration practices reduce the amount of surface water flow into a reservoir or water supply system after a storm event. This water, however, is not lost from the water budget but is transported at a much slower rate via the ground water system.

Infiltration Trenches

Infiltration trenches are primarily onsite controls that generally consist of excavated ditches two to ten feet in depth and backfilled with coarse aggregate. The trenches are generally installed along the down gradient portion of a parking lot or developed site. The purpose of an infiltration trench is to intercept the surface runoff and store it temporarily in the voids of the coarse aggregate. Infiltration trenches can remove both soluble and particulate pollutants from stormwater runoff (HRPDC, 1992). Infiltration trenches can be installed in commercial or industrial areas such as parking lots with special reinforced inlets. They can also be used in residential developments in open space areas with the top of the trench at the land surface. The trenches work best in areas where the water table is 2 to 4 feet below the bottom of the trench and the percolation of the surrounding soils is suitable for infiltration. The life of an infiltration trench can be extended when used in conjunction with a vegetative practice or some other technique to remove sediments from the runoff before it enters the trench.

Infiltration Basin

An infiltration basin is constructed by excavating a pit in a soil with good permeability and a low water table. The purpose of the basin is to store stormwater runoff and slowly infiltrate it through the permeable bottom of the basin. It is generally designed to hold the first flush for a specified storm event. An infiltration basin can typically be constructed for drainage areas of 5 to 50 acres (HRPDC, 1992) and can be used to remove both soluble and particulate pollutants from stormwater. To increase the life of an infiltration basin, a sediment forebay near the inlet and a vegetative buffer around the basin should reduce the input of sediments entering the basin (HRPDC, 1992).

Porous Pavement

Porous pavement can be used to promote infiltration of stormwater runoff into the subsurface. It is only useable in areas where the water table is low, the percolation of the soils is sufficient, and pollutants from stormwater will not be a threat to a

viable ground water resource. Porous pavements can take various forms from porous asphalt to preformed gridded concrete block to poured concrete that remains porous (Tarmac Mid-Atlantic, 1993). One significant problem with porous pavements is the tendency for the porous surface to become clogged in a relatively short amount of time.

Stormwater Treatment

Treating the stormwater with various physical, chemical and biological processes is a BMP option for areas in which the pollutant loads in the runoff may not be handled adequately by the more conventional methods described above. Typical treatment technologies include both onsite and off site treatment. Onsite treatment offers the potential for a greater benefit to reduce the cumulative effect of pollutant loadings flowing into conventional regional BMPs. Offsite treatment offers the benefit to reduce the proliferation of smaller scale treatment facilities. Areas that may be considered critical source areas for pollution include vehicle service areas, parking areas, storage and transfer yards, industrial handling areas exposed to precipitation as well as any other area that may have the potential to generate runoff containing oils, greases, or other organic compounds. The following discussion includes both onsite and offsite alternatives for stormwater treatment.

Oil-grit separators

Oil-grit separators are considered a practical method for removing coarse sediments, petroleum hydrocarbons, and floatable debris from water. There are numerous designs available but all include a similar system of a series of chambers and baffles that trap sediment and petroleum hydrocarbons. Most systems are designed for gravity flow. Regular maintenance is required to remove accumulations of floating debris, petroleum hydrocarbons, and sediment. Oil-grit separators are typically installed in parking lots or commercial sites of one acre or less (HRPDC, 1992) and in industrial sites that have the potential for oil and grease in the surface water runoff.

Enhanced treatment devices

Enhanced treatment devices go beyond the oil-grit separator. These technologies have baffles or other structures used to promote cascading and aeration of the inflow to remove volatile compounds as well as a sump to collect sediment. For areas of relatively small but critical stormwater contributions with high potential for volatile toxics, these methods promise to be cost-effective on-site treatment alternatives. Like the oil-grit separator, the enhanced treatment devices are gravity fed and require regular maintenance to remove accumulated sediment, petroleum hydrocarbons and floatable debris.

Porous conveyance pipes

Although not really a treatment option, porous conveyance pipes to promote infiltration can be used to address problems in pollutant source areas. They are only suitable in areas where the water table is low, the percolation of the soils is sufficient, and pollutants from stormwater will not be a threat to a viable ground water resource. The application of porous conveyance pipes is limited in the Hampton Roads area due to a high water table in many portions of the region.

Sand filters

Sand filters are typically used to treat stormwater runoff from large buildings, access roads and parking lots. As the name implies, sand filters work by filtering the stormwater runoff through beds of sand. Small sand filters are installed in trenches or underground concrete vaults. Larger filters are constructed in above ground concrete vaults and can be designed to handle as much as five acres (Watershedss, 1997). A sediment forebay and an oil-grit separator should be installed before the inlet to protect the sand filter from oils, greases and coarse sediments. Sediment particles and pollutants adsorbed to the particles are removed from the stormwater stream by the first few inches of the sand in the filter. Therefore the maintenance of sand filters is relatively simple. When the top of the layer of the sand bed becomes clogged with sediments captured in the filter, the top few inches of sand must be removed and replaced with clean sand. Underground sand filters have been installed in Florida, Maryland, Delaware, Northern Virginia and the District of Columbia. Above ground sand filters have been used in the City of Austin, Texas, and in Florida (Watershedss, 1997).

Use of Existing Treatment Facilities

The use of existing treatment facilities may be an option in some areas. For an industrial site that may already have an oil-grit separator in line for treating process water before discharge, it may be possible to divert stormwater runoff through the same separator with various flow controls. The local municipal wastewater treatment facility may be able to handle stormwater runoff from areas of relatively small but critical stormwater contributions high in potential pollutants. However, this would be counterproductive to the Hampton Roads Sanitation District's initiative to reduce the amount of plant discharge and would create new CSO situations where none presently exist.

End of the Pipe treatment

There are numerous end of the pipe type treatment technologies that rely on biological, chemical and/or physical process to remove pollutants from stormwater (Moffa, 1996). Much has been gleaned from municipal and industrial wastewater treatment to address generally isolated and very specific concerns for stormwater discharges to reservoir and river systems. The following discussion of "end of pipe treatment" provides a brief overview of some of the processes.

Physical Treatment

Physical treatment methods include screening, filtrating, aeration, and sedimentation process. They can be considered the fundamental treatment process in that some level of physical treatment is a precursor for chemical and biological treatment. Various forms of screens, as the name implies, can be used to screen or remove debris from the stormwater before it undergoes another process. As discussed above, filtering removes finer sediments and particulates coated with pollutants. If volatile organic compounds are a concern, aeration techniques, such as the enhanced treatment devices described above, can be used to strip the volatile pollutants from the waste stream. This can be accomplished in several ways, such as cascading the waste stream over baffles, or injecting air. Sedimentation can be achieved using a settling basin.

Chemical treatment

Some of the techniques used in chemical treatment of stormwater include dissolved air flotation (DAF) (Moffa, 1996), high gradient magnetic separation (HGMS), powdered activated carbon-alum coagulation, disinfection and swirl regulators/concentrators (Moffa, 1996). The DAF is an industrial pretreatment technology that uses dissolved air to separate greases or fine particulates from the waste stream (Moffa, 1996). Coagulation coupled with activated carbon can be used to remove turbidity producing substances and color from the stormwater as well as organic contaminants. Disinfection techniques can be used to treat microbial contaminants.

Biological treatment

Biological treatment systems are "living" systems which rely on mixed biological cultures to break down organic compounds and remove organic matter from solution. Since the treatment unit must provide a controlled environment for the desired biological process it is imperative that the biological process, involved in the treatment of stormwater runoff are well understood (Moffa, 1996). Biological treatment processes include those that are suitable for removing nutrients and capturing inorganic compounds.

CHAPTER 6

CASE STUDIES OF THREE WATER SUPPLY WATERSHED MANAGEMENT PROGRAMS:

Occoquan Watershed in Northern Virginia

Tar and Neuse Watersheds in Raleigh/Durham, North Carolina

Catskill/Delaware and East of Hudson Watersheds in New York State

WATER SUPPLY WATERSHED MANAGEMENT CASE STUDIES

The following three case studies are intended to provide insight on the broad range of options available for regional coordination of water supply watershed management initiatives. The three studies vary in complexity, expense and range of stakeholder involvement. The first case study focuses on the Occoquan Watershed in Northern Virginia. This example is notable for several reasons, including the prominent role of science in policy formulation and the high degree of interjurisdictional cooperation in dealing with both point and nonpoint source water pollution. The second study is of the Tar and Neuse Watersheds in Raleigh/Durham, North Carolina. This initiative is significant in the leadership role that the elected officials have taken in the process. The third and final study features the Catskill/Delaware and East of Hudson Watersheds in New York State. This initiative is notable due to its large size, the sweeping range of initiatives and stakeholders involved, and the expense of the effort.

OCCOQUAN WATERSHED IN NORTHERN VIRGINIA

INTRODUCTION

The Occoquan Reservoir, located in Northern Virginia, is the primary water supply for over 800,000 people. The reservoir is situated on the border between Fairfax County and Prince William County. The watershed occupies parts of four counties - Fairfax, Prince William, Fauquier and Loudoun - and the entire cities of Manassas and Manassas Park. The three major tributaries of the reservoir are Bull Run, Broad Run and Cedar Run. The reservoir has a surface area of 749 hectares and a volume of 41,600,000 cubic meters (NVPDC (a), 1994).

Watershed management in the Occoquan Basin has involved a broad range of organizations in many different initiatives. The reservoir was created in 1950 when the Alexandria Water Company constructed a low head dam on the Occoquan River. In 1957, the Upper Occoquan Dam was constructed, increasing the holding capacity of the reservoir to meet the needs of a growing local population. Ownership of the dam and the water treatment facilities passed to the Fairfax County Water Authority in 1967. During the 1960's land use in the watershed began to change. Both agricultural and urban land uses increased rapidly during this period. In addition, by the end of the 1960's eleven publicly owned wastewater treatment facilities were discharging into the Occoquan Basin. These changes triggered several water quality problems in the reservoir, including the following:

- Massive algal blooms,
- Taste and odor problems in the finished drinking water,
- Shortened filter runs due to clogging during periods of high algae growth,
- Periodic fish kills (NVPDC (a), 1994).

A 1969 study of the reservoir and its tributaries concluded that the reservoir was highly eutrophic and that sewage treatment plant effluents were mainly responsible for the advanced stage of eutrophication. The State Water Control Board adopted "A Policy for Waste Treatment and Water Quality Management in the Occoquan Watershed" in 1971. The Occoquan Policy created the Upper Occoquan Sewage Authority and required the construction of a single sewage treatment facility capable of producing effluent of a quality suitable for discharge to a drinking water supply. This facility eventually replaced the eleven separate facilities.

During the period from 1976 to 1978 the Northern Virginia Planning District Commission (NVPDC) carried out a Section 208 water quality study. The study indicated that nonpoint pollution loadings in the Occoquan Basin were much higher than originally assumed and were a significant contributor to water quality problems in the basin's receiving waters. As a result of this study a multijurisdictional nonpoint pollution management program was developed in 1978 to supplement the advanced wastewater treatment policy. In a concurrent effort, the NVPDC developed the Occoquan Basin computer model during the 1970's. The model played a key role in Fairfax County's decision to downzone major portions of the watershed in 1982. Finally, in 1990 the NVPDC carried out an evaluation of regional BMPs in the Occoquan watershed.

THE OCCOQUAN BASIN NONPOINT POLLUTION MANAGEMENT PROGRAM

The Occoquan Basin Nonpoint Pollution Management Program (OBNPMP) was established in 1978.The primary goals of the program are the implementation of the most cost-effective nonpoint pollution mitigation techniques during the early stages of urbanization and reduction of nonpoint pollution loadings from agricultural lands within the basin. The program is advisory in nature. It attempts to foster interjurisdictional cooperation, provides technical assistance to local staffs and monitors progress in the area of nonpoint pollution management. The program is administered by a Policy Board composed of representatives of the basin's six political subdivisions, the City of Alexandria (a major water user), the Fairfax County Water Authority, the Prince William County Service Authority, the Virginia-American Water Company, and the NVPDC. In addition, the local Soil and Water Conservation Districts and related agencies are voting members of the Policy Board. The Program is funded through a 50% contribution from the water supply authorities that draw raw water from the reservoir, and the remaining 50% from the jurisdictions in the watershed. It is interesting to note that two of the large jurisdictions in the watershed that contribute financially to the program do not depend on water from the reservoir (NVPDC (b)).

The NVPDC performs technical investigations of the Basin under the supervision of the Technical Advisory Committee. The Committee is composed of NVPDC staff, representatives of local planning, environmental, and public works departments, and one citizen representative for each participating jurisdiction. Most of the recent technical investigations have focused on the evaluation of nonpoint source pollution (NVPDC (b)).

THE OCCOQUAN COMPUTER MODEL

The Occoquan Watershed Model was developed in the late 1970s to aid watershed management efforts. The model is designed to predict nonpoint source pollution loadings under various land use scenarios and to forecast their effects on the receiving waters. According to the NVPDC, "The water resource processes represented by the model include the conversion of rainfall to runoff, the washoff of pollutants from the land surface in each basin, the delivery of runoff and associated pollutant loadings to receiving waters, the release of subsurface pollutants in baseflow, the addition of sewage treatment plant loadings to receiving waters and the water quality response of the idealized channels and reservoirs which route the pollutant loadings downstream (NVPDC (c), 1990)."

The original version of the model was designed to run on a mainframe computer. Execution of the mainframe model requires that 20 separate computer runs be executed in a specific order. Turn-around time on complete execution of the model by NVPDC staff dedicated at the 75% level is four to six months. Despite the high overhead cost the model was used extensively from the mid-1960s through the mid-1980s. A series of model runs was used to support Fairfax County's landmark Occoquan downzoning decision and helped uphold it in court challenges. During the last 10 years model runs have been less frequent and have focused on analysis of specific development projects (NVPDC (d), 1996).

A new, PC based version of the Occoquan Watershed Model is currently under development. The new version of the model will be much more user-friendly than its predecessor and will feature a turn-around time of several days for a model run, as opposed to several months for the mainframe version. Also, the potential exists for the model to be used by a much wider group of planners and engineers, although NVPDC staff will maintain primary responsibility for maintenance and running of the model (NVPDC (e)). Phase I of the upgrade will result in a model that will simulate the details of the sub-watersheds that comprise the entire 585 square mile Occoquan Basin. Pollutant loads associated with various land use scenarios will be routed through the basin's network of streams to the reservoir (NVPDC (e)). Phase II of the upgrade will involve land use updates and enhancement of the level of subwatershed detail available in the model. Finally, phase III will involve development of a new model component that will provide a detailed simulation of the Reservoir. The Reservoir Model will be linked to the Watershed Model, providing a powerful management tool.

TRACKING LAND USE TRENDS

Land use tracking for the Occoquan watershed began in the late 1970s. Information from satellite images of the watershed was transferred by hand to a Mylar map. Individual land uses were mechanically planimetered to obtain the land area associated with each use. Subsequently, in 1979, 1984 and 1989, the Mylar base maps were updated based on visual interpretation of high altitude photographs. In 1989 the land use information was also electronically digitized for use in a geographic information system (NVPDC (f), 1994).

The land use information has been used in many aspects of watershed management. The information is a critical input to the watershed model. Land use trend data are a necessary component in evaluation of land use controls. Also, the data are needed to properly design stormwater BMPs.

WATER QUALITY MONITORING

The Occoquan Watershed Monitoring Program, established in 1973, utilizes a network of eleven monitoring stations in the streams of the Occoquan Basin. In addition, discharges from the wastewater treatment plant are periodically monitored and atmospheric pollutant fluxes are measured (NVPDC (a), 1994). The monitoring of tributary streams includes the assessment of ambient water quality and nonpoint pollution loads transported in stormwater runoff. Monitoring sites have been selected to include all of the major sub-basins of the watershed and a variety of different land use types. Baseflow sampling is conducted weekly in spring, summer and fall, and bi-weekly during winter. Automated sampling equipment performs flow-weighted stormwater runoff sampling for all events (NVPDC (a), 1994).

Four locations in the Occoquan Reservoir are monitored on a regular basis. Sampling cruises are conducted on a weekly basis during the bulk of the year. During extreme weather samples are taken at locations accessible by bridge or from the crest of the dam.

STORMWATER MANAGEMENT

Stormwater management in the Occoquan Basin is a compromise between regional standardization and local autonomy. The Northern Virginia BMP Handbook is formally referenced in the Public Facilities Manuals of Fairfax County, Prince William County, the City of Manassas and the City of Manassas Park. For these communities the Handbook has led to a great deal of standardization in BMP planning and implementation. According to Normand Goulet of the NVPDC the Design Calculation worksheets are often copied out of the Handbook and submitted with development application packets. Of the localities in the watershed only Faquier County and Loudoun County do not reference the Handbook (Goulet, 1996).

Regional standardization of BMP facility maintenance has been a more contentious issue. Attempts to develop regional maintenance standards were rejected by the localities in the watershed. Few had the financial resources to deal with the problem. The Northern Virginia BMP Handbook contains general guidelines on BMP maintenance, but the level of detail is far less than the information provided on design of BMP systems (Goulet, 1996).

Regional Stormwater BMPs

Stormwater BMPs are generally categorized as either on-site facilities (serving approximately 1-30 acres) or regional facilities (serving approximately 100-200 acres). In 1990, the NVPDC compared five different BMP alternatives using the Occoquan Watershed Model. The first alternative assumed 70% BMP coverage with onsite BMPs for all new development. The second alternative assumed that 25% of newly developed land drains to regional wet ponds with the remainder of the runoff untreated. The third alternative assumed that 25% of new development drains to regional wet ponds and 70% of the remaining development drains to onsite BMPs. The fourth alternative assumed that 50% of the newly developed land drains to regional wet ponds. The final alternative assumed that 50% of the newly developed land drains to regional ponds and 70% of the remaining development drains to onsite BMPs. The study concluded that the three scenarios that include the onsite BMPs have the highest annual cost. The scenarios featuring only regional BMPs have significantly lower annual cost. In terms of cost per pound of phosphorus removed the two regional BMP only scenarios have the best performance, the two scenarios with a combination of regional and onsite BMPs are in the mid-range, and the scenario utilizing only onsite BMPs has the highest cost (NVPDC (c), 1990).

Problems with Regional BMP Implementation

Mr. Joe Battiata of the Virginia Department of Conservation and Recreation and Mr. Normand Goulet of the NVPDC offered the following observations on the implementation of regional stormwater BMPs. Both Prince William and Fairfax Counties have experienced a great deal of difficulty in obtaining the necessary permits to construct regional BMPs. Prince William County had a major stormwater management project underway that focused on regional BMPs. The project eventually stalled over the issue of wetlands impacts. A few regional BMPs were eventually built, but the County was forced to move in the direction

of on-site BMPs to lessen wetlands impacts. Fairfax County also attempted to implement a system of regional BMPs. The U.S. Army Corps of Engineers (COE) asked for submittal of all of the applications at once, leading to fear of a long approval cycle and a lengthy reapprovial process if a facility were shifted up or down stream. Fairfax eventually dropped the regional approach in favor of onsite systems. In response to this problem a consortium of agencies including the Virginia Department of Environmental Quality, the EPA and the COE met in 1995 and developed a draft guidance document on regional BMP/wetlands conflicts (Battiata, 1996). The draft guidance document is analyzed in Chapter 2 of this Report.

In addition to the wetlands permitting problem, there are a number of ecological concerns associated with the implementation of regional BMPs. Improperly designed regional systems can have an extensive detrimental impact on both upstream and downstream ecosystems. It is possible to mitigate many of the adverse impacts on water bodies downstream from regional facilities through sound design and engineering. Measures such as provision of shade over holding ponds to minimize water temperature increase and inclusion of features that oxygenate water as it is released help to protect downstream ecosystems. However, a system that features only regional BMPs is likely to cause severe degradation to upstream ecosystems. In an urban environment with a high percentage of impervious surface the flow rates into the regional BMPs are often high enough to blow out stream channels. On-site systems that control both water quality and quantity are necessary to protect the ecosystems that are upstream of the regional BMPs. In order for this type of system to work, all upstream contributors must participate and the aggregate system must be designed to handle both first flush and peak flow conditions. It should be noted that in-stream BMP systems create some insurmountable problems such as prevention of fish migration.

TAR AND NEUSE WATERSHEDS IN RALEIGH/DURHAM, NORTH CAROLINA

The State of North Carolina is divided into 18 regional planning areas. The cities of Raleigh and Durham are located in Region J, which includes the county and municipal governments in the area encompassed by Wake, Durham, Orange, Chatham, Lee and Johnston Counties. Region J, which is located in the upper portions of the Cape Fear and Neuse River Basins, has experienced rapid population growth and extensive new development during the past two decades. Two major reservoirs, Jordan Lake and Falls Lake, and several smaller reservoirs provide water to the region. Water supply watershed management programs in Region J are the result of the interaction of state, regional and local initiatives. The statewide water supply protection program ranks water supply reservoirs based on the degree of development in their watersheds and imposes watershed management criteria based on the ranking. On the regional level the Triangle J Council of Governments (TJCOG) and the Upper Neuse Association coordinate watershed management efforts. On the local level each city and county that is part of a water supply watershed maintains its own management efforts. This chapter will examine initiatives at each level, starting with the statewide program and proceeding to the regional and local programs.

NORTH CAROLINA STATEWIDE WATER SUPPLY PROTECTION PROGRAM

The North Carolina Water Supply Protection Program was initiated in 1986 as a voluntary program. The voluntary program proved to be unsatisfactory, particularly in managing water supply watersheds that span multiple jurisdictions. In 1989 the General Assembly passed the Water Supply Watershed Protection Act. The Act required the Environmental Management Commission to adopt minimum statewide water supply protection standards and to assign appropriate classifications to all water supply watersheds. The classification system is as follows:

WS-I: Publicly owned watersheds that are essentially natural and undeveloped.

WS-II: Predominantly undeveloped watersheds.

WS-III: Low to moderately developed watersheds.

WS-IV: Moderately to highly developed watersheds.

WS-V: Tributaries to WS-IV waters.

The watersheds at the low end of the scale are relatively undeveloped and the development restrictions placed on them are more stringent than the more fully developed watersheds at the high end of the scale. Local programs to control non-point source pollution and stormwater discharges are required in watersheds ranked WS-I through WS-IV. In watersheds ranked WS-II through WS-IV, point source discharges of treated wastewater are permitted, but must comply with specific regulations. In watersheds ranked WS-V no categorical restrictions on watershed development or treated wastewater discharges are required, however, appropriate management measures may be required

to protect downstream receiving waters. Tables 6-1 and 6-2 provide a more detailed breakdown of the requirements for each category. These requirements represent the minimum standards that a locality must adhere to in managing water supply watersheds. Local governments are required to adopt and enforce ordinances that meet the minimum requirements, but are free to adopt more stringent measures. (NCDEHNR, 1995)

Agricultural and silvicultural activities are not significantly impacted by the water supply protection program. According to Mr. Brent McDonald of North Carolina Department of Education, Health and Natural Resources the agricultural management programs in North Carolina are not on par with the stormwater and development controls in the water supply protection program. Livestock has the potential to be a real problem in some of the water supply watersheds. Mr. McDonald also commented on the use of development density options by different localities in the State. As shown in Table 6-1, localities may select from two density options in categories WS-2, WS-3 and WS-4. The low density options depend on minimization of impervious surface to control the quality and quantity of stormwater runoff. The high density option utilizes a combination of impervious surface control and structural BMPs to control runoff. According to Mr. McDonald, the larger urban localities tend to use the high density option and rural localities tend toward the low density option. If the high density option is selected, the locality must assume responsibility for inspection and maintenance of BMPs (McDonald, 1996).

The statewide standards are beneficial in that several localities that would not otherwise have any watershed management program have been required to establish one. However, the state program does suffer from several shortcomings, including a lack of state enforcement and a lack of penalties for noncompliance. According to Ms. Lisa Martin of DEHNR/DWQ, the state does not exercise veto power to prevent localities with insufficient staffing and resources from adopting the high density option, but will try to convince such localities to adopt the low density option. The program does have a provision to allow the State to take over a local program that is not in compliance, but according to Ms. Martin that has never occurred (Martin, 1996).

REGIONAL WATERSHED MANAGEMENT INITIATIVES

The Triangle J Council of Governments

The Triangle J Council of Governments (TJCOG) is involved in several watershed management initiatives including the Triangle Area Water Supply Monitoring Project and the establishment of the Upper Neuse River Association and the Upper Cape Fear River Association.

Nine governments in the region cooperatively fund the Triangle Area Water Supply Monitoring Project. The Project involves monitoring at 22 locations in four counties. The program is carried out in cooperation with the U.S. Geological Survey and the North Carolina Division of Environmental Management. The monitoring program is intended to accomplish the following:

TABLE 6-1
GUIDE TO SURFACE FRESHWATER CLASSIFICATIONS IN NORTH CAROLINA

Activities Affected: Surface Freshwater Classification:	Area Affected	Wastewater Discharges Allowed	Development Activities: Low Density Option	Development Activities: High Density Option	Development Activities: Stream Buffers	Erosion and Sediment Control
WS-1	Entire Water Supply Watershed	None Allowed	None: Undeveloped	None: Undeveloped	Not Applicable	Stringent Rules Apply
WS-2	½ Mile Critical Area	General Permits	1 du / 2 ac or 6% built upon area	6-24% built upon area	Low Density: 30' High Density: 100'	Stringent Rules Apply
	Rest of Watershed	General Permits	1 du / 1 ac or 12% built upon area	12-30% built upon area	Low Density: 30' High Density: 100'	Stringent Rules Apply
WS-3	½ Mile Critical Area	General Permits	1 du / 1 ac or 12% built upon area	12-30% built upon area	Low Density: 30' High Density: 100'	Standard Rules Apply
	Rest of Watershed	Domestic and Non-Process Industrial	1 du / ½ ac or 24% built upon area	24-50% built upon area	Low Density: 30' High Density: 100'	Standard Rules Apply
WS-4	½ Mile Critical Area	Domestic and Industrial	1 du / ½ ac or 24% built upon area	24-50% built upon area	Low Density: 30' High Density: 100'	Standard Rules Apply
	Protected Area	Domestic and Industrial	1 du / ½ ac or 24% built upon area	24-70% built upon area	Low Density: 30' High Density: 100'	Standard Rules Apply
WS-5	River Segment	Domestic and Industrial	No Restrictions	No Restrictions	None Required	Standard Rules Apply

Source: North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management, Water Quality Section. "High Quality What? A Summary of Surface Freshwater Classifications in North Carolina." 1996.

TABLE 6-2
GUIDE TO SURFACE FRESHWATER CLASSIFICATIONS IN NORTH CAROLINA

Activities Affected: Surface Freshwater Classification:	Agriculture BMPs Mandated	Forestry BMPs Mandated	Transportation BMPs Mandated	Landfills Allowed
WS-1	Yes	Yes	Stricter N.C. Div. of Land Resources Erosion Controls Apply	None Allowed
WS-2	Yes	Yes	Stricter N.C. Div. of Land Resources Erosion Controls Apply	No New Landfills
	Yes	Yes	Stricter N.C. Div. of Land Resources Erosion Controls Apply	No New Discharging Landfills
WS-3	Yes	Yes	Yes	No New Landfills
	Yes	Yes	Yes	No New Discharging Landfills
WS-4	Yes	Yes	Yes	No New Landfills
	Yes	Yes	Yes	No Specific Restrictions
WS-5	Yes	Yes	Applied as Practical	No Specific Restrictions

Source: North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management, Water Quality Section. "High Quality What? A Summary of Surface Freshwater Classifications in North Carolina." 1996.

- Supplement the existing State data base for major ions, nutrients, and trace metals,
- Begin the first regional data base on synthetic organic compounds,
- Document spatial differences in regional surface-water quality,
- Examine and determine temporal trends in water quality,
- Provide water quality data to local planners and managers.

A fixed-interval sampling program was used to assess water quality in 21 streams and 12 reservoir sites. Samples were collected during periods of runoff at selected stream sites. Preliminary results indicate that concentrations of major ions, nutrients and trace elements were generally within acceptable ranges. Atrazine and other triazine herbicides were detected at nearly all stations, however no concentrations exceeded drinking water standards. Future plans include analysis of Cryptosporidium and giardia at 18 sites.

In addition to the regional program several communities conduct extensive water quality monitoring under separate arrangements. The overall quality of the region's water supply is considered to be good. However, continued population and economic growth will present significant watershed management challenges in the future.

The Upper Neuse Association

The Neuse River forms where the Eno and Flat Rivers converge just above Durham in the Piedmont section of North Carolina. A dam in the upper portion of the River near Raleigh creates the Falls Lake Reservoir. The main body of the lake is in Wake and Durham counties, but some of the embayments extend into Granville County. Falls Lake is the primary water supply for Wake County and the City of Raleigh. The Upper Neuse Association was created in January of 1996 to coordinate management of the watershed. The core working group includes elected officials from the City of Raleigh, Wake County, the Town of Wake Forest, Durham City, Durham County, Orange County, the Town of Hillsborough, Person County, the Town of Roxboro, Granville County, the Town of Creedmoor, the Town of Butner and Franklin County. In addition, the core group includes representatives from the soil and water conservation districts in Region J. The Association also includes a Technical Advisory Committee (TAC) that is composed largely of staff from the member localities. Members of the TAC include water resource planners, land use planners, utility directors and others. The role of the TAC is to provide the core working group with analysis and recommendations on technical, fiscal and policy issues.

The Association is involved in a number of initiatives including the preliminary phases of the creation of a watershed management plan, efforts to obtain relief from regulatory requirements for management of specific water pollutants in exchange for the adoption of a more holistic approach to watershed management, investigation of compensation issues between host and purveyor communities and application for grant funding to support the work of the Association. The Association is also in the process of incorporating itself as a non-profit corporation. A draft of the by-laws for the corporation contains the following mission statement.

The mission of the Corporation shall be to preserve the water quality of the Upper Neuse River through innovative and cost-effective pollution reduction strategies by:

1. Forming a coalition of units of local government, public and private agencies, and other interested and affected communities, organizations, businesses and individuals to secure and pool financial resources and expertise;

2. Collecting and analyzing information and data and developing, evaluating and implementing strategies to reduce, control and manage pollutant discharge;

3. Providing accurate technical, management, regulatory and legal recommendations regarding the implementation of strategies and appropriate effluent limitations on discharges into the upper portion of the Neuse River.

The draft by-laws go on to outline the role of affiliate organizations, which include both public and private organizations. The Board of Directors of the Corporation will appoint outside organizations to be affiliate organizations as needed. Affiliate organizations are not voting entities in the Association.

LOCAL WATERSHED MANAGEMENT PROGRAMS

Little River And Lake Michie

The Little River Reservoir and Lake Michie provide drinking water for both Durham County and the City of Durham. Both Reservoirs lie within Durham County. However, a large portion of the watershed for the two reservoirs extends into Orange and Person Counties. The Lake Michie watershed is split between Person, Orange, and Durham Counties, with the bulk of the watershed in Person County. Approximately two-thirds of the Little River Reservoir watershed lies in Orange County with the remaining one-third in Durham County. The watersheds for the two reservoirs are contiguous and together they are 264 square miles in size.

Land Use

Both of the water supply watersheds are predominantly rural. Based on 1987 data, approximately 70% of the Lake Michie watershed and about 76% of the Little River Watershed are forested. The following table contains specific information on land use percentages.

Approximate Land Use Percentages

	Urban	Forested	Pasture	Cropland
Lake Michie Watershed	6%	70%	10%	14%
Little River Reservoir Watershed	5%	76%	7%	12%

(CDM, 1989)

According to a watershed study performed by Camp, Dresser and McKee in 1989 the major source of pollution in the reservoirs is stormwater runoff from agricultural and urban areas. The watersheds are predominantly rural and most of the residential developments in the watershed use septic tanks for sewage treatment.

Watershed management efforts have been underway since 1983. Durham and Orange Counties adopted watershed management ordinances before the creation of the statewide water supply watershed regulations.

Durham Watershed Management Program

Mr. Terry Rolan, the Durham water resources manager, provided the following history of local watershed management efforts. The 1989 CDM study resulted in several attempts by Durham to coordinate an interjurisdictional watershed management program. These efforts failed to produce adequate results. The general perception by Orange and Person Counties was that the Durham utility was going too far with its demands. The failure of these negotiations was a factor in the creation of the statewide watershed management law and associated regulations. The state program establishes minimum standards for watershed protection based on the class of the watershed. According to Mr. Rolan, the classification system has been a valuable management tool. However, there is still a great deal of variation in the effectiveness of local water supply watershed management programs. In general, host localities that do not depend on a reservoir for their drinking water tend to implement a program that barely meets the State minimum standards. Purveyor communities tend to be more stringent in managing their own water supplies. Another interesting fact is that Durham has a joint City/County planning office. According to Mr. Rolan this has been helpful in implementing consistent and effective watershed management regulations. (Rolan, 1996)

According to Keith Luck, a planner with the joint County/City planning office in Durham, both Durham and Orange County had watershed protection ordinances in place before the advent of the statewide requirements. When the statewide program was enacted its requirements were in some aspects less stringent than the existing local ordinances. This lead to some requests by citizens and elected officials to weaken local programs, however little was actually done in this vain. In contrast, Person County in the northern portion of the watershed had no measures in place and was required to adopt a

watershed management program. This follows a general trend in North Carolina where the statewide watershed management standards had a more dramatic impact on rural localities than urbanized localities. In many cases the rural localities had no zoning or watershed measures in place prior to the initiation of the statewide standards (Luck, 1996).

Orange County Program

According to Ms. Emily Cameron, a planner with Orange County, the statewide watershed management standards have been beneficial for watershed management in Orange County. Some of the watershed management ordinances in the southern part of the County predated the statewide standards and were more stringent. However, in the northern part of the County two of the townships had no zoning or watershed protection measures and the advent of the statewide standards sparked the adoption of both zoning and watershed protection ordinances. At the request of Durham County these ordinances were made more stringent than the state minimums, requiring a maximum density of one dwelling unit per two acres. A task force is looking into compensation issues between Durham and Orange County. One option under consideration by the Durham utility is making water available to the host community (Cameron, 1996).

Person County Program

According to Ms. Julie Kelly, a Person County Planner, the County adopted its watershed protection provisions in 1994 in response to the statewide requirements. Two options were available to the County allowing for either high or low density development. The high density option requires the implementation of a stormwater management program that was too expensive for the rural Person County. The low density option requires a minimum lot size of one-half acre for residential development. This was not a problem due to an existing 1 acre lot size limit due to land area needed to support on-site well and septic systems. However, the creation of a regional water and sewer authority may create a situation where lot sizes smaller than the one-half acre minimum may be possible were it not for the regulatory provisions of the watershed ordinance. The County has a cluster option that may be useful in this event. The impact of the statewide standards on commercial development is a different story. Retail developments have been barred from complete paving of their sites. Some have been forced to chose between removing paved surface or purchasing more land before a certificate of occupancy is issued. Person County does not get any of the raw or finished water from the Little River Reservoir or Lake Michie, and no other form of compensation has been offered by the purveyor community. The State minimum standards were for the most part more restrictive than the preexisting County program and the Board of Supervisors was adamant about only adopting the minimum necessary for compliance. The regulations have not caused any major changes in development patterns or the nature of individual developments (Kelly, 1996).

CATSKILL/DELAWARE AND EAST OF HUDSON WATERSHEDS IN NEW YORK STATE

INTRODUCTION

The raw water supply for the New York City water system consists of two large groupings of reservoirs. The Catskill/Delaware watersheds are located approximately 100 miles north-northwest of the City. The second major grouping, the East of Hudson watersheds, are approximately 50 miles north-northeast of the City.

New York City is in the process of implementing an extensive water supply watershed management program. The Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act (SDWA) requires that New York must either filter its water or meet the criteria for filtration avoidance. Filtration of the water supply is projected to cost $5 to $8 billion for facility construction, and $200 to $500 million in annual operating costs. New York has opted to implement a watershed management program to meet the criteria for filtration avoidance. The City is working with the EPA to devise a program that maintains the existing high quality of the upstate raw water supplies. This is an extremely large and complex undertaking involving nearly a thousand staff members and approximately 1.4 billion dollars. The interjurisdictional nature of the situation has necessitated extensive public involvement in the development of the program.

The New York City water supply watershed management program includes, but is not limited to, the following elements:

- Comprehensive water quality inventory, surveillance and monitoring,
- Promulgation of new watershed regulations,
- Partnership programs with watershed communities and stakeholders, including the development of a Memorandum of Agreement (MOA),
- Kensico Reservoir coliform remediation and spill protection,
- Septic review, inspection and remediation,
- Enhanced enforcement of water quality regulations,
- Stream corridor protection,
- Watershed agricultural program,
- Natural resources management (NYCDEP (a), 1993).

Due to the extensive scope of the New York program, it is not possible to provide an in-depth analysis of all elements of the program. This analysis will focus on the MOA, the watershed management regulations and the watershed agricultural program.

MEMORANDUM OF AGREEMENT

The New York City Watershed MOA consists of four primary elements; a land acquisition program, watershed regulations, the structure and mission of the watershed protection and partnership council, and the watershed protection and partnership programs. The parties to the MOA include the upstate watershed communities, certain

environmental organizations, New York City, New York State, and the federal Environmental Protection Agency. The MOA was finalized in 1996.

Land Acquisition Program

"The Land Acquisition Program will enable the City to acquire, through the purchase of fee title to, or conservation easements on, environmentally sensitive, undeveloped land from willing sellers. The City will not acquire property through its power of eminent domain. The City will pay fair market value for property and continue to pay property taxes. The Land Acquisition Program also includes a community review process for property the City intends to purchase. The City will spend $260 million -- $250 million in the Catskill & Delaware Watershed and $10 million in the Croton Watershed to acquire property deemed important for drinking water quality protection. The State will invest an additional $7.5 million in Croton Watershed land acquisition (NYS (a), 1997)."

"Property in the Catskill & Delaware Watershed has been prioritized into five categories (1A, 1B, 2, 3, and 4) for acquisition, and property in the Croton Watershed has been prioritized into three categories (A, B, and C) for acquisition. The Agreement defines the priority areas according to their proximity to reservoir intakes and their distance from the City's distribution system. The City is not required to purchase a specific amount of acreage in the Watershed, however, it must contact the owners of 350,050 acres of eligible land in the Catskill & Delaware Watershed. The Agreement also sets out the multi-year schedule for the City to contact landowners in each priority area (NYS (a), 1997)."

"The parties recognize that any land acquisition program must provide reasonable opportunities for growth in and around existing population centers while preserving environmentally sensitive, undeveloped areas. The Agreement recognizes these concerns and allows West of Hudson and East of Hudson towns and villages to exempt certain areas from solicitation under the Land Acquisition Program (NYS (a), 1997)."

Proposed Watershed Regulations

"The proposed Watershed Regulations are an important part of the Watershed Protection Program and Agreement. They have been designed to protect the long-term viability of the City water supply and minimize the adverse impacts on the watershed communities. The Watershed Regulations are intended to work in conjunction with existing federal and state regulations and provide additional protections tailored to the upstate watersheds. The City and the State will adopt the new Regulations and will hold separate public review processes in satisfaction of State and City law. The Watershed Regulations are anticipated to become effective three months after the Watershed Agreement is signed (NYS (a), 1997)."

"The Regulations provide exemptions for certain activities in designated areas where existing communities are concentrated. This is intended to encourage responsible economic growth within existing areas while protecting water quality through increased regulation of activities within these existing areas (NYS (a), 1997)."

Key Elements of The Watershed Regulations

Wastewater Treatment Plants

All Existing Plants Must Provide Advanced Treatment Within 5 Years

"All existing plants must have sophisticated wastewater treatment technology installed within five years, including micro-filtration (or an equivalent technology) and phosphorus removal. The City will pay for those upgrades required solely by its Regulations. The City will also provide $5 million in funding to help existing plants located West of Hudson upgrade to meet current State requirements. The New York State Environmental Facilities Corporation (NYSEFC) will manage the upgrades at the existing plants (New York State (b), 1997)."

Prohibitions and Restrictions on Plants Located in Stressed Reservoir Basins

"New plants are prohibited from being built in phosphorus- and coliform-restricted basins and within the 60-day travel time to the City's distribution system, except new plants or expansions to existing plants may be allowed in coliform and phosphorus restricted basins to correct existing water quality problems;

In phosphorus restricted basins, expansion of existing plants may be allowed provided that a 2:1 phosphorus off-set can be demonstrated;

Under a five-year pilot program, in phosphorus restricted basins, up to three new plants of limited discharge capacity in the Cannonsville Basin located West of Hudson and up to three new plants of limited discharge capacity in Putnam County may be allowed provided the plants demonstrate a 3:1 phosphorus off-set in the area of the proposed discharge and meet the phosphorus effluent limit of 0.2 mg/l (New York State (b), 1997)."

Additional Restriction on Treated Wastewater Effluent Discharge Requirements

"No Discharge Allowed into Wetlands;

Discharge Allowed into Intermittent Streams, Subject to NYSDEC Intermittent Stream Standards;

Septic Systems

Prohibitions & Restrictions On Septic Systems

All new systems require prior approval of the City;

No new conventional systems are allowed within 100 feet of a watercourse or wetland or 300 feet of a reservoir;

No new raised systems are allowed within 250 feet of a watercourse or 500 feet of a reservoir, unless site constraints make buffer distances impossible;

Approval Authority for Individual Residential Systems, Except for Systems Located in Certain Sensitive Areas, Will be Delegated to County Health Departments (New York State (b), 1997)."

Development of Scientific Information

"A study will be undertaken to analyze the sufficiency of the 100-foot buffer distance between septic systems and watercourses and wetlands. Study results are expected within three years, and the Watershed Regulations and the State Sanitary Code may be revised based upon the study results.

East of Hudson, a study will be undertaken to assess the effectiveness of galley systems in treating sewage. Study results are expected within two years, and the Watershed Regulations may be revised based upon the study results (New York State (b), 1997)."

Stormwater Controls

Prohibitions & Restrictions on New Impervious Surfaces (i.e. Roads, Roofs)

"No new impervious surfaces within 300 feet of a reservoir;

No new roads within 50 feet of an intermittent stream or wetland, 100 feet of a perennial stream or 300 feet of a reservoir. Access roads to subdivisions will be allowed within the 100 foot buffer distance subject to approval of the City of a stormwater pollution prevention plan;

No new impervious surfaces within 100 feet of a watercourse or wetland, except (1) at a single family home on an existing lot or a new lot greater than 5 acres, and (2) if located in a village, hamlet, or area zoned commercial/industrial in West of Hudson or a Designated Main Street Area East of Hudson and the project sponsor receives approval of the stormwater pollution prevention plan from the City. Agricultural activities undertaken within the buffer distance are exempt from this prohibition (New York State (b), 1997)."

Stormwater Pollution Prevention Plans

"The City has review and approval authority over stormwater pollution prevention plans submitted by project sponsors for certain types of projects, including:

(1) activities that result in the disturbance of 5 acres or more,
(2) the construction of new subdivision,
(3) land clearing involving 2 or more acres, located at least in part within 100 feet of a watercourse or wetland or 300 feet of a reservoir,

(4) the construction of an impervious surface of 40,000 square feet or more,
(5) the construction of solid waste management facilities within 300 feet of a watercourse or wetland or 500 feet of a reservoir, and
(6) the construction of all new gas stations;

State, county, & local officials will make recommendations to the City to aid in the evaluation of proposed stormwater pollution prevention plans. However, the City retains final approval authority (New York State (b), 1997)."

Regulation of Hazardous Substances

Restrictions & Prohibitions on New Hazardous Substance Storage Tanks

"No new NYSDEC registered tanks within 100 feet of a watercourse or 500 feet of a reservoir. Owners of such tanks located between 100 feet and 250 feet of a watercourse, must (1) provide a copy of the State tank registration form before installation, (2) design a plan using best management practices, as required under State law, to prevent or minimize the release of hazardous substances, and (3) meet all other requirements of the State s hazardous substances tank regulations (New York State (b), 1997)."

Regulation of Petroleum Storage

"Restrictions on the Location of New Petroleum Storage Tanks:

No new gas stations within 100 feet of a watercourse or 500 feet of a reservoir;

No new tanks not requiring State registration within 25 feet of a watercourse or 300 feet of a reservoir, unless the limiting distance would preclude the continuation of an existing business;

No new tanks requiring registration under State law within 100 feet of a watercourse of 500 feet of a reservoir, unless the applicant demonstrates that the ban would preclude the continuation of an existing business;

New home heating oil tanks within 100 feet of a watercourse of 500 feet of a reservoir must be aboveground or in the basement;

Above buffer distances do not apply to the replacement in-kind of existing tanks (New York State (b), 1997)."

Establishment of the Pesticide & Fertilizer Working Group

"To Analyze State's Regulations on the Storage, Use & Application of Fertilizers & Pesticides;

To Recommend Any Changes to State Regulations or Enhancement to City's Ability to Monitor Impacts from the Storage and Usage of Fertilizers & Pesticides (New York State (b), 1997)."

Watershed Planning

Comprehensive Croton Watershed Plan

"A comprehensive Croton Watershed planning effort can be undertaken at the request of any county located East of Hudson, and in partnership with the localities in the counties and the City, to identify significant sources of pollution; recommend measures to be undertaken that, in conjunction with other water quality protection programs, will prevent degradation to, and improve water quality with the long-term goal of attaining water quality standards in the Croton System; and recommend strategies to improve water quality in the Croton System and to protect the character and special needs of the communities in the Croton Watershed (New York State (b), 1997)."

West of Hudson Comprehensive Strategy for Phosphorus Restricted Basins

"Where a new wastewater treatment plant or expansion of an existing plant is proposed in a phosphorus restricted basin, a comprehensive strategy may be developed by the City, county and the locality to identify existing economic resources and water quality problems, potential remedies for such problems, and recommend economic development initiatives that could be undertaken to sustain local economies while protecting the water supply (New York State (b), 1997)."

Watershed Protection and Partnership Council

"A Watershed Protection and Partnership Council (the Council) is to be created as a permanent, regional forum to aid in the long-term protection of drinking water quality and the economic vitality of the Watershed communities. The Council will represent a broad-based, diverse group of interests that share the common goals of protecting and enhancing the environmental integrity of the Watershed as well as the social and economic vitality of the Watershed communities. The Council will also be a forum for discussion and review of water quality concerns and related Watershed issues, and will make recommendations on future actions to be taken by the City, federal government, and State to enhance Watershed protection (New York State (a), 1997)."

"Most importantly, however, the Council will have dispute resolution authority to prevent future differences from festering and spilling over to the courts. The Parties have agreed to present all future disagreements to the Council for resolution before resorting to the more historical means of problem solving (New York State (a), 1997)."

Watershed Protection and Partnership Programs

"The Watershed Protection and Partnership Programs include the City's and the State's investment in the Watershed, including the City's investment in a host of programs designed to remediate existing adverse impacts on water quality as well as programs to prevent adverse impacts to water quality in the future.

The City has committed more than $270 million to West of Hudson for water quality protection and partnership programs and an additional $126 million for East of Hudson partnership programs. Together, these water quality protection and partnership programs include nearly $300 million for pollution prevention efforts, such as the upgrade of all 105 public and privately-owned sewage treatment plants; septic system maintenance and rehabilitation; the construction of new centralized sewage systems and extension of sewer systems to correct existing problems; stormwater management measures; public education, improved storage of sand, salt and de-icing materials; and stream corridor protection projects (New York State (a), 1997)."

WATERSHED AGRICULTURAL PROGRAM

Agriculture is a dominant land use in the upstate watersheds. Therefore, proper management of agricultural operations is a significant component of New York's watershed management program. Agricultural operations, and in particular dairy farming, have been identified as potential sources of *Giardia* and *Cryptosporidium*. Although New York's water is presently disinfected with chlorine, microbial pathogens (especially the protozoans *Giardia* and *Cryptosporidium*) are more resistant to chlorination than bacteria and viruses. Management strategies that deal effectively with *Giardia* and *Cryptosporidium* must focus on preventing their entry into the raw water supply.

Initially New York City proposed a set of mandatory regulations that would control agricultural activities. The farmers in the upstate watersheds contended that the regulations would drive them out of business, forcing them to sell their land and allow conversion to other more damaging uses. To deal with this problem an inter-agency/farmer task force was convened. The task force reached the following conclusions:

- Agriculture was acknowledged as a preferred land use for the water supply watersheds.
- Farm practices were acknowledged as a significant source of nonpoint source pollution and a potential source of pathogen introduction.
- Proper farm management was deemed critical for meeting the City's anti-degradation objectives.

In response to the work of the task force, the City developed a voluntary, locally developed and administered Watershed Agricultural Program. The emphasis in this program is on "Whole Farm Planning". Development of a Whole Farm Plan consists of the following.

- "Diagnosis by a Watershed Planning Team of potential sources of pollutants by conducting a systematic audit of each farm's physical and operating conditions.
- Review by the Watershed Planning Team of each farmer's technical and financial options for improving both the environmental and economic health of the farm.
- Review of the plan by local Soil and Water Conservation District and WAC.
- Signing of a contract by the farmer with the local county Soil and Water Conservation District to implement the BMPs stated in the plan (USEPA, 1997)."

The Whole Farm Planning process takes a "multiple barrier" approach to best management practice planning and implementation. The following is a description of the components of each of the three barriers.

> "First Barrier - Pollutant Source Controls: These controls might include herd health maintenance, sanitary improvements, calf housing improvements, Integrated Pest Management and altering rotational patterns to reduce soil runoff.
>
> Second Barrier - Landscape Controls: These controls might include barnyard improvements, manure storage, scheduled and directed spreading of manure, and composting to control application of animal waste to the landscape to reduce or eliminate the risk of pathogens, nutrients, sediments and pesticides from reaching surface waters.
>
> Third Barrier - Stream Corridor Controls: These controls might include streambank stabilization, stream crossings, and animal watering systems, and vegetated buffers to keep animals out of watercourses and reduce transport of pollutants into watercourses (NYCDEP (c)). "

"In late 1992, a major planning effort to develop and implement "Whole Farm Plans" for ten pioneering farms in five counties began. The plans apply and test practices such as barnyard runoff control, manure storage, stream fencing, and obvious soil control measures. Implementation of the ten plans is being funded by New York City up to a total of $1 million. Total funding for this planning phase is $5 million, including the training of project teams in each of the eight counties; development, testing, and demonstration on at least ten farms; implementation of several portions of the plans on all of the farms; and total implementation of structural and management practices on at least one farm (USEPA, 1997)." The next phase of the plan, funded at $35 million, is an ambitious program to sign up 85% of the 500 farms to voluntarily develop Whole Farm Plans and prioritize BMPs.

"In addition to the Whole Farm Plans, research is being performed by the Scientific Support Team from Cornell University, the New York State Water Resources Institute and others. This diverse group of farm economists, agricultural engineers, soil scientists, veterinarians, hydrologists, and other specialists conducts research to improve farm plans, does monitoring, provides engineering support, and develops tools and materials for implementing the plans (USEPA, 1997)."

OTHER WATERSHED MANAGEMENT INITIATIVES

Pathogens

The Department of Environmental Protection (DEP) is involved in a broad range of groundbreaking studies on the source, transport and fate of pathogens in the watershed and its reservoirs and tributary streams (NYCDEP, 1995). The goals of this multifaceted program include:

- Monitoring of pathogen levels in source water;
- Development of improved methods for identifying, counting and determining the viability of pathogens in water, soil and sediment;
- Assessment of the effects of specific point sources, nonpoint sources, and sinks on the occurrence and density of protozoan cysts. These sources and sinks include animal populations, sewage treatment plants, farms, septic systems, wetlands, and storm water;
- Determination of the movement and fate mechanisms of pathogens (NYCDEP, 1995).

The studies include development of a risk model for *Giardia* and *Cryptosporidium*, farm and control site monitoring, and watershed-wide monitoring at 33 sites (NYCDEP, 1993).

Pesticide Permitting

According to the NYC Department of Environmental Protection, "The pesticide permitting program is designed to monitor which pesticides are being applied on lands adjacent to New York City reservoirs, receiving streams, and non-reservoir water bodies within the New York City Water Supply System. Additionally, permitting allows the collection of data on the concentration and frequency of pesticide application, and the proximity of such application to important reservoir features such as potable water intakes (NYCDEP, 1995)."

Modeling

The NYC Department of Environmental Protection is also developing a multi-tiered hydrologic and water quality modeling system. This system is intended to achieve the following goals:

- "Provide estimates of current hydrologic, nutrient, sediment and pathogen loading to all New York City reservoirs;
- Provide a historical record of nutrient loading by combining estimated hydrologic flows with records of measured chemical parameters;
- Aid in the evaluation of differing management options;
- Aid in the identification of potentially sensitive areas for special attention;
- Setting priorities for remedial actions (NYCDEP, 1993)."

A geographic information system (GIS) interface is being developed for the models, and the Soil Conservation Service has already developed extremely detailed GIS coverages for the water supply watersheds (NYCDEP, 1993).

Stream Corridor Protection

The DEP has developed several stream protection strategies, including regulatory programs, establishment of buffer zones, land acquisition, and the Stream Corridor Protection Program. Each stream protection project will assess the character of the stream corridor, evaluate protection options, develop protection plans, and implement protection strategies (NYCDEP, 1993).

Enhanced enforcement of water quality regulations

The DEP has enhanced its enforcement of water quality regulations. The enhanced measures include aggressive policing and inspection of the reservoirs, increased water quality monitoring, full review of proposed developments and vigorous legal actions against polluters (NYCDEP, 1993).

CHAPTER 7

FINDINGS AND RECOMMENDATIONS

FINDINGS AND RECOMMENDATIONS

The following are the key findings of the research documented in Water Supply Watershed Management in Hampton Roads.

Effective water supply watershed management must address the watersheds in question as whole, integrated systems. All aspects of watershed management benefit from a holistic approach to data collection, planning and implementation. Fragmentation of a watershed leads to a skewed understanding of its functioning and yields less than optimum solutions to management problems. To achieve maximum effectiveness all aspects of watershed management, including, but not limited to data collection and analysis, identification of point and non-point pollution sources, BMP system engineering and maintenance, land use planning, hazardous material handling and stakeholder involvement must address watersheds as integrated units.

The USEPA is using the Watershed Protection Approach as an organizational paradigm for both Clean Water Act and Safe Drinking Water Act programs. The EPA continues to organize Federal water quality programs based on the Watershed Protection Approach. In addition, EPA is urging states to adopt a similar approach in their water quality programs. This trend has the potential to improve integration of diverse research and management activities occurring at the federal, state and local levels.

Regional cooperation in water supply watershed management is essential. An inherent difficulty in watershed management is caused by the fact that watershed boundaries seldom follow political boundaries. Given the complex interrelationships between host and purveyor communities and the number of water supply watersheds that cross jurisdictional boundaries in Hampton Roads, it is essential that the localities of the region work together to insure proper watershed management.

Water supply watershed management programs must be tailored to individual watersheds. Many variables come into play in determining the content of a management program, but the degree of development in the watershed in question is among the most critical factors. In the rural watersheds in Hampton Roads development controls are key. Comprehensive plans, land use plans, zoning ordinances and subdivision ordinances all play a critical factor in determining future land use patterns. In more urbanized watersheds stakeholder education and implementation and maintenance of BMPs are the more critical factors.

Watershed planning and management actions that precede the development of serious watershed problems are more cost effective and beneficial than efforts made to correct problems after they occur. Once detrimental land use patterns have been established in a watershed they are nearly impossible to modify. Management practices in this type of scenario are often limited to treating the symptoms rather than the cause of the problems.

Maintenance of forested open space in water supply watersheds is one of the most effective methods of water quality protection. Forested open space provides many benefits including limiting nonpoint source pollution, limiting runoff rates, limiting erosion, maintaining natural water temperature gradients and facilitating ground water recharge. In addition, forested open space requires little maintenance to provide these benefits to a watershed. (However, it should be noted that some localities in Hampton Roads are experiencing problems with deer and beaver overpopulation in forested areas.) In comparison, structural BMPs such as detention ponds are expensive to construct and become ineffective over time if not properly maintained. Many variables impact the effectiveness of forested open space, including the location of the open space in the watershed and the type of vegetation it contains.

Stream buffers are an effective tool for water quality protection. In the absence of larger tracts of forested land, forested stream and reservoir buffers are proven to provide several water quality benefits. A properly designed buffer system acts to slow and diffuse runoff, thereby reducing the adverse impacts of nonpoint source pollution. The width and constitution of the buffer system must be determined based on a host of factors including surrounding land uses, slope and soil type.

Regional stormwater BMPs are more cost effective than onsite systems, but must be carefully engineered to avoid adverse environmental impacts. Proper engineering of regional BMP systems becomes more difficult as the degree of urbanization in a watershed increases. Runoff rates increase rapidly as the percentage of impervious surface in a watershed goes up. In this type of environment it becomes difficult to maintain normal water temperature gradients and to limit transport of pollutants into receiving waters. Analysis of the watershed in question as an integrated unit is essential. Development of an integrated BMP system that incorporates both regional and onsite systems is often necessary to prevent adverse water quality impacts across a broad range of storm sizes.

Use of sound environmental and urban design principles in developing areas is essential to maintaining high quality water supplies. The degree of development and the percentage of impervious surface in a water supply watershed are obviously critical factors. However, the location of the impervious surface, the location and structure of buffer areas, and the details of site design also play a significant role in protecting water quality. All efforts should be made to employ sound environmental and urban design principles in developing watersheds.

Agricultural and silvicultural operations in water supply watersheds should employ Best Management Practices that are sufficient to protect water supplies. Several components of agricultural operations are potentially detrimental to public water supplies, including management of animal waste and application of fertilizers and insecticides. Sufficient buffer areas and other BMPs should be utilized to protect water supplies.

There are a number of institutional models for cooperative regional watershed management to protect water supplies. They range widely in cost and policy level involvement. At one extreme is New York City, where the watershed management

involvement. At one extreme is New York City, where the watershed management program involves a myriad of Interjurisdictional agreements and a cost in excess of $1.5 billion. Others, such as the Occoquan Basin, focus on scientific research and technical recommendations to several local governing bodes. Recommendations are provided to a Technical Advisory Committee, comprised of local government staff supported by the scientific community. Finally, the Upper Neuse Association in North Carolina involves both a Technical Advisory Committee and a policy level association of elected officials in the Basin.

Recommendations

1) **The localities in the region should continue efforts to build a framework for interjurisdictional cooperation on water supply watershed management:** The Water Supply Watershed Management Principles developed by the planning and utility directors of the region's localities establish a foundation for regional cooperation on watershed management issues. Deriving full benefit from the Principles will require the following actions:

   - The Principles should be utilized when localities make decisions on watershed development and management.
   - The existing Principles identify several areas in which development of regional standards and guidance is needed. The localities of the region should continue to work toward the development of the needed standards and guidance.
   - Individual host and purveyor communities should develop specific agreements on the sharing of financial and technical resources needed to facilitate watershed management efforts. These agreements should be based on the Watershed Management Principles
   - The existing Principles should be revised as necessary to incorporate emerging regional water supply watershed management issues.
   - The localities of the region should continue to work together toward the development of an improved scientific understanding of water supply watershed management problems and solutions.

2) **A regional educational program focused on water supply watershed management issues should be designed and implemented.** A comprehensive watershed management program must include a strong educational element. A successful education program must involve a broad cross-section of participants and provide incentives for their participation. The localities of the region should work together to develop a water supply watershed education program with a regional focus. The following audiences should be targeted:

   - **Watershed Residents:** Effective watershed management must include education of residents and businesses located in water supply watersheds.

Incentive programs to encourage the participation of these groups should be explored.

- **Development Community:** Design and technical assistance should be offered to the development community as a method of both educating developers on watershed management and minimizing the adverse impact of new development on water quality.

- **Industrial, Commercial and Business Community:** It is essential that members of the industrial, commercial and business community be aware of their proximity to water supply watersheds, the impact of their operations on water quality and Best Management Practices that can be employed to protect water quality.

- **Elected Officials and Local Staff:** Educational efforts for this audience should include information on the long term financial benefits of effective watershed management, the cumulative impacts of development, alternative approaches to development controls and the benefits of integration of watershed management efforts among different departments of local government.

- **Other Agencies:** Agencies, including but not limited to, the Virginia Departments of Transportation, Environmental Quality, Health and Conservation and Recreation, the United States Military, the Corps of Engineers, the United States Fish and Wildlife Service and others as appropriate, should be included in educational efforts.

3) **An enhanced set of regional water supply watershed management tools should be developed and made available to all localities in the Planning District.** Several tools are needed to support regional watershed management. While many data sets and planning tools exist in each of the localities in the Planning District, few of them are suitable for managing watersheds that cross jurisdictional boundaries. It is essential that each locality that contains part of a water supply watershed has the data and tools necessary to assess the cumulative impact of development in the entire watershed. The following steps are intended to create a suitable set of watershed management tools.

- **Evaluation of Existing Data:** The first step in this process involves the evaluation of existing data on the water supply watersheds in Hampton Roads. Water quality trends, land use trends, data on natural systems, BMP inventories and other significant information should be assembled and evaluated for possible inclusion in a regional data base.

- **Research:** Significant information gaps identified in step one should be addressed through research and analysis of the region's water supply watersheds. Individual watershed studies should be structured to add to a cumulative regional data base and, where possible, add to the understanding of processes impacting watershed management across the region.

- **Regional GIS:** A regional Geographic Information System is an essential tool for both archival research and analysis of information pertaining to water supply watershed management. A regional system would provide a platform for organization, display and analysis of data pertaining to multi-jurisdictional watersheds. A regional GIS would be valuable in determining the cumulative impacts of land uses in the watersheds. In addition, such a system could be used to design regional stormwater BMPs, and as part of a software system to perform hydrologic and water quality modeling. The existing Regional GIS Users Group should be included in the development of a system that supports water supply watershed management.

4) **The localities of the region should formally establish an institutional structure for interjurisdictional cooperation on water supply watershed management.** To continue the Interjurisdictional dialogue and guide the development of the educational programs and analytical tools necessary to support cooperative water supply watershed management, a Technical Advisory Committee, comprised of the region's Directors of Utilities and Planning Directors Committees should be established. The HRPDC should provide staff support for the TAC and the programs. (This action would formalize the existing roles of the HRPDC Directors of Utilities and Directors of Planning Committees in water supply watershed management.) The localities should explore, through the HRPDC, the establishment of a regional policy mechanism for water supply watershed management., which may include local elected officials or their representatives..

5) **The localities of the region should develop an enhanced watershed inspection and maintenance program.** Without rigorous inspection and maintenance it is difficult to realize the full benefit of a watershed management program. In particular, inspection and maintenance of stormwater BMPs is critical to their proper functioning. Opportunities for regional cooperation in this area should be investigated.

6) **The localities of the region should remain involved in the State's efforts to develop a source water protection program.** As the State of Virginia continues the development of a source water protection program, it is important that the localities of Hampton Roads remain engaged in the process to ensure that the State program meets the needs of the region.

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